

**Unstable Climates:
exploring the statistical and social constructions of climate**

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Submitted to *Geoforum* 13 February 2008

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Abstract

The idea of climate has both statistical and social foundations. There are hot climates and cold climates; wet ones and dry ones. Climates can also be enjoyed and feared; they can be celebrated in art and remembered in memories. Both of these dimensions of climate change over time: climate, as defined by meteorological statistics, changes for both natural and anthropogenic reasons; and our expectations of future climate also change, as cultures, societies and knowledge evolves. This paper explores the interactions between these different expressions of climate change by focusing on the idea of 'normal' climates defined by statistics. We show how this idea came into being and how ambiguous it is. Using data from historical and predicted climates in the UK, we illustrate the significance of choosing different baseline 'normals' for our retrospective and prospective interpretations of climate change. Since the choice of these baseline 'normals' reflects cultural and psychological preferences and practices as much as scientific ones, we show how our expectations of the climatic future are influenced by social as well as statistical norms. Seeing climate as co-constructed between the psycho-cultural constraints of society and the physical constraints of the material world offers a different way of thinking about the instabilities of climate and the ways we live with them.

Keywords Climate Culture Normal Memory Acclimatisation UK

[word count c. 7,080]

1 Introduction

Climate can neither be experienced directly by our senses, nor measured indirectly by our instruments. Unlike the wind which we feel on our face or a raindrop that wets our hair, climate is a constructed idea. It is an idea that carries a much richer and longer tradition of meaning than is captured by the rather unimaginative convention that defines climate as being ‘... the average course or condition of the weather at a place usually over a period of years as exhibited by temperature, wind velocity and precipitation’ (Mirriam-Webster, 1994). Climate has both physical and cultural connotations (Hulme, 2008). It has a physical significance - one cannot deny that the climate of the Amazon is wetter in an absolute physical sense than is Saharan climate - but also carries cultural interpretations - the climate of the Sahara means something quite different to a Bedouin than it does to a Berliner. Changes in climate can refer to either connotation. Thus Burroughs (2001), for example, explores the history of the world’s physical climates over the last 2,000 years, while Boia (2005) narrates a parallel story about the history of climate in the human imagination. Climate can therefore be constructed in at least two quite different ways: one that is external to the human imagination through the formal use of meteorological statistics; and one that resides inside the imagination, through individual sensory experience, mental assimilation and social and cultural interpretations.

Climatologists seek to construct the physical properties of climate by working with the statistics of measurable and measured weather over a given period of time (typically 30 years) at a given place or series of places. The pre-dominant means of capturing the physicality of climate has been through meteorological measurement. The application of standardised methods of weather observation in the eighteenth and nineteenth centuries began to displace what had previously been a largely philosophical endeavour or sensory/aesthetic experience. Order was imposed on seemingly chaotic and elusive weather, first, by quantifying it locally at individual places and, subsequently, by constructing statistically aggregated climates from geographically dispersed sites. Climate for the first time became ‘domesticated’ (Rayner, 2003). This quantification of climate opened up new possibilities of interpretation and practical utility. Comparative climatic analysis could be undertaken relying on numerical data rather than hearsay and longitudinal studies of climate through time now became possible, providing a formal alternative to the

tenuous reach of human memory. The question ‘How stable really was climate?’ could be answered numerically for the first time.

The climatologists and meteorologists of the nineteenth century, using a series of formal statistical rules, therefore turned the idea of climate into an entity with quantitative description. This of course is how climate continues to be used in the physical and mathematical sciences and has opened up possibilities for predicting future climate (in this statistical sense). It is not surprising that with its roots so firmly planted in meteorology the dominant meaning of climate from an analytical perspective therefore remains this statistical one. Thus the World Meteorological Organisation (WMO) insists that the climate of a place or region can only be robustly defined once it is compiled from at least 30 years of meteorological measurement.

Individuals and communities, in contrast to climatologists, construct climate in particular places as a function of their experiences and memories of past weather events, synthesised to yield a considered view about their expectations of future climate (Rebetez, 1996). These expectations of climate, and their implicit categories of ‘normal’ or ‘abnormal’ weather, are therefore strongly influenced by individual experiences. These experiences also shape the linguistic repertoire through which weather and climate is described (Stewart, 2007) and the imputed moral categories of ‘good’ or ‘bad’ weather (Meze-Hausken, 2007). These latter distinctions reveal preferences which reflect both individual personality and collective identity. The relationships between these categories of normality and morality are complex and have rarely been examined.

The memory of past weather is biased in favour of ‘extremes’ or exceptional episodes and to those climatic events to which there is a strong personal or collective emotional attachment (Harley, 2003). The depth of this social memory of weather varies between individuals and cultures (McIntosh et al., 2000b; Strauss & Orlove, 2003; Meze-Hausken, 2004). For example, Hassan (2000) argues from historical anthropology that the relevant timescale over which societies effectively evaluate climate variation is between 60 and 100 years (i.e., just beyond living memory). Increasing social mobility, however, might shorten community memory of weather and climate.

This paper examines the interplay between these two constructions of climate – the statistical (formal) and the social (experiential) – set against contemporary scientific narratives and public understandings of future climate change. In particular,

we explore the effect that changing the base period from which climate change is calculated has on representations of normal and abnormal climate and consider how this statistical instability of climate might affect, or be affected by, cultural and psychological climatic instabilities.

