Weather, Local Knowledge and Everyday Life

   

Issues in Integrated Climate Studies

Edited by
Vladimir Jankovic and Christina Barboza

MUSEU DE ASTRONOMIA E CIÊNCIAS AFINS

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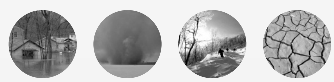

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MAST, Rio de Janeiro, 2009

ICHM 2001 History of Meteorology
MUSEU DE ASTRONOMIA E CIÊNCIAS AFINS
Ministério da Ciência e Tecnologia
BRASIL UM PAÍS DE TODOS GOVERNO FEDERAL

Weather, Local Knowledge and Everyday Life:
Issues in Integrated Climate Studies.
Vladimir Jankovic and Christina Barboza (Eds.)

Book and cover design by Felipe Cavalcanti

Catalogação na fonte do Departamento Nacional do Livro

Acknowledgements

We would like to thank the Brazilian Ministry of Science and Technology (MCT), the National Institute of Pure and Applied Mathematics (IMPA), the Cultural Association of the Museum of Astronomy and Related Sciences Fellows (SAMAST), and the Carlos Chagas Filho Foundation of Support to Research in the State of Rio de Janeiro (FAPERJ) for their support to the ICHM "Weather, Local Knowledge and Everyday Life" Conference, held in Rio de Janeiro, 26-30 May 2008.

We would also like to thank the members of the organizing committees, namely Cornelia Lüdecke (ICHM President), James Fleming (ICHM past-President) anad Samuel Randalls (UCL), Alfredo Tolmasquim (Director of MAST), Priscila Faulhaber and José Antônio Queiroz. Luís Felipe Ferrão helped us with registration fees and ready money, while Ethel Handfas, Felipe Cavalcanti and Cecília Moura were invaluable in the production of printed materials. Finally, we would like to give a special thanks to Roseana Costa, the Conference secretary, who worked full time to create the most stimulating ambience for friendship and our scholarly reflections on the weather.

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I. INTRODUCTION

The Many Lives of Weather

Vladimir Jankovic and Christina Barboza

In May 2008 scholars from four continents gathered in Rio de Janeiro to explore past and present ideas about how weather, climate, and environmental change affect daily practices and beliefs of people worldwide. During the four days of discussions in the superbly equipped National Institute of Pure and Applied Mathematics (IMPA) perched on the hills of Tijuca National Park, historians, sociologists and anthropologists of environmental knowledge engaged to unpack the seemingly mundane question about what it means to 'live in the weather'. Presentations took place in an air-conditioned auditorium, and this fact added to the complications involved in thinking what constitutes weather sensibilities and whether weather could exist indoors. As the air temperature in the auditorium remained around 23 degrees Celsius, some complained of feeling too cold under artificial air currents, while others thought that the room be even cooler. The rest didn't seem to mind either way. Clearly such reactions reflected differences in expectations about environmental comfort: even inside, we continued to speak meteorologically and not only out of academic interest. Meanwhile, we were all delighted by the ambience of the cloud forest jungle and the beaches of Rio, where most of us stayed. In the end, IMPA proved to be something of a laboratory for testing our ideas about personal comfort and a site in which it seemed natural to explore whether individual preferences trickled up to larger scales. Are societies climatologically idiosyncratic as well?

Despite recent debates on the future of global climate, atmospheric processes are not new to social thought. Climate and weather have been recurrent themes in world history despite the alleged uniqueness of our current concerns. It is widely recognized that klima had been central to questions about national character, legal theory, health, agriculture, trade, and colonialism. But some basic questions remain. How could 'climate' ever come to shape – as it does today – global decision making, humanitarian reform, and technological change? How exactly does it feature in social theory, political philosophy or economic policy? What is the relationship between environmental contingency and human rationality if, as an eighteenth-century journalist opined, "[w]e cannot be made better men [sic] or better Christians by believing that our passions and our religion itself are the effect of climate." (1) Furthermore, it is increasingly important to understand how atmospheric realities either stipulate or stimulate practice and provide social identity and expectations in a changing environment. Equally relevant is to look at what might be called 'elementary units' of engagement with the weather as in task scheduling, hygiene, and leisure activities. In relation to such realms, it also remains to be seen whether meteorological expertise can provide sufficient information for running life on daily basis. Perhaps the local climate is always already embedded in praxis and for that reason inaccessible, at some level, for analysis?

There have been only limited attempts to interrogate these issues: the meeting in Rio was an occasion to redress this lacuna. The International Commission on History of Meteorology and the Brazilian Museum of Astronomy and Related Sciences invited scholars from across social sciences to reflect on the ways in which we could see weather as lived rather than theorized. Our hope was for a meeting that would launch a longitudinal and global approach to weather experiences as they emerge (or hide) in routines, rituals, and everyday practices. Such hopes were not let down. The response from scholars was overwhelming, the variety of themes extraordinary and the timetable allowed for plenty of interaction. As editors, we are fortunate that the present collection demonstrates that speaking about the weather – rather than being a banal conversational trope – is really about social reality: about family, city, region, or nation as well as about our religious, ethnic, professional and otherwise 'tribal' identities.

But does weather even matter in a world in which advanced technologies in housing, transportation and weather prediction have all but eliminated its impacts on everyday life? Barring extreme events, is it true that "[i]n our time we have grown used to be able to do what we need or wish to do irrespective of what the weather is up to" (Fort, 2006, p. 12). This possibility is underscored by the fact that the time people spend indoors – in some latitudes almost 90% of life – makes the 'outdoor' weather forecasts look like no more than tid-bits of evening news few people would know how to use even if they had to. We do not necessarily think that traffic disruptions or businesses closures come about solely from bad weather; we rather tend to believe that the reasons have also to do with the vulnerability of technological systems and infrastructures of global economy. Weather then is a relative entity. In some parts of the world, its seasonality structures activities; in other places, it is completely detached from annual cycles of work. It is one thing for those who migrate or travel; another for those working indoors. It affects the roofer, but not the accountant. Depending on the role which atmospheric environment takes in world cultures, weather may be a part of providential order, a self-standing natural force, or an excuse for bad emergency systems.

But weather also makes a difference on different scales: from personal control and indoor air-conditioning, to street turbulence and urban heat island, and to national and global environmental discourses and policies. Steve Rayner, Elizabeth Shove and James Fleming, whose contributions open this volume, all look at how different scales of engagement inform one's aims at thinking, controlling, and representing atmospheric realities. Reflecting on the stakes involved in current climate crisis, Rayner is concerned to see climate policy incorporated into the routines of everyday life where it could secure the vital interests of citizens. In public pronouncements, however, he identifies a crypto-determinist discourse that thwarts action and paints climate change impacts as a matter of geographic fate: the spread of vector-borne diseases, for example, is too often viewed primarily as a function of the countries' respective distances from the equator. Similar mediations, as Shove shows in her manifold history of indoor climate control, have taken place when individual preferences for heat, humidity and air movement have been rebranded as laboratory parameters and artificially re-imposed on users by the indoor systems of air control. Ironically, the artificially created weather is rarely found in 'nature'.

More worrying still is the fact that the energy consumption used for 'domesticating' the weather indoors is among the causes of outdoor climate change. Fleming, on the other hand, explains that such 'domestication' can take on an ominous form when designed on a planetary scale. In the proposals to 'fix the sky' – anywhere from rainmaking to hurricane steering to cooling the global climate by means of trillions of discs in space that would cast a giant shadow over the Earth – he finds a recurring infatuation with 'foggy thinking' epitomized in Phaeton's zeal to drive the chariot of the sun. He draws attention that a decade before the discovery of the destruction of stratospheric ozone, Harry Wexler, a US Weather Bureau meteorologist, had already pointed up the risks of intentional or unintentional modification of the climate.

Policy, personal wellbeing, global engineering: such issues suggest a state of permanent emergency in which climate events cease as 'matters of fact' and become 'matters of concern' (Latour, 2004). Contributions in the section "Weather, History and Emergency" show that this is true especially when material damage and fatalities are involved. But it is also true that in understanding and coping with environmental disasters, different communities develop diverse explanatory frameworks, as Isabel Malaquias, Gaston Demarée and their colleagues show in their rich intellectual history of the reports following the devastating earthquake in Lisbon in 1755. Seismic and hydrometeorological crises reveal the cultural assumptions about their causes but also elicit a moral discourse about human responsibility and official malfeasance. The juxtaposition of these parallel, but not necessarily competing, mechanisms of coping are here exemplified in Anna Carlsson's reconstruction of the public and professional reactions to the London storm surge in January 1928 in which high tides destroyed parts of the Embankment and caused fourteen deaths. Similarly, concerns about the culpability and official decision making are the subject of Christina Barboza essay on a storm which caused a fatal wreck of a passenger steamboat off the Brazilian coast in July 1887. Barboza draws on rich local knowledge to show how the disaster got entangled in a dispute over the control of National Meteorological Service.

Casting blame on nature and authorities can be interpreted as a mechanism of coping with what is painful or unfathomable. But societies also develop the means of coping in the form of preparedness, material as much as cultural. For example, Christian Rohr explains that early modern residents of the Austrian Alps employed the commemorative votive tablets and local registers to build a 'culture of memory' as a repository of techniques needed to adapt and come to terms with the threat from avalanches. But while a similar culture helped the seventeenth-century Germans to protect themselves against the storms of the North Sea, such a culture, explains Matthias Heymann, was entirely absent in Miami Beach when a hurricane in 1926 caused preventable deaths and destruction. Emphasizing the importance of local knowledge in coping with extreme environmental

(1) Remarks on the Influence of Climate, Situation, Nature of Country, Population, Nature of Food, and Way of Life, on the Disposition and Temper, Manners and Behaviours, Intellects, Laws and Customs, Form of Government and Religion, of Mankind. Westminster Magazine [review]. September 1781, p. 492.

conditions, Heymann speaks of a 'coherence' between cultures and environments as a precondition of successful adaptation strategies.

Theorized or experienced, weather and climate have been central to every socio-cultural system. In modern times, this phenomenon can be traced to the early eighteenth century, when leading European scholars argued that people and their surroundings existed in a quasi-homeostasis whose manifestations were visible in the vastly different modes of existence, dietary habits, belief systems and political arrangements. Such claims relied on the idea that air, intellect, and social convention engaged with each other in a way explicable only in terms of a comprehensive social climatology. We traced examples of these 'deterministic' beliefs in the section entitled "Cultures of Climate", in which Heloisa Gesteira examines the climatological assumptions found in the canonical work of Brazilian history written during the Dutch colonization of Northeastern Brazil by seventeenth-century natural philosophers Wilhelm Piso and Georg Marcgraf. But as Mart Stewart demonstrates, the reductionist logic of social climatology extended well into the modern period, when, in the antebellum United States, it served to link African slaves' 'temperaments' to the heat and humidity of the non-European South. Indeed, the foreignness of atmospheric landscapes became a trope that spawned a prolific commentary among Europeans struggling to survive and understand the unfamiliar climates of the Orient, the Poles, and the New World. Even in Europe, personal encounters with outside atmospheres evolved from a formulaic backdrop of anthropocentric arts to a nature-oriented aesthetic of the picturesque. In this sense, Marilyn Gaull's research shows that the English shift from a literary to a real weather owed, in part, to the freedom to roam which enabled the sedentary scholar to experience the elements as an inspiration rather than a threat.

Despite the scientific 'appropriation of weather' (Friedman, 1989), weather and climate enjoined different communities to develop diverse sub-cultures of the atmosphere. The public visibility of 'climate cultures' during the last one hundred years testifies to an enduring fascination with the aleatory and elusive quality of atmospheric phenomenology. From the theaters of war to the meccas of tourism, from agriculture to Hollywood, the specter of weather haunts the environmental age and populates it with extraordinary expressions of 'airmindedness'. The interest was especially animated by the culture of suspicion during the Cold War when, as Teasel Muir-Harmony explains, the atmospheric uses of radarscope provided spectacular evidence for the purported 1952 UFOs 'Invasions of Washington'. Looking at the same period, Roger Turner examines the emergence of TV weathercasters in the USA, exploring the clashing agendas of meteorologists and producers in what concerned the employment of women. Luiz Borges & Ana Villas-Bôas discuss the Brazilian State policy for the development of native satellite technology, stressing its role in the constitution of a community of 'national' meteorologists. And Vladimir Jankovic closes the section with a political economy of weatherproof garment industry which, in unexpected ways led to a commercialization of atmospheric hazards and extreme environments.

One of the lasting results of the nineteenth-century meteorology were observational networks supported by nation states and established to serve within their political boundaries (Fleming, 1990; Nebeker, 1995). This process was accompanied by the professionalization of meteorologists in Europe and the USA and the rise of overlapping 'weather communities' explored in the section on "Weather, Science and History". Katharine Anderson takes the lead by comparing the work of Gavin Pretor-Pinney and his web-based Cloud Appreciation Society with the writings of a nineteenth-century Cuban meteorologist, Andres Pöey y Aguirre. Dissimilar in other respects, Anderson identifies their common interest in cloud observation, seeing this as central to thinking about the relationship between the local and the universal in meteorology. The issue is also central to Russel Lee's account of the interactions between meteorologists and sailplane pilots when they assisted each other during international contests, as information about atmospheric conditions could make all the difference. Cornelia Lüdecke and Flavio Edler extend the theme to explore how individuals and knowledge communities use weather to assert local identities. Where Cornelia Lüdecke's analysis of the medical history of Foehn demonstrates its meaning for the Swiss and Bavarian research identities, Edler explains the creation of 'tropical' medicine in Brazil as a bid for political power by local doctors. These papers demonstrate that weather information often serve more than one purpose, depending on the needs and agendas of their users. Doria Grimes adds to this notion in her report on the collection of weather trivia and anecdotes broadcast in the interwar United States, whereas Mathias Deutsch & Karl-Heinz Pörtge write on the compilation and uses of the nineteenth-century data obtained at Prussian water-level gauging stations.

But we should also point out that meteorology is not always about the weather. Nor is the weather always the subject of meteorological science. It is true that a historical sociology of atmospheric knowledge has in the last several decades raised a good number of issues specific to meteorological and climatological sciences that have greatly benefited scholarly work. The research in science studies and history of science has thus spanned the topics from the politics of global surveillance to micrometeorology of sick buildings to epistemology of weather divination. In our last section we move further afield to consider the growing body of research in environmental anthropology and the indigenous uses of 'atmospheric' space. This research has brought to light that particularly fascinating realm of experience in which the weather and everyday merge on a level of unconscious acts of daily life and thus remain inscribed as indivisible constituents of the quotidian. The weather and climate as lived are different from the weather and climate as analyzed.

Anthropologists at the meeting addressed this issue from a variety of perspectives and with an eye on the fieldwork and interviews they had carried out with 'indigenous' groups from Africa and Latin. The section "Living the Weather" explores this research in a comparative and historical perspective, starting with Chris Low work based on his stay in South Africa, Botswana and Namibia, where he conducted interviews with the KhoeSan in search for the meaning attributed to atmospheric phenomena in their healing rituals. Priscila Faulhaber relates her findings on the astrometeorological knowledge used by the Ticuna during a puberty festival in the Amazon and compares this information with the reports of Curt (Unkel) Nimuendaju, a German ethnographer who studied the same topic during the first half of the twentieth century. Márcio Campos & Tamar Bajgielman examine the Kayapó shamans' understanding of weather 'signs', which alongside astronomical observations are used for marking time and positioning the houses in every village, while Luiz Borges & Flavia Lima reconstruct similar practices of the now extinct Tupinambá and the remaining Guarani people. Heloisa Domingues focuses on the early cultural anthropology, when Claude Lévi-Strauss travelled to Serra do Norte, accompanied by the less known Brazilian ethnographer Luiz de Castro Faria, now considered one of the founders of Brazilian anthropology. In their writings she traces information on the influence of local climate in the Nambiquara's everyday life. Renzo Taddei, in a more contemporary context, investigates the distrust with which the rural population of Brazilian Northeast takes the 'official' climate forecasts, in spite of the local meteorologists' efforts to bridge the cultural gap. Similar interpretative concerns are shared by Frank Uekötter, whose discussion of the American Dust Bowl crisis suggests that the event, rather than being a 'natural disaster' or an 'emblematic event of agricultural capitalism', was a result of the settlers' unfamiliarity with the Great North American Plains. Finally, Karen Pennesi's proposal for a searchable database of 'indigenous' forecasting indicators asks if it might be possible to refashion 'meteorological' knowledge and forecasting methods to take into account the experiences of those who 'live' rather than simply 'analyze' the weather.

We believe that this survey highlight that the ideas about 'living in the weather' or perhaps 'against the weather' open up a new dimension of questions for the community of scholars working in the integrated weather studies and science studies, more generally. Rio meeting was an attempt to release 'weather' from disciplinary shackles. Yet, our goal has not been an abstract 'interdisciplinary' approach. Rather, we believe that the multiple voices, themes and methodologies heard during the meeting have firmly established a deep hybridity of the weather as an entity endowed with meaning, but also reproduced for consumption, created for voyeuristic gaze, and dismantled into oblivion. Weather and climate could then be seen as the omnibus 'markers' of everyday life for communities who in their ways of life depend on coming to terms with the challenge of atmospheric contingency and wonder – from the hurricane devastation to inarticulate beauty of mountain snows and to fatal droughts in the developing world. Footprints in the sand and footprints in the snow will meet one day to allow those who made them to tell stories about where they have been and where they would want to venture next.

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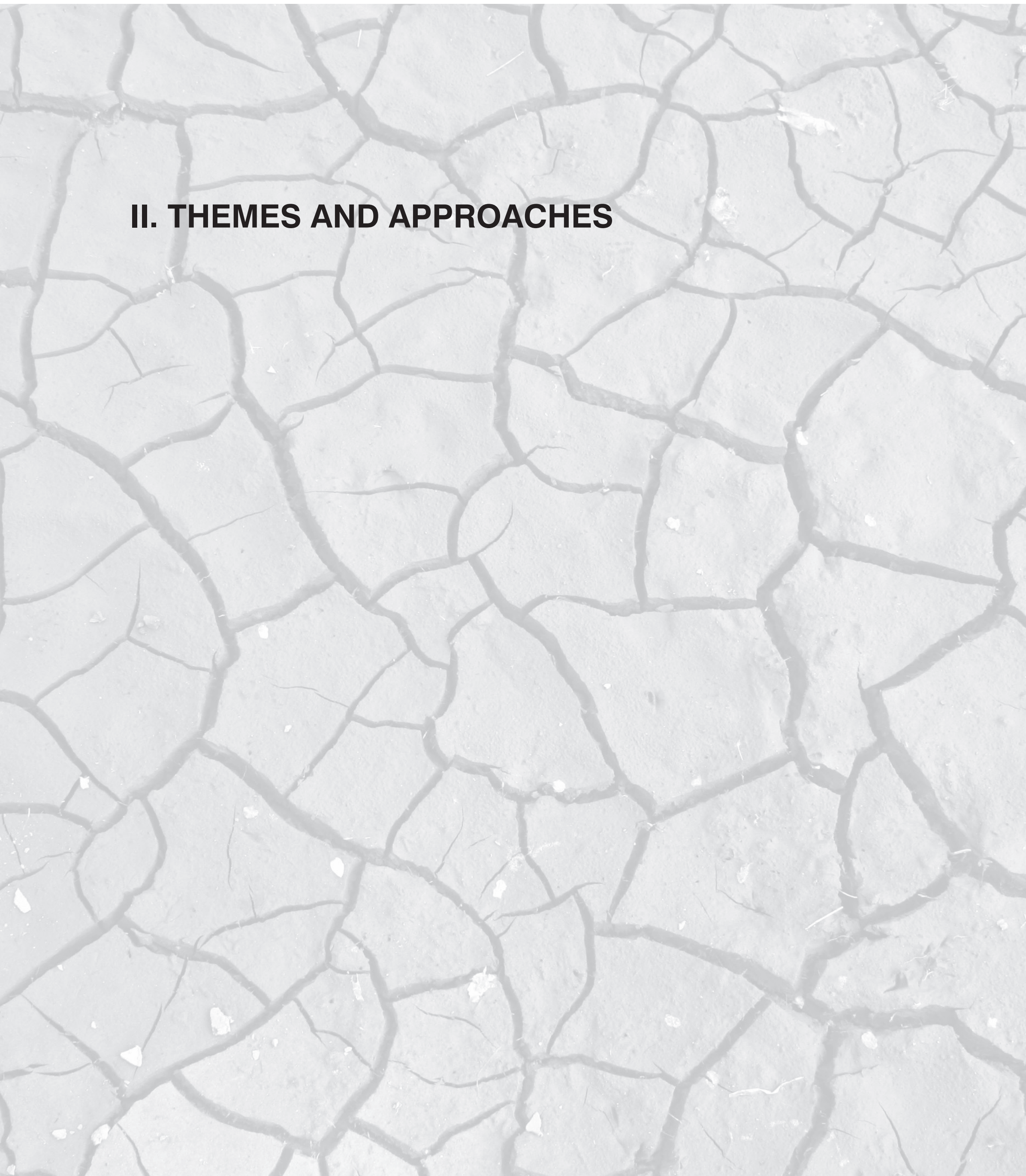
II. THEMES AND APPROACHES



Weather and climate in everyday life: social science perspectives

Steve Rayner (James Martin Institute of Science and Civilization/University of Oxford, UK)

Throughout history, people's collective identity, whether their own or that of others, has been inextricably bound up with their weather and climate. Furthermore, humanity's everyday engagement with the weather has been characterized by attempts through various means to domesticate the uncertainty or the consequences of weather and climate, or to escape from its apparently relentless formative influences. The modes of everyday domestication include forecasting, attempts at weather modification, clothing, infrastructure and buildings, and technologies for heating or cooling.

In these opening remarks, I will start with the idea of climate as a formative or shaping influence on our lives and how our life ways shape our experience of climate. I'll go on to consider various avenues by which humans in different places and times have perceived the weather and sought to domesticate it. In particular, how weather and the technologies of weather forecasting contributed to the formation of nationhood in the eighteenth and nineteenth centuries and how the idea of a global climate has accompanied the economic and political globalization of the twentieth and twenty-first centuries. Finally I will offer some thoughts about everyday weather experience and current climate change policy.

1. Climatic determinism

The idea that weather and climate are decisive forces in forging the characteristics of particular peoples or communities is an ancient one. Climatic determinism dates back more than two-and-a-half millennia. Hippocrates and Herodotus writing in the fifth century BCE both reported the purportedly causal relationships between cultural temperament and the weather. Intriguingly, the ancient Greeks thought that cold weather made the British aggressive and sexually promiscuous – some two-and-a-half millennia before their unfortunate descendants were routinely exposed to the notorious behaviour of contemporary British tourists in resorts such as Faliraki. Tourists behaving badly apart, the ancient Greek view is a remarkable contrast with the more familiar stereotype of the British as being as cool and temperate as their weather. And of course, nineteenth-century British writers turned the Greek's view on its head, attributing the 'hot' Latin temperament to the Mediterranean climate.

By the 18th century anecdote gave way to science in the justification of climatic determinism. Montesquieu took an empirical approach. He studied the taste buds of sheep's tongues and their blood circulation at various temperatures. He concluded from such rigorous scientific investigations that Northern people were bolder but less devious and less sensitive than those from lower latitudes!

American President and polymath, Thomas Jefferson (himself a Southerner) contrasted the "idle and dissolute inhabitants of the South" with the "sober and active" population of the North of the USA. Ironically this slander on those who had settled in the South was itself transmogrified by apologists into a justification for slavery on Southern plantations. Slave owners and their pamphleteers argued that 'negroes' were, by disposition arising from their climatic origins, suited for manual labour under sweltering conditions that were impossible for Europeans of a more delicate constitution.

Climatic determinism was not a peculiarity of Western thought. The ninth-century Afro-Arab Scholar AlJahiz correlated climatic and even geological conditions with the physiological characteristics of human populations, while his better known fourteenth-century compatriot, the Arab historian Ibn Khaldun, heavily influenced by his classical Greek forebears, held similar views of Northern peoples to those of Herodotus and Hippocrates. Comparable ideas can also be found in ancient Chinese writings, which do not appear to have been susceptible to Greek influences.

The early twentieth-century American Geographer, Ellsworth Huntington, is perhaps the most notorious climatic determinist of modern times. His *Civilization and Climate* (1915) was concerned to explain why "people of the European races are able to accomplish the most work and have the best health." Like other climatic determinists, Huntington seemed keen to justify his own experience of a temperate climate as that which is most ideal to the development of civilization.

A twentieth-century triumph of false correlation and an economic manifestation of climatic determinism is the so-called 'equatorial paradox'. According to this theory, reiterated in a book recently published by the eminently respectable MIT press (Parker, 2000), about 70% of the economic development of a country can be predicted from the distance between that country and the equator. In other words, the further from the equator the more developed a country tends to be. It is claimed that the paradox applies equally well to both North and South. Australia, for example, has a higher level of economic development than Indonesia, although Singapore is an embarrassing exception to the rule. It is also said to hold within countries – the Northern US states historically have been more developed than the Southern US states. However, as we enter the twenty-first century, both these claims would seem to be faltering as India's economy develops apace and the population centres of the USA shift decisively to the South.

Climatic determinism is alive and well in the works of civilizational catastrophists such as Jared Diamond (2005) and James Lovelock (2006). It is also rampant in much of the science-driven discourse on climate change, especially with regard to anticipated climate impacts, such as the spread of vector borne diseases (Patz & Khalq, 2002), which seem, often as not, to assume a lack of human responsiveness to signals of change that would be truly remarkable.

2. Social context and weather perception

Partly in reaction to climatic determinism, which, despite its eclectic history, liberal thinkers associate with modern imperialism and neo-colonialism, social science over the past half-century has tended to the view that the perception of climate and weather is shaped more or less strongly by everyday experience of social, political, and economic arrangements.

A definitive case is Mary Douglas's 1962 paper on the Lele and Bushong (Douglas, 1968). Although described in the subtitle as "a case of economic backwardness," the paper begins with the Lele and Bushong's diametrically opposed perceptions of the Congolese dry season, despite the meteorological data for both tribes being virtually identical. Douglas attributed the differences in perception to different economic cycles driven by cropping practices and different marriage systems, which provide contrasting incentives for manual labour at different times of the year. The Bushong planted a series of crops in a rotation cycle and were able to escape the heat of the fields, while the Lele planted only one crop of maize that had to be harvested at the height of the dry season. Hence the Bushong welcomed the dry season as a cool relief while the Lele experienced the same conditions as a hot and dangerous time best spent seeking relief from the relentless elements.

Looking at another time and different continent, cultural historian and geographer William Meyer (2000) reports that eighteenth- and nineteenth-century New Englanders viewed a mild winter as a serious handicap. In contrast with the present when snow upsets transportation schedules and causes school closures, snow pack in earlier times facilitated movement of heavy freight, and also, combined with lighter agricultural work demands, facilitated social visiting, both of which, before the advent of paved roads, were more onerous when the ground was soft.

Interviewing contemporary Americans about their perceptions of climate and weather, Willett Kempton *et al*. (1995) found that middle class respondents, who associated warmer weather with the days at the beach or the pool, often did not view the prospect of global warming with the same concern as some inhabitants from lower income inner-city areas where hot weather may be associated with heat-stress, tension, and even violence.

Kempton *et al.* also found that people who believed that humans are doing immoral or unnatural things to nature (nuclear tests, space shots) were more likely to perceive long-term shifts in patterns of violent or anomalous weather during their own lifetimes.

On the question of weather memory, it does seem, as Trevor Harley (2003) and Ben Orlove (2003) respectively indicate, that our memories of past climates depend very heavily on idealized stereotypes of seasonal conditions. We still expect to see snowmen on Christmas cards although, as Harley points out, there has not been a White Christmas in Lowland Britain since 1970. Even Colin West and Marcela Vásquez-León's (2003) finding that farmers in Southwest Arizona have accurate recollections of rainfall patterns close to the statistical records does not contradict this general principle, especially since the only other source they have is pumped groundwater, so annual and monthly irrigation costs are likely to serve as an independent reminder of seasonal weather conditions each year. Hence, the Southwest Arizona case should not be interpreted as invalidating the rather robust findings that people's recollections of past weather patterns are usually unreliable.

3. Weather and climate as site for investigation of relationship between ideas of nature and social order

Following Mary Douglas's key insight that nature provides the trump card or ultimate justification in a wide variety of arguments, weather and climate seem to provide a fertile site for investigation of the relationship between ideas of nature and the social order.

Todd Sanders (2003) describes the inextricable links between making rain and making the social order of gender relationships among the Ihanzu who inhabit the arid environment of north-central Tanzania. Ihanzu men dominate agricultural production and stock keeping, but once grain is harvested, women control its allocation within and outside the household. Of particular importance is the decision about when to brew beer. Indeed, women control the ebb and flow of the local economy and village life by controlling grain and its products. The sexually charged rituals of rainmaking, involving among other things the male and female symbolism of making fire by rotating a wooden rod in a wooden orifice, also serve to assert the complementarity of male and female roles in ensuring the continuance of the Ihanzu people, both physically, through procreation, and socioeconomically. The risk of failing rain upholds this assertion of gender equality dissolving the gender asymmetries of everyday life.

Weather and climate risk – like other hazards of nature – are thus powerful instruments of social control, as we can hear from various contributors to this volume on the topic of natural disasters. But, like most such instruments weather risks are more powerful when routine, rather than exceptional – hence the importance of the focus of this Conference on weather and 'everyday' life.

But have we merely substituted one determinism for another one? Did late twentieth-century social science merely replace two and a half millennia of climatic determinism with an equally monotonic social or cultural determinism?

The currently fashionable resolution of the dilemma of causation in nature-society relations is 'coproduction' or 'coevolution'. That might be to say, for example, that conditions of aridity will lead the inhabitants of a region to focus on precipitation and temperature, but the particular way in which they express that focus will be culturally shaped and, furthermore, that both processes are tightly linked in mutually reinforcing iterative loops. In all fairness, most of the participants in this Conference have embraced some version or another of this explanation over the extremes of climatic or cultural determinism. That is fair enough, so far as it goes, but it does leave us with some explanatory dilemmas that cannot merely be dismissed as historical contingency. For example, several analysts have suggested that aridity leads farmers to focus on the weather in Arizona, Burkina Faso, and Tanzania.

The British also appear to be weather obsessed but, so their analysts suggest, this is precisely for the opposite reason that they do not often have to contend with weather extremes. Coproduction remains severely under theorized. It is a field that is replete with thick narratives and suggestive metaphors that help us to get our heads around the topic, but there is relatively little articulation of a convincing explanatory theory of coproduction. This of course is an aspect of the general state of interpretive social science as it begins to pick its way back from the intellectual quicksand of postmodernism to recognition that matter matters.

It is hard to imagine a greater contrast with the vulgar sexuality of Ihanzu rainmaking rituals than the famously polite British conversation about the weather, but both seem to be about temporarily dissolving social boundaries. Jan Golinski (2003) emphasizes the "phatic" nature of such weather talk – it is an act of social bonding rather than of information transmission. While Ihanzu rainmaking involves explicit sexual imagery that would make a well-bred Briton blush, British weather conversation does not require any kind of intimate disclosure that might breach class divisions or violate social conventions. But it was not always thus. It turns out that the domestication of the weather as a safe topic of conversation is the outcome of a modernist project to replace a temporality determined by ordinal-scale climatology with a climatology defined by an interval-scale temporality. The result was the emergence of an ideally stable national weather.

4. National weather and national identity

To adopt the terminology that Elizabeth Shove has used to describe indoor comfort, we are accustomed to viewing weather as a natural "attribute" of a particular time and place, but the case of British weather also suggests that weather is equally well understood as a social, even a national "achievement" (Shove, 2003). Jan Golinski shows how eighteenth-century scientific concern about the weather emerged from a broader set of worries about the effects of industrial development on nature in the context of the modern nation state (Golinski, 2003).

In seventeenth- and eighteenth-century Britain, it was commonplace for extreme weather events to be attributed to divine judgment upon the dissolute ways of modern life. The Great Storm of 1703 seems to have stimulated the keeping of systematic weather diaries among natural philosophers (as scientists were then called) determined to assert the regularity, that is, the naturalness of weather in the face of the claims of divines that weather was an instrument of God's judgment. If everyday's weather could be recorded, not just extreme events, it could be reduced to "the formulaic and routine." The eighteenth century also exhibited a trend towards the wider adoption of uniform measures of time, defined by the clock and the civic calendar. For the urban middle classes, at least, work and social activity was increasingly regulated by clock time, based on the Greenwich meridian rather than local noontime. Similarly the uniform interval scale of the calendar began to replace the variable and ordinal rhythms of agricultural life.

Studied in this way, the British climate was found to be generally temperate, punctuated by bracing diurnal variations. A climate free both from extremes and from monotony. Ironically – although perhaps inevitably – the scientists of the day could not resist finding common cause with their religious interlocutors in interpreting this climate as evidence of divine favour towards the newly born British nation state, which had been brought into being by the 1707 Act of Union between the Kingdoms of England and Scotland.

5. Folk wisdom and weather talk

It was only a matter of time before the emergence of the idea of a characteristic national weather led to new ideas about forecasting. Weather prediction had a long and venerable history, based on local observations which became enshrined in folk wisdom. The eighteenth-century English sage Venerable Bede provides the earliest written record of the observation that a "red sky at night is a shepherd's delight." In German speaking lands, weather proverbs or *Bauernregeln* (farmers' rules) were among the first printed publications following the Bible (Strauss, 2003). Weather almanacs have long been popular publications, including *Poor Richard's Almanac* published by Benjamin Franklin in the mid eighteenth century. *Old Farmer's Almanac* commenced publication in the 1792 and continues to this day.

Research related to the reliability of folk methodologies for weather prediction seems to have flourished since the 1990s, giving rise to a whole new field of 'ethnometeorology', splendidly represented in the Conference by authors such as Esther Katz.

Some longer term folk forecasts have been discovered to have a sound basis, even where their methodology may initially appear to be somewhat far-fetched. The most prominent example of this kind of 'ethnoclimatology' is probably Ben Orlove's investigation of Andean farmers' prediction of El Niño impacts based on the visibility of the Pleiades in mid-winter (Orlove et al., 2000). It turns out that this actually works. The apparent size and brightness of the Pleiades varies with the amount of thin, high cloud at the top of the troposphere, which in turn reflects the severity of El Niño conditions over the Pacific. Because rainfall in this region is generally sparse in El Niño years, this simple method seems to work as well as long-term prediction based on computer modelling of the ocean and atmosphere – which brings me to the topic of weather and climate forecasting.

6. Weather and climate prediction

If the eighteenth century represented an important step towards the achievement of nationally identifiable weather in Britain, then the nineteenth century saw its outright nationalization by the state on both sides of the Atlantic. Both weather and postal services were important civic innovations by which the modern state has asserted its authority and identity, as it has been reflected at this Conference in various talks on weather and state policy in Brazil, by Antonio Divino Moura, Christina Barboza and her MAST colleagues (this volume). In view of this role of weather forecasting, there should be little wonder that contemporary proposals to privatize substantial operations of weather agencies have proved controversial, as have parallel proposals to remove state monopolies on mail.

The British Meteorological Office was established in 1854 under Admiral FitzRoy, former commander of Darwin's Beagle. FitzRoy was a pioneer of British attempts at developing weather forecasts based on forward inference from atmospheric observations of precursor conditions. The British initiative was also strongly oriented towards maritime applications. James Fleming (2000) has written definitively on the origins of the US Weather Service, and I won't presume to emulate him on the subject. Suffice it for me to say that attempts were made to establish a weather service in the US around mid-century. But politics and professional rivalries meant that the National Weather Bureau was not formally constituted until 1870.

The initial emphasis and approach to national forecasting in America was different from the British approach in certain respects. By the mid nineteenth century it was well understood that North American weather systems moved fairly uniformly from West to East. The Weather Bureau's original name was "The Division of Telegrams and Reports for the Benefit of Commerce" reflecting the fact that, in the US, weather forecasting evolved with and depended upon the electric telegraph, which was also used to communicate information about crop prices. The initial US audience for weather forecasting was primarily agricultural. Although Meyer (2000) reports that, as early as the 1850s, a telegraphic report that it was raining in Cincinnati in the morning would be sufficient to cause cancellation of that evening's Smithsonian lectures.

Even at this early stage, issues of equity in access to forecasts were raised, foreshadowing those discussed by Alex Pfaff et al. (1999) with regard to El Niño forecasts in the 1990s. A hundred and fifty years ago the concerns were related to the comparative advantage that might be enjoyed by those with access to the telegraph relative to those who did not. In the 1990s it was feared that El Niño forecasts would unduly benefit commercial fishing fleets at the expense of artisanal fishermen who lacked access to forecasts. Both examples illustrate that forecasts are not neutral and that changes in the availability of information frequently result in shifts of comparative advantage.

7. Forecast use

But, as forecasters have discovered, it is one thing to produce forecasts, the question of their uptake and use is quite another thing. There is a voluminous literature attempting to put a dollar value or even a social value on the ability to predict the weather on various scales and time periods.

A common question in recent social research on weather and climate forecasting is how to understand the selective incorporation and rejection of scientific idea of forecasting into social practice among farmers, watermen, and other citizens. Here researchers seem to converge on two counts. First, that people in a wide diversity of climatological and cultural circumstances exhibit some degree of ethnometeorological or climatological competence derived from a combination of experience of past weather patterns, occupational or survival skills, and social organization. Second, researchers consistently report that these existing levels of competence lead to the operation of a collective analogue of what is known to psychologists as the 'confirmation bias'. Put simply, this states that we tend to incorporate new information that is compatible with our existing views and reject that which is irrelevant to or in conflict with them.

Thus, Michael Paolisso (2003) insists that Chesapeake watermen demonstrate effective weather craft skills based on wider cultural models that locate water pollution in the context of values about religion, nature, morality, work, independence, and responsibility with experience-based ecological and economic knowledge. Carla Roncoli and her colleagues (2003), discussing the dissemination of probabilistic seasonal prediction forecasts among rainfed farmers of the Sahel-Sudan Region, demonstrate that forecasts are interpreted through the lens of farmers' own concerns and that they do not necessarily receive the message intended by the forecasters.

Tim Finan's (2003) description of the Northeastern Brazilian "drought industry" shows how climate discourse is embedded in traditional forms of political interaction, including a system of clientelism, which regulates the provision of water and food deliveries and public employment, and provides a framework of incentives through which any scientific information has to be processed. Unfortunately, in this instance, science has often been used to legitimise corruption in infrastructure provision for drought resistance.

My own research on short-term climate forecast use, conducted with Helen Ingram and Denise Lach (Rayner et al., 2005), revealed numerous reasons why forecasts were fundamentally irrelevant to many decision makers. Some interviewees described how they used existing uncertainty in forecasts to meet organizational, political, or operational goals. They were concerned that improved information about future weather conditions could limit their decision space. A construction manager in California described the additional erosion measures he is obliged to implement if a storm is forecast. These can be very disruptive of construction schedules, but if an unforeseen event occurs he is not held responsible for failing to "button down the site." His experience suggested that he would be happier with less rather than more skilful forecasting so that the construction industry can transfer the erosion problem away from its own practices and attach it to the issue of forecast reliability.

In another case, we discovered that water resource managers universally gauge their success by a single indicator – their own invisibility to consumers and political authorities. They are driven by a clear hierarchy of values – security of water supply, quality of water delivered, and (coming in a distant third) cost. Hence, they tend to be very conservative in making changes to their decision-making procedures and criteria, especially if the potential for increased efficiency is accompanied by any prospect of increased risk to continuity of supply or even transitory changes in water quality. This conservatism suggests that water resource managers are using an implicit payoff matrix leading to extreme reluctance to incorporate improved climate forecast information.

	ESTABLISHED PROCEDURES	INNOVATIVE METHODS
DESIRABLE OUTCOME	LOW VISIBILITY "BUSINESS AS USUAL"	LOW VISIBILITY "WHY BOTHER?"
UNDESIRABLE OUTCOME	MODEST VISIBILITY "SOON FORGOTTEN"	HIGH VISIBILITY "HEADS WILL ROLL"

Table 1: Implicit payoff matrix for water resource managers to incorporate new climate forecast information.

In general, people seem to be a bit ambivalent about both the achievability and the desirability of prediction. Whereas the scientific authors of America's Advanced Climate Prediction Initiative (1998) were uncompromising in their promise of better policy through finer grained climate prediction, Chesapeake Bay watermen and farmers in Burkina Faso appear to share a conviction that complete knowledge of the future is a divine, not a human prerogative. Golinski spots the same ambiguity in eighteenth-century Britain in which, "we recognize a reflection of our own ambivalence about enlightenment and modernity. Thinking about the weather obliges us to acknowledge the incompleteness of modernity, even its questionable value as an ideal. [...] the eighteenth century had already perceived some of the limitations of the project to order the weather and was by no means uniformly enlightened [...]" (Golinski, 2003, p. 32). Perhaps invoking a divine prerogative is a way of coming to terms with the disappointments of modernism and the failure of its promise to bring nature under scientific control, as Renzo Taddei discussed in his presentation at the Conference (this volume). Despite our rational pretensions we are forced to manage our lives with not just imperfect, but imperfectable information.

8. From prediction to control

Of course, the urge to manage and control is a powerful one and people have long sought not just to anticipate but to control the weather by various means. James Fleming addressed this topic at the Conference (this volume), but here I will refer to it briefly. Anthropologists have argued about the extent to which rainmaking rituals, such as those of the Ihanzu, are expressive or instrumental, but the performers of such rituals generally may be presumed to have invested them with some instrumental power to control or at least cajole the weather.

In America, the early Puritans frowned on weather magic as it placed the power to harm in unregenerate hands, but prayer for rain in times of drought was common and expected. The scientific optimism of the eighteenth century, however, offered a new way to domesticate the weather. Joel Barlow of Connecticut was a dyed-in-the-wool climatic determinist who, in Bill Meyer's words "took the determinist's point of view to its natural conclusion. If the climate imposed an unsatisfactory state of society, matters must be mended by changing the climate…" (Meyer, 2000, p. 40) The means to do this was by clearing the forest and cultivating the soils in order to warm and moderate the climate. As Giny Cheong had elaborated in the Conference, by the nineteenth century, the doctrine that "rain follows the plough" was firmly, although wrongly, established in the minds of settlers on the Great Plains whose descendants were to experience just the opposite conditions in the Dust Bowl of the 1930s, discussed by Frank Uekötter (this volume).

Barlow notwithstanding, it was not until the mid nineteenth century that serious scientists, such as the impeccably credentialed meteorologist, James P. Espy, known as "the Storm King" proposed the means to manipulate the weather to order. Having enunciated the convective theory of rainfall and observed that rain showers frequently followed the outbreak of brush fires in the Eastern USA, Espy reasoned that rain could be made to order by maintaining a string of wood lots from the Great Lakes to the Gulf, which could be set ablaze to generate rain on a regular schedule. The cost to the taxpayer: a mere half a cent per annum! The greatest fear of Espy's critics was not that his scheme would fail, but that it might work and that the power to control the weather might be abused by special interests in the Federal Government or used as a weapon in the regional conflict between North and South.

So it was a further hundred years, the 1960s and early 70s, before American scientists took a serious crack at weather modification. Most of these were inconclusive attempts to stimulate rain in arid environments or in times of drought through cloud seeding from aircraft. On the other hand, "Project Stormfury", led by Robert Simpson, tried in vain to disrupt the inner structure of hurricanes by seeding them with silver iodide crystals to expand the eye, causing the winds spiralling into it to slow down (Willoughby et al., 1985). Various other far-fetched ideas to neutralize storms have been mooted since then, such as cooling the ocean surface. The latest approach being explored by the US Department of Homeland Security, in the aftermath of Hurricane Katrina, focuses on diverting hurricanes by dumping soot particles into them before they make landfall.

As we can learn with James Fleming (this volume), the successors to this tradition are the climate change geoengineers who propose to counteract the warming effects of increased greenhouse gas concentrations in the atmosphere by measures such as releasing sulphate aerosols into the stratosphere to alter the earth's albedo.

9. Climate and the built environment

Rather than controlling the weather system, a more modest way to domesticate its effects is through architecture. Climatic determinism seems at its most plausible in building design, where structural adaptations to heat, cold, or humidity are often obvious. But despite the apparently obvious adaptations of traditional architecture to weather and climatic conditions, we soon find, upon closer examination, that there is as much variation in architectural styles emanating from similar climatic regions as there is across different regions. Conversely, very different climates seem to support remarkably similar forms of vernacular architecture, as exemplified by the almost indistinguishable characteristics of

Greek island cottages and Scottish crofts.

Furthermore, architectural preferences seem to travel with migrating populations, even though they may be modified to meet new climatic conditions, as illustrated by the persistence of French Canadian house designs as settlers migrated to South through Illinois and Missouri during the nineteenth century. Even today, the houses of North America seem to owe more to the imported preferences of immigrants from Europe to reproduce familiar features of their Old World experience than to the large regional variations in climate and weather across the continent.

The famous 'Queenslander' house, with broad shady eaves and raised on stilts to allow air circulation all around, was once popular along the Northeast coast of Australia, but, with the advent of air conditioning, it is now falling out of favour. As the new air-conditioned Queensland house demonstrates, the increasing availability of active technologies to maintain a consistent indoor climate is resulting in less reliance on passive building features and a global homogenization, even monotony of building design.

10. Indoor climate

For more and more people around the world, more and more of everyday life is spent indoors. Ways of keeping warm in winter have been many and varied. Elizabeth Shove (2003) has called our attention to Jean-Louis Flandrin's (1979) description of nineteenth-century French peasant families who would gather by day with their animals in the warmth of their largest cowshed, returning home only to sleep at night. The cowsheds were places for socializing, courting, and conversation as well as work. Social position and status was clearly visible in seating positions around the fire, each individual taking his or her place in what Shove describes as a well established "social-thermal" hierarchy. She contrasts these arrangements with Hal Wilhite's (1996) account of the kotatsu, a Japanese under-table heater with a quilt for covering the legs of the family members gathered around it to keep warm. Wilhite argues that the introduction of central heating transformed the norms of family sociability related to the kotatsu and re-defined comfort in spatial rather than personal terms.

Migrants have not only carried their architectural preferences with them, but also their preferred heating technologies. Not that these preferences remain fixed. William Meyer (2000) tells how before the 1820s English travellers in the USA suffered the brutal cold of the North American winter, but by mid-century complained bitterly about the infernal heat of the houses and their close, suffocating rooms. On the other hand, American visitors to Britain had the opposite experience, describing English houses in the 1820s as 'cozy'. But by the 1860s, Americans were complaining, "No stranger can live in an English house for a week and not be ill of exposure." The cause for this change in perception was the widespread adoption by Anglo-Americans of the German and Scandinavian woodstove, driven in part by the costs and availability of firewood.

In the twentieth century it was not heating, but cooling technology that was decisive in shaping America's indoor climate. Until the Second World War, British diplomats posted to Washington DC received hardship pay on account of the unfavourable summer climate. This special compensation was eventually abandoned as the use of air conditioning became the norm in the US capital.

American air conditioning manufacturers in the 1920s originally harboured the ambition of emulating ocean breezes or fresh mountain air, but ran into the problem of diverse public opinions of what an ideal cool climate would be like as well as conflict with popular theories about the healthiness of natural ventilation. In her book *Comfort, Cleanliness and Convenience*, Shove describes how thermal comfort research by the American Society of Heating and Ventilating Engineers (later "Refrigeration and Air conditioning Engineers") led to the specification of just one ideal climate defined through the quantitative analysis of mechanically reproducible parameters. These are currently specified in ASHRAE's Standard 55, which informs national codes and standards around the world. Although the science of thermal comfort was developed with the ambition of revealing natural physiological responses to temperature, humidity and air movement, Shove quotes Nigel Oseland's (1993) observation that "the knowledge produced by conventional thermal comfort studies is of a type that legitimizes air conditioning and relates to the needs of that industry" (Shove, 2003, p. 31). Other studies suggest wide variation in the conditions that people describe as comfortable. Pakistani workers are comfortable at temperatures up to 31 degrees Celsius. During the Antarctic winter, people have reported being comfortable indoors at around 6 degrees Celsius. Portuguese office workers are content with seasonal variation of 5 degrees Celsius while Swedes appear to prefer temperature in the workplace to vary by no more than half a degree.

Shove elaborated on these themes in her plenary talk to this Conference, but the point that I want to emphasize here from her work is that just as the British weather of the eighteenth century was a technical achievement, consistent with the nationalist temper of the times, the twentieth-century engineer's idea of a universal physiological human comfort zone appears to be more of a technological achievement than the discovery of any kind of natural attribute.

11. Technological mediation of weather and climate

The case of air conditioning highlights the fact that in the modern industrialized world, our experience of nature is seldom direct. It is invariably mediated by science and technology. Nature as lived-in milieu has been thoroughly domesticated. For urbanites (and that is now half of the world's population) the impacts of extreme weather tend to be buffered by infrastructure, including housing, roads, and storm drainage systems. Information about weather is not derived from personal observation, but from mass media communications based (presumably) on observations using scientific instruments and analysed with the aid of computers.

Anomalous weather in the twenty-first century is no longer the divine judgment that it was in pre-eighteenth century England, it has become spectacle. Americans are treated to a monthly magazine devoted to the weather. The US Weather Channel broadcasts 24-hours a day, interspersing weather forecasts with live and recorded coverage of extreme weather events, such as storms, floods, and droughts. The commercial breaks offer videotapes of hurricane, tornado, and flood footage that John Seabrook (2000) writing in *The New Yorker* has dubbed "Weatherporn." At least in the industrialized world, it seems that "the more weather we watch on TV the less time we spend in it."

Modern buildings (air conditioning and central heating), private transportation technology (SUVs), migration of populations to sunnier climes, choice of vacation destinations for sun or winter sports, all insulate us from direct experience of weather and climate or seek to substitute one experience of weather for another. But the energetics of mediating weather and climate through technology, infrastructure and transportation all lead inexorably to increased energy use, leading in turn to increased carbon emissions and the attendant hazards of climatic change.

12. Climate and governmentality

This brings me to the relationship between inadvertent human induced global climatic change and everyday experience. Climate change is an issue upon which multiple agendas can be hung. These agendas include energy efficiency, nuclear power, renewable energy, international development, national security, corporate social responsibility, even the re-organization of government departments. Indeed, as I wrote as long ago as 1995, "if the threat of climate change did not exist we would have had to invent it, or something very much like it to respond to the challenges of global governance at the end of the twentieth century" (Rayner, 1995, p. 60). The idea that industrial emissions of CO_2 could induce warming of the earth's atmosphere had been proposed by Arrhenius in 1896, and daily measurements of atmospheric CO_2 were begun in Mauna Loa in 1956 in connection with the declaration of the International Geophysical Year. In the 1970s, the idea began to emerge as a public policy issue. But climate change only achieved widespread public attention in the wake of the 1988 heat wave and drought and the fall of the Berlin wall a year later. The coincidence of these two unrelated events enabled what had been a relatively specialized scientific concern to become an object of public policy and, importantly, increased public funding for scientific and diplomatic initiatives. The 'discovery' of the global environment provided a new idiom for 'one-world' international relations to replace the bi-polar opposition between capitalism and communism, which had defined the world order following the Second World War. We should be in no doubt that the very idea of a 'global climate' is every bit as much of a late twentieth-century achievement, as the characterization of national weather was in the eighteenth and nineteenth centuries. This is not to deny that there is a serious climate change issue to address. But recognizing the "social construction of climate and climate change" (Stehr & von Storch, 1995) does help social scientists to ask the question, "Are we addressing the issue in a sensible way?"

The goal of the UN Framework Convention on Climate Change (UNFCCC) is to limit greenhouse gas emissions, in order "to prevent dangerous interference with the atmosphere." But as every social scientist must be acutely aware, the atmosphere has always been dangerous, especially in the everyday lives of poor people living in marginal environments. The Framework Convention glosses over this fact and offers nothing by way of alleviating existing conditions. Implicitly, its conception of "dangerous interference" means climate change that would stretch the coping strategies and technologies in place in the developed world. It assumes that we are content with the climate as we find it, as if our experience of climate and weather is something natural, rather than achieved.

Of course, if we do wish to preserve the current climate regime – with all of its attendant inequities – we have to act effectively. But across the world, policies and targets bear little relation to the scale of the concerns expressed by scientific activists or the rhetoric of green politicians. Democratic victories in the 2006 US Congressional elections were swiftly followed by an odd auction of promises in which members of Congress vied to outbid each other with proposed emissions targets that were simply not achievable. In Britain, Parliament is currently considering a Climate Bill of such scope that at least one Parliamentarian has described it as "the most far reaching British legislation since the 1807 Abolition of Slavery Act."

Meanwhile, the public is bombarded daily by the latest climate change horror story, or by pious exhortations to drive less and to holiday at home. The UK government's former Chief Scientist, Professor Sir David King, has repeatedly declared that the policy response to climate change is a "turning point for human civilization." In Britain, we have witnessed an escalating competition between the three main British political parties over which could propose the most stringent curbs on carbon emissions. In all of this, the main target seems to be the individual householder, motorist, or air traveller.

But the rhetoric and reality of policy seem out of kilter. Climate policy is being promoted alongside other policy priorities that have a quite different focus. The government is raising the marginal costs of train travel, making plans to expand airports, widen motorways, build roads, and build large numbers of new houses in flood plains. In contrast with the proposals to curb individual behaviour, the government seems reluctant to effectively target the emissions-intensive sectors of industry, particularly electric power producers. For instance, it has declared its intention to permit a German based company to construct new coal-fired generating capacity, on condition that it be adaptable for future installation of carbon capture and storage technology, which is a technically meaningless requirement, since the requirements of such technology remain undefined on the relevant scale.

We seem to have entered an era of what Sam Randalls, drawing on Foucault's vocabulary, called "climate governmentality" – the attempt by government agencies to off-load onto individuals the responsibility for awkward decisions. It is an easy step from here to shifting blame to individuals for future failures. "We built the airport/road etc, we tell you not to use it, but you do anyway. So we did our best and it's your fault" (Prins & Rayner, 2007).

The ability to maintain the current moral panic about climate seems to be quite closely linked to people's everyday experience of climate variability rather than climate change. In other words, public attention to climate seems to be driven by their interpretation of the weather. Temperatures in the first years of the twenty-first century have been most obliging for the climate governmentality agenda. We have been experiencing a period of annual average temperatures and seasonal peaks that can be easily understood by politicians and the public as evidence that climate change is indeed upon us. This has recently been taken to extremes in recent UK media reports that the first 10 days of May were the hottest on record or that the temperature on just one of those days was the highest since 1953 as if that were conclusive proof of anything at all.

But what would happen if, as some leading scientists suggest, we enter a decade in which the underlying trend of human caused global warming is masked out by natural variations in ocean temperatures in the Northern oceans around Europe and North America? What would happen if it turns out that the polar bear is in danger from melting sea ice, not because of increasing average temperatures, but because of albedo change in the cryosphere due to deposition of particulate emissions? Will the momentum behind fear-driven climate policies evaporate, as it emerges that the ambitious targets set by today's politicians cannot be met in time through reliance on commodification of climate through cap-and-trade? None of these things detracts from the long-term threat from increasing greenhouse gas concentrations. But, there is a real danger that the public will move from the phase of "alarmed discovery and euphoric reaction" in Anthony Downs' (1972) attention cycle, into "counting the cost" and finally "quiescence." Recall that while climate change hit the front page of *Time* magazine during the US drought and heat wave of 1988, it was soon relegated to the political back burner for almost two decades. The current public momentum cannot be taken for granted.

The danger of conspicuously hitching so many environmental and social agendas to the climate bandwagon is that we might lose them all, if public attention to climate wanes. It is surely far better to incorporate climate policy concerns into the routines of everyday life, the better to secure the mundane, but vital, interests of citizens at the same time as addressing climate, than it is to build a tower of Climate-Babel, the collapse of which risks damaging all of those other interests and missing the goal of climate stabilization at the same time.

Among other things, this would mean re-localizing climate policy by bringing adaptation to current and future climatic conditions into the foreground (Pielke et al., 2007). Although adaptation is no longer the taboo topic it once was, it remains the poor cousin of greenhouse gas emissions mitigation in terms of effort and funding. Furthermore, the current policy framework as laid down by the UNFCCC limits adaptation exclusively to the added incremental risks arising from anthropogenic climate change, even where these may be swamped by current limitations in adaptive capacity that leave poor people in marginal environments highly exposed to the vagaries of weather and its extremes.

It was only a few short years ago that, under the watchful eyes of Bono, Bob Geldof, and a host of other celebrity post-modern prophets, the leaders of the G8 pledged to "Make

Poverty History." Making poverty history has itself become history. If we don't want to see the collapse of the climate stabilization agenda, which, as currently organized will take host of other human development and environmental goals with it, we will need to move beyond climate governmentality to a more profound interpretation, understanding, and realization of 'weather and climate in everyday life'. The talent assembled at this Conference demonstrates that we have what it takes to do just that.

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Manufacturing weather: climate change, indoors and out

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1. Introduction

In many parts of the world, the indoor climate – by which I mean temperature, humidity and ventilation within buildings – has been transformed over the last two centuries in ways that are of direct consequence for global warming and (outdoor) climate change. In this short paper I consider the relation between indoor and outdoor climates. I do so first with reference to representations of the outdoor environment as embodied in lines of scientific enquiry and technical/physiological research around which contemporary expectations of indoor 'comfort' have come to depend. While these ideas position human beings as physiological entities, they also reproduce social conventions about the body and in particular about sweat – a natural form of thermoregulatory control, but one that has become something of a social taboo. Especially in hotter climates, the built environment is configured and equipped with technologies designed to protect inhabitants and preserve them from culturally inappropriate physiological reactions and sensations. This approach to bodies as to buildings is consistent with wider projects like those of using technologies to 'tame' nature. As we now know, the energy and environmental costs of this endeavour are unsustainably high – the resources consumed in 'managing' the indoor environment are, ironically, one of the more significant causes of outdoor environmental change. This conclusion points to the need to develop more forgiving and more sustainable understandings of people and their relation to environments indoors and out. Though concentrating on the manufacturing of indoor climates, this paper raises wider questions about the cultural and historical intersection of ideas about the weather, as manufactured, as 'natural', and as part of the routine organisation of daily life.

2. The parameters of comfort

This is not the place to provide a full review of the history of indoor climate control but when it became possible to manipulate indoor environments with some precision, new questions arose: what sort of outdoor weather should builders and engineers seek to mimic indoors? (Cooper, 1998; Ackerman, 2002) Laboratory based studies, initially conducted in the 1920s, sought to determine and define 'optimal' conditions for the average human. Having conceptualised people as essentially physiological entities, thermal comfort researchers worked hard to isolate the seemingly universal parameters of an optimised indoor environment. Around the world today, many building codes and energy models contain within them assumptions and expectations derived from the work of Ole Fanger whose comfort equations continue to underpin standards developed and used by the American Society of Heating Refrigeration and Engineering (Fanger, 1972).

Fanger's understanding of thermal comfort is based on a 'heat balance' model. Accordingly, situations in which the rate of heat loss equals the rate of heat production by the body are taken to be necessary but not sufficient conditions for comfort. One reason why they are not sufficient is that heat balancing may be achieved through sweating – however, 'too much' sweating is socially problematic. Comfort is consequently also understood as a function of a 'preferred' sweating rate – something that relates to physical activity, but also to situation, cultural setting and context. Since thermal comfort equations are designed to apply universally, and since they treat the human body and its relation to the environment as a matter of biology and physics, these social aspects are routinely bracketed out, 'black boxed' and simply buried in the calculations. There are two points to make here. One is to underline the irredeemably social and historical qualities of scientific enquiry and engineering: in short, these sciences are products of their time. The equations in terms of which heating and cooling equipment is currently sized consequently embody and reproduce culturally specific assumptions about appropriate forms of clothing, sweating, shivering and smelling. Though treated as absolute 'facts', these understandings have often short and very specific histories. For example, over the last two hundred years, 'fresh air' has been highly valued to the point that buildings themselves have been seen as problematically restrictive; heat has been variously feared (Kupperman, 1984) and desired, and the sunshine has been sought and shunned (Carter, 2007).

The second is to notice that ideal climates, as defined through the sciences of thermal comfort, are in fact rather rare. To be more exact, ideal indoor climatic conditions (i.e. those which meet Fanger's definition) are rarely reproduced consistently and reliably 'in nature', hence the need for massive investment in additional heating or cooling, mostly indoors but sometimes also in gardens and other forms of semi-outdoor space. The energy and outdoor environmental costs of maintaining these narrowly defined conditions of human comfort are huge. Heating and cooling accounts for around 50% of the energy used in buildings (Nicol, 2007) and air-conditioning is spreading rapidly across the fastest growing cities in the world.

Standardised definitions and expectations of indoor comfort have become 'normal' by virtue of being designed and reproduced around the globe. Bit by bit and in ways that are undoubtedly fuelled by multi-national interests in manufacturing and infrastructural development, what used to be diverse, seasonally sensitive, 'local' indoor weather patterns accompanied by also local conventions and competences in modifying and varying patterns of activity and clothing, are being replaced by a highly uniform indoor climate, itself an outcome of a universalising mode of scientific enquiry. These trends matter not only for outdoor climate change, but also for contemporary interpretations of the relation between nature, science and culture. I comment briefly on the social significance of sweating as a means of illustrating these relations.

3. Sweat and society

Sweating is an essential part of the body's own thermoregulatory system, this being a complex arrangement that is supremely well adapted to respond to changing climatic conditions. However, sweating is more than a biological phenomenon. I have yet to find a good cultural history of sweating; yet the saying that, “horses sweat, men perspire and women merely glow” gives a sense of its symbolic significance.

Preventing and getting rid of culturally undesirable forms of sweat is currently big business, as demonstrated by the market for deodorants and anti-perspirants, the details of which also hint at the delicately balanced position of the ‘natural’ body with respect to sexual attraction and disgust (Douglas, 1966). In this respect it is important to recognise the link between sweat and smell. Not all sweat smells but related conventions to do with the freshness of air (and not only temperature) are also important in how the indoor environment is managed. Ole Fanger is again a key figure here, being the author of the ‘olf’ – another standard unit, this time of odour. Again purging the indoor environment of natural smells requires heavy investment in what are often resource intensive systems of ventilation.

Indirectly, sweat and smell are big business for those associated with infrastructural design, planning, architecture and engineering. Mechanical systems of cooling remove or at least limit the need for the body to do the work of thermoregulation, and hence reduce the levels of sweat involved. In effect, bodily functions are deliberately delegated to complicated bits of technology. The result is a form of social order and ‘civilization’ that strips us human animals of odour and dampness. This is entirely consistent with a fortress-like strategy of building and indoor climate control designed to keep variable and essentially threatening ‘outdoor’ weather patterns at bay and to create and maintain a standardised bubble of protected space indoors.

Scientific and technical agendas and related concepts of body and social propriety are interlinked and are in turn part of a wider political and economic order. As suggested above, the systems of knowledge associated with the fortress approach require “cheap energy, a disregard for the planetary atmosphere, an ascendant engineering elite, technological regulation, powerful corporations, and cooperative governments” (Shove et al., 2008, p. 310). Understandably enough, ways of thinking that were developed in the pre-climate change era reflect the periods and tribes that made them possible. As we now know, the result was “a method of rationalising the body (activity, clothing, humidity, air flow, temperature, all working toward a perfect balance); along with an essentially bourgeois mechanical logic of controlling the built environment and the everyday possibilities it affords. By these means, middle class ideals, including those of distance from sweaty labour, have been made available to all” (Shove et al., 2008, p. 310). It is increasingly clear that this hegemonic model along with the conditions from which it is derived and on which it depends no longer apply.

4. Reinterpreting the body and the climate, nature and culture

If the fortress model is unsustainable, what might take its place, and what alternative understandings of body, weather, science, nature and culture might take hold in the face of indoor induced outdoor climate change?

There are already signs of environmentally inspired reactions especially to the grip of standardized and standardizing concepts of comfort. In response to global climate change, a new science of adaptive comfort is growing in influence. Outside the laboratory, people have reported being comfortable at temperatures ranging from 6 to 30 degrees Celsius (Shove, 2003). Across this band, field studies show that expectations of comfort vary seasonally and demonstrate impressive variety in how societies have defined and managed the relation between themselves and the elements.

In addition, there is some indication that the power of the 'clo' (the standard unit of clothing – a business suit – embedded in design equations), and the 'olf' (the standard unit of smell used in specifying levels of ventilation) are being called into question. For example, in 2005 the Japanese Environment ministry introduced the 'Cool Biz' campaign. This encouraged companies to turn down the air conditioning, set thermostats to 28 degrees Celsius (82 degrees Fahrenheit), and allow employees to wear less than one 'clo' during the summer months. 'Cool Biz' fashion shows featured new styles of light weight office wear and adaptations by means of clothing alone have apparently led to a reduction of CO_2 equivalent to that emitted by a million households in a month. This is not the same as a more-sweat policy, but promotional images from the Japanese campaign suggest that a bit of damp around the armpit is nothing to be too worried about.

It is especially interesting that American reporting of this initiative talks of the need to 'endure the shame' and cites as wholly unpleasant the experience of an expatriate American manager whose neck, back and palms got sweaty as he worked through the summer in his Tokyo office (Moffett, 2007, p. A1). As these contemporary responses imply, the discomfort of being obliged to spend the working day in sweaty clothes has a very specific cultural history.

As indicated above, there is no reason to expect current conventions to last forever, and hence no reason not to imagine a social and cultural recovery, perhaps even a celebration, of sweat as the comfortably cooling expression of our own beautifully calibrated, supremely elegant thermoregulatory system. Such a discovery would in turn require a significantly new approach to the design and development of indoor environmental infrastructures, broadly defined.

5. Future comforts?

In practical and political terms, going forwards almost certainly means re-encountering (rather than deleting or denying) the body; re-differentiating social practices in ways that make sense of a more variable, more diverse and perhaps more interesting indoor climate; and actively cultivating all the very many ways in which we already interact with the indoor-outdoor conditions around us. In terms of research and especially with respect to scientific enquiry, the history and future of mass-produced, manufactured weather raises a range of familiar and novel topics.

The idea that scientific agendas and problems are shaped and framed by the societies and cultures in which they are formed is not at all new. Nor is the tendency for 'science' to reproduce and foster universalising and standardising forms of knowledge: this applies as much to understanding the weather outdoors as it does to the indoor climate. When dealing with the indoor climate – perhaps more than forecasting conditions outside – understanding the relation between the human body and its immediate environment has been a prominent theme. In framing this as a matter of blood flow, evaporation and heat balance, rather than of meaning, convention and culture, thermal comfort researchers have bracketed out, and sometimes actively denied, the diversity of sociotechnical arrangements associated with multiple and multiplying varied interpretations of 'normal' comfort, clothing and practice, and of 'normal' seasonal variation.

What then of the future? Can we look forward to new kinds of indoor climatic research, to more diverse styles of clothing and building design, and to new social and cultural conventions? Or should we, on the other hand, expect to see more defensive architecture and more energy intensive systems installed and developed in response to the possibly well founded fear of increasingly wild and unpredictable weather outdoors? As these questions make clear, the challenge of climate change is not only one of adopting the right kind of design and engineering: it is also bound up with the definition and production of knowledge, with paradigms and mentalities and with forms of feedback between problem definitions and research agendas within the social and natural sciences.

6. Concluding comments

In this paper I have considered issues that wind between discussions of indoor and outdoor climates. The standardising sciences of indoor comfort generated a definition of outdoor weather as threatening, variable and unreliable: in short, as largely uncomfortable. Ironically, the outdoor climate is changing, and arguably becoming more threatening, in part because of the energy required and consumed in maintaining 'comfort' conditions indoors. Realisation of the anthropogenic causes of global climate change has promoted reconsideration of the indoor environment: do we really 'need' these standard conditions all year round and all over the world? To date, it is true that most effort has focused on increasing the efficiency with which these now taken for granted 'standards' are delivered, but some commentators go further – calling the very future of comfort into question, calling for a much more extensive debate about the dynamic social and cultural relation between bodies, sweat, clothing, heating, and ventilation and

Figure 1: Keeping weather comfort indoors in Singapore.

Photo: Elizabeth Shove.

for deliberate effort to exploit existing diversity in pursuit of more sustainable and by implication more variable and flexible indoor environments.

In presenting the problems of indoor and outdoor climate change in this way, I have tapped into and sought to contribute to long standing debate about the role of technical and scientific expertise in society – raising a number of familiar questions about how knowledge is professionalised and standardised, and about the kinds of tacit assumptions upon which it depends. These themes – how is the climate known, measured and made visible – have their equivalents in social and historical studies of meteorology. In addition, I have contrasted standardising forms of scientific knowledge with more diverse, variable and localised understandings – recognising that comfort is also usefully understood as an active and creative achievement, the details of which are to an extent still laden with culturally specific significance. Again this approach has its parallels in efforts to study and understand 'folk' knowledges of outdoor weather systems, broadly defined.

Taking a step back, these common concerns point to a wider moral and political agenda that has to do with how the 'weather' is interpreted, and about legitimate grounds for intervention. In relation to the outdoors, efforts to 'geo-engineer' the 'natural' weather are both problematic and controversial. By contrast, parallel initiatives indoors have a long and surprisingly respectable – or at least taken for granted – history. What is of course missing is an appreciation of the point that one is of direct consequence for the other: in a sense building scientists, designers, manufacturers and producers of construction materials and technologies have been busy 'geo-engineering' the outdoor climate all along, but without this being recognised as such.

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Fixing the sky: rain kings and climate engineers

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1. Introduction

Let's undertake an historical regress, since today is the future of the past. Today, humanity is facing unprecedented environmental challenges, but perhaps, more than ever, needs to learn from historical precedents. World population has never before been 6.5 billion and atmospheric carbon dioxide has never been as high as it is today, at least not in historical times. Sea level is rising, polar ice is melting, and global temperatures may reach new extremes. The environmental crisis has generated talk of 'tipping points'. Jim Hansen at NASA and others warn of physical tipping points in the climate system beyond which we may see a runaway greenhouse effect; Al Gore and others are urging a social tipping point, a mass and dramatic behavioral change towards conservation, efficiency and new sources of energy beyond coal and oil. The scientists of the world are worried; the governments of the world are scrambling to enact policies and treaties; the people of the world are being warned to reduce fossil fuel use. But there is another voice in all this – a voice of technological unreason promising technological 'fixes' for the climate crisis, promising to 'fix the sky' by building a planetary thermostat, promising to cool the Earth climate and stave off global warming (Fleming, in press).

There is a current batch of climate engineers engaging in wild speculation, yet advancing increasingly serious proposals about how to 'control' the Earth's climate. As alarm over global warming spreads, their radical ideas are gaining momentum. Forget cuts in greenhouse-gas emissions and find a technological fix. Shade the planet by launching a solar shield into orbit. Pump sulfates or reflective nanoparticles into the upper atmosphere to turn the blue sky milky white. Fertilize the oceans to stimulate massive algae blooms to turn the blue seas soupy green. Create a 'planetary thermostat'. While this may again sound like science fiction, this is actually just the latest set of installments in the seemingly perennial story of weather and climate control. Is it in essence a heroic saga about saving the planet, as many of the participants claim? Or a tragic story with no happy ending, ultimately one of human over-reaching and self-delusion? Perhaps tragi-comedy best describes such flawed anti-heroics. So far, much of the story reads as a comedy of ideas, often finding its common denominator in farce, sometimes satire, especially when the hype becomes too great (Fleming, 2004, 2007).

Geoengineering is a hot button issue, but so far no one really knows what to do or how to do it. Recently there has been any number of statements, some from authoritative sources, about the need for more research, primarily on mitigation and adaptation, but with passing mention of 'geoengineering technologies' (Joint Science Academies, 2008). These are about as controversial as a request for more apple pie. Computer-based modeling of an altered climate system has been practiced since the days of Harry Wexler in the 1960s (section 2) and is the primary type of activity being proposed, but other early incarnations of weather and climate control may also provide useful historical precedents. A decade earlier, Irving Langmuir's enthusiastic vision of a quasi-utopian cloud seeded future in many ways informed and in ironic ways competed with a militarized, dystopian vision of clouds and storms as weapons (section 3). A final vignette completes the analysis, and hopefully will open up an interesting conversation. In the 1930s efforts to dispel fog using the latest technologies were surrounded by 'foggy thinking' and were largely driven by the desires (and actual needs) of aviators seeking to overcome the vulnerabilities fog imposed. The roots of the desire to 'fix the sky' extend deep into the cultural past, and can be found in the Western tradition in Milton's *Paradise Lost*, the desire of Archimedes to tip the Earth, and the myth of Phaeton who crashed and burned while attempting to steer the sun chariot of his father Helios. The only thing that is certain, as should become clear in this essay, is that research on the historical, social, cultural, political, and other human dimensions of weather and climate engineering is currently lacking and is sorely needed.

2. Climate control ca. 1962

"The subject of weather and climate control is now becoming respectable to talk about." So began Harry Wexler in his speech "On the Possibilities of Climate Control," given in early 1962 to technical audiences in Boston, Hartford, and Los Angeles (Wexler, 1962). Wexler, who studied meteorology at the Massachusetts Institute of Technology (MIT) and served as Chief of Scientific Services at the US Weather Bureau, supported his claim by citing, among others, President John F. Kennedy's recent speech at the United Nations proposing "cooperative efforts between all nations in weather prediction and eventually in weather control" and the State Department's urging of "early and comprehensive study in the light of developments in outer space of the possibility of large-scale weather modification" (Kennedy, 1961).

There is much to be learned in the details of these speeches, which reside in fragmentary form in the Library of Congress. For our purposes it is sufficient to point out that Wexler, using the results of newly created computer models of the general circulation and new results from satellite heat budget measurements, was able to describe, in considerable technical detail, methods of engaging in planetary-scale manipulation of the Earth's shortwave and longwave radiation budget that would result in "rather large-scale effects on general circulation patterns in short or longer periods, even approaching that of climatic change." These effects included increasing world temperature by several degrees by injecting a cloud of ice crystals into the polar atmosphere by detonating ten H-bombs in the Arctic Ocean (Wexler, 1958); lowering world temperature by launching ring of dust particles into an equatorial orbit to shade the Earth and make it look somewhat like Saturn and its rings; and notably, destroying all stratospheric ozone above the Arctic circle using a relatively small amount of a catalytic agent such as chlorine or bromine.

