Climatic Change (2007) 83:1–8
DOI 10.1007/s10584-007-9237-4

INTRODUCTION

Climate and cultural history in the Americas: An overview

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Received: 14 July 2006 / Accepted: 18 December 2006 / Published online: 10 March 2007

Abstract There is abundant historical evidence that climatic extremes in the past have led to significant and sometimes severe societal impacts. The severity of these impacts depends on the intensity and duration of the climatic event, social organization, and the prevailing socioeconomic conditions at the time of the climatic extreme. In this issue of *Climatic Change* we present the results from 12 studies, which document climatic extremes on different time scales and provide interesting evidence for direct and indirect social impacts of climatic changes in the Americas during the pre-Hispanic, colonial, and modern eras.

1 Introduction

The complex interaction between climate variability and human history has received periodic scholarly attention over the last hundred years. Lately, the subject has attracted renewed interest in academic and popular literature, with several books published in the past few years that explore the nexus between human disasters and climate via the mediating effects of culture (e.g., Davis 2001; Grove and Chappell 2000; Gill 2001; Fagan 2003).

An earlier period of scholarly literature on the subject of climate and human history occurred in the 1970s and 1980s, where the volumes of Ladurie (1971) and Lamb (1982) stand out. The *Journal of Interdisciplinary History* and, more recently, *Climatic Change*[1]

[1] *Journal of Interdisciplinary History* (1980) **10**(4); *Climatic Change* (1999) **43**:1–351.

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have published important research on the role of climate in history. Popular books, such as those by Davis (2001), Gill (2001), and Fagan (2003) describe apparent climatic effects on socioeconomic history and prehistory. Anthropologists have also explored the role of climate in cultural change, by giving an appropriate role to climatic events in the context of prevailing cultural practices and strategies for managing such risks (Hoffman and Oliver-Smith 2002; Moseley 2002).

2 Climate and cultural change: A climatic perspective

Empirical and theoretical research has demonstrated that large-scale climatic phenomena, such as the El Niño-Southern Oscillation (ENSO), the North Atlantic Oscillation, the Asian Monsoon, and other modes of inter-annual, decadal, and longer-scale climate variability, can have profound and widespread effects in many regions of the globe (Shukla and Misra 1977; Cane and Zebiak 1985; Ropelewski and Halpert 1987; Hurrell 1995; Diaz and Markgraf 1992, 2000; Markgraf 2000; Diaz et al. 2001). Because the ENSO phenomenon is such an important factor controlling climate variation on multiple time scales, the last 20 years have seen increased efforts to develop improved historical and proxy records of past ENSO activity and its impact in areas of the globe that are tied to ENSO variability through atmospheric teleconnection processes (Lough and Fritts 1985; Ortlieb 2000; Cook 2000; Cook et al. 2000; Stahle and Cleaveland 1993; Stahle et al. 1998b). At the same time, a large amount of research has been undertaken using historical, instrumental and documentary sources, tree rings, tropical corals, lake sediments, speleothems, and other natural archives to develop high-resolution paleoclimate reconstructions (Alverson et al. 2003). Some of these reconstructions have been used to document severe climatic episodes in the Americas and their possible association with socioeconomic conditions during the historical period, including the weather during the western US "Gold Rush" in 1849 (Mock 1991), mid-nineteenth century drought in the US Great Plains and the Colorado River basin (Woodhouse et al. 2002, 2006), the 1878 yellow fever outbreak in the southern United States (Diaz and McCabe 1999), the sixteenth century mega-drought over Mexico and the United States (Stahle et al. 2000), and many other parts of the world (Weiss and Bradley 2001; Zhang et al. 2006).

Precisely dated annual tree ring records provide centuries long chronologies that document the development of severe and sustained drought in the Americas. Tree ring research has revealed interesting chronological associations between major climate anomalies and colonial and prehispanic accounts of severe famines, disease, and other disasters (Stahle et al. 1998a, 2000; Acuna-Soto et al. 2002; Therrell et al. 2004; Therrell 2005; Gil Montero and Villalba 2005).

Paleoclimate indices derived from lacustrine and near coastal sediment cores also provide a high-resolution record of climate. These records, which extend back through the Holocene, and beyond, have allowed researchers to establish with detailed physical evidence the existence of major climatic shifts that are coeval with significant cultural changes in different parts of the world (e.g., Hodell et al. 1995; Curtis et al. 1996; Weiss and Bradley 2001; DeMenocal 2001; Gill and Keating 2002; Haug et al. 2003).

The advances in understanding the nature and causes of climatic variations, and the progress in documenting the timing of severe and prolonged climatic anomalies with paleorecords indicates that the paleoclimate community can make significant contributions to the study of climate and cultural interaction: 1) accurately and precisely date the timing

of climatic events that are thought to be associated with significant cultural responses in the Americas, 2) estimate the severity of these climatic episodes, and 3) calibrate the paleoclimate records with socially relevant variables such as seasonal precipitation, drought indices, and crop yields (see Markgraf 2000; Alverson et al. 2003).