The motive for this study emerges from the development in the UK of the next generation of national climate change scenarios, the UKCIP08 scenarios to be published in November 2008 (Roger Street, pers. comm., February 2008). The standard baseline period from which projections of future climate change have been made in previous UK scenarios is the standard WMO normal 1961-1990 (UKCIP98: Hulme & Jenkins, 1998; UKCIP02: Hulme et al., 2002). In considerations about the design of the UKCIP08 scenarios some (but by no means all) stakeholders have called for this baseline period to be shifted to 1971-2000, or even to a 15-year baseline 1991-2006, on the grounds of 'reflecting current weather' more appropriately (Roger Street, pers. comm., June 2007).

Implicit in such a proposal is that the interpretation of future changes in climate should be benchmarked against a statistical description of 'normal' climate which most likely approximates the prevailing cultural or psychological expectation of normality. As a nominated baseline period recedes further into the past, the statistical properties of climate thus frozen in time become increasingly detached from those properties of climate that reside in individual or collective memory; they exert less influence over our expectations of normal climate. Evidence suggests that people's experience of past weather – and hence their expectation of future climate – may be shaped as much by the recent past (e.g. 5-10 years) as by a more distant past sampled selectively to filter extreme or high impact weather events.

We set the context for our analysis by reviewing the background to the statistical (section 2.1), anthropological (section 2.2) and psychological (section 2.3) constructions of climate, each approach strongly connected to certain ways of viewing time, change and memory. In section 3, we illustrate the sensitivity of statistical constructions of climate change to different assumptions of climatic normality, i.e., to different ways of framing the experiential construct of climate. Using daily weather data from England over the last 230 years, and exploiting model predictions of future weather for the UK over the coming century, we show the extent to which different assertions of climatic normality can alter narratives and expectations of future climate change. Finally, in section 4 we discuss some of the implications of these ideas for

the public perception of, and engagement with, climate change and the way discourses of climate change may be formed.

2 Reading Climate Through Statistics, Culture and Memory

The aphorism ‘climate is what you expect, weather is what you get’ is a popular way of approaching the elusive relationship between climate and weather. Expected climate in a statistical sense is usually defined using the idea of climatic normals. We first explore the background to this idea and how it has evolved into its current, almost universal, climatological usage. We then introduce ways in which culture and memory shape the individual’s vernacular construction of expected climate. These different expectations, seen respectively through the filters of numbers, culture and memory, might well be quite a long way apart.

2.1 The Development of Climatic ‘Normals’

Every thirty years the international meteorological community, through the WMO, produces and publishes a document that summarizes what is termed the ‘normal’ climate for thousands of meteorological recording stations around the world. The most recent such normal describes the climate of the period 1961-1990. Interim normals are published every ten years, the most recent of which is therefore for the period 1971-2000.

The idea of ‘normalising’ climate – i.e., attaching period durations to aggregated weather statistics for the description of climate - originated with the International Meteorological Committee in 1872 as an effort to assure comparability between data collected at various stations around the world. But it was not self-evident that 30 years should be set as the adopted period, nor even that there should be just one common baseline period used by all climatologists. Until well into the twentieth century most climatic summaries were simple arithmetic averages of weather data collected over the entire period of record (Kunkel & Court, 1990), the longer the better. Work by the Austrian geographer Eduard Brückner with meteorological and hydrological series from central Europe, Russia and North America suggested a widespread periodicity in climate of around 35 years duration (Brückner, 1890). This 35-year cycle began to attach itself to the idea of a standard climatic normal period in the early decades of the twentieth century. Normals based

on shorter periods would not capture the full climatic cycle; normals based on longer periods were not necessary since climate was believed to repeat itself.

Brückner's cycles did not long survive the twentieth century; neither the statistical evidence for them nor any understanding of their cause proved durable or convincing. Nevertheless, Brückner's 35 years were influential when the meteorological community later came to propose a universal period for the calculation of climatic normals. This occurred in 1935 at the International Meteorological Organisation's conference in Warsaw (IMO, 1937). Arguments about the most appropriate averaging period ranged from 11 years (the well known solar cycle), to 20 or 25 years (short enough to enable large numbers of stations to calculate their normals), to 35 years (Brückner's cycle) or even 50 years (to capture more of the inter-decadal variability of climate). In the end, the Climatology Commission of the IMO recommended, '... a period of 30 years as appropriate for establishment of normal temperature conditions and suggested 1901-1930 as a universal period for the calculation of normals.' (Lenherd & Baum, 1954: 392).

Defining climate as a 30-year average of measured weather variables was therefore a compromise between a number of different perspectives. Yet it was very weakly based on any (good) understanding of the variability of climate; nor were dimensions of human or social memory explicitly considered. Instead, the adoption of this common base period reflected two - almost contradictory - perspectives about climate. On the one hand was the assumption that climate was largely invariant over time-scales longer than 30 years (e.g. Brooks, 1926), a view widely held until the 1950s and 1960s. Under this assumption, 30-year normals yielded reasonable estimates of what range of future weather statistics might be expected; they could act almost as the basis for predictions (Lamb & Changnon, 1981; Kunkel & Court, 1990). The very use of the word 'normal' offered up this expectation and allowed for anything outside this range to be viewed as 'abnormal', requiring special explanation. On the other hand, fixing a definition of climate to a universal 30-year period opened up the possibility of more systematic analysis of changes in climate between successive periods (e.g. 1901-1930 versus 1931-1960) and differences in synchronous climates across different regions of the world.

The WMO, which succeeded the International Meteorological Committee in 1950, now defines normals as, '... period averages computed for a uniform and relatively long period comprising at least three consecutive 10-year periods'.