Wexler was interested in both inadvertent climate modification, such as might be created by rocket exhaust gases or other pollution, and purposeful effects, whether peaceful or hostile. So remember it was Wexler not Paul Crutzen who first claimed climate control was ‘respectable’. And this was fifty years ago.

The stratospheric ozone story is also very significant, given that the received history of ozone depletion dates only to the 1970s and certainly does not include Wexler’s role. Recently, I have been in correspondence with three notable ozone scientists about Wexler’s early work: Nobel Laureates Sherwood Rowland and Paul Crutzen, and US National Academy of Sciences President Ralph Cicerone. They are uniformly interested and quite amazed by this story. In a nutshell, details elsewhere, Wexler figured out, with the advice of chemist Oliver Wulf at the California Institute of Technology (Caltech), the catalytic reactions involving chlorine and bromine that could destroy all of the ozone in the stratosphere. In a hand-written note composed in January 1962 Wexler scrawled the following:

> *UV decomposes O_3 —> O in presence of halogen like Br. O —> O_2 recombines and so prevents more O_3 from forming. Br_2 —> 2 Br in sunlight destroys O_3 —> O_2 + BrO.*

These are essentially the basis of the modern ozone depleting chemical reactions.

Wexler concluded that he was not making proposals to intervene, but was involved in studying the basic equations and engineering aspects of general circulation research, including the natural behavior of the atmosphere, unintentional effects, and aspects of particular interest to the US Defense Department.

Wexler was concerned that inadvertent damage to the ozone layer might occur if increased rocket exhaust polluted the stratosphere. He was also concerned that future near-space experiments could go awry, citing Operation Argus (nuclear blasts in near space, 1958), Project West Ford (a ring of small copper dipole antennas in orbit, 1961), and Project Highwater (ice crystals injected into the ionosphere, 1962) as recent significant interventions with unknown risks. The figure on the right is a handwritten note by Wexler on the topic of ozone depletion by halogen reactions.

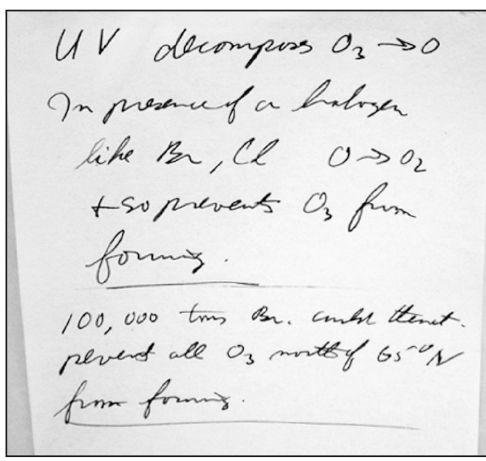
UV decomposes O_3 → O
In presence of a halogen
like Br, Cl   O → O_2
+ so prevents O_3 from
forming.
100,000 tons Br. could theoret.
prevent all O_3 north of 65° N
from forming.

Figure 1: Handwritten note by Wexler, January 1962.

“UV decomposes O_3 —> O in presence of halogen like Br, Cl. O —> O_2 and so prevents more O3 from forming. 100,000 tons Br. could theoret[ically] prevent all O_3 north of 65º N from forming.”

Source: Harry Wexler Papers, Box 18, U.S. Library of Congress.

In the summer of 1962 Wexler accepted an invitation from the University of Maryland Space Research and Technology Institute to lecture on “The Climate of Earth and Its Modifications,” and might, under normal circumstances, have prepared his ideas for publication, perhaps as he had done in his 1958 article in *Science*, “On Modifying the Weather on a Large Scale.” However, Wexler was cut down in his prime by a sudden heart attack on August 11, 1962, during a working vacation at Woods Hole, Massachusetts. The documents relating to his career, especially his remarkable work on ozone depletion and climate control headed into the archives, probably not to be seen and certainly not to be re-evaluated until today.

The idea that chlorine, bromine, and other halogens could destroy stratospheric ozone was published in 1974, while CFC production expanded rapidly and dramatically between 1962 and its peak in 1974. Had Wexler lived to publish his ideas, they would certainly have been noticed and could have led to a different outcome and perhaps an earlier coordinated response to the issue of stratospheric ozone depletion. However, the issue of a technological fix for climate – perhaps by intervening in the radiation budget of the planet (and thus its general circulation), perhaps by ocean engineering or some other approach remains very much alive.

3. Cloud seeding for peace and war

Irving Langmuir (1881-1957), Nobel Laureate and associate director of research at the General Electric Corporation, was both a Rain King and a friend of weather warriors. He was also the leader of a team of rain kings that included Vincent Schaefer ‘the snowflake scientist’ who in 1947 developed dry ice seeding, and Bernard Vonnegut, who identified the chemical silver iodide as a seeding agent. Langmuir’s work in surface chemistry was solid, even brilliant, and his scientific intuition was usually quite sound. By some measures, he was considered to be a genius and was by no means a charlatan. Yet his work in weather control exemplified his own warnings about the pathological nature of science.

Based on some relatively simple and as yet inconclusive tests involving dry ice and silver iodide seeding, Langmuir repeatedly expounded his sensational vision of large-scale weather control and even climate control, with possible military implications. It was verging on the pathological. For example, even before the data were collected and other possibilities explored, he made the outrageous claim that his single ground-based silver iodide generator located in New Mexico was causing large-scale seven-day periodicities in the nation’s weather. On other occasions, he spoke about how the GE-military collaboration called Project Cirrus had redirected hurricane King in November 1947 and made similar claims on national TV on the *Today Show*. Never mind that the storm had made an abrupt turn after, but probably not because of seeding, and had devastated Savannah, Georgia.

The condensed story of all of this is that Langmuir saw the desert blooming as the rose, all severe storms being somehow redirected, and even climate perhaps being controlled.

The military saw each cloud a potential surreptitious weapon with perhaps as much power as an A-bomb, or in the case of a hurricane, multiple H-bombs. The military actually used Langmuir's technique in Vietnam when they engaged in cloud seeding over the Ho Chi Minh Trail. Such 'weather warfare' was subsequently outlawed by at UN treaty called ENMOD.

4. Foggy thinking

One characteristic of weather and climate control is that its practitioners use, or claim to use all the latest technologies. Computers, satellites, and surplus military equipment now, airplanes, electric fields and surplus military equipment then. In the 1930s and '40s there were multiple attempts to dispel fog in the service of aviation. This is a placeholder for one of those stories.

"Fliers Bring Rain with Electric Sand," the *New York Times* headline announced on February 12, 1923. The story itself however was quite underwhelming. Between 1921 and 1923 field trials conducted in Dayton, Ohio at McCook Field seemed to show that electrified sand could dissipate clouds and might some day both dispel fog and generate artificial rain. The demonstrations were the brainchild of Luke Francis Warren (fl. 1930), a self-styled and self-taught independent inventor and dreamer who frequently misstated his credentials as 'Dr. Warren of Harvard University'. Credibility and financial support came from Wilder Bancroft, a well ensconced, but controversial chemistry professor at Cornell University. Technical assistance came from a Harvard electro-physicist, and aircraft facilities (and a patina of respectability) were provided by the US Army Air Service. Although the hope of making rain and driving mists from cities, harbors and flying fields was great, the hype was even greater (Warren, 1928). Little is known about Warren, save for a few press clippings, but his story can be augmented from documents in the Wilder Bancroft Papers at Cornell.

Warren served as the front man, raised funds and interfaced with military patrons. Bancroft was a sugar daddy, a source of funds, and Emory Leon Chaffee at Harvard provided electrical equipment and some theoretical underpinnings for the attempts to bust up clouds with sprays of electrified sand. They claimed to be able to dissipate fogs and make rain, but all the experiments done involved the relatively simple task of interfering with fair weather clouds, in part due to the sand, but more likely due to the prop wash of their aircraft as they made multiple passes through the clouds.

This did not slow down Warren's claims for his technique. Ever the businessman, Warren summarized his accomplishments and frustrations to date and fantasized in a 1928 pamphlet, *Fact and Plans: Rainmaking, Fogs, and Radiant Planes*, that "once rainmaking is mastered" thorough good high-tension engineering, "the wealth and prosperity arising from increased production, and decreased cost of living, will reach figures almost 'beyond the dreams of avarice', not only for our country but for the entire world."

The rise of civilian and military aviation in the early decades of the twentieth century placed fog clearing centrally on the research and development agenda. The airplane provided a new tool, a new research platform, and its vulnerability to fog provided a new urgency. Cloud physics and chemistry got its start in this era, as did serious attempts to make clouds, in the form of smokescreens, as well as to dissipate them. So too did air conditioning, which grew by leaps and bounds from a novelty to a seeming necessity for larger and larger spaces. In common with later eras, weather control research before 1944 benefited from military patronage and the passing interest, if not support of large corporations.

5. Nineteenth-century rainmaking and cannonading

James Pollard Espy (1785-1860), a leading meteorologist of his day, was the first to be employed by the U.S. government in this capacity. In the 1840s and '50s he held an appointment as the 'national meteorologist' in the US Army Medical Department. Espy developed a 'thermal theory' of convection still recognized today. He also promoted the much more speculative idea that significant rains of commercial importance for agriculture and navigation could be generated by cutting and burning vast tracts of forest. He believed the heat and smoke from these fires would create huge columns of heated air and believed this would generate clouds and trigger precipitation, much like the effects of volcanic eruptions. For his tireless promotion of this idea he earned the derisive sobriquet 'The Storm King'.

In 1842 the popular magazine writer Eliza Leslie published a short story in Godey's Lady's Book called *The Rain King, or A Glance at the Next Century*, a fanciful account of rainmaking a century in the future, in 1942. In the story Espy's great-great-grand-nephew offers weather for the Philadelphia area on demand. Various factions vie for the weather they desire. Three hundred washerwomen petition the Rain King for fine weather forever, while cabmen and umbrella makers want perpetual rain. An equal number of applications come from both the fair- and foul-weather factions, until the balance is tipped by a late request from a winsome high-society matron desperately seeking a hard rain to prevent a visit by her country-bumpkin cousins that would spoil the lavish party she is planning.

Of course, when the artificial rains come, they satisfy no one and raise widespread suspicions. The Rain King, suddenly unpopular because he lacks the miraculous power to please everybody, takes a steamboat to China, where he studies magic in anticipation of returning someday with new offerings. "Natural rains had never occasioned anything worse than submissive regret to those who suffered inconvenience from them, and were always received more in sorrow than in anger," Leslie wrote. "But these artificial rains were taken more in anger than in sorrow, by all who did not want them" (Leslie, 1842).

Leslie's short, humorous fantasy revealed a dramatic and instantaneous change in public attitudes 'precipitated' by artificial weather control. Espy received honorable mention in 1843 in Nathaniel Hawthorne's *Hall of Fantasy* – a marketplace of wild ideas that most of us visit at least once, but some dreamers occupy permanently; a marketplace seemingly perfectly suited to the millennial ideas of rain kings and climate engineers. Here the statues of the rulers and demi-gods of imagination, Homer, Dante, Milton, Goethe, are memorialized in stone, while those of more limited and ephemeral fame are made of wood. Plato's Idea looms over all. Here are social reformers, abolitionists, and Second Adventist 'Father [William] Miller himself!' Civil and social engineers propound ideas of "cities to be built, as if by magic, in the heart of pathless forests; and of streets to be laid out, where now the sea was tossing; and of mighty rivers to be stayed in their courses, in order to turn the machinery of a cotton-mill." "Upon my word," exclaimed Hawthorne, "it is dangerous to listen to such dreamers as these! Their madness is contagious." Here are inventors of fantastic machines aimed to "reduce day dreams to practice": models of a railroad through the air, a tunnel under the sea, distilling machines for capturing heat from moonshine and for condensing morning-mist into square blocks of granite, and a lens for making sunshine out of a lady's smile. "Professor Espy was here," reminiscent of Aeolus, "with a tremendous storm in a gum-elastic bag." The "inmates of the hall" it is said (remember all pass through here on occasion) take up permanent residence by throwing themselves into "the current of a theory," oblivious to the "landmarks of fact" passing along the stream bank (Hawthorne, 1843).

A generation later, following the U.S. Civil War, some experimenters using cannon, explosives, fireworks, and explosive balloons – and harboring some very loose theories of influence and very low standards of proof, showed up on the Texas frontier to try to generate rainfall by concussion. They succeeded only in entertaining onlookers with their pyrotechnic displays. Other quintessentially American ideas emerged from this tradition, such as 'rain follows the plow'; perhaps so too does global warming.

6. Mandan culture

The American painter George Catlin (1796-1872) juxtaposed traditional rainmaking and Western technology in his account of the manners and customs of North American Indians (Catlin, 1844). When the Mandan Indians, who lived along the Upper Missouri River, were facing a prolonged dry spell that threatened to destroy their corn crop and the women cultivators had beseeched the tribal leaders for relief, the medicine men assembled in the council-house, with all their mystery apparatus about them – with an abundance of wild sage, and other aromatic herbs, with a fire prepared to burn them, that their savory odors might be sent forth to the Great Spirit. The lodge was closed to all the villagers, except some ten or fifteen young men, who were willing to hazard the dreadful alternative of making it rain, or suffer the everlasting disgrace of having made a fruitless essay.

Each youth, in turn, spent a day on the roof of the lodge while the medicine doctors burned incense below and importuned the Great Spirit with songs and prayers. Wah-kee (the shield) was the first who ascended the wigwam at sunrise; and he stood all day, and looked foolish, as he was counting over and over his string of mystery-beads – the whole village were assembled around him, and praying for his success. Not a cloud appeared – the day was calm and hot; and at the setting of the sun, he descended from the lodge and went home – his medicine was not good, nor can he ever be a medicine man. On successive days Om-pah (the elk) and War-rah-pa (the beaver) also failed to bring rain and were disgraced.

On the fourth morning Wak-a-dah-ha-hee (hair of the white buffalo) took the stage, clad in his finest garb with a shield decorated with red lightning bolts to attract the clouds and a sinewy bow with a single arrow to pierce them. Claiming greater magic than his predecessors, he addressed the assembled tribe and commanded the sky and the spirits of darkness and light to send rain. The medicine men in the lodge at his feet continued their chants.

Around noon, the steam boat Yellow Stone, on her first trip up the river, neared the village and fired a twenty-gun salute which echoed throughout the valley. The Mandans, at first supposing it to be thunder although no cloud was seen in the sky, applauded Wak-a-dah-ha-hee who took credit for the success. Women swooned at his feet, his friends rejoiced, and his enemies scowled as the youth prepared to reap the substantial rewards due a successful rainmaker. However, the focus quickly shifted to the ‘thunder-boat’ as it neared the village, and the hopeful rainmaker was no longer the center of attention. Later in the day, as the excitement of the boat’s visitation began to ebb, black clouds began to build on the horizon. Wak-a-dah-ha-hee was still on duty. In an instant his shield was on his arm and his bow drawn. He commanded the cloud to come nearer, “that he might draw down its contents upon the heads and the corn-fields of the Mandans!” Finally, with the black clouds lowering, he fired an arrow into the sky, exclaiming to the assembled throng, “My friends, it is done! Wak-a-dah-ha-hee’s arrow has entered that black cloud, and the Mandans will be wet with the water of the skies!” The ensuing deluge, which continued until midnight, saved the corn crop while proving the power and the efficacy of his medicine. It identified him as a man of great and powerful influence, and entitled him to a life of honor and homage.

Catlin draws two lessons from this story. “When the Mandans undertake to make it rain, they never fail to succeed, for their ceremonies never stop until rain begins to fall.” Second, the Mandan rainmaker, once successful, never tries it again. His medicine is undoubted. During future droughts, he defers to younger braves seeking to prove themselves. Unlike Western, technological rainmaking, in Mandan culture the rain chooses the rainmaker.

7. Phaeton’s blunder

In uncovering the deeper cultural roots of weather and climate engineering, it is instructive to consider the wisdom invested in mythological and traditional stories, since, whether we realize it or not, much of Western civilization rests on these foundations. In Greek mythology the youth Phaeton lost control of the sun chariot. His recklessness caused extensive damage to the Earth before he was shot out of the sky by Zeus. In the story as told in Bulfinch, Phaeton asked his father to be permitted for one day to drive the chariot of the sun. Helios implored Phaeton, prophetically, “Beware, my son, lest I be the donor of a fatal gift; recall your request while yet you may... It is not honor, but destruction you seek... I beg you to choose more wisely” and follow the middle course of the zodiac.

Since Phaeton was a completely inexperienced driver without a clue as to the proper route to take, the chariot veered out of the zodiac, with hapless Phaeton looking down on the vast expanse of Earth, growing pale and shaking with terror. Phaeton, losing control completely, dropped the reins and the chariot plummeted from the sky. With the Earth on fire, the oceans at risk, and the poles smoking, Atlas did more than shrug, he fainted. The Earth implored Zeus to intervene. After much of the Earth is incinerated, Phaeton is killed by a higher authority to avoid further damage. And rightly so (Bulfinch, 1970).

Figure 2: Phaeton, from the series *The Four Disgracers*, 1588.

Hendrick Goltzius Netherlandish (1558-1617).

The story of Phaeton was recently invoked by the noted meteorologist Kerry Emanuel to frame a short discussion of contemporary climate change science and politics for a Boston magazine (Emanuel, 2007). Emanuel, widely known and respected for his hurricane studies, pointed to a growing scientific consensus on climate change prominently and authoritatively spearheaded by today's IPCC reports, yet admitted pointedly, that "we are [...] conscious of our own collective ignorance of how the climate system works." Abruptly returning to myth, Emanuel ends his essay, "Like it or not, we have been handed Phaeton's reins, and we will have to learn how to control climate if we are to avoid his fate." Emmanuel thus advocates repeating Phaeton's blunder. Think, "Underage driver of gasoline tanker, taken with father's permission, veers out of control in reckless, high-speed chase before being subdued by the authorities." Or more globally, "Geoengineering project given the green light last year results in the collapse of the Indian monsoon, millions are starving."

What about Emanuel's final thought, that we "will have to learn how to control climate?" That is the subject of later chapters of this book. Cambridge scientist Ross Hoffman has proposed a speculative 'star wars' system to redirect hurricanes by beaming lasers at them from satellites assuming one knew where the storm was originally headed and that there would be no liabilities along its new path! Is this an example of Phaeton's reins? Since the sun god Helios was directly involved, what about other means of "managing solar radiation" such as Nobel Laureate Paul Crutzen's recent suggestion (actually an older proposal) to cool the earth by injecting sulfates or other reflective aerosols into the tropical stratosphere using balloons or artillery guns? Or astronomer Roger Angel's giant one trillion dollars + space mirrors? There are many, many more such dangerous and expensive proposals of environmental control that invoke the inexperience and possible tragedy of the myth of Phaeton.

Remember, Helios made a fundamentally flawed decision to give his son the reins. His decision had catastrophic consequences. He did, however, give Phaeton a piece of good advice on steering the sun chariot through the zodiacal signs: “keep the mid way, the middle way is best.” For humanity the best we can do between this world and the next is to admit our ‘own collective ignorance’, remain humble, and avoid angering both the sun god and his boss. Will this involve following the ‘middle way’ of collective energy efficiency, environmental stewardship, and ethical choices? Certainly to do nothing is out of the question. But could we try to do too much, and will someone or some group trying to ‘fix’ the climate repeat Phaeton’s blunder?

8. Conclusion

The promise of controlling the weather or climate is typically motivated by pressing problems (global warming, cold war competition, aviation needs, or, the need for rain); based on relatively new and speculative technologies (back of the envelope calculations, simple computer models, satellite observations, chemical or electrical processes); and accompanied, at least in Western culture, by excessive hype (a simple, affordable, and ‘sweet’ technological fix for the pressing problems listed above). These cycles seem to come and go perennially; so that the current wave of fixes and claims is just the latest such wave (Fleming, 2006). They also appear to be rooted hubris and spring from the deep mythologies of the past.

Archimedes tipping the Earth is a favorite icon of the climate engineers. According to legend the overly-confident Greek engineer claimed, “Give me a lever long enough and a place to stand, and I will move the Earth.” Climate engineers point to the lever and claim that science has now made levers long enough and powerful enough to control climate. I point to the lever and ask, where is Archimedes standing, and where will the Earth roll if he tips it? Also, who gave him the right to exercise such leverage?

In *Paradise Lost* John Milton alluded to a divinely instituted shift in the Earth’s axis (and thus its climate) as a consequence of the original lapse from grace:

> Some say, He bid his Angels turn askance the poles of earth, twice ten degrees and more, from the sun’s axle; they with labor pushed oblique the centric globe [...] to bring in change of seasons to each clime; else had the spring perpetual smiled on earth with verdant flowers, equal in days and nights... (Milton, 1831)

So in this sense, the wages of sin are... climate change; and the bumbling tinkering of the climate engineers may well turn out to be the worst case scenario imaginable.

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III. WEATHER, HISTORY AND EMERGENCY

Volcano eruptions, earth- & seaquakes, dry fogs vs. Aristotle's *Meteorologica* and the Bible, in the framework of the eighteenth-century science history

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> There will be great earthquakes, famines and pestilences in various places, and fearful events and great signs from heaven (Luke 21:11).
>
> *Un jour tout sera bien. Voilà notre espérance. Tout est bien aujourd'hui. Voilà l'illusion* (Voltaire*, Poème sur le désastre de Lisbonne,* 1756).

1. Introduction

Ever since an immense seaquake had devastated the shores of Southeast Asia on the 26th of December 2004 causing a toll of several hundred thousands of lives and leaving at least one million homeless, the word *tsunami* entered our daily vocabulary. The fact that this catastrophe occurred in Christmas time and made its victims among the poor and needy humanity of Third World countries, shook the foundations of our worldview. World media immediately connected the tragic event to other global issues such as global climate change, ecological policy, North-South contrasts and weather-related disasters. In her study, Nordlie (2006) noticed in the philosophical literature "biblical dimensions," where again like in the Lisbon 1755 event, the meaning of the disaster was sought as if it carried a divine message. Pratt (2005) even considered the occurrence of the 2004 catastrophe, just like the Lisbon earthquake, as statistical [sic] evidence that the hand of God was involved.

Very similar considerations were held on the occasion of the famous Lisbon sea- and earthquake of the 1st of November 1755, occurring also on the holy day of All-Saints. To name only one, Voltaire made Candide witness the destruction of the town of Lisbon and asked the famous philosophical question of the goodness of our world. A "seismic crisis" took place in the period 1755-1762 as earthquakes did occur frequently in North-West Europe (Alexandre & Vogt, 1994). Death toll estimates of the Lisbon 1755 disaster vary from 70,000 till 100,000 to much more conservative estimates ranging around 10,000.

The meteorological descriptions of the Lisbon earthquake can be divided into two groups, the first one which tells that the weather for the weeks preceding the sea- and earthquake has been very fine and clear, and that the quake occurred with a clear sky. In literally terms these descriptions are helping to provide a strong contrast with the catastrophic events of the destruction of the town. Demarée and Nordli (2007) as well as Demarée *et al.* (2007) provide a detailed description of the weather and of the volcano-related elements in the weather, while Malaquias and Thomaz (2007) provide published examples of eyewitnesses accounts that were spread around in Europe.

However, it was striking that several authors who were direct witnesses of the events augmented their weather descriptions with descriptions of dark, coloured, bad smelling fogs observed before the fatal earthquake. Although these descriptions are fully in line with the ongoing scientific theory of that time, namely Aristotle's *Meteorologica*, the descriptions are too detailed and numerous from independent sources that the authors of the present paper made a hypothesis. The authors interpret these descriptions as dry fogs produced by the Icelandic Katla volcanic eruption a fortnight before. Similar phenomenon was witnessed in Lisbon in the portentous summer of 1783 due to the Icelandic Lakígigar volcanic eruption (Demarée & Ogilvie, 2001).

2. The effects of the sea- and earthquake

The effects of the Lisbon 1755 earthquake were felt in North Africa (Gazeta de Lisboa, 1756a, p. 142) and Europe but mainly on the Iberian Peninsula. However, light tremors were also witnessed in France, Switzerland, and Italy and even in the Low Countries.

Accounts mention tremors, vibrations and water movements in the Low Countries but without the sad effects that occurred in Spain, Portugal and Morocco. In Goch the local priest Mr. van Haaren noted: *"Anno Post Christum Natum 1755 in Festo omnium Sanctorum Primo Novembris* there has been such a heavy earthquake, that the whole town did nearly sunk down and burnt, which has been felt here and in other places" (Anonymous, 1977, p. 30). Another chronicle from the same town says "...thanks to God little has been perceived here" (Anonymous, 1977, pp. 89-90).

Jan de Boer notes in his manuscript *Vervolg der Chronologische historie van a° 1753, 1754, en 1755* the following concerning the earthquake in Amsterdam: "On land little was perceived here of the earthquake. [...] But in the White Friar's church, as it was All-Saints, the chandelier hanging in the middle of the church, was seen moving vigorously, without being touched, and also without somebody knew the cause of the movement" (de Boer, n.d.).

The Lisbon 1755 *tsunami* affected three continents: Europe, Africa and America. The *tsunami* waves were observed in nearly whole Atlantic Europe, but also overseas in Northern Africa, Madeira, the Azores, the Mediterranean Sea, the Antilles and even Newfoundland and probably Brazil, Cabo Verde and the east coast of North America (Gazeta de Lisboa, 1756b, p. 45).

Few people in the Low Countries or Portugal knew the word *tsunami* before Christmas 2004 and even less were aware of its potential danger. However the Lisbon *tsunami* was observed at the Low Countries coast: "At the time of the big earthquake in Lisbon, November 1, 1755, toward the ten hours in the morning, one has observed in Nieuport [Flanders], by a very quiet time, an unusual movement and an extreme agitation in the waters of the sea: the tide was extraordinarily high, to the point to arrive until the gates of the city; what gives 5 or 6 feet more than the highest tides of the high waters unaffected by the wind. Everybody ran to the port, astonished of this phenomenon of which one could not then guess the reason" (Mann, 1783, pp. 140-141).

In Europe, numerous manifestations of movements of water bodies, the so-called *seiches*, were witnessed. As The Netherlands is a country with many water bodies such like rivers, canals, lakes and delta areas, the *seiches* were well noticed and several pamphlets and booklets were soon published.

De Boer describes the movement of the water in the harbour of Amsterdam as follows: "This morning, a quarter to eleven, we have had here an earthquake which was felt more in the water than on the land. In the Singel, the movement of the water was so great and strong that the ropes with which the ships were moored up were torn off. The same ropes, no matter how strong they were, broke off as if they were thin silk treads and the ships were thrown by the wild water against the banks or embankments so that in the middle of the canal the bottom was shown. It happened so in several other canals and waters in and around this town" (de Boer, n.d.).

Johan Georg Muller (1755) publishes as early as the 12th of November, before the news of the Lisbon disaster had even reached The Netherlands, a booklet on the water movement observed in Friesland in particular. He attributes the movement of the water to an earthquake.

De Boer discusses these findings in his manuscript notes on the 14th of November as follows: "As many want to find out the natural cause of the earth and water movements, the discussions did become fairly excessive. Many are found that would like to bring the case to the natural without letting something to the hand of the Almighty. I do not want at all to become involved in all such discussions but believe that many things do occur in a more natural way which for an ignorant is supernatural. But I also believe that the Creator governs his creatures according to his own will and that the natural order in many occurring matters is due to the all-ruling hand of the Creator, and as such not to lose out of the eye the fear for this forcing hand" (de Boer, n.d.).

3. A description of the dramatic events at Lisbon

Most letters from Lisbon or from other places in Portugal and Spain report only the most beautiful weather conditions the day of the fatal earthquake. This description is at odds with the catastrophic events as is shown by the Rev. Charles Davy (1722-1797): "There was never a finer morning than the 1st of November; the sun shone out in its full luster; the whole face of the sky was perfectly serene and clear; and not the least signal of warning of the approaching even which has made this once flourishing, opulent and populous city, a scene of the utmost horror and desolation, except only such as served to alarm, but scarcely left a moment's time to fly from the general desolation" (Tappan, 1914, p. 618).

Extracts from a narrative of the dramatic events at Lisbon and how they were perceived by the inhabitants is given by an anonymous French author who witnessed the tragedy:

> The 1st of November, All-Saints Day, in the morning there was a fog which was dissipated later on by the rays of the ardent Sun; there was no wind at all and the sea was calm. [...] At 9 hours and 36 minutes, suddenly a very severe earthquake was felt. [...] An infinite number of persons, of all states, of all sexes, and of all ages, were buried under the ruins of the churches and convents. In the same instant the houses crumbled and crashed those ones who tried to escape, or that went into the streets. [...] A new earthquake, less violent than the first one, increased the distress; one imagined to be buried in the fissures that the first quake had opened from all sides some minutes before. [...]
> However, fire broke out in the churches, in the palaces, and in the houses that were abandoned and half demolished. [...] A violent northerly wind rose. The fire became general. The whole town was afire. [...] The Sea was jealous that Man was less afraid from it than from the Earth and the Fire. [...] The sea vomited swirls of black and thick water that seemed to come from the deepest abysses. After being swollen in a surprising way the wretched waters returned to the sea with the same speed. They took with them the fragments of the ships, of the boats, and a thousand other materials that were on the shore. The flux was so fast that one was tempted to see the river Tagus dry when at this moment the foaming waves returned with a dreadful noise. They brought back what they had dragged along, disrupted the ships, broke the anchors and the ropes, and advanced within the streets and the neighboring squares. The quays fell down; the people who were on the shores were carried along (Anonymous, 1953, pp. 9-10, 12).

It can be truly noted that all four classical Greek elements play an important role in the description of the events.

4. Earthquakes, volcano eruption in Iceland and tephra fallout in October 1755

On the 10th of September 1755 heavy earthquakes started to occur in northern Iceland, but most violently near Húsavík and on the island Flatey (Þoroddson, 1925; Anonymous, 1758). The natural scientists concluded that the earthquake's epicentre was situated at sea. They further believed that the earthquakes were connected to the Katla volcanic eruption that was to come.

Katla, a volcano located near the southern end of Iceland's eastern volcanic zone, erupted on the 17th of October 1755. It started with incessant earthquakes before noon. A *jökullhlaup* or glacier-outburst flood started in the evening and lasted all night. On the eighteenth of October 1755 the earth was like stunned and the sky full of clouds and fog so that one could not see the mountains but lightnings flashed through the darkness accompanied by frequent roaring, bangs and earthquakes not so strong as on the first day. The eruption produced much ash that was brought over most of the country, and brought also over a long distance at sea.

A passenger on board of a ship bound for Charlestown in South-Carolina mentions black dust falling in the night of the 23rd or 24th of October (Whytt, 1757). Tephra fallout was noticed on the twentieth of October on the Shetlands (Mitchell, 1758). Another source of tephra fallout comes from a captain sailing in the second half of October 1755 from Húsavík to Europe (J.H.R., 1756). All these sources believe that the volcano Hecla [sic] in Iceland was responsible.

An earthquake in Greenland was reported: "Copenhagen, 15th of November 1755. According to the information from our colony in Greenland one had there in the beginning of this month a severe earthquake which has caused much terror and fear among the inhabitants" (Amsterdamse Donderdaegse Courant, 1755). It may be questioned if this information doesn't refer to the Icelandic earthquakes of September 1755.

5. Earthquakes, exhalations and volcanoes

Until the late eighteenth century Aristotle's *Meteorologica* still remained the principal source of meteorology (or what was being considered as meteorology by that time). Indeed all sub-lunar manifestations such as winds, earthquakes, thunder; lightning, exhalations, and even falling stars are considered as 'meteors'. This term is used in that way here. Vapours, named 'exhalations', occur in the lower stratum of the atmosphere that is the region where 'meteors' defined by the action of the air including winds, earthquakes, thunder, lightning, etc. take place. Under the earth, subterraneous caverns full of inflammable gasses, loaded with sulphurous mixtures, nitrous and bituminous matters, etc. strongly interact and explode causing tremors and quakes. Exhalations venture through the cracks. These exhalations are sometimes witnessed as sulphurous vapours and are described to condense as falling stars in the higher regions (Ortiz Gallardo de Villarroèl, n.d.; Jankovic, 2000).

By the beginning of the eighteenth century, several physicists started to make observations and asked the question "whether there follows not great winds, rains, thunder and lightning after the earthquake is over." For centuries, generations of physicists and meteorologists took this sentence as a working programme. The atmospheric conditions preceding an earthquake could be disputed as it turned out quite naturally, but the question was never abandoned. The latter consequently provided plentiful of weather descriptions (von Hoff, 1840/41), data now treasured by the historical climatologists. It was believed that earthquakes generally begin with calm weather, and a black cloud. And when the air is clear, just before an earthquake, yet there are often signs of plenty of inflammable sulphurous matter in the air (Jankovic, 2000).

Giuseppe Boni dealing with historical and philosophical accounts of the doleful events of 1755 states that: "The air then clears from dimness and fogs, and also anticipates earlier the tremblings many times, and we have the example of this in the earthquake fatal to Lisbon and to the rest of Portugal, and so widely spread over Spain, and over a so large part of Europe;..." (Boni, 1756, p. 135) All these 'meteoric' actors were noted at the Lisbon earthquake, true or not true.

G. Rapin sees the subterraneous fires as the origin of the outbreak of the fires in the destroyed town after the shocks. "One wasn't able to witness, because of the clearness of the day, that by its openings the earth vomited fires which set afire the combustibles of several houses, [...] from where a thick smoke, that could be seen in other places, announced together with the impetuous winds which suddenly arose, the general fire of the whole town" (Rapin, 1757, p. 16). However, most probably, the falling of burning candles or kitchen fires under the churches and houses caused these fires. Indeed, a large part of the population was in the churches and monasteries to celebrate the religious festivities of All-Saints Day. Rapin following the scientific theories of his time wrote: "The Earth that had opened itself under the foundations of the houses of the town, vomited at the same time bituminous and sulphurous matters, which catching fire by syncope, in the openings or otherwise the cracks, exhalations evaporated that weakened the strongest hearts" (p. 22).

Joachim Joseph Moreira de Mendonça writes: "Fiery raging winds developed from the many dry exhalations that carried the earth, these are produced by the fire that is in movement indicating sufficiently the proximity of one or the other tremor of the earth" (Moreira de Mendonça, 1758, p. 260). The last words of this treatise are the following: "This signal has ambiguity. It is true that the last earthquake was preceded by strong winds in the previous summer. But in what concerns these winds, it is true that since more than one year they were observed as stormy over the whole Kingdom of Portugal and its coasts. These are the signals that were noted by various authors. I have exposed the causes according to my own system" (Ibid.).

6. The traditional religious views vs. the Enlightenment

The occurrence of minor earthquakes that struck England in February and March 1750 left a terrorizing effect on the population that was by that time considering earthquakes rather as rare and abnormal events (Kendrick, 1957). These earthquakes raised their attention and when, five years later, the Lisbon earthquake took place, it immediately had an immense response in England, the traditional ally of Portugal.

The hypothesis of the wrath of God for the sinful way of living of people was one of the constants in the literature that was occasioned by the dreadful Lisbon earthquake. Of course emphasis and views were different according to the authors whether they were Roman Catholics, Anglicans and Lutherans. In non-Roman Catholic media the brutal and bloody actions of the Inquisition in Portugal were denounced as one of the factors of the wrath of God.

One of the key players in the debate was without doubt Voltaire (1694-1778) who, shortly after the earthquake, wrote his famous poem in which he expresses his Deist vision on the world and where God is not so much seen as an actor but rather as a spectator of what happens on this earthy floor. One of the interesting voices was the French Jansenist Laurent-Etienne Rondet (1717-1785) who claimed a justification of the Lisbon earthquake as Portugal being one of the countries where the Jesuits were very welcome. As a matter of fact, the Marquis de Pombal, the dictator that emerged from the earthquake shut down the Jesuit order in Portugal in 1759. Rondet wrote a treatise in which he tries to prove with biblical texts that all 'meteoric' appearances could be seen as prognostications.

Rondet dedicated his work with the quotation: "He looks at the earth, and it trembles (Psalm 104: 32)." The movements of the waters were explained as signs that redemption was near: "On the earth, nations will be in anguish and perplexity at the roaring and tossing of the sea (Luke 21: 25)." According to the Bible, the waters represent the people: "The waters you saw are peoples, multitudes, nations and languages (Revelation 17: 15);" "He turned rivers into a desert, flowing springs into thirsty ground, and fruitful land into a salt waste, because of the wickedness of those who lived there (Psalm 107: 33-34)." Johann Karl Koken (1756) also hears the voice of God in the above quoted Psalm 104: 32.

Veríssimo Moreira de Mendonça tries to balance the religious view of the fire of hell with the traditional scientific view by warning that "in the centre of earth there exists the fire of Hell, that so many times the Holy Scripture reminds us" and that "even this fire be destined to the torment of the condemned souls and eternal satisfaction of the Divine offences, it still remains a true fire, and of the same nature of the elemental one, although by the sulphurous matter, and bituminous it is denser and more abrasive" (Moreira de Mendonça, 1756, p. 7).

It is clear that the traditional views on the causes of the Lisbon earthquake collided directly with those of the Enlightenment. The Enlightenment philosophers were putting more stress on 'observation', 'scientific evidence' and 'change'. However, the debate was still influenced by the Aristotelian view on earthquakes and one had to wait until new theories emerged. As a matter of fact, the Lisbon earthquake served as a laboratory for new seismological concepts. Authors like Immanuel Kant, Friedrich Jacobi, Elie Bertrand, John Bevis, John Mitchell, and others, soon published on the subject.

7. Conclusions

The Lisbon earthquake of the 1st of November 1755 is without doubt one of the most important landmarks of the eighteenth century. Not only, it was one of the earthquakes that has left a very deep impression on the general public in Western Europe by the size of its destructions but also by its impact in philosophy. Immediately, a large number of letters, papers, pamphlets, books dealing with scientific, religious, political, philosophical aspects, or merely of an informative character, were published.

In previous papers the authors have collected quotations out of contemporaneous publications dealing with the earthquake related to the 'meteoric' observations where the appearance of a dark cloud, smell of sulphur and even of a yellow fog or smoke is stated (Demarée & Nordli, 2007; Demarée et al., 2007). In many cases, these mentions are in line with Aristotle's *Meteorologica* that was still largely the surviving scientific theory at that time. Another interpretation came from the religious point of view where the appearances dealing with sulphurous events were related to prognostications from the Bible. In this view, the earthquake was often seen as the wrath of God.

These mentions are rather difficult to interpret and much caution should be given. It is not always clear if the authors write what was consistent with the dominant scientific and philosophical theory of their times or if it corresponds to factual information. However, the authors of the present paper are inclined to accept that part of the information corresponds to facts. As Aristotle's *Meteorologica* belongs itself completely to the reign of the History of Science, another explanation had to be sought. It is suggested that these observations are related to the Katla volcanic eruption in Iceland of mid October 1755. Black dust fallout has been reported in the Shetlands and over the Atlantic Ocean by late October. Indeed, the time scale of the process of the injection of large amounts of SO_2 gases into the atmosphere, its conversion into sulphate aerosols and the transport of tropospheric aerosols (having a lifetime of one to three weeks) by the atmospheric circulation patterns is largely consistent with the observations on the Iberian Peninsula.

The synoptic weather patterns in the second part of October 1755 could provide valuable additional information to strengthen this hypothesis. Unfortunately, the State-of-the Art Sea Level Pressure field reconstructions for the mid eighteenth century (Luterbacher et al., 2002) remain monthly and therefore it is not yet possible to demonstrate the full picture of the daily circulation patterns.

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Confronting avalanches in the Alps in the late Middle Ages and early Modern Era

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1. Introduction

This paper is devoted to a natural hazard that occurs primarily on steep slopes in high Alpine areas devoid of forestation. To understand this natural hazard it is necessary to start with some basic information on avalanches. Secondly, some methodological considerations pertaining to cultural history approaches to natural hazards and their impact on human societies will be presented. Thirdly, the question must be posed as to why we know so little about historical avalanches in late medieval and early modern times. To these ends, some examples from Switzerland, Austria and Northern Italy are presented in greater detail. Fourthly, the perceptions, popular explanations and interpretations of avalanches in historical Alpine societies are analyzed. Finally, the development of risk management systems will be highlighted.

2. Avalanches in the Alps

Two main types of avalanches can be distinguished: snow avalanches, among them loose snow avalanches, slab avalanches and slush avalanches, all of which stay on the ground when they come down the slopes with a moderate speed between 25 and 120 km/h. When the snow mixes with the air, powder snow avalanches are created, which accumulate up to millions of tons of snow and increase in speed – up to 350 km/h – when leaving the ground. As powder snow avalanches also flow for longer distances along flat valley bottoms, they may reach settlements that are normally considered safe. Most of the damage is caused by the high air pressure.

There are several contributing factors, which favour the generation of avalanches: the layout of the terrain, the snow structure and weather phenomena such as wind or sudden warm and sunny weather. Slopes with less than 25 degrees or more than 60 degrees are hardly suitable for avalanches, whereas an angle between 35 to 45 degrees is most endangered. Areas with dense tree vegetation, below the tree line of ca. 2,000 meters in the Alps, do not have as a high a risk factor as concave slopes. For this reason, the Western Alps in modern day France and Northwestern Italy, central Switzerland and Western Austria (Vorarlberg, Tyrol) are most frequently hit by avalanches than the (lower) Eastern Alps (Fraser, 1966; Nussbaumer, 1996; Ammann et al., 1997).

3. From natural hazards to natural disasters

Approaches towards natural hazards from a cultural history perspective have become very popular in the last decade (Rohr, 2007, pp. 36-45). They focus for instance on the perception, interpretation and management of these events by the affected people and human societies in general. In this study, the term ‘natural hazards’ means the natural event, which in some instances impacts the human environment, whereas ‘natural disaster’ is used to denote the perception of such an event by the people affected.

Several factors are necessary for the perception of a natural ‘hazard’ as a ‘disaster’:

a) the helplessness of the people trying to cope with the damage with the available means,

b) people’s helplessness in explaining the reasons and the meaning of the event,

c) the material and personal affliction,

d) the unexpectedness of the event, which depends on how prepared a society is for one-time or recurrent hazards,

e) a series of natural hazards within a short period of time, which can raise the vulnerability of the afflicted people,

f) symbolic connotations and patterns of interpretation, such as connections to natural disasters described in the bible, and

g) a general crisis, such as the simultaneous economic, religious and climatic crises during the sixteenth century in Europe.

If a society is prepared to cope with a natural hazard, people will account for them in their daily life and their socio-economic system. They will adapt their settling places and their behaviour to minimize risks based on their experiences from the past. The grade of vulnerability of this society will be lower and the result can be a ‘culture of disaster’ (Bankoff, 2003) or – maybe better – a ‘culture of risk management’ (Rohr, 2007), because in many cases these affected people will no longer perceive most of the natural hazards as disasters.

4. Why do we have such limited knowledge about historical avalanches? Some examples

In contrast to reports on floods, storm tides and earthquakes, there are only very few records about avalanches before the eighteenth century. Obviously there were hardly any settlements in areas with a high risk of avalanches. In addition to this consideration, afflicted rural regions were typically areas with low levels of literacy. Analyzing the following examples, we are able to discern three different types of affected populations:

a) travellers, mostly merchants, pilgrims and soldiers, crossing the Alpine passes in winter,

b) miners working in high Alpine mining districts, and

c) settlements in normally safe places, which were hit by powder snow avalanches.

The sources for these events are normally very short and of poor quality. Only a handful of detailed travel reports, local chronicles, charters, administrational reports and other written sources have survived.

4.1 Rudolf, abbot of Saint-Trond (Belgium), crosses the Great Saint Bernard Pass

One of the earliest detailed reports concerning a group of travellers affected by avalanches dates from the first half of the twelfth century. In the winter of 1128/1129, Rudolf, abbot of the monastery of Saint-Trond in nowadays Belgium, crossed the Great Saint Bernard Pass on his way back from Rome. This connection between the Aosta Valley (nowadays Italy) and the Valais region (nowadays Switzerland) was one of the most frequented pass routes in Antiquity and in the Middle Ages. It reaches an altitude of 2,473 meters. In this way, the upper part of the route leads through a high Alpine landscape without any woods and that is threatened by avalanches until the present day.

The biographer of the abbot provides us with a dramatic insight in the dangers of travelling in former centuries. He relates that many travellers were stuck in the village of Saint-Rémy due to the large masses of snow along the pass route. Ultimately, avalanches destroyed parts of the village and killed some of the local guides, the so-called *marones*, who had tried to traverse the pass in advance. In their fear, the pilgrims expected an imminent death and started to pray together, but at the end, when the weather became more stabile, they succeeded in crossing the pass. It is remarkable that numerous people apparently tried to cross the Alps during the winter. So we may consider that avalanches must have been a frequent threat for such travellers.

The work of the *marones* at the Great Saint Bernard Pass is described in more detail: they had good equipment, they wore shoes with spikes and special winter caps, and they used long sticks to search for safe passage. When they were buried under an avalanche, the rest of the local community mounted immediate rescue operations and in some cases succeeded. This is not the only report about a successful rescue operation. So, we may consider that these Alpine communities living along the major pass routes were not only specialized in guiding the travellers, but had also established an effective rescue system. The *marones* were organized in specific communities and received support from the local authorities, who had a vivid interest that the pass routes in their territories were relatively safe.

On top of the Great Saint Bernard Pass, a first hospice was founded around 1050 by Saint Bernard, a wandering preacher. In these hospices, clergymen cared for the travellers as a charitable service. During the following centuries, more hospices were erected on top of all major pass routes (Rohr, 2007, pp. 401-403). The hospices and the so-called *Tauernhäuser* (little taverns along the pass routes in the eastern Alps) were frequently hit by avalanches as well: in 1662 an avalanche covered the so-called *Rauriser Tauernhaus* (province of Salzburg, Austria) and destroyed some side buildings. For 14 days, no light came into the main building; people could enter and leave only through one of the windows (Gärtner, 1991, pp. 45-46).

4.2 The destruction of Mittewald (1456)

In 1456, the small village of Mittewald (nowadays a part of the village of Bichlbach) in the Tyrolean Ausserfern Valley was hit by a disastrous powder snow avalanche. Most of the inhabitants were killed; the village itself was totally destroyed. The settlement was rebuilt some hundred meters away on a new and safer location after 1456. It is remarkable that this new village was called Lähn, which means ‘avalanche’ or ‘slope with frequent avalanches’. Nevertheless, another severe powder snow avalanche struck the new village in 1689, a year with numerous destructive avalanches in many Alpine regions (Linser, 1992, pp. 59-62).

We do not have any contemporary narrative sources that refer to the 1456 disaster, but we can consider a very specific ‘culture of memory’ which lasted until the early twentieth century. It was not only the name of the new village which reminded its inhabitants of the threat of further avalanches. On the church of Lähn, erected in 1467, a votive tablet told the local community and travellers the story of the vanished village of Mittewald. In 1726 this tablet was updated and served to recall the avalanches in 1456 and 1689. A copy from 1930 is still extant. In addition to that, another tablet, which is lost today, was fixed on the church wall and also some houses were decorated with inscriptions referring to the avalanches of 1456 and 1689, such as:

> This house is mine,
> but in fact not mine,
> and also my successor
> will not be its owner.
> The third owner will receive it,
> even the fourth one will be killed in it,
> and the fifth one will be carried out dead as well.
> Oh God, who will be the real owner of this house?

It is remarkable that these inscriptions, which were documented in travel reports from the late nineteenth and the early twentieth centuries, have now vanished. It seems that people in modern Western societies have banned extreme natural hazards from their daily life (Rohr, 2007, pp. 413-415).

4.3 Miners killed at the Schneeberg (1580)

Starting in the High Middle Ages, gold and silver mines were established in many parts of the eastern Alps – such as in the so-called *Hohen Tauern* (presently in the Austrian provinces of Salzburg, Carinthia and Eastern Tyrol) and in Southern Tyrol (in modern day Italy). Due to these mining districts, the population in these high Alpine regions was relatively dense, such as in the upper Passeier valley (Southern Tyrol). The villages of the miners’ families and the entrances to the mines were often threatened by avalanches. In 1500, the village of Moos was destroyed by a series of avalanches; a votive tablet in the local parish church testifies to the death of 30 people. The problem was less the first avalanche, which covered the two commanders of the mine, but a second one shortly afterwards: 37 mine workers had tried to search and dig out their commanders, but were struck by an even stronger avalanche which killed 28 of their group.

In 1580, the foot path to the mines situated at the nearby Schneeberg ('snow mountain') at more than 2,000 meters altitude, was hit by another series of avalanches. Again, only one miner had been buried by the first avalanche, but the second avalanche killed at least 29 colleagues who were searching for their comrade. These two examples show that rescue operations started immediately after avalanches, but sometimes resulted in even more victims due to subsequent avalanches.

In 1693, one of the miners' barracks situated near the entrance of the mine was totally destroyed. The roof could no longer support the weight of the snow and caved in; 19 of the 70 mine workers living in this house were killed. Another danger for the miners arose when the entrance to the mines was blocked by an avalanche; in this case, the workers could suffocate inside the mine. To avoid this danger, the entrances were protected by so-called *Schneekrägen*, long corridors with a stabile roof leading to the mouth of the mine (Gruber, 1977).

5. Perceptions and explanations

Most of the narrative sources do not include any remarks concerning the perceptions and explanations of avalanches, neither in the scientific discourse nor in popular beliefs. From the sixteenth century onwards, some geographical treatises are extant, in which the reasons for avalanches are described. They show a lack of knowledge, in particular of how avalanches can build up and then come down to the valleys. The first treatise by Josias Simler, entitled *De Alpibus commentarius* (Simler, 1574), argues that snow starts moving due to slight concussions or noise, such as the echoes of human voices or singing birds. The avalanches themselves were imagined as huge snow balls (Rohr, 2008).

Also the pictorial evidence from the sixteenth to eighteenth centuries is dominated by the same misperception. In all of the woodcarvings and copper plate prints up to David Herrliberger's *Topographie der Eydgenossenschaft* (Herrliberger, 1754-1773; Ammann et al., 1997, p. 26), avalanches are depicted as big snow balls, carrying people, animals, trees and even houses (Figure 1) with them. An early and typical example is one of the illustrations of the so-called *Theuerdank*, an epic poem in the tradition of the Middle Ages about the emperor Maximilian I. The elaborate woodcarvings are made by Hans Burgkmair and other artists.

The lack of knowledge about the reasons for avalanches sometimes led the common people to develop supernatural explanations. In the oral tradition, fairy tales and legends, avalanches were called 'white virgins'. This interpretation fits with the model that the unpredictable and sometimes wild parts of nature were seen as female (Merchant, 1982). In other popular tales avalanches are described as 'white snails' (Lehner, 1995).

6. Risk management

The aspect of risk in the daily life of the Alpine populations has been highlighted in only a few studies (Granet-Abisset & Brugnot, 2002; Rohr, 2007). As has been shown above, people mostly avoided settling in hazardous areas, with some exceptions: living along the main pass routes was obviously a good business, because the peasants and shepherds could also work as local guides. They also installed a system for rescue in the event of an avalanche along these pass routes, both for themselves and the travellers.

Figure 1: *Theuerdank* (the emperor Maximilian I) faces an avalanche during a horse ride in the Alps. The avalanche is depicted as a series of big snow balls.

Source: *Theuerdank*, 1888 [woodcarving].

To protect villages and pass routes from frequent avalanches, the authorities restricted the cutting of high-Alpine forests and commanded that cattle graze in the woods, illustrating that the beneficial nature of dense tree vegetation was evident for the medieval population. Nevertheless, in the late fifteenth and early sixteenth centuries, large forests were cut down in the territories of Tyrol and Salzburg because wood was needed on a large scale for mining, smelting and cooking salt in the saline. It is striking that the occurrence of avalanches in the mining district of Schwaz (Northern Tyrol) started between 1528 and 1531.

Protective buildings against avalanches date back to the sixteenth century and can be found first around the Swiss spa of Leukerbad. Guide walls and so-called *Spaltkeile* ('splitting wedges') should deflect the avalanches from settled areas. New house types were developed starting around 1500, such as the so-called *Ebenhö(c)h* houses ('plain level' houses) in Switzerland. These houses are adapted to the specific angle of the slope. The shape of the roof follows the profile of the area around. In this way, avalanches may flush over the roof without destroying the house (Laternser & Ammann, 2002; Schoeneich et al., 2002).

As the example of Mittewald and Lähn shows, a 'culture of memory' served to ensure the continued safety of the people by reminding them of the danger of avalanches. Pictures and inscriptions on votive tablets reminded the surviving people of the victims of the last disastrous avalanches. When frequently affected settlements and slopes were named *Lahn* or *Lähn*, anyone knew that these areas were always threatened by new avalanches. This ‘culture of memory’ vanished during the twentieth century. In 1999, a destructive powder snow avalanche hit the ski resort of Galtür (Northern Tyrol): 14 buildings in Galtür and Valzur – mostly hotels – were totally destroyed, 60 houses were damaged, 38 people killed, 48 insured; hundreds of tourists were evacuated via helicopter. Most of the affected hotels were built within the ‘red zone’, where the construction of houses was officially forbidden based on knowledge from the past. The warning that 13 major avalanches had killed at least 57 people in Galtür during the last 500 years had been forgotten.

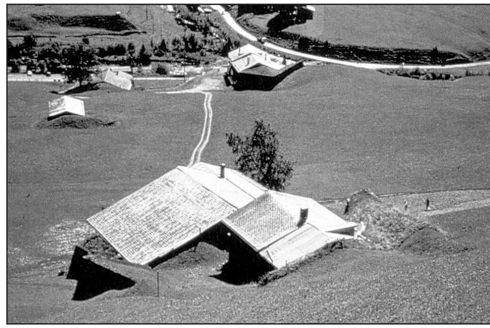

Figure 2: Ebenhöch houses in Switzerland. Photo: WSL - Institut für Schnee- und Lawinenforschung SLF.

Source: Ammann et al., 1997.

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The *Rio-Apa* shipwreck: scientific meteorology and everyday life in Brazil

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1. Introduction

On the evening of July 11, 1887, a terrible storm at the Rio Grande sandbar to the extreme south of Brazil caused serious damage to three ships and the shipwreck of the *Rio-Apa*, a passenger steamer *en route* between Rio de Janeiro and Montevideo.

The first indications that there had been a shipwreck began to appear in Rio de Janeiro newspapers on July 13, when a telegram received by the National Navigation Company *(Companhia Nacional de Navegação)*, owner of the *Rio-Apa*, was published in the *Jornal do Commercio*. According to the short message, strong winds and a stormy sea at the Rio Grande sandbar had impeded the entrance of that ship into the Lake Patos.

This paper intends to analyze the scientific controversy established among educated sectors of Brazilians regarding the path of the storm that sank the *Rio-Apa*. It aims to demonstrate that this controversy had been strongly influenced by the immediate political and intellectual contexts and more specifically by the elites' internal disputes over the institutional spoils of a declining Empire.

2. The wreckage of the Brazilian Empire

In 1887 Brazil was an Empire in crisis. The long period of economic prosperity during the reign of Don Pedro II had only heightened the contradictions of an extremely hierarchical society, still dependent on slavery in a time of expanding capitalism. Rio de Janeiro was a commercial and financial center, and the main port of the Empire, where capital, merchandise, and the immigrants who would replace the slave labor that had since long been condemned to extinction arrived. It was also the Court, seat of the government, including its cultural and scientific institutions as well as the residences of the emperor and a large part of the Brazilian political and economic elite. For this reason the city constituted a privileged stage for the emergence of social tensions and uprisings against the government, the emperor and the monarchical regime.

Since the early 1870s discontent from the educated sectors of an emerging urban middle class was stimulated by what Silvio Romero called "a pack of new ideas," referring to their often confusing and contradictory assimilation of such diverse authors as Auguste Comte, Ernest Renan, and Herbert Spencer. According to some Brazilian historians, a more precise definition of doctrines would only have been evident during the clashes between different social and political projects of reform (Paim, 1967; Barros, 1986). In any case, independently of the commitment to a particular philosophical school, educated Brazilians of the period in general shared the notion of 'progress' and trusted in science and technology as the driving forces to bridge the 'gap' existent between Brazil and the industrialized countries, the so-called 'civilized' nations (Alonso, 2002).

Prominent among the main causes raised in the name of 'progress' was the establishment of a public health program in Rio de Janeiro, aiming to turn the city more attractive for foreigners. In this sense, successive campaigns in the newspapers demanded that the government combat decisively the epidemics that ravaged the local population and especially the immigrants, supposedly more susceptible to diseases like yellow fever. To join the 'civilized' nations also meant exploring Brazil's natural resources, and investing in the renovation of older districts of Rio de Janeiro city as well as in the construction of rail and telegraphic networks throughout the entire country.

"Brazil, a nation supplied with natural wealth, much of which still lies delivered to abandonment, is in need of engineering works that break through the forests, bound over the mountains, navigate the rivers, conquer the valleys, furrow the soils, apply natural forces in benefit of industry and immigration, and defend its coast and frontiers," argued Antônio de Paula Freitas (1843-1908), synthesizing a generalized claim of Brazilian engineers (Freitas, as cited in Ferreira, 1989, pp. 122-123). Paula Freitas was a significant leader among his colleagues, working through a scientific society founded in 1862, called the Brazilian Polytechnic Institute (*Instituto Politécnico Brasileiro*). According to historians the Institute actually represented a fundamental marker in these intellectuals' struggle to simultaneously validate their profession and push forward the 'material modernization' of Brazil (Ferreira, 1989; Marinho, 2002).

It is necessary to emphasize that this modernization project presented a conservative and authoritarian character, for in spite of being abolitionists and often republicans, the Brazilian engineers in general defended the maintenance of the ruling hierarchical social structure and fought for the strengthening of the state, seen as the protector of the social order and promoter of 'material progress'. From this perspective it is easier to understand the reason why a good part of them were Comte's positivism sympathizers at the turn of the twentieth century. The struggle of the 'polytechnicians' for the official recognition of their profession had thus soon unfolded from the valuing of their technical-scientific competence to a dispute for strategic state positions, marginalizing politicians and bachelors of the administrative functions they executed. Paula Freitas expressed this demand very clearly as he claimed the duty that should be attributed to the Brazilian Polytechnic Institute at that moment:

> This corporation, evidently the only one capable of undertaking the study of technical issues which tend to increase in number and importance, the organization of preliminary measures of public works, and everything else it entails, is of uncontestable necessity, and cannot renounce to be administrated by the engineers charged with commissions throughout the Empire, so that the inspection of such works and the interest that the work of such engineers may reinforce, when presented and connected, are accomplished with better results (Freitas, as cited in Ferreira, 1989, pp. 122-123).

Along this professionalizing process, the ‘polytechnicians’ also had to impose themselves over their competitors in the field of exact and natural sciences, such as the astronomers of the Imperial Observatory of Rio de Janeiro. In this sense, throughout the last decades of the Empire the two groups frequently placed themselves at opposite poles of scientific controversies, an example of which is the controversy over the path of the storm that sank the *Rio-Apa*.

The Imperial Observatory of Rio de Janeiro had been founded soon after the Brazilian independence, but had only effectively begun functioning in the mid-1840s with the initial responsibility of offering practical training in astronomy to the students of the Military School and the Naval Academy. In the early 1870s, under the protection of the emperor and the direction of the French *savant* Emmanuel Liais (1826-1900), the Observatory had received new regulations and undergone several reforms, being transformed into an autonomous institution of civil character, with the purpose of producing scientific knowledge (Barboza, 1994). Its main activity became astrometry, i.e. the mapping of positions and trajectories of the stars in the sky – a duty rooted in its geographical position in the southern hemisphere, which in the view of Liais and his disciples was unique and therefore could contribute to the inclusion of Brazil into the so-called “general concert of nations.” In the Introduction to the first volume of the *Observatory Annals*, published in French for good reason, Liais complained that this choice had resulted in resentment and the relative isolation of the institution:

> To make a new country, which until half a century ago was a colony, understand that today, as a free and independent nation, it must be concerned, beyond material issues, with the participation in the general concert of nations towards the progress of humanity, so as to obtain an elevated and dignified position, attracting general sympathies, is evidently a difficult task and one that demands time. Still more difficult in a distant region, where there are no evident elements of comparison is to cultivate appreciation of all the benefits that the advancement of science can give to a country; to make understand the practical utility of studies whose application, *a priori*, one cannot conjecture (Liais, as cited in Barboza, 1994, p. 45).

The dispute between the ‘polytechnicians’ and the astronomers began in 1879, when the Observatory employees responsible for elaborating the General Chart of the Brazilian Empire collectively resigned, and placed the methods used in this institution for determining the ‘absolute meridian’ under suspicion. Cloaked in a technical-scientific character, this first controversy originated a series of conflicts, including repercussions in the press, in the academic arena and in parliament, going even as far as to the justice department. The dimensions it assumed can only be understood in face of the wider struggle then established between the two groups for the monopoly of scientific authority, a necessary prerequisite to the imposition of the respective validation criterion for scientific practices in Brazil. For ‘polytechnicians’ the legitimacy of exact and natural sciences resided in its immediate uses and in its application to the project of modernizing the country. For the Observatory astronomers, scientific practices should be guided by the ‘originality’ of produced knowledge. The controversy about the ‘absolute meridian’ was prolonged until at least 1883, with Luiz Cruls (1848-1908), the successor to Liais, already as the director of the Observatory. And over time the new director also began to see more clearly the outline of the opposition that he suffered:

> The Observatory counts as gratuitous enemies: nine-tenths of the faculty of the Polytechnic School, the members of the Polytechnic Institute and the Navy officers (Cruls, as cited in Barboza, 1994, p. 34).

3. The shipwreck of the *Rio-Apa*

Soon after the first news about the disappearance of the *Rio-Apa,* the main periodicals in Rio de Janeiro began to speculate over the fate of its crew and passengers, since only ten days later some flotsam – pieces of wood, buckets and uniforms – began to be seen on the open sea (Jornal do Commercio, 1887d). News about the victims was even slower in coming – only on July 27 the first bodies were found on the beaches, some of them already eaten by fishes and therefore unrecognizable.

At the beginning there was speculation that there had been an explosion of the boilers, which could have been the true reason for the sinking of the ship (Jornal do Commercio, 1887c). Afterward, since bloodstains were found on what could be the remains of the captain’s quarters and supposed knife wounds were found on the body of a soldier, the hypothesis was made that there had been a fight aboard ship (Jornal do Commercio, 1887b). Finally, since some of the cadavers were very thin and wore life-vests, it was published that a good part of the victims had died days after the shipwreck of cold and starvation (Jornal do Commercio, 1887a). The ship’s capacity was 160 people, among free men and slaves, but the official number of passengers aboard was never revealed. At any rate, there were no survivors from the shipwreck of the *Rio-Apa*.

In light of the anxiety for news and the perspective of a tragedy, both the National Navigation Company and the imperial government were soon faced with inquiries about the event. Beginning on July 19 several letters were published in the newspapers containing complaints addressed to João Antonio Mendes Totta, president of the Company. Some of them evidently were written by relatives of the victims, but some shareholders of the company also raised their voices. The *Rio-Apa*, valued at about 262,000 *réis*, was not ensured. In a letter published in the *Jornal do Commercio* on July 21, Totta gave a rather unexpected answer to the disgruntled, putting to evidence the liberality of the capitalist model adopted by the elites of the Empire. According to him, not only the entire fleet of the Company had been insured for a lesser value than that stipulated in the statutes, but also the *Rio-Apa* in fact had not been insured at all. This was because according to the statutes, only the ships destined for oceanic navigation should obligatorily be insured, and the *Rio-Apa* did not belong to this category. It had been designed for river navigation. Some days later the company president would return to comment on this point, trying to justify the reasons by which a ship destined for river navigation, and therefore with a flat bottom, had been misapplied to oceanic navigation. At the very first moment, however, he was more concerned with the financial aspect of the issue. The tone of his letter was even a bit aggressive:

> A few months ago the passenger steamer *Apa* had made the same trip that began on the fifth and was not concluded, and with no insurance. But for this there was no complaint and no one remembered to censure the board, which if it were given the gift of foretelling destiny, not only would have insured the ship; it would not have permitted the trip (Jornal do Commercio, 1887e).

In addition, since the beginning of July 1887 the budgets of the Ministries of the Navy and the Army for the following year were being discussed in parliament. As a consequence the minister of the Navy, Carlos Frederico Castrioto, saw himself obliged to appear before the Congress, where he would accompany in person the enormous repercussions of the shipwreck among the Rio de Janeiro population (Figure 1). In early August, when the tragic fate of the passengers of the *Rio-Apa* had been confirmed, Castrioto was finally called to mount the rostrum and answer to a formal interrogation by the Rio Grande do Sul deputies Antônio Ferreira Vianna and Francisco Antunes Maciel. The interrogation consisted of three questions:

> 1st What was the fate of the steamship *Rio-Apa*?
>
> 2nd Did the empowered authorities employ all available resources to save the ship, crew and passengers?
>
> 3rd Does the government consider the resources at its disposal to be sufficient to aid in similar cases? (Camara dos Srs. Deputados, 1887, p. 41)

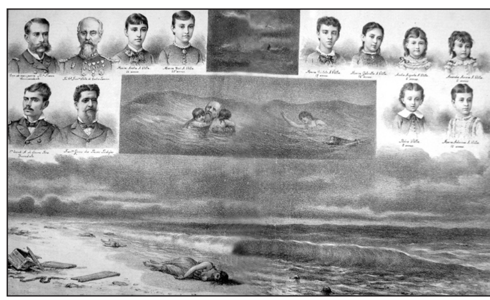

Figure 1: The *Rio-Apa* shipwreck portrayed in the Rio de Janeiro press.

Source: *Revista Illustrada*, v. 12, n. 463, August 26. 1887.

The minister only responded to these questions on August 31, in a lengthy testimony during which he read the report of the inquiry held by the Naval Base of Rio Grande do Sul (*Capitania dos Portos do Rio Grande do Sul*), on request of the provincial governor. During the investigations regarding the responsibility for the shipwreck, twelve witnesses had been heard, among officers and seamen who worked at the Rio Grande Sandbar Pilotage Authority (*Inspetoria de Praticagem da Barra do Rio Grande*). Briefly, to the first question the minister restricted himself to repeat what at that point everyone already knew: the ship had sunk. To the second question, he responded that the government had sent the cruiser *Almirante Barroso* to search for the ship and any possible survivors – only on July 29, actuality. Also, the provincial governor had ordered the chiefs of police throughout the coastal cities to avoid theft of cargo. Through the reading of the minutes of the witnesses' testimonies, he still attempted to convince the deputies that the towboat *São Leopoldo*, sent to guide the *Rio-Apa* into the lagoon as soon as it was seen, only had given up the mission and returned to the harbor relatively early, at 4:30 p.m., because the thick fog hindered the ship's visibility, as a terrible storm approached. Similarly, the sandbar authorities sent no further help before July 15 due to the continued strong winds and rough sea. As for the cause of death of the passengers, the medical report was inconclusive, given the advanced state of decomposition of the corpses. The minister had though been informed that in the opinion of the inhabitants the victims had not died of cold or starvation, but "by effect of the violence of the storm" (Camara dos Srs. Deputados, 1887, p. 535).

In his answer to the third question, Castrioto listed some available resources for avoiding and rescuing what he called "ordinary" cases of shipwrecks: the Rio Grande Pilotage Authority, for example, possessed three towboats and two lifeguard boats. But he did not consider the shipwreck caused by the storm on July 11 an "ordinary" case. In synthesis, according to the minister,

> To rescue cases similar to the one that occurred in Rio Grande do Sul on the 11th day last month, neither the government possesses resources, nor do I believe there are any possible resources (Camara dos Srs. Deputados, 1887, p. 535).

The deputies contested this opinion. Taking the Argentine Republic as an example, Ferreira Viana cited a series of improvements that could be made to increase the security of the ships in the southern seas of Brazil, such as installing a lighthouse at the cape of Santa Marta (near Laguna), luminous and sonorous buoys along the coastline, and a network of both lifeguard and meteorological stations, capable of providing storm warnings to ships through lighthouse signals. The last proposal had already been raised in the press, and had been a target of discussions in several sessions at the Brazilian Polytechnic Institute. Indeed, on July 27 one of the members of the Institute, Viriato Belfort Duarte, had announced that the emperor Don Pedro II, although traveling through Europe and ill, had authorized the government to finance the establishment of the Central Station of a future Brazilian Meteorological Service. It would be located in Rio de Janeiro, on Santo Antônio hill, and put under the direction of the 1st Lieutenant Adolpho Pereira Pinheiro (1851-1895). According to Pinheiro, present at that session, the first arrangements were already being made, such as the importation of instruments that would be regulated, registered and compensated at the Kew Observatory in England. At the same session it had also been decided that an official letter would be sent to the minister of the Navy, so that he were induced to commit himself to the imperial initiative:

> The valuable and spontaneous offer, which His Majesty the Emperor who still stricken by the cruel illness to which he has succumbed has decreed with the purpose of building a central station for the Imperial meteorological and magnetic service at this Court, under the direction of the brilliant member of the Institute, the 1st Lieutenant of the National Navy, Adolpho Pereira Pinheiro, is one step that must be followed for the whole and complete resolution of such an important problem. [...]
>
> With this intention the Brazilian Polytechnic Institute deemed necessary to address Your Excellency specifically, to whose intelligence and patriotism is confided the

> command of the Navy, which can grant a greater impulse to meteorological and magnetic studies, by possessing of arsenals, naval bases, naval recruit academies, lighthouses, flotillas of the Alto Uruguay and Amazonas, hospitals, and the ships of the entire squadron, as well as lighthouse stations, which will have to be established along the most strategic points of the coast to offer immediate aid to endangered ships, as is the custom in all European countries and in the United States of America, soliciting of Your Excellency to promote the necessary measures for the comparative studies of meteorological observations made at the Court and at the other coastal points of the Empire, and any other such arrangements that with these share an immediate relationship (Revista do Instituto Polytechnico Brazileiro, 1890, pp. 27, 29).

The official letter would be written on August 12, consequently before the statement of the minister at the House of Representatives (*Camara dos Deputados*). In case it had been sent on this date, apparently it was not taken into consideration. The fact is that in 1887 there was no consensus among the educated Brazilians in regard to the meteorological contribution to weather forecasting. Actually, as we will see in the following, there was no consensus whatsoever about the most adequate institutional model for the meteorological network that should be established in the country.

4. The scientific controversy about the storm of the *Rio-Apa*

There is no doubt that the storm on July 11 was of devastating proportions. According to the newspaper *Gazeta de Noticias*, "only in 1856 was there a storm that strong, affirm the sailors" (Gazeta de Noticias, 1887). But as for the storm's trajectory, it is possible to identify the existence of at least two different analyses in dispute.

It is of the utmost importance to clarify that the catalyst for the establishment of meteorological networks in both France and England had been a storm. The so-called Black Sea storm occurred in the region bearing the same name on November 14, 1854, in the midst of the Crimean War, and caused the loss of several allied ships, among them the *Henri IV*, the pride of the French Navy, and the *Prince*, an English cargo ship that transported tons of medical supplies and clothes for the soldiers. According to the military history of the two countries its consequences have been truly tragic, insofar as from that moment on, exposed to the rigorous Russian winter, the allies had suffered a long period without achieving any significant victory (Landsberg, 1954; Fleming, 1990; Barboza, 2005).

Lieutenant Pinheiro knew this story well. In the early-1880s he had been indicated by the Baron of Teffé, director of the Hydrographic Office, for an educational trip to Europe and the United States. The objective of the trip was precisely the search for models that could orientate the establishment of a meteorological network along the Brazilian coast, especially for the purposes of navigation. The experience that Pinheiro had acquired abroad was registered in a report published soon after his return to Brazil in March 1884, and was extensively divulged in conferences offered at the Brazilian Polytechnic Institute and at the Geographical Society of Rio de Janeiro.

> Reading the documents of the period, one easily discovers how France was induced to organize the new service. On November 14, 1854, a tremendous storm leaves horrible damage in the Black Sea, and simultaneously manifests its effects in Paris. Marshall [Jean-Baptiste] Vaillant, who was then the minister of War, writes to Mr. [Urbain] Le Verrier, director of the [Paris] Observatory, and asks him to make the necessary inquiries to discover the cause and main conditions of the phenomenon. A rigorous survey is made, information is collected from around the world, the documents obtained are studied and conscientiously analyzed by Mr. Liais; and it is concluded that the wave on November 14 covered nearly the length of all of Europe, that it had crossed this part of the world in four days, and that the direction of the phenomenon had no general defined relationship to the direction and velocity of the wind, etc. [...] (Pinheiro, 1886, p. 3).

The project of establishing the referred service was only presented to the Congress in May 1886, together with a more extensive reorganization project for all of the Hydrographic Office – and was rejected. By this time the Imperial Observatory of Rio de Janeiro had already assumed the mission of organizing a network of meteorological stations throughout the Brazilian territory. Although weather forecasting had been in the long-term plans of Cruls since the beginning, the main objective of that initiative was the study of the country's climatology. Henrique Morize (1860-1930), who at the time was a young engineering student recently promoted to 3rd astronomer of the Observatory, was charged with organizing the network. The new institution only became effective as of January 1887, when the scientific journal *Revista do Observatorio* began to publish meteorological observations performed by fourteen voluntary collaborators (Observações meteorologicas simultaneas, 1887). The observations consisted of data on temperature, atmospheric pressure, relative humidity, rainfall, and force and direction of the prevailing winds. Among the Observatory collaborators were engineers of the imperial government charged with public works, naturalists on scientific expeditions, provincial professors and doctors.

Not all the volunteers made meteorological observations with the expected regularity, and given the reiterated complaints of Morize, many of them had not acquired the practice of reducing the registered data according to the Observatory's instructions (Aviso, 1887b). Additionally, in a note published by the *Revista do Observatorio* in May 1887, the collaborators were requested to perform their observations simultaneously, and informed that they should contact the Observatory so that it could exempt them from the costs of transmitting the meteorological data by telegraph.

