Advanced Review

Climate and history: a critical review of historical climatology and climate change historiography

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This paper provides a critical analysis of recent climate history (or historical climatology) scholarship. It identifies four key subfields in this historiography of climate change. First, it examines scholarship on climate reconstructions that use a variety of innovative historical sources to document past climatic conditions. Second, it analyzes scholarship on social impacts and responses to climate change. This literature is prolific with significant attention given to climatic variability and climatic or weather-related disasters. Third, the paper discusses research on the uses and abuses of climate knowledge, such as innovations in meteorology and climatology as well as ways that Western climate knowledge helped justify colonialism and perpetuate racism. Fourth, the paper examines research on cultural constructions and perceptions of climate. This includes analysis of diverse climatic understandings and climate narratives that have varied across time and space. While the climate historiography is steadily expanding and constantly probing new areas, this paper contends that the field overall would benefit from a stronger emphasis on social history to examine race, class, and gender in climate history while also focusing on how social relations and power dynamics affect human–climate interactions. Additionally, it argues that the uncovering of more diverse climate meanings and narratives, partly through better social history, could both enrich the historiography and contribute to today's broader discussions about global climate change in the past and future.

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INTRODUCTION

Climate history is a rapidly growing field that has made significant contributions to the understanding of the past and could contribute much more than it has to present-day discussions about global climate change knowledge, impacts, and responses. Historians of climate—or historical climatologists, as Europeans more often refer to the field—have tended to study climate–human interactions in the distant past. This climate history scholarship for the period before the twentieth century is much more abundant than post-1900 studies. In fact, there are relatively few studies that historicize current cultural and socio-political understandings of global warming.[1–8] When focusing on this more recent period, researchers tend to focus on the science of global warming more than the social or cultural aspects. Yet, as Matthias Heymann points out, the history of climate ideas should be integrated into our current views of climate.[6] J.R. McNeill makes a similar point, suggesting that 'the more one unpacks the concept of climate change into its components, the more the record of the past becomes relevant to imagining the future'[9] (p. 45). When it comes to global warming discussions today, this record of the past is particularly important for understanding the broader historical processes that have led to anthropogenic climate change and created the unequal geographies of vulnerability that exist in the world today.[10,11]

The body of scholarship on climate history can thus—and should—contribute substantively to current debates about climate change. Scholars of

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climate history, who are not always historians, have long been asking insightful, probing, critical questions about human–climate dynamics. And other studies[12–17] have analyzed this climate historiography. This essay builds on those contributions by examining a broader range of climate history and historical climatology scholarship, by focusing on the state-of-the-art scholarship in recent years rather than providing a historical evolution of the historiography, and by emphasizing the need to incorporate scholarly insights from past periods into recent climate studies and ongoing public discussions of climate change. The paper identifies four principal subfields in the climate historiography: (1) climate reconstructions, (2) societal impacts and responses, (3) the uses and abuses of climate knowledge, and (4) the cultural constructions and perceptions of climate. Examples cited in these four categories are meant to provide representative examples of approaches to the study of climate history. They are not meant to offer comprehensive coverage of all periods and world regions—an impossibility in such a paper. The essay concludes by arguing that climate historiography could benefit from a stronger emphasis on social history and cultural analysis. By social history I mean the study of social relations among diverse groups or historical actors (stakeholders), with an explicit focus on power dynamics embedded within and expressed through those social interactions. Cultural analysis involves a concentration on beliefs, values, narratives, and discourse. It recognizes and thus validates the presences of diverse knowledge systems. And it allows that these cultural expressions influence public perceptions, policymaking, and even climate science.

RECOVERING PAST CLIMATES

Historical climatology, especially as it evolved in Europe after the 1960s, has always sought to use historical archives with data unavailable to most scientists to help reconstruct past climates. In fact, up through the 1980s, it seemed one of the principal—if not *the* principal—focuses of climate history was on climate reconstructions.[18] Emmanuel Le Roy Ladurie had popularized this approach to climate history in his famous book *Times of Feast, Times of Famine*. He offered an account of Little Ice Age climate by examining glacier tongue positions and dates for grape harvests—both of which provided new information about the history of climate in Europe over the last millennium.[19]