Normals are computed every decade by individual countries to keep up with any changes in climate that may take place, but a coordinated international effort to compile global standard normals is undertaken only once every 30 years. The US National Weather Bureau, for example, adopted this 30-year standard for all of their observing stations in 1955 (having previously used the periods 1899-1938 and 1901-1950) and now recalculates normals at the end of each decade, using the preceding 30 years' data as input.

The idea of a statistical definition of climate therefore offers some formal basis to expectations of future weather. A 30-year average August daily maximum temperature of 21°C at a place offers a benchmark against which the actual maximum temperature for any specific August day can be compared and interpreted as being usual or unusual, normal or abnormal. The climatic normal therefore serves both as a benchmark for retrospective evaluation and also prospectively in a 'predictive' sense for design and planning purposes. It is in this predictive sense that the idea of a climatic normal presents the greatest difficulties. Thirty-year normals might be fine for stationary climates, but if climates are changing then shorter-period normals might well yield greater 'predictive' power, a point indeed successively demonstrated by Landsberg (1947), Court, (1968) and Lamb and Changnon (1981). The latter authors, for example, found that 15-year normals, or sometimes 5-year normals, actually offered a better insight into 'expected' future weather than the standard 30-year normals. And climates are of course now changing all around the world (IPCC, 2007) offering new challenges of interpretation to the idea of climatic normals. These challenges were recognised nearly 50 years ago by Hubert Lamb (1959), writing '... our attitude to climatic 'normals' must clearly change. Recent decades could not be called normal by any standard of the past ...' and Lamb saw no reason to expect the next decades would be normal either. Lamb's main point, emerging from his studies of weather reports back to Medieval times and now confirmed by our understanding of the functioning of the global climate system, was that regional climate change could be substantial, long-lasting and relevant for human decision-making (Lamb, 1966). We will explore the significance of this perspective for the idea of the climatic normal, or baseline, in section 3.

Through statistical normalisation, climates become enumerated and universalised.

2.2 Reading Climate through Culture

In his 1915 book *Civilization and Climate*, Ellsworth Huntington dedicates an entire chapter to describing what he refers to as ‘The Ideal Climate’. The centrepiece of the chapter is an analysis of climate characterizations based on temperature ranges, relative humidity and frequency of cyclonic storms used to map the distribution of human energy across the globe. Because areas with higher human energy levels are, in Huntington's opinion, more conducive to industriousness and productivity, they implicitly represent the ideal climate. Unsurprisingly, at least if one is aware that the author was a university professor in the United States and in line with other environmental – and climatic – determinism theories of the time, the ideal climate (or areas with ‘very high energy’; Huntington 1915: 142) is found throughout much of the USA and western Europe. Though today most may scoff at this self-serving and circular reasoning, it nevertheless exemplifies the notion that climate does not just happen. Rather, climate is the result of what Rayner (2003) identifies as the co-production between natural and human systems, between the physical and the cultural (see also Hulme, 2008). These dynamic linkages have connotations for the concept of a changing climate.

Climate gains identity and relevance, entering personal and social memory, as a result of the biophysical and psychological outcomes of specific atmospheric conditions and events. These interactions between humans and weather are mediated by a host of social, economic and cultural factors (Wilhite & Glantz, 1987; Meyer, 2000) and regions with a similar statistically described climate may have quite different cultural assessments of climate. Mary Douglass (1966), for example, describes the different interpretations of the summer season by two populations separated only by a river, the Kasai River in Belgian Congo. For one group, the summers were seen as long, hot and unpleasant. The other group described the climate for the same period of time as a cold season. Douglass attributes different social and economic relations for the ‘curious discrepancy’ between the two interpretations (Douglass, 1966: 211). The two sides of the international border separating the US and Mexico also have very similar physical climatic and ecological settings, yet very different interpretations of the same meteorological events. Arizonans, when asked about a drought now entering a second decade, commonly respond with the interrogative ‘what drought?’ (Pennesi et al., in review). Ninety

kilometres to the south in Mexico, however, where individual vulnerabilities to climate are much greater, severe impacts on domestic livelihoods have left little doubt amongst the population about the reality of a drought.

Context is important not only for mediating impacts of global climate change, but also for the way that climate information is internalized. There is a general assumption that information regarding large-scale climate phenomena (e.g. El Niño) flows from the scientific community to different countries and populations through relatively straightforward pathways. Yet the ways in which different actors engage with and transform universalised ideas and images while ignoring others, demonstrates the processes by which the same (statistically framed) climate can have a multiplicity of meanings in different cultural settings. In an analysis of the 1997-98 El Niño event in Peru, Broad and Orlove (2007) highlight how scientific information and global discourses about El Niño are locally (re-)interpreted to provide cultural relevance and to advance particular local agendas. Donner (2007) offers further examples of the binding together of culture and climate in the context of Fijian belief systems.

Yet cultures are in a constant state of change. If climate is co-produced by dynamic linkages between natural and human systems it follows that as cultures change our comprehension and definition of climate will also change. Huntington evaluated and described climate in the early twentieth century from a perspective based on his cultural bias. It would be an interesting experiment to see which variables individuals and societies would currently use to define an ideal climate and, more significantly, the metric by which they would rank the social value of climate in different regions.

Enumerated and universal climates thus become encultured and localised.