> We appeal to our dedicated collaborators in the meteorological observations who reside near telegraphic lines to please cooperate in the simultaneous observations that are performed daily at 9:07 a.m. in Rio, as we recently have begun to carry out, aiming at the knowledge of the general state of the atmosphere at the same physical moment and over a large area of our territory, in hopes that we may initiate the first experiments in weather forecasting, that they address

by letter to the Imperial Meteorological Service of Brazil, whose headquarters is at the Imperial Observatory, so that we may provide the necessary means to obtain the transmission of their telegrams, as was already graciously permitted us by the celebrated Director of the Telegraph for some stations (Aviso, 1887a).

So, when the storm that sank the *Rio-Apa* occurred, not all of the stations of the incipient meteorological network of the Observatory were interconnected via the telegraph. As a consequence, Morize only managed to acquire the necessary data for an analysis of this phenomenon days after the tragedy. In a scientific article published in the *Revista do Observatorio* in August 1887, he exposed a table containing the daily data of atmospheric pressure, force and direction of the winds between July 8 and 13, sent by fifteen collaborators (Figure 2).

ESTAÇÕES	LATITUDE	DIA 8		DIA 9		DIA 10		DIA 11		DIA 12		DIA 13	
		Bar.	Vento	Bar.	Vento	Bar.	Vento	Bar.	Vento	Bar.	Vento	Bar.	Vento
Ouro Preto.....	20°28'	771.0	NE f.	770.6	NE M. ✱	770.2	NE M.	768.1	NE f.			768.0	NF
Queluz (Minas)..	20.40							768.3	Calma			768.0	NW M. g.
I. do Governador	22.49	771.7	SE f.	772.5	NE f.	769.2	NW f.	768.0	NW f.	761.0	NW M.	767.0	W M. ✱
Côrte..........	22.54	772.7	NE f.	773.4	NW f.	770.4	N f.	767.9	NW f.	761.4	NW f.	767.9	NNW f.
S. Paulo........	23.36	773.2	NE M.	772.0	E f.	770.6	E f.	764.3	E M. ✱	766.0	W F. ✱	770.1	NW M. ✱
Santos.........	23.56	773.0	Calma	773.2	Calma	778.0	Calma	766.6	Calma	763.8	NW F.	770.0	N F. ✱
Ponta Grossa...	25. 7	773.0	SSE f.	773.1	SE F.	770.9	SE M.	765.0	NW F. +	766.6	NN FF. g.	772.0	NE F. g. ⊙
Guarapuava.....	25.24	771.5	S F.	772.0	E M.	770.5	E M.	766.0	N FF. +	768.2	W FF. ⊙	772.7	SW f.
Curytiba........	25.25	771.7	Calma	772.3	Calma	769.7	E f.	763.8	SSE f.	764.5	N F.	770.8	NE f.
Paranaguá......	25.31		SE F.	769.2	SE f. ✱	768.7	S f.	765.0	Calma	765.5	W F.	769.0	W f. ✱
Morrettes.......	25.29	772.3	E f.	772.8	SE f. ✱	769.7	Calma	762.6	NW f. +	762.6	NE FF.	769.4	Calma
Palmas.........	26.29			775.3	NE F.	773.1	SE M.	767.1		771.6	SE F. ⊙ ✱	775.1	Calma
Desterro........	27.36			771.0	Calma	771.0	NE M. ✱	765.0		761.3	W f.	769.5	SE F.
Porto Alegre...	30. 2	771.4	Calma	771.0	Calma	768.4	SE f.	769.2	SSE f. ✱	761.2	WNW f. ✱	771.7	SW F.
Rio Gr. do Sul..	32. 6	773.3	NE M.	769.0	NE M. ✱	765.0	E M.	759.2	SE F. ✱	764.2	S FF.	771.8	Calma

Figure 2: "Weather conditions in the southern Empire from July 8 to 13, 1887."

Source: Morize, 1887.

According to Morize, the small number of stations and their unequal spatial distribution had not permitted a construction of isobaric lines and synoptic charts. However, through an analysis of the table itself it was possible to perceive that the depression verified since July 8 at stations located in the southern provinces of Brazil had not been significant. In addition, the registered winds had been moderate and with varied directions. In fact, on the morning of July 11 the Rio Grande station had registered a considerable barometric depression, but according to Morize this variation had been isolated, since only on the 12 other stations to the north registered some "atmospheric movement." Morize then concluded that

> forecasting storms in this part of Brazil is especially difficult and that even with a greater number of stations than the few we possess there, little would have been achieved. Certainly, all those who know the coast of Santa Catarina to Prata [River] know that the most dangerous storms there, called by the characteristic name of carpenters, are those of the Southeast. These storms coming from the open sea become extremely difficult to forecast because they may be quite developed at sea, where there are no islands where stations can be organized, before demonstrating significant preambles at the coastal stations (Morize, 1887, p. 119).

Perhaps because he feared that the known protection given to the Observatory by Don Pedro II could lead him to terminate his generous contribution for the 'polytechnician' project of founding a meteorological and warning signal service in Brazil, Pinheiro did not delay in refuting Morize's theory. In the Polytechnic Institute session on September 28 he took it upon himself to analyze the storm of July 11, based on telegrams received from other locations. According to him, the table used by Morize could not have any relationship to the storm, since the majority of the locations listed – with the exception of Rio Grande – were situated "outside the storm zone" in Brazil. On the contrary, the variations in atmospheric pressure and temperature at the stations he analyzed, during the days preceding the storm, had been a sufficient indication of its approach to the region affected. For Pinheiro the storm had crossed the interior of the Brazilian territory, moving from the Andes towards the Atlantic (Revista do Instituto Polytechnico Brazileiro, 1890, p. 34).

5. Conclusion

The Central Meteorological Office (*Repartição Central Meteorológica*) was finally founded in April 1888, with decree n. 9916, made by the ruling princess. Among its attributions were not only the supply of "meteorological warnings to the ports and agriculture," but also "the study of atmospheric movements, the organization of observatories and meteorological and magnetic stations [along the coast and inland], the nomination of provincial and district commissions, and the publication of its works and studies on meteorology in general and climatology" (Decreto n. 9916, 1888).

As frequently occurs with scientific controversies, the dispute over the path of the *Rio-Apa* storm was closed without being resolved (Martin & Richards, 1995). Similar to the controversy about the 'absolute meridian', it should be understood in relation to the struggle of Morize and Pinheiro for the monopoly of scientific authority on meteorological issues (Bourdieu, 1983). At first, given the popular commotion provoked by the media coverage of the tragic shipwreck, and the fragility of the government and the regime, the utilitarian project of the 'polytechnicians' managed to be imposed on the plan of scientific work idealized by Cruls and his team. Nonetheless, when the new century began the Navy's meteorological network was still limited to seventeen stations. Only some years later did Morize, then the Observatory director, officially speak about the institution founded in the heat of that moment. In his opinion, the initiative of the imperial government had hindered all further development of meteorology in Brazil.

> On the same occasion, instead of concentrating all their efforts to develop that which was already established, and with little aid, overcoming the initial difficulties, could have given Brazil the meteorological network that it still needs today, the Government created in 1887 a new division subordinated to the Ministry of the Navy and intended to manage and concentrate all meteorological observations [...] This inopportune diversion had no practical result, and [...] the meteorological organization of Brazil was never manifested from paper to reality (Morize, 1903, p. 21).

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What is a storm: severe weather and public life in Britain in January 1928

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1. Introduction

At 1 a.m. on Saturday the 7th of January 1928 a depression in the North Sea sent a storm surge through the heart of London. Flood defences were breached and rapid flooding of homes and businesses followed, leaving hundreds of families homeless and penniless. Fourteen people died. Despite the relatively low fatality rate the flooding became a major topic of discussion for many years, with several inquiries into the event. An official narrative of the event was soon formulated, using a scientific and 'natural' causality model that emphasised the exceptional character of the event and de-emphasised the responsibility of the establishment. However, the official establishment narrative was continually contested by different actors, who argued the event also had social causes. The establishment narrators had to defend themselves again and again, and the narrative of the event did not so much settle as fizzle out in the Second World War.

At any given time since antiquity a multiplicity of causes of extreme weather have been discussed, with different interests being served by different causal narratives (Anderson, 2005; Fleming, 1990; Golinski, 2003; Hamblyn, 2005; Jankovic, 2000; Taub, 2003). Definitions and understandings of causality have also varied across time (Haskell, 1977; Kern, 2004). This essay discusses the construction and contestation of the multiplicity of causal narratives about the 1928 surge and the implications of this. Different conceptions of causality have different implications for issues such as justice and blame. When a disaster takes place, blame is as a rule apportioned afterwards. By studying this apportioning of blame, disasters reveal the workings of power (Douglas, 1992, pp. 76-78).

The storm surge flooding was the climax of a succession of extreme weather events. As *The Times* put it "[o]ne meteorological freak has lately pursued another" (Times, 1928x). A cold spell affected England for a week in mid-December 1927, then followed by an ice storm. Between Christmas and New Year a severe snowstorm affected the south of England, including London (Douglas, 1928). Thaw and flooding followed, with nearly twice the average rainfall in London and Surrey during the first week of 1928 (Mirrlees, 1928). By Friday, the 6th of January, the inland flooding was easing in most places (Times, 1928z). Meteorologists were forecasting an intense depression in the North Sea to deepen and move east-south-east, expecting it to produce severe gales and precipitation in England for at least two days (Times, 1928ab, 1928d). That it would cause an unusually high tide and flooding was not predicted.

However, the storm tide (the combination of surge and astronomical tide) did indeed cause flooding. The depression initially crossed north of Britain, then veered south along the British coast only to then again change direction towards the continent. The depression caused gale force winds in the east and south east of England until early evening on Friday, as well as creating what we would call a storm surge – then called an 'abnormal' or 'extraordinary' tide – at the same time as springtides. "Shortly after midnight on January 7th, an abnormal rise of the Thames occurred, the tidal reaches of the river attaining the highest level for at least fifty years" (Mirrlees, 1928, p. 17).

Flood defences were not designed to withstand a tide of this 'abnormal' height and were overtopped and broken through in several places, with water flowing fast into basement rooms near to the Thames where many were sleeping and fourteen drowned. The flood defences were designed for a maximum tide of 18 feet, based on earlier tidal flooding. The tide in 1928 exceeded the previous record from 1881 by 11 inches, reaching well above 18 feet. The surge (the difference between the actual and predicted height of the tide) was 5 feet 10 inches at London Bridge (Gibbon, 1928). A surge of this height was shown to be "quite common" though they only caused extraordinary tides when combined with spring tides (Doodson & Dines, 1929, p. 4). There was flooding in the City, Westminster, Southwark and less central areas, including Putney and Hammersmith (Mirrlees, 1928).

Of the fourteen who died most were young and female and all were trapped in basement flats (Times, 1928h). Ten lived in a crowded working class area in Westminster, between Lambeth Bridge and Vauxhall Bridge. The embankment wall there had been breached in two locations and rapid flooding had affected streets up to 500 yards inland (Observer, 1928a, 1928c, 1928d). Outside Westminster, flood defences had also been overcome and many houses, playing fields and gardens were flooded. Two domestic servants were drowned in Hammersmith and two cousins in Putney. Thousands of homes were damaged and there was much material damage (Daily Mirror, 1928f).

Overall, little warning had been given, apart from that given spontaneously by police and neighbours. Similarly, the immediate rescue and relief operation seems to have been organised spontaneously (Times, 1928c). However, by the morning after the flooding large scale aid was being organised. Food, clothing and blankets were being distributed by local authorities and charities (Guardian, 1928l; Times, 1928h). An important part of the immediate relief effort was the setting up of charity funds by political leaders in the affected areas, such as the Lord Mayor of London and the Mayors of the boroughs. Donations came from all parts of society, including the King and Queen (Guardian, 1928e; Mirror, 1928f; Times, 1928h, p. 14). Emergency repairs were conducted on the embankments, which were patrolled by police at high tides (Daily Mirror, 1928e; Times, 1928p). Both anxious local residents and sightseers watched the high tides, making them into a spectacle, though there was "little to provide excitement" (Times, 1928p). In addition, the damaged houses became a tourist attraction (Guardian, 1928l; Daily Mirror, 1928e; Times, 1928p).

Political inquiries were immediately demanded by Members of Parliament, with Labour being critical of the behaviour of authorities. They wanted London County Council's (LCC's) role in the upkeep of embankments investigated (Times, 1928g, 1928m). In response to these demands, the Prime Minister Stanley Baldwin issued invitations less than a week after the event to a 'conference' of national and local government and other authorities within the LCC area (Times, 1928o). The Prime Minister side-stepped the critique of the authorities from Labour and others, by emphasising future prevention: "The object of the conference is not to discuss the responsibility for the incidents of last week-end, but to consider steps that should prevent a recurrence" (Times, 1928o). This conference quickly led to the setting up of a warning system and further scientific inquiries by tidal scientists and meteorologists (Doodson & Dines, 1929; Gibbon, 1928). However, this initial inquiry was followed by several more inquiries by various bodies over several years. They eventually led to an increase in the height of flood defences and demands for a unified Thames authority for flood defence (Guardian, 1933; Hart, 1933; Daily Mirror, 1930; Times, 1930a, 1930b).

In terms of legal responsibility, there was a lack of central authority for the prevention of flooding in London. The riparian owner had a duty to keep flood defences repaired and they in turn were controlled by a range of bodies (Times, 1928m). The 1879 Thames River Prevention of Floods Act set out some of the controls in London. According to this Act LCC had a duty to ensure that surveys and repairs were carried out on flood defences "whenever it is made known" to them that a bank was out of repair or not an efficient flood defence (Metropolis Management Amendment Act, 1879, paragraph 24). Formally, there was no duty to inspect regularly and the wording of the Act allowed LCC to avoid charges of blame (Times, 1928w), though the 1928 event also led to them being given formal duty to inspect continuously (Local Government Act, 1929).

2. Causality

If this event happened today, it would be said to be caused by "severe meteorological conditions, which produce abnormally high sea levels, known as storm surges" (Smith & Ward, 1998, p. 148). More functionally, surges are defined as "the difference in elevation between the observed and predicted tide" (Smith & Ward, 1998, p. 148). Surges are formed when "the atmosphere forces the water body, which responds by generating oscillations of the water level with various frequencies and amplitudes" (Gönnert et al., 2001, p. 7). In addition the decreased atmospheric pressure has a small impact on the rise in the sea level (Smith & Ward, 1998). Such an oscillation is then transported by the wind until it comes into contact with a coast. The southern North Sea is vulnerable to storm surges due to its semi-enclosed funnel shape which intensifies the height of the surge. They have been experienced over many centuries and have regularly caused catastrophe and hardship, sometimes leading to the loss of land or thousands of lives (Smith & Ward, 1998). In short, storm surges are a regularly occurring hazard in Britain. Though rare, and perhaps to some degree increasing in severity due to land subsidence (Meteorological Office, 2008), they are not truly exceptional events.

But how was the event explained in 1928? How were the causes of it represented in the media?

The scientific narrative of causes of the high tide in 1928 was similar to modern explanations of flood surges to the extent that the main cause was seen as the windstorm. The term 'surge' only gradually came into use as part of the scientific investigations. An example of the scientific narrative is the *Meteorological Magazine's* roundup of the event, published in February 1928. It explains the flooding as a result of a coincidence between a spring tide and high winds from the northwest in the North Sea, with a minor influence from land water (Mirrlees, 1928, pp. 17-18).

As Ted Steinberg points out, seeing a disaster as 'natural' often serves the interests of the establishment – those currently in power and those aligned to them, e.g. media (Steinberg, 2006, pp. xx-xxii). In 1928 the establishment actors – central, regional and local government, including organisations such as the Thames Conservancy and the Port of London Authority, and conservative media – extensively used the scientific narrative of the 'natural' causes of the high tide when narrating the event. This aspect of the establishment narrative is well summarised by the Ministry of Health Conference statement:

> [M]ore cannot be said in explanation of the tide of January 6-7 than that it was due to the combination of the following causes:
>
> (a) The spring tide [...]
>
> (b) The raising of the water in the estuary by meteorological conditions in the North Sea [...]
>
> (c) Flood waters in the Upper Thames (Times, 1928y).

In addition, the establishment actors presented the event as wholly exceptional and unprecedented. If the event was exceptional, it would have been impossible to predict and to prepare for, which implied that the preparation made by the authorities had been appropriate – they had done all they could have known it was necessary to do. In this form the establishment narrative therefore protected the establishment from blame. In its first editorial after the event *The Times* defines the event as unparalleled: "a calamity which has otherwise no parallel in living memory" (Times, 1928b). In its initial report to the press the Ministry of Health Conference repeatedly called the event unprecedented. The difference between the previous record tide and the one in 1928 was used to support this:

> That a record which has stood so long and which was only three inches in advance of the next highest should suddenly be exceeded by a whole foot clearly points to the fact that there must have been on this occasion a most unfortunate and probably unique combination of adverse circumstances outside previous experience and beyond human foresight (Times, 1928v).

Mike Davis has found a similar emphasis on exceptionality in the press and official accounts of tornadoes in Los Angeles (Davis, 1998, p. 132).

An establishment narrative of the causes of the catastrophe was thus created fairly quickly. The establishment narrative emphasised, or framed, the catastrophe as natural, exceptional and unpreventable (de Vreese, 2005). Framing the event like this in turn made it difficult to lay responsibility onto humans, i.e. the establishment, and to see how social systemic causes were implicated in the disaster. The establishment narrative was immediately contested from many angles both by those who did not agree with the official scientific explanation and, more strongly, by those, such as *The Observer* and *The Guardian,* who wished to lay responsibility on humans and to use the event as a social lesson, especially for the Conservative Government.

Even in *The Times* the establishment narrative was contested. Alternative causal narratives of the high tide were presented (Times, 1928l, 1928q). *The Times* itself also pressed the role of land-use planning (Times, 1928b). In opposition to the many statements claiming this was a unique, exceptional event without precedent *The Times* also published articles and letters to the editor outlining previous floods (e.g. Times, 1928i, 1928o, 1928s). Indeed, a later editorial admitted that high tides often follow certain gales, but still called the event "unprecedented." This editorial continued to argue that part of the flooding problems was due to increased development in flood prone areas. It argued against lack of drainage as a cause of floods in London, indeed claiming increased drainage would increase floods (Times, 1928x).

Elsewhere the establishment narrative was more radically contested, with many causes of the high tide and flooding suggested in other media. The *Daily Mirror* concentrated on the impact of the event, but reported both the official causal narrative from the Port of London Authority and the more controversial idea presented by Lord Desborough, chair of the Thames Conservancy, of a tidal bore "rushing in from the North Sea" (Daily Mirror, 1928b, 1928c). These statements were also published by other papers (Guardian, 1928a, 1928c; Times, 1928i, 1928l). In an editorial the *Daily Mirror* debunks Lord Desborough's statement by pointing to the lack of warning as a key cause of the disaster (Daily Mirror, 1928j). *The Observer*, published the day after the event, similarly concentrates on social aspects of the event and blames the flooding on a lack of drainage: "If the Thames has developed a menace unknown for more than a century, it is because our national system of land drainage has fallen reproachfully in arrear, and overbearing flood is the inevitable penalty" (Observer, 1928i). *The Guardian* also identified lack of drainage as a root cause (Guardian, 1928g, 1928j). In both papers the implication is that the Conservative Government had not done enough to deal with the supposed lack of drainage. Neither mentions the storm as a causal factor. Both however, report on flooding along the East Coast caused by a "tidal wave" and "one of the highest [tides] within living memory" without connecting this to the situation in London (Guardian, 1928i; Observer, 1928b). *The Guardian* later emphasised housing conditions, discussing an "abnormal housing shortage," instead of an abnormal tide (Guardian, 1928k, 1928m).

That the event's exceptionality exonerated the authorities was quickly contested. The *Daily Mirror* printed an editorial just two days after the event analysing the effect of calling the flood exceptional in allowing the authorities to avoid blame: "according to themselves, the authorities are to be excused – because 'no record exists' of conditions like these." Despite "a common British delusion that our climate [...] is, on the whole, equable, mild, and, as we may say, 'normal' [...] we *seem* always to be grappling amateurishly with weather alleged to be *exceptional*" (Daily Mirror, 1928h; emphasis in original). The paper not only contests the establishment narrative of the current event but more generally the definition of normal weather.

3. Coroner's inquests

An example of how the different narratives of the event were contested and constructed is provided by the three coroners' inquests. I will compare how the event was framed by the three coroners in Westminster, Hammersmith and Fulham. They each framed the causes of the event differently, with consequences for the issues they investigated and how the issue of responsibility was understood.

3.1 Westminster

The coroners' inquests into the deaths in Westminster and Hammersmith were opened on Tuesday the 10th of January. At Westminster the coroner Mr Ingleby Oddie immediately raised the responsibility for the collapse of the walls, seeing the flood as much a social as a natural event (Guardian, 1928b; Times, 1928k). For him the flooding had social causes, and what is more, he claimed these causes were straightforward: "[A] Westminster jury will be a very appropriate tribunal for dealing with questions of this kind, which are not, after all, of a very complicated character" (Guardian, 1928b).

The inquest was re-opened on the nineteenth of January with representatives from various governmental bodies giving evidence. The ownership of the sections that had been breached was contentious, which mattered as it was the owner who was responsible for upkeep of flood defences. Inspections of the defences were also discussed. In the end, the Coroner used the argument of exceptionality to claim no blame could be given:

> [I]n view of the synchronization of three very exceptional sets of conditions, it would not be reasonable to attach blame to anybody [...] it was quite plain that the Council had made it a practice, whether it was their duty or not, to inspect the walls. That was the kind of conduct one would expect (Times, 1928w).

The coroner pulls back somewhat from looking at social causes to the deaths. On the other hand, though the jury returned a verdict of accidental death, they raised the issue of responsibility: "The jury are not satisfied that sufficient attention has been given to the safety of certain sections of the wall" (Times, 1928w).

The jury does what the coroner has shied away from by pointing to social causes of the event, even though they gave the verdict of accidental death. They identified potential systemic causes due to the political establishment. Their framing of the event, provided at least in part by the coroner's initial remarks, included social causes, enabling them to see these.

3.2 Hammersmith

At Hammersmith, where two people died, the coroner framed the event very differently, as due to God or Nature, whose forces cannot be resisted. He links this to there being no issues of blame or responsibility to investigate.

> I am not in the position [...] to lay before you the responsibility of any local, municipal, or county authority in this matter [...] Certainly the works of man in face of the strength of God and nature are nothing but futile (Guardian, 1928b).

By framing the event as divine or natural this coroner rejects the possible socio-political causes the coroner in Westminster wished to investigate.

Evidence was later given by the chief engineer at LCC who stated that the relevant breaches were in privately owned walls. All the work on these walls requested by LCC had been carried out (Times, 1928w). The coroner again de-emphasised social causes for the flooding by framing it as exceptional:

> [The Coroner stated that] such a flood has not occurred within the last hundred years, and it was due to adverse circumstances which were almost beyond the foresight of man to prophesy would occur [...] what had happened obviously was in the nature of an accident. He did not see how any local authority or the LCC could be blamed for what was an unprecedented bursting of the Thames (Guardian, 1928f).

The jury again gave a verdict of accidental death, but in Hammersmith they found no blame. As Arthur McEvoy has pointed out, using the term 'accident' implies randomness as against something with a cause (1995). Different people at different times and under different circumstances will be able to perceive different causal relationships and this will serve different interests. At Hammersmith social causes were outside the frame and could not be perceived.

3.3 Fulham

In Fulham the key narrative was a retelling of the two heroic rescues carried out by Miss Irene Franckeiss and her neighbour. All involved were commended and the jury said "they did all they could have done as human beings" (Times, 1928f). At Fulham the coroner framed the event as natural and inevitable – it was not possible to defend against natural and divine forces. However, he thought the muddled legal situation was unsatisfactory, setting up a sharp distinction between natural and social aspects of the event:

> The London County Council have requested me to adjourn this inquest in order that they may go into the question of legal responsibility of parties. I do not know

> what they will get at, I am sure. You cannot keep a tidal wave from the North Sea from coming up. Any defences of man against the forces of God and nature are puny and nothing, and may be broken down at any time. But we ought to know whose is the legal responsibility for the safeguarding of the banks of the Thames (Guardian, 1928d).

The inquest was resumed on the 25th of January; again with the chief engineer of LCC stating that the wall that had failed was privately owned but had been maintained as requested (Times, 1928t). The coroner raised certain social causes but insisted that the authorities could not be blamed. He assigned a mix of personal and corporate or semi-public responsibility:

> The question is, "Why did that telephone fail?" I want to know [...] No blame could be attached to any public bodies so far as the evidence went. Personally [I] would not live within half a mile from the edge of the river. Why people should choose to live practically on the edge of the river, [I can] not understand. For private residential dwellings to be built within a few feet of the river seem[s] a most extraordinary thing (Guardian, 1928n).

He lays some responsibility for the event on individuals choosing to live close to the river, ignoring the economic forces involved in the issue, and also on corporate or semi-public bodies, such as the telephone companies and house builders. While these are social causes of the deaths, he does not seem to perceive the systemic socio-political issues related to the event, which are outside his framing of the event as caused by natural or divine forces. The jury returned a verdict of accidental death, though the foreman of the jury stated that the height of the walls should be raised (Times, 1928t). The jury only suggested improvements and did not lay blame on the authorities.

How 1928 was framed in these coroners' inquests mattered – if the event was framed as an exceptional consequence of natural or divine forces that could not be defended against it was difficult if not impossible to attribute blame to the authorities. Legal investigations into responsibility for flood defences were by definition outside this frame, as the event could not have been forecast and thus not prepared for. In order to consider issues of official responsibility it was necessary to frame the event as having social and systemic causes.

4. Conclusion

After the coroners' inquests both the contestation and definition of the establishment's narrative continued. While some of the more scientific aspects of the debates settled, the social and political aspects continued to be debated for many years. The authorities defended their actions as sufficient using the establishment narrative, while others contested this using different causal narratives. The contestations were accompanied by further research, inquiries and flood defence work, and may in some cases have been crucial for their inception. In early 1936, eight years after the 1928 storm surge, the issue of tidal flood prevention in London was thus still summed up by Law Lord MacMillan as follows: “The dissipation of responsibility among a number of authorities doubtless provides an interesting legal problem, but affords shelter to them rather than to the inhabitants” (Times, 1936).

5. Acknowledgments

I would like to thank the Economic and Social Science Research Council (ESRC) for providing me with funding through a +3 PhD quota award, and also CHSTM for further financial support which enabled me to attend the conference “Weather, local knowledge and everyday life.”

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______. Parliament and the Flood. January 9, pp. 14, 16. 1928m.

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______. Floods in the City. January 7, p. 10. 1928c.

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Natural disaster and environmental coherence: lessons from a storm flood and a hurricane

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1. Introduction

Natural disaster has been neglected by historians for a long time (Borst, 1981). But in recent years interest in natural disaster in history has increased enormously. A large number of research projects, publications, conferences and special issues of scholarly journals have developed around this theme (Lübken, 2004; Gisler et al., 2003; Environment and History, 2003; Johns, 1999). Most of this research has focused on single events at specific times and places. Although it is as yet unclear how and to what extent this research will impact general narratives and interpretations in historiography, it is likely that by looking at many instances interesting insights will be gained.

Cases of natural disaster in history, for example, provide insights into the relationship between cultures and their environment and the changes in that relationship that have occurred over time. Different cultures developed different forms and intensities of attachment to and knowledge about their environment. The degree of such attachment and knowledge may be called 'environmental coherence'. Cultures gain knowledge from environmental experience and develop practices to cope with and adapt to environmental conditions. Cultures, on the other hand, transform their environment in order to adapt it to cultural needs. On one side, environmental coherence depends on environmental conditions and change, such as weather, climate, topography and ecology. On the other side it depends on cultural practices, such as the emergence and use of technologies and social institutions as well as the development of experience and knowledge, beliefs and ideologies, traditions and norms, collective rituals and memories.

In this paper I will investigate two cases of natural disaster, a storm flood on an island close to what is today the Nordfrisian coast in northern Germany and a hurricane in Florida in the U.S.A., in order to explore aspects of environmental coherence, which these cases may reveal. I am aware of the fact that the concept 'environmental coherence' as yet lacks clarity and definition, and the hope is that this exploratory study can be a first test of the following idea – different cases of natural disaster in history may provide interesting information on the relation of human cultures and their environment and so on environmental coherence (or incoherence). The investigation of environmental coherence, on the other hand, may be a useful approach to link the results of investigations into individual natural disasters in a more encompassing and coherent historical narrative.

2. The ruin of Strand

My first example is dedicated to the island of Strand situated off the eastern North Sea coast in northern Germany. [1] October 1634 started nice and sunny on the island of Strand with a long period of calm weather. The people of Strand celebrated the completion of the construction of a strong dike surrounding the whole island and separating several parts of it, the result of several years of hard work and drudgery for many of the islanders. On Saturday 11 October in the afternoon, however, the wind came up bringing an end to the spell of calm weather. By the evening the wind became stronger and it went on to develop into a remarkable storm. Wind gusts were so long lasting and powerful that the so-called *Deichvogts* (dike reeves) called their men – farmers and workers on the island – to the dikes. The rising tide of the North Sea had to be watched and the workers needed to be ready to repair the dike if it should break. Many families left their homesteads in fear and made their way through the dark stormy night to the larger houses of their landlords or to churches which were positioned on higher dwelling mounds. It was common practice to gather where it was considered to be safest.

This night, however, proved disastrous. The storm turned from southwest to northwest and pushed the waters high on the tidelands, the so-called *Watt*, which surrounded the island. The combination of the vigorous storm and a new moon caused a dangerous springtide increasing the height of the water enormously. The dike must have broken in the northwest of the island before midnight. But with little equipment and manpower and little light there was no chance to detect and repair the damaged dike. After further breaches in the east of the island, the island was not only flooded, but a strong stream of water took houses, men, cattle, and a considerable share of the fertile soil away. At 44 sites the dike was broken in the course of the night. The tide reached a height as never before seen and flooded the major part of the land, at some places by more than four meters (Hinrichs, 1985, p. 84, footnote 3).

More than 1,300 houses and 28 windmills were lost. All 21 churches suffered heavy damages. Almost the whole of the year's harvest was destroyed. More than 6,000 people on the island lost their lives, which accounted for around three quarters of the total population. So did an estimated 50,000 cows, sheep and pigs (Riecken, 1985, p. 41, footnote 3). As much of the land was below sea-level, the water did not even flow off. It remained. A renovation of the dikes and reclamation of the lost land failed due to a lack of everything: manpower, money, equipment, food. The island of Strand was lost forever. Only three smaller islands – Pellworm, Nordstrand and Nordstrandischmoor – remained.

2.1 Disasters are God's will

Life in the marshlands on the North Sea coast proved to be perilous (Allemeyer, 2006; Rieken, 2005). Many settlements have been destroyed in storm floods. Over the last 5,000 years, storm floods have occurred in many years, and major floods have been recorded about three to five times a century. These storm floods changed the coastline considerably, and also almost every generation was affected by at least one heavy flood

(1) This case study is mainly based on Hinrichs et al., 1985.

(Petersen & Rohde, 1977; Jakubowski-Tiessen, 2000; Meier, 2005; Behre, 1999).

Until well into the eighteenth century, these floods were seen as a sign of God who expressed his dissatisfaction with the sinful life of humankind. Death and suffering represented divine admonishment and punishment. Great floods with heavy damage and losses of life became known as *landverderbliche Sündfluten* (land ruining sin floods). God was described either as an angry God, enraged by the sins of humankind, or as a caring God, who wanted to guide humankind to a godly, pious and humble life. While technical causes like damaged or neglected dikes were considered and discussed in law suits, the primary cause of disaster, the will of God, was not questioned (Jakubowski-Tiessen, 2003, 2002; Wade, 1995).

Inhabitants along the North Sea coast were well acquainted to violent storms and storm floods. Over centuries subsequent generations of inhabitants developed knowledge, practices and traditions to cope with the risk of disaster. Of particular importance was dike building and dike maintenance which ranked very high in the organisation of communal life. Complex codes controlling the rights and plights of dike building and maintenance had developed over time and assured dike building as well as the resolution of conflicts about the share of burden. Houses were built on dwelling mounts (if the house builder could afford it), and in cases of violent storms with a high risk of flooding, it was a common habit for the area's inhabitants to gather at these estates.

Rituals and practices were also adapted to the danger of storm floods. When a storm flood occurred, the shocked people prayed to God, undertook religious processions, worshipped saints, collected sacred items and visited sanctuaries and churches. The betterment of humankind was preached and claimed. For the cause of disaster, the perpetrator was believed to be the behaviour of man. Putting the guilt on the people living along the coast served an important purpose. It ensured that the people felt responsible for their own safety. The inhabitants of the coast were not at the mercy of an unknown, unpredictable and unreachable force. It was them who could control the future by an honest and godly way of life. Furthermore, this belief provided confidence that disasters could be controlled and did not have to be as devastating and deadly as the flood of 1634 (Rieken, 2005, pp. 281-283, footnote 6). This was the moral legacy of premodern knowledge and belief.

3. Miami Beach

Now I will jump a few centuries forward and a big ocean westward to the American state of Florida. In the twentieth century, Miami Beach became one of the most well-known resorts for well-to-do Americans. [2] At the beginning of the century, however, Miami Beach as well as large parts of southern Florida consisted of swamps and marshland full of red mangroves, mosquitoes and alligators. The state changed fundamentally within only a few years. It was the railroad magnate Henry Flagler who helped to clear the way

(2) This case is mainly based on Steinberg, 2000 and 1997.

for human occupation of the land. In the late nineteenth century he constructed a railroad from Jacksonville in the North of Florida to Miami, and in 1905 even to Key West in the far south. The building of this latter railroad was a daring enterprise and took seven years. It cost some twenty-million dollars and employed as many as 40,000 workers. During construction three hurricanes hit the area in 1906, 1909 and 1910. Heavy winds caused surges to flood the low lying keys. The hurricanes killed 700 workers, demonstrating the riskiness of the business that Flagler insisted to carry on (Barnes, 1998, pp. 85-97; Steinberg, 2000, p. 66, footnote 10).

What became Miami Beach was at that time a slim strip of sand off the coast line, 200 feet wide and adjacent to a swamp of mangroves filling up Biscayne Bay. In 1910 the automobile magnate Carl Fisher purchased 200 acres of sand on this land and systematically developed it for tourism (Carson, 1955, pp. 10-15).

> He financed the clearing away of 1,000 acres of Mangroves from Biscayne Bay in 1913.
>
> He engaged in building the Dixie Highway, a network of highways from upper Michigan to southern Florida, ideally suited to carry the automobilists to a new paradise for tourism.
>
> Fisher was well aware of the potential value of waterfront property. In 1917 he pursued a plan to create artificial islands in the Biscayne Bay. He purchased bay bottom from the state, erected bulkheads and pumped sand into the bay to create Star Island.
>
> Later, he helped to construct a road crossing the Biscaya Bay (today called the McArthur Causeway).

Being easily reachable by car, situated amidst the Biscayne Bay with nice views of Miami and Miami Beach, Star Island became valuable real estate that could be sold at a good profit. In the early 1920s land speculators flooded Biscayne Bay, built bulkheads and filled sand to create many more artificial islands. These islands were given Italian-sounding names like San Marco, San Marino, Di Lido, Rivo Alto and consequently became well-known as the Venetian Islands. By 1931 twenty-four square kilometres of artificial land had risen out of Biscayne Bay. The total property value in Miami Beach increased from 250 thousand dollars in 1915 to 44 million dollars a decade later. By 1926, Miami Beach had 50 hotels, nearly 200 apartment blocks and over 800 private homes (George, 1996).

3.1 The Great Miami Hurricane

On September 11, 1926, weather services recorded a tropical wave in the southern Caribbean Sea (Barnes, 1998, p. 111, footnote 11; Pfost, 2003; Mitchell, 1926). The system moved quickly westward and intensified to hurricane strength as it moved to the north of Puerto Rico on September 15. Winds were reported to be nearly 240 km/h as the hurricane passed through the Bahamas on September 17. Little in the way of meteorological information on the approaching hurricane was available to the Weather Bureau in Miami. As a result, hurricane warnings were not issued until midnight on

September 18, two hours before the storm crashed into Miami Beach at about 2:00 a.m. on September 19. At 3:00 a.m., telephone services in Miami stopped, because telephone wires and poles had been blown down. The wind velocity continued to increase steadily until 5:00 a.m., when it reached a maximum of about 180 km/h. After 6:10 a.m. there was an abrupt decrease in the wind velocity. At 6:30 a.m. it had fallen to 16 km/h. The centre of the storm, the eye of the hurricane, had reached Miami.

Many casualties resulted because people ventured outdoors during the half-hour lull in the storm as the eye passed overhead. Residents of the city, unfamiliar with hurricanes, thought the storm was over and left their places of refuge and went out into the city streets. People even began returning to the mainland from Miami Beach. But the worst part of the hurricane was only about to arrive. During the hurricane's second half, winds reached 200 km/h. The wind just washed people from the bridges. Parts of Haulover Bridge in the northern part of the barrier islands were torn away. The onshore south-easterly winds in the second part of the hurricane resulted in a 3 meter high storm surge which crashed onto Miami Beach and the barrier islands and flooded them totally. A 4.5 meter high surge flooded Coconut Grove, an area on the mainland just south of downtown Miami. The water front of Miami was flooded for two to three blocks back from the bay.

The 'Big Blow', as the Great Miami Hurricane was also called, caused enormous damage. Cars were overthrown, roofs torn from buildings, houses shattered, and boats and ships thrown onto the land. Miami Beach was devastated. A Red Cross report listed 373 deaths and 6,381 injured; 4,725 homes were destroyed, 9,100 damaged and 25,000 people remained without shelter after the storm. Damages in 1926 dollars were estimated at 105 million dollars, which is the equivalent to more than 100 billion dollars today (Barnes, 1998, p. 126, footnote 12).

3.2 Narratives of catastrophe

Apparently, there was little sense of alarm in Florida. Most of the 200,000 people living in the storm's path were new to Florida, some lured there by the easy money of the land boom, others mostly poor black people seeking work in this prosperous region. Having never seen a hurricane, they had little knowledge of a storm's destructive force. Storms, at that time, were in principle known, but completely neglected. Of course, Miami was situated in a region where tropical storms and hurricanes, which developed in the Caribbean Sea and travelled to the north-west, were a regular occurrence.

But hurricanes were not part of a common memory of Floridians, not part of the experience of fathers and mothers. Hurricanes were but a distant piece of abstract knowledge, systematically suppressed from public awareness. The last major hurricane had hit Florida in 1910. At this time Miami had a population of about 5,500. By 1920, the population of Miami had swelled to nearly 30,000; by 1925 to more than 100,000. Furthermore, real estate developers did their best to conceal any risk (if they were aware of it). The place was advertised to tourists as well as investors as secure and free from fatal storms. From the businessmen's perspective Miami Beach was a warm and sunny paradise with white beautiful beaches and a calm and clear turquoise sea.

The historian Theodore Steinberg has described how disaster in Miami was received. The hurricane was the worst of advertisements Florida's boosters could expect. The *Miami Herald*, strongly attached to business developers, diligently engaged in downplaying the event. The costs of damages were intentionally underestimated by a factor of ten. "Miami is not in ruins," the paper wrote. "Miami will be her smiling self again within short time." The article was illustrated with a cartoon, titled "The wind that does the most damage." It was not the storm, according to the paper; it was the rumours and exaggerations that did the most damage to Miami. Others blamed a distant God or a capricious, unpredictable nature, both beyond human reach and responsibility (Steinberg, 2000, pp. 54-61, footnote 10).

Steinberg, in contrast, told a different story. According to his investigations, real estate development was knowingly started on an extremely unstable piece of land. Both, state officials and businessmen consciously downplayed impending risks in order not to hamper economic development. Building codes did practically not exist. Houses were not constructed so as to provide protection against hurricanes. An effective warning system, evacuation plans, flood control measures and the like did not exist. Indeed, they were not allowed to exist, because such measures would have confirmed the existence of a risk. Steinberg concluded contrary to contemporary appraisals that the Great Miami Hurricane was not a 'natural' disaster: it was 'human-made' (Steinberg, 2000, pp.66-68).

4. Natural disaster and historiography

Obviously, the cases presented provide contrasting impressions. The people on the island of Strand had created a human habitat with moderate technological intervention compared to real estate developers in Florida. Their ancestors lived along the North Sea coast for many centuries, while Floridians had just arrived. They transformed their landscape with their hands, shovels and horse carts, while Floridians used powerful heavy machinery. They drained land, built mounds and dikes, while Floridians created whole new islands.

Also mentalities obviously differed fundamentally. While the people of Strand had to live in a kind of respectfulness of nature and God, which subdued them regularly, Floridian developers self-confidently reshaped their environment and didn't bother at all about deadly waters surrounding them. Finally, the moral implications of catastrophe differed greatly. The people on Strand believed in divine admonition, so humans were seen as the perpetrators of disasters due to their lapses, and nature became victim. People in Florida argued with reversed causality. Nature had turned the perpetrator, while the victim was man.

Mikael Hård and Andrew Jamison have described the modern mindset as a narrowing of perspective. The rise of scientific and technological knowledge since the sixteenth and seventeenth century has encompassed a deprivation of the moral content of knowledge

(Hård & Jamison, 2005). The case studies presented suggest that it also encompassed a deprivation of environmental coherence. Environmental coherence was affected by scientific and technological change. Technological potency greatly increased the degree of interference in the environment. It enabled the creation of technological landscapes that led to a loosening of the connection between humans and the processes occurring in their environment.

Technology, however, is only part of the explanation. Sets of beliefs and mentality provide another clue to understanding differences in environmental coherence. While the people of Strand lived according to personal knowledge and practices deeply embedded in traditions, collective memories and moral convictions of many generations, people in Florida were new to their land, without knowledge, traditions, memories and local experience. Respectfulness towards environmental conditions and the natural forces was an inherent feature of mentality and social organisation along the North Sea coast, while self-confidence and trust in the power of man characterized the developers in Florida. Fear seemed a part of common memory and everyday experience on Strand, while it was deliberately eliminated from Floridian consciousness.

We may conclude that environmental coherence was subject to change in history. Different cultures produced different forms of environmental coherence. Studying the history of natural disaster may therefore prove to be a valuable (though not the only) way in which to come to an understanding of environmental coherence and enrich our understanding of cultural and environmental change.

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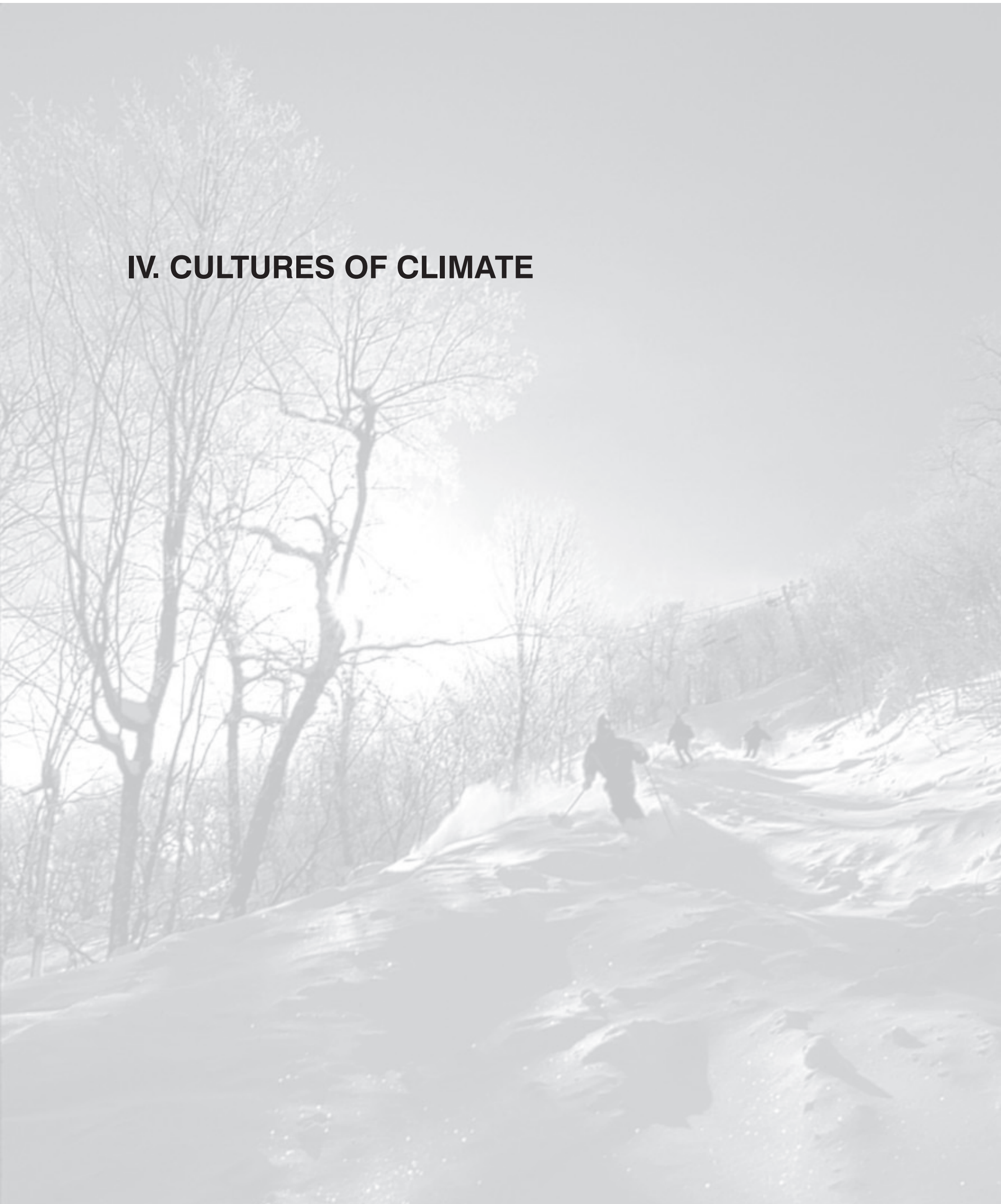
IV. CULTURES OF CLIMATE



Climate and the people of Brazil: observations of nature and the Netherlandish colonization in America (1637-1645)

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1. Introduction

This study is part of the research in which the books about the Natural History of Brazil written by Wilhem Piso and Georg Marcgraf during the period of the Dutch colonization in the territories of Pernambuco, Itamaracá, Paraiba and Rio Grande do Norte (the area that corresponds nowadays to the Brazilian Northeast) were analyzed. Climatic determinism is a strong concept which has lasted for centuries under various forms. A field of knowledge that has contributed towards the persistence of this idea is Medicine itself, especially that one which is a legacy of the tradition present in what are, supposedly, the writings of Hippocrates, and, in particular, the text known as *Air, Waters, and Places* where he defends the intrinsic relationship between health, diseases and environmental conditions. This relationship is not restricted to men's physical conditions, but is also manifest in the intellectual potentialities of the enormous range of human groups.

Just as relevant is the fact that, as from the late fifteenth century, and especially from the sixteenth century onwards, the accounts concerned with the processes of conquest and occupation by Europeans of the New World were narrated in such a way that more and more pages were dedicated to the description of lands and peoples. Amongst the many categories of writings, or *genre*, Natural History had a noticeable role in providing elements that contributed towards the consolidation of the environmental determinism in Western culture.

The present communication intends to highlight the importance that Natural History and Hippocratic Medicine had as references to the production of knowledge about the New World. Moreover, we shall see how some narratives about the American lands contributed towards the knowledge regarding regional climate particularly in tropical zones. In our view, this knowledge was intertwined with the occupation process and conquest of new territories in many aspects, be it as a justification for colonization or as a reflection on the problem of the Europeans' adaptation to the tropics. Our reflection on this matter shall be supported by the texts of the physician Wilhem Piso and the astronomer Georg Marcgraf concerning the Natural History of Brazil.

One of the greatest legacies of the Netherlandish people is the collection of books that describe their colonizing experience, in particular those that speak of the American nature. In order to analyze the relationship between the knowledge regarding nature and the Netherlandish project of expansion, we shall analyze the book *The Natural History of Brazil (Historia Naturalis Brasiliae)*. The book, published in 1648, is divided in two parts.

The first part, supposedly written by Wilhem Piso, is entitled *Illustrated Natural History of Brazil or História Natural do Brasil Ilustrada (Medicina Brasiliensis)*. The second part, *History of the Natural Things of Brazil* or *História das Coisas Naturais do Brasil (Historiae Rerum Naturalium Brasilium)*, was a result of the work by Georg Marcgraf. Besides this edition, another was published with slight changes and under the title *Natural and Medical History of the Western Indies* or *História Natural e Médica da Índia Ocidental (Indiae utriusque re naturali et medica)*, which includes the work about the Eastern Indies by Doctor Jacob Bontius.

This paper shall be divided into two parts. The first one will explore fragments of the work by Piso who, whilst pondering over the climate in Brazil, reflects upon the possibilities of Europeans' adaptation to the New World. The second one shall explore how some characteristics attributed to the native population by these two authors were seen as a result of the effect of climate over the physical and moral conformation of men.

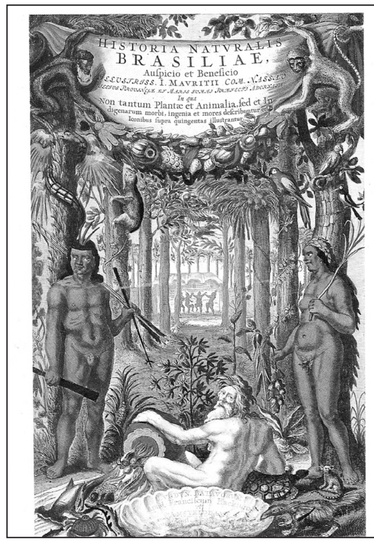

Figure 1: *Historia Naturalis Brasiliae*, 1648.

In this book written by Piso & Marcgraf we can found important information about Brazilian natural resources including in its first part a description of the climate.

2. The problem of adaptation to the Tropics

The problem of Europeans' adaptation to the tropics emerged as a strong concern during the process of colonization in the Modern Era, especially when the occupation of America, amongst other things, became crucial to guarantee the domain over the territory. Under those circumstances the book *Natural and Medical History of the Western Indies* may be considered a tool to facilitate the occupation, as it taught Europeans how to survive in that place without degenerating. The belief that climate and environment could influence men's physical and moral conformation was part of the European cultural tradition, and had its roots in an intellectual tradition that originated in Antiquity with Hippocratic Medicine as one of its models. As early as the days when Piso studied at the University of Leiden, in the Low Countries, Vortius, who was responsible for the Faculty of Medicine, made a translation of the aphorisms by Hippocrates. Since Classic Antiquity, the temperate climate was considered the most suitable for the development of intellectual and physical capacities. This was the basis for the Euro-centrism present in Western culture and still current at that time. To think over the adaptability of men, and European men in particular, to the tropics, an area considered torrid and insalubrious, had always been a concern.

Within the perspective of the work by Wilhem Piso, the concern with collecting information about the place was part of the Hippocratic heritage still present in the seventeenth century, particularly the fluids related to the Humor Theory – blood, phlegm, yellow bile and black bile – that circulated in the human body. One of the factors that could influence humor was the effects of temperature. In fact, moral and physical health was kept through a balance between the environmental temperature and that one of the human body. The belief that climate could have a direct influence over the human being and his intellect sprang from this theory. Diseases, as well as men, varied from place to place depending on the climate. In the opening of the text, Piso cites Hippocrates when referring to how a physician should value all the knowledge he could gather about the place while performing his duties:

> The physician, having been instructed about most of those issues, all of them if possible (the winds, waters, the temperature of the sun, the soil and way of life), and arriving in an unknown town, shall not ignore the local illnesses nor the nature of general diseases. This way, he will not hesitate to prescribe a treatment, nor will he make the mistakes with which he would certainly be confronted had he not studied beforehand those essential questions (Piso, 1948, p. 14).

Up until the Age of the Discoveries, the Torrid Zone was considered inhabitable. Still in the seventeenth century, the tropics were seen as insalubrious places as well as inhospitable. When Piso talks about the local diseases, he considers them to be a result of the hot climate, where degeneration and putrefaction occur at a much faster pace and more frequently, especially for those species that were introduced through the colonization process, men included. Despite recognizing, in some passages, the salubriousness of nature in the tropics and the healthy aspect of the Americans, Piso stated that the Europeans, originated in distinct environments, had to be careful and follow some principles to avoid degenerating. The naturalist's concerns show us how the problem of that 'adaptability' was dealt with during colonization: many of his suggestions aim at guiding the Europeans towards the acquisition of new practices in order to survive in the tropical zone.

According to the lessons by Hippocrates, the first step that a physician should take to be acquainted with the possible forms of life in a different place should be the study of the environmental aspects, the air and the water. According to the Hippocratic way of thinking, the practices and the forms of life of men were related to the environment where they lived. It is no mere coincidence that the habits of indigenous people were at the core of Piso's work, for they revealed the ways through which one should proceed. The medical practice here was not only concerned with the healing processes, but also, with the maintenance of health, only possible through the balance of humors, which were in turn affected by the 'elements' above mentioned. Thus, Piso's book represents a guide to how to live in the tropics:

> Therefore, to the unadvised newcomers who have just arrived to this land, it (the sun) may appear nasty and harmful, and it almost takes away any hope to spend a happy life in these strange lands of the Indies (Piso, 1948, p. 31).

He continued by stating that the torrid zone, contrary to what those of Antiquity used to believe, is habitable, and showing a detailed medical knowledge about the place that could help men, even those who came from a different environment, but could also adapt to the new conditions of life. For that to happen, it was necessary to change habits, including eating habits, and to take some precautions. The choice of the living place was important due to the variation of winds. The house should be built on a high location and facing the sea, thus ensuring the protection against continental winds, which are hot and harmful, and favoring the sea breeze, which is refreshing and good for health.

Still concerned with the winds, the physician advised newcomers to keep the body covered up, both indoors and outdoors, and especially

> the chest area and stomach, since nothing is worst for these parts of the body than the night chill after a hot day. What happens in effect is that once the pores of the skin close, the lingering sweat causes many illnesses. Those, whose sweat is allowed to flow, remain healthy or if they happen to fall ill, they are easily cured (Piso, 1948, p. 56).

As far as baths are concerned, Piso gives instructions on how they should be given. Not so hot that they could cause lethargy, nor so cold as to induce vomiting. Physical exercise and intellectual work should always be done at dawn and sunset, periods which are more suited to mental or physical work, since intensive heat can cause exhaustion with potential harm to the memory.

Eating and drinking habits were themes also present in this first part of the book. Both local products and those introduced through the colonizing process should be ingested correctly. Only knowledge would lead men to an optimum utilization of the qualities of each product from nature. Regular dieting was crucial for the maintenance of health. When referring to foods of vegetable origin, the naturalist would provide information on when to sow the seeds and when to harvest the crop. The eating practices, as can be noticed, had a direct relationship with the environmental conditions. Piso himself suggested that:

> Oranges, lemons [...] mangaba, passion-fruit, melons [...] and any other refreshers, either raw or preserved, should be ingested while fasting [...] for they are good for the heart, and especially when they reach maturity in the hot months [...] One has to be careful not to pick the fruit before it is purified from the nocturnal exhalations by the sun rays (Piso, 1948, p. 59).

In the first section of the book, the naturalist does not investigate the animal and vegetable properties deeply. He only emphasizes that a proper diet could guarantee the balance of humors and consequently men's health, proving to be also of help in the adaptation process to the tropical zone. An orderly life could ensure the adaptability of the European to the torrid zones as it maintained the balance of humors.

This may have been one of the motivations behind Piso's commitment to the detailed study of nature in the newly colonized region. Being well acquainted with the place and conditions of life, the physician was able to positively intervene in the colonization enterprise, ruling over nature itself.

> Until now we talked about the use and misuse of things, so that the inhabitant of this part of the world may know how and by what means he shall protect and preserve good health (Piso, 1948, p. 65).

3. Natural History and the inhabitants of the New World

It is noticeable in Georg Marcgraf's text how he praises the physical aspect of the native population. They are always described as strong, healthy, tall and slim. Quoting Marcgraf, "we can see a big number of old men among them, of a hundred or a hundred and twenty years of age" (Marcgraf, 1942, p. 268). Observing the paintings, we can also notice that they are represented as strong men. But how can we interpret the merit granted to the native population's vigor in the work of this naturalist?

It is worth recalling the references to Aristotle throughout Piso's and Marcgraf's works, not to mention the fact that among the many duties of native Indians in the Brazilian colonial society was that of forced labor and even slavery. As suggested by Antonello Gerbi, "being robust can be stigmatized as predisposition for slavery" (Gerbi, 1996, p. 68). He justifies this stigmatization following Aristotle: "Nature seems to desire to make a distinction between the bodies of free men and those of slaves: the latter are full of vigor so they can take hard work, the former, in contrast skillful and elegant, are unfit for the type of work seen as useful for civil life" (Aristotle, as cited in Gerbi, 1996, p. 68). The Greek philosopher's ideas constituted one of the lines of thought in the seventeenth century world.

The inferiority of the 'Brazilians' (a term used in the seventeenth century referring exclusively to the native population), was acknowledged by Marcgraf when he observed their practices. They were treated as barbarians for they lacked discipline towards work and took great pleasure in drinking, singing and dancing instead.

> Their children are of a docile mood: in fact, as they reach adolescence they become ruder, and few are literate, or able to write, or skillful in any European art which they do not seem able to appreciate [...] Life among them can be tranquil except when they drink, for they then spend many days and nights dancing and singing. They are very susceptible to drunkenness [...] nor can they be kept away from this vice, which they overrate, resulting in disagreements and bad habits.
>
> They are also very susceptible to laziness and avoid work at all costs: especially the Tapuyae who do not tolerate work (Marcgraf, 1942, p. 269).

The American men were docile only during childhood, gradually becoming more and more uncivilized, until they finally degenerated. They never showed any interest for 'European Art'. The unruly way of life of the native population was observed by Marcgraf in relation to other aspects such as having no fixed time to eat, and when eating, behaving in a strange manner, holding the food with their hands and throwing it in their mouths. The drinking habit, or rather, drinking vice, was a recurring topic in the text. Coincidently, Marcgraf described in the chapter nine of his book types of alcoholic drinks made by the ‘Brazilians’, as well as the *Cacitata*, made from the sugar cane by Europeans. After presenting this list, the author added that “men and women spend whole days and nights singing, dancing and drinking” (Marcgraf, 1942, p. 274).

The rudeness of the Indians was described in the work by Piso with the Hippocratic tradition as a reference. According to Hippocrates, immutability in the temperature would result in an “apathetic character” and a type of indolence. Inversely, the sudden changes of seasons would encourage greater physical variety as well as higher intellectual capacity. When explaining the apathy brought about by hot climate that affected men, Piso once again referred to that physician from Antiquity:

> I believe, the same way Hippocrates did, that the reason for this to be is that the same aspect of things and of times that are immutable result on indolence, while variety incites the spirit and the body to work (Piso, 1948, p, 51).

Marcgraf and Piso had no doubts about the European superiority, which in itself would justify the colonizing process of Modern Era. However, it is worth remarking that the inferiority status bestowed upon the native Indians was supported by the scientific arguments of the naturalists. The medical knowledge found in Piso’s practice was a result of an undertaking with the objective to seek and discover the properties of things. “To observe, dissect and go through the interior of things” was the methodology used in this work in order to guide men into the true knowledge about the medical art.

> The inhabitants would have deservingly experienced happiness, had they known the Creator of all things. Yet, to the contrary, under such auspicious skies, their faculties are so rude and misshapen (Piso, 1948, p. 48).

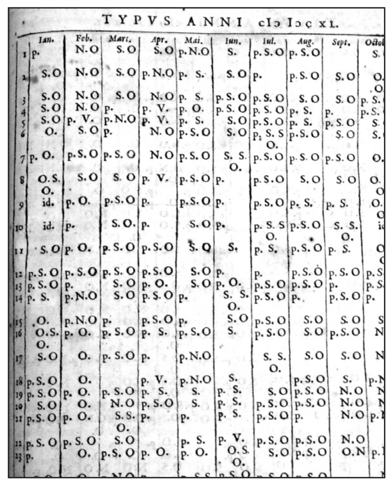

Figure 2: Marcgraf’s meteorological tables for 1640, 1641 and 1642.

The meteorological data consisted of daily observations of the prevailing winds (e.g. SO and NO, meaning respectively SW and NW winds) and rainfall (the letter “P” indicates rain). Information on thunder and lightning is appended to the table. There are no temperature records. One possible reason for that is the characteristic climate of the state of Pernambuco, where rainfall is more significant for defining the seasons than temperature itself, which is quite stable during the year.

Source: Piso, Wilhem. Indiae Utriusque re naturali et medica. Amsterdam: Elzevier. 1658.

Rare Books Division, National Library, Rio de Janeiro.

When compared by the naturalists to Europeans the inhabitants of the New World were turned into beastly beings. The native Indian, within this perspective, was seen as a man degenerated due to the climatic conditions of the tropical zone.

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‘If the Bard was weather-wise’: nineteenth-century British Weather

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In *The Weather,* Kenneth Goldsmith transcribed the weather reports for one year, 2003, from a twenty-four hour all-news New York City radio station, WINS – “Weather on the Ones,” the reports were called, repeated every ten minutes. Entries might read: “It’s a bitterly cold morning out there. That’s nothing new it’s, uh, very similar to the way it was yesterday. We’re in frostbite territory. It going up to twenty-seven, though, this afternoon, some relief, but still, very cold. Tonight, going to twenty in midtown, ten to fourteen in many suburbs. Tomorrow sunshine, temperature inching up toward thirty-two. We have a shot at thirty-four to thirty-six degrees on Sunday before the next cold front arrives. Flurries, or a period of snow late, Sunday or Sunday night into early Monday, and then partly sunny late Monday, high twenty-six. It’s eight degrees, relative humidity fifty-seven percent, winds out of the west northwest at thirteen, gusting to seventeen, the real feel temperature minus eleven, the temperature eight heading to twenty-seven. Repeat, eight heading to twenty-seven.”

Each report is slightly different, all day, all night, always vernacular, local, citing numbers, places such as Central Park, LaGuardia Airport, Islip and Westchester, hesitant, provisional (a chance of this, maybe that, possibly something else), and partial (partly cloudy, partly windy, partly sunny, storms bearing down, departing, by late today, maybe tomorrow), the repeated temperature at the end like the incremental repetition of eighteenth century ballads, like little ballad-dramas, the episodic confrontations, threats, escapes from a weather front, a falling barometer, or defeated, overcome by freezing rain, high winds, nothing changed. If the form has antecedents, it resembles those weather records published in London newspapers and magazines such as the *Gentleman’s,* in the early decades of the nineteenth century, retrospective diagrams of months, locations, rainfall, temperatures, moons and tides, all measured and confirmed, but belated. While one can identify many reasons to have instant weather, current conditions, except for historians of weather such as ourselves, monthly or annual records seem pointless. And yet, even belated, weather information creates community – and numbers make people tick.

In March, 2003, Goldsmith records, after the invasion of Baghdad, “Weather on the Ones” included the battlefront weather reports as well – just as the British in the early nineteenth century became concerned with continental weather during the Napoleonic wars, reporting on it along with the casualties. As in the American Revolution, weather was as much an adversary as the human enemy and for protection, along with their swords, the British officers carried huge umbrellas to protect their colorful and unique uniforms from the rain. So, on March 20, 2003, the first day of spring, the day that the U.S. invaded Baghdad, “Weather on the Ones” reported: “Oh we are looking at, uh, weather, uh, across, uh Iraq obviously here for the next several days, uh, we have, uh actually some good, good weather is expected. They did have a sandstorm here earlier, uh, over the last twelve to twenty-four hours those winds have subsided and will actually continue to subside. Uh, there will be enough of a wind across the southern portion of the country that still may cause some blowing sand tomorrow." And later, "It's going to be overcast, drizzly, with some fog today. We'll have drizzle, rain, and fog tonight and tomorrow, uh, temperature today not going to go up much, it may even drop a couple of degrees, and the lows tonight will be near thirty in the northern and western suburbs, and that means there can be some freezing rain, as well as just rain, high temperatures tomorrow forty-five to fifty, Sunday mostly sunny with a high around fifty. The, uh, battlefield forecast, the heat will peak Saturday, with highs in Baghdad near one hundred, then not as hot Sunday and Monday, but windy at times. Those gusty winds will pick up some sand and dust, and cause areas of reduced visibility. Right now it is forty-one and cloudy in Central Park and our temperature today going up only to forty-three. (My boundless debt to Marjorie Perloff for bringing Goldsmith to my attention and for her entire analysis; Perloff, 2005.)

The characteristics of these recurrent weather reports on radio and TV stations, at least in the Western world, originated in the British and European experience from about 1760 to 1850, the Romantic period, when a few but influential, literate and observant people recorded and disseminated the weather in diaries, letters, and through the new journalism to a large, diverse, anonymous, and distant audience. But it was also recorded in literature and painting, where it has survived – politically inflected, economically based, in the context of human experience.

Then as now, there were sufficient thermometers, barometers, wind gauges, weather maps, and original instruments of all kinds to convert the experience of weather into numbers. But the numbers were not information until they are interpreted, personalized, localized, placed in context. So after the numbers, the weather becomes an independent agent, effects without causes, autonomous, anthropomorphized in pronouns, verbs, most notably in the names applied to hurricanes. And people are altered as well, weather adventurers and sufferers, gathered into weather communities, addressed in collective pronouns and phrases: "you can expect," or "we may see some showers," or "you can feel the cold," he says.

The weather on WINS, like all the others, is built on the subjective and sensational, what the reporters call the "real feel" of weather, or another weather report calls the "wind chill factor," what the temperature feels like against the skin. When artists and poets first encountered actual weather as opposed to textual, they excelled at identifying and conveying the "real feel" of weather, and they may have been the first of these weathermen to do so. Here, an example from John Keats's *The Eve of St. Agnes*, a metrical romance based on a superstition that a virgin would dream of her future husband if, on January 21, she performed rituals before retiring. This sensual, heated, passionate poem is framed by the most frigid imagery in the language, a cold intensified by allusions to the conventionally warm and comfortable:

> St. Agnes' Eve – Ah, bitter chill it was!

The owl, for all his feathers, was a-cold;
The hare limp'd trembling through the frozen grass,
And silent was the flock in woolly fold:
Numb were the Beadsman's fingers, while he told
His rosary, and while his frosted breath,
Like pious incense from a censer old...

Seem'd taking flight for heaven, without a death.
The sculptur'd dead, on each side, seem to freeze,
Emprison'd in black, purgatorial rails:
Knights, ladies, praying in dumb orat'ries,
He passeth by; and his weak spirit fails
To think how they may ache in icy hoods and mails (Keats, 1820a).

Weather, what happened, how it looked and felt, appeared in and sometimes dominated all the poetry and painting of the period, often conflated into a concept historians call 'Nature', which the Romantic generation was supposed to have revived or discovered – as if it were ever lost. Something new involving the environment did enter the literature and art of the period, but it was not 'Nature'. Rather, it was weather, neither nature nor culture, as Jonathan Bate said, but something that tied them together (Bate, 1996).

Although the science of weather was a way off, if it ever arrived, during this transitional period, weather was known through both individual and subjective experience, through encounter, with which art and poetry are concerned and the sciences that were based on it: the new sciences, geology, astronomy, physics, meteorology and biology, all the narrative, non-mathematical and observational sciences. Among them, each generated theories of life, a vision of the universe that was older, larger, and more mysterious than anyone had before conceived, a secular universe, sustained by natural forces identified with weather, by water, wind, sun, and ice. These sciences were secular, popular, vernacular, disseminated alongside poetry, painting, music in a pre-disciplinary period, discretely altering how the natural world but mostly how cold, wind, rain, and sun, were perceived, represented, and experienced.

Some background: in the eighteenth century, as Vladimir Jankovic has so brilliantly explained in *Reading the Skies* (Jankovic, 2000), artists and poets inherited textual weather, weather conventions, which since Homer, Hesiod, Virgil, served several acceptable purposes – mostly background noise, the choric voices in the tragedy intensifying emotions, setting a mood (it was a dark and stormy night), creating a crisis (ship wrecks), symbolic in the mythic tradition, (lightning, power), in religion (floods, whirlwinds, all punitive), in philosophy (sun equals reason), and in politics (the winds of change or war) (Favret, 2004).

Through much of the eighteenth century weather was still an aesthetic category: ancient and contemporary Mediterranean atmospheres were imported to a frigid Europe still lingering in an ice age. Weather was imagined, domestic, textual, depicted indoors in works composed by candlelight. For example, the longest loco descriptive poem in the late eighteenth century, William Cowper's *The Task* was composed by an invalid author as he lay on his sofa. Even in landscape paintings, like folklore and nursery tales, there is no weather, just a certain kind of impossible and Italian light learned from other artists and designed to be viewed by the artificial fire light indoors.

According to the prevailing deistic view of nature and the weather narrative based on it, the actual countryside was part of the fallen world, full of mystery, peril. The weather was an expression of God's wrath and power, in aesthetic terms either as sublimely turbulent, or as picturesquely ordered and civilized. In a transitional period, the first tourists or recreational travelers ventured into the countryside to find examples of the paintings, traveling in curtained carriages, emerging at stations identified in guidebooks, again textual: backs to the scene, they viewed the landscape through a curved smoked glass which composed the landscape to look like a painting by Claude Lorraine (who did all his paintings indoors), no weather at all.

But after 1770, in a great cultural shift, a reversal of sorts, while vagabonds, gypsies and criminals who once owned the roads were imprisoned, sent to work houses, deported, or farmers and shepherds exchanged their lands and weather-lore to work in factories and mills. Poets, painters, and scientists, the new and leisured middle classes, turned from domestic life, from shelter and refuge, and repossessed the natural world of England, not just rustics and country parsons such as Gilbert White in Selbourne, but even King George III, who rode about the countryside talking to potato farmers. Recreational travelers took to the roads and the hills, collecting things, feathers, pebbles, shells, even fossil bones, drawing landscapes, writing letters, and, along the way, discovered weather outside the textual tradition in unmediated and original encounters.

How can one account for it, this great migration from sheltered domestic space and libraries into the out of doors? What led William Hershel to set up his telescope on the sidewalk outside his cottage in Bath to observe the heavens, literally discover infinity? He made himself totally dependent on the weather in Bath, a place at that time afflicted with storms, rain, wind, mud. No matter how it is depicted in the movies, Bath was by all accounts a damp and foggy valley of confusion, all the discomfort that could be imagined. A German émigré, Herschel could have gone to Greece or Italy, but he chose the wind, mud, fog, and rain of Bath. Among his meteorological discoveries: sun-spots that lower the temperature, the Dalton Minimum, as it came to be called, validating everyone's suspicion that the world was indeed growing colder. His original but socially isolating defense against the cold: rubbing his body with onions, which may account for his remaining a bachelor well into his 40's.

And James Hutton, the Scottish gentleman farmer looking for a way to preserve arable land, left his library, his club, sat on a cold hillside by the sea and observing the wind and rain, concluded that the landscape had to be much older than the 6,000 years that theologians had claimed through analyzing biblical texts, so old one can't even imagine a beginning, or an ending. Therefore its origins must be the same as its being, created and recreated by the same forces he saw around him, shaped by wind and rain, by the weather, assisted, he believed, by internal fires (but we can overlook that). For him, the weather had taken on the creative power of divinity.

While Hutton's new geology altered the age of the earth, and Herschel's astronomy extended the size of the known universe, chemistry, through the discovery of photosynthesis revealed the processes of life within it, again processes shaped by weather, not divinity. Though it took him twenty years to complete it, in 1793, Joseph Priestley formulated photosynthesis for the British, making the human and natural world participants in a self-sustaining system dependent on sunshine, on the green and growing things, and on the rain. Photosynthesis turned all creatures, all living things into solar powered recycling machines – among the many subliminal concepts that brought people out of doors. Like geology and astronomy, photosynthesis appropriated the language and power of divinity, sacralized light, sun, air, the "all sustaining air," as Shelley called it – the title of Michael O'Neil's amazing new analysis of Shelley's poetry. It was heresy, of course, as Coleridge illustrates in *The Aeolian Harp* displacing all the divine powers on light, sun, air, weather, and full of joy,

> ...the one Life within us and abroad,
> Which meets all motion and becomes its soul,
> A light in sound, a sound-like power in light,
> Rhythm in all thought, and joyance every where – (Coleridge, 1796).

Similarly, Wordsworth in this rhapsodic passage from *The Prelude*, worshipping the sun:

> already I began
> To love the sun; a boy I loved the sun,
> Not as I since have loved him, as a pledge
> And surety of our earthly life, a light
> Which we behold and feel we are alive;
> Nor for his bounty to so many worlds –
> But for this cause, that I had seen him lay
> His beauty on the morning hills, had seen
> The western mountain touch his setting orb,
> In many a thoughtless hour, when, from excess
> Of happiness, my blood appeared to flow
> For its own pleasure (Wordsworth, 1850).

In painting, Constable's landscapes, the looming clouds, the connectedness of the green world and the human figures within it similarly express the power photosynthesis gave to sun and differentiate his *Haywain* from, say, Gainsborough's *Harvest Wagon*, with its decorative clouds and stationary foliage, painted only fifty years before. Constable considered painting itself to be a scientific act, capturing the subtle processes of things, the interaction of weather and forms. Assisted by a new chemistry, that made painting portable, Constable worked in the weather he was depicting and, because the paintings were displayed indoors, bad lighting and worse air, he developed techniques to retain, highlight, and project that weather. Following Luke Howard's *On the Modification of Clouds* with its precise and evocative drawings, first published in 1804 and copied in all the newspapers and magazines, Constable spent the summer of 1821 drawing clouds on Hampstead Heath, turning the sky and clouds from ornaments and background into subjects, agents, actors, sources of energy in the universal drama of photosynthesis. And the human structures, a church, a wagon, a cottage, like the human figures are overcome by growing nature, absorbed into the cycles of life, overpowered by the architecture of clouds, the weather systems that are the source of life itself, ephemeral yet constant, subtle, compelling – as close to realism as one could come before cameras, before anyone had explored any higher than a mountain or in a balloon.