Since then, many historical climatologists, especially in Europe, have continued research on climate reconstructions. Christian Pfister, Rudolf Brázdil, and Jean Grove have focused their work on Little Ice Age climate reconstructions. Their research reveals how diverse sources from paintings and diaries to newspapers and daily weather observations can help reconstruct past climatic conditions. It also demonstrates how their creative sources and research inquiries can enrich historical understandings more broadly by illuminating new forces of change.[12,20–23] In Robert Claxton's identification of periods of drought and other climatic hazards in colonial Guatemala, he also used a variety of innovative sources, from indigenous petitions to reduce labor and tribute demands to Spanish traveler chronicles to a variety of other ecclesiastical records.[24] His climate reconstructions for Latin America also reveal that the region experienced many periods of warming and cooling during the Little Ice Age that were similar to those in Europe, and which also had corresponding societal impacts.[25] A different study provides a comprehensive analysis of documentary records and archives in South America and Spain to help reconstruct the region's climate history. Interestingly, research showed that climate reconstructions are more abundant and accessible for the colonial period than they are for the post-1810 republican period when there was a gap in records. Analysis of these records points to many long- and short-term climatic trends in South America, which in many cases can be aligned with other proxy records and scientific studies.[26] The role of climate in agriculture has also been important, and some studies have recognized the importance of linking climate reconstructions with agricultural history in the United States.[27]

Innovative climate reconstructions have occurred for Africa and Asia as well. For the Kingdom of Lesotho and nearby areas of South Africa, scholars have also used creative methods to reconstruct the history of rainfall variability during the nineteenth century. Using government documents and missionary reports and correspondence, David Nash and Stefan Grab were able to reconstruct a precise history of drought episodes and wet periods or floods to show climatic variability over more than 70 years.[28] In another study, Grab and Nash used similar documentary records to reconstruct nineteenth century cold seasons in Lesotho between 1833 and 1900. They then matched that documentary evidence with instrument-based temperature data from Maseru and found the two methods aligned well, demonstrating both the validity of document-derived climate reconstructions and a valuable methodology for linking historical and scientific approaches.[29] Using the extensive meteorological data recorded in

local gazettes from the Guangdong Providence in southern China since 975 AD, researchers have been able to reconstruct a high-resolution list of typhoon landfalls over more than 1000 years.[30] Indeed, China offers scholars a rich set of documentary records for historical climatology: classical documents dating back more than 2000 years; local gazettes during the Ming and Qing Dynasties from 1471 to 1911; memos to the emperor from 1736 to 1911, when daily snow, rainfall, and other weather conditions were reported daily to the emperor; archives of the Republic of China 1912–1949; and many books and diaries. Using these documentary sources and sometimes comparing them with field measurements or instrument-based records, scholars have reconstructed detailed histories of precipitation, weather-related disasters, and other long-term climatic conditions in China.[31–33]

Researchers are using documentary records to reconstruct climate histories through innovative methods in Australia, Europe, and elsewhere as well. In one case, they used the daily temperatures and barometric pressure observations from two local residents in Sydney Cove, New South Wales. They then tested the reliability of these data with other documentary records and paleoclimate reconstructions, demonstrating well how historians can collaborate with scientists and utilize scientific analyses in historical studies.[34] Some scholars have used other creative methods to recover past climates, including the analysis of artwork and paintings. Hans Neuberger studied more than 12,000 European paintings to discover cloud cover, visibility, and the amount of clothing people wore to extract a record of climate change during the Little Ice Age.[35] Thornes and Metherell examined Monet's 'London Series' paintings in the late nineteenth century to help reconstruct climate, as well as perceptions and anxieties about it.[36] Another fascinating way researchers have recovered past climates is through the analysis of ship logs, which have provided data about weather and climate as well as oceanic conditions.[37,38] Other scholars have used various historical records to reconstruct past El Niño events or to identify specific floods, droughts, or hurricanes from China and Europe to the Caribbean and Australia.[39–43]