2.3 Reading Climate through Memory

If statistical climates can be transformed through passing through (external) cultural filters, they are also mutated through (internal) mental filters. And here the idea of memory becomes central. Research into memory and recall has revealed the complexity of its manifestations and operations, both at individual and social levels. Memory is not only the collection of notions about past events, but is also understood as the psychological ability to recall past events in relation to more recent affective experiences, self-appraisals, beliefs and goals (Wilson & Ross, 2003; Levine & Safer,

2002; Friedman, 1993). It is generally acknowledged that individuals without major physical or mental impediments are able to recall past events throughout their lives. Furthermore, it is well known that memory bias does occur: for example recalling an incorrect time, place or source (Dodson et al., 2000; Bradburn, 2000). Ageing also bears influence: older adults, unlike younger people, tend to recall factual information (i.e., memories not tied to a specific place or time) more easily than episodic details (St Jacques & Levine, 2007). There is also a tendency to remember the distant past with more accuracy if it is related to unusual or outstanding events (Pereira & Koifman, 1999).

In relation to climate, individuals have been shown to recall personally-salient past weather events - although not necessarily date them with accuracy - and to imagine future weather according to past experience and to personal beliefs about the future. Surveys of past weather and climates indicate that recall accuracy declines steadily with receding time (e.g. Palutikof et al., 2004; Malmberg & Blanken, 2006). It is also documented that people tend to nostalgically associate past weather events with bygone times. The expectation of a white Christmas in the UK is culturally perpetuated by the imagery and expectation reiterated every festive season; yet the likelihood of snow at Yuletide in most parts of England is less than one in ten years (Harley, 2003). On the other hand the generalised view of 'English winters not being as they used to be' may have a statistical foundation from earlier decades in the twentieth century when 'real winters' of cold months were more frequent.

The view that winters in the UK are becoming warmer could be a combination of (a) older people's experience of severe winters in 1946-7 and 1962-3 permeating collective notions of past weather; (b) recent experience by large numbers of the population of warmer winters during the 1990s and 2000s; or (c) thermal comfort provided by central heating distancing the experience of unusually cold spells. People tend to think using averages. But individuals also remember exceptional events. If those exceptional memories supplant the perception of the average, then the exception may become the rule, or at least something fairly 'normal'. False expectations of future climates based on memories of past experiences are not uncommon: Rebetz (1996) found that two widespread complaints about long-term weather changes in Switzerland (lack of snow at Christmas and lack of sunshine in summer) were not supported by climatological data.

Memories, although biased, create our own individual and cultural identities (Peterson, 2002; Gardner et al., 2000) and shape our future. In most Western cultures, however, the future is perceived by individuals as two decades at most from the present (Tonn et al., 2006; see also Lorenzoni & Hulme, in press). This is in contrast to most narratives about future climate change which emphasise the longer term timescales of decades to centuries over which the climate system responds to anthropogenic forcing. Yet it is on the more immediate timescales that decisions are made and behaviour enacted. This distinction in perceptions has significance for the way expectations of future climates are constructed.

Enumerated and universalised climates, as well as being encultured and localised, also become memorised and individualised.

3 Illustrating Multiple Climate Instabilities

We have explored three different ways in which climates may be constructed – through statistical constructs such as the pervasive idea of the climatic normal; through the contrasting experiences of social, economic and cultural diversity; and through the varied mental abilities of individuals to recall climatic events in the past and to imagine climatic events in the future. These three approaches open up the possibility for climates to change in statistical, cultural or psychological ways: through changing statistical normals, through changing cultural contexts and practices, and through changing memories, perceptions and expectations. Climates are therefore subject to multiple expressions of instability.

What has rarely been explored – if at all – are the ways in which these three expressions of climatic instability interact with each other, these interactions either amplifying or attenuating the idea of climate change; or conversely the extent to which they are distinct from each other. For example, does the idea of (statistical) climate change alter the cultural conditions in which discourses and meanings about climate can be constructed? Given the complex dependencies between individual memories of past climate and expectations of future climate, how does the formal and universalised language of statistical climate weave into these personal expectations? And given the different time-scales over which these constructions of climate operate – the statistical, the cultural and the psychological – what does this mean for public

policy? Drawing upon Barbara Adam's suggestion (Adam, 2000), a full 'timescape' analysis of climate change is overdue.

The illustration around which this paper is framed concerns the way in which the representation of past and future changes in UK climate can be altered by varying the way in which the idea of normal (expected) climate is represented by statistics. The baseline period from which previous published projections of future UK climate change have been made (e.g. Hulme & Jenkins, 1998; Hulme et al., 2002) is the standard WMO normal 1961-1990. Yet as we have seen, evidence suggests that people's experience of past weather – and hence their expectation of future climate – may be shaped as much by the recent past (e.g. 5-10 years) as by a more distant past. And whichever past is influential it will have been sampled selectively to disproportionately emphasise extreme or high impact weather events. Thus, '... a community's selective memory of climate and the processes by which social perception of landscape filters out or highlights climate data, play important roles in the construction of reality.' (McIntosh et al., 2000a: 25).

The question we pose here is similar to the debate in the 1980s about what climatic normal should be used to best represent the climate of the African Sahel, at that time undergoing severe desiccation. Was the standard 1931-1960 WMO normal the benchmark to be used against which to represent anomalous conditions, or should more recent and shorter periods – for example, 1951-80 or 1971-1986 – be preferred? (for the debate see Todorov, 1985, 1986; Quinlan, 1986).

We show below, using the example of UK temperature, that different formulations of the baseline period from which climate change is statistically described (therefore reflecting different experiential constructions of climatic normality), can lead to quite radically different portrayals of past and future climate.