I suspect there were other Huttons, Priestleys, and Herschels, another Luke Howard, John Dalton, and Humphrey Davy, more poets than Wordsworth, Coleridge and Shelley, and other painters besides Constable and Turner, observant men and women who come into the open air, into what Wordsworth called "the light of things" and from their encounters with weather displaced myth, theology, and aesthetic convention. I say 'suspect' because the evidence of encounter is as unreliable as the weather unpredictable, unverifiable, irreproducible – in brief, perfectly suited to an historical study of weather with its intuitive and hypothetical demands.

Dissemination is the question: how were their individual encounters so widely shared that the image of British weather during the Romantic period is unlike the images that preceded it? While the significant weather elements had changed, the wind, rain, sun especially, the weather itself had only changed imperceptibly. Where is the influence, the textual verification, who said what to whom and when, how did he or she know it? For encounter, like the weather, we must depend on contiguity, context, the possible, the hypothetical, on juxtaposition and allusion.

Before media, the poets, painters, and scientists were the mediators. They recorded the weather, as five Greek scientists discovered in compiling a history of volcanic activity from 1500 to 1900, based solely on the effects in paintings. And emancipated from texts, laboratories, and libraries, they created the weather communities, shared the landscape, mountains and pathways, the social gatherings, lectures, magazines. In fact, as John Ruskin said in 1839, *Remarks on the Present State of Meteorological Science*, weather has to be studied collectively, in communities: "The meteorologist is impotent if alone; his observations are useless; for they are made upon a point, while the speculations to be derived from them must be on space. It is of no avail that he changes his position, ignorant of what is passing behind him or before; he desires to estimate the movement of space, and can only observe the dancing of atoms; he would calculate the currents of the atmosphere of the world, while he only knows the direction of a breeze" (Ruskin, 1839). But weather was also communal then, as now, because it provided the common language of poets, artists, scientists, everyone, in every conversation, letter, diary entry which is why even scientists objected to Luke Howard's naming his clouds in Latin, a textual language, rather than the vernacular (Jankovic, 2000).

The encounters with weather were the occasion and defining condition of social encounters through which information was exchanged. For example, The Lunar Society, a group of scientists, philosophers, and inventors, the driving force behind the northern British industrial revolution met at Erasmus Darwin's house in Birmingham between 1765 and 1813 when the weather was clear and the moon was full so they could find their way there and home again. Similarly, besides writing for the Royal Society, Herschel shared his telescope with anyone who wanted to look through it and gathered parties to view unusual celestial events which he willingly explained. Hutton belonged to a raucous club in Edinburgh where with David Hume and Adam Smith they ate oysters, drank, and evolved many of the ideas that characterize the modern world. John Dalton, a Quaker schoolmaster, remembered for his atomic theory, studied with the blind sage in Kendal who had inspired Wordsworth, kept a weather diary for his entire life, solving so many mysteries except the clouds and winds and what they meant and again, shared his enthusiasms with students in Manchester and friends along the way (on the communities, see Golinski, 2007).

Similarly, Humphrey Davy, one of the most influential scientists of the day, in chemistry, electricity, and theories of gravity (a combination that Coleridge believed contained the secret of life) – his ideas originated while visiting Wordsworth and Coleridge in Somerset on the west coast of England and in the Lake District, where the dramatic weather occupied whole years of Dorothy Wordsworth's journals. Dorothy recognized before the ecologists a natural world "unified" (her word) by wind, clouds, and rain, by weather. And, when Wordsworth was in Germany, where he was imprisoned by the cold, it was Davy who revised the Preface to *Lyrical Ballads*, which celebrates the connectedness of poetry and science: "Poetry is the breath and finer spirit of all knowledge; it is the impassioned expression which is in the countenance of all Science" – it is in other words, like the weather (Wordsworth, 1800).

They all climbed Helvellyn in the Lake District, a mountain that by its odd placement – so high, so close to the sea – captured weather, shaped it, created its own weather, and collected clouds. A few years later, Luke Howard, the celebrated Quaker chemist, took refuge from his own laboratory to hike Helvellyn, and found himself in the original laboratory, wrapped in the very clouds he had named before. Or later, like a whisper, like a cloud, he passed through Chawton, Jane Austen's home, and suddenly, her novels acquired weather, precise enough for the obsessive Austenites to try to date the fictional events to a real weather diary. Weather, freshly observed, encountered, tied them together, across disciplines, geographical areas, generations, the lines of influence we prefer as textual scholars defeated by encounters, by knowledge exchanged, disseminated like seeds in the wind.

One major distinction survives between the sciences of weather and the art and poetry. While weather as a science is progressive, old theories and practices replaced by new ones, art is cumulative, all new ideas added on and nothing is ever lost. So, the inherited symbolic vocabularies of weather, the biblical, mythical, psychological, economic, religious, and political meanings of wind, sun, rain, cold (our favorites), survived, reconciled with the actual, literal, environmental, and ecological. The traditional subjects and forms of Romantic poetry and art acquired depth and range from the scientific subtext. For example, Constable's landscapes, however contemporary the details, acknowledge the formal beauties of earlier landscapes, the subjects and perspectives. Byron's *Darkness* is an apocalyptic poem in the literary and theological tradition depicting the end of the world, an ecological poem depicting the horrors of global warming, and an historical poem, describing the summer when Mount Tambora erupted and so obscured the skies over northern Europe that there was no summer. Literary works such Mary Shelley's *Frankenstein* or Coleridge's *Frost at Midnight* survive by their provocative mythic associations with cold, the traditional religious and political connotations, and reflect the contemporary preoccupation with cold, the challenges of keeping warm, finding light, creating heat. Sometimes, however, as in *The Eve of St. Agnes*, or Coleridge's *Rhyme of the Ancient Mariner,* the cold prevails: in the *Rhyme,* Coleridge depicted the desolation, fog, and ice Captain Cook encountered at the South Pole in the 1780s while he was searching for a tropical paradise, an adventure belatedly entering the parlors of London in 1798. Again, weather was the connection between nature and culture. And art provides evidence (Zerefos et al., 2007).

At the beginning of the period, the 1790s, the new sciences, poetry and art not only displaced the powers of divinity onto weather but also turned weather into a high romance, sensual, seductive. So Wordsworth recalls at the opening of *The Prelude*,

> Oh there is blessing in this gentle breeze,
> A visitant that while it fans my cheek
> Doth seem half-conscious of the joy it brings
> From the green fields, and from yon azure sky.
> Whate'er its mission, the soft breeze can come
> To none more grateful than to me (Wordsworth, 1850).

This "correspondent breeze," as he called it, would awaken his inner life, caressing him, responding to his passion, a "spousal verse," he once called it, a marriage of mind and nature, mediated by wind and sun, by weather. He believed, as he claimed in *Tintern Abbey* that "nature never did betray the heart that loved her" – a faith shared by many of his generation who had discovered weather in original encounters (Wordsworth, 1798). Less than five years later, after his beloved brother was drowned in a storm at sea, he conceded that nature, that weather, was unpredictable, unaccountable, indifferent, the wind and water, the sun and clouds as remote from human love, need, prayer, as the ancient inscrutable gods that weather had displaced. While the pagan gods had become as familiar and commonplace on stage and in children's books, the weather, the agency by which they had controlled human behavior was still mysterious and arbitrary.

In similar spirit, Percy Shelley wrote *Ode to the West Wind*, the ode, a form for both weddings and funerals, an invocation, a celebration, an elegy, in Shelley's hands an appeal from a helpless, alienated, exiled poet, whose powers are failing to a mysterious force that both inspires and fails, punishes and blesses, buries and awakens, creates and destroys – a great cumulative poem alluding to a history of suffering figures including Orpheus, Job, and Christ, the winds of political revolution, the geological winds of Hutton, and the actual autumnal winds on the coast of Italy. Invisible, he calls it an "unseen presence," "Wild Spirit," "Destroyer and Preserver," "Uncontrollable," "fierce," "impetuous":

> Drive my dead thoughts over the universe
> Like withered leaves to quicken a new birth!
> And, by the incantation of this verse,
> Scatter, as from an unextinguished hearth
> Ashes and sparks, my words among mankind!
> Be through my lips to unawakened Earth
> The trumpet of a prophecy! (Shelley, 1820)

Here Shelley anticipates the wary and adversarial attitudes of modern life toward weather, not totally scientific or artistic, with lingering spiritual connotations, anthropomorphic, the floods, earthquakes, Perfect Storms, without meaning, without a divinity to blame. This west wind and the ode it inspired, nearly as powerful as the wind itself, may have been a "trumpet of prophecy": disregarding the blustery winds, the premonitions, warnings, advisories, appeals, Shelley set sail in the Bay of Lerici and was drowned by an errant gust of the very West Wind he had invoked.

When poets, artists and scientists first discovered real as opposed to textual weather, they believed it was a beneficent force, allied with both nature and mankind, a force Constable depicted and Coleridge celebrated, that Wordsworth believed would not betray the heart that loved her. In little more than a decade, however, the weather victims mounted – Wordsworth's brother, Shelley, a ship of slaves Turner painted drowned at sea –, and as the toll increased, as weather adventurers challenged the "uncontrollable," the narrative darkened. By 1815, as the generation that first encountered it discovered that it was as arbitrary as the gods it had displaced, weather was demonized.

The entire weather narrative appears in the paintings of Joseph William Turner, from the idyllic pastorals pictures where, like Wordsworth, he conveys his faith in a benign universe to battle scenes, avalanches, raging storms at sea and blinding sunrises, human beings overcome, obliterated by natural forces, an effect he literally encountered by lashing himself to the mast of ship in a storm.

One more Romantic image, Keats *To Autumn*, again an ode, celebratory and elegiac as Shelley's *Ode to the West Wind*: the season is personified as a woman, ripe and dying, drugged with the fume of poppies, seated amid the harvest, "her hair soft-lifted by a winnowing wind," the last vision of a sacred and spoiling wind to which even the goddess of nature is subject (Keats, 1820b).

After 1830, the common conversation of science and art broke down in a professionalization that occurred in all disciplines, and that Ruskin lamented in his comments at the founding of the Meteorological Society. Yes, weather became meteorology, with rules, goals, languages, practices, and technologies, as Katherine Anderson illustrates in *Predicting the*

Weather using a faculty, the imagination that poets and artists legitimized in the Romantic period (Anderson, 2005). Meanwhile the art and poetry of the Victorian period, Tennyson, Browning, Arnold, Hardy, Yeats, the pre-Raphaelites, Impressionists and Expressionists turned inward, reverted to the textual, the derived and artificial conventions, withdrawing indoors, or into a subjectivity which excludes the weather, the power, light, and forces that animated Romantic art and poetry.

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Naturalizing culture: climate and culture in the American South

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In a perambulating and edgy essay in the *American journal of the medical sciences* on the problem of acclimation and fevers in the South, the Mobile physician and ethnologist Josiah Nott asserted a conclusion he had come to about race and climate: "If this permanency of type be, as it now universally is among naturalists, admitted, we have no reason to expect that climate will produce changes in races during the next thousand years which it has not been potent enough to effect in all recorded time of the past" (Nott, 1856, p. 322). Nott begins the essay with a legitimate medical question about the relationship on the two most dangerous fevers of the American hot zones, yellow fever and malaria. But in several impassioned and not entirely logical digressions (a style increasingly common in the writings of Southerners whenever questions of race were broached) he makes an argument that he had been developing for some time and that was soon to become part of a book of race that he was co-authoring with another ethnologist, George Glidden. (1)

This article, and the argument that racial differences were permanent and immutable – or at least, relatively immutable – and at the same time adapted and indigenous to particular climatic zones, converged in the political hothouse years of the 1850s with a widely referenced trope at large among the South's planter class. (2) Southern planters, in writings on agricultural improvement and climate, on medicine for the South, and on slavery and the South in general not only linked climate and race but also climate and the South's distinctive culture. As the South Carolina planter and prominent local leader William Elliott explained, in a widely-publicized and circulated anniversary address before the State Agricultural Society of South Carolina in 1848, the way of life and the institution of slavery in the American South was "an affair of climate... [that] will endure as long as the climate which called it into being; which sustains it, and at the same time justifies it, in the opinion of all unprejudiced men. This climate is of God's making; and so long as it continues fatal to the white race, so long will the countries subject to it, continue to be cultivated by men of vast African stock" (Elliott, 1849, p. 43). The belief that climate and race were bound together inexorably had in any case long been a convention among Southerners. Elliott was simply reminding his audience what they already assumed and what Josiah Nott later attempted to leaven with scientific credibility, that Southern society

(1) In this paper, the American South is considered to have consisted generally of those states that seceded from the Union in 1860-61 and formed the Confederacy, about which the U.S.A. fought a Civil War: Mississippi, Louisiana, Arkansas, Texas, Georgia, South Carolina, North Carolina, Tennessee, Florida, and Virginia.

(2) Planters were defined by the U.S. Census as slaveholders who owned twenty or more slaves – in 1860, about 47,000 people in a population of about three million 'whites' and four million slaves. This small minority held the preponderance of property and political office – of both wealth and power – in the South.

was unique to the place, had an organic integrity, was God-created, and was part of the natural order of things.

Many journalists, geographers, novelists, and historians in the American South, recent and past, have all, like Elliott, begun with the weather, in an argument that held currency in the region well into the twentieth century. But what kind of climate were they pointing to? Many parts of the American South do have a hotter climate than the rest of the United States – the longer growing season in some of this region made it possible to grow commodity crops such tobacco, rice, sugar, and cotton that gave this region some economic distinction. But did climate trump culture as a causative force? And if so, in what way?

The fullest assertion of the argument that climate caused culture came close to the end of the time Southerners began to quit making it. In his 1936 classic, *Life and labor in the old south*, one of the most prominent historians of the region, U.B. Phillips, began with the formulation (often quoted uncritically by more recent historians), “Let us begin with the weather, for that has been the chief agency in making the South distinctive” (Phillips, 1936, p. 3). Phillips then approximately followed the argument made by Elliott and other Old South apologists, and hitched up together the cultivation of certain plants, the institution of slavery, and a climate also deemed ‘peculiar’. Because of the climate, staple crop agriculture was the best adapted to the region; because of this agriculture, the plantation was the best unit of organization for growing staple crops; because of plantations, slavery was the best labor system; because Africans were better suited for labor in the long, hot summers – according to some variants of the argument –, they had been imported as plantation laborers; because of all four, the South possessed an economic and cultural uniqueness. (3) In an integrated conceit, this argument repeated all of the parts of the assertion that Elliott and other elite planters and medical men made in the decade just previous to the outbreak of the war between the South and the North. But what kind of climate were they talking about, based on what kind of knowledge? And how did they imagine or conceptualize it? And what about race – how was race connected to climate in these assertions, especially when we keep in mind that eighteenth-century climatic determinism had largely disappeared by this time?

First of all, Enlightenment-era environmental determinism had not disappeared entirely, and a residue of it continued to influence the thinking of antebellum Americans about climate and culture (Breeden, 1988, pp. 1-6). Early nineteenth-century Americans also commonly drew upon an ancient medical model that assumed an organic connection between climate and health and disease: in the general sense, between temperature and temperament (both physical and moral) and more specifically, between temperature, moisture, soil-type, plant cover, certain pathogens, and individual temperaments in combinations particular to each person and place. Most early nineteenth-century general reports of climate measured it by both temperature and mortality rates. Further, just as Americans traditionally judged the soil of the place by what naturally grew on it, they

(3) For a full consideration of the Phillips argument, see Stewart, 1997.

described the climate by what grew in it (Rosenberg, 1977, pp. 485-500; Logan, 1836, pp. 348-356; Gunn, 1986). Nothing in these practices, however, led to the conclusion that the South was a region with any climatic homogeneity. Indeed, the meteorology of doctors and farmers and planters moved in the other direction, toward the identification of the characteristics of neighborhood climates and the unique climatic traits of each locale, and usually in terms that could not be easily generalized – that indeed were often contested by the experience of climate as something always in flux, always changing, enormously varied, and something quite lived.

Southern medical practitioners were also more attentive to the unique qualities of climate in each locale than to larger patterns. As John Harley Warner has explained, they commonly adhered to the doctrine of ‘specificity’ in their therapeutic practices. Practicing American physicians of all regions commonly shaped and applied medical therapy in terms of the specific conditions of patient and environment, instead of aiming mainly and routinely only at the disease. Each patient in each place and in each environment required a different application of medical principles, this doctrine held. The consequence at first for medical practitioners was again an emphasis on the neighborhood (Warner, 1988, pp. 197-198).

In the 1840s and 1850s, partly in a defensive response to economic and political challenges to the region and partly to fine-tune therapeutic practices that would better fit Southern conditions, but also by way of participation in influential national and international trends, leading planters and medical men sought reform of prevailing practices in the direction of a larger and more scientific manipulation of the physical world. Medical men connected to the newly formed or revivified Southern medical societies or to several prominent medical institutions organized the data of individual record-keepers or conducted themselves careful studies in medical topography in small, often only county-wide locales throughout the South, in order to develop a medicine that was more closely adapted to local Southern conditions. Even when these studies were generalized, however, as they were in Daniel Drake’s study of the Mississippi Valley, *Principal diseases of the interior valley of North America*, published in 1849, they did not mark out a region that corresponded to the political and cultural one that planters and medical men were calling ‘the South’ (Drake, 1971).

Improving planters also sought a more systematic understanding of local climatic environments through a more systematic gathering of data. Many of the agricultural societies that improving agriculturists organized in the 1830s and 1840s to respond to economic and political challenges and that dabbled, sometimes quite seriously, in scientific agriculture, also sponsored efforts to study meteorology and to gather records of the weather. Many of these efforts proceeded haphazardly. Some planters collected a run of temperature readings that were submitted to the group in an annual ritual, or recorded reflections on the weather sometimes punctuated with thermometer readings, in correspondence to the editors of agricultural journals. Others attempted to create a consistent and cumulative statistical record that would eventually allow them to identify larger climatic patterns in the locale and in relationship to patterns elsewhere. The best and longest run of records, those kept by the Black Oak Agricultural Society in South Carolina, was patterned after the national data-gathering network organized by the Smithsonian Institution in Washington, D.C. (Fleming, 1990, pp. 70-93, 175-184). Henry William Ravenel, the prominent South Carolina mycologist and planter who joined the Smithsonian network of observers soon after it was established in 1848, was prominent in setting up the local system. The statistics that could be compiled by the Black Oak planters, he explained in a paper he presented before the Society in 1849 on the connection of meteorology and agriculture, would teach them about "those causes which affect us injuriously" (Ravenel, 1849, p. 16). Organized in tabular form and "adapted to the cotton months," these statistics would help them to correlate precisely the "production of crops" with the "condition of the seasons." Later, after South Carolina had seceded from the Union, when Ravenel was seeking to establish a network of weather observers in the Confederacy similar to the Smithsonian one, he was plain about the importance of gathering weather data: "Agriculture is our natural calling, and meteorology is the handmaid of Agriculture" (Ravenel, as cited in Aldredge, n.d., p. 252). And statistical data was the handmaid of meteorology; in the precarious exchange between agriculture and climate, the data bank would be a rock, "unchangeable and unchanging, always reliable," he said, that Southern planters could hold to, and one that promised eventual understanding and a more precise adaptation and management (Ravenel, 1849, p. 16).

The language and the form of investigation put Ravenel and the Black Oak planters akin to the larger statistical community of Smithsonian data-gatherers and calculators of means, but their purpose was a more parochial one. Indeed, the data from most of the efforts by reform planters remained self-contained and seldom integrated into banks of data from other locales, largely because they remained fixed more on variation than on pattern. Like the medical topography studies, climate records gathered by improving agriculturists marked out an extraordinary variety of local climates, rather than demonstrated a larger regional homogeneity or unity. What was important in the end was how the practice of scientific meteorology affirmed class interests rather than how it yielded information – practices were more important than information – and scientific data. When the latter was generated and used, it was integrated into traditional understandings of the organic unity of climate and culture, rather than employed to establish climate as an independent variable. This allowed planters to argue both ways, from culture to climate and back again – and this, along with the feverish politics of the 1850s, is what produced the notion of the South as a relatively homogenous climatic unit.

Many of the arguments for the distinctiveness and promise of Southern agriculture and institutions that included the "peculiar climate of the sunny South" as a fundamental component did not contain all the elements of Elliott's, or of Phillips' consummate formulation. But they often referred to it, using part of the argument to reference the whole. And one of the most common coded remarks that appeared in addresses to agricultural societies or essays in the agricultural and medical press pursued the longstanding belief that only African Americans could labor in the Southern heat.

The trajectory of this last belief in the decades between 1830 and 1860 included yet another development in the considerations of the relationships between organisms and climate in the South and deserves emphasis. A strong shadow of the eighteenth-century doctrine that environment, and especially climate, caused racial differences, persisted in America well into the antebellum period and was not challenged until the 1830s and 1840s by the scientific elite – and continued to hold sway in the popular mind until well after that. In the 1840s and 1850s, the challenge to climatic determinism as an ethnological doctrine gathered force in the efforts of several ethnologists and medical men to prove the immutability – beyond climatic or any other environmental influence – of races and the separate origin of Africans. This effort was stimulated by the publication in 1839 by Dr. Samuel George Morton of *Crania Americana,* perhaps the most thorough analysis of skulls in American history. On the basis of measurements of skulls Morton and collaborators had collected, he divided families into twenty-two families, and these he subdivided into five races. Racial differences were reckoned by Morton in terms of intellectual differences – and the data showed, he argued, that races were clearly ranked in terms of intellect – with members of the Caucasian race having "the highest intellectual endowment," and those of the "Ethiopian" race having the lowest (Morton, as cited in Kiple & King, 1984, p. 176). This was a major difference between races that had nothing to do with climate. Perhaps other differences were also immutable, and not affected by climate, this argument implied. Several ethnologists, indeed, proposed as much in the next decade, and proposed it vigorously. The most prominent of these was Josiah Nott, who in a series of articles and in two books co-authored with George Glidden, *Types of mankind* (1855) and *Indigenous races of the earth* (1857), made the argument for permanent differences between the races. Nott and Glidden refined Morton's findings, and found those of African descent to be so different from other races that they constituted a separate class of man – the lowest species of humans, they asserted. And of course, they also implied that such an inferior being was incapable of governing himself (Frederickson, 1971, pp. 2, 72-96; McCardell, 1979, pp. 78-83).

Nott promoted his ideas in *De Bow's* and other publications and through converts who popularized his ideas. Of these converts, Dr. Samuel Cartwright, a native Virginian with practices first in Natchez and then in New Orleans, was certainly the most influential. Cartwright became an expert on the diseases of slaves, and acquired a reputation as one of the most knowledgeable in the South in this specialty. He also became the chief popularizer of polygenesis, the doctrine of a separate genesis of Africans, which was the source of the architecture of types that Nott and Glidden asserted. [4]

Medical treatment, apart from developments of ethnology, had in the cause of a distinctive Southern medicine begun to distinguish racial characteristics of health and disease and

(4) Opposition to the climate-race argument among other Southern apologists for slavery was almost strong enough to defeat it – most proslavery apologists argued from Scripture, and could not accept an idea that so clearly appeared to contradict Genesis. The curse of Ham made sense, but the doctrine of polygenesis seemed to be heresy. Yet on the eve of the Civil War slaveholders conflated the doctrine of polygenesis, albeit often in veiled terms, with the larger proslavery argument and with arguments from Scripture – some Southern theologians even suggested that Native Americans and Africans had been included among the "living creatures" over which Adam had been given dominion in Genesis (Frederickson, 1971, pp. 87, 49).

to move away from the earlier focus on environmental causes – here, medical thought, and especially the explanation of many diseases, reflected the racial orientation that was developing in the second quarter of the nineteenth century in scientific research throughout the western world. This orientation, along with developments in ethnology and the intensifying belief among Southern medical men that the South needed a medicine of its own that made clearer distinctions between 'whites' and 'blacks', converged in Cartwright's work. Indeed, the ignorance by northern medical men of the medical and physiological peculiarities of African Americans was for Cartwright one of the main causes of sectional tensions between the North and South. In one of his more important tirades, *The Diseases and physical peculiarities of the negro race*, published in 1850, Cartwright asserted that the notion that "the negro is a white man, but, by some accident of climate or locality, painted black," was an error common among Northern medical men (Cartwright, 1850, p. 423). In fact, 'darkness' was an entire condition for Africans – not just skin deep, but pervasive in every part of Africans, in bodies and brains, even in the humors.

Cartwright went on to explain the physiological basis for apparent African American indolence, lack of courage, apathy, childlike behavior, and mental inferiority – and in the process summarized two decades of discussions by Southern medical men about the physiological differences between 'blacks' and 'whites'. Not all medical men followed Cartwright's lead, and some of them even ridiculed Cartwright's notion that the internal organs of 'blacks' were different than 'whites' – and his assertion that African had a natural love of slavery. But his work was also widely accepted, and the many essays he wrote for non-professional audiences had even more influence (Kiple & King, 1984, pp. 179-181).

So if climate was no longer a prime shaper of racial differences, why did it continue to be a cornerstone of the proslavery argument? In an essay, *Slavery in the light of ethnology*, included in the 1858 collection of proslavery arguments, *Cotton is King*, and other essays, Cartwright promoted and explained the doctrine of polygenesis and the "natural history" basis of the inferiority of 'blacks', and here also talked about the relationship between climate and race. He affirmed the conventional wisdom about the unique ability of 'blacks' to do hard labor and thrive in hot, humid climates. He explained,

> Negroes glory in a close, hot atmosphere; they instinctively cover their head and faces with a blanket at night, and prefer lying with their heads to the fire, instead of their feet. This ethnical peculiarity is in harmony with their efficiency as laborers in hot, damp, close, suffocating atmosphere – where instead of suffering and dying, as the white man would, they are healthier, happier, and more prolific than in their native Africa – producing, under the white man's will, a great variety of agricultural products, besides upward of three million bales of cotton, and three hundred thousand hogsheads of sugar (Cartwright, 1860, pp. 720-721).

However, Africans did not have this ability because they had developed it in a long interaction with tropical climates. They had it because they were created differently.

Acclimation was now evidence of permanent and immutable differences, rather than of a process of differentiation. "Negroes [...] are proved to belong to a different species from the man of Europe or Asia," pronounced Cartwright (Cartwright, 1860, p. 707). Slavery, the perfect institution for civilizing and managing an inferior race and the perfect labor system for the production of the South's staple crops, was perfectly adapted to the South's climate. And it always had been and always would be, this proslavery argument implied.

This racial reasoning repeated an argument – of the separate origin of Africans, and that they were also created as an inferior species – that was made by colonizing powers throughout the western world. British and French colonizers were at this time creating a kind of medicine, in fact, that as David Arnold and others have argued, has been unique among medical specialties in being defined in reference to the part of the world where it is practiced and where the diseases it studies are endemic – that is, tropical medicine. The first defining moment in the history of the development of this medicine – which was a scientific and cultural response to the challenges posed by tropical climates to European efforts to establish colonies – was the publication of James Johnson's *The Influence of tropical climates on European constitutions* in 1813. Johnson argued that yes, European constitutions would undergo the bodily changes that would allow them to live like native Indians, but it would take generations, even centuries, for this to occur. And the changes in temperament and character that would accompany these bodily changes, Johnson and others like him argued, might not be such a good thing. He sought to introduce a medicine that would give colonizers the skills and knowledge to interact with this climate, and right away (Johnson & Martin, 1846). Colonial medical men in the British and French colonies in Africa and Asia began to take on the challenges of adapting British culture to the tropics and vice versa by creating a kind of medicine that went further than studying the diseases of the tropics and that in addition made arguments about the relationships between culture and climate. At the same time, an argument that character and body types and eventually racial compositions were something essential and unchangeable began to seep in and permeate this medicine and the practices it proposed. This medicine, then, which began as a life-or-death encounter by Europeans with tropical climates, eventually produced a justification for imperialism, for a belief by Europeans that their bodies and their culture were both superior to native ones, that these differences were both innate and relatively immutable and not caused by climate, but that native bodies were better able to live without special adaptations – hill stations, for example – in the tropics. Climate did not cause differences, but differences made some races better able to function in the tropics at the same time that it made some races more suitable for ruling and others for serving. The literature on the development of tropical medicine in several places in European colonies in the global South is now fairly rich – and suggests that response of leading Southerners to both climate and race was a common one (Arnold, 1993, 1996, pp. 141-168; Worboys, 1970, pp. 76-98; Osborne, 1994; Harrison, 1999; Warwick, 2003).

The difference in the South was that its elite also enshrouded in science a justification for imperialism, not just to colonize but also to assert their own nativeness – as a defense against efforts by the Northerners to control them (they believed) and to abolish slavery. This kind of ideological fence-straddling was uncommon, and may have been fairly distinctive. But it is useful to notice that it was not unknown – by looking at the *Tropicalista* movement in Brazil in the second half of the nineteenth century. The *Escola Tropicalista Bahiana* was an informal school of about thirty Brazilian and a handful of foreign physicians who studied beriberi, leprosy, and parasitological disorders that were common in Brazil, with the idea that a tropical medicine should be produced in the tropics and that Brazilians could do it better than Europeans. But they also challenged one of the basic assumptions of Europeans about the tropics at the time – indeed, one of the justifications for both tropical medicine and imperialism: that tropical climates, if not encountered with proper adaptations and mediated by the proper medicine, caused degeneration in those who sought to live in them. They also argued that tropical climates were inhabited in the first place by natives who were already of inferior stock. The *Tropicalistas* argued that a tropical medicine produced by a 'Creole' elite in Brazil could mitigate against the degenerative effects of hot climates, help bring civilization to Brazil, and also make it a fit place for 'white' people – and for people who were becoming 'white' as well. They did not reject European medicine, but like Southern medical men who sought a southern medicine to help them live better in the distinctive southern climate, they worked to transform it into something homegrown – and made an argument about Brazilian nationalism at the same time (Peard, 1999, pp. 81-108).(5) Southern medical men and the *Tropicalistas* engaged in a science that was transregional and transnational and that expressed a larger current of colonial medicine, with a discourse about acclimation, and a drive for conceptual control of the torrid zone that was an important part of nineteenth-century European imperialism in response to hot places. But it was also profoundly local and driven mainly by assumptions about the organic unity of place and culture – knowledge that was produced elsewhere or scientific methods that were part of a global discourse on medicine were made to fit local uses and local purposes.

Reform planters and medical men in the American South naturalized ideology with an argument that linked body, place, and climate – one that sought to justify their domination of one group of people and defend themselves and their cultural interests against another. They created an argument about culture and nature that was also an argument about region. And in the process, the regional weather they made was more distinctive than the weather they got. In fact, when Southerners used climate to legitimize a social order, they did not begin with the weather, but ended with it, and ended with it with an argument of such force and conviction that it long survived the storm of the Civil War.

(5) It is important to emphasize here that the scientific accomplishments of both Southern medical men and the *Tropicalistas* were, by some assessments, negligible – but that their ideological accomplishments were not.

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UFOs or Weather: the 1952 "Invasions of Washington"

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"The air force feels a very definite obligation to identify and analyze things that happen in the air that may have in them menace to the United States" (Department of Defense, 1952). So began the largest Air Force press conference since World War II. On Tuesday July 29, 1952, Major General John Samford, director of Air Force intelligence, and representatives from Project Blue Book, the Air Force's recently formed Unidentified Flying Object (UFO) investigation unit, gathered in a room at the Pentagon to dissuade fears of both a terrestrial and extraterrestrial attack on Washington, D.C. On two consecutive Saturday nights before the press conference, air traffic control operators at Washington National Airport had picked up strange blips on their radarscope. The operators could not identify these blips and feared that they might be spacecrafts from another planet. They sent requests to local Air Force bases to scramble aircraft to intercept the objects causing these blips but the planes were not able to find anything. For days following the 'invasions' people from around the world were held in suspense. What could these strange blips be? Alien spacecrafts? Soviet weapons? Or, could they merely be the result of the weather?

Why have people for hundreds of years disagreed about the origin and meaning of unfamiliar objects in the sky? (Peebles, 1994, p. 8) The answer to this question is complicated and cannot be simply chalked up to public ignorance. This paper considers this question by investigating the 1952 "Invasions of Washington," one of the most noteworthy and notorious flying saucer cases of all time (Ruppelt, 1956, p. 209). Experts, not just laypeople, were in disagreement over the 'invasions'. I argue that there is a precedent for the kind of events that foster confusion. The "Invasions of Washington" were deeply embedded in the context of early 1950s America. Sci-fi movies, newspaper articles, and Cold War-related fears helped create an environment where pilots, radar operators, military spokespersons, and the press were at odds with each other as they tried to rationalize the origin of strange objects in the sky. Furthermore the Navy and Air Force heightened the confusion by initiating a formal investigation, keeping information classified, and giving vague answers to questions about the existence of UFOs. By examining the "Invasions of Washington" I will shed light on why people – both laypeople and experts – can be at odds over the origin of unusual aerial phenomena. I argue that a disagreement over aerial events often occurs at times of political or social unrest. This is not to say that confusion arises simply because people's perceptions are merely products of a particular context, but that social and political climates can encourage skepticism of both political and scientific authority. This skepticism, in the case of the "Invasions of Washington" drove the conflicting interpretations of the events, which reveals the complexity behind diverse perceptions of aerial events.

1. Unidentifiable aerial phenomena

Disagreement over the origin and meaning of strange aerial events has long and storied history. In the sixteenth and seventeenth centuries Europeans attempted to make sense of comets and other inexplicable events by viewing them as signs from God. Often the larger social context of the event, especially during politically charged times, shaped the way it was interpreted. By the end of the sixteenth century political and religious unrest intensified the portentous interpretations of events (Daston, 1991). Disputes over the origin of aerial events continued through the eighteenth and nineteenth centuries. In 1716 strange lights appeared in the London sky. The popular interpretation of this event was that a sky battle was taking place, which was seen as a sign that a catastrophe or the Day of Judgment was on the horizon. In his analysis of the sky battles Vladimir Jankovic suggested: "In the seventeenth and early eighteenth centuries, the constitution of an event could not be divested from the urgency that it possessed in that environment" (Jankovic, 2002, p. 459). The sky battle over London occurred at a time when two Jacobite lords were executed. Jankovic called the battle imagery a 'sociolinguistic trope' that was employed in political and religious debates (Jankovic, 2002, p. 431). In 1873 a phantom ship that sailed from water onto land was spotted on the Cornish seas. Although some people claimed that the ship was a cloud others saw it as a portent. In 1896 similar 'airships' were seen across the United States, from the Midwest to California. Just as in earlier eras, in the twentieth century reports swelled during periods with political tension. The rise of UFO sightings in the early 1950s in particular was closely linked to increasing fear over communism, nuclear weapons and political uncertainty (Spooner, 1961, pp. 323-329; Ruppelt, 1956, p. 19; Peebles, 1994, pp. 1-2).

2. UFOs in the United States

In 1947 flying saucers soared into the American public consciousness and became firmly rooted in popular culture. In late June 1947, Kenneth Arnold, a private pilot, spotted "a chain of nine peculiar looking aircraft flying" near Mt. Rainier (Peebles, 1994, p. 8). After he landed his plane he took his story to the local newspaper, the *East Oregonian*, which sent a report to the Associated Press. Within a day the story was printed in newspapers across the country (Ibid.).

By the first week of July 1947, flying saucers were spotted all over the United States. The *Los Angeles Times* reported that flying saucers were "seen in 28 States by hundreds of persons" (Los Angeles Times, 1947, p. 1). A front-page article in the 6th of July edition of the *New York Times* noted that "scientists were at a loss for an explanation of the so-called 'flying saucers' reported seen speeding through the sky by observers throughout the country" (New York Times, 1947, p. 1). Within a month of Arnold's sighting over a hundred and ten newspaper articles had been published on flying saucers. [1]

After Arnold's sighting the U.S. government assigned the Air Force the responsibility of

(1) Proquest newspaper search for "flying saucers" on March 3, 2008.

investigating UFOs. In addition to the value of tempering flying saucer reports, the U.S. military saw a UFO investigation unit as an important component to border security during the early stages of the Cold War. In response to the UFO craze generated by Arnold's story, the Air Force undertook a propaganda campaign in order to stifle sighting reports in April 1949. According to the Air Force's official line, flying saucer reports were a threat to American security. The Soviet Union could send out 'UFOs' to create mass hysteria and clog military communications channels. As political scientist Jodi Dean noted "despite the military efforts to dismiss UFOs, to assimilate them into something controllable and scientifically explicable, by May 1950 sighting reports were at an all-time high" (Dean, 1998, p. 36). She suggested that this rise in reporting was in part due to popular books by UFOlogists Donald Keyhoe and Frank Scully, and efforts of newly formed 'flying saucer societies' to raise interest in UFOs (Dean, 1998, p. 36; Keyhoe, 1953; Ruppelt, 1956, p. 223). After a wave of sightings in the fall of 1951 the Air Force asked Captain Edward Ruppelt to review the Air Force's investigation of UFOs. Ruppelt had been an Air Force pilot and radar operator during World War II. Once the war ended he went back to school to receive a degree in aeronautical engineering before returning to active duty at the Air Technical Intelligence Center (ATIC) at Wright-Patterson Air Force Base, in Dayton, Ohio. In 1952, at Ruppelt's recommendation, the Air Force revamped their UFO investigation unit, gave it the code name 'Project Blue Book', and assigned Ruppelt the directorship (United States Air Force Projects, 1968, pp. v-vi; Ruppelt, 1956, p. 20).

2.1 Leading up to the 'invasion'

The 1950s was a time when conflict between the United States and the Soviet Union appeared inescapable and when the fear of nuclear attack introduced an overarching atmosphere of vulnerability in people's daily lives (Whitfield, 1996, p. 231; Kuznick & Gilbert, 2001, p. 2). By 1952 the country faced a time of uncertainty. The Soviet Union had detonated its own atomic bomb, the Korean War had reached a standstill, a new presidential election was underway and the threat of communism provoked widespread anxiety across the nation (Halberstam, 2007, pp. 624-627). It is likely that science fiction became extremely popular in the 1950s because it satiated a new "appetite for vicarious scientific adventure and a need to externalize fear" that arose because of the presence of the atomic bomb (McDougall, 1985, p. 99). Doubling their prewar circulation, sci-fi books and magazines flooded shelves while movies about monsters, atomic mutants and UFOs filled movie theater seats. According to an article in *Life* magazine from 1951, over 2 million Americans read sci-fi (McDougall, 1985, pp. 99-100). UFO theories, with the aid of newspapers, sci-fi movies and magazines, infiltrated all levels of the popular imagination in the early 1950s. During a six-month period in 1952, a hundred and forty-eight leading newspapers carried over 16,000 items on UFOs (United States Air Force Projects, 1968, p. 99; Ruppelt, 1956, p. 27).

In April 1952, three months before the 'invasions', *Life* magazine carried an article titled "Have We Visitors From Space?" In addition to its evocative title, the article implied that reports of UFOs, and thus UFOs themselves, might be real. On the day after the *Life* article was published, nine UFOs were reported. This article also prompted an intense reaction from the press, which resulted in an outpouring of coverage. Between April 3 and April 6 there were 350 references to the article in daily newspapers and, not surprisingly, the number of reported sightings rose (United States Air Force Projects, 1968, p. 99; Ruppelt, 1956, p. 27). The *Condon Report* (1968), the Air Force funded scientific study of UFOs, pointed out the significant role media attention played in the rise of flying saucer sightings in the early 1950s. The report proposed that as more articles on UFOs were published, people were more likely to watch the skies and consider reporting what they saw (Condon, 1969, p. 32). The first serious book intended to challenge the extraterrestrial origin of UFOs was not published until 1953, a year after the 'invasions' (Rasmussen, 1985, p. 11). Donald Menzel, a Harvard University astronomer, explained that by July 1952 the buildup of saucers reports was producing "a state of near-panic" (Menzel & Boyd, 1963, p. 155).

2.2 The 'invasions'

Like most Washington, D.C. summers, the summer of 1952 was hot and humid. In late July, however, the temperature rose even higher than normal and the city suffered a record drought, which was extending across the country from Maine to Texas (Klein, 1952, p. 118). On Saturday July 19 the temperature climbed to 93 degrees fahrenheit during the day and at night, with no cloud cover, it dropped to 76 degrees fahrenheit. Just before midnight, a controller at Washington National Airport's Air Route Traffic Control (ARTC) spotted eight unusual targets on his long-range radar southwest of Washington near Andrews Air Force Base (AFB). These targets were clearly not planes because they moved slowly and then disappeared at extremely high speeds. The ARTC alerted Andrews AFB, which responded almost immediately (Peebles, 1994, pp. 61-62; Condon, 1969, p. 227; Ruppelt, 1956, p. 211).

The ARTC also radioed commercial pilots in the area. A Capital Airlines pilot, Cat 'Casey' Pierman, after receiving the message yelled: "There's one – off to the right – and there it goes" (Ruppelt, 1956, p. 213; Peebles, 1994, p. 62). The ARTC controller also saw a target to the right of the plane that quickly disappeared. Over the next fifteen minutes the airline crew saw another six lights. Some of the lights moved quickly while others hovered before disappearing. Pierman, who had seventeen years of experience with Capital Airlines, explained that the targets "were like falling stars without tails" (Washington Post, 1952b, p. 1; Peebles, 1994, p. 62). Another pilot on a different flight reported that a light followed his plane for four miles before he touched down. Air Force interceptor planes were sent out to chase the UFOs but were not able to find anything (Menzel & Boyd, 1963, p. 155; Peebles, 1994, p. 62).

Ruppelt did not find out about the sightings until he read about them in the Washington newspapers. He later recalled: "When reporters began to call intelligence and ask about the big sighting behind the headlines, INTERCEPTORS CHASE FLYING SAUCERS OVER WASHINGTON, D.C., they were told that no one had ever heard of such a sighting. In the next edition the headlines were supplemented by, AIR FORCE WON'T TALK" (Ruppelt, 1956, p. 212). The newspaper's overstated response to Ruppelt's confusion was an illfated beginning to what would become a drawn out struggle between the Air Force's account and the popular perception of the evening's events.

On Monday July 21 an Air Force intelligence officer briefed Ruppelt at the Pentagon. Air Force intelligence concluded that the ARTC, which included a senior controller and a technician, were too experienced to mistake something as common as, say, the effects of a temperature inversion for UFOs. In addition the visual targets that pilots and Air Force officers spotted laid further claim to this theory. Instead, they came to the conclusion that the blips on the radarscope must be material objects. Historian Curtis Peebles claimed, "from Ruppelt's account, it appears that the Washington sightings had convinced the Blue Book staff that the Extraterrestrial Hypothesis was at least a possibility" (Peebles, 1994, p. 63). Since the targets were picked up by multiple radars, seen by reliable eyewitnesses in planes and on the ground, and flew in prohibited airspace, the group's confusion and concern was justified.

Although an official "no comment" was given to the press, the July 22nd edition of the *Washington Post* carried a front-page article noting, "the Air Force disclosed last night it has received reports of an eerie visitation by unidentified aerial objects – perhaps a new type of 'flying saucer' – over the vicinity of the Nation's Capital" (Ruppelt, 1956, p. 125; Washington Post, 1952b, p. 1). The entire article strongly implied that the targets were UFOs. In the following days, what came to be known as the "Invasion of Washington," made headlines around the world. Ruppelt later noted that, "during July 1952, reports of flying saucers sighted over Washington, D.C. cheated the Democratic National Convention in Chicago out of precious headline space" (Ruppelt, 1956, p. 27). The Truman White House and press from London to Mexico City contacted Ruppelt. According to Ruppelt, "a junior-size riot was only narrowly averted in the lobby of the Roger Smith Hotel in Washington when I refused to tell U.S. newspaper reporters what I knew about the sightings" (Ruppelt, 1956, p. 209). The public's interest was becoming palpable.

Government red tape and funding issues blocked Ruppelt from carrying out an investigation. He returned to Dayton, Ohio, the location of the headquarters of Project Blue Book instead of visiting Washington National Airport, Andrews AFB, various airlines offices, and the weather bureau to collect information about the case. When he arrived he told Captain Roy James, a Project Blue Book staff member and radar expert, about the 'invasion'. James "thought it sounded as if the radar targets had been caused by weather" (Ruppelt, 1956, p. 216).

Just one week after the first 'invasion', under similar weather conditions, Washington was 'invaded' again. Late in the evening on Saturday July 26, the same Washington National Airport controllers and Andrews AFB tower operators started picking up blips on their radarscopes. A number of commercial airplane crews also started reporting strange lights in the sky.

Two military officials drove to the ARTC in time to see the radarscope for themselves. The

ARTC had already barred reporters and photographers from the radar room when they arrived because, as Ruppelt suggested, "not a few people in the radar room were positive that this night would be the big night in UFO history – the night when a pilot would close in on and get a good look at a UFO – and they didn't want the press to be in on it" (Ruppelt, 1956, p. 219). One of officials, even though he found out from the airport weather station that there was a slight temperature inversion that night, believed that the targets must be due to something besides weather (Ruppelt, 1956, p. 218; Peebles, 1994, p. 64).

The ARTC diverted all commercial air traffic away from Washington National Airport and four Air Force interceptor planes were sent after the targets. Lieutenant William Patterson, one of the Air Force pilots and a veteran of the Korean War, explained: "I tried to make contact with the bogies below 1,000 feet, but [the ARTC controllers] vectored us around. I ceased chasing them because I saw no chance of overtaking them" (Peebles, 1994, p. 64). Although he was eager to make contact with the strange objects Patterson never found anything in the night sky above Washington. Like the first 'invasion', by sunrise the second 'invasion' had ended.

2.3 The press conference

When Major General Samford faced reporters on Tuesday July 29 he was already fighting an uphill battle. He had called a press conference before the Air Force had gathered sufficient information to answer all of the press's questions, which put Samford and his colleagues at a disadvantage. Although most of the questions were factual and aimed at clarifying details about the sightings the representatives from Air Force intelligence gave ambiguous and seemingly evasive answers. James drew most of his information from newspaper articles that he read on his flight to Washington that morning. In response to many of the press's questions he had to reply, "I'm not positive about that," "I'm not sure," "I don't know," or "the information we have isn't good enough to determine that" (Peebles, 1994, pp. 8-11). James and Samford were reluctant to provide a definitive reason for the sightings. They claimed that there was a 50 percent likelihood that the sightings were caused by a temperature inversion but they acknowledged there was some information, such as visual reports, that countered this theory.

To add to the media's suspicion the two military officials who had actually witnessed the second 'invasion' from the control room and who did not believe the targets were weather related, were noticeably absent from the press conference. One reporter asked: "I understand there were radar experts who saw these sightings Saturday night or early Sunday morning. What was their interpretation of what they saw on the scope?" Samford danced around the issue and responded that they saw good returns but that good returns in the past have come from birds. A reporter asked if birds could cause the large returns that were observed, and Samford responded "no" (Peebles, 1994, pp. 1-2, 7, 15). Later Ruppelt recalled that "a great deal of the press's interest was caused by the Air Force's reluctance to give out any information, and the reluctance on the part of the Air Force was caused by simply not having gone out to find the answers" (Ruppelt, 1956, p. 224).

3. Solutions to the "Invasions of Washington"

In 1968 James McDonald, an atmospheric physicist at the University of Arizona interested in optical phenomena and UFOs, noted "the field of meteorology has long been used to cull 'explanations' for UFOs" (McDonald, 1968). The case of the "Invasions of Washington" was no exception. Investigators from the Technical Development and Evaluation Center of the Civil Aeronautics Authority examined the weather conditions in Washington and found that a temperature inversion was common in the area during the summer. Long known to weather observers taking vertical soundings, radar operators first began to observe the electro-magnetic effects of temperature inversion as early as 1940. The Washington Weather Bureau also reported that on the nights of the 'invasions' there was an abnormal distribution of moisture in the atmosphere in addition to a small temperature inversion. According to Menzel, the blips picked up on the ARTC's radarscope did not require large temperature inversions since "at radar frequencies, refraction is influenced by both temperature differences and the distribution of water vapor in the atmosphere" (Menzel & Boyd, 1963, p. 158). Variation in moisture content and temperature in the atmosphere can refract radar beams so that they pick up ground targets. These ground targets can have the appearance of flying objects on a radarscope. Menzel believed that the visual targets spotted by a number of pilots were likely stars or city lights, which took on the appearance of flying saucers owing to the excitement of the evening. In the weeks following the 'invasions' investigators agreed that flying saucers spotted over Washington, D.C. were merely secondary reflections of the radar beam, which were created by a temperature inversion and moisture in the atmosphere (Menzel & Boyd, 1963, pp. 150-160).

3.1 Aftermath of the 'invasions'

According to his reading of the Air Force files, Menzel suggested that the sightings "terrified a large number of officials who in a more normal emotional climate would have recognized the 'invisible' flying saucers for what they were – radar signals produced by weather conditions" (Menzel & Boyd, 1963, p. 155). Ruppelt believed that the constant threat of atomic bombs prompted some people to look towards outer space for salvation, hoping that aliens were more advanced and could save the human race. In many other instances, he noted, people have linked UFOs with the problems that plagued the earth (Ruppelt, 1956, p. 22). The popularity of UFOs in public culture in the early 1950s harkens back to the seventeenth century when "meteorological apparition narratives could be seen as a platform from which those, who perceived themselves in a precarious social, confessional or existential condition could voice their discontent and even threaten to change it" (Jankovic, 2000, p. 66). Ruppelt suggested, "many of the people who were associated with the project [Blue Book] believed that the public was suffering from 'war nerves'," which contributed to the rise in UFO sightings (Ruppelt, 1956, p. 19).

It is important to note that the 'invasions' took place at a time when the threat of an airborne attack, both extraterrestrial and terrestrial, was a topic on many minds across the country. In addition to the testing of atomic bombs the military was also working on a weather weapon, which would potentially release enough energy to match that of an atomic bomb (Fleming, 2004). Throughout the summer, under the advice of the Air Force, the state civil defense directors had put the Ground Observer Corp, a volunteer surveillance network with an anticipated 500,000 participants, on a twenty-four-hour alert to watch the skies in the hopes of deterring a sneak Soviet air attack (New York Times, 1952b, p. 1). In June 1952, health physicists at the University of Chicago found a layer of radioactive debris blanketing the city, which had been carried by clouds across the country from the Yucca flats atomic proving grounds. Although the Chicago Daily Tribune reassured its readers that the fallout had not reached a dangerous level, the city, like the rest of the country was vulnerable to new sky-borne menaces (*Chicago Daily Tribune*, 1952, p. 25).

Media coverage after the second 'invasion' ranged from mockery to criticism of how the Air Force was handling the situation to concern over the vulnerability of the United States. The 'invasions' were teasingly referenced in a *Washington Post* advice column and a *Los Angeles Times* article titled "Saucers Add Zest to Events of Day" (Washington Post, 1952a, p. 34; Los Angeles Times, 1952, p. 29). The *Wall Street Journal* took the Pentagon to task for the clumsy way they treated the alert. The article used a mocking tone when it explained that,

> It's not flying saucers. It's the heat and humidity... The favorite theory of the experts has to do with temperature inversion, caused by heat and humidity. This latest theory ought to take care of everything now. And since the heat and the humidity have left us and Washington maybe the flying saucers will go away and leave the Pentagon and us in peace (Wall Street Journal, 1952, p. 4).

The tone of the *Wall Street Journal* quote stressed that no position – neither the experts nor the proponents of the flying saucer theory's position – was seen as privileged. The article along with newspapers across the country, from the *Hartford Courant* to the *Indianapolis Star*, carried similar stories that challenged all interpretations of the 'invasions' (Hartford Courant, 1952; Indianapolis Star, 1952, p. 4). The *New York Times* printed an article on July 29 titled "Air Force Explains 2-Hour Delay in Chasing 'Objects' Over Capital," which critiqued the way the Air Force handled the 'invasions'. It noted that the request for interceptor planes was sent to the Air Force flight center instead of directly to the Pentagon. This article underscored increasing doubt over the Air Force's authority and ability to react to potential 'invasions' (New York Times, 1952a, p. 23).

In the months following the 'invasions' popular periodicals also criticized the Air Force's handling of the 'invasions' but this criticism appeared in sensational articles, which perpetuated the possibility that aliens had visited the capitol. The August 4th edition of *Life*, called the sightings "the most startling 'flying saucer' incidents recently reported" (*Life*, 1952). In their December 1952 issue, *True* magazine published an article that lambasted the Air Force's conclusions. The article "insisted that the radar echoes had been caused by strange machines and, in effect, accused the official investigators of releasing an explanation they knew to be at variance with the facts shown by radar"

(Menzel & Boyd, 1963, p. 158). As historian Howard McCurdy noted, “reassurances by political and scientific elites who told the public not to worry only fueled suspicions that the government was not disclosing all it knew” (McCurdy, 1999, p. 74). The media’s reaction to the sightings was not surprising given Air Force officials’ vague responses at the press conference. Ruppelt claimed “besides being the most highly publicized UFO sightings in the Air Force annals, they were also the most monumentally fouled-up messes that repose in the files” (Ruppelt, 1956, p. 209). Disagreements over the ‘invasions’ lasted long after the Washington, D.C. summer heat had died down.

4. Why was there so much confusion?

Like most famous UFO sightings the “Invasions of Washington” were not a completely settled case. Even though the media, from the very start, presented a dramatic account of the ‘invasions’, eventually reporters accepted the official line. The public, on the other hand, has been more divided. Forty-nine years after the ‘invasions’, Kevin Randle, an UFOlogist and author of a number of books claiming the existence of extraterrestrials, published an account of the ‘invasions’ purporting that they were part of a massive government cover-up. According to proponents of the UFO theory, the government was hiding the truth from American citizens (Randle, 2001). Menzel noted: “Saucer enthusiasts protested (and still insist) that the inversions were not large enough to produce radar anomalies” (Menzel & Boyd, 1963, p. 158). This distrust is not surprising given the way the “Invasions of Washington” were treated by Air Force intelligence. Ruppelt noted that after the first sightings in 1952, confusion reigned, “there was a lot of talk but no action” (Ruppelt, 1956, p. 215). Without early proper investigation Air Force intelligence was ill-equipped to field reporters’ questions, which contributed to the chaos, and as Ruppelt pointed out, the confusion that came to define the “Invasions of Washington.”

By 1953 most of the excitement of the previous summer had died down. According to a Project Blue Book report “because of the decrease in newspaper publicity, fewer reports have been received from civilians with the result that military sightings now account for approximately 60 per cent of unidentified flying object reports” (Status of Project Blue Book, n.d.). The most significant feature of this report was the emphasis given to how the Air Force improved its methods for reporting and investigating UFOs. The implementation of more standardized reporting procedures and investigation cleared up some of the confusion that lingered from the 1952 sightings. But, according to scientists, temperature inversions and other weather-related phenomena, like unusual cloud formations, lightning, sundogs and weather balloons, however, continued to be reported as UFOs for decades to come (Peebles, 1994, pp. 283-291).

The “Invasions of Washington” illuminate important dimensions in the relationship between the military, scientists, the media and the public in the interpretation of aerial events. With the threat of communism, war and the development of overwhelmingly powerful weapons weighing on their minds, Americans, both experts and laypeople, reacted to unfamiliar radar returns in the summer of 1952 with confusion, hysteria, cynicism and humor. As the “Invasions of Washington” can confirm, in an anxiety-ridden environment fashioned from nuclear fears, sensational press coverage, Air Force mismanagement and experts' conflicting claims, disagreement over the reality of aerial phenomena can arise.

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Climate, scientific strategy and the political state: the Brazilian Space Program

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1. Science and society: a multidimensional relationship

We propose to present a sociological and discursive analysis about the Brazilian Space Program (BSP), which began in the 1940s. We will discuss issues related to the scientific-technological policies and practices associated to developing programs and plans of action that affect territorial monitoring and data collection for scientific and politico-economic purposes, in addition to the collection of climatic data essential to guaranteeing sustainability for a country of continental dimensions presenting several geographical and meteorological conditions within its borders. We will discuss what has been done concerning the development of programs, policies and devices used for weather forecasting and controlling agricultural activity, focused on guaranteeing this sustainability. We will feature two aspects that could be considered autonomously, but in this context are interconnected: scientific-technological development and national sovereignty. These are then developed into relationships that unite society-science-market in the present globalized society, and in strictly political terms, we consider the problems that are actually specific to space technology, and territorial and political control, called 'transboundary' issues. Starting with the BSP, we intend to demonstrate that scientific and technological development equally implies socio-political and economic relationships, by which the activities, programs, and policies of science and technology are oriented, and that these characteristics are greatly intensified when they are space programs.

In the world arena where technology plays the lead role, notably in the field of digitalized communication and remote monitoring, the tendency to credit national states with a preeminent function is observed, giving them the responsibility of intervening in and evaluating negotiations of multilateral or multinational programs. The strengthening of the state is a supposed guarantor of its territorial sovereignty and the necessary conditions to its politico-economic and scientific-technological sustainability. When dealing with the strategic importance of state investment in space programs, Roberto Amaral confirms that it is a "project of the state, an action of technological inclusion aiming to take the country to a new level of development. What we seek here is to guide our history" (Amaral, 2008, p. 7). A socio-techno-scientific network is created in which various agents of the space production chain (institutions, companies, and government) are connected and compete to meet the demands for space systems.

The recognition of these impacts caused the search for self-sustainability to integrate with the international political agenda. Accompanying this tendency, a techno-scientific and political movement is confirmed, supported in the discourse of environmental preservation, and acts towards the goal of global governability (Viola, 1997). It is an international and multinational system, widespread and without territorial borders, created to administrate the (environmental) problems of the planet, whose regulating action would occur through companies and organs that would not deter their action when facing local interests or national barriers or limits.

This process transcends national boundaries, although it is intertwined with the boundary of state sovereignty and inaugurates a new phase of the civilizing function of capitalism (Ianni, 2004), generating a series of transboundary effects that could be evaluated by the present stage of industrial and techno-scientific scope (Viola & Leis, 1991; Hardt & Negri, 2001). The questioning of national state autonomy and territory, whether as a debate strategy or whether in the form of inter-state pressures, returns to the globalization of increasingly more fluid capital, before which the boundaries and national-local interests are made flexible (Gruppi, 1978; Darc, 2004).

Considering that "international relations react [...] to political relations," we see that a state is organized and acts accordingly with the transformations of the socio-economic structure so that "the more economic life [...] is subordinated to international relations," the more their mechanisms of sovereignty and sustainability tend to be affected by this relationship (Gramsci, 1978, p. 44). It represents an arena of international friction in which the transboundary issue is emphasized. This is a component of the hegemonic apparatus instituted in the international politico-economic arena, production and particularly the economic and social impacts caused by scientific advancement. It has become commonplace to say that society is defined by the presence of science and technology. It is undeniable that science and technology have a powerful role in the means of production and the cultural education of contemporary society, since scientific rationality produced a change in the relationship between man and nature and this was a determining factor for the phenomenon of globalization.

The relationships between science and society are developed in a socio-historic situation marked by hegemony on one side and the overlapping between scientific-technological practice and means of production on the other. In this scenario, space technologies enable us to perceive the complex interactions among science, technology, national states, territory, sovereignty, and present geopolitics. Global observation systems act as the support for implementing sustainable standards of economic development; as the means and result of their own economic-technological development focused on orienting the non-predatory exploitation of the ecosystems; as a socio-political vector that subsidizes political decisions; and as a political and geo-technological determiner that qualifies and gives points to those nations that dominate this type of technology.

A complex situation is outlined in that global governability is limited by the interests and policies of the self-sustainability of the nation-states, while it also impacts local governability, notably concerning the domination of the latest technology. In a globalized scenario, the difference between dominating or not dominating technology implies a strategic differentiation between nation-states that are capable of manufacturing and launching satellites – and at the same time find themselves equipped to monitor and control from meteorological systems to the security of a nation's territory, as well as the territories of other states – and those who become technologically dependent.

2. The BSP, strategic and operational value

Beginning with the strategic role of the BSP for the Brazilian state, whether referring to the construction of techno-scientific and politico-economic self-sustainability when encountering international pressures, or whether concerning the internal issues such as territorial security, the perfecting of telecommunications and environmental control (soil, subsoil, forecasting of crop harvests, control of natural and man-induced disasters such as storms, undersea earthquakes, forest fire and deforestation), we will emphasize that its importance in the development of long-term strategies and public policies supporting the increase of Brazilian capacity in the scientific and technological field of meteorology and climatology, with this leading to the formation of institutions, specialized teams and basic and applied research programs, not only helps Brazil become technologically competent, but also increases its political prestige and contributes to consolidating international partners in programs for monitoring from space.

Concerns about giving Brazil a space program go back to the 1940s. Since its beginning, the BSP has been characterized as a program with a strategic axis that focuses on the development of scientific and technological sustainability in the field of space activities and associated actions. Openly, the Brazilian government does not manifest defense proposals in regard to nuclear and space technologies. The tenuous limits between dominion and development of technologies for defense or peace-keeping technologies in the field of space activities – and especially nuclear armament – have led to debates within and outside of the government, as illustrated in the polemic issues that arose in President Lula's first government (2003-2006) caused by the declarations of the then Minister of Science and Technology, Roberto Amaral, who had appeared in favor of investment in technology for the manufacture of nuclear defense artifacts, as a way to guarantee a prominent role for Brazil in the international scenario.

Figure 1: Alcântara Launching Center.

Brazil was one of the first developing countries to execute space activities in an institutionalized manner, creating organizations within the state organ with the principal objective of developing, accompanying and regulating research programs in the space sector. These beginnings are characterized by the creation of these institutions, such as the Ministry of Aeronautics in 1941, the Aerospace Technical Center in 1946 and the Technological Institute of Aeronautics in 1950. The more important mark of this period was Decree 51.133, on August 3, 1961, which created the Organizational Group of the National Commission of Space Activities (*Grupo de Organização da Comissão Nacional de Atividades Espaciais* – GOCNAE). With this organ, President Jânio Quadros instituted the National Commission of Space Activities (*Comissão Nacional de Atividades Espaciais* – CNAE) with the mission of studying and suggesting a space program. In the 1970s, this commission transformed into the Brazilian National Institute of Space Research (*Instituto Nacional de Pesquisas Espacias* – INPE), which is one of the more important institutes of the Brazilian space complex. The following is a succinct chronological chart of the BSP.

YEAR	PRESIDENT	EVENT
1961 1962	Jânio Quadros	Founding of the Organizational Group of the National Commission of Space Activities (GOCNAE). Founding of the National Commission of Space Activities (CNAE), which in the 1970s was transformed into the INPE.
1962	João Goulart	Founding of The State of São Paulo Foundation of Support to Research (*Fundação de Amparo a Pesquisa do Estado de São Paulo* – FAPESP).
1965	Castello Branco	Creation of the Barreira do Inferno Rocket Launching Center (*Campo de Lançamento de Foguetes da Barreira do Inferno* – CLFBI) in Ponta Negra, Natal, Rio Grande do Norte state. Until 2002 more than 2,600 Brazilian-produced probe rockets were launched, specifically 300 of the Probe I, Probe II, Probe III and Probe IV each. Launching of the first meteorological probe (Probe I), a Nike-Apache, in cooperation with NASA.
1967	Costa e Silva	The RADAM Project (Amazon Radar) was founded, which mapped radar images. After 1975, it was renamed Brazil Radam (survey of natural resources of Brazilian soil).

1969	Emílio Médici	Brazil ratifies the Treaty on the Regulatory Principles of State Activities in Exploration and Use of Outer Space, including the moon and other celestial bodies.
1970		
1971		Creation of the Institute of Aeronautics and Space (AIE).
1973		The educational satellite SACI is proposed for transmissions of tele-educational programs.
		Founding of the National Institute of Space Research (INPE).
		Reception of data and images of the first satellite of the Landsat series, Earth Resources Technology Satellite (ERTS), the ERTS-1.
1976	Ernesto Geisel	The first Probe III rocket, bi-stage, was launched.
1979	João Figueiredo	The 2nd Seminar of Space Studies is held. Founding of the Brazilian Complete Space Mission (MECB): a) solid propellant rocket-launching vehicle; b) new launching field; c) four satellites, whereas two are data collectors and two are remote global observing systems.
1982		Founding of the Alcântara Launching Center (*Centro de Lançamentos de Alcântara* – CLA) complex.
1984		Launching of the first Probe IV rocket, bi-stage, with solid propellant. Convention on the States' Activities on the Moon and Celestial Bodies.
1985	José Sarney	Founding of the Ministry of Science and Technology (MCT) to which INPE is associated.
1987		Signing of the Missile Technology Control Regime agreement by USA, France, England, and Canada.

1989		Last flight of qualification of the Probe IV. Cooperation between Brazil and China towards developing satellites for optic remote global observing systems, called China Brazil Earth Resources Satellite (CBERS).
1993	Itamar Franco	The first Brazilian satellite from the Data Collection Satellite series (SCD), the SCD-1, is put in orbit, to collect data on climate, weather forecasting and the environment.
1994		Founding of the Brazilian Space Agency (*Agência Espacial Brasileira* – AEB). Approval of the Brazilian National Plan of Space Activities (*Plano Nacional de Atividades Espaciais* – PNAE).
1995	Fernando Henrique Cardoso	Adhesion to the MTCR agreement (Missile Technology Control Regime). Partnership with NASA in the AVIRIS images to study the forest fires.
1996		The Brazilian National System of Development of Space Activities (*Sistema Nacional de Desenvolvimento de Atividades Espaciais* – SINDAE) and the PNAE are instituted, for the period of 1996 through 2005.
1997		The VLS-1, the first Satellite Launching Vehicle is launched without success.
1998		The second Brazilian satellite, the SDC-2 is launched. Brazil signs an agreement, under the shelter of the International Union of Telecommunications (UIT), giving access to a geostationary orbit. Doctorate course in remote global observation systems is created, at the INPE.
1999		The CBERS-1 remote global observation satellite is launched, product of the Brazil-China Bilateral Agreement, and two Brazilian scientific satellites as piggybacks of the CBERS-1, one of which is the SACI-1 are constructed by the INPE.

2000		The 5th probing rocket from the VS-30 series is launched as a result of the cooperation between Brazil and Germany. The CLA, the 1st prototype of the probing vehicle, VS-30/ORION, from the microgravity project, is inserted in the PNAE. The Space Fund is created to fund scientific and technological activity in the Space sector.
2001		The SCD-1 satellite, launched at Cape Canaveral completes more than 40,000 orbits around the earth.
2002 2003		The probing rocket VS-30/ORION is launched in cooperation with Germany. The Agreement of Cooperation with China is renewed, with the expectation of launching the CBERS-2 (July 2003) and the CBERS-3 (in 2006). In August, explosion of the VLS and the Launching Platform at the Alcântara Base.
2007	Luiz Inácio Lula da Silva	Brazilian Research Network on Global Climate Change (Climate-Network), MCT Bill n. 728 from 03.12.2007.

Table 1: Chronological development of the BSP.

Source: Villas-Bôas, 2001, p. 76.

Despite the heavy losses caused by the explosion at the launching base, not only of materials, but mainly of human resources – with the death of the technicians, engineers and other qualified personnel, another virtually irreplaceable and intangible patrimony was lost: their knowledge and expertise –, other BSP activities were not affected. Those involving monitoring of Brazilian territory under the responsibility of the INPE are particularly important.

2.1 The INPE, the Amazon and the dialectic arena

Among the INPE objectives are developing technology and programs, and generating products related to weather and climate. The monitoring of forest fires as well as resulting emissions, of deforestation, and of hydro resources are part of the INPE mission. Studies in space and atmospheric sciences, weather forecast and climate studies, space technology and engineering, earth observation, remote global observation and geoprocessing are found within the active areas of this complex. The Climate-Network's mission is to produce and disseminate knowledge and technology that respond to the challenges of global climate change. An example of this concern is the development of a research program and a system based in Rio de Janeiro for monitoring severe storms, cyclones and hurricanes in the South Atlantic. Concerning the INPE, the Center for Weather Forecasts and Climate Studies (*Centro de Previsão do Tempo e Estudos Climáticos* – CPTEC) is the organ responsible for the development of methods and instruments for weather forecasting and monitoring of climate conditions. It is a relatively strategic area, particularly when the success of agricultural production, for example, depends on the quickness of circulation and exactness of information. Climate monitoring presently depends on the data sent by imagery satellites of the METEOSAT series and the GOES series (Geostationary Operational Environment Satellite), a reference in meteorological studies, in addition to being operated by the National Oceanic and Atmospheric Administration (NOAA).

The INPE concentrates part of its expertise on monitoring the Amazon. It is a strategically important region due to its territorial dimension and its biotic characteristics, hosting a complex biodiversity and ethnodiversity. Monitoring the Amazon meets three objectives: territorial security monitoring (boundary, clandestine operations); mapping of natural resources (mineral wealth, hydro resources – energy potential and navigational feasibility); and control and prevention (natural phenomenon, forest fires and deforestation). The items of greater concern are the detection of clandestine movement (smugglers, drug traffickers and foreign troops) and the intention to establish prevention programs that control forest fires and deforestation.

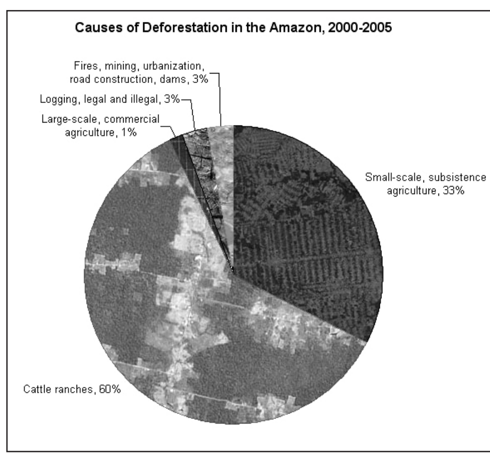

Figure 2: Graphic on deforestation.

Source: Google Image.

There are two programs specifically dedicated to monitoring the Amazon, the DETER system (Detection of Deforestation in Real Time), which has sensors in the TERRA, ACQUA, and CBERS-2 satellites; and the PRODES (Monitoring of the Brazilian Amazon Forest by Satellite) system. INPE maintains an updated Forest Fire Data Bank. Data about forest fires and deforestation show that there is a constant growth in the rate of forest devastation by fire or deforestation for economic exploitation. In the period between 2006 and 2007, the rate of deforestation was of 11,200km^2 per year, but from August 2007 to March 2008, 4,730km^2 were deforested, leading to a prediction that from August 2007 to July 2008, the devastated area should surpass the previous calculation.

These data are not received, processed and interpreted neutrally. There is a dispute of meanings around them, in which each contending party uses the data for their own interests. The arena of dialectic dispute encompasses federal powers, state governments, and civil society organizations (institutions, groups associated with agribusiness and the press). The federated states that are more committed to agribusiness contest the INPE data and petition for less regulation within the tribunals; federal government organs use the data to create administrative instruments as a form of containing deforestation; the members of congress debate and propose laws that regulate the sector, where the game of interests is also reflected. In civil society, this data serves to guide the actions of several non-governmental organizations, in the same way that the press also fulfills its role by reverberating the diverse frictions and meanings that the data and its interpretations produce throughout the dialectic arena. This dispute for meaning is verbalized in the expression 'sustainable development' (cf. Orlandi, 2005), which for each group and its respective network of interests represents a different meaning.

3. National states: sovereignty and transboundary issues

In face of the science-society relationship, we emphasize that in capitalism technique and science are deeply bonded. The strengthening of this relationship is expressed in the scientific form of contemporary society, which cannot be understood without referring to the techno-scientific component, since "scientific activity is increasingly converted into an integrating part of social action, [...] achieving such a degree of institutionalization that [...] it constitutes one of the strongest instruments of power, both politically and economically" (Herrera, 1981, p. 22). Also, as Schaff emphasizes, we cannot neglect the structuring effects that the techno-scientific revolution has over social relationships (Schaff, 1995).

The presence of this component in the context of social reproduction can be measured by its incorporation to the definition and operation of society, performing a strategic function, as a productive force or even as merchandise. This demonstrates that the political state and the technical state have reciprocities, since scientific and technological advancement are offered as part of a global system in which state policies and the market are entwisted.

There is a symbiotic relationship between science, the power of the state and the market, in which the relative expectations for the applications of science are increasingly immediate, according to their results and interests. Thus, influencing the production of globalized surplus value, every new scientific breakthrough is a highly potential profit enhancer.

To argue the technological imperative as a foundation for transformations processed in society is to touch on the issue of diversifying the points of decision that redefine political space and the relationships of power, which have been reiterating the persistent need to discuss sovereignty and the territory of the states. This new context is founded on commercial, technological and financial concentration, combining the accumulation of capital and the control of the scientific-technological knowledge diffusion, and thus generating an economic and techno-scientific polarization upon which new relationships of power are built among the nations (Darc, 2004).

The transboundary concept is related to the Hardt-Negrian concept of ‘empire’, characterized by the absence of fixed boundaries and by the decentralization of power – a type of sovereignty that we would call liquid (Bauman, 2001) –, weaving an economic-socio-political network composed of “national and supranational organisms, united by logic or unique rule” (Hardt & Negri, 2001, p. 12), a logic of domination also noted by Ianni (2004). According to Bauman (1999), the development of space technology is capable of generating a synoptic form of internal control, by means of the production of politico-technological instruments that equip several sectors of the government machine, and whose result is to maintain the totality of the internal elements under several forms of vigilance (direct or subtle): fiscal control, control of the means of analogue and digital communication, etc.

This politico-historical configuration reminds us of the Gramscian notion of hegemony (cf. Gramsci, 1978; Portelli, 1977; Gruppi, 1978; Buci-Glucksmann, 1980), characterized by the exercise of leadership to maintain a network of alliances, basing its political and cultural action on a set of actors and factors that lead to the formation of an order and an ideological-cultural orientation, whose purpose is to “mediate the extremes, *socialize* the technological innovations that enable the functioning of every activity of direction” and, in this way, maintain the network of correlations of forces in a system and in balance (Gramsci, 1978, pp. 51, 192-193).

The national state is constructed through debate as an inevitable universal phenomenon, in the same way that the capitalist-world-economy (Wallerstein, 1991) is reached at a global level. It is thus understood the reason why the irradiating centers of technological progress and capital concentration are also the most benefitted parts. The concepts of centre and periphery work as a spatial metaphor linked to the transboundary concepts of globalization, since the periphery is not extrinsic to the center, it is part of it, even when it is integrated to the set of actors engaged in the dispute for hegemony. The periphery is defined as to the politico-economic statute, but equally scientific and technological, from its insertion in the world economic network (Villas-Bôas, 2001).