3 Climate and cultural change: A cultural perspective

Several recent events and publications have highlighted the role of human behavior in the development of "natural" disasters. Glantz (2001), in particular, has discussed the interplay between major climatic events and societal responses. Paradoxically, human vulnerability to natural hazards has in some cases increased over time, in spite of vigorous engineering efforts (e.g., the urban flooding following the landfall of Hurricane Katrina).[2] Nevertheless, there is ample evidence that large, naturally occurring climate fluctuations have had profound impacts on many ancient and modern societies (Gill 2001; Fagan 2003). These impacts take a variety of forms, and may operate through famine, disease, and social upheaval. Historical and archaeological research has highlighted cases in which great societal changes are associated chronologically with major climatic anomalies. Nevertheless, proving that cultural shifts are a response to climate change remains the key challenge in what is referred to as "Historical Disaster Research" (Garcia-Acosta 1997, 2002), because the timing of climate and societal changes cannot always be determined with sufficient accuracy and precision.

To help foster a continuing exchange of information and ideas about the subject of climate impacts on human history, a meeting was organized at the Centro Ecológico de Akumal, in Quintana Roo, México in the spring of 2005 on the subject, *Climate and Cultural History in the Americas*. Exploring the connection between distinct climatic episodes and cultural responses in the western hemisphere was a key goal of the workshop.

The workshop brought together anthropologists, epidemiologists, historians, and paleoclimatologists to examine the available data from well-dated prehistoric/historic cultures and paleoenvironmental records in the Americas. The objective was to document the timing of sustained, severe climatic conditions, e.g., prolonged droughts, over the past ~1,500 years, and to examine existing hypotheses about environmental change that are thought to have been pivotal in shaping societal responses and cultural decline (e.g., Gill 2001). The development of long-term collaborative research among these interdisciplinary specialists was another key goal of the workshop. For example, tree-ring researchers have teamed up with epidemiologists in an attempt to characterize the seasonal climate conditions that prevailed during some of the great killer epidemics of the past several centuries in Central America (Stahle et al. 2000; Acuna-Soto et al. 2002, 2004). This volume includes a cross-section of paleoclimatic and historical perspectives on the study of climate impacts on human society.

[2] In his influential dissertation entitled "Human adjustment to floods," published in 1945 by the University of Chicago [Department of Geography Research Paper no. 29], Gilbert F. White argued that an over-reliance on structural works in the United States had increased damages caused by flooding rather than decreasing them.

4 Climate can matter

The concept that human risk to natural hazards is mediated by culture and social organization (e.g., White 1994; Pulwarty and Riebsame 1997; Hoffman and Oliver-Smith 2002) has been made obvious by recent catastrophes. We only need to witness the death and destruction caused by the Asian tsunamis (2004) or Hurricane Katrina in New Orleans (2005) to understand that the social impact of catastrophes arising from powerful natural phenomena are intricately tied to human behavior and responses. Societies spanning the economic scale can be seriously impacted by weather and climate extremes. However, many societies have developed elaborate economic cushions against the negative effects of climate disasters. All decadal droughts do not bring societies to their knees, and every cultural collapse cannot be attributed to climatic catastrophes. But documenting past climatic extrema and their potential socio-cultural impact has become an interesting focus of paleoclimatic and historical research, and may help prepare modern society to cope with the probable anthropogenic climate changes of the coming century.

Some of the most significant scholarly work in this arena was published by Ladurie (1971), Lamb (1982), and Bryson (1988). But with the recent proliferation of high-resolution paleoclimatic proxies and historical climate data, the evidence for chronological associations between prolonged drought and past cultural disruption has increased dramatically (e.g., Hodell et al. 1995; DeMenocal 2001; Weiss and Bradley 2001; Acuna-Soto et al. 2002; Haug et al. 2003; Peterson and Haug 2005; Endfield and Fernández-Tejedo 2006; Zhang et al. 2006).

This special issue of *Climatic Change* presents a suite of studies, which critically examines the issue of cultural response to climate and whether major climatic events present in the paleoclimate record are indeed coeval with previously documented cultural change. For example, Benson et al. investigate the isotopic evidence for maize agriculture in the Chaco Canyon region of New Mexico and argue that drought was a significant factor in the abandonment and migrations of the US Four-Corner societies around the late thirteenth century. However, they acknowledge the modeling results of Gummerman et al. (2003) and concede that cultural factors must have played a role, since even with a severe drought, some areas of the Ancestral Pueblo settlements during that time were still viable from a climatic perspective (i.e., enough maize could be grown to support small populations).

The paper by Hodell, Brenner, and Curtis explores the possible association between severe and sustained drought inferred from high-resolution lake sediment records in the Yucatan Peninsula and several of the critical Mayan cultural markers over a thousand-year period. Their latest work on the paleolimnologic and paleohydrologic Holocene history in Central America, suggests a major climatic change occurred near the end of the Late Preclassic period of Mayan history (a rapid change toward much drier conditions, between 100–250 A.D.). This change may have coincided with a time of active deforestation for agriculture. This climatic change may have affected the trajectory of Mayan civilization into the Classic Period, because control of water resources may have contributed to political power. Hodell et al. (this volume) also document severe and sustained drought episodes in the Terminal Classic Period (750–1050 A.D.), which may have played a significant role in the ultimate decline of this unique American culture.