3.1 Analysis of past climate

We first use daily mean temperature data from the Central England Temperature series (Parker & Horton, 2005) for the period 1772-2006 to illustrate how the choice of different statistical baselines (normals) affects the (retrospective) interpretation of climate change. In these analyses we calculate the annual frequency of anomalously 'very warm' days, adopting a number of different assumptions about baselines. We use both *fixed* 30-year normals and retrospective *rolling* multi-year normals. The fixed 30-year normals are calculated as: 1772-1801 (the earliest historical period),

1977-2006 (the most contemporary period) and 1961-1990 (the standard WMO normal period). Retrospective rolling multi-year normals are where the baseline period is updated each year thereby, we suggest, reflecting in a statistical sense changes that may be closer to the cultural and personal experience and construction of climate. We consider rolling multi-year baseline normals of 10, 20, 30 or 50 years, each calculated for the immediately preceding relevant years and updated each year.

We define a ‘very warm’ day in any given year as a day on which the daily mean temperature was two standard deviations or more above normal (i.e., the baseline average), where the standard deviation for each day is determined from the temperature data for each respective day in the baseline period. Different definitions of ‘very warm’ days could of course be used, but adopting a two standard deviation threshold is a reasonably common way of representing ‘extreme’ weather (e.g. Jones et al., 1999). Even with different thresholds for this definition, which we explored (not shown), the general conclusions and discussion below (Figure 1a-c) still hold.

Figure 1a shows the two extreme cases of normalising climate using a fixed 30-year normal, one reflecting the climate of the late eighteenth century (1772-1801 as normal) and the other reflecting the climate of the most recent 30-year period (1977-2006 as normal). With the general warming of British climate over this period ($\sim 1^{\circ}\text{C}$ on an annual average), the number of ‘very warm’ days today as perceived by an inhabitant of Georgian England teleported to 2008 would be almost double that perceived by a contemporary citizen. The recent trend from the 1960s towards more ‘very warm’ days in the UK would also be perceived as stronger in absolute terms, having risen from about 20 to 35 for our Georgian citizen, compared to from about 13 to 20 for a twenty-first century citizen (although these represent quite similar proportional increases).

If we compare the case of a fixed 30-year WMO normal (1961-1990) against the use of a retrospective rolling 30-year baseline (Figure 1b), we find that difference in perception of ‘very warm’ days only arises during the period of strong trends, i.e., from the 1960s. For the rest of the period, with a more or less stationary climate resulting from largely offsetting natural and anthropogenic factors, whether one’s expectations of normality is updated statistically each year or not makes little difference. During a period of rapid warming, however, a significant difference in perception emerges. UK citizens who regard the climate of the 1961-1990 period as

normal will be experiencing several more perceived ‘very warm’ days in recent years relative to a citizen who’s expectation of normality is more fashioned by the climate of the last 30 years (1977-2006).

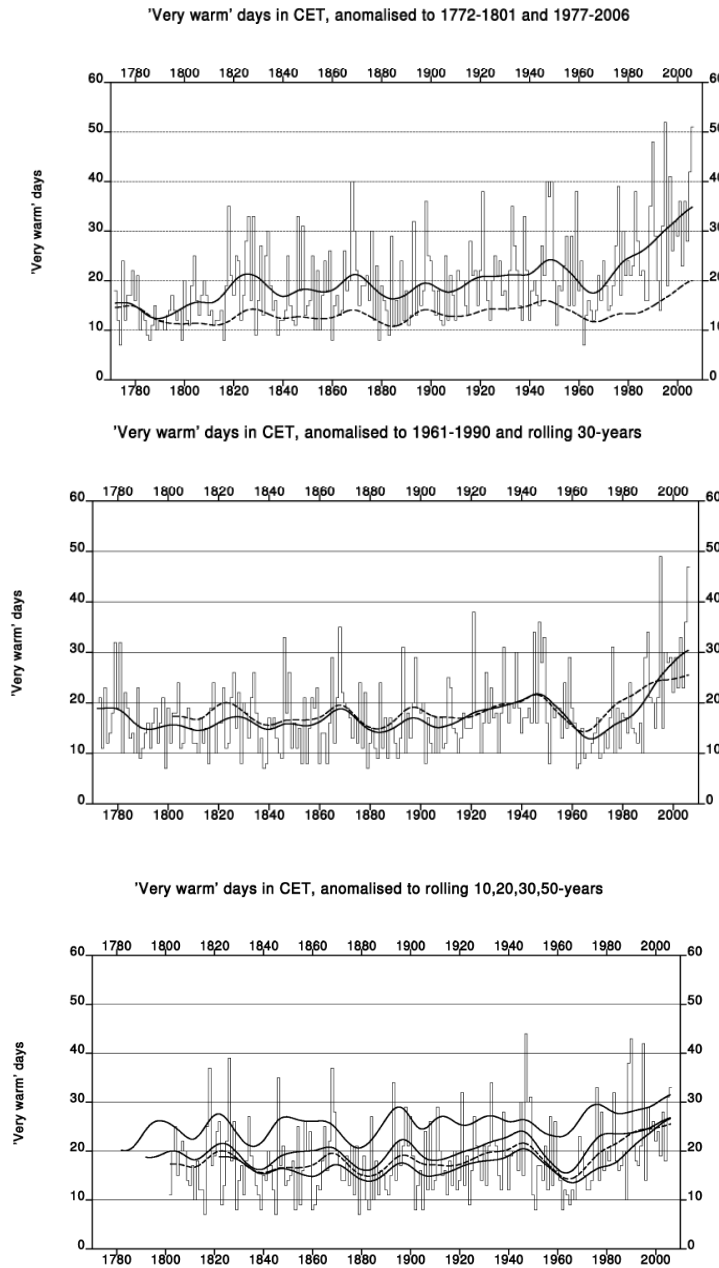


Figure 1: Annual number of ‘very warm’ days in the Central England Temperature series from 1772 to 2006 depicted using a number of different definitions of the baseline period from which the statistics of ‘normality’ are based. Annual data (histograms) are shown only for one series in each panel; the smooth curves represent trends extracted using a 30-year low-pass filter.