The international techno-scientific and economic space is built as a hierarchical space, and its expansion is achieved through exacerbated competition between the members of the hegemonic system. The dispute over power in the periphery of the system tends to intensify, especially in relation to sustainability, marking the widening of symbolic and digital territory of this dispute on a global level (Adda, 1999). Because of scientific-technological progress, and the degree of capital accumulation of the countries that lead this process, a *modus operandi* simultaneously politico-cultural and socio-economic was imposed, and continues to predominate until today.

Scientific and technological products simultaneously become strategic property and merchandise. The states with a long tradition of investments in scientific research possess a potential institutional structure with generous investments in goals and projects that are established and constantly redefined according to the degree of competition given to them in the world economic arena. As strategic resources, science and technology become instruments of power in the international arena. And they are protected as assets, which is why they are not freely passed on, since their availability is strategically restricted in the global market, in which they are privatized and commercialized by the great economic agents.

This process of expanding the economic boundaries of the world powers, associated to technological development, comprehends an economic structure divided into economic subsystems with different levels of development, and because of this, it establishes a relational circuit between rival national economies (Hobsbawn, 1977, 2007).

Within this rather competitive international context emerges a conflict resulting from the symbiosis between science and politics in contemporary society, whose results are soon felt, notably in the fields of physics, engineering, chemistry and biology, given the strengthening between scientific-technological development and politico-economic strategies of the nation states. On the other hand, this evidence (as noted by Shinn & Ragouet, 2005) reveals a preconstruction by which the scientific practice and the political practice are kept as two separate operations by the discursive apparatus. Scientific knowledge constitutes a part and the effect of a historically determined process, and particularly the process of economic production itself (Pêcheux, 1988), whose indications are found in its practical application and its political use.

With the event of World War II, a decisive moment of new composition in relation to science and society is inaugurated: “the atomic bomb [was] fruit of a possibility caused by the so called *pure science*, uncompromised with respect to technical applications” (Bartholo, 1987, p. 120). It is a rather representative expression of the contemporaneity, given the destructive potential that marches parallel to productive potential, even surpassing it:

> The Manhattan Project is the best example [...] of operational viability being inserted into a technological scientific practice in a complex division of work [...], within which each link contributes to add conditions promoting the success of the Project, although if each one of these were isolated, they could be interpreted as [...] possibilities of action, uncompromised with respect to the finalist sense of the whole (Bartholo, 1987, p. 120).

The logic of competitiveness emanating from the market and the intersystem confrontation is extended and internalized in scientific practices, open and formally integrated into the objectives of the states, which direct their efforts towards politically strategic and economically advantageous objectives. Stronger economies focus on establishing the infrastructure of institutional and instrumental apparatus that demand extensive financial resources. We can thus establish a connection between the fluidity of scientific-technological boundaries and the economic-political ‘transboundary’. In both cases, neither territories, nor identities are annulled, but porosity allows the representations of the socio-economic-cultural, and therefore techno-scientific, matrix to go across the boundaries, as well as the hegemonic discourse.

4. Society, science and hegemony

Space activities have found in the politico-ideological and technological fields where nations are in dispute for supremacy very promising fields, and this feature helps us to understand why the military objectives appear as priority goals in space programs. In addition, space capacity was determined more by scientific-military imperatives than by economic reasons, and to a lesser extent, by market forces. This perspective recalls, on the one hand, a symbolic demonstration that the latest technologies are a privileged display of power for the world powers, similar to what occurred in the large scientific expositions of the nineteenth Century; and, on the other hand, it recalls the double dialectic reference we have previously mentioned.

Scientific organizations and practices, while social forms, establish relationships and mediations with the whole of society. As such, they integrate the device of hegemony shaped by an intercommunicative network, practices and agents, involving national and international organs, means of communication, and educational and cultural systems. The role of the intellectual-scientist is prominent, and his action in the field of knowledge and publicity guarantees and maintains subjection to the ruling hegemony, especially regarding the image of science as the guardian of the wide gnosis-quality of the reality where we are immersed in. This network of discourses includes all the processes of production, procedures within and outside of the field, corporative organization, hierarchies and associations, means of publicity and protocols for validation and legitimacy.

The BSP integrates the strategic spheres of state decisions and needs, thus the strong military-industrial component that it portrays. Space programs and technologies have interdisciplinary scope and impact, and above all, they are boundless. From either space or the earth's surface, exploration and monitoring actions whether for prevention, environmental preservation, or as a contribution to production involve issues that transcend local interests. Technologically, the structure of a space program depends on a network of relationships ranging from techno-scientific to industrial and commercial.

Competition for technologies and investments needed for maintaining a space program results in both associations of the science-industry and civil-military types and in the exercise of control by those who are more advanced in this field. In this manner, the transmission and commercialization of this technology are inserted in the strategy of the producer states to maintain hegemony, reinforcing dependent relationships.

By outlining the historical and socio-political profile of the BSP, we find evidence to the institutional capacity of Brazil in this key area, considered an important element in terms of territorial sovereignty, in a world order marked by contradictions between the local and global levels. We demonstrate that through investment in technological development programs, space systems and supporting infrastructure, Brazil has consolidated an internationally recognized scientific community in the area of remote global observation systems, meteorology, oceanography and space engineering and technology. It has also accumulated a significant space patrimony with positive impacts on the industry of components and extremely high precision parts (Villas-Bôas & Borges, 2006).

In the dialectic arena where national territory and sovereignty are confronted with the globalized economy in which commercial, technological and financial concentration leading up to economic polarization is observed, and where information circulates from large producing centers to other network members, the struggle for greater investments and self-sufficiency in the scientific and technological fields represents a priority strategic goal for those states that wish to maintain their sovereignty and guarantee sustainability.

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Keeping meteorology masculine: the American Meteorological Society's response to television 'weather girls' in the 1950s

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1. Introduction

For most people in the United States today, and indeed for many people around the world, television is central to the daily experience of weather. People make decisions that range from the mundane ("should I take an umbrella?") to the life-altering ("should I evacuate my home?") on the basis of television's representations of weather (Lazo & Chestnut, 2002). While these images and narratives depend upon a global infrastructure of observing stations, satellites, computers, technicians and analysts, television news rarely makes this technological system explicit (Edwards, 2006). Instead, the creator of these wondrous images is implied to be one friendly person, about 85% of whom are men, whose regular presence in the living room has made him a comforting, familiar and trusted source of information (Wilson, 2008). Weathercasters also report being involved in public outreach activities like giving guest lectures, participating in science and career fairs, and mentoring students, at a higher rate than any other group of American Meteorological Society (AMS) members (Reynolds et al., 2008). The TV weatherman is the public face of American meteorology, and broadcast meteorologists affect the authority of atmospheric science more generally. Exploring the historical construction of the TV weatherman as a social and theatrical role reveals how it became perhaps the most prominent type of modern science communicator.

The mid-1950s were anxious times for American meteorologists. President Eisenhower cut the federal budget, and Weather Bureau Chief Francis Reichelderfer chose to reduce the number of ships patrolling for hurricanes off the Atlantic coast (Whitnah, 1961, pp. 207-208). Then the weather shifted, and hurricanes Carol, Edna, and Hazel swept up the Eastern seaboard in 1954, the first major storms to hit America's cultural and political core in fifteen years. As millions of people turned to television for weather information, they increasingly saw entertainers embellishing tomorrow's forecast, rather than technically trained meteorologists explaining the atmosphere's behavior. Many stations employed clowns, cartoonists or puppets; dozens of other stations hired 'weather girls', aspiring actresses and beauty queens with no experience in meteorology, to wrap the forecast in poetry, songs and double entendres (Henson, 1990). As *Life* magazine put it, "between girls and gimmicks, men are more and more being left out in the rain" (Life, 1955, p. 9). The public image of the weather expert was becoming a sexy young woman holding not a degree in science, but a ukulele (Figure 1). Meteorologists thus found their authority over the weather challenged by nature, entertainment and femininity.

This paper examines how meteorologists used professionalization to secure public recognition of their authority, focusing on an effort to gender television weathercasting as a male occupation. Like the professionalization of engineering that Ruth Oldenziel describes in *Making Technology Masculine* (1999), the professionalization of meteorology established social structures that disproportionately barred women, contributing to the under-representation of women in atmospheric science that persists to this day (Murillo et al., 2008).

2. Professionalizing American meteorology

Starting with President Carl-Gustaf Rossby in 1944, a series of AMS officers and committees sought to transform the AMS into a professional society responsible for regulating the employment, scientific practices, and public statements of weather experts. During the 1940s, the AMS launched a research journal, created a class of 'professional' members, with the exclusive right to elect AMS officers, and encouraged industries to hire meteorologists. In the 1950s, AMS committees tried to codify rules for meteorological consulting practices, began to publish consensus statements about the limits of scientific capability, threatened to expel members who made exaggerated claims in public, and created certification programs. While AMS efforts to discipline meteorology never gained the statutory recognition that empowered professions like law, medicine or engineering, they did produce considerable benefits for the career prospects of credentialed meteorologists. These gains, however, came at the expense of people systematically excluded from the institutions of meteorology, especially women.

The contemporary era in American meteorology began during World War II, when Carl-Gustaf Rossby coordinated the nation's five graduate programs to train the thousands of weather forecasters needed for the Army and Navy's rapidly expanding air arms. Rossby managed to secure an elite group of military cadets already well educated in calculus and physics. By War's end, more than 6,000 young weather officers had imbibed the Bergen School's calculation-driven approach to weather forecasting. These men, the weather cadet generation, represented a ten-fold increase over prewar numbers of weather researchers and forecasters (Turner, 2006). About 200 women were also trained in the same classrooms by the same faculty. While military rules prevented them from being posted overseas, women worked as aviation forecasters, classroom instructors and scientific researchers just like their male counterparts (Lewis, 1995; Williams, 2001).

After the war, many in the weather cadet generation sought to make careers in meteorology. The growing airlines hired some, while graduate programs also expanded with funds from military research contracts and the G.I. Bill. Rossby, with an almost paternal concern, worked through the AMS to create job opportunities. He created an employment file at AMS headquarters, encouraged the development of 'cultural' meteorology courses at liberal arts colleges, and evangelized to corporations about the benefits of hiring staff meteorologists. Rossby emphasized that the men of the weather cadet generation were a new class of weather experts; their university training and wartime forecasting experience made them 'professional' meteorologists. This language of professionalization partly reflected long-established Weather Bureau usage, where the ‘professional’ and ‘sub-professional’ grades marked a key difference in rank and responsibility; the professional grades worked as analysts, forecasters, and managers, while the ‘sub-professional’ grades read instruments and recorded observations. Rossby also used ‘professional’ to draw sharp lines between people with certified education in meteorology (either in universities or military institutions like the Naval Post-Graduate School) and people who did meteorology-related work but lacked formal training (Turner, 2006, pp. 162-164).

Constructing meteorology as a profession also meant marginalizing women. In post-war employment, women were offered only ‘sub-professional’ jobs below their experience and training. Maud Greenwood, for example, had been a Navy forecaster responsible for giving trainee pilots pre-flight weather briefings during the conflict. She hoped to be an airline forecaster after the war, but was told, “A woman could not deal with pilots and dispatchers,” but “could be hired as a map plotter” (Lewis, 1995, p. 2199). Within the Weather Bureau, women were rarely employed in forecasting and supervisory positions (Dean, 1958). In education, many male professors refused to accept women for graduate study, even women who had earned masters degrees for research conducted during the War (e.g. Simpson, 1989). Meteorology was part of the much larger pattern of employment and educational discrimination against women after World War II (Rossiter, 1995; Milkman, 1987).

During the 1950s, the AMS created two certification programs in an effort to exclude practitioners who did not fit its vision of meteorological professionals. The Certified Consulting Meteorologist program aimed to control cloud seeders and other weather advisors, by requiring meteorological training and prohibiting public claims that exceeded the commonly accepted limits of scientific capability. The Seal of Approval program for broadcast meteorologists sought to improve the public image of meteorology by encouraging TV stations to employ trained forecasters and present the weather as a serious subject. Exploring the development of televised weather in the light of meanings of gender in the 1950s reveals how weathermen used professional certification programs to exclude women from an emerging career in meteorology.

3. Television and the ‘Weather Girls’

The television weather report is a genre invented in the late 1940s by members of the weather cadet generation like Louis Allen, Harold Taft, and Francis Davis. These men adapted the narrative form and the visual pedagogy style they first used to inform military pilots about the weather. The narrative emerged from the pre-flight briefing, as Harold Taft recalls:

> We thought it would be a good idea to use the briefing techniques that we used for pilots during the war for television, because it was a natural medium for it. [...] We would put a map up, we’d show ‘em what the weather was, what it was going to be at the target, and what they’d expect when they returned. We gave ‘em a briefing. Same thing we do today. [...] Give me a map, a piece of chalk,

and a stick and I'll tell you about the weather (Dempsey, 2001, p. 52).

The visual style of TV weather evolved from mating wartime educational practices with synoptic maps, the long-established public representation of meteorology, under the constraints of low-resolution TV screens (Turner, in preparation). Many draftee pilots learned meteorology from illustrated manuals that used the conventions of comic books, part of a military effort to tailor technical education to vernacular reading practices. During the war, meteorologists like Maud Greenberg had used cartoons to help rookie pilots understand and pay attention to weather briefings (Lewis, 1995, p. 2198). The first generation of TV weathercasters sketched a simplified synoptic map live on the air, while narrating the conditions. Louis Allen, broadcasting in Washington, D.C. in 1948, thought education was a crucial part of the weather report and felt that 90% of learning was visual. He held his audience's attention by sketching a 'doodle' that symbolized tomorrow's weather. Viewers requested copies of his maps and doodles, writing, "the maps and the diagrams make a subject, otherwise technical, very easy to follow," and "All our neighbors gather 'round our TV set every evening just to see you," more interested in learning about the weather than ever before (Stone, 1949, p. 35; Henson, 1990, pp. 34-35). Allen's doodles generated so much enthusiasm that cartoon weather reports spread across the country. As a 1952 *New York Times* headline put it, the "Televiewer is Wilted by Wave of Weather Men, Pointing, Doodling and Spouting Temperatures" (New York Times, 1952).

While Allen used weather comics as an engaging pedagogical device, television producers misinterpreted them as entertainment. Comic books and cartoons were low culture, enjoyable rather than educational. Since viewers liked weather comics, it stood to reason they must not consider the weather to be an important subject. Station managers began to use comic weather reports to leaven their serious news programs. Using the data and official forecast available to anyone at the local Weather Bureau office, men with no meteorological training became some of the most successful weathercasters during the 1950s. Cartoonists P.J. Hoff in Chicago and Tex Antoine in New York created beloved characters like the Vice-President-in-Charge-of-Looking-out-the-Window and Uncle Wethbee (Henson, 1990, p. 36). While Antoine was very respectful of the Weather Bureau and the science of meteorology, he saw the weather report itself as "a rather dull subject" in need of "sugar coating" (Time, 1968, p. 83). Many television producers agreed with him, hiring personality over meteorology (Jehn, 1964).

The success of Tex Antoine and Uncle Wethbee on WNBC created a ratings battle that led to the introduction of women as weathercasters. New York City was a key market, home to flagship stations for all three of the major networks. In 1952, WCBS and WABC tried to break Antoine's lock on weather watchers by hiring women to do the weather. WABC's station manager Joseph Stamler explained the move this way: "We feel that women – or ladies – have greater acceptance than men, because, well, with the combination of an attractive-looking personality the men prefer to look at and the women are attracted to because of the fashions they wear, we've really got a two-fold program" (Allen, 2001, p. 16). The stations hired beauty queens, models, or actresses, who had no technical training in meteorology. A *Vogue Pattern Book* (Figure 1) spread featured an image of a smiling Jan Crockett strumming in front of a weather map, wearing "a figure skimming 'Young Fashionables' coat dress of clear water-lily green worsted and silk, double-breasted with self-covered buttons" (Vogue Pattern Book, 1962, p. 55). Another picture showed Jan taking her script from a suited, rather dumpy-looking male meteorologist who actually produced the forecast. The 'weather girls' represented hegemonic femininity, put on screen to attract the heterosexual male gaze, not educate the public about meteorology. The trend caught on nationally. As Robert Henson, the leading historian of broadcast meteorology has documented, by 1955, "women made up a major fraction of all weather anchors, if not a majority" (Henson, 1990, p. 82). 'Weather girls' were profiled in mass-market magazines like *Life* (Life, 1955, pp. 8-10), and became subjects of episodes in situation comedies like *The Dick Van Dyck Show* and *The Beverly Hillbillies* (Reiner, 2003; Filmways, Inc., 1989).

Since relatively few early local news shows were recorded, *The Beverly Hillbillies* episode "Granny versus the Weather Bureau" (1964) offers a useful source for exploring how 'weather girls' threatened the authority of meteorologists. The episode also suggests how different kinds of viewers were expected to react to 'weather girls', admittedly in caricatured form. As the show opens, a gangly young man leaps out of his jalopy and rushes into the family mansion, announcing "It's time for the weather on television!" Jed Clampett asks his daughter Elly May, "Since when is Jethro so interested in the Weather?" "Since he seen that pretty girl that talks about it," she answers. The scene cuts to an attractive young brunette whose pearls emphasize a swooping neckline, televised in front of a simplified map of the northern hemisphere. With an alluring smile and a provocative sway of her hips, she announces that a high-pressure system will hold back the mass of moist air moving in across the Pacific. ("Hot diggity dog, ain't she pretty!" comments Jethro.) "By the way, there'll be a full moon tonight," she continues, "Perfect for a weenie roast on the beach. See you there..." she invites with a wink (Filmways, Inc., 1989).

Figure 1: Jan Crockett presenting the weather report on WABC-TV in New York City.

Like many 'weather girls', Crockett was a talented entertainer who had no training in meteorology. Here she uses her trademark musical style to model a flexible wardrobe designed for Indian Summer.

Source: Vogue Pattern Book, 1962, p. 57.

These images threatened the authority of credentialed meteorologists by obscuring male scientific labor and making weather forecasting seem like a trivial activity unfit for scientific status. The huge amounts of men's work in collecting, charting and analyzing weather data disappeared behind a pretty, female face, which rendered the actual atmosphere almost irrelevant. Choosing a weathercaster based on looks suggested that anyone could be a forecaster, and that research, theorizing and observation were irrelevant. But most importantly, that pretty face connoted a set of hegemonic feminine associations with subjectivity, sex, and emotional engagement. 'Weather girls' implied meteorology could not produce the objective, reliable predictions considered the hallmark of true scientific knowledge.

For meteorologists in the 1950s, historical connections between the feminine and subjectivity particularly threatened their credibility. "The only thing as variable as the weather is the ways of women," wrote *Life* in 1955 (Life, 1955, p. 9). Femininity invoked a long-established discourse about the need to maintain emotional distance between the object of scientific study and researcher, which stood in contrast to equally long-established cultural notions of women as emotional and irrational beings. The imagined closeness of women to nature was believed to make it impossible for them to detach themselves emotionally to produce objective knowledge (Keller, 1985; Merchant, 1980). Dynamic meteorologists from Vilhelm Bjerknes through his student Carl-Gustaf Rossby through Rossby's thousands of weather cadet protégés asserted that the atmosphere was fundamentally predictable, working to transform weather forecasting from an intuitive, experiential art into objective calculations based on the basic equations of physics (Friedman, 1990; Turner, 2006). After a long history of being connected with charlatans and false prophets (Anderson, 2006; Spence, 1980), meteorologists felt they were finally becoming recognized as reliable and accurate scientists. As Frank Forrester, later a TV weathercaster in Washington, D.C. wrote in 1957,

> Not too long ago the weatherman was caricatured as an ineffectual, bearded, finger-wetting and preoccupied sky gazer. Today's weatherman is much more impressive. He is part of a complex corps of specialists who are constantly laboring to expand and apply their science. Industries and armies have come to rely upon him for guidance in their planning (Forrester, 1957, p. 292).

As earlier caricatures faded, a new image was emerging: the meteorologist as heroic man protecting society from dangerous female weather. The panels of a 1958 Chesterfield Cigarette advertisement, "Men of America: Hurricane Alert," credit the US Weather Bureau for a series of "live action shots" that feature a thick-necked, clean-cut, cigarette-smoking man reading the teletype, plotting a hurricane track, and issuing a "radar warning, storm will hit our shore" (Chesterfield Cigarettes, 1958). Beginning in the early 1950s, the Weather Bureau publicly named hurricanes after women, an informal meteorological practice that first came to widespread attention after the 1941 publication of George Stewart's novel *Storm* (Stewart, 1941). But the 'weather girls', like hurricanes Carol, Edna and Hazel, threatened claims that meteorologists produced dependable knowledge essential to keeping society safe. Women weathercasters subconsciously reminded viewers that forecasting remained a subjective and intuitive enterprise, that the weather remained uncontrollable, and that meteorology might not be so 'hard' a science as its professional practitioners asserted.

4. The AMS response

The AMS responded to 'weather girls' and comedian weather presenters by launching a Seal of Approval program. Serious discussions about the Seal began at the peak of 'weather girl' era, when the AMS Council voted to establish an *ad hoc* Committee on Radio and Television at its meeting in New York in January 1954. In May 1955 the Committee became permanent, and the Council agreed to its suggestion that the AMS approve exemplary programs, rather than condemn low-quality broadcasts. Efforts to define a good weather program focused on the personality of the presenter, emphasizing that presenters must maintain a "professional manner," in the words of Committee member James Fidler, a Weather Bureau meteorologist who was one of the first to appear on television. As far back as 1948, Fidler had argued,

> There is no place for a 'character' insofar as the profession of meteorology is concerned. The weatherman has too long been pictured in the public imagination as a grotesque creature, so care must be taken that this new medium presents him to the public in what (we trust) is his true personality (Fidler, 1948, p. 330).

The proper weathercaster should make "an accurate presentation of the facts," that was "audibly coherent" and "smooth to watch," while "always appear[ing] sincere and confident" (Ibid.). Fellow committee member Frances Davis seconded Fidler's focus on the persona projected by a weather presenter, implying that the authority of meteorology depended upon the representations shown on TV. Under the assertion "Weather is no Laughing Matter," Davis went public with the AMS's plan in a July 1955 article in *TV Guide*, writing

> If TV weathermen are going to pose as experts, we feel they 'should' be experts. We think the weather should be discussed with dignity. Dignity, not dullness. We think many TV 'weathermen' make a caricature of what is essentially a serious and scientific occupation, [and] help foster the notion that forecasters merely grab forecasts out of a bowl (as cited in Henson, 1990, p. 9).

Displaying a professional manner thus required a weathercaster to perform a confident, dignified and technically accurate presentation of weather facts while projecting the authority of natural science. University of Texas meteorologist K. H. Jehn, writing 'as a professional', sought to add a pedagogical component to this burden. Believing that "the educational feature is essential," Jehn hoped, "viewers will learn something about the weather at the same time that they hear [...] the forecast for tomorrow." He argued that the "basic criteria for issuance of the seal" should include "a technically correct presentation, with an educational feature and entertainment value" (Jehn, 1956, p. 351). At the time, Jehn was not a broadcaster, but the AMS apparently appreciated his contributions enough to appoint him chair of the Radio and Television Committee.

While it was easy to tell other scientists that the weatherman should be dignified and accurate, educational and authoritative, the realities of commercial broadcasting gave meteorologists little control over the presentation of the weather. As Frances Davis noted as early as 1949, because broadcasting was a money-driven business,

> the professional meteorologist in radio must be reconciled to having the virtues of various products extolled before and after his weather broadcast, and sometimes in the middle. And he will find it to his advantage occasionally to tie the sponsor's product in with the weather incidents described in the body of his own script, contrary as it may be to his professional principles (Davis, 1949, p. 86).

Photographs show sponsors' logos displayed prominently on maps and behind weathercasters during the 1950s (Leep, 1996, p. 502), while video clips from 1960s weather reports show weathercasts supported by gasoline companies and local banks. The Savannah Bank and Trust Company sponsored Cap'n Sandy on WSAV-TV in Georgia during the early 1960s. A series of different weathercasters played Sandy over the years, each wearing a captain's hat and naval jacket while they narrated their hand-drawn weather maps. Pausing between describing the national and the regional weather conditions, Sandy would introduce a message from his sponsor, like a one-minute pitch for a vacation loan and a reminder to buy traveler's checks, which the Cap'n said was "mighty good advice." Wilber the Weather-Bird, dressed in rain gear, might drop in with a forecast clamped in his beak, and then Sandy would read "the official Department of Commerce Weather Bureau forecast" before thanking "Arthur" for showing 88 degrees and noting with a twinkle that "Arthur-mometer is right up there today" (Captain Sandy, 1964). In the eyes of the station managers who hired and fired, it was sponsorship that defined a successful weathercast, not the presentation's educational value or the dignified authority of a professional meteorologist.

The tensions between commercial reality and meteorologists' conceits delayed the Seal of Approval program for nearly four years. It was not until February 1959 that K. H. Jehn, describing himself as "older and wiser now, and with nearly two years experience in the ways of radio and television production," was able to announce the criteria for awarding Seals of Approval (Jehn, 1959, p. 85). First, all Seal applicants had to be Professional Members of the AMS. In 1957, the AMS Council had changed the procedure for becoming a Professional Member, requiring that a candidate be sponsored by two existing Professional Members, "have completed a professional course in meteorology at an institution of recognized standing and have been employed in meteorological or climatological work at a professional level for at least two years, one of which must be the year prior to election" (American Meteorological Society, 1957, p. 144). After meeting those standards, a weathercaster would submit an application and fee to the AMS. Members of the Radio and Television board, along with local AMS members in the broadcast region, would then evaluate "the performer and his or her program" on four criteria: informational value, audience interest, educational value, and professional attitude. Each criterion was judged unsatisfactory, marginal, satisfactory, or excellent, and a performer had to score at least satisfactory in all criteria to be accepted. The committee placed special emphasis on professional attitude, defining it by noting: "He [the weathercaster] acts in such a way as to enhance the prestige of meteorology as a science and a profession." In a footnote, the Committee emphasized that a professional attitude "is an expected attribute of a competent *meteorologist*," in contrast to merely a creditable weathercaster (Jehn, 1959, pp. 85-88; emphasis in original). True meteorologists were professionals, and professionals were not women.

The Seal of Approval program's statistics reveal how the practices of professionalization excluded women. Because AMS Council members and committee members generally retained their own records, I have been unable to find evidence of who applied and who was rejected. The gender of successful applicants, however, provides telling evidence. Between January 1960 and December 1972, the AMS awarded 95 Seals to men before approving the first woman. Of the first 200 approved weathercasters, from 1960 to 1979, just 3 were women. The rate of women in the next hundred seals more than doubled, but was still just 4%. By the end of 1984, twenty-five years after the start of the program, just 11 out of 352 seal holders (3.1%) were women (historical list of Seal holders published in Henson, 1990, Appendix II).

5. Conclusion

Today, as the Seal of Approval nears its fiftieth birthday, women weathercasters continue to work beneath a "chromakey ceiling" (Wilson, 2008, p. 78). While the AMS has taken positive steps to integrate women into meteorology, such as establishing a Board on Women and Minorities in 1975 and awarding a significant percentage of its undergraduate and graduate scholarships to women, women constitute only about 20% of the AMS membership overall (Murillo et al., 2008, p. 731). Regarding professional certifications, women hold about 18% of active television Seals of Approval, a higher percentage than ever before (Table 1).

Certification	Men	Women	Percentage
TV Seal of Approval (active)	671	149	18.2%
Radio Seal of Approval (active)	22	1	4.3%
Certified Broadcast Meteorologist (Total)	264	30	10.2%

Table 1: Gender of active AMS broadcast meteorologist certification holders, September 2008.

Source: Kelly Garvey Savoie, AMS Director of Special Programs (Savoie, personal communication, October 2, 2008).

Yet two disturbing facts challenge the idea that broadcast meteorology is making progress in integrating women. First, American women weathercasters are much more likely to broadcast at less prestigious times; nearly three quarters of women work the weekend, morning or noon shows, while almost 60% of men work prime time (Wilson, 2008, pp. 78-79). Second, the AMS's new, more advanced certification program has an even lower percentage of women than the AMS membership as a whole. Introduced in January 2005, the Certified Broadcast Meteorologist program aims to raise the professional standard in broadcast meteorology and encourage a broader range of scientific understanding, especially with respect to environmental issues. The goal of the CBM program is to certify that the holder meets specific educational and experience criteria and has passed rigorous testing in their knowledge and communication of meteorology and related sciences needed to be an effective broadcast meteorologist (American Meteorological Society, 2008).

While improving public understanding of environmental issues is laudable, certifying the education and professional standards of broadcasters is a problematic way to achieve this end. As the history of the AMS Seal of Approval shows, professional certifications can be exclusionary tools used to establish public authority. Once a profession has established its authority, certifications reinforce existing social hierarchies, requiring new entrants to gain the approval of older leaders. A certification program's internal effects on the behavior and demographic composition of professional members are much more direct that its external effects on public education. The act of judgment is inextricable from the act of exclusion; it is through such exclusions that gender boundaries are crystallized and maintained.

6. Acknowledgements

This research has been partially funded by a Graduate Fellowship in History of Science from the American Meteorological Society. The views expressed are solely those of the author.

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The end of weather: outdoor garment industry and the quest for absolute comfort

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In the well-known paper on climate stabilization appearing in *Science* in 1974, Kellog and Schneider addressed the intentional and accidental climate changes. There they said that the ability of human actors to alter climate depends on their chosen scale of action: for example, "wearing warm clothes on a cold day is probably the smallest scale, heating and cooling the air in a house is a slightly larger conventional undertaking, and changing the air temperature over a large city is now quite commonplace, although not planned" (Kellog & Schneider, 1974, p. 1166). Today I'd like to revisit these scales of engagement and, in particular, focus on the relationship between the perception of daily weather, environmental comfort, and the recent boom in outdoor clothing industry. This I do partly because clothing practices are still the most common and familiar form of climate control and partly because their invisibility in the science studies betrays a continuing appetite for the megalomaniacal approaches thrust upon us by the fascination with climate and weather as 'global' phenomena.

If weather and climate are global, so is clothing. We dress for many reasons and here I will not be able to look into those related to aesthetics, economics, power, gender, or class. Instead I will discuss the uses of weather and climate in lifestyle campaigns that promote 'healthy', 'comfortable', and 'high-performance' clothing. I will briefly mention the uses of new fabrics as part of the new outdoor culture and the ways in which industry uses the material science and imagery for advertising purposes. But I will also suggest that many such campaigns use the physiology of sports and textile biophysics as the scientific basis and commercial valuation of outdoor safety and bodily comfort in virtually any weather conditions. Such arguments make sense to and gear-intensive leisure *communitas*, technophilic affluent classes, and, more generally, in a market-driven culture of personal comfort and risk-aversion.

The physiological analyses of clothing hark back to the Enlightenment campaigns for promotion of wool as underwear fabric, underwritten by Count Rumford's experiments on hygroscopic and insulating properties of materials (Thompson, 1787; Little, 2001). Nineteenth-century doctors promoted wool as the fabric of choice for adverse condition and, by the 1860s, rational clothing took sway over Europe and North America (Renbourn, 1957; Renbourn & Rees, 1972). Inspired by Amelia Bloomer, a Victorian guru of comfortable dress and the inventor of female trousers, the Rational Dress Society was founded in 1881 and in 1884, Gustav Jaeger, professor of Physiology at Stuttgart developed his Sanitary Woolen (Cunningham, 2002; Summers, 2001). But nineteenth-century industry also used man-made materials, as for example in the first commercially available rainwear, Mackintosh, the jacket made of rubber coated fabrics which kept the rain out but also kept the sweat, inside making it uncomfortable and smelly during exercise. Other 'rainproofs' included the paraffin wax impregnated fabric by Helly Hansen by the end of the nineteenth century and the fishing wear by the English company Barbour. One solution to breathability was with *Burberry* gabardine patented in 1879, developed for field sports and unrivalled until 1920s, when the lighter *Grenfell* and the wartime *Ventile* broached the market (Parsons & Rose, 2003).

The rise in the use of sportswear and expedition gear after 1945 inspired a functional approach in design and stimulated the use of synthetic fibres, especially nylon. In this development, protection against the elements was advertised as a standard element, but, importantly, the comfort – especially breathability, wind and waterproofness became very important as well. During the 1970s, the quest for the breathable continued with Noel Bibby's foundation of the brand name *Peter Storm* with his waterproof *No Sweat* (Weston Thomas, 2008).

One of the crucial developments in the market was the *Gore-Tex*, currently one of the most popular and most trusted breathable fabrics on the market. The history of *Gore-Tex* started in 1958 when Wilbert Gore identified a market opportunity for polytetrafluoroethylene, or PTFE, better known as DuPont *Teflon*. Gore's son Bob discovered that PTFE could be stretched to form a strong, porous material patented as *Gore-Tex* – a smooth strong, air permeable, hydrophobic, biocompatible and weather durable fabric. During the 1970s the Gore industry textile unit discovered that outerwear could be both waterproof and breathable at the same time. Gore's membrane technology changed that with the introduction of GORE-TEX® fabric, engineered as an impenetrable barrier against wind and water while maintaining breathability (Purington & Filter, 1992).

With the registered logo "Guaranteed to Keep you Dry," it comes in the form of patented *Windstopper Outerwear and Airvantage* that allows the wearers to control the amount of insulation without adding or removing layers. *Gore-Tex* offers them a range of educational sources – from catalogues to promotional tours to dynamically designed website – to learn about their technologies. The emphasis in all of these is on the science of micro-climatic fibres. The research centres on the microporous structure of the garment membrane, in which each microscopic pore is claimed to be 20,000 times smaller than a drop of water so that no external moisture penetrates the membrane. On the other hand, the pores are 700 times bigger than a water vapour molecule, so that perspiration can evaporate through (cf. Gore-Tex website at www.gore-tex.co.uk).

Similar 'sciencey' approach is the trademark of another major player in today's outdoor market, *Polartec*. Known as a high-quality polyester fleece, *Polartex* has been invented by Malden Mills industries during the 1970s and 1980s, following the collapse in the imitation fur market. The company was led by Aaron Feuersteien who used his upholstery experience to introduce the first generation of 100% polyester performance fleece known world-wide under a variety of registered trademarks including *Polartec* and *Polarfleece*. From 1980 and 1995 company became one of the leaders in the man-made fibers production and high performance fabrics (Altman & DePalma, 2003). Today *Polartec* comes in a variety of options – for example the latest *Polartec® Wind Pro®* fabrics are breathable and provide more wind resistance than traditional fleece. As one would expect, company advertising captures the idea of careful science behind the fleece-protected, whimsical gravity defiers hovering above the weather. *Polartec*, like *Gore-Tex*, empower the individuals to go beyond what the god-given fabrics have allowed us to do before. By purchasing such clothing the customer becomes a weather-transcendent self.

Finally a word on *Dry Flow*, a new base-layer fabric developed by the company Lowe Alpine. It is a concept based on the physiology of body's thermo-regulatory system, in which perspiration serves to cool off the body. Where the Alpine Lowe technology comes in, is when it is observed that the body does not produce heat in a uniform manner. Some areas emit more heat than others and identifying these areas and adapting apparel to keep them cool results in increased bodily comfort for the user. *Dry Flo* zone is what is called 'an active' next-to-skin technology that uses customised areas embedded into the fabric which correspond to the body's perspiration hot-spots. The fabric within these zones increases moisture-vapour transfer and the final result is an overall sense of comfort and performance. These virtues are important after the exercise and in cold conditions where the cooling wet shirt can increase risk of hypothermia.

As these promotional campaigns indicate, laboratory and fieldwork have become preconditions for the biometeorological and biomedical application in clothing industry. Experimental biometeorology and biophysics of fabrics are the rapidly growing sectors which are capturing the appetite of outdoor industry and can be used to harness the imagination of the new generations of adventurers. But these sciences already play a role in the outdoor companies' ability to fashion credentials in a market in which the heart of the customer must be won by building a trust in matters of life and death. Who to trust on an ascent to Anapurna or a shower in Burma: *Arcteryx*, *Macpac* or *North Face*? Equally, who can be trusted in providing a fashion statement of outdoor competence in the urban setting, a question relevant to armchair adventurers and the environmentally conscious middle classes? (Brooks, 2000; Lander, 2008)

Consider the example of the experimental field-trial organized and paid by the Swiss company *Mammut*. In this so-called 'experiment' the distinctions between science, advertising, adventure and fun are hard to draw. And of course the harsh weather conditions play a leading role. The trial involved a 30-person expedition into Korvatch area of the Swiss Alps where they were asked to report on their experiences while sleeping in the company's sleeping bags. It is a winter time at 2,700 meters altitude and the colony of human larvae – the first alpine 'sleep lab' – is camping on a glacier. *Mammut* Manager is reporting on a website of the company: "Here I am, tucked up all nice and cozy in my Mammut Ajungilak sleeping bag, lying in a proper outdoor bed on a comfortable mattress out in the open; it's minus 15 Celsius and I'm staring up at the stars. Lovely and warm is possible at minus 15 degrees" (Mammut, 2008). In a similar vein, *Mammut* publicized their more recent campaign called "the First Alpine Underwear test with 200 human guinea pigs" (see Figure 1).

Such and similar stunts of commercial experimentalism serve as the source of customer feedback and portray outdoor industry as serving the ever-demanding users rather than preying on the fantasy of status seekers. There is an assumption that developments come on the heels of a real need and demand from outdoor specialists as has been recently argued by a journalist who explained that "outdoor lovers create market for green clothing" (Alsever, 2007). Of course, the question is whether this is the case – whether the invention of expensive, technical materials has indeed come about as a *response* to the outdoor needs or, conversely, these needs have been molded after the fact, that is, after the industrial developments had already taken place. Is it the case that the industry is driving a new outdoor adventurism by the scientifically constructed immunity to both environmental risk and personal discomfort?

Figure 1: *Mammut's* "First Alpine Underwear test with 200 human guinea pigs."

Source: http://testevent.mammut.ch/ (retrieved May 2008)

My intention here is not to argue one way or another, but rather pursue a related issue of how this production, commercialization and the personal use of new fabrics change the understanding of atmospheric outdoors and how this trend affects the public perception of risks associated with extreme weather. I am arguing that the commercialization has resulted in the consumer belief that apparel industries can help the outdoor enthusiasts improve their performance by 'transcending the weather'. For the select few that can spend on the high-tech garments, the outdoor industry has served an image of weather as something that can be kept away, possibly eliminated, in the uninhibited exploration of unfriendly terrain. The recent *North Face* slogan is "All weather is good weather." Sales and popularity of outdoor activities show that some social and economic groups (at least) are under the impression that their engagement with the big outdoors has become safer, more comfortable and largely independent from adverse atmospheric conditions. Advertising enhances this belief by offering the customer an opportunity to go 'above the weather', as is frequently presented in the visual metaphors such as that on the websites of Outdoor Designs or the 'trail running' link on *Patagonia's* site (See Figure 2).

But this "no-fear, no-limits, no-constraints," is as good a slogan for the new breed of hikers as it is for the new breed of SUV drivers. [(1)] In other words, nothing should stand in the way of safety and comfort of those with power to go places. That is: complete accessibility translates into an annihilation of environmental contingency. For example, one of the earliest companies to introduce waterproof lining, *Sympatex*, has recently

(1) SUV literally means 'Sport Utility Vehicle', which in Brazil are also known as 'off-road vehicles'. (Ed.)

written that “the twenty-first century demands higher performance, more flexibility, better ideas. To stay ahead of the game, people need intelligent technologies that reliably support them in their daily lives. This challenge is our vision. *Sympatex*® Technology develops innovative functional systems for clothing and footwear – the right solution for a demanding new era.” One needs to ask – which game does *Sympatex* refer to? (Trespass, 2008)

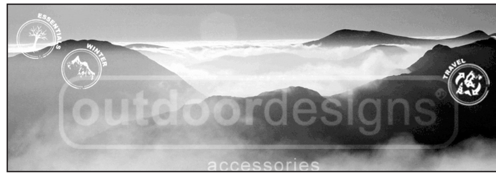

Figure 2: *Patagonia’s* website advertising garments that are ‘above the weather’
(‘above the weather’ being a standard aviation term, nicely exemplified recently in *The Aviator*).

Source: www.patagonia.com (retrieved May 2008).

Staying ahead is important as a social statement too. Technical outdoor garment has a following which is much larger than a small group of athletes and extreme sportsmen. In equipping themselves with such clothing, this community has built an image as well. As the sociologist R. Belk suggests, objects in our possession can extend the self and allow us to do things of which we would otherwise be incapable. The body and its adornments can be used as symbols of role identities acted out in the natural *and* social environment, where manipulation of visual cues serves the purpose of impression management. Symbolic self-competition theory predicts that consumers who have an incomplete self-definition tend to complete it by acquiring and displaying symbols associated with it – in this sense, for example, the urban groups who have little opportunity to engage with outdoor activities, but would wish so and would like to be seen as doing so – and doing so more and better than others – compensate this lack by acquiring the garments and gear which provide visual and branding cues to such activities (Schlenker, 1980; Celsi et. al., 1993; Deighton, 1992). Or, if such groups engage in those activities, they do so in a highly conspicuous and gear-laden manner. It is an observation made among social psychologists that stereotypical symbols of role competency – such as waterproof-lined jacket or Windproof laminate softshell – may be chosen to reinforce perception of adequate performance even if no such performance is ever performed. To come back to our automobile analogy – most of SUVs will never ever turn on a gravel road, but it is an important factor in their appeal that they *can* do so.

In this last sense, the performance clothing industry is as much about meeting the needs, as it is about creating an image of the full experience, competence, control and domination. As Featherstone suggests (1991), the role of the retailer of such garments is more central to the total outdoor experience than merely that of a supplier. The artifacts surrounding the outdoor consumer often communicate messages that are important to the meaning of the total experience. Thus being outside in the weather has less meaning and less allure if a person is without the weather-intensive garment because those who lack such symbols look like they are there accidentally, that they are ‘caught’ in the weather, rather than transcending it. With technical garments, however, we transcend weather with an additional assurance of higher performance. Severe weather is even desirable as it makes sense of our investment that proves such weather irrelevant! With proper protection, we become more daring and more risk-prone which has resulted in a recent increase in risk taking activities in extreme sports, North Pole competition and mountain sports more generally (Baker & Simon, 2002).

But there is a next step to where more daring industries have chosen to venture in their advertising campaigns. This bold new step is not so much to persuade the customer to buy a climate-specific or activity-specific garment but to simplify her/his needs and save (by paying more). The new concept called ‘seasonless-ness’ is predicated on the idea of annulling atmospheric contingency with a minimal management of clothing, and ideally, with just one type of fabric. Most recently it is the wool that has taken on that role. The leading brand in the microfiber wool maverick from New Zealand is the company *Icebreaker,* whose understated garments won accolade among consumers worldwide. The appeal of wool as a natural fabric that heats in cold and cools in heat is captured in the *Icebreaker’s* design iconography of nakedness. The micro-wool base layer is thin, organic, and performing in all conditions that it fells and acts like a second skin, in the way wool is the natural cover of sheep. ‘Seasonless’ is the key because the micro-fiber wool enables insulation in harsh conditions while allowing perspiration in hot and, importantly, without absorbing much of the body odour. With *Icebreaker*, but also with *Gore-Tex* and *Polartec*, one is invited to neutralize the seasons and weather. But one is also invited to neutralize the effect of clothing *per se*, avoiding sweat, stink, strain (Figure 3).

‘Seasonless’ is becoming a catch-phrase outside the performance apparel industry. It is even being linked with anthropogenic climate change in the recent advertising campaign of the company *Weatherproof* which is selling a range of products in major department stores in the USA. Their philosophy has been developed to counteract the ‘seasonless’ world of global warming. In the Fox New’s report titled “Weatherproof your wardrobe” the *Ecofashion* style host Noelle Waters is finding out about the company’s “fabrics that can adapt to unpredictable weather.” Frederick Stollmack, *Weatherproof* president says: “In all these years in my business I have never seen more buzz about the weather – whether bad global warming or unseasonable weather; sales are influenced by the temperature out there.” Speaking to Stella Vakirli, a designer, Noelle asks: “Tell us as a designer, how have you dealt with the whole issue of global warming, and how are you adapting

Figure 3: *Icebreaker* ad alluding to ‘seasonless’, nature-friendliness, and high-performance aesthetic of the fit outdoor culture.

Source: www.icebreaker.com (retrieved May 2008).

to that?" Stella Vakirli: "We try to keep that in mind and try to keep garments that are functional and fabrics that are not harmful, and zip-outs and things that can be worn in a lot of seasons." Noelle: "As global warming is becoming an issue and weather changes, how do you take that into consideration when you're designing coats?" Ken Sporne, men's coat designer: "This is actually a transitional fabric so you can wear it depending on where you live, anywhere from September until February... this is totally seasonless" (Fox News, 2007).

But why should these analyses even matter to historians and sociologists of weather, climate and atmospheric sciences? In the introductory section, I have used the term 'megalomaniacal' to describe the point of view which both in science and history continues to privilege a large-scale and physics-based understanding of weather (and climate). Most histories take the broadly correct view that atmospheric phenomena represent the sum total of the dynamic and physico-chemical processes evolving on the synoptic scales and that the goal of atmospheric sciences is to explain, forecast, and represented such processes by means of rational systems of signs, narratives and images.

What is being unaddressed in such studies is what remains of the weather *outside* of meteorology. In other words, how such processes can be translated to a human and daily size, to the level of 'lived' weather? This ICHM conference tried to look at where and how one might conceptualize this scaled-down identity of 'lived' weather because it seemed relevant to acknowledge that people do not normally experience either a 'scientific' weather or its planetary scales. They simply do not *meaningfully* reside in such an entity. For the most part, the world populations dwell in a boundary layer measured in meters and characterized by turbulence and micro-phenomena or, even more invisibly, in the next-to-skin weather regulated by what they wear (or not wear). This turbulent meta-synoptic and meta-scientific weather does not obviously lend itself neither to spectacular forecasts nor major devastation. Yet it is arguably one of the most important weathers we will ever have a chance to experience.

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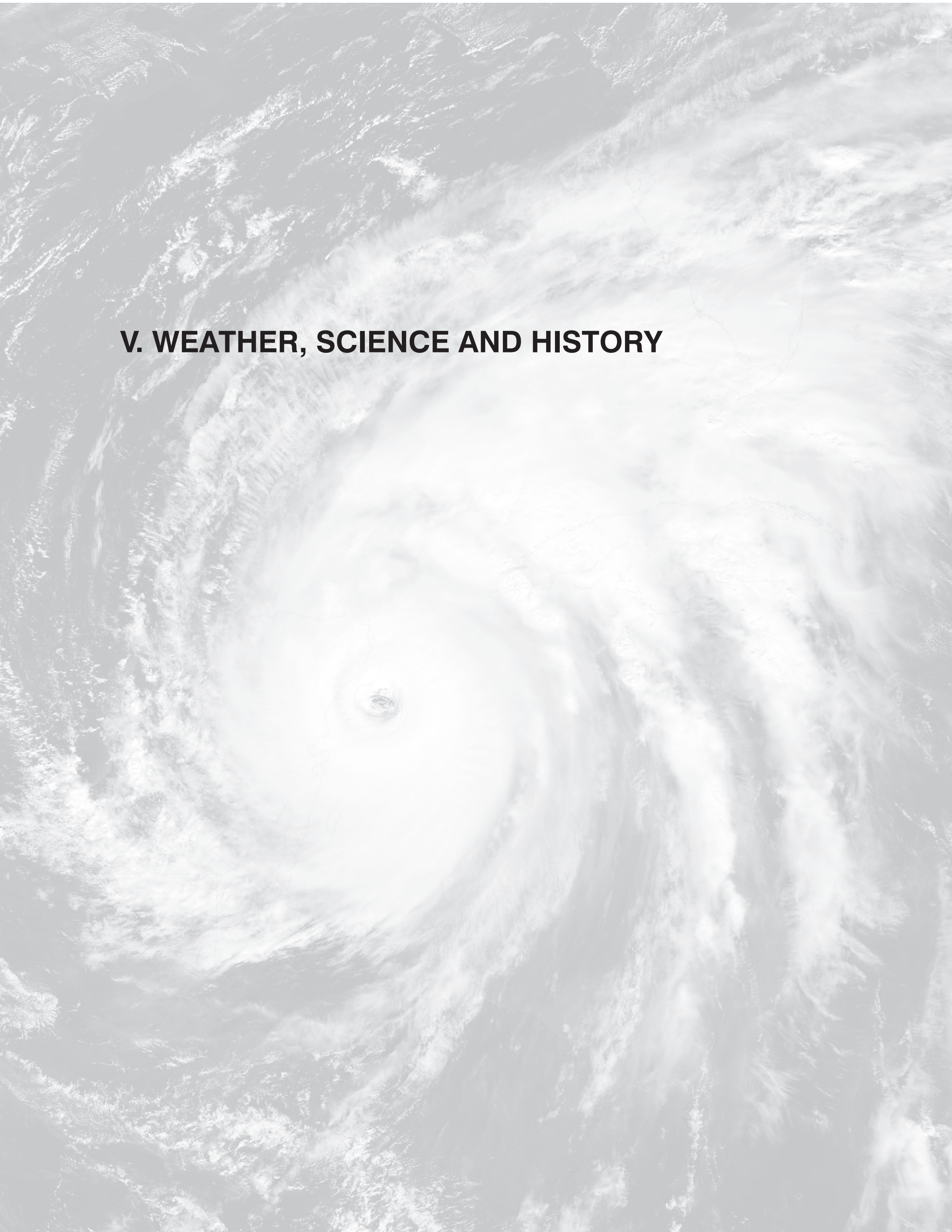
V. WEATHER, SCIENCE AND HISTORY



Cloud-spotting, past and present

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> *Disons que le nuage est un grand livre de la nature, constamment ouvert à l'étude de toutes les classes de la société. Semblables à une boussole, les nuages nous marquent à tout instant la direction, la vitesse et l'altitude des courants supérieurs, qui ne tardent point à descendre à la surface du sol. On a ainsi une girouette en permanence tant que le ciel nous offre la moindre trace d'un nuage: miroir de la force réfléchie de la circulation atmosphérique* (Poey, 1879b, p. 2).

Clouds: in this characteristic account quoted above, a book of nature, always open, a compass, a weather-vane, a mirror rendering visible invisible forces, available to every eye. Clouds and cloud observing bridge the everyday and the scientific experience of weather, linking daily experience, aesthetic traditions like photography or landscape art with the instruments and networks of dynamic meteorology. The history of the study of clouds gives us a window into the development of the science, and particularly into the relationship of expert and lay accounts of weather as the discipline of meteorology was established. Most existing accounts focus on the nineteenth century up to the publication of the International Cloud Atlas in 1896. In this narrative, the nomenclatures of Lamark and Howard at the beginning of the century and the international standardization at its end are the landmarks that matter (Abercromby, 1888; Clayden, 1905; Delange, 1997; Hamblyn, 2001; Hildebrandsson et al., 1896; Kingston, 1968, 1969; Wilson-Barker, 1890). A consideration of earlier accounts of clouds and winds might give us a different story, connecting an understanding of weather more closely to physiology and medicine, geology or even architecture (Jankovic, 2000; Golinski, 2007). Incorporating the history of the icons of the modern televised weather map, including cloud symbols, might be equally revealing, giving us a sense of a continued public engagement with representations of the weather (Boyd Davis, 2007; Monmonier, 1999). My subject here, however, necessarily has a far narrower compass and concerns cloud enthusiasm as much as it does cloud science. It focuses on the writings of two dedicated students of clouds, one contemporary, one historical. My contemporary example is *The Cloud-spotter's Guide* (2006), by Gavin Pretor-Pinney a British journalist and founder of the Cloud Appreciation Society; my historical example is *Comment on observe les nuages* (1879b) by Andres Poey, a meteorologist from Cuba who published extensively on cloud classification in the second half of the nineteenth century.

These are obviously very different sort of texts, authors, and perhaps intended audiences, and the distance between 2006 and 1879 should not be trivialized. But I want to consider them primarily as observers of nature, and highlight their accounts of observation. Both authors not only present readers with instructions, or demonstrations, of how to observe, but also present an account of the context for such observation. That is, they tell us why we observe, and discuss the place of an individual's view of the sky within a larger picture of search for knowledge.

The study of clouds bring forward such concerns because it is so obviously involved with the particular and the general, and hence with critical debates, historical and in contemporary, on empiricism, objectivity and subjectivity (Daston, 2008; Daston & Galison, 1992, 2007; Galison & Assmuss, 1989; Ginzburg, 1980; Yeo, 1986). The first step of modern cloud study, defining a cloud's type, challenges immediately our impression that each cloud is unique. Indeed, this is not really an impression, but a cultural tradition, as perhaps most famously expressed in the conversation of Hamlet and Polonius in Shakespeare's play, in which clouds epitomize not just mutability but the individuality of our perspective on the natural world. A classification of clouds battles this sense of an individual reading of nature much more intensely than a classification of birds and beetles, for instance, even though we face the same issues of 'the individual' and 'the species' in observing the latter (Ritvo, 1997). Pretor-Pinney and Poey handle this challenge of particular and the general in very different ways.

The Cloud-Spotter's Guide, published in 2006, was a British bestseller. It moves chapter by chapter through the ten modern cloud genera, from cumulus to cirro-stratus. Each chapter is a breezy combination of anecdote, folklore and scientific description of the cloud and its formation. Although its structure is organized by the scientific nomenclature, the book assumes that the aesthetic appreciation of clouds is the real foundation for the reader's interest, and moreover insists that this appreciation is a kind of observation very different from that of the scientists: "Meteorologists are busy indexing the different genera, species and varieties of clouds on your behalf. They call it work. Yours is a far more gentle and reflective pursuit – one that will lead to a deeper understanding of the physical, emotional and spiritual world" (Pretor-Pinney, 2006, p. 25). This non-specialist aesthetic can also be found at the heart of the Cloud Appreciation Society, the online community Pretor-Pinney formed in 2004, in part to share stunning examples of cloud photography. It boasts some twelve and half thousand members, overwhelmingly from Britain and the U.S. The manifesto of the Cloud Appreciation Society celebrates the "ephemeral beauty" of the cloudy sky, seeking to fight "sun fascists" and "blue sky thinking" everywhere (Cloud Appreciation Society, 2004). The tone overall, for both book and website, is casual, with an easy blend of information and entertainment that ironically undercuts every statement about observing and understanding nature. For example, a short photographic quiz to test reader's ability to identify cloud types ends with a joke, a photograph of clouds for which the correct identification is the-abominable snowman-and-his-pet-seahorse cloud. Look up, but don't take this too seriously, seems to be the conclusion.

Andres Poey y Aguirre (1826-1919) was a very different character, and badly wanted to be taken more seriously. A Cuban, Poey founded and directed a meteorological observatory in Havana in the 1860s and 1870s. Biographical details are scarce: he was the son of Felipe Poey Aloy (1799-1881), a prominent naturalist during a time when Havana, loyal to Spanish colonial rule, was the region's most cultured, technologically advanced and wealthy city. In the middle decades of the century, Poey the son traveled in France, the United States and Mexico, and (like his father) mainly published his scientific works in French, not Spanish, often initially in the journal of the meteorological society of France of which he was a member (Locher, in press). He produced a definitive catalogue and bibliography of hurricanes, treatises on lightning, essays on climate, and several works on clouds (Poey, 1855a, 1855b, 1857, 1858, 1873, 1879b, 1882). He also conducted a model series of cloud observations from 1862 to 1864 in Havana, which formed the basis for his arguments about classification. In his essays, he repeatedly drew attention to the challenge of international cloud observation, which was a poor cousin in the standardization of observations that occurred in the congresses of European and American meteorologists from the 1850s to 1870s (Anderson, 2005; Davies, 1990; Edwards, 2006). Poey himself championed a revision of Luke Howard's nomenclature, which was in widespread but by no means universal use among naturalists by these decades. In distinction to Howard's nomenclature of stratus, cumulus, nimbus and cirrus (Howard, 1865; Hamblyn, 2001), Poey argued for two main categories only, cirrus and cumulus. He retained stratus as a term that referred strictly to ground fog, but dismissed nimbus altogether, arguing that it was more properly understood as two joined layers of cumulus and cirrus. He introduced the term pallium (or its prefix pallio-) to replace the nimbus, and the term tracto-cirrus to describe an intermediate layer of clouds below true cirrus.

Poey is only one among half a dozen energetic figures in this period who debated Howard's terms during this era (e.g. Hildebrandsson, 1889; Ley, 1894) and the details of his classification are not particularly important here (for a summary, see the table in Poey, 1879b, pp. 34-35). His influence probably peaked in the early 1870s and his last essay on clouds was published in 1882. Three years before that, in 1879, the international organization of meteorologists, meeting at in their congress at Rome, had finally tackled the slow job of organizing international observing standards and begun to circulate prototype atlases. These led to the International Cloud Atlas of 1896 (Hildebrandsson et al., 1896). Well before the mid-1890s, Poey understood he had lost the argument about his particular cloud nomenclature, and, at this turbulent time in Cuban history, he turned to didactic novels and philosophical polemics instead (e.g. Poey, 1890). Yet his meteorological writings, justly neglected or not, remain fascinating as a set of claims about scientific observation and scientific knowledge more generally.

I want to now highlight some of these claims, before returning to contrast them with Pretor-Pinney's *Cloudspotter's Guide*. The two most significant things about Poey are that he was a positivist and a Cuban. As the former, he was a follower of Auguste Comte, the French philosopher who saw the progressive evolution of intellectual understanding about the world as the key to human history. As is well-known, Comte held a three-stage theory of development that moved from the theological to the metaphysical to culminate in the 'positive' (also sometimes called the 'scientific') approach. Within this evolving positivist era, the modern scientific disciplines, according to Comte, would trace out a hierarchical path, building on each other, and becoming more and more complex in the number of inter-related phenomena they covered. Yet all knowledge would rest ultimately on the solid foundations of geometry and mechanics, structure and forces – even the most complicated disciplines of all, sociology and politics (Lenzer, 1998).

Poey followed Comte's philosophy devoutly (Poey, 1876, 1879a). What did it offer him? In the first place, positivism gave Poey a notably broad understanding of classification as a methodology as well as a practical activity. Secondly, it gave him the Comtean concept of *milieu* or environment. For the purposes of this discussion, we can think of these two influences from positivist philosophy as 'epistemological' and 'environmental'. Armed with these, Poey could present the science of clouds as a striking example of the way knowledge moved between local observation and a synthetic global picture. Clouds were both 'meteorology', the local weather, the here-and-now, and part of *la Physique du globe*, indicators of global atmospheric circulation and manifestation of general physical laws (Poey, 1879a, p. 1).

First, the epistemological dimension. Classification, for a positivist, was an essential rather than a merely descriptive activity. As a critical stage of positive analysis, it represented the only assured way to escape from the sterility of isolated facts. In Book V of his *Cours de philosophie* (1830-42), which treated biology, Comte gave an explicit defense of classification. It is a simple matter to see, not least from the systematic structure of his *Cours* as a whole, that these statements go beyond the ostensible subject of biology. "Philosophical classification," he wrote, "necessary not only to aid the memory but to perfect scientific combination, cannot be absent from any branch of natural philosophy…. multiplicity and complexity are not, as it might first appear, obstacles to the systematic arrangement of subjects; on the contrary, they are aids, as the diversity of their relations offers a greater number of analogies" (Lenzer, 1998, p. 180). Classification thus epitomized the work of combination and comparison that Comte insisted was the means of penetrating the surface of phenomena to uncover the laws of geometry and mechanical force underneath.

With this Comtean influence in the picture, we can see the fuller dimensions of Poey's projects of cloud nomenclature. Poey's cloud types were linked to his understanding of the physics of the atmosphere (he emphasized pressure, heat and electrical action as the keys) and to circulation patterns. Cloud classification would reveal upper and lower layers in the atmosphere, wind speeds and directions to the scientist. Poey's cloud observations are always layered – he insisted observers pay attention to vertical space as well as horizontal distribution – and always dynamic. His language emphasizes movement across vast spaces: *La zone équatoriale est encore le point de départ de toutes les grandes manifestations météorologiques du globe: des vents alizes et des contre-alizes, des vrais ouragans, du gulf-stream, des courants généraux de la mer, et d'une multitude de perturbations qui s'étendent jusqu'aux régions polaires* (Poey, 1879b, p. 49). Currents of the atmosphere sweep in towards to the Antilles and head west and north to the poles as part of global circulation patterns.

In addition to a clear account of classification as the critical means of achieving generalized and global understanding, positivist philosophy provided Poey with a kind of environmental thinking. Comtean thought included the concept of the *milieu*, a sweeping theory of interaction between organisms and environment, with more complex organisms (like humans) modified more deeply by inorganic features of their surroundings than simple forms. For Comte, this explained why climate, along with race and political action, was one of three causes of the variation among human societies throughout the world (Braunstein, 1997; MacDonald, 1976). Poey's earliest published meteorological writings, in the 1850s, are most obviously indebted to this concept: he called in 1857 for a science of acclimatization or, as he calls it, experimental biological meteorology, to be studied alongside agriculture in the Museum of Natural History in Paris. This work, he thought, should be supported by local experimentation in a network of meteorological institutes worldwide (Poey, 1857, pp. 375-383).

The call for an international network of institutes for meteorology is noteworthy. Poey was a positivist, but he was also a Cuban and a colonial. Poey's colonial status was the social equivalent of his synthetic epistemology, leading him to insist that local observations contributed to a global picture, with the meteorology and meteorologist of Cuba therefore important to the American and European scientific leadership. Sensitive to question of language and translation, he championed the use of the vernacular in cloud observation, to be guided by tables of equivalents for international comparison (Anderson, 2005, pp. 228-232); he insisted, following the lead of Alexander Humboldt and others, that tropical climates had a kind of simplified weather that could materially aid the progress of meteorology (Poey, 1879, p. 31) and he described the tropical hurricane as part of a global pattern, which burst out in the equatorial regions, traveled to the heart of Europe and then exhausted itself at the poles (Poey, 1879). These were standard interpretation and concerns, yet taken together they display well Poey's assumptions about his observations. As Poey put it in 1882, *la météorologie embrasse de la sorte d'universalité dans l'espace et devient cosmopolite sur terre. L'idée de la localization des manifestations météorologiques, normales ou perturbatrices, est une idée petite et irrationnelle... Tout tend au cosmopolitisme* (Poey, 1882, p. 13; cf. Poey, 1857, p. 430). Meteorology begins with universalities, descending into the varied forms we see from the ground. It is therefore necessarily a pursuit that breeds a cosmopolitan spirit.

The account of observation in the *Cloud Spotter's Guide* is superficially concerned with the same questions that drove Poey's work: what do you call a cloud, and how do your local observations fit into the broader understanding of the atmosphere? Just as in Poey's work, then, Pretor-Pinney's subject compels him to consider the shift from particular to general. But in contrast Poey's emphasis on the connection of local observations and global physics, Pretor-Pinney does so by sharply distinguishing between the two sorts of knowledge. The one may illuminate the other, but the barrier between the local view and the generalization is fundamental. This is most evident in the narrative hook of his writing, in which the personal experience provides the thread for each chapter's explications about a cloud genus. His technique is to seize and isolate both the observer and his object of study – the cloud type – and to leave them as individual drama, eccentric points of view that do not lead to any wider meaning. The chapter on stratus, for instance, uses the author's reaction to a London fog as its thread, following his moods through the day until he experiences the elation of a clearing sky at sunset. The chapter on cumulonimbus, in another instance, starts and ends in a narrative circle with the incredible story of Lieutenant Colonel William Rankin of the US Air Force as he bounced in his parachute through the violent updrafts and downdrafts of a thunderstorm for forty minutes in 1959. It is striking that both these examples draw attention to the isolation of the observer – suspended blindly in the city fog, or suspended alone in a web of parachute lines.

We could consider this focus on the personal perspective simply as the incantation of 'human interest', a blunt and familiar journalistic technique. Yet in writing about human knowledge and experience of the natural world, such a technique has other implications as well, and belongs to a distinct sub-genre of popular science writing. At its best this sort of writing moves back and forth between personal and impersonal description and in narrative form acts out a compelling, thoughtful play with forms of objectivity and subjectivity (Dillard, 1982; Steingraber, 2001). Pretor-Pinney instead is deliberately naïve and nostalgic about the individual observer, and his or her confined perspective. The typical Victorian anxiety about the significance of mere instances (Yeo, 1986) seems to have disappeared from view, to the extent that Pretor-Pinney can extol cloud watching as pictures-moments of individual significance. The photograph is the material embodiment of this isolated moment; it is not surprising, then, to find it taking centre place in his Cloud Appreciation Society. To clarify his approach, it helps to think of the cloud photograph as an implicit contrast, or rebuke, to other visual records of sky and weather: the weather map, the satellite image, or the non-stop television weather channel (the temporal opposite of a photograph).

This account of the observer could not be more removed from Poey's account. The polarization of the individual and local perspective on the one hand and the generalized abstract perspective on the other hand was exactly what the nineteenth-century meteorologist rejected. The challenge and fascination of the weather, for Poey and many of his contemporaries, was 'translation' between local and the general knowledge. A local vision was not intuitive or unlearned, a kind of elemental, direct insight into the meaning of the sky; it was skilled and sensitive in ways that were assumed to be compatible with instrumental data, in ways that were learned (Daston, 2008). That is, it might be 'difficult' to interpret – just like it might be difficult to build a network of institutions to record instrumental observations – but from a philosophical point of view, it was certain to be possible, and part of the same enterprise.

So, when Pretor-Pinney writes approvingly of a charming subjectivity in Constable's, Goethe's or Ruskin's different order of appreciation of nature, he has his history and epistemology wrong (Reed, 1984; Gaull, 2009). His text, moreover, is philosophically inconsistent, adopting a position on the primacy and isolation of personal experience but accepting without comment the classification of natural phenomena as its chief organizing principle – this, when classification is precisely about not letting individual cases remain unconnected into a web of relationships. He does not display any understanding of the way scientists wrestled in the past with questions of objectivity and subjectivity, and especially so in case of the subject that concerns him, clouds. These shortcomings might be sufficient to discourage a few readers with specialized interests. But does this matter to any wider audience?

It matters, in my view, because it bears on the stated intentions of Pretor-Pinney's own work, in which cloud appreciation is designed as a "reflective pursuit" which will train the ability to draw "deeper meanings" (Pretor-Pinney, 2005, p. 25). As Poey's suggestive reference to a cosmopolitan perspective makes very clear, natural knowledge is politics as well as science. Pretor-Pinney's approach instead leads him into accounts that are a-political almost to the point of caricature. Take, for instance, the man who parachuted through a thunderstorm. Rankin's experience in and out of his jet plane over Norfolk Virginia at the height of the Cold War has some obvious relevance to Pretor-Pinney's discussion of the history of military weather modification in the penultimate chapter. Both are part of the complicated relationship between aviation, military goals and meteorology. No links are drawn; Rankin's is a purely personal experience. Of course, the connections may not belong in detail in Pretor-Pinney's text, but there is something disconcerting about ignoring them altogether. As another example, consider climate change – again, not the book's subject, but inescapably part of the framework of observing and understanding the weather in the twenty-first century. There is one brief reference to climate change and the need for individuals to take unspecified action at the end of the penultimate chapter. But the succeeding and final chapter returns to the focus on personal experience with an account of cloud investigation as eccentrics, recounting the author's pursuit of the "morning glory" as a rollcloud, or stratocumulus that is the mecca of Australian hang gliders. Embedded in this Australian story, we can see a final example of the book's self-consciously a-political tone. Analysing the cloud tourist-hang glider and gathering details about the phenomenon they seek to experience, Pretor-Pinney notes the "very different relationship" of "aboriginal ladies" to this cloud (Pretor-Pinney, 2006, p. 293). For these observers, the cloud has a different meaning; and we are invited as readers to consider, briefly, what a natural curiosity, what the exotic might mean if our subjectivity shifted. In all these instances – the mention of military weather modification, action on climate change, and the allusions to gender and indigenous knowledge – the author is evidently aware that there are unexplored layers to his subject here, but his commitment to an idea of individual perspective gives him no traction to move in this terrain.

Is Poey best considered as an admirable failure and Pretor-Pinney as a discouraging success? Yet it is not my intent to disparage popular science writing, just as it is not my intent to be nostalgic about the systematic impulse (*l'esprit du système*) of nineteenth-century positivism. Indeed, readers familiar with nineteenth-century positivism will realize that I have given a truncated view of the philosophy. If it was a global view that emphasized inter-connections, relationships and *milieu*, it also could express deeply conservative social politics, and corrosive racism. Cloud and camera lovers, too, may also feel I am too harsh with Pretor-Pinney. Perhaps the sub-title to this paper should be "two largely harmless enthusiasts." I have treated their work as distinct contrasts for the purpose of argument here, but they may have more in common than I have allowed – not least, their sincere passion for clouds and the wide audience for that passion that they assume – in Poey's parlance, the book of nature open to every gaze.

For this last reason I want to conclude with a brief justification of the comparison of these works, with its mixture of historical periods, genres, and authors. Perhaps historians of science are too cautious about combining historical analysis with analysis of the unfamiliar terrain of contemporary popular science, even though we often acknowledge that both seem to be our professional business (Govini, 2005; Miller, 2002). While there is much to say about the differences between these two examples, Poey and Pretor-Pinney, the fact that they may occupy different spaces in the spectrum of scientific narratives and conceive of their audiences in different ways does not seem to be a problem. The historical investigation of popular science writing is well established (for a recent collection, see Fyfe & Lightman, 2007) and it seems appropriate and timely to extend its methods to contemporary examples. The comparison across genres, centuries and points of view is justified in order to draw attention to the continued intersection of weather knowledge and human concerns. The weather is never really a space apart, and our individual perspective is never really the isolated glimpse that a photograph preserves.

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Why the weather?

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1. Introduction

Why the Weather is the name of a series of daily public service announcements syndicated by the Science Service, a non-for-profit organization with the objective "to advance public understanding and appreciation of science among people of all ages..." These announcements were a regular feature in newspapers and broadcast over the radio from May 1923 through April 1941.

The National Oceanic and Atmospheric Administration (NOAA) Central Library maintains a mimeographed set of these transcripts in sixteen bound volumes that are preserved in its Special Collection Room (Why the Weather, 1923-41). These 6,500+ announcements have been digitally imaged, indexed, and are now searchable and retrievable online through a new website: http://docs.lib.noaa.gov/rescue/whytheweather/whytheweather.html

2. Charles Franklin Brooks set the standard

The genesis for *Why the Weather* was a revision of class notes by Dr. Charles F. Brooks for his courses in meteorology at Clark University where he was a Professor in Climatology from 1921 to 1931. His contributed essays presented meteorology to the public through clear and simple explanations of weather facts and phenomena in syndication from May 12, 1923 through April 23, 1927. In addition, Dr. Brooks also consolidated his notes by theme and season into a book also titled *Why the Weather* which was published by Harcourt, Brace and Co. in 1924 and later re-issued with revisions in 1935 (Brooks, 1924).

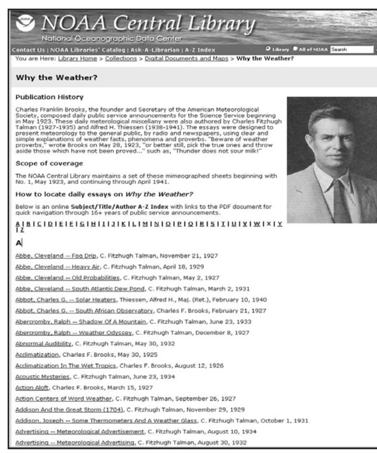

Figure 1: *Why the Weather?* home page.

Dr. Brooks developed the format and released his weather facts to follow the seasons and to coincide with special days of the year. Each daily submission contains the release date, date mailed, title, byline, and is one page, double-spaced, in length. This format was largely followed by the successive contributors to the series, Charles F. Talman, and Alfred H. Thiessen.

For example, on every February 2, there was an article on Candlemas Day, later known as

Groundhog Day. Dr. Brooks added anecdotes and humor along with the meteorological facts so that each essay was slightly different from the previous year. On February 2, 1924, he wrote that "any one particular day cannot indicate the weather of the weeks to follow..." when referring to the legend. In the 1926 version "Mr. Groundhog is denounced as a false prophet as well as a pest" when nine years of weather data were analyzed from February 2 through March 15.

While educating the public on weather facts and phenomena, Professor Brooks advised caution. "Beware of weather proverbs or better still, pick the true ones and throw aside those which have not been proved..." he wrote on May 28, 1923. He adhered to this throughout his essays as he debunked some and reinforced others. For example, Dr. Brooks showed great respect for the American Indian. He cleverly connected a well-founded American Indian proverb with the hygrometer: "When the locks turn damp in the scalp house, surely it will rain." The hygrometer also uses human hair to detect the presence of absence of moisture in his essay of July 9, 1923. He stated that the Zuni Indians were "scientifically correct": "When the sun is in his house, it will rain soon" (May 26, 1923). Even the Apaches are acknowledged as masters of local weather modification when they created dust-spouts by burning the spines of cactus. Enough heat was obtained to start a whirling updraft and a signal (September 5, 1923).

A recurring theme was weather basics for the public. The words 'why', 'how', and 'what' were the opening words in many of his articles:

- Why Stars Twinkle (July 26, 1923)
- How to Use a Weather Map (January 28, 1924)
- How Icicles Form (February 16, 1924)
- Why the Sky is Blue (June 12, 1924)
- How Snowflakes Fall (March 6, 1926)
- What Makes Highs and Lows (March 10, 1926)
- What Makes a Wind (May 8, 1926)
- What is the Temperature (October 13, 1926)

Dr. Brooks's creation and contributions to *Why the Weather* set the standard for public literacy regarding weather by blending facts and legends with humor in easily understandable essays. Mass media was still in its infancy. The majority of the population was largely in rural areas, and yet, the public had access to accurate information upon which to increase their weather knowledge beyond oral tradition.

3. Charles F. Talman and his *tour de force*

Whereas Charles Franklin Brooks was well credentialed, having received his A.B., A.M., and Ph.D. from Harvard University, and was well recognized in the profession, being a founder and first Secretary of the American Meteorological Society, his successor Charles Fitzhugh Talman was a career employee of the US Weather Bureau. Although Talman lacked the equivalent academic credentials, his mastery of the subject matter is evident. He loaded his contributions with more facts, historical references, and scientific data. His byline was “Charles Fitzhugh Talman Authority on Meteorology” while Dr. Brooks’s more humble byline was “Dr. Charles F. Brooks of Clark University.” Where Brooks referenced one or two publications, Talman would mention six.