Some of these efforts to reconstruct past climates have led to much larger, innovative, and cross-disciplinary projects including the Atmospheric Circulation Reconstructions over the Earth (ACRE), the Climatological Database for the World's Oceans 1750–1850 (CLIWOC), and the South Eastern Australia Recent Climate History (SEARCH). The ACRE (http://www.met-acre.org/) is a global project with seven international collaborating agencies that seek not only to compile and reconstruct surface terrestrial and marine weather data during the last 500 years, but also to digitize historical documents such as books, journals, and ship logbooks, and make them freely available to researchers and the general public. They have, for example, recovered weather data from 900 logbooks of the English East India Company from the 1780s to the 1830s, as well as approximately 7000 Royal Navy logbooks between 1914 and 1923.[44] Another project, the CLIWOC (http://www.ucm.es/info/cliwoc/), existed from 2000 to 2003 and collected European ship logbooks of voyages between 1750 and 1854. The project showed that this documentary evidence provided even more detailed information than originally anticipated, and it found particularly notably data on wind speed and direction that can contribute to both historical understandings and climate reconstructions.[45] The SEARCH (http://climatehistory.com.au/) project is another collaborative project linking science and the humanities to understand Australian climate during the past 500 years. Like these other projects and the research on historical climate reconstructions in general, the SEARCH project relies on scientific proxy data from tree rings, coral, ice cores, and cave deposits as well as both documentary evidence from newspapers, settler accounts, and government records and weather data from journals, gazettes, and observatories.

Research on climate reconstructions continues today. This subfield of historical climatology, however, has been eclipsed somewhat in recent years as scientists—rather than historians—have taken over most climate reconstructions through their use of increasingly precise proxy data from tree rings, lake and ocean sediments, ice cores, and other sources. Nevertheless, as the literature demonstrates and as the collaborative projects show, historians continue to discover important archives and data to help reconstruct and thus better understand past climates—and increasingly beyond Europe where historical climatology traditionally focused.

SOCIAL IMPACTS AND RESPONSES

Social scientists from a diversity of disciplines continually plead for more empirical studies on the social impacts of climate change and diverse responses or adaptation to those changes.[46–49] To date, however, relatively few historians have taken up this charge for the recent period.[50,51] For periods prior to the twentieth century, the scholarship on climate impacts and responses is more abundant than for the post-1900 era. And compared to the other topics addressed

in this paper, there is much more scholarship on climate impacts, particularly if the analysis of weather-related disasters such as hurricanes, droughts, and floods are included, though of course these studies usually focus on particular events rather than longer-term climate change. Some studies examine climate impacts on societies by explaining the climatic influences over the *longue durée*—that is, over many millennia, often since the end of the last Ice Age more than 10,000 years ago.[7,52–58] Others have focused on narrower but still huge periods by examining climate–society interactions in ancient periods, in the modern world, or during the Little Ice Age.[19,23,59–61]

Catastrophic societal collapses such as the Maya and the Greenland Norse have attracted significant attention in scholarly and popular literature on the social impacts of climate. Widely read books such as Jared Diamond's *Collapse* help reinforce these ideas and the historiography's orientation.[57] Many of the studies on these societies use innovative methods of paleoclimatology and geoarchaeology. They investigate a variety of topics from the fall of the Roman Empire, the disappearance of the Moche society, the Maya Collapse, the decline of the Greenland Norse, the 'Five Relocations' among people near the Yellow River in ancient China, and many others.[62–67] Some of this research follows the trend to emphasize climate catastrophes, focusing on dramatic historical events and reinterpreting them from previous understandings to show how environmental forces shaped historical processes. The role of climate in the Maya Collapse is a classic case of attributing climate change—along with many other factors—for the major demographic changes and abandonment of city states throughout Mesoamerica from the eighth to the tenth century. Although some researchers argue for the predominant effect of drought on Mayan societies, other scholars are increasingly complicating that view by examining the ways in which global climate change intersected with regional climatic conditions, especially drought, and human-caused deforestation that also affected local climates.[68–71] Some scholars, however, continue to question the role of climate or deforestation for the Maya collapse, thus indicating the limited data available to reconstruct this history.[72,73]

While most of these studies on ancient climate impacts focus on societal collapse or major negative effects, some research discusses how climate change aided certain societies. The Inca Empire, for example, benefited from improved irrigation, expanded settlement into the high Andes, and heightened crop yields during the late Medieval Warm Period leading up to the fourteenth century. These advances facilitated the rise of one of the world's most expansive empires that thrived from the fourteenth century to the early fifteenth.[74] Archaeologists and anthropologists studying these periods use creative and diverse methods to understand human–climate dynamics. The lack of written records and only limited availability of cultural artifacts makes it challenging to truly understand attribution (cause–effect) or to probe beliefs, values, and narratives of climate change impacts on societies in the distant past.