a) top: 'very warm' days defined from two fixed 30-year climatic normals, the earliest period in the series 1772-1801 (annual bars and bold curve) and the most recent period 1977-2006 (dashed curve).

b) middle: 'very warm' days defined from fixed 1961-1990 (histogram and bold curve) and from a retrospective rolling 30-year normal (dashed curve); note: the latter curve can only start in 1802, once a full retrospective 30-year period is available.

c) bottom: 'very warm' days defined relative to retrospective rolling climatic normals of 30 years (histogram and dashed curve) and 10, 20 and 50 years durations (the three bold curves, respectively from highest to lowest).

In the third case, Figure 1c, we compare four different cases: climatic normals determined in each case on a rolling basis, but with different durations influencing the perception of normality, i.e., 10, 20, 30 and 50 years. The higher frequency of 'very warm' days in the case of the rolling 10-year normals is owing to the method we use to define 'very warm'. Standard deviations based on shorter periods, in this case 10 years, are likely to be lower than those calculated over longer periods giving rise to a larger number of 'very warm' days. In the other three cases, it appears to make some modest difference whether ones expectations of climatic normality are influenced by the deeper past (e.g. 50 years) or the more recent past (e.g. 20 years). The recent trend towards more frequent 'very warm' days will be perceived as strongest for those whose expectations are shaped by the climate of the 1950s and 1960s (e.g. an older cohort) compared to those who are influenced only by the climate of the 1980s and 1990s (e.g. a younger cohort).

3.2. Analysis of future climate

We repeated the analysis of section 3.1 using model-simulated daily mean temperature for an area representative of central England extracted from a model simulation of climate for the period 1961-2100 for a scenario of changing atmospheric composition. The data are extracted from a climate change experiment performed using the Hadley Centre global climate model, HadCM3, forced with a greenhouse gas and aerosol forcing scenario based on the IPCC SRES A1. This is a mid-range forcing scenario and the HadCM3 model has a climate sensitivity of about 3°C, close to the median of the global population of published climate models (Meehl & Stocker,

2007). The precise scenario or the specific model, however, are of little interest to us; it is the sensitivity of the representation of future change in the number of ‘very warm’ days to different formulations of normal or expected climate that is of interest.

As expected, with a strong warming trend projected for UK climate over the coming century, the choice of baselines from which one’s perception of normality is defined makes a significant difference. Figure 2a shows the extreme case. For someone living at the end of the twenty-first century whose expectation of normal British climate is still stuck in the 1961-1990 period they will be experiencing very large numbers of ‘very warm’ days: between 80 and 100 per year (i.e., 25 to 35 per cent of all days) will appear to be ‘very warm’. This is about a four-fold increase compared to such a person’s experience of the present decade. Conversely, for someone in this future period who has adjusted their expectation of climatic normality to accommodate their recent experience of climate, they will still be experiencing between 15 and 20 ‘very warm’ days each year. For them, looking back to the beginning of the twenty-first century, the remarkable feature will be just how few ‘very warm’ days her grandparents would have experienced during their lifetime.

A fairer comparison is shown in Figure 2b, where we compare the number of future ‘very warm’ days using the fixed 1961-1990 WMO normal against three retrospective rolling baselines: calculated over 10, 20 or 50 years. Even under a climate showing a strong warming trend - $\sim 3^{\circ}\text{C}$ in average annual temperature during the century – the trend in the perceived number of ‘very warm’ days for someone whose expectation of climatic normality is continually being adjusted to account for recent experiences (whether recent means 10 or 30 years) remains very small indeed. Compared to today’s expectation of around 20 ‘very warm’ days each year, our future strongly acclimatising citizen will be experiencing only about 25 such days, despite the strong warming trend.