For example, a comparison of the various essays on the saints and their influences on the weather illustrate more clearly the differences between these authors. Dr. Brooks limited his essay on St. Swithin’s Day (July 15, 1924) with the saying and remained on the topic:

> St. Swithin’s Day, if thou dost rain,
> For forty days, it will remain

Charles F. Talman, on the other hand, expanded his essays to include additional French wet weather saints such as St. Medard, St. Gervais, & St. Protais (July 20, 1927; July 15, 1933). Charles Brooks wrote about the Ice Saints, and Talman expanded it even more to include saints of Scotland and Flanders.

It is interesting to note that the most frequently cited saint and related weather phenomena was St. Elmo’s Fire, found in twelve essays.

The origin of the saying “Raining Cats and Dogs” was the topic of Dr. Brook’s essay of August 28, 1924. Talman, however, expanded on the topic three times with contradictions. The first explanation occurred on April 21, 1928 with a statement that it does sometimes rain fishes and frogs. On May 10, 1928 Talman refuted such events as hearsay, but clearly validates an event on December 24, 1929. The complete listing of ‘rained’ events is colored dust, soot, earthworms, insects, shell fish, grain, hay and pollen. Talman’s *tour de force* also includes the official US Weather Bureau Statement on the subject:

> We have no observations that show just when and where such things were caught up in a storm... It is our conviction that the great majority of such reports have no basis of fact... If we accept as true any of the reports [...] these things were caught up somewhere from the surface of the earth [...] by a violent storm... (Showers of Living Creatures, May 10, 1928)

Talman promoted the US Weather Bureau more extensively than Brooks, and included the government’s Weather Library in his essays. He was, after all, the first person ‘in charge’ of the collection, describing it as the “largest library of its kind in existence” in his essay of July 8, 1927. Thus he quoted heavily from the contents of the library’s collection which added considerable historical documentation to the essays. The “Fastest Weather Services in the World” (October 30, 1923) and “Making the Weather Map” (November 27, 1925) were the titles given by Brooks for the processes – beginning with twice daily observations, telegraphing in code, decoding the messages, and map making. Talman updated the processes by predicting that four observations and reports are “likely to become standard practice” and teletyped in his writings dated January 24, 1929, and

February 21, 1929.

Talman's daily announcements include the effect of weather and forecasting on aircraft, such as icing on the wings, updrafts, lightning, and storms. He predicted that for future Atlantic flights "weather maps will probably be received on board the plane at intervals of a few hours by a telephotographic process..." (July 12, 1927) This clearly predicted aeronautical services before radar.

The teaching of meteorology "has never occupied the place it deserves in the curricula of American universities," Talman wrote on September 9, 1927, and it is interesting to follow the evolution of the discipline in academia in subsequent articles. This continued until 1941 when the series ended.

Charles F. Talman contributed to the series for the longest period of time, having written his essays from April 1927 through December 1935. His contributions were indeed a *tour de force*, more facts, more history, more data, and quotations. [1]

4. Major Alfred H. Thiessen and the military connection

Another US Weather Bureau employee, Alfred Henry Thiessen, authored the daily submissions to the series beginning in January 1, 1938 through April 5, 1941. The articles were untitled, single-spaced, and shorter in length with the average daily input of eleven lines of text. His style was more factual with fewer historical references than Talman, but still scientifically accurate. His byline was "Major A. H. Thiessen" due to his retired rank from military service during World War I.

Thieseen's military experience influenced his choice for over twenty-five essays on warfare and preparations for war, an indication of the pre-World War II era. Examples are:

- Forecasting For Armies (November 21, 1939)
- Chemical Warfare and Wind (November 17, 1939)
- Forecasting At the Front (October 27, 1939)
- Climate and Warfare (October 21, 1939)
- Weather and Artillery (September 20, 1939)
- Weather Hazards in War (September 14, 1939)
- Meteorology and Defense (September 12, 1939)
- War and Weather (September 5, 1939)
- Weather and War (July 30, 1938 and September 30, 1939)

Major Thiessen's was visionary. His article of December 13, 1939 is an excellent example of his accurate prognostications:

(1) Please note there is a gap of two years in the archive for 1936 and 1937.

> ...we [will] have in 25 to 50 years a weather service as exact as the present time service. Instruments will have been invented to indicate the weather of all parts of the atmosphere over sea and land and the data transmitted at once to all forecasting agencies. Forecasts would then be made available to all activities for a day, week, month or year in advance through press, radio, and telephone. One may in that future time take up his telephone, touch the proper button, and the required forecast will immediately be recited by robot information clerks (December 13, 1939).

The exact form of today's modern telecommunications and satellite systems may not have been described in detail, but Major Thiessen's foresight was on target.

Alfred Thiessen must also have been an avid gardener due to the number of articles concerning gardening. He wrote about which crops to plant, when to harvest on a particular month, and killing frosts. There are over twenty short essays on these topics.

His contributions to *Why the Weather* ended on April 5, 1941. There was a major shift in priorities and reassignment of duties at the US Weather Bureau at this time. The donation of time and labor for articles for the Science Service ceased.

5. Most frequently cited references

Brooks, Talman, and Thiessen referenced many of the same sources throughout the sixteen years of the publication. Three outstanding examples follow. Robert DeCourcy Ward was cited several times every year for his book *The Climates of the United States* in the context of climatology or climatic change essays (Ward, 1925).

For weather lore, Dr. William Jackson Humphreys, a meteorological physicist of the US Weather Bureau, extensively published on the subject. He is cited over fifty-five times, including his 1924 classic *Weather proverbs and paradoxes* (Humphreys, 1934).

Several times every winter, Wilson Alwyn Bentley, the self-taught photographer from Jericho, Vermont, who developed the technique for photographing ice crystals, would be referenced in snowflake articles (Bentley, 1962).

In the context of early American meteorology, George Washington's weather records and Benjamin Franklin's observations were always included. Almanacs were not held in high regard. Talman clearly states "though Benjamin Franklin was the leading American scientific man of his day, and though his most conspicuous quality was common sense, he adhered in his famous *Poor Richard's Almanack*, to the nonsensical custom of including weather predictions for the whole year" (October 27, 1930). Talman's injected subtle humor and later explained that Franklin clearly indicated in the preface to his 1737 edition that his weather predicting was a joke.

The above is a classic example of the humor and care that the authors took to interest the reading public in weather as a science. They informed the readership without elitism. They related to the common man without overwhelming them with too much data. Through short, one page tracts, they presented topics to which all could relate. Dr. Brook's advice to readership was "Watch the weather. It is a free show, and will last a life time" (December 11, 1925). This is a classic example of the genuine sincerity and passion of the authors for their profession.

Why the Weather can be viewed as a precursor of today's popular Weather Channel segments, online 'blogs', and similar products by governments and professional meteorological organizations.

6. Website and indexing

Why the Weather is the twelfth historical website created by the NOAA Central Library staff. It builds upon ten years of experience imaging and creating websites. Beginning in 1998, NOAA started to fund, on a competitive basis, digital imaging grants for special projects under its Climate Data Modernization Program. The NOAA Central Library competed from the onset and has successfully been awarded funding every year to provide online access to unique historical items in its collections. The current websites are at http://www.lib.noaa.gov/collections/imgdocmaps/index.html.

The Digital Documents and Maps Collections home page is also referenced from the library's home page at http://www.lib.noaa.gov.

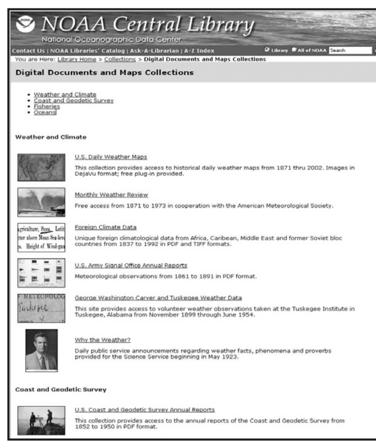

Figure 2: NOAA Central Library online documents and maps collections.

The *Why the Weather* documents were imaged in black & white at 300 dpi in pdf format. Each daily announcement was a single page and labeled as a separate document. The file labels are yyyy,mm,dd in chronological order. Please note that the pages were imaged and are not searchable by keyword within the text.

The unique feature of *Why the Weather* is its index and its transparent link to the full text of the document. The index is an online A-Z title/subject/referenced author listing with links to the pdf for quick navigation through 16+ years of announcements. In addition, similar articles were grouped together by subject. For example, the articles on 'barometer' did not all begin as the first word of the title. Thus, they are grouped by subject and subdivided alphabetically. For example:

- Barometer – Beginning of the Barometer
- Barometer – Biggest Barometer
- Barometer – Darwin's Barometer (also referenced under Darwin)

- Barometer – High Barometer Winds
- Barometer – Low Barometer and Wind

Researchers simply click on the title for full text retrieval.

7. Acknowledgements

Funding for this project was made available from the NOAA Climate Database Modernization Program. HOV Services in Beltsville, MD scanned and labeled each page, i.e. document. The staff of the NOAA Central Library cataloged, indexed, and performed quality control on the documents. Several pages were re-scanned and re-indexed during the process to produce a quality product that provides online access to a unique series. Finally, gratitude is given to the Science Service in Washington, DC, for permission to provide complimentary use. Even though there is the statement at the end of each document "All rights reserved by Science Service, Inc.," the Science Service, true to their philosophy "to advance public understanding and appreciation of science among people of all ages..." granted online access on the condition that there would be no charge. This series is truly one of a kind.

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Flying high and far: The impact of meteorological knowledge on the sport of Soaring Flight

Russell E. Lee (Smithsonian National Air and Space Museum, USA)

> Weather judgment is probably the greatest factor in the making of a soaring champion; without it, all the technique in the world won't win a task, or get you to a goal (Seibels, 1970, p. 120).

On October 24, 1911, Orville Wright soared at the controls of a glider for 9 minutes and 45 seconds into the teeth of a 64 km/h (40 mph) wind above the sand dunes at Kitty Hawk, North Carolina. His flight set a world record that remained unbroken for almost ten years. Despite the flying skill and experience Orville had acquired the previous decade, the 1911 flight depended upon the steady winds blowing against the dunes to produce the required lift. Orville's brother, Wilbur, had decided on Kitty Hawk as the place to test aircraft in 1900 after studying the tables of average hourly wind velocities recorded at 120 weather stations managed by the US National Weather Bureau (Crouch, 1989, pp. 182, 444; McFarland, 1953, p. 12). The data showed the winds at Kitty Hawk blew at the sixth highest velocity in the nation. This fact, and the site's isolation from news reporters, led to Wilbur's decision but this was not the first time knowledge of weather influenced soaring flight. Otto Lilienthal, the first person to soar an aircraft repeatedly, relocated his flying experiments to the Rhinow Mountains near Berlin in the early 1890s, in part to take advantage of more favorable winds (Hirschel, 2001, p. 22).

Germans flyers organized the first gliding competition in 1920 as a means to continue flying after the Treaty of Versailles had barred them from operating nearly all types of powered aircraft. Eleven gliders competed at the second organized contest held atop Wasserkuppe Mountain in south central Germany in 1921. During the meet, a pilot more than doubled Orville Wright's record with a slow descending glide but pilots gave little thought to maintaining altitude or soaring higher in regions of strong lifting air. To do so was very difficult, but not due to lack of basic piloting skills or technical deficiencies in the aircraft (McDonald, 1942, p. 122; Schweizer, 1988, p. 9). Missing was the meteorological theory necessary to guide pilots into the flight sustaining lift.

On August 18, 1922, following advice from the German meteorologist Walter Georgii, pilot Arthur Martens soared to 108 m (354 ft) above the Wasserkuppe and remained airborne for 1 hour and 6 minutes. Georgii had counseled Martens to seek the strongest lift above the mountain slope facing the prevailing winds, and to keep to this narrow region by flying a figure-8 pattern. Georgii declared years later that true soaring began with Martens' flight. Before the meet ended, another pilot had soared more than 3 hours.

News of these flights swept across Europe, increasing the numbers of participants in many countries and encouraging Georgii to specialize in soaring meteorology. He took charge in 1926 of the *Rhön Rossitten Gesellschaft*, or RRG, an organization responsible for developing and maintaining the two centers of German soaring research at Rossitten on the Baltic Sea coast and atop the Wasserkuppe. Georgii instructed his staff to make their highest priority the understanding of the atmospheric conditions required to soar aircraft to high altitudes and across long distances (Welch, 1980, p. 57; Hirschel, 2001, pp. 58-59, 63).

Despite what he did by 1925, the sport of soaring flight was declining in Germany as pilots became bored with skimming the hillsides, and frustrated with the slow speed and the difficult retrieves that followed most landings (McDonald, 1942, p. 123; Welch, 1980, pp. 69-70). Affordable light powered airplanes that became available in Germany in 1926 lured many soaring pilots away from competitive soaring and the sport might have disappeared if meteorologists and pilots had not discovered and mapped new forms of lift. In 1926 during the German national contest, Max Kegel naively surrendered his glider to powerful updrafts entrained ahead of a fully developed thunderstorm. Although the glider's open cockpit left his head unprotected, Kegel survived extreme turbulence, rain, and hail and doubled the world distance record to 56 km (35 miles). Storm soaring was perilous (Figure 1), and pilots died, but the practice helped reinvigorate the sport by generating publicity as German pilots doubled the world record for distance in less than three years (Zanrosso, 1996, p. 65; Riedel, 1984, p. 141).

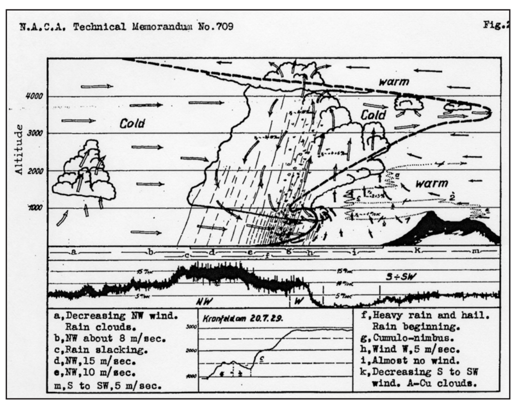

Figure 1: By 1932, pilots had pinpointed the strongest and smoothest lift within a narrow region 2 – 3 km (1.2 – 1.9 miles) ahead of the storm.

Source: Technical Memorandum n. 709, fig. 2 [NACA translation], National Advisory Committee for Aeronautics, Washington, D. C., May 1933.

By the early 1930s, pilots were flying sailplanes equipped with instruments that allowed them to maintain control while flying in the clouds. Their research contributed to the broader knowledge of storm meteorology, led the soaring community to work out special routines for soaring in clouds and storms, and provided designers the data they needed to design sailplanes that could withstand storm turbulence (Flying eds., 1974, p. 26; Hirth, 1938a, p. 86). Alexander Lippisch designed the *Fafnir* in 1929 specifically for storm flight by strengthening the airframe and covering the cockpit to protect the pilot from the harsh elements (Zanrosso, 1996, p. 79).

Yet the risks involved and the necessary commitments in time and money to train and equip a pilot to soar storms always limited its appeal. What drew recreational and cross-country soaring within the reach of virtually anyone was the discovery of 'thermal lift', a term generally credited to the soaring community that applied to any "relatively small-scale, rising current of air produced when the atmosphere is heated enough locally by the earth's surface" (Hertenstein, 2005, p. 7). Pilots had occasionally experienced thermal flying since the early 1920s without knowing its causes and characteristics (Riedel, 1977, pp. 130-131; Welch, 1980, pp. 58-59). Prof. Georgii began studying thermals at Darmstadt Griesheim airfield in spring 1928 and in April and June, his research pilot, Johannes Nehring, used 'thermal lift' to maintain altitude in a conventional powered aircraft for more than 10 minutes with engine off.

Proving that thermals could lift sailplanes led to another question. How would pilots navigate their way into the 'thermal lift'? When soaring the slopes, they could determine the position relative to the strongest lift by sighting along nearby peaks and ridges; yet thermals were often encountered many thousands of meters above any landmarks. The problem grew more difficult after experiments confirmed that puffy cumulus clouds did not always mark thermals. They could be strong, numerous, and extend across a wide area even under a cloudless sky.

Within weeks of Nehring's flight, a sailplane designer and pilot named Alexander Lippisch, who had once worked for the Zeppelin Company, suggested trying out an instrument developed by balloonists in the nineteenth century to register small changes in altitude. The device came to be called a variometer and pilot Robert Kronfeld used it to locate thermals and circle within them as he soared back and forth to a nearby mountain 8 km (5 miles) away, during the national meet on the Wasserkuppe, in August 1928 (Zanrosso, 1996, pp. 71-72; Simons, 2001, pp. 59-61). The following year, Kronfeld more than doubled the record for distance, soaring 150 km (93 miles), by using a combination of thermals marked by cumulus clouds and those detected with his variometer. After a research flight made in August 1931 to gauge the variometer's sensitivity, Georgii concluded that thermals "are apparently so plentiful that if the weather is favorable and the sailplane has enough altitude, a short gliding flight [from one thermal] leads again to [the next]" (Simons, 2001, p. 65). Over the years, pilots and engineers improved the variometer's accuracy and reduced the delay time that passed before the instrument registered a change in air pressure. The United Kingdom's team victory in the 1952 World Soaring Contest was credited to recent refinements they had made to the instrument (Irving, 1999, p. 38). Another major improvement occurred a decade later when engineers added an audible chip that permitted pilots to monitor the variometer with their ears while focusing their eyes outside the cockpit to maneuver the sailplane and avoid other aircraft. (1)

By the early 1930s, meteorologists had grasped the relationship between geography and atmospheric convection. Cumulus clouds were seen to form more often above wide mountain valleys dotted with bodies of water, mountain slopes heated by the sun, swamps and other areas likely to produce water vapor, as well as open fields and meadows (Eisenlohr, 1933, p. 23; Georgii, 1935, p. 3). Meteorologist C. E. Wallington had

(1) Meteorology Research, Inc. advertised an audio variometer inside the front cover of *Soaring*, March 1963.

identified six distinct geographic variables controlling ground surface temperature by the mid-1970s (Wallington, 1977, pp. 130-131).

The possibility that thermals could form nearly anywhere on earth inspired soaring expeditions to distant lands. Georgii led a group of German scientists and pilots to South America, where Heini Dittmar set a world height record by ascending to 4,621 m (15,200 ft) through the core and out the top of three cumulus clouds developing in rapid succession, during a flight from the Campos dos Affonsos airfield, outside Rio de Janeiro, on February 16, 1934 (Dittmar, 1938, p. 92). The first Frenchman to soar beneath a cumulus cloud, Georges Abrial, led an expedition in 1954 to Brazzaville in the African Congo. Abrial's group spent nearly two months flying and studying soaring meteorology (Zanrosso, 1996, p. 151).

Of course, sport pilots wanted to soar close their home and to do so, they needed to understand local soaring conditions. Roland Eisenlohr wrote an article advising the members of soaring clubs to "promote the spread of distance and cloud flying" by studying local cloud formations (Eisenlohr, 1933, p. 23). He explained how developing cumulus had been studied with the aid of a high-speed film exposed at a rate of one frame every 5 seconds, revealing the "dramatic evolution in the turbulence, disruption, and piling up of the cloud[s]" (Eisenlohr, 1933, p. 23). Eisenlohr acknowledged the technique was impractical for some clubs, so he described how to sketch them on paper as they formed. Eighteen of his sketches accompanied his article (Figure 2).

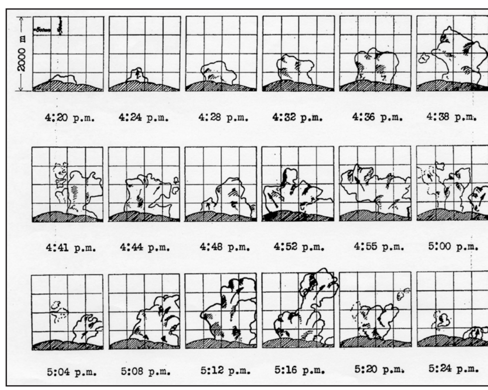

Figure 2: Each side of the 12 squares in Eisenlohr's grid measured 500 m (1,640 ft).

Source: Technical Memorandum n. 709, fig. 10 [NACA translation], National Advisory Committee for Aeronautics, Washington, D. C., May 1933, Fig.10 .

For scale reference, Eisenlohr suggested that the observer could simply sight through a hanging net. Club members, he said, should continue these 'systematic observations' throughout the year and from different locations simultaneously, in order to build a three-dimensional map of the clouds and show how they changed with the seasons (Eisenlohr, 1933, p. 24).

Ground studies could provide sufficient weather knowledge for recreational flying but to advance soaring meteorology, it was necessary to fly instruments aboard sailplanes. During the spring 1938 Southwest Soaring Expedition to Wichita Falls, Texas, undertaken to evaluate the soaring conditions over flat terrain, Lewin Barringer carried equipment aboard his sailplane to measure temperature and humidity. To help interpret the results, meteorologist Dr. Karl O. Lange accompanied the expedition. By one account, the data collected helped the designers of commercial aircraft to understand better the extent, frequency, and strength of clear-air turbulence (Merrell, 1938, p. 15). Barringer set a national distance record during the expedition and the publicity that followed, together with the meteorological data collected, helped encourage pilots to abandon the ridges and hills and begin soaring the flat lands of the Southwestern USA (Schweizer, 1988, p. 59; Barnaby, 1974, p. 40). In the fall, Barringer explored the soaring conditions around the White Mountains of New Hampshire. He planned his flights around the daily weather reports received via short-wave radio from a station on nearby Mt. Washington (Barringer, 1938, p. 2). Although Barringer did not understand the phenomenon at the time, he made the first U.S. soaring flight in a standing mountain wave on October 25, 1938 (Whelan, 2000, p. 159; Schweizer, 1988, p. 222).

Wind blowing against a ridgeline, mountain, chain of mountains, or even an air mass can trigger waves that form downwind through the same hydraulic mechanism that forms standing waves downstream from stones in shallow, fast-flowing water (Selvidge, 1971, p. 27). These waves have lifted sailplanes to heights above 15,200 m (50,000 ft). In March 1933, Hans Deutschmann and Wolf Hirth became the first soaring pilots to fly in wave near Grunau, Germany (Whelan, 2000, p. 159). Soaring birds had first hinted at the possibilities of flying in ridge and ‘thermal lift’ but soaring pilots discovered the potential for strong lift when they explored the wave in their sailplanes. Their work complimented the scientific research carried out by meteorologists, which led in turn to farther and higher sailplane flights. For his doctorate in meteorology, Joachim Küttner collected data to study the wave generated downwind of the Hirschberg and Riesengebirge mountains from twenty-five sailplanes carrying instruments during a soaring contest held in May 1937. Küttner gathered data sufficient to map the entire wave system, and then soared to 7,387 m (24,300 ft) in this wave during his own exploration flight, four months later. This world record ascension bettered the old mark by a wide margin but earned the pilot no formal recognition due to questions raised about his past by National Socialist politicians (Hirth, 1938b, p. 110; Grubišić & Lewis, 2004, p. 1127; Whelan, 2000, pp. 7-11).

Following War World II, interest in studying wave meteorology shifted to the western USA. Military and civilian pilots, flying both powered aircraft and sailplanes, had encountered the phenomenon over the Sierra-Nevada Mountains, surrounding the Owens Valley, in central California near the Nevada border (Whelan, 2000, p. 32). By 1951, the US Air Force Cambridge Research Center, US Navy Office of Naval Research, US Weather Bureau, Los Angeles branch of the American Meteorological Society, and the Meteorology Department at the University of California, Los Angeles, had formed a group to study the Sierra wave. Personnel from these military, government, and academic organizations played key roles, but it was the group of amateur sport sailplane pilots, who called themselves the Southern California Soaring Association (SCSA), that first proposed the Sierra Wave Project, and then pushed it through a tedious definition and validation process before winning official approval and funding. The SCSA supplied the surplus US Navy training gliders used in the study, modified them with special instruments and equipment, furnished the pilots to fly them, and conducted the research flights (Whelan, 2000, pp. 74-79; Grubišić & Lewis, 2004, p. 1127).

Phase I of the project began on October 31, 1951, and ended a year later. SCSA pilots reached a world record altitude of 13,453 m (44,255 ft) after a gain of 10,465 m (34,426 ft) on March 19, 1952, during Phase II. It was probably the SCSA that proposed, but did not receive approval for, a third phase of 250 thousand dollars to study wave at 21,280 m (70,000 ft) using a sailplane with pressurized crew cabin (Schweizer, 1988, pp. 124-125, 128). Another program called the Jet Stream Project, organized to study Sierra wave influence at higher altitudes on the jet stream, and the wave's influence on severe weather, began in 1955 (Whelan, 2000, p. 127). On April 14, SCSA member Betsy Woodward set the world altitude record for female pilots flying sport sailplanes, reaching 12,158 m (39,994 ft) after a record gain of 8,510 m (27,994 ft). Later that month, the wave demonstrated its power to destroy an aircraft when severe turbulence tore apart the sailplane piloted by SCSA pilot Larry Edgar (Schweizer, 1988, pp. 144, 147-148).

Wave soaring grew increasingly popular as the participants in the Sierra Wave Project began to publish their meteorological findings. The Soaring Society of America (SSA), Federal Aviation Administration (FAA), and the US Air Force collaborated on the Altitude Training Program, in 1964, to prepare the broader community of sport pilots for wave flying at high altitudes. In two years, the Air Force allowed 120 sport pilots, who were also SSA members, into a pressure chamber operated by the service so they could experience in a laboratory setting the worst hazards of wave flight: lack of oxygen and extreme temperatures. By 1966, seven commercial sailplane operators around the USA had begun offering wave flights. Between October 1962 and April 1967, pilots made 409 significant flights in wave at 32 locations across the country. Meteorologist Charles V. Lindsay described in January 1968 the possibility to put satellite photographs showing the telltale lenticular clouds, that often mark wave formations, into a pilot's hands within minutes of their transmission to the ground, using the Automatic Picture Transmission (APT) system, which had reached operational status in February 1966 (Schweizer, 1988, p. 218; Lindsey, 1968, p. 11). Moving the information with such speed was important because the strongest wave conditions could form and dissipate in a matter of hours.

Perhaps the bureaucracy had grown faster than the technology, but whatever the cause, the government had still not implemented Lindsey's idea for distributing wave images from satellites to the soaring community twenty years after he first described it. When Robert Harris soared the Sierra wave on February 17, 1986, and pushed the sailplane altitude world record to 14, 899 m (49,009 ft), he did so without first obtaining a 'wave window' from the FAA, as required by federal law to prevent conflicts with other air traffic flying at high altitudes. Harris had for years tried to attempt the record flight legally, but on every occasion, the FAA had opened the 'wave window' only after the strongest conditions had passed (Baker, 1987).

The requirement for speedier reporting, analysis, and forecasting dates to the early days of soaring. Prof. C. G. A. Rossby of the MIT (Massachusetts Institute of Technology) Meteorology Department sent a special team to the third U.S. national meet held at

Elmira, New York, in July 1932. Led by the German Meteorologist, Dr. Karl O. Lange, the group took "soundings ever morning, which made it possible to give much improved weather briefings," and may have aided pilots to set two national records (Schweizer, 1988, pp. 34-35; "Motorless Aircraft", 1932). The sport took a hiatus during World War II but beginning with the first postwar U.S. national contest held in 1947, competitive soaring continued to evolve. By 1953, pilots competing at the regional or national level could often fly as far in a day as they had flown during an entire contest held before the war. Meet directors had to devise new tasks to challenge the improvements in pilot skills and sailplane performance. To the simple free distance and race problems common before the war, the directors added such complex problems as prescribed area distance that allowed pilots to choose their own courses between 4-7 turn points and then attempt to fly the longest distance (Welch et al., 1977, pp. 390-391).

As contest performance improved, interpreting weather knowledge also became easier. By the late 1960s, the soaring community had developed several handy pilot aides. With a circular slide rule called the Thermal Forecaster, a pilot could bypass the more laborious calculations required to forecast thermals using the standard adiabatic lapse rate chart. A linear slide-rule called the Weather Guide combined pictures of various cloud forms with inserts corresponding to the weather sequences found in six different regions of the USA to help a pilot forecast local wind direction. The Weather Guide was most accurate when used in conjunction with the national weather map published in many newspapers (Selvidge, 1971, pp. 39-40).

Despite the advances in hand-held devices, trained meteorologists still provided the most accurate forecasts, as illustrated by Bill Holbrook's 1973 record distance flight along the ridges of the Appalachian Mountains that furrow the east central USA. Responding to the pilot's written request, the National Weather Service assigned meteorologist Charles V. Lindsay to help Holbrook plan the flight. After discussing weather, routing, departure and arrival times, and other details nearly every day from February to May, the men devised a plan that called for Holbrook to fly 1,314 km (816 miles) along a precisely calculated route at 113 km/h (70 mph). The morning of May 5, 1973 dawned with favorable weather conditions. After officially declaring that he would fly to a certain spot before returning to his point of origin, Holbrook took off. Lindsay's forecast was so accurate that Holbrook was able to remain within a few miles of the planned course. He landed 11 hours and 54 minutes later and missed his estimated time of arrival by just 4 minutes (Holbrook, 1973, p. 20).

In 1992, Swiss computer scientist, Olivier Liechti, wrote an algorithm that modeled atmospheric convection over a geographic region whose shape depended on the homogeneity of the weather above it. To pilots planning soaring flights, the algorithm provided the optimum time to take off and land, and the height and strength of thermals a pilot could expect along a particular course. The formula did this by correlating height of convection, cloud base altitude, and lift rate over the region with the glide ratio and glide speed characteristics of the type of sailplane the pilot planned to fly (Liechti, 2005). By mid-2005, it was possible to load 120 homogenous regions in Western Europe and

Scandinavia into the computer program called TopTask Competition built around the Liechti algorithm. Based on the reports from contest pilots who have used the TopTask forecasts, the current world records for soaring flight listed at the *Fédération Aéronautique Internationale* website (altitude above 15 km, or 9 miles, and non-stop distance exceeding 3,000 km, or 1,860 miles) may soon fall. (cf. http://www.fai.org/records/) At the Colorado State University, work began in 2007 to adapt the TopTask system to planning regional soaring flights in the USA (Hindman et al., 2007).

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"I always feel the foehn, even if it‘s not there"; the Bavarian foehn phenomenon in everyday life

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1. Introduction

If you plan to visit Munich in Bavaria (southern Germany), you may be interested in the weather during your stay. In the World Wide Web you can find the following description. "The climate is strongly influenced by the proximity of the Alps. Winds from the SW to SE lose their moisture on crossing the Alps, resulting in Föhn conditions in Munich. The Föhn invariably brings warm, dry weather at all seasons, and a strong Föhn can bring exceptionally clear viewing conditions [...] (S)trong Föhn conditions only affect Munich on a few days per year and are, hence, a less significant factor in the local climate than is popularly believed. Föhn is most common in autumn and winter, while being very rare in mid-summer" (Justgermany, 2008). This description indicates that foehn has a certain meaning for the people living in Munich. The perception of foehn in the general public in the course of time will be focussed in this paper.

2. Foehn – a weather phenomenon and its influence on human beings

In contrast to the occurrence of foehn in the valleys of the central Alps in Switzerland and Austria pointing south-north, where it is connected with very strong and dry winds, foehn in Bavaria north of the Alps, called 'south foehn', is usually characterised by clear blue sky and some white altocumulus lenticularis clouds, also called 'foehn fishes'.

One of the oldest scientific descriptions of the effect of foehn on human beings is given by a Swiss naturalist, who lived at Altdorf, one of the well-known foehn villages in Switzerland (Lusser, 1820). He especially described the feeling of foehn before its breakthrough. And he also mentioned the weakening or the cessation of the effects after the full development of foehn, when "sleeplessness, weariness and aversion to work continues" (Lusser, 1820, as cited in Berg, 1950, p. 7).

The theoretical explanation of the foehn phenomenon is closely connected with the Austrian meteorologist Julius Hann (1839-1921). The presentation of his thermodynamic theory in meteorological textbooks until the year 2001 is discussed by Seibert (Seibert, 2005). One of the typical sketches is given in Figure 1.

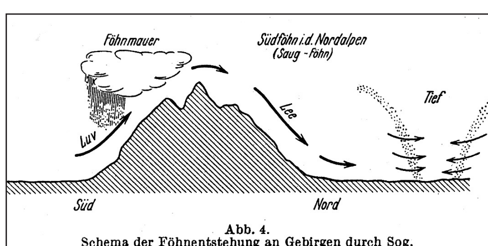

Figure 1: Development of foehn in the Alps.

Source: Rudder, 1952, p. 26.

In Italy on the windward side of the Alps, for example, the air of 10 degrees Celsius temperature and of 75% humidity moves north towards the mountains (Rudder, 1952, p. 26; Ungeheuer, 1958, p. 8). There it rises, cools and condenses resulting in 5 degrees Celsius and 100%. Clouds are developing and it starts to rain in banking up. This process is visualized by the formation of a long cloud topping the mountain ridge of the central Alps, called 'foehn wall'. Here the temperature has dropped to -3.6 degrees Celsius. On the leeward side north of the Alps south foehn develops, which is drawn by a cyclone over England. Finally in the Alpine foreland like Bavaria we get warm and dry air of 16.4 degrees Celsius and 31%, which is connected with a clear blue sky and various effects on people.

An early monograph about foehn as contribution to orographic meteorology and comparative climatology presented three synoptic charts with isobars of November, 15-17, 1867 at 8 a.m. showing high pressure over Spain moving to France and low pressure over the Black Sea causing strong southerly winds crossing the Alps (Berndt, 1896). The author devotes 27 pages to describe the air pressure during foehn, 45 pages for the air movement, 76 pages for the temperature and 69 pages for the humidity, while the causes were not yet really understood. One of the first German women in meteorology, Luise Lammert (1887-1946) analyzed pilot balloon observations in the Italian Po basin for her dissertation (Lammert, 1920). She found that the air flow during south foehn does not usually follow the valleys in the relief of the Southern Alps.

Besides meteorological interest in foehn as phenomenon of air masses crossing an obstacle, also a medical interest in foehn as cause of several diseases developed at the same time. Willy Hellpach (1877-1955), a psychologist and physician, professor and Minister of Culture and Education in Baden at that time, described the effect of foehn in his book on *The Geophsychic Pheonomena* (Hellpach, 1925, pp. 34-36). When he worked at a psychiatric military hospital in southern Germany during World War I (1915-1918) he personally experienced the longest foehn duration within living memory during the mild winter 1915/16. He described the psychophysical effects of foehn as "foehn disease," which increased the consumption of medicaments to maintain the ability to work. The foehn disease was characterised especially by weariness, general dislike, headache, combativeness, and violent temper (see also Berg 1948, p. 99).

Foehn occurs not only in the Alps but also as weak but noticeable event in the German low mountain ranges like the Riesengebirge in Silesia, today Poland (Tichy, 1939). An early investigation over the period 1886-1905 resulted in a mean value of 11 days with foehn per year and a maximum of 21 foehn days in December. In the period 1928-1935, the number rose up to 101 foehn days per year in the whole region of the Silesian Sudeten with a maximum of nearly 13 foehn days in October and November and a minimum in February with only 5 foehn days. The tenfold rise was due to a denser network of meteorological stations in Silesia. Also here the psychological and pathological effects are evident. The foehn of the Riesengebirge is also connected with a special cloud form, the so-called *motzagotel* or *moazagotl*, which is a special long airship like altocumulus lenticularis cloud, to be seen southwest of Breslau (today Wroclaw) along the whole Sudeten range.

The name *motzagotel* originates in the local weather prophet Gottlieb Matz, who used the appearance of this cloud close to Hirschberg (today Jelenia Góra) to predict – mostly successfully – the end of foehn and a change to bad weather. In rural region people like to use the family name as prefix to the surname like *Matzengottlieb* (Tichy, 1939, p. 505). After a vernacularly use his name changed to *Motzagotel* and became a synonym of an unmistakable weather sign.

The first investigation of the *motzagotel* with a glider was performed by the famous aviator Wolf Hirth (1900-1959) of the gliding flight school Grunau close to Hirschberg on March 17, 1933. He experienced a stationary field of strong up winds up to 4 m/s. Hirth described the upwind under the *motzagotel* as a long wave originating in the turbulence behind the ridge of the Riesengebirge. Recent investigations indicated that sonic like waves possibly produced by such turbulence were a possible cause for physiological effects of the foehn.

3. Medical investigations

A map in a text book on biometeorology by the psychiatrist Volker Faust from Freiburg (Black Forest) shows the mean occurrence of foehn in Bavaria, which indicates that Munich only experiences 3-5% of foehn days during a year, i.e. on 11 to 18 days, compared to Garmisch-Partenkirchen on the foot of the highest German mountain of the Alps (Zugspitze, with 2,962 m) with 18 to 26 foehn days and east of it up to 37 days due to topography (Faust, 1978, pp. 29-32). There are two maxima during the year in March and April as well as in October and November. People living in Munich feel a special relationship to foehn, which was investigated in the late 1920s.

Viktor Struppler (1905-1963) from the Pathological Institute of the Schwabing Hospital in Munich studied the death rate due to the influence of the atmospheric conditions (Struppler, 1932). In the years 1928 and 1929 he investigated the causes of death and separated them in seven groups: death due to 1. tuberculosis, 2. pneumonia, 3. cerebral haemorrhage, 4. heart disease, 5. kidney disease, 6. high blood pressure and 7. pulmonary embolism. These cases were combined with the atmospheric conditions as given in the daily weather charts of the Bavarian Regional Weather Observatory (*Landeswetterwarte*) in Munich. Although no correlation between temperature and pressure diagrams could be made, a strong variation of the death rate was observed. Struppler's results showed that people mostly died on days with depressions. The influence of foehn came a close second, the position of Munich placed at the border between high and low pressure areas came third, and the influence of the anti-cyclone over the Azores came fourth. Besides 14 failures within two years, Struppler found 141 cases which strongly indicated a correlation between death rate and influence of atmospheric conditions. Referring to 21 foehn events observed, he found in all cases except one a significant increase of fatalities especially due to tuberculosis. His investigation proved the atmospheric influence on death rate.

After World War II new investigations were published on foehn. Professor of meteorology of the university in Cologne, Hellmut Berg (1908-1960), wrote a book on weather and diseases (Berg, 1948). On page 100 he confirmed that a foehn disease exists. Discomfort appears in nature as well as in buildings and there are special “foehn localities” at which the effects are visible very well. Local people like people born at Munich are mostly not affected, in contrast to people who moved to Munich. In a later paper Berg stated that not only in talking to the inhabitants but also to physicians the foehn affection is described as enormous that it even may be considered as a mass psychosis (Berg, 1950, p. 5).

A chapter in a book on foehn and foehn effects by Bernhard de Rudder (1894-1962), director of the children’s clinic of the University of Frankfurt/Main (Rudder, 1948; see also Kuhn 1989, pp. 425-484) summarized the symptoms in great detail independently of Berg. Rudder also presented the four theories explaining the long range effect of foehn, i.e. the feeling in advance even in closed rooms. They are related to (1) variations of the electrical field of the air, (2) changes in the concentration of trace gases especially of a mixture called Aran consisting mostly of ozone, (3) variations of oxygen content in the air, and (4) variations of pressure of 4 mm hg (about 5 hPa) within a period lasting 9-15 minutes in connection with inversion conditions, i.e. when temperatures are rising with increasing pressure. Two years later in the proceedings of the first International Conference of Alpine Meteorology in 1950, Berg even gave the advice not to operate on somebody during foehn days, especially not on heart cases (Berg, 1950, p. 10).

Walter Mörikoffer (1892-1976), director of the Physical Meteorological Observatory in Davos (Switzerland), came to similar results. He found a twofold rise in foehn diseases before breakthrough of foehn, which falls to a 1.4-1.1 fold rise after it (Mörikoffer, 1950). As therapy he recommended to ‘retune’ the vegetative nervous system and to avoid surgeries on days with foehn, because cardiac people were in acute danger. But even in the early 1970s, when experiments in a climate chamber were undertaken at the Institute of Balneology and Medical Climatology of the University in Munich, research still was far away to develop special pills against the effects of foehn (Keil, 1970).

Up to the 1950s, foehn was considered to cause traffic accidents, crimes and suicides. This became subject of a very interesting study on the correlation of foehn and crimes in Munich, Innsbruck (Austria), and Zürich (Switzerland) during 1951-1953 (Meixner, 1955). The result showed that during this period the number of suicides in Munich did not rise before or during foehn days, neither in Innsbruck nor in Zürich. A correlation between foehn and traffic accidents in Munich and Zürich also became not evident, which was reinforced by another investigation from Reinhold Reiter (1920-1998) of the Physical Bioclimatological Research Center in Munich in 1953. Also accidents at work, as well as murder, violation, and exhibitionism were not affected by foehn in Munich. Nevertheless Meixner acknowledged that in single cases foehn might affect the accused, witness, or detectives and due to this in some cases uncertainties could lead to assert extenuating circumstances due to foehn in court.

A more recent study in Switzerland showed that pressure variations with periods of 4 to 20 minutes appear close to weather fronts or during foehn, i.e. always in cases when internal boundary layers are present (Richner, 1983). Pressure variations during foehn are explained by so-called atmospheric gravity waves, which develop on the surface of a so-called 'lake' of cold air, when warm foehn air flows over it. A successful therapy would be, for example, to send the patient away from the cold air lake, closer to the Alpine ridge or on a high mountain above the inversion layer (see Figure 2).

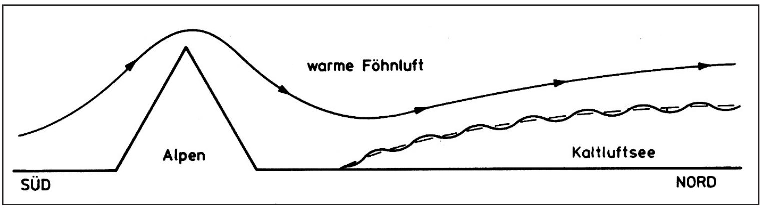

Figure 2: South-north cross-section of the Alps during foehn.

The warm foehn air-flow slides itself over a lake of cold air (Kaltluftsee) in the Swiss Midland.

At the boundary, temperature differences up to 18°C and a wind shear up to 20 m/s prevail, which lead to the development of Klevin-Helmholz waves on top of the lake of cold air.

They become noticeable as pressure variations on the ground.

Source: Richner, as cited in Kuhn, 1989, p. 493.

4. Meteorological foehn experiments

In the early 1950s the German Weather Service (DWD) published two reports on foehn in the foreland of the Alps (Berg, 1952; Ungeheuer, 1952). Then the general interest in foehn declined obviously. After some occasional meteorological descriptions of foehn events (e.g. Staude, 1970), it came to a renaissance of the investigation of foehn as meteorological phenomenon in the 1980s. This happened due to the deployment of special research aircraft, mathematical models for analysing meteorological data describing three dimensional fields with a computer, and international collaboration. The Global Atmospheric Research Program (GARP) jointly organized by the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) included a major field investigation, the 1982 Alpine Experiment (ALPEX) (Kuettner, 1982). One of the aims was to understand small scale local phenomena of the Alpine region like foehn. Meteorological services and scientific communities of twenty nations took part in the special ALPEX observing period from March 1 to April 30, 1982. The preparation of the ALPEX program uncovered that scientific literature on foehn sometimes is inaccessible. Due to this a collection of important and / or rare papers on foehn was published (Kuhn, 1989).

Unfortunately the weather conditions during ALPEX in spring 1982 were not favourable for probing a classical 'south foehn'. Thus another observational foehn experiment was executed subsequently by the Institute for Atmospheric Physics of the Deutsche Forschungs- und Versuchsanstalt für Luft und Raumfahrt in Oberpfaffenhofen (south of Munich) with measurements of research aircraft on six days during May and during October to December 1982 (Hoinka et al., 1982). In this period the so-called 'once-in-a-hundred-years foehn' occurred in Switzerland on November 8, 1982, which also was detected by aircraft measurements during the Bavarian experiment (Frey, 1984). This cataclysmic storm caused a damage of over 30 million Swiss francs in central Switzerland. This case and other recent foehn cases became subject of a thesis on south foehn in Tyrol (Seibert, 1985).

The Mesoscale Alpine Programme (MAP) was the biggest research programme in the Alps after ALPEX. Its special observing period took place from September 7 to November 15, 1999 (Binder & Schär, 1996). Among other questions the dynamics of foehn was investigated, especially the interaction between the air flowing over the Alps and the air laying in the valleys and in the foreland. Altogether during twelve foehn cases measurements were taken in great detail producing a data set for various analysis and dissertations, for example on interaction between foehn and the planetary boundary layer (Gubser, 2006).

5. Foehn in the public

Besides meteorological and medical interests, the foehn phenomenon not only inspired literature, but also art and movie makers. The famous writer Hermann Hesse (1877-1962) for example captured the special atmosphere of foehn within the Alps in his painting *Föhn*, when he was living in the Swiss Tessin (Hesse, 1924). In 1929 Arnold Fanck (1889-1974) finished his famous silent movie *White hell of Piz Palü* (*Die weiße Hölle vom Piz Palü*), a story about a dangerous rescue of a couple just married, which had been stopped by a foehn storm, when climbing a steep wall in the Central Alps. It is interesting to note that a remake of this film as a co-production of the German Democratic Republic and Switzerland came out under the new title *Föhn* in 1950. Another 138 minutes-movie of the sometimes called 'anarchical' moviemaker and author Herbert Achternbusch (born 1938 in Munich), produced in Bavaria in 1985, described 'foehn scientists' (*Die Föhnforscher*) in a very weird way. He also published a book with the same title and contents of the movie, which was printed in two different editions (Achternbusch, 1985, 1991).

In his first novel *Peter Camenzind* published in 1904, Hesse reflected on foehn, when he was living in Basel (Switzerland) and experienced this special phenomenon while hiking in the Alpine region: "When foehn is close, men and women, mountains, game and livestock feel it many hours before [...] There is nothing more peculiar and delicious than the sweet foehn fever, which attacks people of the highlands namely women during times of foehn, stealing sleep and stroking appeals all senses" (Hesse, as cited in Steiger & Zimmermann, 1983, pp. 8-9).

A research on the webpage of the German Amazon Books (http://www.amazon.de/) on September 24, 2008 provides 27 belletrist books with the word 'foehn' in the title. Among them you find a novel on a real bank robbery with hostage-taking in Munich on August 4, 1970 during days of foehn, which described a special mood of the city and its people (Gregor-Dellin, 1974); love stories (Hoffmann-Ostenhof, 1937; Martin, 1953); poems (Denecke, 1965; Neumann, 2008) and special collections of various chapters from novels and poems dedicated to give some comfort to people suffering from foehn (Macher, 1988, 1991; Rübesamen, 1988; Steiger & Zimmermann, 1983).

Bavarian newspapers of course report on extreme foehn events like the 'once-in-a-hundred-years' foehn or when a local foehn storm raged over southern Bavaria (Süddeutsche Zeitung, 1987). During slack season they print pictures from beautiful weather conditions during foehn.

When Wolfgang Koeppen (1906-1996), one of the most prominent German authors of the post-war period, gave an acceptance speech of thanks for the cultural prize received from the city of Munich in 1984, he said: "I stayed in Munich [...] Perhaps it was the foehn driving me, the Bavarian sky sung about many times, [...] In Munich I feel the ever possible touch of the terrestrial with the celestial in the sense of Novalis, this venturesome and dangerous espousal of matter and esprit, creating restlessness as well as the arts, living from the restlessness" (as cited in Macher, 1988, p. 146).

6. Recent biometeorological investigations

In the early twenty-first century biometeorological investigations of foehn were resumed at the Institute and Polyclinic for Occupational and Environmental Medicine of the University in Munich. The local press of Munich was full of headlines. Before the foehn season started in 2002 the new project was announced: "The University of Munich wants to besiege the foehn," because, as the subtitle explained: "Many people suffer from health problems during classical foehn weather with splendid sunshine" (Tageszeitung, 2002a). Then in October, one of the usual yearly foehn articles was published under the headlines: "When the Alps are very close, the head hurts – at least each third person in Munich suffers under this weather" (Abendzeitung, 2002). Finally a newspaper issue from November gave recent information about the foehn project and the title read: "Why we suffer during foehn – Peter Höppe: Our bodies are not used to these extremes" (Tageszeitung, 2002b). The idea of the project was to measure and to analyse low frequent pressure variations in Munich between September 1, 2002 – February 28, 2003 and to combine them with services of the emergency medical service and traffic accidents, as well as with interviews with meteorosensible persons. The results were published in a Diploma thesis (Wanka, 2003). Similar to Richner's results 20 years ago, they showed that during foehn in Munich pressure variations have a period with a length of several minutes and amplitude of about 0.3 hPa. The results also approved that there are either people who show strong reactions of discomfort due to foehn or people who do not suffer at all.

7. Munich correlation with foehn

Meteorosensible people in Bavaria sometimes express their feelings in the following way: "I have a headache, thus it is foehn!" (Ungeheuer, 1958, p. 8) Obviously this cannot be concluded straightforward due to a lack of differentiation between various meteorological processes causing similar effects. Nevertheless the occurrence of foehn still is an excuse for various adversities in Munich. Nobody can express this fact better than the well-known

Munich comedian Karl Valentin (1882-1948), to whom the last sentence is ascribed: "I always feel the foehn, even if it's not there."

8. Acknowledgements

My thanks go to Eva Regina Wanka, who explained me the results of her Diploma thesis (German equivalent to Master's thesis as first degree on a University) and her recent investigations at the Institute and Polyclinic for Occupational and Environmental Medicine of the University in Munich. I also want to thank Michael Heß, who allowed me to borrow some of his old books on foehn from his wonderful meteorological second-hand bookshop NOTOS in Munich.

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Medical Geography outlines a new cartography for the medical knowledge: the Brazilian case

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1. Introduction

In 1822, Brazil politically emancipated itself from Portugal. The struggle for independence had achieved a new dimension with the sudden transfer of the Portuguese Court to its American colony in 1808, fleeing from Napoleon's troops. That event had enormous consequences for the construction of medical institutions on national bases. The Portuguese fleet brought with it a printing press, the government archives and various libraries that would form the basis of the National Library of Rio de Janeiro. A degree of cultural excitement was thus introduced with the access to previously prohibited books and a considerable degree of circulation of ideas. The professional organization and regulation of medical teaching in Brazil, as activities distinct from those practiced by blood-letting barbers, practitioners and *curandeiros*, thus only began in the nineteenth century.

Thus was begun a strong clinical tradition marked by the figure of the family doctor, who functioned as clinician, surgeon and hygienic adviser, as the occasion called for. In 1832, the two Medical-Surgical Academies were transformed into the Medical Colleges of Rio de Janeiro and Bahia. The same decree instituted courses in medicine, pharmacy and childbirth. The new colleges followed the French model, oriented by the Society for Medicine of Rio de Janeiro (1829-1835) – the embryo of the Academia Imperial de Medicina created in 1835.

The configuration of medical institutions during the imperial period (1822-1889) was marked by a series of initiatives that inaugurated profound changes in the panorama of medical assistance, sanitary legislation, the formation of professionals and the means of producing and validating medical knowledge on health conditions in the tropical Empire. The consequences of these transformations and the relationship with European medical institutions, in the context of the colonial contribution of Africa and Asia, will be discussed in this paper.

We emphasize here the active role played by the Imperial medical elite in appropriating theoretical instruments of European medicine to focus on the production of original medicine for the pathology of the tropical Empire and of a hygiene agenda directed to the solution of sanitary problems in the main cities and ports, in accordance with the strategies of the constructors of the Imperial State to affirm the bases of their territorial power and impose seigniorial order on a rigidly hierarchized society. [1]

(1) The most significant works on the topic of the medicalization of imperial society are Machado, 1978; and Costa, 1979. Other approaches on the construction of the professional power of doctors and their relationship with the Imperial State are referred to in Edler, 1998.

2. Academic medicine and production of the Empire's nosographic map

In the period that followed independence, there were no significant changes in the demographic composition of Brazilian society, where the heteroclite cultural heritage maintained the same standard in providing medical services. During the colonial period 'white' society resorted indiscriminately to cures brought from Europe or those that the diverse ethnic groups with which they were in constant contact utilized to fight the illnesses that attacked them. Even the opulent Portuguese, although they used their doctors, surgeons and barbers from Portugal to treat themselves, did not hesitate, when they needed to cure their wounds, to utilize the *copaíba* oil used by the indigenous people for this purpose. Afterwards, with the arrival of African slaves, they also accepted certain cures related to magic, as the documentation of the inquisitional visits of the Holy Office shows us.

When the Academia Imperial de Medicina was created in 1835, hygiene and anatomo-clinical medicine were given a strategically placed position from which to weaken the influence of the old Portuguese surgeons and those formed by the Medical-Surgical Schools of the Court and of Bahia (Ferreira, 1996). In this period, marked by a belief in the dependency of pathology and therapeutics on environmentally circumscribed climatic-telluric factors, rejection of the colonial heritage of the Fisicatura and the more or less impressionistic legacy of medical information described either in medical treatises of the colonial period or by lay cults or naturalist travelers, imposed itself as a precondition for affirmation of the new professional ethos.

Through the Academia de Medicina, the medical elite strove to produce original knowledge regarding Brazilian pathology in accordance with the program formulated by the nascent medical geography. From its creation to the middle of the century, it was able to monopolize two important tasks: at the same time that it imposed itself as an instrument of imperial policy for public health, it became the principal arbiter of medical-scientific innovations, contributing to sanctioning innovations in diagnosis and therapy, as well as new theories and concepts strictly concerned with knowledge of Brazilian pathology. Like the Academy of Medicine of Paris, which served as a model, it offered prizes in annual competitions, collected and examined epidemiological information, administered smallpox vaccination and assisted the government in the subject of medical education, hygiene policy and public health. The production, coordination and arbitration of medical knowledge, oriented toward public health, resulted in a precarious organization of the medical profession seeking to constitute a network of information and data collection that had to be processed, analyzed and eventually applied by the academics. Thus regional inequalities were solidified to the benefit of the medical elites of the capital, the direct beneficiaries of their proximity to the sources of state power.

3. The medical geography research program

Geographic pathologization, which the medical topographies of the eighteenth century had carried out under the influence of neo-Hypocratism, achieved a new dimension in the Age of Empires thanks to an unprecedented mobilization of a vast combination of nosological, pathological and therapeutic phenomena around the globe. A specific group of medical professionals, almost all military doctors who practiced in regions politically, culturally and economically subordinated to the principal European colonial powers, headed this enterprise. They claimed for themselves the responsibility and the task of defining medical-hygienic problems and establishing the parameters for their solution in the inhabited zones peripheral to the main centers of medical culture (Edler, 1999).

A broad commercial interchange, coupled with European colonial policy, introduced the practical and theoretical problem of understanding why certain diseases were limited to certain regions of the globe, while others had a differentiated impact and a distinct pattern of endemicity. The experience of the colonial armed forces doctors was added to the practice of resident medical communities in the tropical colonies and ex-colonies, generating another intense interchange, namely of facts and medical theories, among the scientific centers of the Old World and the emerging medical communities of the periphery.

The dominant version in the historiography of Tropical Medicine claims that medical geography was based on a body of fossilized knowledge, with no reference to scientific practice and anchored on a scientific criterion that was outdated or displaced by contemporary currents of investigative medicine (Arnold, 1996). This view is wrong; Medical Geography was a dynamic medical force at the time, capable of motivating a research program that involved thousands of doctors who practiced medicine with the conceptual tools of anatomo-clinical and statistical medicine – gradually incorporating parasitology – at the periphery of the main centers of European medical culture. For us, the history of the genesis and development of medical knowledge under the aegis of medical geography in the middle of the nineteenth century was inseparably linked to the expansion of contemporary European medical culture to the periphery of the empires, as well as to the post-colonial regions. In fact, the construction of the idea of the singularity of tropical pathology and therapeutics was not limited to doctors that practiced there. A similar epistemological discourse, namely the same set of presuppositions regarding pathological causality, as well as the same representation regarding the rules that ought to produce and validate medical knowledge, governed the clinical practice of academic medicine in the main European medical centers. (2)

The internal division of medical work between national and regional molds was, in fact, a vertical hierarchical division that expressed itself in terms of professional power and scientific prestige. We argue, thus, that the effort to redefine the medical problems of the tropics, based on an appreciation of environmental factors (climatic, racial, telluric and hygienic) of endemicity, was broadly conditioned by jurisdictional competition internal and external to the medical profession. At a later stage we will describe the manner in which doctors who practiced in Imperial Brazil mobilized their theoretical arsenals and

(2) For a similar interpretation in the American historiography on Southern medicine during the Civil War see Warner, 1985. On colonial medicine in India, see Naraindas, 1994.

clinical and medical statistics techniques to meet this task.

A number of hygiene doctors, who occupied administrative positions and were responsible for the institutionalization of the techniques of statistics in French medicine in the 1830s, delineated the initial bases of a research program that sought to establish a nosographic map of the world. (3) They were succeeded by doctors of the French navy, prominent agents in the construction of this discipline in the second half of the nineteenth century. Together, they acted strategically – as did their Brazilian, English, German and other colleagues – to create a system of scientific authority that would give them legitimacy *vis-à-vis* a specific client, the state.

Encouraging research on tropical nosology and constructing a global nosological map, as well as coordinating and controlling the new knowledge was fundamental for achieving this objective. Affirmation of the notion of a geographic specificity for pathology and therapeutics thus harmonized with the interests of doctors who focused their professional practice on the tropics, benefiting from this supposed 'natural' monopoly to demand their privileges in the production, control and application of a regionally circumscribed knowledge.

The study of actions perpetrated by the Academia Imperial de Medicina, which we will present below, makes it clear how groundless the interpretation that identifies medical climatology with a fatalistic determinism has been. The notion of hygiene, as opposed to the idea of 'natural region', would serve as an antidote to the morbiferous factors of climate. (4) Unfortunately, within the limits of this paper, we cannot touch upon the wide range of positions on the main subjects of this topic, nor analyze in depth the epistemological and ideological bases of the beliefs sustained by the sources of disciplinary authority that we have identified as the most notable of the period. These include the treatises of medical geography or tropical climatology, more frequently cited as classics, and the *Archives de Médecine Navale*, the main institution that undertook the task to organize the field between the 1860s and the 1880s. In another work, we pointed out that this publication played a crucial role as an alternative route to scientific legitimation for emerging medical groups in the Brazilian medical panorama (Edler, 2001).

4. Reinventing Brazilian pathology

In the academic works published in the *Propagador das Sciencias Medicas*, *Diario de Saude*, *Semanario de Saude Publica* and the *Revista Medica Fluminense* – the last two being organs of the Academia Imperial de Medicina – malarial fever was highlighted as the dominant illness of the national pathology (Ferreira, 1996). According to the rules for producing facts and theories shared in the context of the above-mentioned socio-cognitive experience of anatomo-clinical medicine and the climatological paradigm,

(3) Boudin was chief doctor of the Marseille hospital. Becquerel and Lévy held various administrative posts. On the topic, see Lécuyer, 1977; and Berge, 1984.

(4) On the opposition between social statistics and the notion of 'natural region', see Chartier, 1998, p. 213.

this conviction was scientifically grounded. Such an epistemology presupposed the existence of institutions, such as the Academia de Medicina, that regulated a collective practice, territorially defined, designed to collect records of clinical observations that encompassed the description of the diagnoses, etiologies and therapeutics and postmortem anatomo-pathological examinations. Such a regimen of producing medical-scientific facts presupposed the commitment of the local corporate medical body to produce knowledge necessarily limited to its own environmental jurisdiction.

Other endemic diseases found by that body of professionals were rheumatism, erysipelas, yaws, hydrocele, leprosy, hemorrhoids, inter-tropical anemia, filariasis and hemato-chyluria. In addition to these endemic diseases, a number of other diseases had received attention in their weekly sessions: influenza, syphilis, smallpox, liver, heart and skin diseases, chickenpox, scarlet fever, typhoid fevers, tetanus and scurvy. The evaluation of academics in the first half of the 1800s was that the country enjoyed good health conditions.

Wishing to monopolize the dialogue on national medical problems before the Imperial Government and European medical-scientific centers, the Academia de Medicina undertook the task of translating and updating the contemporary European hygienic and anatomo-clinical agenda, which would legitimize the interpretation of Brazilian pathology. In the face of these issues, consecrated by medical geography, Brazilian doctors presented original responses, some of which opposed the old raciological stigmas circulated in European medical compendia. In addition, they produced a positive evaluation regarding Brazilian pathology, where some of the most feared diseases, such as yellow fever, the plague and cholera had no claim to call their home.

Some of these original solutions were gathered together by one of the founders of the Academia de Medicina, a doctor of French origin, José Francisco Xavier Sigaud (1796-1856). Among the climatic-telluric factors, the academics attributed a predominant role to heat and humidity in Brazilian pathology, describing their direct or indirect pathogenic action (miasmas) on the human economy and prophylactic ways to avoid their deleterious action. Meanwhile, according to the medical consensus of the time, the decisive morbiferous factors were related to hygienic habits. Thus, the "first agents of mortality" in Brazil would be "the dietary regimen" and abuse of the "venereal act." A healthy attitude focused on excluding these predisposing factors would result in attenuation of the main instigating climatic agents, namely heat, humidity and miasmas (Sigaud, 1844, p. 59). The academics also presented a generous evaluation on the problem of acclimatization, which was directly linked to the serious question of European immigration, seen by eminent politicians as the alternative solution to the end of black slave traffic imposed by England. [5] And they did so, condemning certain European customs imported indiscriminately.

(5) For theoretical debates on acclimatization in Rio de Janeiro, see Chaloub, 1996. Optimistic evaluations on climatic adaptation (acclimatization) of the Europeans in Brazil are in Edler, 1999.

5. Conclusion

The presentation of a hygienic prescription book, written by Sigaud in 1844, *Du climat et des maladies du Brésil ou statistique Médicale de cet Empire* adapted to the new climatic conditions and focused on a healthy adjustment, should be interpreted as a victory to be credited to national doctors in their efforts to revise European treatises on pathology and hygiene and create a local medical culture. As a result, both the work of theoretical revision, related to downgrading the role of meteorological agents and 'temperament' in the hierarchy of the production of diseases due to good habits, as well as recommending these same secular habits, such as "cold baths," "alcoholic beverages," "the use of milk," and "the tendency to follow Paris or London fashions would be contrary to healthy hygiene," reflected the effort of the national medical culture to conform to the precepts imposed by the exclusively Brazilian pathology (Sigaud, 1844, p. 100).

Lastly, we provide one more example of the originality of Brazilian doctors in the first half of the 1800s in the face of scientific beliefs considered sacred in European medicine. Contradicting the opinion of a number of European colleagues, who attributed the emergence of new diseases that did not exist in the European pathology to "a mixture of the races," the Academia de Medicina asserted that "the diseases that each of the races brought to the country had not degenerated after transmission to other races [...] Yaws, imported from Africa, the syphilis of the indigenous people and smallpox from Europe" were identical to what they had been three centuries before. Only the "pathological secret of the country" could be ascribed to the "nature of the locations" and the "regimen of the populations" (Sigaud, 1844, p. 157). It is important to note, however, that a good part of these scientific beliefs were not consensual, being the object of fierce dispute among academics.

Despite being polemical in some aspects, description of the nosographic map of the Empire was a spectacular triumph of the Academia Imperial de Medicina. By adapting European medical knowledge to Brazilian climatic-telluric conditions, it became the guarantor and controller of the nosographic map, virtually monopolizing all dialogue with hegemonic medical institutions until the middle of the nineteenth century.

Meanwhile, two events jeopardized the social position that the Academia Imperial de Medicina had achieved in its first quarter century of existence. First, the unexpected eruption of two outbreaks of the most feared epidemics known to man, namely yellow fever (1849) and cholera (1855), afflicted the capital of the Empire and other important coastal cities. The second event refers to the epistemological dislocation caused by experimental medicine, which resulted in the appearance of competing societies and medical publications that began in the 1860s. These new avenues of scientific legitimation would break the monopoly until then enjoyed by the official medical publications of the Academia de Medicina.

Beginning in the 1870s, an inflection would occur in the medical research program now captained by a set of medical journals. New groups of doctors began to pursue *pari passu* the institutional reform movement that, under the impact of the dynamics of experimental research, subverted the medical hierarchy headed by clinical medicine and hygiene. The emergence of disciplines that were labeled experimental medicine and new clinical specialties made the curricular reform of medical teaching imperative, one that contemplated a redefinition and expansion of the old body of knowledge.

Meanwhile, a research program of this kind lacked the scientific stamp for the Pasteurian medicine that, at the end of the nineteenth century, would triumph over not only the hypothesis of a parasitical etiology of diverse diseases previously associated with the climate, but also the ontological conception of disease, thereby revoking all the legitimacy of the climato-telluric *démarche.* The shift of scientific facts to the category of beliefs or myths at the end of the nineteenth century corresponded to an alteration in the rules of producing facts, i.e., a change in the status of certain practices and the groups that sustained them, as well as a redefinition of hierarchies and socio-professional values. In this process, the scientific interchange started by many native medical journals and upgraded by the *Archives de Médecine Navale* favored the legitimation of the new knowledge.

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Early water-level measurements and weather observations on Prussian gauging stations: examples from the Prussian Province Saxony (1817-1875)

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1. Preliminary remarks

During the past fourteen years, the members of a project-group of the Institute for Geography of the University of Göttingen were able to find about 60 historical files of early gauging observations. These files are stored at State Archives (such as in Magdeburg and Merseburg) as well as in the archives of various environmental state departments.

Consequently, early nineteenth-century water level measurements as well as weather observations by Prussian gauging stations will be presented. The examples of the former Prussian Province Saxony will be further explained. These observations deal with the daily water level data. The measurements of the water level were taken from countless rivers in the Prussian Province Saxony from 1816 to 1818 and were continued until app. 1910. The reading of the gauging levels took place once a day between 12 and 13 o'clock. Only at times of flooding were the levels read more often (normally in the morning at 7 a.m. and in the evening at 8 p.m.).

Aside from the water levels, until 1850, the observers noted the daily atmospheric conditions in the gauging lists. This included the cloud data, rain fall and wind direction data. The atmospheric conditions noted in the old gauging lists are of particular importance to current research of the history of the climate of the nineteenth century. These previously non-scientifically processed values represent significant supplemental information for early meteorological instrument data. Furthermore, the gauging and atmospheric data from the nineteenth century can be used to reconstruct the extremely historic incidences of flood water occurrences.

2. Goals

The intent of this paper is to introduce the structure and mode of operation of water-gauging practices at selected stations in the former Prussian Province Saxony. Subsequently, the meteorological observations of the gauging stations and thus the values of these meteorological observations of the Prussian gauging stations will be examined in more detail.

3. Area of examination

The area to be examined is the region of the former Prussian Province Saxony. This province was a part of the kingdom of Prussia. The Province Saxony was founded in 1815 and existed until 1944 / 45. It measured approximately 25,500 km^2 and essentially encompassed the territories of two states: Thuringia and Saxony – Anhalt.

The Prussian Province Saxony was divided into three areas (so called Regierungsbezirke): Magdeburg-district, Merseburg-district, and Erfurt-district.

Large parts of the Prussian Province Saxony belonged to the Elbe watershed. Significant rivers in this region are: Elbe-river, Saale-river, and Unstrut-river.

Map 1: Catchment area of the Elbe river.

4. Development of the gauging characteristics in the Prussian Province Saxony

Early data dealing with the setup of gauging stations and the regular readings of the Province Saxony's river water levels are available from the year 1811 onwards. In 1810 (on the 13th of February) the Prussian government decreed the first gauging proviso which contained detailed information of the measuring instruments as well as the reading of the water level (Schmidt, 2000). Hydraulic engineers took part in the preparation of this decree. Noteworthy is the Prussian civil engineer Johann Albert Eytelwein (1764-1848), who was involved in the construction of many rivers and who published several books dealing with problems on hydraulic engineering.

This decree lasted for fifty years. Then new decrees took place. Significant to the gauging observations in the kingdom of Prussia and thus for the Prussian Province Saxony were the following laws / regulations:

- The law governing the observations of water levels (9th of September 1881),
- the regulations governing the structure of gauging stations and their observations (pertaining to the Merseburg-district, from the 10th of January 1883) as well as a circular containing a collection of notes dealing with water level observations (15th of April 1883).

There were two main reasons behind the distribution and operation structure of gauging stations in Prussia. Firstly, important data was to be gained by the gauging observations so as to use this to warn the people of rapidly rising water levels. This in turn made these stations the main aspect for the structure of warning systems (1889 for the Saale-river and Weisse Elster-river) (see Deutsch & Pörtge, 2001). Secondly, with the daily readings of the water levels and the measuring of flood water occurrences, exact data of the maximal water levels of a river was collected. These values were then used as the basis for the structure of these rivers and the decision on which of these rivers required the immediate construction of dams.

Atmospheric conditions also played an important role. Thus, the observers had to carry out daily atmospheric condition observations and keep close track of the results. These included:

- Cloud data,
- rain-information, also information about snowfall, and
- storms, thunderstorms and other atmospheric phenomena data (see Figure 1).

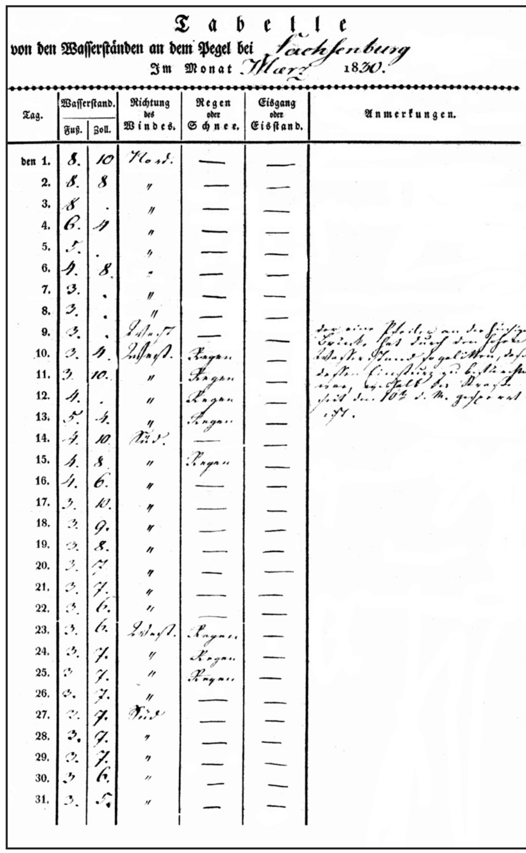

Tabelle
von den Wasserständen an dem Pegel bei Sachsenburg
Im Monat März 1830.

Tag.	Wasserstand. Fuß.	Wasserstand. Zoll.	Richtung des Windes.	Regen oder Schnee.	Eisgang oder Eisstand.	Anmerkungen.
den 1.	8.	10	Nord.	—	—	
2.	8.	8	"	—	—	
3.	8	.	"	—	—	
4.	6.	4	"	—	—	
5.	5.	.	"	—	—	
6.	4.	8.	"	—	—	
7.	3.	.	"	—	—	
8.	3.	.	"	—	—	
9.	3.	.	[illegible]	—	—	[illegible]
10.	3.	4.	[illegible]	Regen	—	
11.	3.	10.	"	Regen	—	
12.	4.	.	"	Regen	—	
13.	5.	4.	"	Regen	—	
14.	4.	10.	[illegible]	—	—	
15.	4.	8	"	Regen	—	
16.	4.	6.	"	—	—	
17.	3.	10.	"	—	—	
18.	3.	9.	"	—	—	
19.	3.	8.	"	—	—	
20.	3.	7.	"	—	—	
21.	3.	7.	"	—	—	
22.	3.	6.	"	—	—	
23.	3.	6.	[illegible]	Regen	—	
24.	3.	7.	"	Regen	—	
25.	3	7.	"	Regen	—	
26.	3.	7.	"	—	—	
27.	3.	7.	[illegible]	—	—	
28.	3.	7.	"	—	—	
29.	3.	7.	"	—	—	
30.	3	6.	"	—	—	
31.	3.	5.	"	—	—	

Figure 1: Original gauging-list (March 1830), station Sachsenburg (Unstrut-river).

The administration of the Prussian Province Saxony, between 1811 and 1820, set up twenty-five to thirty gauging stations on several rivers. These included the following gauging-stations:

Elbe-river:
- Torgau,
- Wittenberg,
- Magdeburg.

Saale-river:
- Weißenfels,
- Naumburg,
- Halle.

Unstrut-river:
- Sachsenburg,
- Nebra,
- Freyburg.

Between 1880 and 1883, about fifteen more stations were created.

5. Examples of water level measurements and atmospheric conditions observations at the gauging stations

In the nineteenth century all stations measured the data with the aid of gauge staffs made of either wood or steel. The units of measurement until 1871 were the Prussian foot and inch. In 1872 this was converted in new stages (centimetres / meters). The following examines the operation of these stations and the atmospheric conditions will be more closely explained.

5.1 The gauging stations near Sachsenburg and Nebra at the Unstrut-river

The Sachsenburg and Nebra gauging stations are located at the Unstrut-river (see Figure 2). The Unstrut is a significant feeder to the Saale and today measures about 190 km. From prior data, in 1817 Sachsenburg and in 1821 Nebra, daily measurements of water levels were begun.

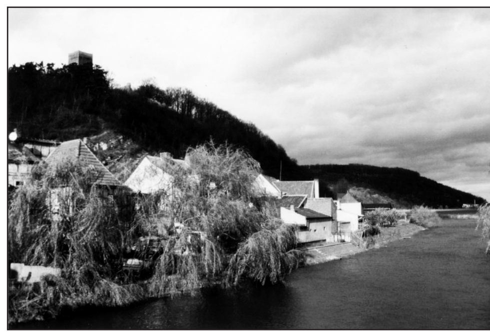

Figure 2: Unstrut-river near the former gauging-station Sachsenburg. Photo: Mathias Deutsch.