Climate change has also influenced Chinese history. David Zhang and others, for example, study long-term climate records and point to specific periods when climatic fluctuations correlated with times of population change, frequency of war, and even dynastic shifts. They also assert that climate change affected agricultural production, which influenced prices, social conflict, famine, and warfare.[75–77] These ways in which climate change corresponds with agricultural change, price fluctuations, social conflict, and political transformations have been studied worldwide, and not just in China. But Ka-wai Fan argues that historians and non-historians must be careful when attributing major historical events to climate change because they sometimes lose the relevant societal context and just correlate historical events with climatic changes. In short, Fan challenges not just historians of China but all scholars working on human–climate dynamics to clearly decipher cause–effect relationships and strive to more explicitly attribute social change to climate change.[78]

For the Early Modern and Modern eras, scholars have also studied both climate shocks and long-term climate change impacts. Many of these studies link imperial or revolutionary periods to climate variability. In the Near East, for example, the onset of the Little Ice Age had profound effects on the Ottoman Empire, which was nearly obliterated in the late sixteenth century but went on to recover and expand subsequently. As Sam White shows for the Ottoman Empire, the Little Ice Age climate intersected with other political, military, agricultural, and economic forces to affect the course of history over the long run.[79] Sherry Johnson argues that the great revolutions in the Unites States, France, and Haiti occurred in a particularly tumultuous period of climate change and catastrophic weather events between about 1750 and 1810 that shook the entire Atlantic World.[80] Other scholars have also shown how climate change in this same period of the eighteenth and nineteenth centuries had profound effects on societies, politics, and economies—from the French Revolution, Mexican independence movements, and other cases

of revolutionary movements worldwide.[81–83] In other cases, researchers reveal subtle ways that climate affected society over long periods—how it changed farming, influenced crops, shaped economic opportunities (or the lack thereof), affected politics and social interactions, and influenced religious practices.[59,84–86]

Just as climate change affected these diverse aspects of society, human responses to climate change were also conditioned by the particular historical and spatial contexts. As Georgina Endfield explains in her study of climate–society interactions in colonial Mexico, responses to climate change and weather events such as droughts, floods, famines, and earthquakes 'varied according to the changing social, political and economic circumstances throughout the colonial period'—and they hinged on the degree of people's social and environmental vulnerabilities[84] (p. 3). Climate never acts alone, in other words. After all, nature–culture dichotomies blur together and overlap in what scholars now call dynamic social–ecological systems or coupled natural–human systems.[87–89] In this context, it can be difficult to distinguish precisely the role of climate on societies, and thus scholars such as Endfield, Fan, and many others increasingly reveal intertwined forces shaping societies with climate as one among many variables that act alongside technological, political, economic, social, cultural, and environmental forces.

Many histories of climate impacts focus on climatic or weather-related disasters, and a significant portion of these studies examine the last two centuries. Some of this research analyzes sustained climatic phenomenon that occur repeatedly over time, such as hurricanes in the circum-Caribbean basin.[80,90–93] Others investigate droughts, such as in Northeast Brazil and the US Great Plains.[94–97] El Niño events are increasingly attracting attention as well, with research focusing not only on the mega El Niños that crippled ancient societies along the Peruvian coast, but also worldwide El Niño impacts up through the early twenty-first century.[98–103] Research on glacier hazards such as avalanches and glacial lake outburst floods caused by climate change also demonstrates the diverse societal impacts and responses that occur among distinct social groups vulnerable to these alpine disasters.[1,104] In another case, Franz Mauelshagen examines hailstorms in Switzerland and shows the role of insurance companies in long-term climate adaptation.[105] Eleonora Rohland has also examined the relationship between climate and insurance in historical perspective based on her study of fire.[106]

Research on impacts and responses has also yielded some of the most innovative climate history scholarship—that of cross-disciplinary collaboration, such as among historians, glaciologists, and ice-core climatologists. In one case, scholars have examined Greenland ice core data alongside written records from Europe from the seventh to ninth centuries to better understand how societies responded to climate anomalies.[107] In another example, archaeologists and glaciologists collaborated to understand the dramatic collapse of the Moche society during the sixth and seventh centuries.[108] Researchers have also collaborated to analyze glacier hazards in more recent periods, examining the physical dynamics of avalanche-outburst flood triggers with societal responses over time.[109]