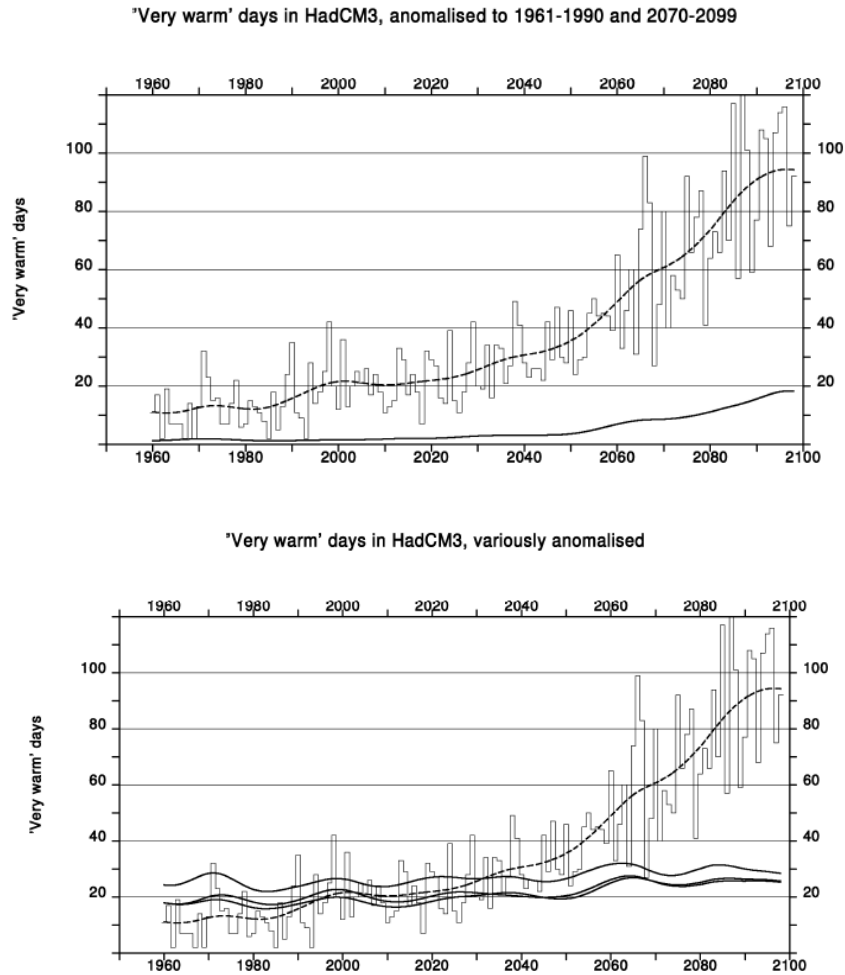


Figure 2: Annual number of 'very warm' days for a region representative of central England from 1961 to 2100 depicted using a number of different definitions of the baseline period from which the statistics of 'normality' are based. Annual data are shown only for one series in each panel; the smooth curves represent trends extracted using a 30-year low-pass filter. Data extracted from the HadCM3 climate model forced by the IPCC SRES A1 scenario.

- a) top: 'very warm' days defined from two fixed 30-year climatic normals, the earliest period in the series 1961-1990 (histogram and dashed curve) and the latest period in the series 2070-2099 (bold curve).
- b) bottom: 'very warm' days defined relative to a fixed 1961-1990 normal (histogram and dashed curve) and with respect to retrospective rolling 10, 30 and 50 year normals (bold curves, respectively from highest to lowest).

4 Discussion and Conclusions

People construct their expectations of the climatic future in different ways. This paper has elaborated three of the more important dimensions of these constructions: the statistical, the cultural and the psychological. Over the last twenty years a new influence has become increasingly important: the predictive, based on glimpses of the long climatic future offered by scientific models of the climate system. These elements interplay with other in complex ways to construct what we may call the socio-cultural expectation of future climate. We have also illustrated one particular facet of this multiple instability using historical and projected daily temperature data for the UK.

This multi-faceted perspective on how our expectations of future climate are constructed is important for a number of reasons. First, this perspective draws attention to the role of baseline selection in the construction of the socio-cultural expectations of future climate. As we have illustrated, different statistical climatic normals implicitly connote different psycho-cultural configurations of the relationship between memory of past weather and expectations of future weather. This is merely one illustration of the much wider point that definitions of normalcy influence narratives of change and of the abnormal. We can cite other instances in this regard. For example, the stated EU climate policy goal of restricting global warming to no more than 2°C has been interpreted variously (see Tol, 2007) as applying to the baseline of pre-industrial (i.e., mid-nineteenth century) climate or to the 1990 base year (already 0.5°C warmer) most frequently used in IPCC reports. Which baseline is adopted matters, not simply for the numerical indexing of how much more warming is ‘tolerable’ (i.e., either 1.2°C or 1.7°C), but also for our framing of what constitutes a ‘normal’ global climate. A mid-nineteenth century baseline resonates much more weakly with the cultural and psychological factors that influence our construction of climatic normality than would a baseline of 1990, or even 2005. We have shown that interpretations of recent trends in the UK towards more frequent ‘very warm’ days is strongly influenced by the assertion – whether by climatologists or, implicitly, by citizens and their perceptual apparatus – of climatic normality.

Another example of this principle in a wider context concerns the way seasonal forecasts of temperature are presented to the public. In September 2005, updated in November, the UK Met Office issued a forecast for the coming 2005/06 winter which was widely communicated to the public. It stated that there was a ‘2 in

3 chance of a colder-than-average winter' in the UK, especially in the south. It further added that, '... the last eight winters have been relatively mild and perhaps have given the impression that these are 'normal' ... the balance of probability is for a winter colder than those experienced since 1995/96.' (Graham et al., 2007). By claiming the winter would be the 'worst for nearly a decade', the forecast triggered a public and institutional reaction which was, indeed, to prepare for the worst. In fact, the winter in Central England turned out to be milder than the 1961-1990 normal, almost identical to the 1971-2000 normal, yet colder than all of the eight preceding winters since 1995/96. Public expectations and perceptions of what constituted a 'cold' winter - what was constructed as 'abnormal' in the public mind - were heavily influenced by this sequence of mild winters; a much worse winter in terms of absolute temperature was anticipated than in fact occurred. The popular construction of a severe winter had changed, whereas the formal statistical definition of 'cold' was still wedded to using distant WMO 30-year normals. And yet, whereas in statistical terms the forecast was 'incorrect', in terms of perception and expectation it induced, inadvertently, the required social response; it was 'correct'.

The perspective offered by this paper is important for a second reason. It allows for changing cultural and psychological influences to shape our expectations of future climates, as much as may do scientific predictions of changes to the physical climate. Discourses of future climate change often take as their starting point projections of future climate change derived from climate models; these are perceived to have predictive power and thus claim our attention. Changes in cultural and personal psychology are less accessible to the predictive tools of the natural sciences, certainly over the decades to century timescales here being considered. This situation easily lends itself to our interpretation of these future putative physical climates being shaped by the cultural and psychological lenses of the present. Even if we recognise that these broader cultural and mental processes of adjustment and assimilation will alter in the future – perhaps radically as we move from generation to generation – we do not have the tools to bring such conceivable, but unknowable, changes into play alongside our predictions of physical climate. Our illustration in Figure 2 is an attempt to suggest what this might look like were we able to do so.