In Sachsenburg and Nebra, the staffing gauging were located on bridge pylons and it was here the observers measured the levels. They also had to observe the atmospheric conditions at these two locations, which now makes it possible to reconstruct severe flood water conditions of the nineteenth century.

5.2 Flooding occurrences in the year 1830

The flood of winter 1830 represents an extreme occurrence and thus is considered to be one of the most severe flooding occurrences of the nineteenth century in Middle Germany. The winter of 1829 / 30 was very cold and snowy. At the end of February / beginning of March 1830, thaw conditions set in and in a short time, large amounts of water began to run off. This caused the flooding of large areas and hundreds of homes in the villages next to the rivers were destroyed. By means of the historic gauging and the meteorological observations, this incidence is able to be well reconstructed.

5.3 The catastrophic summer flood in 1871

The second incidence of flooding presented here took place during the summer. It is the first ever flooding taking place in the summer time (June and July) at the Unstrut-river. The spring of 1871 had been cold and wet. The ground had been softened and the farmers had a difficult time getting their seedlings to ground. At the beginning of June 1871, heavy rains began to fall. This turned into a continuous rainfall on the 22nd of June 1871, which lasted about 24 hours, causing a catastrophic flood (see Figure 3). On the 27th of June, the dams broke. Large acreage stood under 2 meters of water. This example shows that even in this case, by way of the historic gauging data and meteorological observations, historic floods are able to be reconstructed.

6. Conclusion

In the kingdom of Prussia, beginning in 1810 / 1820, regular gauging measurements of the rivers were begun, which in turn caused the creation of a tight network of gauging stations of the rivers in the Prussian Province Saxony.

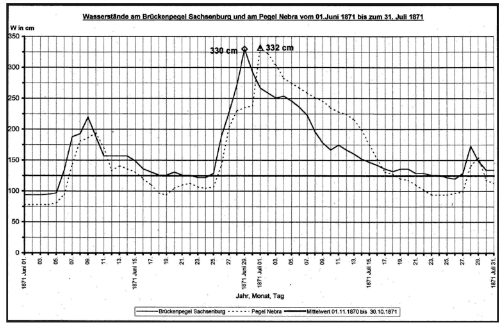

Figure 3: Waterlevel of the Unstrut-river (station Sachsenburg and Nebra) in June and July 1871.

As the members of the Göttinger project-group have shown in the past few years, many of the historical observations of these gauging stations are still in existence today and are available for scientific analysis.

The first examination of gauging of the Unstrut-river shows that large amounts of significant hydrological data as well as climate and atmospheric conditions are available as far back as 1818.

These old gauging observations have intrinsic value when reconstructing significant floods of the past (Bjarsch et al., 2007). Furthermore the meteorological data contained in the gauging lists offer the opportunity to supplement early meteorological observations and / or data.

In the future, examination of the climate history of Middle Germany during the nineteenth century will take note of the rarely noted data and information contained in the historic gauging documents. This will require a tight interdisciplinary cooperation between environmental historians, geographic specialists, hydrology specialists as well as meteorologists.

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VI. WEATHER AS LIVED

Working with potency: the role of weather in KhoeSan healing

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Since the 1970s there has been considerable academic and popular interest in relationships between the historical /Xam Bushmen, recent Kalahari !Kung and rock art found across southern Africa which is possibly hundreds if not thousands of years old. The wider world has consequently been introduced to the San through a multitude of books on Cape /Xam San beliefs and elaborate San exhibitions in South Africa's key museums. A current display in one of these museums, Cape Town's Iziko South African Museum, is subtitled: "Paintings and engravings of the San people that were inspired by beliefs about the spirit world, rain-making and healing." This tripartite spirit, rain, healing link captures what academics see as central elements of San culture.

In this paper I explore these three interrelated themes in terms of how knowledge and experience of weather are profoundly tied to KhoeSan ideas of spirits and medicine. (1) I contextualize these ideas within wider KhoeSan weather and healing related concepts I have encountered during eighteen months of doctoral and postdoctoral fieldwork (ten months in 2001, eight months in 2007-8) amongst a range of KhoeSan peoples, including Nama, Damara, Topnaar, Hai//om, Nharo, Ju/'hoan, !Kung and ≠Khomani in South Africa, Botswana and Namibia. After sketching the more widely known material on KhoeSan relationships with rain I broaden my analysis to examine how weather, principally rain, thunder, lightning and wind become embodied, manipulated and transformed in the healing process. I propose that the experience of weather feeds into KhoeSan healing ideas and practices and weather phenomena transform into interlinked ideas of wind, rain, potency, breath, smell, contagion and potent arrows. Within this KhoeSan healing world, 'normally' perceived boundaries of self dissolve as healers move the power or essence of weather and the potency of healers and animals between each other and in and out of the sick. The pattern and themes of ideas I present support recent work on San healing by Guenther (Guenther, 1999) and Keeney (Keeney, 2003) that engages with the long recognised problem of how to make sense of the very fluid, inchoate and variable nature of KhoeSan thinking.

To understand how weather informs KhoeSan cosmology and healing, one has to understand how KhoeSan thinking, born from experience, allows for the transformation of things and those things carry some of the powers or potency of the original phenomena with them into their new form or host. Rain, lightning and wind are conceptually merged

(1) KhoeSan is an artificial combination of 'Khoekhoe' (old Khoikhoi) and 'San' and is used as a reference to these culturally related peoples (see Barnard, 1992). Khoekhoe equates to the now disparaging old European appellation 'Hottentot'. 'San' equates to the name 'Bushman' which some academics have thought disparaging but appears to be, at least now, the name of preference amongst most Bushmen I have encountered.

with spirits, deities and devils. Building on Guenther, Keeney suggests such conceptual fluidity holds the key to understand confusing transformations of things and ideas in the San healing world. Keeney identifies overlapping ideas as a Bushman "way of knowing that derives from the constantly changing forms they see in nature as well as the transformational personal experiences that arise in their healing dance and in a doctor's special dreams" (Keeney, 2003, pp. 143-144). KhoeSan experience of life revolves around constantly trying to live with and work with changes in nature, be they arrivals of sickness, whirlwinds, chattering birds, lightning strikes or unknown howling noises in the bush.

Guenther identified ambiguity as the "ontological and conceptual substance of the beings (shamans, tricksters, therianthropes) and states (trance, transformation, the inchoate First Order)" in San religion, belief and myth (Guenther, 1999, p. 236). Keeney further proposes that to understand KhoeSan religion one must not begin with the essentially benign creator God and envisage that the trickster God is one of a number of possible lower order manifestations. Alternatively, one must begin with the trickster, one aspect of whom is the benign creator and the other a Satan figure (Keeney, 2003, pp. 144-145). This prioritising of transformation represents KhoeSan thinking far better than a fundamentally Christian colonial prioritising of benign creation. In a sense, before there was matter there was flux. An understanding of transformation is the key to KhoeSan cosmology, ontology and epistemology and essential to understand ideas about healing, spirits and weather.

1. Water and rainmaking

The Western ethnographic link between Africans and rain-making has a long history and one intimately bound to the colonial context in which professional anthropology first emerged. Frequently framed as witchdoctors and herbalists, rain-makers were often perceived as obstacles to the introduction of Christianity (e.g. Casset, 1904) and the worst sort of primitive criminals who indulged in all manner of heinous crimes and obscenities, even anthropophagy (e.g. Hodgson, 1931).

It is not surprising that life in and around the Kalahari semi-desert where the KhoeSan live should emphasise the importance of rain and water. The arrival of the rainy season heralds flow of ephemeral rivers, a fleeting greening and blossoming of the dusty semi-desert in grass and flowers and an increase in game animals grazing on new shoots. The fundamental relationship between transformation, weather and ideas about, spirits, gods and healing is visible amongst many KhoeSan peoples whose deific figures are intimately connected with water and storms. The nineteenth-century Cape /Xam Bushmen, for example, called their deity !Khwa, meaning water or rain. The heavily acculturated ≠Khomani of the Northern Cape still describe how they used to watch the lightning arrive and set out for the accompanying rain in distant pans where they feasted on Tsama melons, hunted the game and stayed until the water dried up.

Since early colonial encounters with 'Hottentots' (Khoekhoe) accounts of the KhoeSan and rain have woven in and out of the darker African meta-narrative, although never really becoming a part of it. Early accounts of KhoeSan belief did seem to fit Tylor's 1881 assertion that “the highest deity of the African negroes is the Sky, who gives the rain and makes the grass grow” (Tylor, 1881, p. 358). African ‘magicians’ and witchdoctors were identified amongst KhoeSan, but they appeared more as foolish charlatans rather than powerful authority figures or criminals and they lay very much on the edges of Western images of KhoeSan. This reflected both realities of KhoeSan social structure and beliefs and the idiosyncrasies of the KhoeSan ethnographic record. That healers and rain-makers amongst the KhoeSan were not, and still are not, granted particular status in most social contexts is an important reason for their low profile in the ethnography. As is, similarly, the lack of witchdoctor type objects amongst these pastoralists and hunter-gatherers, although magic bags, amulets and other simple ‘magical’ accoutrements have long been identified by travellers.

The importance of rain to ‘Hottentots’ was noted in early contexts but details were never extensive. From his 1737–1743 work amongst the Cape Hessequa, the missionary George Schmidt left short but informative notes on a ceremony during which they sang “O Tiqua, our Father above our heads, give rain to us, that the fruits [..] may ripen, and that we may have plenty of food” (Schapera, 1930, p. 378). Schapera has linked Tiqua with Tsu //Goab, a mythical KhoeKhoe figure still known by some Damara as ‘the old God’. Tsu //Goab was a warrior but also an alternative conception of rain giving clouds and fertility in the fields (Schapera, 1930, p. 378). The dual knowledge of Tsu //Goab is partly indicative of a KhoeSan propensity to anthropomorphise weather phenomena, although anthropomorphism does not really capture what is at stake. The Nharo Bushmen similarly speak of clouds as ‘God’s face’, *N!eri k’i*, and God’s hair, *N!eri /oo*, N!eri being the creator God (Guenther, 1999, p. 63). In Theophilus Hahn’s 1881 scholarly work on KhoeKhoe mythology he linked Tsu //Goab with Tūsib, also known as /Nanub, the thunder cloud. He observed that *tū* means rain, Tūsib, raingiver, “or the one who looks like rain, who comes from the rain – the one who spreads green shining colours” (Hahn, 1881, p. 139). Hahn’s work indicates how the identity of this figure is intrinsically linked to what happens, rain and greening of the earth. In this process Tūsib is more a name for the unfolding phenomena, rain and greening, than for an anthropomorphosised person, although the rain event can be talked to and hence holds some human like characteristics.

Hoernlé’s 1922 *A Hottentot Rain Ceremony* which concerned the ≠Aunin or Topnaar of Walfish Bay in Namibia stands as a significant account of rain-making beliefs from a later colonial context. Hoernlé located Khoekhoe rain ideas within benign symbolic rain-making ceremonies which still remained distanced from the stuff of dark African witchdoctors.

Despite the extent of colonial change that separates early Khoekhoe from recent, there is clear continuity between recent beliefs and those recorded by early colonial ethnographers. In northern Namibia *tū* remains a word associated with rain and refers to the smell that precedes rain as well as *tū ≠oab* or rain wind. /Nanus is used in contexts of healers, */nanu ≠aob* (s) who are said to have the *≠oab*, wind or spirit of the rain. /Nanus is also the place or deity of thundercloud to which Hai//om healers travel in their shamanic journeys to take the rain. These healers describe how they travel into the cloud home of /Nanus. If the healer has the rain spirit or */gais*, when the cloud thunders he can enter through a doorway. If he does not have the */gais* he must steal in through a window and risk being struck by lightning. Once in the cloud-house healers move through the dark rooms to a light one where they find the rain. They take the rain from this room back to the people.

Ideas of rainmaking and links with fertility do exist amongst contemporary Khoekhoe but they are neither widely known nor particularly associated with power or authority. Rain-making skill sits quietly waiting to be drawn upon should a crisis present itself when someone who knows the old ways and has the talent to make rain will come forward to throw herbs on a fire or carry out other low-key rain-making procedures. Damara who are now in their early forties took part in rain traditions when young, such as girls around the time of their first menstruation running around naked in rain storms to secure their fertility. It is hard, however, to determine whether such practices still continue, as it is whether or not younger people are continuing the tradition of rain men healers.

Like the Khoekhoe, rain-making amongst the Bushmen does not fit the flamboyant and status laden image of other African rain-makers, although there are suggestions that the status of healers and rain-makers has changed in response to recent and historical social and economic change (Lewis-Williams, 1994, p. 84; Guenther, 1999, p. 195).

Recent academic interest in Bushmen and rain is rooted in accounts of nineteenth-century South African Bushman beliefs, and comments certain Bushmen made regarding Bushman paintings in the Drakensburg Mountains. In the 1870s a Lesotho San guide, Qing, described to a colonial Magistrate, Joseph Orpen, that paintings he had shown Orpen represented a supreme being, Cagn, and “men who had died and now lived in rivers”, who “tamed” elands and snakes. They were initiated men who danced until they fell, sometimes with blood pouring from the nose. They had charm medicine incorporating burnt snake powder and they healed people by placing their head and hands on the sick and absorbing the sickness (Orpen, 1874, pp. 1-13). Qing’s account overlapped with ideas held amongst a contemporary group of /Xam Bushmen working with a philologist, Wilhelm Bleek, in Cape Town. These /Xam lived hundreds of miles from the Drakensburg Mountains. They nevertheless seemed to talk about similar things to those Qing described. Subsequently, further crossover of ideas and practices has been observed between these historical accounts and recent anthropological accounts of Kalahari San. This has led researchers to conclude that KhoeSan culture has long been associated with the sort of shamanistic practices that came to light through these nineteenth-century San accounts.

What Bleek’s /Xam informants described is how shamans were thought to ‘possess’ the rain or game animals and have certain powers over these phenomena. Rain shamans could travel in a dance induced trance-like state to the home of the rain bull or water cow. They would charm this phantom animal towards them, capture it and lead it across the land, spreading water as they went. There are suggestions that if the rain animal were a bull this brought dangerous stormy male rain and if a cow, gentle light rain (Hewitt, 1986, p. 299). The idea of male hard rain and female light rain is common amongst contemporary KhoeSan.

The 'supreme being' Cagn or /Kaggen described by these nineteenth-century Bushmen equates with mythical figures found throughout the KhoeSan in different places and at different times. These ambiguous and enigmatic figures carry out acts of transformation, creation and regeneration in benign, mischievous and malicious contexts. There is some disagreement as to whether the /Xam had one such deity, /Kaggen, or whether !Khwa, the water, also deserves similar status (Skotnes, 2007, p. 152). Undoubtedly !Khwa was highly significant to the /Xam. !Khwa was the embodiment of storms and appeared as a bull, an eland, a snake, mists, massive clouds, whirlwinds and thunder and lightning. As Skotnes notes he was, however, more than this. He worked with malevolent spirits to cause illness and misfortune. In this sense !Khwa equates strongly with other Bushman deities responsible for both illness and weather. Valiente-Noailles, for instance, identified amongst the Kalahari G//ana a belief in Kaonxa as 'the master of illness' responsible for violent rain and windstorms. Like !Khwa, Kaonxa was also sometimes described as a big snake (Skotnes, 2007, p. 154). Although it is tempting to work out a relative hierarchy for these mythical and divine figures, it might be more representative to simply think of them as different aspects of the diverse unpredictable all powerful nature of existence, rather than focus on which being is thought of as supreme or godlike to particular Bushmen.

Numerous KhoeSan groups, including the Damara and Hai//om, hold beliefs in a deity called //Gamab or //Gâuab whom, reflecting missionary influence, is often referred to as Satan but does not fit any easy categorisation. As Barnard summarises derivatives of these names found across the KhoeSan with gender suffixes, are also "almost universally" terms for "the evil god, the evil aspect of the good god, the evil spirits, or the spirits of the dead" (Barnard, 1992, p. 259). Whether or not //Gamab is a secondary or lesser god remains an academic question that is similarly probably better answered by thinking of //Gamab as one aspect of the essential trickster nature of life. Damara I encountered said they only had one god //Gâuab, although they then confusingly seemed to talk of two, both of clear missionary influence, Elob (from Hebrew Eloah or Elohim; see Barnard, 1992, p. 262) and Satan. Damara and Hai//om I have encountered thought of //Gâuab as the cause of fights and illness but also the teacher of healers.

Reminiscent of !Khwa, Vedder suggested in the context of early twentieth-century Damara belief that the name //Gamab is derived from //gami, meaning water and //Gamab was originally the god of the rising clouds and of thunder and fountains (as cited in Schapera, 1930, p. 397). //Gamab is intimately connected to water, storms, healing power and the spirits of the dead, known as variously //gâuaba or //gamaba. The spirits of the dead are often envisaged as the cause of sickness which is rooted in their longing to be with their loved ones. Amongst early twentieth-century Damara sickness was attributed to //Gamab firing arrows at victims and ideas of invisible arrows causing sickness still exist amongst some Damara. Similar associations between invisible arrows as a means of carrying both healing power and sickness remain a key explanation of sickness and cure amongst Bushmen groups.

Some Damara and Hai//om know that a big dangerous snake lives in the sky with //Gamab and they see a potent lightning strike, 'god's thing', as the bite of the snake. There is some evidence to suggest that living with the snake equates to possessing or working with the snake and rain in a similar manner to the relationships identified between !Khwa and Kaonxa and snakes and rain. Hahn suggested that Tsu //goab, the ancestor of men, lived in the cloud and caused it to stream, */au*, or rather, to cause the water snake to come down (Hahn, 1881, p. 105). Hahn identifies the ideational relationship in Khoe language in the morpheme */au* lying at the root of words for 'flowing', 'rain', 'snakes' and, further, 'blood' (p. 101). It is testament to the fluidity, change and complexity of both Khoe language use and European orthography that Haacke provide the following spellings: */au* (flow gently, see Haacke & Eiseb, 1999, p. 52), */au.b* (spring, p. 52), */awi* (rain, p. 53), */ao.b* (snake, p. 51), */ao.b* (blood, p. 51).

In recent decades one Hai//om healer from northern Namibia related how a spirit woman Kaindaus 'beat him up' and 'opened him up' to become a healer (Ilse Schatz, personal communication; Schatz, 1993, p. 8). From his 1950 folklore research, Van Vreeden related how an old Griqua woman from the South African Drakensburg Mountains referred to a powerful extra-natural water snake as Keinaus (as cited in Morris, 2002, p. 155). The similarity between Kaindaus and Keinaus is too strong to be dismissed as coincidence and provides a very good example of variation in both KhoeSan ideas and European orthography. This tenuous looking connection makes sense in KhoeSan idiom and language. The two names are most probably derived from *kai aos* meaning big (great, esteemed) snake. To be beaten up or to have a fight is an expression commonly used for an extra-natural potent phenomenon. Marshall observed that the !Kung Bushmen use the terms 'a fight' for both Bushman healing potency, *n/um*, and a whirlwind, a 'death thing' (Marhshall, 1962, p. 239; 1969, p. 351). Across the KhoeSan the whirlwind is thought to contain spirits of the dead who are after the lives of the living. It is accordingly thought a very dangerous thing and a //Gâuab thing. *N/um* is the god given potency latent in certain phenomena at certain times that makes significant things happen in the !Kung world. It is also the way !Kung healers refer to their medicine; it has *n/um*. To be beaten up by spirits is therefore a very KhoeSan way of talking about spiritual transformation ultimately from god which equates strongly to the biting of the //Gamab snake and opening up to *n/um*.

As Morris discusses, Keinaus the water snake is part of widespread KhoeSan belief in a snake that in many contexts is synonymous with water. It was, and still is in some parts, thought that the snake can cause springs to dry up or rivers to flood. This water snake clearly overlaps with nineteenth-century Cape /Xam Bushman belief in rain animals that was at times merged with ideas of a snake that could in one Bushman's words "fill the country with water" (Morris, 2002, p. 158). Morris even suggests that the nineteenth-century Nama idea of an eland antelope having a snake in its head is one elaboration of an epistemological link between the mythical eland antelope and the water snake (Morris, 2002, pp. 157-158). Hai//om I encountered similarly spoke of a snake about 15 centimetres long that lives in the hair on an eland's forehead. The eland is considered a very special animal amongst the KhoeSan and is a central component in the shamanic world of nineteenth-century /Xam Bushmen and historical Bushmen rock art. Skotnes observes that /Xam Bushmen believed !Khwa roamed the sky in the form of one of the large herbivores including the eland but the link goes deeper still (Skotnes, 2007, p. 152). Tixai ≠Gkao a Ju/'hoansi Bushman described to me that the eland and the python are the same: "the eland gets that fat from the python into him. It just comes with the wind, like the wind that blows on you, it goes into the eland." Part of what Tixai is referring to here is the way KhoeSan envisage things that are experienced in some sort of unity as working together. It is no coincidence that the Khoe name for a python is tūros, linked to *tū*, water and rain, for pythons are frequently found in water holes. This aspect of the wider snake water linking fits alongside other animals known to 'work with' water, including tortoises and frogs.

This rich nexus of ideas demonstrates the complexity and fluidity of associations that befogs any easy relation of KhoeSan cosmology. For current purposes it is enough to draw attention to ideational links between rain and fertility, fertility with the highly desirous edible fat of the eland and python, of the water snake as an ambiguous powerful deific entity living in clouds that can 'bite' or 'beat' people as lightning or as a spirit. The snake again overlaps with the idea of a rain bull that is a central theme of San rock art. What unlocks much of this KhoeSan ideational world is being aware of the metaphors, symbols and folklore that inform a recurrent though varying complex of ideas and at the heart of these associations lies the ability of one phenomenon to morph into another, including weather into sickness causing and curing ability.

2. Morphing weather essence

A pot made from clay carries the essence of its base material in its smell, its density, its colour, its consistency and in other subtle configurations that become intrinsic to its new form. KhoeSan peoples see such continuities in a far more fluid and connecting manner than most 'Western' people. A key idea behind the KhoeSan world concerns how wind represents or holds the essence of a person and can carry that essence into another, thereby conveying key qualities from the source to the host as it does so. Behind life lies God wind, the wind that blows and enters people and animals. Each person or animal is known to KhoeSan by their own characteristics, including size, shape, talents, illnesses and possibilities. This living possibility rests on life and internalized God wind serves as the way of thinking about different people and animals. Each has their own wind. KhoeSan hunters know, as others do, that game animals are disturbed when they catch the 'wind of the hunter'. This smell of the hunter is a concept that is intrinsically wedded to the notion of personal wind and the ideas are often interchangeable. In healing contexts the idea is extrapolated further such that sweat, the smelly thing specific to individuals, is known to carry the smell of someone and in a sense their wind. The healing wind of a healer can be conveyed to a sick person by rubbing on the healer's sweat. Many KhoeSan protect their children by giving them a necklace to wear with a pouch containing the skin or hoof of an eland antelope. The pouch gives them the wind of the strong animal and protects them from other children and possible even smelly adults who also have 'strong wind' (Low, 2008).

Many KhoeSan healers attribute their healing strength to possession of special qualities variously thought of as animals helpers, spirits, ancestors, God given talents – in the Christian sense, or in local Khoe idiom, /gais 'force' or 'power' and ≠oab or 'wind'. The strongest rain men say they receive the rain wind or rain spirit by being struck by lightning. If this occurs they are said to run mad and naked in the bush until a dance is held which draws them back into the community. Through certain ritual acts they are socially reintegrated in their new capacity as a rain healer or prophet (Low, 2008).

Amongst the KhoeSan many people, but particularly the elderly, will talk to the wind or to a whirlwind to tell it to blow somewhere else. Often people lead a whirlwind away from their homesteads by pointing at the wind and tracing their finger in a distant direction. To talk to the rain however is rarer. The Hai//om believe people can talk to the rain and negotiate with it if they scrape their tongue on a rain tooth, */nanu //gû*. This scraping confers the rain */gais* or wind into them. A rain tooth is a hard white object found under a tree struck by lightning. Marshall found a similar belief amongst the Kalahari Ju/'hoansi. Marshall, who identified the 'tooth' as fulgarite, observed that the Ju/'hoansi placed such 'lightning teeth' in a rain horn to call the rain. They could also use 'lightning teeth' maliciously to call lightning to strike a person they wanted dead (Marshall, 1999, p. 235).

3. Plotting the connections

Silberbauer presented an unusual interpretation of the /Gwi Bushman world based on entropy, wherein the /Gwi believe everything is constantly driven towards disorder by the divinity G//awama. Medicines and healing serve to 'correct departures from normality', to restore equilibrium. Silberbauer identified that sickness or negative entropy was fired by bow and arrow into women by G//awama. It then spread to the men. Cure was effected by G/wi healers pulling out the negative entropy in the 'exorcising dance' (Silberbauer, 1981, pp. 57, 119). Despite its very un-Bushman ring, the word 'entropy' serves well to capture KhoeSan ideas of potency flow between divinities, weather and people.

The diagram in Figure 1 represents a similar example of an entropy flow amongst the Damara and Hai//om. It additionally indicates how this ideational flow might be visible in linguistic relationships. Khoe is an agglutinative language. From stems with suffixes that denote gender and number, one can explore relationships of ideas. Identifying and following these stems is not however easy and particularly so because of differences in orthographic representation, the variety inherent in KhoeSan ideas and similarly the variety inherent in pronunciation of words. In partial support of links I envisage might exist, linguists have suggested that omission or replacement of clicks is sometimes part of Khoe speaking life and this is certainly my impression (Low, 2008, p. 10). During the course of many interviews Khoe speakers insert, omit or even shift clicks even in the course of one sentence.

The first stage of the flow runs from the sky divinity //Gamab (//Gâuab), related to *//gami*, meaning water, to the words *//gawa*, *//gapa* meaning a strike of lightning (Haacke & Eiseb, 1999, p. 80). *Âu*, *au* and *aw* seem transcriptions that might be particularly prone to inconsistent and interchangeable representation. Linguists recognise Khoe ‘b’ and ‘p’ as interchangeable. It may well, therefore, be relevant that *//gaba* is also a verb referring to the necklace pouch wind of a strong child making another sick. A squeeze of the !hutubis beetle onto the anterior fontanel of a child prevents another from ‘//gabering’ it. In the second phase the lightning enters the healer. Some healers describe the potency inside them, conferred by lightning or another force as ‘defenders’ for which they use the word *gawas*, to speak. Old Damara healers and recent Hai//om use the term */gais* (*!gais*, *gais*) for a healing dance. Recent Sesfontein Damara refers to an *arus*. */Gais* is the same word used for the rain or lightning potency or defenders, spirit helpers, or animal helpers said to be in a person. Haacke lists */gai.b* as ‘power’ or ‘force’ (Haacke & Eiseb, 1999, p. 57). Some healers equate numbers and types of */gais* with different healing power and strength. When the healers dance they wake up the potency or */gais* in themselves and fire arrows of potency into one another to confer healing ability or to ease the pain associated with awake potency. They refer to these arrows as *!gais*, *//gâmas*, */gaiga*, *//gabas*. This complex of words relates back to the */gais* dance and the spirit force and to //Gamab and lightning.

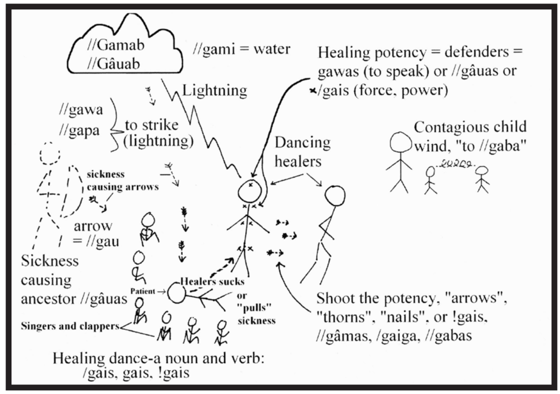

Figure 1: The flow of ideas and language in a Damara and Hai//om healing dance.

This chain of words indicates the difficulty of trying to deal with fluid thinking and fluid language habits. The complex could readily be extended to include many of the aspects previously discussed; one must, however, be cautious not to play increasingly confusing language games of an increasingly tentative nature. What I have represented are patterns of word use that have arisen during my research supported by historical linguistic analysis and words listed in an extensive authoritative recent dictionary (Haacke & Eiseb, 1999). Even if some of the words can be proved to be of different derivation, I am not sure that this would always be readily appreciated by contemporary KhoeSan users. It is important to remember that language is always flexible but particularly so amongst these people to whom flexibility is essential to their habits of thinking, and dictionaries remain a very recent fixing of information. What this flow represents is a deep understanding that locks weather into a world of participation. Weather phenomena are essential to understanding life, and as they merge into healing potency become essential to understanding KhoeSan healing.

4. Acknowledgments

I am very grateful to the ESRC for their support of the DPhil and Research Fellowship projects that underpin this paper.

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Anthropology of weather and indigenous cosmology inscribed in ritual artifacts

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1. Introduction

Changes on the visibility and the brightness of the stars influence the subsistence calendar of several indigenous peoples. They create images and tales that correlate atmospheric and astronomic phenomena to their seasonal and daily activities. I will deal in this paper with some aspects of Ticuna people's mythology and cosmology examining celestial bodies depicted in the iconography of artifacts used in their puberty festival. I am especially interested to think about the Ticuna representations about the weather variability. (1) Their observation of the movement of stars that appear in this ritual is correlated with the observation and anticipation of changes in weather.

After the girl's menarche, the Ticuna submit her to a seclusion period when they accumulate food for her puberty festival, whose meaning they associate with their expectation for success in subsistence activities such as hunting, fishing and cultivating land. The girl remains completely secluded at least for the last night of her initiation when the elder women prepare her for the depilation which occurs in the early morning.

After the festival the Ticuna consider the girl prepared for her social obligations as woman. Promoting the girl's puberty festival is a way in which the Ticuna manifest their expectations in relation to the changes in the weather and everyday life. Several Ticuna's chants and stories told to the girl during that night deal with cosmological feelings related to meteorological phenomena such as the relationship between the shadows on the moon and the prohibition of incest.

The relationship between ritual, mythology and environmental perception is understandable when one examines the indigenous peoples' comprehension of the influence which the annual movement of the stars and seasons has on subsistence practices. These changes are part of current indigenous understanding of, for instance, unexpected exaggerated floods or droughts, the latter of which dry up rivers and streams, depriving them of potable water causing both starvation and disease. I would like to consider in this paper Ticuna interpretations of the weather variability.

(1) The Ticuna is the most numerous Amazonian people living on the border region between Brazil (35,000), Colombia (10,000) and Peru (6,000), according to the indigenous organizations. They have had contact with the national societies since the arrival of the European to the region in the seventeenth century. However, they keep their traditions, their language and their main rituals.

2. Anthropology of weather

I will start my historical approach of anthropology of weather with Claude Lévi-Strauss who presented, during the 1960s, anthropological correlations between astronomy and meteorology. He compared myths about the rainbow and the different constellations. Lévi-Strauss correlated specifically indigenous thinking to the biological and economic consequences of the weather. He focused on Curt Nimuendaju's observations on the seasonal lack or abundance of fish in both Central and Amazon regions in Brazil.

Based on systematic comparison between weather religions in the world, Johannes Wilbert presents alternatives to structural anthropology focusing on the "weather religions" performed by Amazonian Warao Indians (Wilbert, 1996). As Wilbert argues, Amazonian Indians' weather religions are designed for protection against seasonal starvation and food shortages. He examines the significance of weather rites and myths on subsistence activities showing that the weather religions and rituals are correlated to strategies of food stock piling for periods of scarcity which usually occur in the Amazon during the rainy season. Wilbert's argument seeks to understand indigenous adaptation to Amazonian environment, focusing on weather religions as forms of social organization which have as effect subsistence strategies. I see an interface between anthropology of weather and "ecological anthropology" (Orlove, 1980), considering processual approaches on actor-based models. I will focus on cultural interpretations of mechanisms of change of environmental phenomena considering in the analysis the role of social organization.

The anthropology of weather focuses on the "bi-dimensional interaction" relationship between the weather and human cultures. Weather is defined in series of atmospheric changes over a given location (Katz et al., 1997). The divination and predictions are forms of interpreting and defining the causality of weather, within systems of classification that vary according to who is able to define a criterion of intervention in weather change. This order fixes the relationship between individuals, societies and the environment.

I understand in this paper the Ticuna orientation to the cosmos as predominantly participatory (Tambiah, 1995, p. 105). The ritual proscriptions advise against provoking beings which may cause catastrophes and destruction to local communities. However, the mythological time is linked to the historical time. The observation of Ticuna socio-cultural subsistence activities shows how they have adapted mechanical techniques to their traditional knowledge. This adaptation implies the introjections of causal thinking about cosmos that include words from conventional vernacular scientific paradigms such as atmosphere and even 'weather forecasting'.

Human intervention has been perceived to have degraded the environment and thus threatened the individual's health. To talk about the weather is to talk about social upheavals, about relationships among humans, spirits and the divinities that affect the world. So the weather is a pretext to talk about relationship between people. When the relatives prepare the girl's initiation, they need to stock food for the party and they need to deal with weather factors. Doing that, they deal with weather restrictions that affect their subsistence, the scarcity of fish, game and agriculture during the rainy season, made worse by the human exploitation of environmental resources. To talk about the weather is to talk about strategies of adaptation to these changes. It is interesting to exam how, during the puberty ritual, the Indians perform several of these adaptation strategies.

3. Weather in Ticuna's ritual and cosmology

The Ticuna observation of the regular movement of the celestial bodies is associated with the explanation of weather and atmospheric phenomena performed during the puberty ritual. Through these performances they communicate with the beings that control the environmental phenomena. During the initiation, the old women teach the secluded girl to read the sky. Attending this initiation, the girl enters in contact with the cosmological beings that control the Universe and the weather, who are the owners of the environmental phenomena. These cosmological beings are depicted in the iconography of artifacts used in the Ticuna girl's festival. The *Worecü* stars are the most significant of the celestial bodies depicted in this iconography. The observation of the movement of these special stars is correlated with the observation and anticipation of changes in weather.

Worecü is a Ticuna word meaning the girl for whom the initiation ceremony is being performed and the *Worecü* stars are related to several aspects of Ticuna mythology. During my fieldwork from 1997 to 2002 I gathered information which I correlated to ethnographic information obtained by the German ethnographer Curt (Unkel) Nimuendaju (1883-1945). Nimuendaju collected Ticuna artifacts whose iconography shows the (spatial) proximity of the three *Worekü* stars which appeared in 1941 at the beginning of the rainy season close to *Coyatchicüra*. [(2)] In 2000 I attended a puberty festival in the Indian Land Evare II. In that occasion, the Ticuna told me stories interpreting the proximity of the *Worecü* stars to the 'Cayman's Jaw'. I inferred by these stories that this approximation meant for them a singular phenomena that gave special meaning to the puberty ritual promoted during this time.

According to the Ticuna the *Worecü* stars are children of an incestuous relationship between two humanized celestial bodies: the moon (the brother) and the sun (the sister). The story referred to a pregnant girl; nobody knew who the father of the child was. Her grandmother told the girl to squeeze some genipap and keep it beside her hammock and use it to stain moon's face. Then, as the grandmother told her, when Moon came to

(2) In the Amazon the rainy season (Winter) is from December to February and the 'Summer' season from Mars to October. It continues raining during the 'Summer' season. However, it rains more during the 'Winter'. When the sun shines continually during the rainy season, one can say that it is 'Summer'.
The movements of the Ticuna constellations correspond to the seasonality of rainfall. These constellations are related to myths: the ascension and fall of Baweta (the Turtle Collective), Coyatchicüra (the 'Caiman's Jaw'), Wücütcha (a heavenly beast related to the Jaguar Clan), and the fight between the Anteater and the Jaguar. Baweta appears in the eastern sky at nightfall towards the end of November. After Baweta rises, the 'Caiman' appears. Wücütcha's Leg corresponds to Orion which begins to disappear from the western sky on May 20 at nightfall. Some days later, the 'Caiman's Jaw', corresponding to Taurus, also disappears to the west. The appearance of the fight between the Jaguar and the Anteater is an indicator of the drought.

lay down beside her, she put her hand in the genipap juice and pretending to caress and please him she covered his face with the pigment. This is the reason why today, we see the Moon's face covered with stains. That myth is a cosmogonist source for the Ticuna social organization as a specific ethnic group

4. Social organization, the division of the universe, and the environment

Ticuna society is divided into two exogamic moieties to which the clans belong and which present certain characteristics. The division into moieties and clans structures Ticuna society in that marriage is only permitted between members of clans belonging to different moieties while marriage between people of the same moiety is prohibited as these are considered to be relatives. This is a rule that is very much respected by the Ticuna. Nimuendaju pointed out that these moieties correspond to the Ticuna's division of the universe into a "western moiety" and an "eastern moiety," respectively. The complementary relationship between the moieties is a group's mechanism for consolidating its identity (Nimuendaju, 1952).

The festival is a fertility ritual. The girl's parents and relatives perform the festival to bring success in agricultural and fishing practices. The preparation for the festival begins after the girl's first menstruation. Whereby, her father begins to store manioc flour and meat. The beginning of the dry season is considered to be a good period for the preparation of the puberty festival. There is plenty of fishing and hunting and the river has still enough water for the guests' to arrive. They prefer to hold the festival during the full moon because it illuminates the night. At dawn the girl is taken from the compartment, in which she has been kept isolated all night, and adorned with a headdress made by the women of the tribes from red macaw feathers to represent the sun rays.

Then appear the masks. The masks represent the threats to Ticuna subsistence caused by the intemperance of atmospheric phenomena such as rain and storm. There is a specific order in which the masks enter: first enter the monks (*Toü*) who announce the arrival of the winds, second enters *Mawü*, the owner of the rains, third appears the gales (*O´ma*) and finally arrives the tempest (*Yureu*), who may bring disasters, destruction of houses and harvests and death. This last mask brings a wheel on his back. This wheel means that the persons who attended the ritual will be protected by the end of the festival (Faulhaber, 2006). The old women begin to pull the girl's hair up after the sun rises. The hair symbolizes the menstrual blood, the rain, purification, the fertility of the woman and nature and the strengthening of indigenous identity living in their own locations.

5. Weather religiosity, seasonality and subsistence activities

Ticuna community groups have been establishing themselves in mythical territories, ethnic locations also characterized as environmental sanctuaries, where the Ticuna are less vulnerable to the seasonal starvation, as a way of living in conformity to the will of their cultural heroes. However, besides these traditionalist movements, they live in contact with national society, and have adapted their traditional stocking techniques with techniques of stocking salted fish for commercialization.

According to the Ticuna Indians who value the ethnical identity and their own rituals positively, they seek to live close to the identity and environmental sanctuaries located upstream, at the headwaters of *igarapés*. There is a subsistence reason for that because the influence of seasonality upon their subsistence activities is more marked along the Solimões River, where, due to lack of environmental resources, they are more dependent on the merchants that exploit them. Whereas at the headwaters of the *igarapés*, where *Enepü* and other mythical sanctuaries are located, there are plenty all year long. Due to the abundance of natural resources, these mythical territories are considered better locations to perform the puberty ritual.

The Ticuna describe the *Enepü* as an environmental sanctuary: they say that there are plenty of fruits, fish and hunting useful for the feeding of the people invited to attend the puberty festival. According to them, trees like the *ingá* (a delicious fruit plenty of vitamin) and palms such as the nutritive *açaí* provide fruit all year long because the soil is 'virgin' and enriched by natural compost. The same thing occurs with the fishing on Lake Preto within the limits of *Enepü*, where residents are able to supply themselves abundantly with fish.

On the Solimões, however, there is lack of conditions to perform the ritual: one finds fish only from April to July, when the water level drops. The same is true for hunting, which also stretches from April to July/September. When the river is flooded, fishing becomes more difficult. The fruit of the native *açaí* palm is collected in the summer and customarily saved for preparation during the winter, the time of poor hunting and fishing. However, it is possible to conduct subsistence activities even in situation of scarcity, because through planning and regular gardening, agricultural harvests are available all year long. A certain degree of flexibility exists in the adaptation of the agricultural and extractive calendar to the rainy season, when fishing and hunting resources are rare. During the dry season however, there is greater abundance. The harvest of cultivated plants also occurs during the drought months. The *pupunha*, nutritive fruit used for breakfast, takes three or four months to grow and is gathered in March and April.

Traditional culture is not prepared, however, for unforeseen alterations in the rainy season such as occurred in 2002. In that year, July saw the beginning of the *repiquete* (the rise in water levels), which normally occurs in September. The Ticuna who lived in the *Enepü* who were preparing a puberty ritual I attended were astonished by this unpredicted phenomena and worried because it destroyed the short-range agricultural cycle and made the fish scarcer, causing difficulty to stock food for feeding the people they invited for the puberty festival. They were astonished because this unpredicted phenomena altered the regularity of traditional seasonality.

6. Interpreting cosmogonic wheels

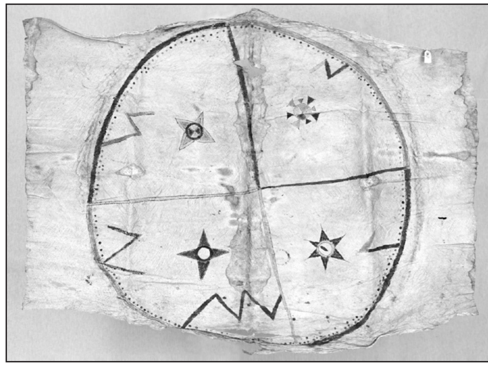

Figure 1: The stars of the world.

Source: Nimuendaju Collection, R.G. 4046, Goeldi Museum, Belém.

Nimuendaju collected the cosmogonic wheel on the right (Figure 1) in 1941. According to the Ticuna, its first quadrant is associated with *Baweta* (collective for turtle) and the drawing beside the circle is associated to *Coyatchicüra* (the 'Caiman's Jaw'). In the second quadrant are the star *Woramacuri* (morning star) and again *Coyatchicüra*. In the third quadrant is *Emarutä*, *Wücütcha* (a celestial beast associated to the Jaguar clan), and *Coyatchicüra*. In the fourth quadrant is *Emacüari* and *Coyatchicüra*. An analysis of this wheel attended by the Ticuna, in a planetarium session, led us to the conclusion that the wheel is related to the movement of the 'Caiman's Jaw' throughout the year.

The Ticuna said that this wheel means "The stars of the world." However, its meaning is attributed to beings that live in the "upper world" (the minor and major cousins of the morning star / the children of the Moon). They are also correlated to beings that affect how a person grows. According to the Ticuna the shooting stars or *Tchitacüü* are associated to an unbreakable branch of a palm, eternally bending, yet never falling. All these entities are denominated by the generic term *e´ta* or star.

A Ticuna artisan originally designed this wheel in 1941, when Jupiter and Saturn were in Taurus. In 2000, when I attended a Ticuna puberty ritual, both planets were again in Taurus. This event led me to suppose that the Ticuna narrator, a seventy year old elder, was talking about the succession of events during his life. He was respected by the younger Ticuna for his knowledge about environmental phenomena. He said that attended several puberty rituals and observed the influence of the *Worecü* stars for every secluded girl and her group of reference. I perceived that with his statement he stressed the significance of the movement of celestial bodies for the formation of the life of the Ticuna and their understanding of the influence of such specific *Worecü* stars for the passage of generation time.

The concept of solar system is absent of the Ticuna cosmology. According to them, the stars are permanently in the skies. However, their appearance occurs to mark some special event. The *Worecü* stars are special stars that appear for the girl's initiation. The elders are respected because they had the occasion to observe the return of *Worecü* stars to special areas of the sky such as the area were appear the 'Cayman's Jaw'.

In December 2000, after I had attended a puberty ritual in the community of Ribeiro, the

Ticuna gave to the Goeldi Museum a wheel used in the festival (Figure 2).

According to the Ticuna description, its iconography represented the celestial body *Emarüta*, circled by the Boa constrictor pattern. The celestial body *Emarüta* or *E´ta*, the axes on which the world turns, is drawn within the circle. This axis is also a three pointed star, represented by different colors: the night - black, the dusk - orange, and the day - yellow. According to the Ticuna, the world's axis is a channel that conducts the sunlight across different worlds. The world's vital energies run through this axis in a flux that penetrates the girl's puberty. These energies within the celestial bowl were at the bottom of the primordial sea, where the rainbow was born.

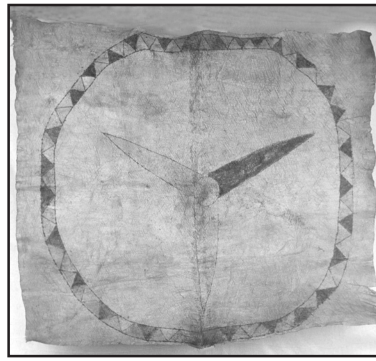

Figure 2: The axis on which the world turns.

Source: Faulhaber Collection, n.c., Goeldi Museum, Belém.

The Boa constrictor is a form assumed by the mythic rainbow serpent. The vital energies are correlated by the Ticuna to this mythical rainbow Boa. They have the power to produce the vegetal and mineral colors, to give life to inanimate beings, and consequently, fertility to women. The women's fertility symbolizes the natural resources that provide feed for humans. These results can be obtained by the means of human labor.

The movement of Ticuna constellations is a seasonal sequence that announces the weather variability, and, consequently, abundance or lack of food. The Anteater (*Tchatü*) fights with the Jaguar (*Ai*) throughout the summer, ending with the death of the Jaguar and ascension of *Wücütcha* (the 'Jaguar Leg'). According to the Ticuna, this was caused by the rape/murder of a pregnant woman. The victim's relatives killed the beast, associated with the Jaguar Clan, in order to prevent the eclipse. The leaving of *Tchatü* from the western sky at nightfall at the end of November coincides with the reappearance of *Wücütcha* to the east, representing the beginning of the rainy season.

7. Conclusion

The analysis of the symbolism of Ticuna artifacts can help us to understand the people's anticipation of weather variability based on their culture. They are a form of considering their subsistence activities in face of an environmental variability. The correlation between their and our conception about the movements of celestial bodies is based on systematized knowledge rooted in a certain arbitrary consensus resultant of a shared reading of the skies. Even though we deal with different conceptions of the Universe we can find similarities. Both for the Ticuna and for us the observation of the sky is a representation of the succession of events. For them it is important to know how many moons passed when a girl became a woman and how many times a star goes back to the same position in the sky for a human to be respected as an elder. For us it is important to differentiate the generation time, the calendar time and the cosmic time, or to differentiate the velocity of light, the velocity of sound and the velocity of the winds.

The Ticuna story about the primordial incest shows the significance of the feminine gender for this people. The girl puberty festival is correlated with the strategies adapted to seasonal variability of stocking food, which today is affected by global environmental changes. This fertility and identity puberty ritual involves the group's strategies of handling exhaustible resources and is a mechanism of socialization between generations.

The rite of the masks relating to the arrival of the rain, the winds, the gale and the tempest, expresses their knowledge of routines and weather variability. To understand them with a certain degree of predictability the elders observe the movements of the celestial bodies and correlate them with their knowledge passed down through mythical stories. This knowledge is employed on practical problems that occur in subsistence activities dealing with weather variability.

8. Acknowledgements

I would like to thank Vladimir Jankovic for his comments about this paper's first version.

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The Tupinambá and Guarani contribution towards the understanding and control of weather

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1. Local traditions of knowledge (1)

The systematic study of celestial systems conceived by many Brazilian indigenous peoples, specifically concerning their cosmological and mythological concepts and way of life are still being outlined in the Brazilian academic arena. In the field of science history, the initiatives for investigating this type of knowledge from historical documentation are still incipient. The purpose of this work is to analyze the Tupinambá and Guarani tribes from two perspectives, a) to point out the contributions of these peoples towards understanding, forecasting and controlling meteorological phenomena, and b) to understand the way missionaries observed and documented this knowledge. The reason these two tribes were chosen is a result of history. Given their territorial, cultural and linguistic dominion, they are two tribes of great importance in the colonization process, establishing extensive contact at that time with many colonizing agents. In addition, we have a good deal of documentation on these tribes. In what concerns the Guarani, we emphasize that these people have effectively preserved their cultural identity to the present day, throughout 500 years of contact.

(1) We want to acknowledge our gratitude to the Guarani of the Paraty Mirim (Itatim) village, who have been willing to supply us with the necessary data for our research.

In recent years an increased interest in native, ethnoscientific, and scientific themes related to cultural diversity has been observed. It is a recent phenomenon demonstrating that the academic field has come to recognize the importance of 'local traditional knowledge' (Turnbull, 1997) and the technical developments accumulated by indigenous peoples throughout their history. In general, there are several works seeking to address these systems in the areas of archeoastronomy and ethnoastronomy. An ethnography of knowledge about the sky has been instituted, where the emphasis is on a description of the elements comprising this knowledge. The relevance of these studies is emphasized in part because it is an area of knowledge that does not fit the established paradigms of the scientific definition; and also because, especially in Brazil, it implies an expansion of the historic frontiers defining ingrained subjects of research (see Borges & Gondim, 2003).

As for ethnoastronomy, we understand it to be an investigative area open to the dynamics of the human/nature relationship, which is part of a farther reaching relationship occurring between earth and sky that integrates symbolic, ecological, meteorological, cosmological and astronomical aspects. Ethnoastronomy should then include the analysis of the events that distinguish determined periods of the year (such as the heliacal rising of the stars, the zenithal passage of the constellations, etc.) and their relationship to the economic and ritual calendar; the description of empirical knowledge, including the analysis of the denomination and classification of constellations, the spatial orientation, notions of space and time, counting, measurements, distinction between the stars and the planets, explanation of phenomena such as seasons, rain, meteors and other celestial events. And it should also include the description of the myths and models, especially cosmological ones, and their connection to empirical knowledge, as well as the analysis of the astronomical contents in artistic objects and crafts.

Despite this, Brazil's production in the field of ethnoscience is incipient, and the history of science studies in this direction remain rudimentary. In Brazil there is an enormous diversity of indigenous ethnicities, each one supplied with a rich body of knowledge that was generationally constructed and transmitted. (2) Taking this deficiency into account and seeking to ally this type of investigation to the history of science field, by studying these tribes our goal is to map out, systematize, and publicize a part of this astronomical and meteorological knowledge from members of the Tupi-Guarani family; among these, we focus on the Tupinambá and Guarani, whether diachronically, according to the reports of missionaries, travelers, and naturalists from the sixteenth and eighteenth centuries, or synchronically, based on information being collected in the Guarani villages located in the state of Rio de Janeiro. (3)

We aim to establish a basis for drawing a picture of the Tupi cultural astronomy (whose consolidation still depends on studies with other groups of the Tupi linguistic family), which will contribute to improved comprehension of a culturally differentiated *episteme*. As for representative relationships between memory and history, this study also intends to contribute to an understanding of history of science that embraces systems of production of the so-called local or traditional knowledge.

2. Tupi expansion and legacy

In ethnohistorical terms, Tupinambá and Guarani were originally part of the same group, called Proto-Tupi, and only after its diffusion they became independent tribes. Our hypothesis is that in addition to culturally common elements, the geographical and temporal distance between them must have caused the distinctions in either configuration or celestial denominations. And although the Tupinambá became extinct in the eighteenth century, the present day Guarani, who maintain their traditions, offer us a synchronic

(2) According to the Brazilian Institute of Geography and Statistics (IBGE) nowadays there are about 227 ethnic groups speaking about 160 languages, in an estimated total of 700 thousand individuals (2000 census). There is a controversy around these numbers, since the National Indian Foundation (FUNAI) counted 325 thousand in 1995, and the National Health Foundation (FUNASA), around 411 thousand.

(3) In the State of Rio de Janeiro the Guaranis are distributed in five villages, four of them in the southern coastline of the state and one in the coastline of Niterói, near Rio de Janeiro city.

reference and thus contribute to the establishment of a comparison.

Ethnological, linguistic, archeological, and ethnohistorical studies leave no doubt about the relation between the Tupinambá and Guarani, who like other equally related peoples, share a common ancestral reconstruction, called Proto-Tupi (Fausto, 1992; Schiavetto, 2006; Schmitz, 1999; Tenório, 1999; Urban, 1992). As for the origin and area of diffusion of these Proto-Tupi, no consensus has been reached. The current hypotheses and interpretations, which are based on remnants and documents, are divergent, whether regarding the chronology, the geographical area of origin and diffusion or the possible routes that these peoples used on their long journey of territorial and cultural expansion, a phenomenon interrupted when the colonizers arrived. In general, on the basis of what historical sources have registered, the Tupinambá territory extended from Iguape, in the southern coast of São Paulo state, to the coast of Pará state. The Guarani occupied the Paraná-Paraguay basin and the coast from Lagoa dos Patos (in the state of Rio Grande do Sul) to Cananéia (in the state of São Paulo), and extended beyond Brazil to Paraguay. There are also discrepancies regarding dates, although it may certainly be affirmed that at the moment when the colonizers arrived, the Tupinambá and Guarani occupied territories where the colonial process affected them. The better-known hypotheses for dating the beginning of the Proto-Tupi exodus vary from approximately 4 to 6 thousand years ago (cf. Fausto, 1992; Ladeira, 2001; Schmitz, 1999; Tenório, 1999).

What characterizes these peoples is their intense territorial mobility. Even now they advance in the opposite direction of their historical movement, towards Rio de Janeiro state and Espírito Santo state (cf. Chamorro, 1999; Djekupe, 2003; Garlet, 1997; Guimarães, 2003a, 2003b; Ladeira, 1992, 2001; Simão, 2003). Guarani migration is motivated by socio-cultural issues (prophetic words, familiar dissention, and pressure from surrounding society) and/or economic issues (increased demographics, territory with low capacity for sustainability). In this way, the "circularity is formed in the migration exercised by the group within a culturally recognized and delineated space, understood as a territory" (Garlet, 1997, p. 17). For Graciela Chamorro, (1999), the migration of the Guarani indicates their search for a place where they can securely establish their way of life. In the Guarani language this territorial migration is called *oguata porã* or 'the sacred walk', and is subject to a hermeneutist analysis to decipher and interpret signs left by their ancestors.

Solange Schiavetto (2006) emphasizes that a predominance of archeo-ethnological and linguistic manifestations surrounding the Tupi led to the construction of a great idealized cultural block, in general like a monolith: uniform, static and omnipresent. This condition has influenced these peoples' historical thought and scientific imaginary.

2.1 Missionaries and Tupinambá knowledge

The influence of climatic factors on the daily life of all peoples is undeniable: rainy and dry seasons, the presence or absence of wind, the demarcation of the passing of seasons, and by extension, the passing of time. How did Brazilian indigenous peoples deal with the climate factor in prehistoric times and how do they currently deal with it? Did they possess and do they still possess techniques and knowledge to forecast the best time of year to plant and harvest crops? Could they and can they forecast climate changes through atmospheric and astronomical signs? To answer these questions, we will examine the historical and ethnographic documentation that we have of the Tupinambá and Guarani tribes. We will present some examples of this local knowledge referring to climate factors, demonstrating their relationship with the daily routine and the cultural education of these peoples (Borges, 1999; Borges & Gondim, 2003; Lima, 2004).

The majority of authors of the first centuries of colonization were in contact with the Tupinambá – the term used to designate Tupi groups inhabiting the Brazilian coast. These groups were linguistically and culturally united, and were located in areas where contact with colonizers was more intense and regular. The Tupinambá have become extinct as a consequence of wars with Europeans and other indigenous groups, of epidemics caused by contact with the colonists, of slavery, starvation, etc.

The Jesuit Fernão Cardim (1548?-1625), author of the *Treaties of Land and People of Brazil*, arrived in Brazil on May 9, 1583, and lived there for more than thirty years. During his missionary activity he visited many places: Salvador, Ilhéus, Porto Seguro, and the states of Pernambuco, Espírito Santo, Rio de Janeiro and São Paulo. He made observations about the cosmology of these people, relating it to Christianity, most notably concerning the Flood.

> These natives seem to have no knowledge of the beginning of the World; of the Flood it seems they have some news, but [...] such news is obscure and confused because they say that the waters drowned and killed all men, and that only one escaped on a trunk of a janipaba tree with his sister who was with child, and these two were their beginning, and from these their multiplication began (Cardim, 1980, p. 87).

Cardim also perceived the exceptional visual acuity and efficiency in orientation of the Tupinambá. According to him, “they have above average vision because they can see anything within a league [...]; ruled by the sun, they travel in all directions [...], through dense forest without error” (p. 95).

The French Calvinist Jean de Léry (1534-1611) arrived in Brazil on February 26, 1557, and resided for nearly a year with the Tupinambá. In his work, he lists 22 villages located in present-day Rio de Janeiro state. He shows great interest in cosmography, observed through his discourses on astronomic concepts and on the Southern hemisphere’s sky, when his ship crossed the equator line. Describing the Tupinambá, Léry gives us a clue to the Tupinambá system of marking time, saying that “although many reach 120 years (they know how to count age by the moon) few are those who have white or graying hair in their old age...,” and he adds: “ignorant of the creation of the world, they do not distinguish the days by specific names, nor do they count the weeks, months or years, but simply calculate or mark time by moon” (Léry, 1980, pp. 111, 205-206). Nonetheless, Léry’s text does not demonstrate how the conversion from moons to years is made, or what value he attributes to the lunar month to make this conversion. One interesting detail in Léry's work is his transcription of a dialogue that he kept with a prominent Tupinambá (p. 283). We have extracted from that dialogue some terms related to the sky:

Text in Brasilic, or Tupi	Translation from the text in Brasilic, and of Léry's explanations
Ybák (Ybág)	Sky
Kuarasý	Sun
Jasý	Moon
Jasytatá uasú	Large Star (The large morning and afternoon star commonly called Lucifer)
Jasýtatá mirí	Small Star (They are all the other small stars)
Ybý	Earth/Land

In the seventeenth century the French capuchin, Claude D'Abbeville (?-1632), writes one of the most important historical documents about the astronomical knowledge of the Tupinambá, the *Histoire de la mission des pères capucins en l'isle de Marignan et terres circonvoisines où est traicté des singularitez admirables & des moeurs merveilleuses des indiens habitans de ce pays*, published in 1614. This chronicle brings descriptions of constellations and calendar systems of the Tupinambá located in Maranhão state. We present some excerpts from D'Abbeville's work related to the climatic and temporal markers of the Tupinambá in the following. According to these notes, the Tupinambá "also observe the course of the sun, the route that it follows between the two tropics as its limits and frontiers that it would never pass." In this manner, they used the sun as a climatic marker, since "when the sun comes from the arctic pole it brings winds and breezes, otherwise, it brings rains when it comes from the other side rising towards us." Besides this, they used the sun to mark time, since "they count the years with twelve months as we do, by the course of the sun going and coming from one tropic to another. They also recognize years by the rainy season and the breeze and windy season" (D'Abbeville, 1975, p. 250).

In addition to the sun, the Tupinambá also used a stellar (sidereal) calendar, being guided especially by the constellation they called *Seichu*, corresponding to the Pleiades, a star cluster located in the zodiac constellation of Taurus:

> In addition, the *Seichu* star begins to appear some days before the rainy season and disappears at the end of this season; it reappears above the horizon at the beginning of the rainy season of the following year, from where the natives

> in Maranhão perfectly recognize the interval and time of a full year. In its hemisphere, it begins to be seen in mid-January and soon after it appears they affirm that the rainy season is coming, and soon after this it effectively begins (D'Abbeville, 1975, pp. 250, 246-247).

D´Abbeville says that the *Seichu* begins to appear some days before the rainy season. The expression "begins to appear" may refer to the heliacal rising of the star cluster, or its cosmic rising (anti-heliacal). The heliacal rising of the Pleiades corresponds to the first appearance of the Pleiades, after its invisibility owing to its conjunction with the sun, in the east side, a little before the rising of the sun. This occurs in the beginning of the month of June. The cosmic rising is the first day in which a star or constellation becomes visible on the east horizon at sunset. The cosmic rising of the Pleiades occurs in mid-November.

We should note, however, that D'Abbeville said that the *Seichu* begins to be seen in January, a period that neither corresponds to its heliacal rising nor its cosmic rising. Since the rainy season begins in December, it is more probable that D'Abbeville was referring to the cosmic rising, having mistaken the month the Pleiades appears (instead of January, November would have been correct). The heliacal rising of the Pleiades in June corresponds to the beginning of the dry season in the north of Brazil.

According to D'Abbeville, the Tupinambá established a relationship between the moon and the effect of the tides, since "they attribute the flux and reflux of the sea to the moon and they distinguish the two full tides that are verified in the full moon and in the new moon very well or a few days after" (D'Abbeville, 1614, p. 320). (4) This observation has an important significance, since, at the time when D'Abbeville wrote his book, the cause of the tides had not yet been discovered. Isaac Newton was the first scientist to correctly demonstrate how the generating forces of the tides function, in the eighteenth century.

The investigation of Tupinambá knowledge of the sky involves some relevant methodological issues. Firstly, our access to this knowledge is second hand, since we only possess documented sources, and, in general, missionaries' narratives. It is not difficult to perceive the existence of ideological conflicts in the documents, especially when we consider that, as a conversion strategy, the indigenous knowledge was received, reinterpreted and used as a resource in the conversion discourse. Secondly, it is difficult to verify the accuracy of the related observations. Since the Tupinambá are extinct, there is no way to validate the alleged information. One resource at hand, which is still indirect, consists in the diachronic and synchronic comparison of colonial period information, whether it refers to the Tupinambá or the Guarani, with the data we already have from our investigations concerning present-day Guarani.

2.2 The Guarani between earth and sky

The Guarani also present strong indications of possessing knowledge for forecasting climatic phenomena and determining the passage of time. According to some Guarani

(4) Free translation from the French original text.

myths different winds coming from different regions of the sky announce the changing of the seasons. They also possess agricultural customs related to the phases of the moon (see Barros & Castro, 2005; Borges, 1999; Borges & Gondim, 2003; Cadogan, 1959; Pissolato, 2007).

Nevertheless, there is a lack of large-scale research on the paradigms and systematizations by which these people contemplate and classify the world; this is despite the considerable accumulation of anthropological and linguistic information, thanks to which we possess indications about the science of these peoples. We have managed to systematize some information, and because of this, we have been able to further some considerations about astronomical and meteorological facts, some of which are found in the various texts that compose the *Ayvu Rapyta* (cf. Cadogan, 1959), also in accordance with the observations made in the Guarani villages of Rio de Janeiro.

As for the historical Guarani, observations by father Antonio Ruiz de Montoya (1585-1652) in the seventeenth century are prominent, documenting what he had heard about the mythic traditions referring to the eclipses: "they had a certain belief that there was a very large tiger or dog in the sky, which in certain moments of anger would eat the moon or the sun, which we call eclipses, and when these moments passed, they demonstrated great feeling and admiration" (Montoya, as cited in Meliá, 1994, p. 31). Yet according to Meliá, in the *Vocabulary of the Guarani language*, published in 1640, Montoya also included an entry for the eclipse, explaining that the cause of this phenomenon was a blue jaguar who at times would eat the sun, at others would eat the moon, therefore causing darkness.

The Guarani called the solar eclipse *kuaray onheama* or 'the sun lets itself be captured'. They presented two explanations for the solar eclipse, one mythological, the other religious. It would be the result of: (a) a battle between the sun and Xaria (the enemy of Nhamandu): "our father *Pa'i* became furious, they fought, they struck one another. [5] Xaria could not win and the sun continued to rise up. This resulted in what is now called solar eclipses"; and (b) from not observing righteous conduct, which occurs when the *mbyá* do not offer prayer to the sun: "...when many do not offer prayer to the gods, there is a solar eclipse" (Cadogan, 1959, pp. 82, 100).

In general the marking of time is ruled by the moon. For example, the month is called *kova'e jaxy re* or 'during this moon'. This gives importance to the phases of the moon by which some activities are regulated, especially agricultural activities. In Guarani the phases of the moon are called: *Jaxy Guaxu*, meaning 'big moon', or *Jaxy Tova Guaxu*, 'big-faced moon' (full moon); *Jaxy Pyau*, 'new moon', or *Jaxy Ray*, 'son of the moon' (new moon); *Jaxy Mbyte Py*, 'moon in the center', or *Jaxy Pa'ū*, 'interval of the moon' (waning moon); *Jaxy Endy Mbyte*, 'half shining moon' (waxing moon).

In the following we present some indicators as to the existence of temporal and climatic markers based on observation, correlation and systematization of signs in the

(5) In Guarani cosmology, Nhamandu is the supreme deity.

environment. We emphasize that at the present stage of our studies, this information still lacks better development and confirmation.

1. Temporal markers:

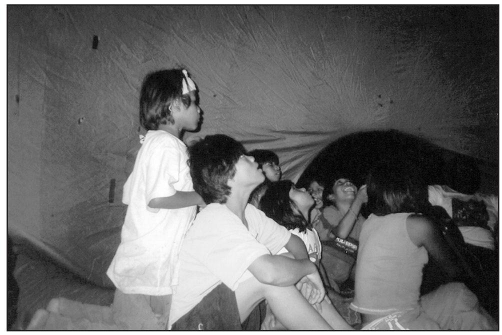

Figure 2: In the Guarani Village of Itatim (near Paraty), children in a session of the portable planetary.

Photo: Luiz C. Borges, 2006.

Observation of the sun's trajectory, and to verify the hour one needs only to stand and observe the shadow projected by the sun. If it is rather round, around the person, then it is midday (*kuaray mbyte* or 'sun at the middle'). The longer the shadow, the earlier or later the hour, and this depends on the position of the sun in the sky and the direction of the shadow. Other signs related to the sun are: if a halo appears around the sun, it signals the death of a person. The movement of the sun is also used to determine the period of the 'naming ritual', between the 23rd and the 25th of January. This ritual marks the beginning of the Guarani year.

2. Meteorological markers:

When the weather is stifling there will be rain, the leaves fall and the trees seem to be renewed. The phases of the moon also indicate changes in climate conditions; the bird *poipoi'i* sings at the beginning and the end of summer, but when its song is heard out of season this indicates that a couple will separate; the song of the *guyra itapu* (bare-throated bellbird) indicates the arrival of summer. When 'stripped', 'fine' or 'painted' clouds appear in the sky, this indicates the coming of rain. The south wind indicates that no rain will come, the north wind that rain will come. If the wind is muggy, then it will rain, but if it is fresh and 'cool', then it will not rain.

3. Sidereal markers:

a) Constellations: when *Kuruxu* (the Southern Cross) is upright in the sky it indicates that it is summer, when it is tilted towards the west it indicates winter. When *E'ixu* (the Pleiades) is almost disappearing in the west (for example at the end of April), it is a sign that winter is coming.

b) Celestial bodies: a halo appearing around the moon indicates that it will rain. The waxing moon indicates rain, and the waning moon the end of rain.

3. Ethno-knowledge and history of science

If, as we said, studies in the ethnoscience field have gradually been established and consolidated in the academic environment, specifically in the history of science we are still in the exploratory stage. Only very recently a systematic study of documentary sources has been initiated, aiming to analyze specifically the narratives about Tupinambá astronomical and meteorological knowledge (Lima, 2004; Lima & Moreira, 2005; Lima et al., 2006). The same has been done with the Guarani, although in this case, the focus of the studies has been the understanding of the constitution and functioning of the manner by which they produce their knowledge, as well as its interrelation with the other socio-cultural spheres of their lives (e.g. Borges, 1999, 2003, 2004).

In general, we can say that the great difficulty in dealing with indigenous knowledge, mainly in the field of astronomy, does not exactly reside in the amount of available information but rather in its quality. Such information lacks more conducive treatment to the astronomy discourse. In other words, many times we can find a list of constellations but not a description of their location in the sky. In addition, locating these constellations is no easy feat, since we meet with difficulties, such as: a) the location of the village, which depending on the time of year and the hour can turn the visualization of the stars more complicated; b) discrepancies between the references of knowledge between the researcher and interviewed; c) often, a determined name refers to more than one object in the sky; d) even with the use of instruments, we have not always managed to determine the identification and location of the stars, whether from literature or information gathered on site.

According to what we demonstrate, we should emphasize that the indigenous people represented here, the Tupinambá and Guarani, possess knowledge of astronomical and meteorological phenomena, the greater part of which still awaits investigation. This is an important aspect of this type of study, considering mainly that there is a traditional manner of representing the 'Indian' as a being without systems of knowledge, or as is most frequent, as an unworthy subject for programs of academic investigation.

By comparing historical data about astronomy and climatic markers of the Tupinambá and Guarani and present data being collected and analyzed, we desire to establish a basis for forming a panorama of Tupi cultural astronomy (whose consolidation will still depend on studies with other groups of the Tupi stock), contributing to a better understanding of a culturally differentiated *episteme*. This study, reaching the constitutive relationships between memory and history, also aims to contribute to an understanding of the history of science that equally envelops systems of production of knowledge not yet academically established.

By focusing on the myth as an example of cosmological theory, we would like to specify that we consider the myth, especially mythocosmology, as representative of an *episteme* – the fruit of a kind of thought that continually questions the origins, existence and workings of the universe, which are manifest in the constitutive relationship earth/sky. This questioning and the theoretical formulas it originates reflect the existence of a systematic process of producing knowledge derived from empirical observation and developed over the history of these peoples, which is historically proven by what is known about the Tupinambá and the studies we have been making together with the Guarani Mbyá.

In this manner, the knowledge and techniques of the indigenous peoples as well as other types of local knowledge begin to be implanted in the field of the history of science, whether they refer to the description and naming of celestial bodies or establish markers for forecasting (and even control) atmospheric phenomena using semiotics based on environmental and/or sidereal signs. As the cosmologist Mario Novello has said, in the academic field, the explanations that led to a disqualification of local knowledge cannot resist the reason of critical judgment (Novello, 2006).

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Weather dependent methods for observing the sky and reckoning time among the Kayapó of Gorotire, Brazil

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1. Introduction

The Kayapó Indians are experts in detecting special events in their terrestrial and celestial environments. When such events occur, especially at specific times of the year, the Kayapó use them as time markers to indicate the passage of the seasons. Regarding celestial events, they observe the changes in the positions of some stars in relation to the Sun to build their 'calendar'. In addition, they adapt their observation methods to the atmosphere visibility, which varies seasonally. They live in a region of transition between the savannah and the equatorial Amazon forest, which due to mist or smoke, get very smoggy at periods, bringing difficulties to the observation of stars at dawn.

Here, we discuss the Kayapó ways of reckoning time and some cleverly chosen methodologies that correlate earth and sky time markers. We will also discuss how they adapt their methods of observation to atmospheric conditions.

2. The Kayapó of Gorotire, Brazil

At the beginning of the twentieth century, the majority of Kayapó lived in a huge circular village called Pyka-tô-ti, with an estimated population of 6,000 people. The first decades of the last century saw a dramatic reduction in the Kayapó population, due to epidemics introduced by the intensive contact with non-indigenous populations. Gifts of clothes and other goods contributed to the spread of diseases and to decimate the population. Tensions between the groups and internal disputes led to the segmentation of the Kayapó into smaller villages, distributed over a huge extension of land in central Brazil (Posey, 1987).

Today, the population of approximately 7,000 people is distributed over twenty or so Kayapó villages, some located at Xingú Indigenous Park (Mato Grosso State), and others at the Southeast of Pará State. Most people speak Kayapó, a language belonging to the Jê family.

Gorotire village, in which we conducted our research, is located in the Kayapó Indigenous Land (*Terra Indígena Kayapó*), a territory of over 3.2 million hectares in Pará State. [(1)] There are other five Kayapó villages in this territory, with a population of approximately 3,000 people (Ricardo, 2000). Gorotire village stands at the right bank of Fresco River,

(1) Gorotire's latitude and longitude are respectively 7o47'20"S and 51o08'25"W.

an affluent of Xingu River. Its population was of about 700 inhabitants at the end of 80s, when fieldwork was conducted. (2)

The Kayapó division of functions and specialties is established according to sex, age and knowledge. The expertise of the *waiangá*, shamans with extensive knowledge regarding earth and sky, as well as time and space relations, contributes to the social organization of the group (Hamu, 1987; Posey, 1984).

Teachings by Beptopoop and Kwyra-Ká, two knowledgeable *waiangás*, are central to this analysis. Beptopoop was an expert on ants and their interactions with the habitat, particularly with the gardens and the bush. Kwyra-Ká was a specialist in bees and their relations with the environment. Both were also very knowledgeable about the treatment of diseases (Elisabetsky, 1986). Beptopoop, especially, was an expert on earth-sky relations.

Here, we will present some aspects of the village spatial orientation and of the Kayapó scheme of body orientation. Then, we will see how time and rhythms are represented in space and how the local celestial dome is used in the process of reckoning time. To conclude, we will present a brief discussion of the Kayapó methods for selecting time markers.

3. The village space, the human body and the Sun, as means of orientation

The old Pyka-tô-ti village, mentioned by the elders, used to have two 'men's houses' (*nabi*), one for the people living in the eastern and the other for the people living in the western part of the village. The *nabi* is a place where men meet, take decisions and produce arts and crafts as well as weapons and instruments for their survival. After the segmentation of the old village, the Kayapó adopted only one *nabi*, displaced from the center to the side of the sunrise (Figure 1).

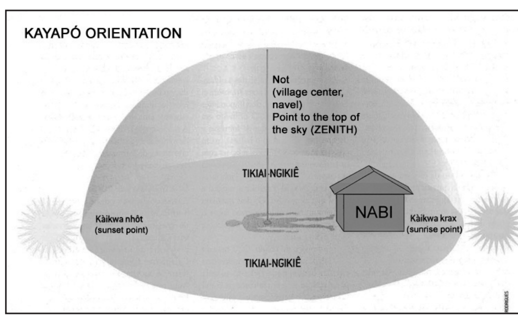

Figure 1: Body, village and 'men's house' as means of spatial orientation.

The location of the *nabi* in relation to the Sun allows visitors to orient themselves in any Kayapó village. The central ridge of the *nabi*'s roof is always perpendicular to the 'Sun's pathway'. Each of the families homes in any of their villages is located in the same position in reference to the *nabi*, and consequently to the Sun. Therefore, Kayapó who has never been to Gorotire can find their kin straight away, since the location of their family home in the village of origin corresponds to the same location at Gorotire.

(2) For general information on indigenous people in Brazil consult ISA website (http://www.socioambiental.org/pib/indexenglish.htm).