A key contribution of the literature on social impacts of climate is how studies show climate in dynamic interplay with a number of human and other environmental (non-human) factors. This is an important move away from the climatic determinism of past generations and offers a more nuanced way of understanding climate–human interactions, as several scholars suggest.[18,85,110] Another strength of this body of literature is the way it illuminates vulnerability: the ways in which marginalized populations tend to suffer disproportionately from climatic variability and weather-related hazards because they lack the socio-economic means to buffer themselves, possess little political power to avoid or recover from their situations, or are pushed into their vulnerable positions by outside factors attributed to power imbalances, economic inequality, and social divisions. This emphasis on vulnerability has particular relevance for understanding global warming today because it suggests how certain marginalized peoples or poorer countries will suffer from global climate change more than ruling classes or industrialized nations. Moreover, social science research today emphasizes adaptation and resilience, which these historical studies tackle through actual case studies. These studies show the cost of long-term adaptation—the witches burned for weather-related crimes and the thousands killed by glacial lake outburst floods—while larger societies rarely actually collapsed, or they did only because of multiple forces working in tandem with climate.[1,7,111] This effort to link climate research with the much richer scholarship in disaster studies is increasingly occurring. In fact, the Intergovernmental Panel on Climate Change (IPCC) released a 2011 report from a prominent working group on 'Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX)', which seeks not only to identify climate-related hazards, but also to merge research on disasters and climate.[112] Historical climate studies of past social

impacts and responses thus have much to inform histories and other social science research on global warming occurring today and in the recent past. It provides the key empirical evidence that is lacking in much of the existing social science scholarship that discusses global warming today and for the future.[50]

THE USES (AND ABUSES) OF CLIMATE SCIENCE

Climate knowledge must always be contextualized within a variety of societal forces and factors because, like all science, climatology emerges from distinct cultural conditions that differ in time and space.[113] As Matthias Heymann explains in his synthesis and periodization of climate ideas from the Early Modern era to the present, climate understandings changed over time, were associated with distinct historical actors and social groups, and 'depended not only on scientific achievements, but also on broader technological, social, political, and cultural contexts'[6] (p. 582). An increasing body of scholarship reveals these various forces that shaped past knowledge about climate—everything from Alexander von Humboldt's legacy of human-caused climate change to the global politics of climate knowledge from Antarctica in the 1950s.[114,115]

Given the societal contexts of climate science, it is not surprising that scholars have also demonstrated how certain social groups have used that climate knowledge to pursue their own agendas—both directly and indirectly, intentionally and unintentionally. Indirectly, the accrual of climate science in the hands of government bureaucracies or among the intellectuals and the ruling elite has resulted in the accumulation of power for those groups—the power to withhold weather data, to manipulate understandings, or to economically benefit certain groups over others.[116–119] Even in cases when meteorological data is locally produced—as research on the geography of science shows—there is still a degree to which weather observations and instrumentation can eclipse local knowledge and feed nationalization or nation-building agendas.[118,120] In other words, weather maps, like all maps, represent power.

More directly, climate discourse has been used to justify colonialism, economic expansion, racism, slavery, and social divisions.[121] Ruling classes, colonial administrators, and government officials have used and abused climate science, especially in previous periods when ideas about climatic determinism proliferated. Some of these ideas about climatic determinism—how climatic conditions affected human bodies and societal development on broad scales—justified European colonialism ever since the fifteenth century.[122] In the eighteenth and nineteenth centuries, this idea of climatic determinism affected everything from ideas about health and medicine to colonial policies and beliefs about Social Darwinism and eugenics. Western science showed Europeans that people in the tropics were slothful, morally corrupt, and intellectually inferior to the vibrant, smart people of northern latitudes.[123–127] Ethnoclimatology and climatic determinism even provided the scientific justification for slave owners to justify the institution because they maintained that Africans were more fit to labor in warm climates than Europeans were.[128] After the mid-twentieth century, weather modification and climate control schemes became diplomatic tools and ways to bolster nation-building agendas amidst Cold War conflicts.[3,129,130] Clearly, the construction of climate and various weather discourses were not simply objectively studied and understood through science. That discourse and knowledge could be used and abused to pursue specific agendas, to exploit and subjugate other peoples, and to expand the power of ruling classes from Europe and North America.