A third contribution this perspective offers to our thinking about climate change is to contain naïve interpretation of results from climate model predictions of future climates. Whilst for pedagogic and rhetorical purposes it makes sense to

display such projections as deviations from a fixed (historical) baseline, this device makes no allowance for changing cultural or psychological expectations of what constitutes normal, or acceptable, weather and climate. We referred in section 1 to the debate about the choice of an appropriate baseline for the next UKCIP08 climate scenarios. In this debate it has been argued that portrayals of what constitutes climatic normality need continually to be updated, as we illustrate for UK past and future temperature in Figures 1c and 2b. Projections of future climates published in 2008 may have limited psychological resonance when benchmarked against a baseline climate from a different era. The period 1961-1990 represents an era half a human lifetime ago; if we take the mid-point of this period, 1976, no-one under the age of 32 years would have any first-hand memory of the benchmarked climate. Or to think ahead, it is doubtful that narratives of climate change published in the year 2050 continuing to refer to an anomalous summer temperatures as ' χ '°C above the 1961-1990 baseline would be particularly engaging. The extreme case of this is illustrated in our Figure 2a, although the more nuanced and plausible case is shown in Figure 2b.

This is not to suggest that we can simply deconstruct climate change through the use of rolling baselines and changing perceptions of normality, but it does hint at something very important about how people construct and interpret their expectation of the climatic future. There may well be a mismatch between, on the one hand, the presentation of far-distant future climates, referenced to the normalcy of a receding (and forgotten?) past and, on the other, the ability of individual minds to make sense of future climates and climate anomalies thus portrayed. The time-frames within which people construct their expectations of normal climate, and hence interpret claims of future climate abnormality, may well be shorter than allowed for by the statistical conventions of climatology. As we show in Figure 1b, people who adjust their mental expectations of high temperatures to the climate of the 1980s and 1990s will perceive less of a trend towards high temperatures than those who, for various reasons, may still perceive a normal British climate as that experienced in the 1960s and 1970s.

This leads us to offer two final reflections that emerge from this study. The first concerns one aspect of adaptation which has not been as thoroughly explored as it should – the idea of acclimatisation, i.e., 'to adapt oneself to a change in climatic or environmental conditions'. Acclimatisation has been most widely explored in the context of physiology, health and human comfort studies (e.g. Donaldson & Keatinge,

1997; Dessai, 2002; Kovats et al., 2008), but one could also extend the concept to consider the cultural and psychological dimensions of acclimatisation. This was the context in which the lively nineteenth century discourse about acclimatisation took place, carrying the ideologies of imperial exploration, settlement and racial attributes (e.g. Livingstone, 2002). It is also the context in which Meyer (2000) reveals the radical changes in domestic climates – the indoor temperatures that surround people’s domestic life – which have occurred over the last 200 years in North America and Europe. Hitchings (2007), too, explores the cultural conventions of thermal adaptation by examining the changing culture of the outdoor patio-heater. Acclimatisation can work with the grain of a changing physical climate (i.e., we adapt to longer, warmer summers; see Kovats et al., 2008), but also against it (i.e., we become less tolerant of heavy rain and flooding; see Furedi, 2007). What is important, however, is that the changing cultural and psychological contexts in which acclimatisation occurs, and/or can be accelerated, should not be ignored when evaluating the impacts of climate change.

Finally, seeing climate, and the future of climate, in this light challenges the notion of a stable climate as a public good, a notion which has found favour recently in some quarters. For example, the UK’s special climate advisor, John Ashton, recently wrote, ‘We need to see the pursuit of a stable climate as an imperative to be secured whatever it costs through the urgent construction of a low carbon global economy, because the cost of not securing it will be far greater.’ (Ashton, 2006). It may be possible to physically engineer a stable (global) climate through some purposeful series of policy interventions to moderate and control global greenhouse gas emissions or, as some have suggested more recently, through large-scale geo-engineering interventions (Kintisch, 2007). Yet the cultural and psychological processes to which people’s expectations of future climate are subject would always offer the means for further climatic de-stabilisation. The interactions between culture, memory and meaning are not stable, thus allowing for the possibility of a change in ‘social’ climate even within the confines of a statistically ‘stable’ climate. Or, conversely, these interactive processes of social adjustment could allow for ‘re-stabilising’ a climate which remains physically changing (see our Figure 2b).

As Meyer concludes from his extensive study of Americans and their weather, ‘The belief, widespread throughout American history, that the climate itself is not the same as it used to be, is a projection onto the climate of the rapid changes of

American life.' (Meyer, 2000: 213). Climates are unstable in all the dimensions explored in this study - the statistical, the cultural, the psychological – as well, of course, as the physical.

Acknowledgements

The daily Central England Temperature data were obtained from the Met Office Hadley Centre and Tim Osborn is thanked for assistance with the extraction and processing of the daily climate model data. Conversations with Roger Street and colleagues at the UK Climate Impacts Programme helped in the genesis of this paper and Street offered comments on a draft of this manuscript. Karsten Shein (NOAA) and Nolan Doesken (University of Colorado) are thanked for pointing the authors towards the early literature on climatic normals. Dessai and Nelson acknowledge funding support from the Tyndall Centre for Climate Change Research.

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