Regarding space orientation and the human body, in the Brazilian schools we are generally taught to stand up and point our right arm to the sunrise, in order to orient ourselves in reference to the four cardinal points. (3) Kwyra-Ká, when showing his basic system of orientation used to lie down on the ground aligning his body with the sunrise-sunset line. This alignment is perpendicular to the line formed by the midday positions of the Sun in both solstices.

In this case, his foot points to the sunrise side (*kàiykwa krax*) or the 'beginning of the sky' and the head to the sunset side (*kàikwa nhôt*) or the 'end of the sky'. The navel (not) represents the center of the village (*ipôkri*) with its upward projection to the Zenith (*kàikwa ipokri*) – 'the heights of the sky'.

It is worth noting that North and South receive the same name in the Kayapó system: *tikiai-ngikié*. This suggests a kind of symmetry, perhaps because they are so close to the Equator, at latitude of only 8º to the South. In fact, as seen from Gorotire, during the June and December solstices, the midday Sun appears respectively at almost the same annual lowest angular positions. At Gorotire, the highest Sun's positions happen in March and September equinoxes. At other higher latitudes such as in the Tropics, there is no such symmetry; the Sun is up in the Zenith position at midday Summer and lowest near the horizon at midday Winter.

In sum, the Kayapó have specific words to what we classify as East and West and use a single word to refer to what we classify as North and South. This suggests the saliency of East-West orientation. We can also infer that by classifying our North and South cardinal points into the single word *tikiai-ngikié*, the Kayapó recognize that 'their' Sun is symmetrically deviated from the Zenith at both midday solstices.

4. Seasonal time markers and earth-sky relations

It was mid September. By the end of the afternoon it started to rain a little, a rare event for that period, as observed Kwyra-Ká:

> You see? The first drizzles came earlier this year. I think that this is the reason why the chief asked us to hunt earlier this year, before Bemp's final feast. The Ngrôt-Krỳre [Pleiades or 'the heap of ashes'] have not even passed to this other side [pointing up, a bit to the west of the Zenith].

The Bemp ceremony marks the start of a new year, around June, with the appearance of the *bemp nhõ djá* – wide colorful rays that originate in the sunset. [4] Bemp festival happens

(3) For a discussion about misunderstandings in the practices of orientation in northern and southern hemispheres see the SULear website (http://www.sulear.com.br). SULear – a new word coined in Portuguese – is to be understood as 'to SOUTHernate'.

(4) These are probably the crepuscular rays, also called 'Rays of Buddha'. For illustrations see for instance: http://www.islandnet.com/~see/weather/elements/sunbeams.htm and www.metvuw.com/photoofweek/photo-20051213-03.jpg (both retrieved on May 18, 2008).

during the dry season, the 'beautiful weather' (*mêx*), the season to fish and to prepare and cultivate the swiddens. It lasts for 'four moons' (months), ending with the arrival of the rainfalls in September. The Bemp is the most important festival of the calendar. It is during this festival that the rituals of naming the youths entering adulthood take place. Bemp is also the name of a fish. During the celebrations, men sing songs that the fishes taught them in the old times, when the two species maintained conversations.

Bemp and the 'clearing cycle' feasts (*puru metôro*) mark the beginning of an agricultural cycle that will last for almost the entire year. Bemp ritual cycle ends with the start of the maize ceremonial cycle (*bà-ỳ metôro*), which lasts until the ripened corn silk dries and turns brownish ('dry plume'). At the arrival of the rainfalls, wild fruits fall down from the trees attracting game, which are hunted by the Kayapó. This is known as the 'deep' or 'full water' season (*ngo tàm*). The Kayapó correlate the rainy and dry seasons to the size of the beaches and islands of Fresco River.

When the rains attenuate, the harvest period starts, together with the 'feast of the cassava juice' (*kwỳra ka ngo*). After that, there is a small leisure period dedicated to family gatherings, crafts making and confection of ornaments for the feasts of the New Year.

Going back to Kwyra-Ká's speech, one can observe that he recognizes an interconnection between time markers from the natural realm ("the first drizzles") and those of the social realm ("the chief asked us to hunt"), and that both achieve confirmation through a precise celestial marker: the Pleiades.

Thus, trustworthy sky markers and their cyclic occurrence anticipate and corroborate their perceived cosmic order. Celestial regularity also allows them to verify if the times of the sky correspond to the ones expected from the natural, social and religious spheres. Sky markers regularity also reassures their beliefs in the cyclic return of the provisions of nature and in the social survival of the group. The Kayapó attribute occurrences against their expectations to weather irregularities, aggressions against nature and disrespect of norms and ceremonials.

In Kayapó societies, the contradiction of cosmological expectations may lead to the performance of rituals that subvert the social order. The intention is to keep a mirror-like order between Earth and Cosmos. For example, if an unexpected eclipse or a conjunction of Venus and the Moon occurs, the Kayapó may perform a taboo-breaking ritual, involving incest, for example, to pacify their worries.

Using the horizon as a frame of reference, the Kayapó from Gorotire choose certain stars (*kanhetire*) or star clusters as their time markers. From before the sunrise, they observe a star that rises from the east side, close to where the Sun will rise approximately an hour later. In some cases, particularly at foggy periods, they also observe the star that is crossing the celestial meridian (N-Z-S) near the Zenith (Z), therefore crossing from the east to the west side of the sky dome. In astronomy, those events are known respectively as 'dawn heliacal rising' and 'dawn heliacal meridian passage' of a star. [5]

(5) See animations of heliacal risings at http://solar-center.stanford.edu/AO/dawn-rising.html (retrieved on May 24, 2008)

5. The circle of time markers

Many stars, constellations and star clusters are part of the Kayapó classifications of celestial objects. Among those most commonly used as time markers are the Milky Way ('the ashes of *jatobá* tree' or *Moi Ngrôt*) and the Pleiades ('the heap of ashes' or *Ngrôt Krỳre*). (6) Special time markers and the Milky Way are represented in Figure 2, entitled "The Circle of Times" (Campos, 2006).

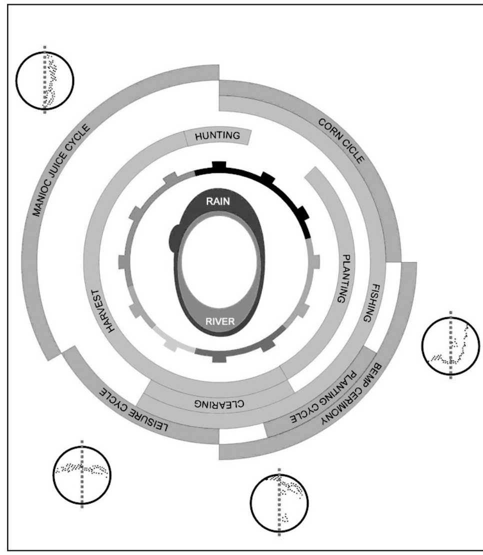

Figure 2: "The Circle of Times."

Moi Ngrôt or Milky Way is an extremely important time marker. When, before dawn, its alignment is almost parallel to the 'Sun's Path' – or to the East-West line – the Milky Way announces the beginning of the dry or 'beautiful' weather, around June. About two months before the 'beautiful weather', the Milky Way is seen 'cutting' the celestial parallel (East-Zenith-West) or, in other words, crossing the 'Sun's pathway'.

The Pleiades marks two important moments of the Kayapó planting and fishing season, as indicated in Figure 2. When the year begins, the Pleiades appear low at the eastern horizon before sunrise. The moment of the "first drizzles," mentioned by Kwyra-Ká, separates the planting in the dry soil from the planting in the wet soil. The species planted in dry and wet soils are different. The marker separating these activities is precisely the heliacal meridian passage of the Pleiades.

Observing phenomena related to the sky and to their territory, the Kayapó assure a good degree of sustainability, adopting throughout the year a synchronicity between their timing of activities and nature's seasonality production. In their rituals, they renew their gratitude for the gifts of nature in order to stimulate their replenishment each year at the appropriate time.

The times of the stars allow for the awareness of possible conflicts between celestial and terrestrial time markers. Celestial time markers are immune from human actions, and from the consequences of destructive practices such as dams building and deforestations, which may affect, among other things, the patterns of rain distribution.

(6) Jatobá is the common name of Hymenaea courbaril L.

6. Atmospheric conditions and the Kayapó methods of reckoning time

Because of the importance of sky markers for reckoning time, the Kayapó developed a methodology to read the sky under adverse conditions. The region where they live is prone to the occurrence of fog. Smoke caused by fires in neighboring agribusiness farms is also frequent, particularly around September. Fog and smoke often preclude the observation of the sky. Unlike many indigenous societies that reckon time through the heliacal rising of a star, during foggy and smoky periods the Kayapó adopt the heliacal meridian passage of the Pleiades or of the Milky Way. By looking upwards instead of looking to the horizon, they avoid the effects of a larger atmospheric band of absorption, which would render the observation of stars at the horizon impossible at certain periods of the year.

7. Conclusions

As we can see, the Kayapó recognize various time markers, belonging to the social and to the physical environment (Bemp festival, planting ceremonies, 'dry plume' of the corn, the fall of wild fruits, the size of Fresco River beaches and islands). Important markers derive from weather/atmospheric phenomena, such as the 'wide colorful rays', the "first drizzles," the rainfalls. But the ultimate time markers are the celestial bodies, reliable sources of information, unsusceptible to human interference. The 'Sun's pathway', the Milky Way, the Pleiades are all central to their construction of Time. To achieve permanent access to this information, the Kayapó have developed a sophisticated method of sky observation, adapted to local atmospheric conditions. Sky markers are constantly confronted with terrestrial markers, allowing the Kayapó to verify if the terrestrial rhythms are in accordance with the celestial ones.

To conclude, the cycles of terrestrial and celestial phenomena influence important social activities, being integral to the social organization of the Kayapó, and informing the construction of 'calendars' based on local observation of environmental phenomena.

8. Acknowledgements

The data herein published were collected during the Kayapó Project coordinated by the late Darrell Posey, to whom the authors would like to express their gratitude, in memoriam.

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Rain and drought: seasons in the *Tristes Tropiques*

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1. Introduction

In 1938, two anthropologists, Claude Lévi-Strauss and Luiz de Castro Faria, sharing the same fieldwork in the expedition led by Lévi-Strauss in the Serra do Norte region, in Mato Grosso State, made similar observations about the daily life of the groups that were visited, especially concerning their relation to the climate. Why did both, although distant on the point of view of their upbringing and their institutional origin, consider the same weather aspects as determinants for social life relatively to the exploration of natural resources and food preparation? The answer to the raised issue is that both were part of the same anthropological rationality field within a "discovering context," although they kept their own scientific styles (Paty, 1990). In this epistemological context culture became the object of anthropology (it was the beginning of the social and cultural anthropology), and particularly the daily relations amongst men as well as between men and the environment.

At that same moment in the history of anthropology, climate and other environmental facts, considered 'regulators' of life in society, became the main subjects in ethnological studies. Present studies on the history of climate show that many calendars were formed due to social culture (Jankovic, 2000). In this sense it is possible to say that Castro Faria and Lévi-Strauss observed the "work in progress" of a calendar. Although not comparable in terms of their international repercussion, Lévi-Strauss' work, and in a smaller proportion Castro Faria's, were both in the same epistemological context in anthropology. Both observed that there were two seasons in that region, the winter, dry season, and the summer, a rainy season, and that there were also two regions, the hot (dry) and the humid, shaping the landscape that conditioned the life of these communities. Such observations about the Amazon climate were not original. A century before many studies had already shown that the universality of the four seasons did not apply to the reality of climate in that region (Greenfield, 2001).

However, cultural particularities were not being taken into consideration by the climate studies of their time, which were inserted in the existent economical and political systems. The questioning both authors raised remains contemporary. Nowadays, their 'nature-human' dialectical perspective is present in the debates of whoever works with environment. In 1984, Maurice Godelier began his book *The ideal and the material* calling attention to the economical crisis the world was facing, and argued that people could not think that one's development would lead to others' development. He stated that an economical rationality, based exclusively on the rule of short term profits, brought along with it a gigantic waste of world natural resources and also an increasing environmental pollution, and that it was necessary to reduce and to impede them: "Expenditure, pollution, inflation, austerity, became the mark of world situation that deepened the differences and instituted a gap between the developed countries and the others" (Godelier, 1984, p. 43). According to him, it was necessary to analyze the conditions of the reproduction and non-reproduction of the systems that coexisted in the world and dominated all people, capitalism and socialism. But Godelier also said that this analysis should be supported on data collected by anthropologists who were immersed in societies more and more detached from the industrial countries and even shunned by their expansion. That was the case of anthropologists like Castro Faria and Lévi-Strauss, in 1938. They did one of these 'immersion works' that, according to Godelier, should be considered.

2. The Serra do Norte expedition

The best known result of the Serra do Norte expedition was Lévi-Srauss' book *Tristes Tropiques*, published for the first time in 1955, perhaps until today a reference source for whoever studies indigenous groups. Recently, in 2001, Luiz de Castro Faria, the Brazilian ethnologist who accompanied the expedition, published a book entitled *Another look: a Diary of the Serra do Norte Expedition*.

If for many reasons this book could be considered "another look," there are significant similarities between both works, especially regarding the relations between the social culture and the environment. Not by chance the title of each book appeals to geography. Even if they cannot be seen as pioneers, these books can be seen as emblematic of a moment when anthropology was being redefined.

Claude Lévi-Strauss (born in 1908) travelled to Brazil interested in ethnology and the study of Indians, seen at that moment as 'primitives' because they had not had any contact with the 'civilization'. He was in Brazil since 1936, teaching at the University of São Paulo, accompanied by his wife Dinah, anthropologist like him, who worked at the Culture Office of São Paulo. The journey to Serra do Norte would be Lévi-Strauss' doctoral thesis, and for that reason he was reluctant to accept the presence of another ethnologist in the expedition. However, everything turned out well (Domingues, 2001).

Luiz de Castro Faria (1913-2004), as Lévi-Strauss, was also beginning his career as ethnologist. He was nominated to participate in the Serra do Norte expedition as representative of the National Museum and the Inspection Council of Scientific and Artistic Expeditions (Conselho de Fiscalização das Expedições Artísticas e Científicas), a governmental institution created with the function of controlling the national territory (Faria, 1995).

Both carried their notebooks and latest generation cameras. The photographs substituted the drawings and paintings characteristic of previous naturalist expeditions. The group included the physician and naturalist Jehan Albert Véllard and Dinah Lévi-Strauss, who was forced to abandon the expedition in its beginning due to an eye infection. They intended studying the Nambiquara Group. The journey lasted six months. It began in

Cuiabá, in Mato Grosso State, and ended in the North. Lévi-Strauss and Véllard went until Guajaramirim, at the Bolivian border, and Castro Faria, after Guajaramirim, travelled up to Belém (Pará State), going through Manaus.

Tristes Tropiques is not a journal as it is *Another look*, but in many aspects the author narrates parts of the journey. The book is divided into two big parts: in the first one he shows the contrasts between the southern and northern hemispheres and southern/southern countries, making some comparisons between Brazil and India, and in the second part he compares different groups of the Indians he visited. Lévi-Strauss observed the social relationships of such groups and emphasized the 'violence' of men to the environment. In fact, if he initially wanted to understand the 'primitive' man, in comparison to the 'civilized', as it is said in the introduction of *Tristes Tropiques*, he ended his journey sure of having only found different social cultures.

Castro Faria's book, on the other hand, is the diary of a journey, but despite that limitation as an 'objective' document it reveals the profound native knowledge of the environment. For Castro Faria cultures were singular and geographically rooted. The economic production of Indians, although poor, was a result of their knowledge and action on the environment. Castro Faria, in a 1946 speech whose original manuscript he never finished, made a study on "ecological anthropology" based on the tribes visited by the expedition. His quest was to understand the Indian socio-ecological equilibrium. However, contrary to the 'chroniclers of the first decades of the eighteenth century' accounts that didn't recognize the ever existence of such balance, the data he collected showed that if there was socio-ecological balance it would represent an outstanding example of the crowded Indian communities economical adjustment to the unfavorable environmental conditions, which he did not observe. He concluded that the devastation of the region reflected on the environment and social relations. Castro Faria's diary, divided into six chapters, is marked by its images and is a last resort of the stated *savoir-faire* and geography of the Indian culture (Domingues, 2001).

They dealt particularly with a controversial region, the Central-North of Brazil, including the Amazon area. Tropical regions, object of scientific and political debate, were seen at the time by the geographer Pierre Gourou (1947) as environments "inhospitable to be civilized," because poverty, insalubrity and instability of the ground were effects of the climate and affected men deeply and visibly. However, these problems were caused by a political tradition that let the climate dominate the inhabitants. Contrarily to the anthropologists Lévi-

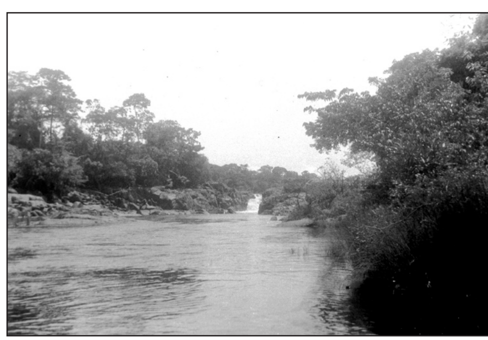

Figure 1: The exuberance of the Amazon forest and its rivers.

Photo: Luiz de Castro Faria, 1938.

Source: Arquivo Castro Faria, CF f0011/foto 4, MAST, Rio de Janeiro.

Strauss and Castro Faria, Gourou did not take into consideration the knowledge about the environment developed by those populations due to the surrounding conditions.

3. Dryness, humidity and rain in the geographical scenery of two seasons

Lévi-Strauss and Castro Faria observed that social and biological life was adapted to environmental conditions but also observed, on the other hand, that the Natives adapted the environment to their needs. One of the common observations was about life related to climate, that is, life oriented by the two seasons of the year, the dry and the rainy seasons; and by the existence of two different geographical regions, the dry and the humid. These contrasts could explain the dialectic relation between man and environment.

In the study of the socio-ecology of the Nambiquaras, Castro Faria identified two different seasons: summer and winter. The first, the rainy season, normally starts at the end of September and finishes in March. The dry season, the winter, represents in fact a period that can be easily characterized because the effects of the lasting and continuous dryness are seen everywhere. Its effects were sensed, he said, by the flora and fauna and had deep reflections on indigenous cultures. To Castro Faria the relation between human society and environment was so important that it was impossible to study social or cultural aspects of the Natives' way of life apart from the natural environment.

It calls the attention his vision of abortion. He mentioned the knowledge of three 'drugs' that served to abortion practices. It was known, he said, that such practices didn't follow religious precepts and disrespected taboos and prohibitions of any nature. But he ascribed such practices to economical causes. A larger number of individuals represented a better equipping for the continuous struggle against the environmental adversities, though in other circumstances, with the need of fast and regular displacement throughout large areas, it might condemn the existence of a large offspring – the aridity of the region and the hostility of others groups would thus lead to such practices.

Castro Faria said that the most noticeable feature of the *cerrado* (low vegetation found in northern and central Brazil) was the plants physiognomy – small, branchlike vegetation, contorted and always protected by a thick layer of bark. The living period of the plants starts in mid September, with the first rains. In March they reach maturity and in May the plants enter a new period of rest. From May to September the field and the *cerrados* are mercilessly punished by fire. However, even in adversity

Figure 2: Nambiquara Indians in the dry area of Chapadão, near Utiariti (Mato Grosso State).

Photo: Luiz de Castro Faria, 1938.

Source: Arquivo Castro Faria, CF f0004/foto 96, MAST, Rio de Janeiro.

it was possible to take some advantages, like ashes being entirely transformed into fertilizers. Castro Faria said that only during the rainy season the Nambiquaras stayed around the manioc field they had cultivated.

Not only was the food adapted to climate but also the housing. When arriving to Pimenta Bueno (now located in Rondônia State), Castro Faria observed that some houses had eaves, others had gables, with very sloped roofing, forming an acute angle. The internal partitioning was “very intelligent, and more or less uniform in all of the houses: a room at the front, or more exactly a veranda, since in general the wall reaches only halfway up, a corridor to the side, with a door opening onto a central room, and in the rear a very wide kitchen. Sometimes they also leave a veranda along the side” (Faria, 2001, p. 142). Therefore they had very cool houses during hot and sunny days, while sufficiently protected against the storms, stirred up by the southern winds.

In what concerns the relation between the fauna and the social culture Castro Faria observed that during the dry season, when the region turned almost into a desert, the grasshopper predators proliferated and became food – “the grasshoppers became victims” –, showing the degree reached by the adaptation or submission of men to the climate.

On the other hand, entering the Amazon region, Castro Faria emphasized the differences between the dry plateau and the hot and humid forest, stating that as they were going to the North the vital forces swelled around them, plants became more vigorous, the deep stream running through the forest became denser, showing abundant life (p. 140).

To Castro Faria, the forest was a shelter to whoever arrived there pushed by the fires, which were called the continuous struggle between the Natives and the forest. Both him and Lévi-Strauss considered the forest fires an aggression to the environment.

To Lévi-Strauss the miserable life conditions of the Nambiquaras represented submission to nature and he observed the dominance of climate over the daily life. As Castro Faria, he observed that the Nambiquaras' year was divided in two distinct periods. From October to March, during the rainy season, each group settled in a high plateau along a river where they would build rough shelters. Burning the forest they opened galleries in the humid valleys to cultivate the land, from where they harvested manioc (sweet and bitter), tobacco, cotton, peanuts, pumpkin and several kinds of corn. The horticulture granted enough food during part of the sedentary life. The Nambiquaras preserved the manioc sticks by burying them in the ground and digging them up, half rotten, some weeks or months later, to cultivate them.

During the dry season, from April to September, they abandoned the village and the group was divided into some nomadic groups, he observed. For seven months they wandered, hunting through the savanna, searching for small animals, such as worms, spiders, grasshoppers, rodents, snakes and lizards, and searching for fruit, grains, roots or wild honey, all things that impeded them from dying of hunger. The camps built up, during one or more days, sometimes weeks, were also rough shelters, one per family, made with branches of palms stuck in the sand in semicircle and tied up on the top. As the day passed, the sticks were removed from one side to the other so the protecting screen would always be turned to the sun. It was the time when the search for food called all attention. The women used the sticks to extract the roots and to kill small animals; the men hunt with a large variety of bows and arrows: some for birds, other for fish, other poisonous with their tips dipped into curare to hunt larger animals like jaguars. Then Lévi-Strauss asked himself, "how do these nomads have established in both sides of the Western hemisphere and adapted themselves to such different climates, to the point of discovering, domesticating and spreading the wild species transformed by their hands into tobacco, beans, cassava, sweet potato, peanuts, cotton or corn?" (Lévi-Strauss, 1986, p. 247)

4. Conclusion

Each one of them, on their own ways, or their 'scientific styles', translated the Natives' daily cultural lives and concluded that climate was a predominant factor. Castro Faria's objective was to make "ecological anthropology" and he was concerned with culture in its different material manifestations. Lévi-Strauss, on the other hand, searched to know what caused the cultural singularity of these societies, and believed that the relations between men and nature were defined by thought. He asked himself about different forms of thought, trying to sketch an ideal social pattern.

Both realized that the culture of the Nambiquaras was basically influenced by the weather – dry or rainy – that also shaped the landscape vegetation. Castro Faria concluded that "ecological balance did not exist," considering the adaptation of their lifestyle. In his later studies, he reiterates that the social relations generated by the socio-economical activities were related to the environment. He emphasized the material culture and studied the daily lives and the social organization conditioned to geography, meteorology, fauna and flora. For him, the tropics were happy.

Castro Faria saw the Natives as part of his own society and concluded that the influence of nature over the indigenous communities was more deeply felt because they were not prepared for the "daily fight," which needed to be based on rational methods of nature exploitation. However, like Lévi-Strauss he was against the intervention on these cultures.

Lévi-Strauss observed that historically the relationship existent between men and nature was undeniable, but concluded that it was defined by the same forms of thought. For him, the natural conditions were not experienced, did not have their own existence – they were consequence of the techniques and the ways of life that defined and gave sense to the natural resources' exploitation. Therefore, there was no contradiction in nature. There could only be a contradiction in terms of the particular human action inscribed in nature which gave a different meaning to the environment, according to a technical and historical form of any activity. According to Lévi-Strauss the relations between men and the environment were produced by the thoughts: men don't experience them passively, neither reduce them to concepts forming a system which is never predetermined (Lévi-Strauss, 1976).

Lévi-Strauss signaled that in the "age of the myth," men were not freer than at that any other time but on the contrary their simple lives turned them into slaves. As the myths became knowledge, power of men over nature increased. However, this power was an agent of destruction and men became its own "colonizer" (Lévi-Strauss, 1986). He concluded it was important to know the foreign societies because such knowledge was a way of freedom; a way to know better our own societies. The knowledge of such foreign societies should not be used to intervene in them, but to reform our own society. Summarizing, he said: "Only by knowing the society to which we belong we are able to transform it without risking its destruction" (Lévi-Strauss, 1986, p. 388).

Lévi-Strauss' and Castro Faria's works were in the opposite way of the dominant systems. In the 1930s and 1940s, when scientific internationalism was being transformed into political instrument of the State and meteorology was considered a stronghold (Cushman, 2005), their works about the cultural particularities of the seasonal life in non-Western societies were divergent from the dominant consensus and therefore did not echo.

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The farmer and the weather

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Everyone is concerned about the weather, but some are more concerned than others. Farmers clearly fall into the latter category, as weather and climate are key factors in any system of agricultural production. Every type of farming includes a whole host of environmental factors, and some of the key factors are meteorological. Plants need a certain minimum temperature over a certain time span, they need protection from freezing temperatures, but also safeguards against excessive heat; they need sufficient amount of water either from rainfall or from irrigation; and they need to cope with wind, thunderstorms, and all the other vagaries that weather has in store around the globe. Furthermore, the weather also has an impact on livestock and even on farm buildings and technology, as harsh weather significantly reduces the lifespan of buildings and farming implements (cf. Schnider, 1912). Farmers are clearly one of the most weather-dependent professions, and it is little surprise that they monitor the weather closely. The agricultural literature contains numerous books that discuss ways of learning about the weather (for some German examples, see Keßler & Kaempfert, 1948; Seyfert & Runge, 1964; van Eimern, 1971). In fact, the rules of thumb that farmers developed over time have come to be seen as a special treasure trove for folk wisdom about the weather, as books on the "weather rules of the peasants" serve to attest (Knauss, 2007). The meteorological history of agriculture is certainly a rewarding topic, and it seems that historians are only beginning to discover its full richness.

However, this situation makes it all the more advisable to reflect cautiously on the general approach to the topic. After all, a naive approach would risk producing a curious mixture of novelties and banalities. For example, it seems to make little sense to ponder the relationship between crop choices and climatic conditions: it is utterly clear why date palms grow in the desert and banana trees in the tropics. Furthermore, such an inquiry could easily lead into the quagmires of environmental determinism, a path that environmental historians have long recognized as a dead end street. For example, corn, a plant of Mexican origin, has gotten hold in northern latitudes as well, even though these regions, with its rather low median temperature, are on the fringe of what the plant can tolerate (Uekötter, 2007). The spread of meteorological expertise is probably a more rewarding topic: it was clearly a major cultural achievement to move from traditional knowledge about the weather towards broadcasts from faraway experts. Preliminary studies suggest that this transition was a long-term phenomenon, as both types of expertise coexisted peacefully for quite a while. Remarkably, a book on popular meteorology of 1902 made no bones of the difficulties in forecasting: "At the present, our weather forecasts are still standing on shaky ground, meaning that we still have to account for failures of various kinds" (van Bebber, 1902, p. 8). A third rewarding approach is to look at the specific meteorological challenge that defined a farming society's relationship to the weather. While many meteorological factors matter, some matter more than others. In the Central European context, temperature and rainfall may influence the grain harvest, but hail can destroy it in a whiff of time – certainly the reason why farmers sought an insurance against hail disasters already in the nineteenth century (Oberholzner et al., 2004). When farmers try to make sense of the weather, it obviously matters whether a certain meteorological factor has an impact, or whether it can spell disaster.

In the search for a place to discuss these kinds of questions, few places seem more adequate than the American Great Plains. After all, the Great Plains was the site of what was arguably the most-publicized drought disaster of modern history: the Dust Bowl, which received its name from the massive clouds of sand rolling over the land in the 1930s. The meteorological causes are quite plain in retrospect: the Great Plains, and especially its southern part, experienced a number of dry years, which caused the local crops – mostly wheat – to fail. As a result, the unprotected soil dried up and became powdery, and when winds picked up, massive dust storms were produced. The hazards were numerous. Blowing dust destroyed crops and property and even endangered human health: if someone got caught in a dust storm on the open field, there was a severe threat of suffocation. In fact, the dust storms were so dramatic that they entered world literature through John Steinbeck's *The Grapes of Wrath*, though one may argue with the adequacy of this reference: after all, the novel centers on people who left the Great Plains as a result of the Dust Bowl, and while these migrants have received great attention, the fact remains that they were a minority (Steinbeck, 1939). Even in a severely affected region like southwestern Kansas, only a quarter of the population left, while three-quarters of the residents stayed (Riney-Kehrberg, 1994, p. 2).

While the Dust Bowl seems like a perfect case to argue for a link between agriculture and meteorology, the situation is in fact trickier, at least according to Donald Worster, who wrote a widely acclaimed book on the Dust Bowl that was published in 1979. For Worster, the Dust Bowl was not a simple accident of history, not an isolated event but the emblematic event of agricultural capitalism: "the inevitable outcome of a culture that deliberately, self-consciously, set itself that task of dominating and exploiting the land for all it was worth," as he wrote emphatically (Worster, 1979, p. 4). Since then, talking about the weather is mined territory when it comes to the Dust Bowl, as every attempt to blame 'the weather' is inevitably suspicious of distracting attention from the broader context of agricultural capitalism. Therefore, it seems imperative to reflect more closely on the guiding questions for research: How can a discussion of the weather and the Dust Bowl lead to more than a rejuvenation of convenient *clichés*?

A key aspect is certainly whether the Dust Bowl region is a peculiar one from a meteorological point of view. However, the record is somewhat confusing in this regard. The Southern Plains are arguably a region with rather violent weather: it experiences warm and humid weather from the Gulf of Mexico as well as cold air from the North, resulting in enormous fluctuations in temperature and rainfall; furthermore, it is a prime region for tornadoes. On the other hand, the region's key problem – drought – is by no means spectacular, and in fact arguably the key meteorological problem of agriculture on a global scale, as the burgeoning debate over desertification serves to attest. With that, it seems wise not to overemphasize the peculiarity of the Dust Bowl region: while the specific meteorological context may be peculiar, the general problem is not.

As a second step towards a more sophisticated approach, it seems advisable to look more closely at the link between farming practices and weather predictions. To what extent did weather shifts and farming practices correlate on the Plains? On first glance, that question might seem absurd: the Dust Bowl was not the least notorious for coming out of nowhere. “When the storms hit, they usually came without warning,” Timothy Egan noted in his widely acclaimed story of the disaster (Egan, 2006, p. 7). But the Dust Bowl not only consisted of spectacular storms but also of countless smaller, local episodes, where a field had dried up and caused trouble for neighbors; locals said that a field was ‘blowing’ when soil became airborne and moved towards neighboring fields. However, it was possible to stop a ‘blowing’ field by cultivating the land, and that is what many people did as *ad hoc* measures against the consequences of the drought. In fact, a district court in Haskell County, Kansas, even upheld the right of a farmer to enter a neighboring field to stop this kind of wind erosion (Riney-Kehrberg, 1994, p. 122).

It seems that this practice implies a broader significance that historians of agriculture and meteorology are well advised to reflect more deeply about. The relationship between agriculture and meteorology is frequently about timing: key concerns are when the weather is right for planting, when it is time for harvest, when the soil contains the right amount of humidity, etc. But in the Dust Bowl region, there was obviously more happening here: the concern was not just about timing but also about the strategy of agriculture – working the land in response to spontaneous weather fluctuations in order to forestall trouble. The crucial question is: Are we dealing here with a single practice that has no broader significance – or are we talking here about a nascent strategy to control the risks of agriculture in an arid region? It could be rewarding to look at other arid regions in search for other agricultural systems that make spontaneous adjustments of farming practices, and adjustments that are about more than timing.

In conceptualizing these adjustments, it may be rewarding to draw on the concept of ‘vulnerability’, which experienced a boom in studies on natural disasters and society. In a nutshell, vulnerability describes the resilience of societies towards unexpected events (cf. Hoffman & Oliver-Smith, 2002). The argument is that while some societies categorize natural disasters as hazards that one simply has to endure, others have developed certain mechanisms to deal with events of this class. Greg Bankoff recently provided an impressive discussion of these kind of mechanisms in his study of natural hazards in the Philippines; in fact, Bankoff went so far as to describe the Western discourse on disasters, which sees natural disasters as singular, fateful occurrences, as a disturbance of these local mechanisms and as an intellectual occupation (Bankoff, 2003). In a similar fashion, one may classify *ad hoc* adjustments as part of cultural strategies to cope with events that occur not every year, but with a degree of regularity that evokes cultural responses. Remarkably, recent studies on oscillating agroecosystems like El Niño are already drawing on the concept of 'vulnerability' (Rosenzweig & Hillel, 2008).

Interest in this kind of issues was surprisingly scant in the Dust Bowl region. One reason was clearly a lack of local knowledge. The Southern Plains were a late-comer in the settlement of the American West – the Great American Desert that land-hungry settlers tried to avoid as long as they could. As a result, few people had any long-term knowledge about the local weather because most had arrived only recently. Furthermore, it is important to recognize that cultivating the Great Plains had a significant effect on the local climate. The traditional land cover in the Great Plains was grass – and the job of the farmers was, at its most essential, to replace this grass with more seasonal plants, thus changing local climates enormously. As a result, most people thought that the weather would stay as it was in the late 1920s and early 1930s, when the region enjoyed favorable weather and several bumper crops; and when the weather looked different, they reacted with emigration or, alternatively, grim determination. One of the more remarkable effects of this determination was the conflict over a painting by Alexandre Hogue entitled *Drought Survivors*, a picture that became one of the emblematic representations of the Dust Bowl (the picture is even to be found in schoolbooks; see Radkau, 2002, p. 172). Hogue was a painter who had long lived in the region and made the crisis one of his themes, but the local reaction was hostile: people in the region hated being portrayed as a disaster region. Therefore, the Chamber of Commerce of Dalhart, Texas, decided to send a representative to the Pan-American Exposition in Dallas, where picture was on display at that time, with the order to buy the picture and bring it to Dalhart, Texas so that the Dalhart Chamber of Commerce could burn it on the street of the city in an act of protest. However, the Chamber of Commerce gave its representative only 50 dollars for the purchase, while the picture already cost 2,000 dollars at that time – and so the picture was saved (Worster, 1979, 32n). If anything, this episode mirrors a grim determination to stay, and hostility towards the outside world. In this context, any reflection on weather and agricultural adjustments was clearly beyond the horizon. When it came to the weather, local opinion was clear: they wanted the rain to return – period.

Remarkably, the interest was not much more pronounced when it came to the political response. The Dust Bowl was a watershed in the fight against erosion, and not only within the confines of the United States. Conventional wisdom has it that the Dust Bowl led to the formation of the Soil Erosion Service in 1933, a federal program to combat erosion under the guidance of Hugh Bennett; that the Soil Erosion Service became the Soil Conservation Service (SCS) in 1935 and that the SCS became one of the prime advocates of erosion control. As so often, the story was in fact more complicated, with one of the complications coming from Hugh Bennett, the much-acclaimed "father of soil conservation" (Brink, 1951). Bennett was quite ambiguous about the Dust Bowl, clearly a surprising fact in the light that the Dust Bowl was a dramatic event that resonated all over the country. However, when Bennett thought about soil erosion, he though first and foremost about *water* erosion. Bennett was a Southerner, a native of Wadesboro, North Carolina; and in the South, the key problem was not drought and wind erosion but water erosion due to heavy rain and the exhaustion of the soil through monoculture. Bennett always had an emotional attachment towards the South, he traveled there much more frequently than to the Dust Bowl region, and he designed the federal soil conservation program especially with a view to the South. As a result, Bennett was clearly struggling to take wind erosion seriously as a problem. In a report of June 1934, Bennett warned that the land in the Southern Plains "is in optimum condition for the greatest possible destructive effects from heavy rain that may occur any time" (Bennett, 1934, p. 2). Obviously, Bennett had not yet understood that everyone in the Dust Bowl region was *hoping* for rain, rather than fearing it.

Furthermore, the general philosophy of the SCS was clearly at odds with thoughts about adjustments to changing weather. It is not easy to describe this philosophy within the span of this article, but one crucial aspect was that the SCS, under Bennett's charismatic leadership, was waging the fight against erosion as nothing less than a fight for civilization. "History has shown time and again that no large nation can long endure the continuous mismanagement of its soil resources. The world is strewn with the ruins of once flourishing civilizations, destroyed by erosion," declared Bennett in a typical speech (Bennett, 1935, p. 5). With that, the overarching goal of the SCS was to save the soil for eternity – to assure, through adjustments in production methods, crop choices, contour plowing, irrigation, *et cetera*, that the soil of America would be preserved forever. And if you conceive soil conservation in such a broad way, it is clear that spontaneous, *ad hoc* adjustments to changing weather were not part of the agenda. The SCS was looking for a permanent fix, not for quick, flexible improvisations that the farmers would have to do themselves.

With that, this article offers an interpretation of the Dust Bowl disaster that moves beyond the region, though in a somewhat different way than Worster. From the standpoint of the history of meteorology, the Dust Bowl highlights the difficulties and the challenges of agriculture in a marginal region where conditions just barely allow an agricultural use. Against this background, the broader significance of the Dust Bowl is that it illustrates the limits of the Western model of high-intensity agriculture. It is probably no coincidence that modern, science-based agriculture comes from a region with an enormous 'built-in' tolerance for mistakes. Western and Central Europe is a region where water scarcity is not a general problem and where the soil has a rich humus layer that serves as a buffer against mistakes and unexpected events. In the pioneering regions of modern agriculture, bad weather could ruin a harvest, but it could not ruin the soil – and that kind of certainty ended in the dust clouds of the 1930s: modern, high-tech, high-input agriculture could ruin the soil, and in a spectacular fashion. That is also the key reason why the disaster was so prodigious and why it deserves much more scholarly attention. Spectacular as the dust clouds may be, they tend to obscure the real issue: the Dust Bowl provides a case in point for the limits of modern, science-based agriculture.

When this paper was presented in Rio de Janeiro, the global rise of food prices was making all over the world, and it would probably mean a missed opportunity if the author would not mention, albeit briefly, that the topic under debate here has also enormous implications for today's challenges. The relationship between farming and the weather is receiving more and more attention in recent years, as farming experts in many countries are wondering whether established practices will remain feasible if the climate changes (see, for instance, Flückiger & Rieder, 1997). However, it seems that there is also a second, related challenge at stake here which usually receives less attention in public discourse. As a result of the growing concern about the global food supply, there is much talk in agricultural circles about another Green Revolution, fashioned after the spectacular introduction of new seeds in Mexico and some South Asian countries (cf. Perkins, 1997). Of course, there are those who stress another quick fix: seed companies are touting that, with genetic engineering, they could produce new, more productive plants that would save the world from the brink of starvation. But there are also other approaches which stress the cumulative gains of many small adjustments, implying that farmers can achieve a productivity revolution by being clever, flexible actors who know the peculiarities and chances of their respective place: "The Green Revolution at its most fundamental level treated all the world the same, but the lessons being learned in agriculture now are local," a recent book on *The Next Green Revolution* declared (Manning, 2000, p. 12). Could meteorology be one field that offers small but significant benefits to the farmers, benefits that will demand local knowledge and attention to detail? Of course, the question remains open whether this perspective proves feasible. But, if anything, it is enough of a reason to inquire more into the history of the link between agriculture and meteorology, and to wonder whether twentieth-century agricultural science has underestimated the true potential of this link.

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The politics of uncertainty and the fate of forecasters: climate, risk, and blame in Northeast Brazil

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1. Introduction

The goal of this paper is to discuss the political uses of uncertainty, and how it affects configurations of accountability and blame, focusing on the politics of climate-related uncertainty in Northeast Brazil as a case study. This research was carried out in the state of Ceará, in Northeast Brazil, with a focus on the production of climate knowledge – local rain prophets and the local meteorological agency. I carried out fieldwork for three years, relying on participant observation, interviews, and surveys. Soon I came to realize that what I was dealing with was what I call the 'social life of uncertainty', that is, how uncertainty is managed, disputed, feared, or concealed.

One of the goals of the study was to understand the reasons why, despite important recent technological advances, meteorology has a lower degree of social recognition than other scientific disciplines in most parts of the world.

Uncertainty and its effects are socially and politically distributed in specific ways. More systematic anthropological research on the 'social life of uncertainty' – that is, how it is dealt with in cultural formations and personal and collective psychologies, socially distributed, and politically manipulated – is yet to be done, in part because of the logical and methodological limitations of working at the limits of culture and cognition (Daniel, 1998). Climate is an especially interesting locus for observing how social and cultural processes deal with uncertainty, particularly because of the fact that climate phenomena constantly remind us of how fragile our categorical systems (and political institutions) are, and consequently, how clumsy are our attempts to forecast and control natural processes. At the same time, the impacts of climate events usually connect a wide range of socio-cultural phenomena: political structures and institutional configurations, cosmologies and religious rituals, collective psychological responses. This is also a methodological challenge: the problem can multiply *ad infinitum*, in a fractal fashion. For this reason, I shall focus only on the ways political discourses interact with the activity of producing and disseminating climate forecasts in the State of Ceará, Northeast Brazil.

2. Scapegoating forecasters

During the 2006 annual meeting of the Brazilian Meteorological Society, a local civil defense official described his participation in the events that proceeded the moment in which Hurricane Catarina hit the southern region of Brazil, in March of 2004. He and a meteorologist from the local climate agency went to the state governor and, given the seriousness of the threat posed by the hurricane, suggested that he should personally warn the population on TV, rather than having it done through the local civil defense, as usual. The governor immediately consulted his advisors. He then heard from his secretary for public affairs that an evacuation warning could create chaos in the state, given the lack of official evacuation plans and the bad state of local roads. And if the hurricane did not hit the state, the advisor said, the governor would lose credibility with the population, what could have disastrous results for his future reelection. At that moment, the civil defense official reported having said that, given the destructive potential of the hurricane, it would more advisable to err on the side of exaggeration. After all, he reminded the governor, he could always blame it on meteorology.

That immediately triggered a series of associations in my mind: throughout my research, I had found references to violence against forecasters at many different sources. In some cases, the ritual sacrifice of the forecaster was the normative way of dealing with extreme climate crises, as we find in the famous Herman Hesse's Rainmaker tale (Hesse, 2000). We also find this in popular culture, as in the 2005 film *The Weather Man*, where the main character, interpreted by Nicolas Cage, suffers physical assaults on the streets for no apparent reason.

In Brazil, I collected interviews where meteorologists told me of their avoidance of going to public places like supermarkets, whenever they feel there is a general perception that previously issued climate forecasts were wrong, out of fear of being verbally abused (Taddei, 2005). And finally, I had heard jokes ridiculing meteorologists while doing fieldwork in rural Northeast Brazil (Taddei, 2005, 2006), and I had found comic strips making fun of meteorology in Argentina, Brazil, England and the USA.

Figure 1: Mafalda, a famous comic strip from Argentina.

Miguelito: How formidable!

A meteorological observatory in England has electronic machines to forecast the weather.

Mafalda: Well... At last they found a way to automate fiascos.

For the sake of our analysis, we can treat physical violence, verbal abuse, and making ridicule of meteorologists as different degrees of the same phenomenon: the degradation of the social identities of forecasters. The main point of my argument is that for this to happen, a specific understanding of uncertainty is necessary. Contemporary climate theories share with quantum physics the understanding of uncertainty not as a measure of our ignorance (as probability is generally understood), but as part of the way reality is structured and organized (Hacking, 1990). Atmospheric systems are overwhelmingly complex; they are 'chaotic', in the mathematical sense of the term. If I say, for instance, that there is 83.3% of chance of getting between one and five as a result when throwing a die, and I do it and get a six, there is no mistake made: it is just a probabilistic outcome. In general, scientific climate forecasts are distributions of probabilities (e.g. 40% of chance of total rains below the historic average for a given rainy season); but differently from the case of the die, very often communities around the globe interpret forecasts in ways that make meteorology accountable, in some ways, for the negative impacts of climate events, as if forecasts were not probabilistic statements.

As Mary Douglas theorized (1984, 1992), risk and danger evoke collective emotional responses, and for this matter, everything that implicates risk becomes a moral matter. Such state of affairs very often triggers social responses that Douglas called "forensic theories of danger" (Douglas, 1992), in which someone unpopular is made accountable for the situation and punished according to local practices. For this reason, danger is always politicized. Throughout her career, Douglas struggled to show that this way of dealing with risk and danger characterizes the majority of societies in the planet, including urban Westerners.

My argument is that the work of blaming is incompatible with an understanding of uncertainty as something insurmountable: the acceptance of pure randomness would make it difficult to unequivocally declare someone guilty. So here I suggest that when we see Douglas' forensic theories of danger in action, they are necessarily accompanied by a specific way of understanding uncertainty, and that is *misrepresenting* uncertainty.

As we shall see below, this misrepresentation may happen through the ways in which political discourses frame events. It happens in different scales: from local politicians trying to avoid social unrest by providing a sense of control when things are chaotic, to the way economic development agents present climate science knowledge and technology as part of their solutions for the suffering of poor regions of the globe. Political rhetoric as a discursive genre tends to use uncertainty in specific ways: politicians rhetorically create the illusion of certainty, while their everyday lives consist of a never-ending struggle to tame the unavoidable uncertainties of the political arena (Bailey, 1969, 2001). Winston Churchill has reportedly affirmed that a political leader has to be able to say what is going to happen in the future, and later, to explain why it didn't happen (Bailey, 2001).

Climate events are filled with uncertainty, and as a result they trigger all sorts of emotional responses. The usual understanding that managing collective anxieties is the role of leaders – political and religious – turns climate forecasting into a political matter. Therefore, climate is a deep concern for politicians at all political levels; it is also a fertile ground for blaming and scapegoating rituals. Evidence shows that the number of witches murdered in Renascence Europe is positively correlated with the negative impacts of historic climatic variations on local communities (Oster, 2004, p. 215). In today's rural Tanzania, the number of witches killed doubles during years of extreme rainfall (Miguel, 2005, p. 1153). Davis suggests that one of the causes of the Boxers Wars in China was the belief that the presence of Western missionaries in that country took the *feng shui* of the land out of balance, thus generating droughts (Davis, 2001). Examples are innumerous. We could safely say that the oldest and most deeply rooted meteorological theory in human history is that "it didn't rain (or rained too much) because of the actions (or sins) of the community (or of specific individuals)."

3. Scientific climate forecasting in Northeast Brazil

The Brazilian Northeast is a relatively highly-populated region, and the poorest of the country. It is known for its pristine beaches and for the periodic droughts that devastate the state's hinterland. The socio-economic standards of the region are deeply connected, according to Costa, Kottak, and Prado, to a reality of "periodic severe droughts, poor soils, skewed land distribution, low levels of education, high levels of poverty and underemployment, and limited physical and social infrastructure" (Costa et al., 1997, p. 138).

The rainy season in this region lasts from February to May, a period in which there is abundant stream flow in the rivers. During the rest of the year, there is no significant precipitation, and before the construction of reservoirs, rivers commonly dried out. As explained by local populations, given the fact that very often the rainy season fails in the region, in the first half of the year they live with the 'uncertainty' of rainfall, and in the second half, with the 'certainty' of the absence of rain.

Given the central role of climate in diverse aspects of life in this semiarid region, it is not surprising that efforts to combat drought have included intense scientific endeavors. In addition to past applications of cloud seeding technology, reservoir building, and the adoption of efficiency-driven water management models for the state hydro-system, one recent technical response has been an attempt to improve climate prediction. The capacity to predict general patterns of climate variability has improved over the past twenty years, especially after the *El Niño* phenomenon was modeled and studied in depth. Towards the end of the 1990s, the meteorological agency of the State of Ceará, FUNCEME, became part of a network of national and international institutions that jointly monitor meteorological indicators and issue forecasts for the Brazilian Northeast. FUNCEME achieved computational power to run sophisticated mathematical models developed jointly with meteorologists based in New York.

All these infrastructural aspects do not solve the main problem Brazilian meteorologists have: the unpredictability of some types of meteorological systems. For many meteorological phenomena of short duration (although of potentially catastrophic effects), such as 'cold fronts', there are no reliable forecast models available. Even for the meteorological systems that are well known and more predictable, the number of variables is high and the phenomena involved, amazingly complex. That means that no computational apparatus running mathematical models can provide a climate forecast that is not a certain distribution of probabilities for specific climate configurations. In Ceará, forecasts for the rainy season are presented as a distribution of probabilities for the seasonal rain, in reference to the categories above, similar to, or below what is calculated as the historical average precipitation for the region.

4. Forecasting in political and religious contexts

Climate information has strong political implications and, for that reason, it is constantly subject to political manipulation. In Brazil, as in many places where economic development has been and still is induced by central governments, it is not unusual for meteorological agencies to be located inside the local government institutional apparatus. It is also a rule that heads of meteorological agencies are politically appointed by state governors or by ministries of the federal government. Having meteorology under close political control seems to be a strategy for taming uncertainty – although a somewhat ineffective one, given the unavoidable uncertainties present in climate phenomena. For this very reason, local political discourses on climate systematically use the idea of uncertainty in a way that damages the social image of meteorology, making promises that cannot be fulfilled and blaming failures on the supposed lack of competence or scientific underdevelopment of local meteorologists.

Climate forecasting occurs in an environment of political tension between official agents and local rural producers. This directly affects meteorologists: climate forecasts are perceived as being potentially ‘politically explosive’, and therefore need to be handled with extreme care. The announcement of a possible future drought can generate a wave of declarations of emergency situation in the hinterland, in which municipalities request emergency funds from the state and federal governments. Many municipalities of Ceará’s hinterland live with a constant scarcity of drinking water, which is supplied by an inconsistent fleet of tanker trucks that usually sell bad quality water at high prices. For these municipalities, the possibility of drought worsens what is already a difficult situation, and evokes haunting images of malnutrition, rising mortality rates among children and the elderly, conflict and migration.

For such reasons, there is always caution within the state government in terms of what information to publicize and the recognition of any situation that could be technically considered a drought. Governmental interference in the communication of climate information in the years 1992 and 1993 constitutes an interesting example. In December 1991, the local meteorological agency issued a forecast with high probability of drought for the following year. The governor then traveled throughout the hinterland distributing drought-resistant seeds. While rains dropped 73% from average, harvests dropped only 18%. The government addressed the media and affirmed that science had finally won its battle against climate, and against the traditional knowledge of local rain prophets (Nelson & Finan, 2000; Orlove & Tosteson, 1999). According to the perception of meteorologists, results were disastrous: it reinforced expectations among local populations that climate sciences were finally capable of providing society with deterministic forecasts, something climate scientists know they are not able to do.

Then in 1993, a forecast pointing to a high probability of regular amounts of rain was issued in January. A month later, global meteorological conditions changed, and a new forecast, this time pointing to a drier than usual rainy season, was produced. The governor feared that a bad forecast would attract negative attention to the government, and forbade the dissemination of the drought forecast. By April, the state was going through one of the hardest droughts of the decade, and the media harshly accused meteorologists of making gross mistakes in their prediction activity.

There is also another aspect of the existence of climate inside local political discourses, and it is linked to the ways in which climate is encoded in religious beliefs. The majority of the state population is Catholic, but local religious practices mix Catholicism with indigenous beliefs. The most important local saint, Padre Cícero, is not recognized by the Catholic Church. For the rural inhabitants of the state, climate is an aspect of spiritual order in the cosmos. Pilgrimages to the towns of Juazeiro do Norte and Canindé are organized at the beginning of the rainy season (especially on Candlemas Day, February 2), where peasants pray for abundant rains. In 1877, while the region was going through the harshest drought of the nineteenth century, the local bishop produced a pastoral epistle in which he stated that the drought was a divine punishment for moral corruption amongst his contemporary fellows. A hundred and twenty-seven years later, during the floods of January 2004, inhabitants of the same region manifested the belief that the flood was also divine punishment for the sins of local inhabitants, but also for the moral decadence of humanity in general – reasons cited went from the invasion of Iraq, to the cloning of animals, to the expedition to Mars (Taddei, 2005).

At the same time, the ability to produce rain forecasts is knowledge shared by a large number of people in rural areas. Some local elders in rural areas are recognized as rain prophets, issuing seasonal forecasts based on the observation of local ecosystems, the stars and the atmosphere, or on reading results of 'experiments', such as burying a bottle full of water under a fire or leaving salt stones on the house roof overnight.[(1)] While the media tends to present scientific knowledge as competing against local traditional knowledge in terms of forecasting accuracy, the government has a less clear position, often making use of one or the other strategically. In March 2005 (O Povo, 2005), for instance, while peasants pressing for relief actions claimed to be going through a drought – which was indeed taking place and had been forecasted by meteorology two months before –, the head of the state government agricultural secretariat tried to stall for time and affirmed that the government would wait until Saint Joseph's day. Local politicians seem to use scientific discourse or traditional knowledge according to the specificities of the context: they may choose to act pro-actively, including science and its forecasting powers in their political rhetoric; or they may decide to act in conservatively and in reactive ways, questioning the accuracy of all available forecasts and affirming the need to wait for climate impacts to be measured after they have hit the state.

An important aspect of the issue at hand refers to the fact that the results of meteorological work sit inside a field of representations in which 'certainty' versus 'uncertainty' is represented as either possession, or not, of knowledge and power, with little space for nuance and gradations. In the religious version of this discourse, climate is seen as forming part of a morally ordered and predictable universe, in which there is a metaphysical reason for suffering caused by collective crises, and therefore what is uncertain on a first level (in this case, climate) reflects, even if difficult to interpret, a divine, absolute and just

(1) For a full discussion about the roles and performances of rain prophets in the region, see Taddei, 2005, 2006; Finan, 1998, 2001; Lemos, 2000; Martins, 2006; Montenegro, 2008; and Pennesi, 2006, 2007a, 2007b.

will. Religious narratives function as semiotic operators that afford to give certainty to the uncertain and lend the appearance of being definite to what is probable. Politics is also a field in which the uncertain is presented as certain, and in which ambiguity is constructed and deconstructed according to the moment's needs. Politics and religion are fields in which protection is the currency in a highly emotionally-charged symbolic market. Within this environment, meteorology is unable to act effectively. And because of this, once again, meteorology becomes the perfect victim for symbolic sacrifice, that is, to have its public image severely recurrently damaged.

Now, it is important not to suggest that meteorology is a passive victim of political manipulations, cultural paradigms and collective anxieties. Eventually, local meteorologists created strategies for avoiding the political censoring of scientific forecasts: since 1997 they use their international networks and have been organizing international climate outlook meetings, where climate scientists from other parts of Brazil, as well as from the USA, Germany, England and Japan, present their climate forecasts for Northeast Brazil. In such meetings, they all combine their models and produce one single forecast, which is authored by all climate agencies at the same time and disseminated in the websites of each institution. Politically speaking, the climate forecast has become larger than Ceará, and therefore it became impossible for the local government to impede local forecast dissemination. Although it does not solve most of the problems that meteorology faces in its relationship with social expectations, it shows some degree of awareness that the problem has important symbolic elements, and more than that, that these can be strategically manipulated. Meteorologists learned to make effective political use of the widely shared view that physical sciences are apolitical, and in doing so, achieved some degree of protection against one type of political manipulation to which they are most vulnerable (for a detailed analysis of this case, see Taddei, 2005).

5. Why meteorology?

A very popular joke in the Jaguaribe Valley during our fieldwork period was:

> FUNCEME technicians stop at a house in the hinterland to spend the night. The owner of the house, an old man, offers the technicians a room inside the house. However, they say they would prefer to sleep on the porch, where they will hang their hammocks. The old man warns them that it is going to rain. But the technicians look at the clear skies and say it is impossible. So the old man enters the house and locks the door behind him. In the middle of the night he is awakened by the technicians banging at the door, hit by the predicted storm. In the morning, the technicians ask the old man how he knew about the storm. He points to a donkey at the front of the house. "See that ass missing an ear? When he goes to sleep under that shelter over there, it means that it is going to rain. He doesn't like getting water in his ear." The moral of the story is: a meteorologist ass is worth more than an ass of a meteorologist.

While there are widely known jokes ridiculing meteorologists in Ceará's rural areas, there seems to be no joking about other types of technicians. In Ceará's hinterland, forecasts strongly index social class differences and the affiliation to specific social groups. Scientific climate forecasts are issued in a formal, technical language, by a governmental agency located in Fortaleza, using temporal and spatial scales that are very different from those understood and used by local peasants. The characteristics of these forecasts are signs of a socioeconomic and political world – that is, the world of urban elites – which poor rural people can only integrate into their lives through the historical feeling of being marginalized. The forecast then becomes linked to a group of concepts where nature, society, politics and religion are fused into an integrated representation of the world in which everything, in one sense or another, is linked to hierarchical structures and distinction mechanisms. Scientific forecast is then locally taken to be a governmental product, and, when used to regulate public policies, like the times of official programs of drought-resistant seed distribution, it is seen as a government attempt to gain control over productive aspects of the hinterland population. There is one important difference in the way the poor rural populations of the region relate to official forecasts and to other acts or products of the government: even if scientific climate forecasts are issued by the Fortaleza technical elite, there is no direct mechanism through which these forecasts can be imposed and their use enforced. Although the imposition of regulations made into laws – especially in the form of decrees – affects the ways in which local populations relate to the natural environment in many ways, as it is the case with the hunting of wild animals, water use, animal health, the commercialization of agricultural products and pollution and garbage production, just to mention a few examples, there is no way of applying the same 'imposed governability' to the collective comprehension of climate issues and to the use of climate information. In this respect, official meteorology is perceived as being part of an empty governmental rhetoric, and it becomes an object of ridicule, in part, because there is no risk of retribution (Girard, 1979; Scott, 1992); that is, contrary to the relationship between the rural population and other government agencies, where there is some kind of exchange, there is no palpable relationship between meteorologists and farmers. [(2)] Meteorology becomes a scapegoat to express the frustration against the government felt by the rural population, and this is manifested through making fun of meteorological agents.

6. Conclusion

Meteorology is undergoing a situation that I call a 'hangover of modernity'. On the one hand, public expectations and political discourse expect science to fulfill the promises of modernity as understood by the nineteenth century positivistic project, in which absolute certainty – and therefore control – was the inevitable destiny of Western knowledge. To some extent, the monotonic focus on technology and infrastructure that characterizes current discourses on economic development, as sponsored by institutions like the World Bank, indirectly reproduces the fetishization of science as savior of the planet's poor and vulnerable. On the other hand, climate studies are perhaps the only scientific

(2) As the distribution of drought resistant seeds by the State Agriculture Secretariat, which regardless of the existing disputes between local farmers and the government over the best time to carry it out, is locally appreciated.

branch where uncertainty meets everyday life in a post-Newtonian, stochastic sense.

In the end, the external observer is impressed by the degree of social pressure heaped upon the shoulders of meteorology, not only by rural producers, but also by the media, the urban population and the government. This pressure stems from a very specific semiotic regimentation: the discourse of the 'naturalization of misery', that is, a situation in which the extreme poverty of Ceará's rural population is solely related to climate events. This is an old narrative, already heavily criticized by academics and political activists, but one that still exists as a distinctive trace in collective imagination and in the official discourse concerning drought. The contiguity of drought or flooding and their accompanied peaks of social suffering lead people to see the former as the 'immediate' cause of the latter. However, something to which little attention is given is that climate is not the only determining factor of rural hunger and misery, but that other elements also play a crucial role in these extreme conditions, such as specific sociopolitical arrangements – mainly the concentration of fertile land and water – which prevent poor sectors from increasing their means of survival and reducing their vulnerability to climate variations. When the lack of rain is presented as the sole cause of poverty, the role of excluding social structures, which have developed throughout history, goes unchecked and therefore remains invisible. Climate is made the villain, and meteorology, acting as the oracle responsible for forecasting abundance or misery, receives projected upon itself a great deal of the collective anxiety that revolves around climate phenomena.

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Creating an online archive of traditional weather prediction indicators: notes from a round table discussion

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1. Introduction

Interest in weather and climate change has been steadily growing in an ever-widening range of domains beyond meteorology to geography, economics, politics, environmental studies, medicine and anthropology, to list just a few. Researchers around the world, funded by governments and the private sector, are investigating the ongoing and potential impacts of climate change and extreme weather events. An example is Canada's ArcticNet, a network of natural, social and health scientists who work in partnerships with natural resource managers, northern communities and government agencies "to study the impacts of climate change in the coastal Canadian Arctic" (www.arcticnet-ulaval.ca). Considerable effort and resources are being spent to develop forecasts of weather, climate and natural hazards because of their potentially far-reaching social and economic implications in local, regional and global communities (Connor et al., 2006; Hansen et al., 2006; Pielke & Carbone, 2002). Forecasting models range from local empirical observations made by laymen, to published almanacs, to highly complex mathematical models run by scientists on computers. Just as many people rely on a combination of 'Western' medicine and alternative healing practices when seeking a diagnosis of physical ailments, pluralism exists in the realm of weather forecasting, such that people can choose to follow advice from various scientific and traditional knowledge systems.

The availability of multiple information sources creates an arena for debate about what counts as expert knowledge (Pennesi, 2007) and about the utility of scientific forecasts (Blench, 1999; Stern & Easterling, 1999). Within this context, some researchers are turning their attention to indigenous knowledge and traditions as they explore alternative perspectives to the globalized science of meteorology and climatology (Luseno et al., 2003; Orlove et al., 2002; Roncoli et al., 2002; Strauss, 2003; Taddei, 2005). As a topic of anthropological inquiry, the study of how weather and climate are understood in different cultures is known as 'ethnometeorology' (LaBarre, 1942). Building on my previous research in ethnometeorology (Pennesi, 2007) I aim to create an online, searchable database of indigenous weather and climate change indicators used in making predictions. This database will be designed to address the issue of how to mobilize ethnometeorological knowledge in a useful and meaningful way that will maximize accessibility. It is conceived as an important tool in pursuing the following research question:

> What can cross-cultural patterns in indigenous practices of weather prediction tell us about the relationship between changes in the environment (including climate) and changes in the production of knowledge?

This question seeks to expand our understanding of the dynamic links between nature and society. For instance, Carla Roncoli and colleagues report that the decreased reliability of traditional prediction methods in Burkina Faso is perceived to be caused by increased variability in climate (Roncoli et al., 2002). In another African context, Michael Sheridan analyzes the discourse of Tanzanian farmers in which the perception of declining rainfall and the inability of powerful individuals to "bring rain" is linked to changing political and social relationships (Sheridan, 2007). From research conducted in 2003 and 2005, I learned that 'rain prophets' in Ceará, Brazil blame environmental degradation caused by human action for inaccurate 'signs' of rain that they observe in the ecosystem. The rain prophets note that certain species of birds whose behavior used to indicate variations in climate have disappeared from the region, thus reducing their repertoire of potential signs. By providing detailed information for cross-cultural comparisons, the database will facilitate investigation of such issues on a regional, or even a global scale, leading to new insights connecting environment, culture and knowledge.

The target audience for users of the database is researchers, academics and students, but it is expected that there will be interest from the general public as well, including the research informants. For example, some rain prophets I work with in Brazil welcome recognition of their traditions within academia and have taken opportunities to have some of that knowledge recorded in books (Magalhães, 1963; Martins, 2006), a documentary film (Moura, 2006) and scholarly works (Lemos, 2000; Pennesi, 2007; Taddei, 2005). Making the information and prediction methods available on the Internet is an extension of this dissemination process. Therefore, the first step of creating the database from the Brazilian data achieves a worthwhile objective of documenting traditional knowledge. The expanded database will draw on anthropology's strength in providing detailed and contextualized descriptions which serve various public interests in traditional knowledge and practices, in addition to serving as data for other researchers in disciplines such as geography, history, environmental studies, natural resource management and meteorology.

2. Types of Data

There are two levels of knowledge and practice involved in generating weather and climate predictions:

1. Knowledge of what the indicators of specific conditions are and the practice of observing these indicators to gather information (i.e. data collection).
2. Knowledge of how to synthesize the information from these observations and the practice of generating a prediction (i.e. creating a prediction model).

If there were only one indicator, the practice of generating the prediction would be straightforward. However, the prediction process becomes complicated when multiple indicators and many observations over time are involved, as is the case with weather and climate forecasting. The initial phase of the project will only deal with the first level of knowledge described above: recording what the indicators are and how observations are made. This was the topic of the round table discussion.

To illustrate, in Ceará, Brazil, some rain prophets observe the timing of when mango trees produce fruit and how the fruit is distributed on the tree. This information is one indicator of whether the following rainy season will be wet or dry. Data at this level will be included in the database, but an accounting of how the mango tree indicator is evaluated in relation to hundreds of other indicators observed throughout the year in order to make a final prediction about the season will not be included in the initial phase. I recognize that the holistic nature of much environmental knowledge means that a database of discrete chunks of information will lack depth of meaning. When more resources are available, it is expected that the scope will be widened in future research to include the second level of knowledge and practice as well, bearing in mind that a deep understanding of such complex and dynamic knowledge systems can take decades to acquire. This is one issue that concerned participants in the discussion.

To be clear, the database being proposed here is intended to lay the groundwork for a program of research in which patterns and questions can be identified and then pursued further by researchers from various disciplines. It is not meant to be a catalogue of alternatives to scientific meteorology such that one could read a checklist of indicators and make a prediction.

3. How is this database distinct and significant?

Scholarly efforts to document indigenous environmental knowledge used to predict weather and climate are scattered in various publications and typically refer to a single culture (Afonso, 2006; Albores & Broda, 1997; Goloubinoff et al., 1997; Taddei, 2005; Strauss, 2003; Verma, 1998). For example, Brazilian writer Alberto Galeno has written an admirable book on rain indicators in Northeast Brazil (1998), but it is based primarily on information from one informant. An earlier work by Magalhães is more comprehensive but does not cite sources or explain how the information was gathered (Jósa Magalhães, 1963). Both of these books are only available in Portuguese and are, therefore, unlikely to be read by researchers outside of Brazil. There is a website based on original research which is maintained by the United Nations Framework Convention on Climate Change (maindb.unfccc.int/public/adaptation). It includes information for predicting and adapting to specific hazards or climatic conditions (such as drought) for a small number of communities in various countries. My intention is to construct a more inclusive and wide-reaching database of indigenous forecasting knowledge. Another research-based website is maintained by the Australian Bureau of Meteorology and is part of its Indigenous Weather Knowledge project (www.bom.gov.au/iwk/index.shtml). The strength of the Australian project is that it involves academic researchers, government meteorologists and indigenous communities; however, the site is largely a description of different seasonal calendars used by five indigenous groups and does not address prediction. Other websites related to ethnometeorology tend to be presentations of myths or 'curious beliefs' and lack a serious research component (e.g. http://open-site.org/Science/ Weather_and_Climate/Folklore). Two examples are the Wikipedia entry for "weather lore" and a WikiHow description of "how to predict the weather without a forecast." Thus, this project fills a need for a research-based source of compiled information on indigenous prediction practices that could serve as a tool for comparative analysis and as a reference. The goal is to mobilize knowledge so that it is useful for research, not simply to produce a list of interesting facts.

Creating the database as part of a website has significant advantages over publishing a text. An online database is free and is therefore accessible to a larger population of users and contributors. There is potential to expand the website over time to include images, sound files and more information, such as interviews with traditional weather forecasters. Most importantly, an online database can be continually updated. This is an essential feature because of the dynamic nature of this knowledge. Predicting variations in weather and climate is a function of "practical knowledge" (Scott, 1998), meaning that new methods emerge over time as environmental conditions and human needs change. Traditional or indigenous knowledge is not an unchanging list of rules and facts passed down through the ages, but an evolving set of principles and experiences that comprise an approach to problem-solving. The ability to track the evolution of prediction knowledge in relation to changes in environments and climates will make the database valuable to a wide range of scholars and perhaps even to policy makers. The website will include a discussion forum so that researchers can collaborate or debate theories together.

4. Research Plan

4.1 Build database

To begin, I will use the available data from my previous research with traditional rain prophets of Ceará, Brazil. This data consists of approximately 1,000 indicators for predicting rain or drought based largely on changes in the atmosphere, cycles in the ecosystem, and observations of plant, animal and insect behavior. Providing information in the original language as well as in English, in addition to giving scientific species names, will ensure maximum accessibility and will create an opportunity for cross-linguistic comparison. Species names in standard Portuguese, English or Latin will be sought through consultation with biologists and botanists and/or publications.

When the database is ready, the website will be designed with an introductory page that includes links to supplementary materials and documentation, such as descriptions of research methodology, scholarly references, and citations of sources that provided the prediction data. The final task will be to create a search utility so that users can search the database through the web.

4.2 Develop international collaborations

Other partners with an interest in ethnometeorology will be invited to contribute to the database, making it a resource for cross-cultural and cross-linguistic comparisons. Direct contributions from indigenous or traditional weather forecasters will be encouraged.

4.3 Co-evolution of database and research

Once the database is established and contributions from others have been incorporated, comparative analysis can then be undertaken on many different levels. New studies will be developed either individually or collaboratively. Possible investigations could compare the distribution of particular aspects of environmental knowledge across geographical space, through time or among different populations. Another area to explore is how economic factors such as livelihood strategy or access to education and technology influence the prediction methodology and meaning-making processes. Knowledge of cross-cultural patterns in indigenous practices of weather prediction can contribute to the general pursuit of improved forecasting. The goal is to provide a research tool that will serve a variety of interests and will spark new research questions. Findings generated by these new projects can in turn inform the database so it will grow in depth and breadth over time.

5. Discussion

The discussion questions initially proposed for the round table included the following:

- How could such a database facilitate research or lead to new research questions?
- How much context and interpretation of this 'data' should be included in the database? What are the benefits and potential problems associated with including more or less information?
- Whose knowledge counts? Does there have to be some level of consensus in a particular community or do we include knowledge and practices of individuals?
- How do we give credit and/or protect privacy?
- What is the best way to set up the database in terms of content, features/functions and software?
- Who would do the translations and what are some difficulties that may arise?
- What are potential sources of funding to keep it going and update it?
- What are some venues for advertising the database to get more contributors and encourage people to use it once it is up and running?

As expected, we were unable to debate all of these issues due to time constraints. Here are some of the results of that discussion.

- The goal of the project is not merely to document knowledge or put it on the web but to create a tool for generating new knowledge. Participants agreed that such a database would be valuable for those with an interest in ethnometeorology seeking comparative data or doing preliminary research. Researchers would be able to make queries about particular geographical areas, species of animal or plant or weather conditions predicted, for example. The potential uses are many and varied. It is a tool to assist information gathering, not the definitive source for all information on the topic. The value of the archive is its organization: including some kinds of information and excluding others not relevant to the topic. For example, over time, changes in weather predicting practices, appearance of species and reliability of predictions could be useful information for environmental historians and those studying climate change. One participant even suggested that bird watchers may be keen to discover where particular species can be found.

- There was agreement that it is important to be specific about sources of information, names and contacts of contributors, and the context in which the information was obtained. Also, a space should be provided for adding contextual information for interpretation of the data provided. For example, the region, the cultural group, subgroups of society, description of the physical environment or ecosystems involved, indications of how reliable the indicators are thought to be, how the forecasts are used, etc. should be given. Bibliographical references and links to other sites should be included where relevant.

- Rather than creating a 'database', it was suggested that we make it an 'online archive'. The concept of a database seemed too restrictive to many people because it entails setting up very specific fields that would be filled in for every entry in a uniform way. A database is essentially a detailed index of a body of comparable information. An archive is more flexible in terms of content and format, and is therefore more suitable to this project because of the diversity of sources. With an archive, contributors can include explanations and comments on epistemology and ethics, avoiding constraints of database fields.

- There was considerable debate over the term 'traditional' and whether to explicitly separate traditional / indigenous / local / non-scientific weather prediction from official / instrumental / Western / scientific meteorology. I argued that the distinction is an important one to make, whatever terms eventually are adopted. 'Scientific' meteorology is well documented already, with various scholarly publications and information on the Internet. It is an established academic discipline. My aim with this online archive is to make available information that is not otherwise accessible or is restricted either because of language or format or lack of recognized legitimacy. It is important to access the unpublished material and to bring together resources that currently are scattered.

- There was a general push to be more inclusive rather than exclusive so that the archive could contain explanations of extreme weather events or hazards such as earthquakes as well as predictions for future conditions. This also means making no restrictions on the time frame so historical weather prediction indicators will be welcome in addition to contemporary methods (e.g. Farmer's Almanacs). This is related to the discussion in the previous point. If we accept information about early meteorological instruments and practices from, say, Europe in the 1800s as representing folk knowledge at that time, where do we draw the line to exclude modern meteorological instruments and practices such as radar and satellite imagery? No definitive answer was reached but my inclination is to identify the historical precursors to modern meteorology separately. This remains an issue to be resolved.

- Such an enterprise always opens the door to questions of representation – whose knowledge gets included or excluded? There was concern about verification of data and responsibility for accuracy if it is to be used as a scholarly tool, so it was decided that to start with, data for the archive would only be accepted from academic researchers. Special requests from non-academic sources will be considered but not automatically accepted in order to prevent anyone from putting up whatever they want. One suggestion was to set it up as a scholar 'wiki' but this possibility has not yet been investigated.

- Potential difficulties that may be encountered in developing the archive are: (a) ensuring the participation of contributors, and (b) securing ongoing funding to maintain the website. It was suggested that after entering the Brazilian data, I then turn to published materials from other areas to determine what other categories and keywords will be useful and to refine the setup before soliciting data from others. That way there will be sufficient material for a good demonstration that can inspire both contributors and funders.

The discussion raised more questions than it produced answers. The number of ethical, theoretical and methodological issues we debated indicates that such a project is by no means simple and must be well thought out in order to be successful. It was also proof that a multidisciplinary approach can generate insights that otherwise would have remained unarticulated.

6. Acknowledgements

I want to extend my thanks to everyone who participated in the discussion and contributed valuable input.

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