Scholarship on the history of climatology since the twentieth century has most frequently focused on explaining how scientists came to understand and prove the notion of anthropogenic warming. This scholarship usually starts with current knowledge about global warming as the endpoint, and it then highlights particular innovations in the past, such as Svante Arrhenius who in 1896 noted the effects of carbon dioxide on global temperatures, or Guy Stewart Callendar who in the 1930s and 1940s linked carbon dioxide emissions to anthropogenic warming, or Charles Keeling who detected a strong increase in carbon dioxide in the atmosphere from pre-industrial periods up to the 1950s.[131–135] Spencer Weart has demonstrated how these scientific ideas about climate change have spread from science to popular discussions and politics since the 1980s, thereby linking his study of climate science to popular debates between skeptics and global warming advocates.[136] In his innovative scholarship, Paul Edwards examines the history of climate models and the emergence of what he calls 'global data' to help scientists convincingly represent (or simulate) global climate.[2] This approach—which probes not only what we know about the climate, but also how and why we have come to know it—represents a unique approach to recent climate history. Edwards contextualizes global warming understandings in a way that takes a critical angle of analysis on meteorology and

climatology, while simultaneously demonstrating that skeptics are wrong to question climate science models today. Deborah Coen has also examined how climate models evolved, but in the period prior to World War I.[118] She shows how models emerged in a context of continental interactions among European empires, thereby illuminating the political dimensions of climate models and knowledge.

Another important aspect of climate science is the increasing emphasis on the combination of traditional ecological knowledge (TEK) or indigenous ecological knowledge (IEK) with western science in the detection of climate change impacts.[137–141] TEK involves diverse forms of knowledge—including technologies, beliefs, and skills—that enable local people to maintain their livelihoods by using natural resources and interacting with the local environment. The knowledge is passed among individuals and across generations through stories, oral histories, myths, narratives, rituals, and other cultural practices and communications. Integration of TEK with scientific observations to detect human and environmental impacts of climate change is important for several reasons—and it is highly relevant for historical climatology because TEK generally evolves through people's historical relationships with their physical environmental and through historically produced identities. First, it is essential to incorporate indigenous people's perceptions and voices into broader reports about climate change because they have had little responsibility for the causes of anthropogenic climate change, yet they have or will experience the consequences of it disproportionately. Second, TEK can help detect climate change impacts because elders and climate experts in indigenous communities possess knowledge accumulated over many generations that often focuses on areas without any scientific instruments to measure or observe the processes or impacts of climate change. Third, climate models often have low resolution at local and even regional scales, and this is precisely the scale at which indigenous observations emerge. Fourth, indigenous peoples in some cases are already experiencing the effects of climate change, and in some cases they have implemented creative ways of adapting to climate change from which others can learn. Fifth, indigenous peoples—like all human societies—are active parts of the ecosystems they inhabit and thus must be integrated into climate analyses. Sixth, historical power imbalances have marginalized both indigenous peoples and their knowledge; including TEK is more equitable and democratic.[138,140,142–146]

Cases in which TEK and scientific studies both detect the same phenomenon offer a higher level of confidence about climate change impacts and environmental change.[139,144] In Peru's Cordillera Blanca mountains, local residents and instrument-based scientific analysis both report increasingly rapid glacial recession, less snow in the upper watershed, and an increase of falling glacier 'blocks' since the latter half of the twentieth century.[147] Examples from the Arctic are the most common in literature on coupled TEK-scientific detection of climate change impacts. Inuit experts and scientists report changes in wind patterns as well as the thinning of multiyear sea ice, the shortening of the sea ice season, and the declining extent of sea ice cover.[139,145,148–151] While research demonstrates the important ways in which TEK can contribute to the detection of climate change, there are often discrepancies between TEK and scientific observations that indicate uncertainty in the identification of climate change impacts and the correlation of the two knowledge systems.[152] Nevertheless, the nascent incorporation of TEK into national policy discussions represents at least some change in the way climate science is viewed and demonstrating the situatedness of climate knowledge even today.

CULTURAL CONSTRUCTIONS AND PERCEPTIONS

By now scholars have well established that climate is both the physical characteristics of the climate system and a cultural construction that emerges from perceptions, meanings, spirituality, discourse, and distinct knowledge bases that vary in time and space.[4,7,153,154] Climate histories on these cultural constructions of climate tend to focus on perceptions and climate narratives. In their introduction to a 2009 special issue of the *Journal of Historical Geography* on climate narratives, Steven Daniels and Georgina Endfield explain that it is crucial to uncover diverse narratives because stories about climate emerge from 'a range of, often overlapping, forms of climate knowledge and citizenship, professional, popular, academic, indigenous, commercial and religious, and their relation to various forms of experience on the ground. As a discursive field, this includes many narrative forms, social memory, scientific modeling, economic forecasting and apocalyptic prophecy'[155] (p. 217). The editors of an anthology about climate history recognize that, in addition to diverse understandings and knowledge that shapes perceptions of climate, there are also shared beliefs that affect human responses, which they refer to as 'social memory'. As they explain, people survive and adapt to climate change 'by networks of social