The paper by Metcalfe and Davies (this volume) presents an analysis of lake levels in central Mexico based on different paleoclimate methodologies. They conclude that dry conditions in that region – in their words, "probably the driest of the Holocene" – occurred from about A.D. 700–1200. This period has been the subject of many studies in the past 30 years (see Bradley et al. 2003 and references therein and in the cited reference list

below) and the available evidence suggests that it was a time of rather significant climatic episodes worldwide, with dry conditions prevalent in many areas of the Americas, particularly in the tropics and subtropics. The areas that are thought to have been dry relative to the modern records are those, which today tend to experience dry conditions during inter-annual to decadal scale La Niña conditions.

Tree ring records partially overlap with those of other paleoclimate reconstructions in many areas. Villanueva-Diaz et al. (this volume) use tree-ring chronologies to develop a 700-year long reconstruction of winter-spring precipitation over northeastern Mexico. Winter-spring precipitation is vital to crop production in this arid subtropical climate, and major social upheaval occurred during some of the major droughts documented by this new reconstruction.

Using the new gridded tree-ring reconstructions of the summer Palmer drought severity index (PDSI; Cook et al. 2004), Stahle et al. compare the magnitude and duration of major North American drought episodes since A.D. 1300 with those witnessed in the twentieth century. They conclude that the multi-decadal droughts of the thirteenth, fourteenth, and sixteenth centuries in western North America may have exceeded the severity and duration of any droughts of the instrumental period. The important message for present-day western society is that the reoccurrence of such sustained and severe drought in North America, as expressed in the tree-ring record, in concert with rapid growth in population and water demand, and with the rising surface temperatures now observed across the western United States (Mote et al. 2005; Westerling et al. 2006) would likely lead to severe socioeconomic impacts, especially in the irrigated agricultural sector.

Georgina Endfield's paper examines both the cultural and climatic contexts of the so-called *El Año del Hambre* (The Year of Hunger) by a careful consideration of the time-specific social setting of Mexican society during the mid-1780s. Articles by García-Herrera et al., and by M.R. Prieto using historical documentary sources from Spanish and Latin American archives present interesting case studies of significant climatic events while at the same time illustrating the impact of these events on local populations. A study by Mock et al. using multiple early nineteenth century historical sources from the US together with tree-ring records describe the environmental and social impacts of the very unusual winter of 1827–28. These four papers document the severe social impacts of selected climate extremes during the historical era, and demonstrate the value of a strict comparison between well-dated climate and historical information. They also provide a proof of concept for the potential impact of climatic extremes in these areas during the pre-colonial era.

Another interesting study is that presented by B. Mendoza et al., namely a statistical analysis of data from a historical drought catalogue for southern Mexico for the sixteenth through nineteenth centuries. A clear connection is made between periods of severe drought in this region and the development of food scarcity, disease, and high mortality in the agriculture-based economy of the Yucatán Peninsula region during that time. Another interesting finding is that while modern droughts have not lasted longer than 4 years, in historical times, there were droughts documented that lasted 6, 7, and 10 years. Such long-lived drought episodes, were they to recur today, would place significant stresses on Mexican society even in today's more globalized economy.

Finally, the article by N. Graham et al. explores the large-scale ocean-atmosphere patterns that may have been present during the so-called Great Drought in the twelfth and thirteenth centuries in the American Southwest, using paleoclimate data to drive a regional hydrological model. They conclude that the period sometimes referred to as the Medieval Warm Period (~A.D. 900–1350) was characterized by sea-surface temperature (SST) patterns that today correspond to periods of enhanced drought in the southwestern United States.

5 Summary

A central theme of the Akumal meeting was to consider the possible societal impacts of extreme climatic anomalies – those that were likely to surpass the buffering behaviors that may have been developed to mitigate against climate extremes. Most nature-driven human disasters probably involved enhanced vulnerability to natural hazards as a consequence of antecedent human actions and behaviors. The studies presented here do not refute this assumption, but they do suggest that extreme climatic episodes can exceed the normative expectations of society and may sometimes transcend the capacity for mitigation and adjustment. These effects take a variety of forms, and operate through famine, disease, and social upheaval.

The articles presented in this special issue of *Climatic Change* aim to stimulate further interest in this topic within the interdisciplinary paleoclimate community. The likelihood of significant impacts to world society arising from global climate change underscore the need for integrated studies of the impacts of major climatic episodes on modern, historical, and pre-colonial societies, realizing that society is often both the victim and the cause of natural disasters.

Acknowledgments We gratefully acknowledge travel support from the NSF Paleoclimatology Program (grant number ATM-0454625) and NOAA (award number DG133R05SE3516), and the NSF Earth System History Program for research support to the University of Arkansas (Grant Number ATM-0400719).

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