relations through which they gain access to extra labor, food, and other resources, and by cosmologies and myths that preserve an unwritten record of past climatic episodes, successful responses to them, and proper relations to the environment'[156] (p. 5). Given this broad array of historical actors and perspectives, it is clearly important to understand not only whose view of climate is being scrutinized, but also how different social groups have understood and represented climate—and how those views among distinct groups have changed over time.

Climate perceptions vary widely among distinct groups of people, and these perceptions also change over time. Clarence Glacken's classic analysis of climate ideas from the Greeks to the Enlightenment presents both state of the art knowledge about climatic systems during those two millennia as well as changing understandings about how climate-affected individual bodies and societies more generally up through the eighteenth century.[157] During the onset of the Little Ice Age, for example, many Europeans believed the climatic variability that caused an increasing number of hailstorms and other crop-killing disasters was the work of witches. Tens of thousands of the so-called witches were burned at the stake or otherwise prosecuted because people blamed them for the inclement weather in the sixteenth and seventeenth centuries.[21,111] These perceptions thus had significant social and religious implications, leading to many deaths, singling out women, and showing how politics, crime, and spiritual beliefs intersected in the perception of and response to climate change. Julie Cruikshank, in another case, shows how geoscientists, Romantic poets, and indigenous peoples in Canada and Alaska expressed distinct ideas about causation for Little Ice Age climate change but actually, upon closer scrutiny, were actually conveying similar conclusions about environmental change.[158,159] Michael Bravo demonstrates the importance of situating climate change perspectives within the specific culture being analyzed, in his case the Inuit, because these groups not only have distinct understandings but also can have entirely different ways of explaining climatic and environmental change—and the role of humans in those processes.[160]

Understandings of climate can also be tied to national identities, as Jan Golinski shows for British identity during the Enlightenment.[161] Weather and climate meanings in Britain during this period had extensive roots and, as Vladimir Jankovic and Alvin Snider reveal, those ideas emerged from multiple, intersecting factors related to meteorology, local geography, religious beliefs, politics, and agriculture.[162,163] There were also multiple types of climates, and thus the emphasis on atmospheric climate misses important considerations of climates such as indoor air or place-based weather patterns as opposed to the global climate.[114,164,165] The history of meteorology also has many insights about weather, science, and society that are beyond the scope of this essay because its vast literature comprises its own subfield.[166]

Climate perceptions have also intersected with science in other ways. During the eighteenth and nineteenth centuries, medical climatology demonstrated the healing effects of certain climates and regions, such as the Mediterranean, European alpine regions, Caribbean highlands and wind-blown beaches, the British Hill Stations, or the US Southwest.[167–171] Climate, which was often tied to places up through the early twentieth century, was thus used to heal bodies and cure diseases, especially tuberculosis. Health travel has occurred for thousands of years, but it became more systematic and popular (and easier) after the eighteenth century. Whether seeking out the supposedly purifying air of the British sea coast, soaking in therapeutic alpine spas in the Alps, or escaping to the hypothetically healthier outlying areas around Cape Town, South Africa, Europeans and later North Americans have sought out many different climates and regions to heal their maladies over the centuries.[172–176] Scholars recognize that these perceptions of salubrious climates had as much to do with cultural factors as they did with medicine.[172] European views of the Caribbean tropical climate, for example, shifted dramatically over time. In the seventeenth century, many Europeans saw the tropical climate as morally corrosive and disease ridden.[177,178] By the early twentieth century, however, some parts of the Caribbean such as Barbados had transformed into one of the world's most desirable tourist destinations; medical breakthroughs, tourism opportunities, economic agendas, and travel preferences were all responsible for this transition.[167] Understandings of climate acclimatization during the nineteenth century also emerged from this combination of scientific and cultural perceptions.[179] Whether a European could acclimate to new climates, especially in tropical regions, had as much to do with the political economy of empires and cultural perceptions of the Tropics as it did with state of the art medical science on the subject.

Narratives of climate change that have varied across time and space continue to affect understandings of present-day climate change. Scholars, however, are just beginning to uncover the diversity of these narratives, not to mention their implications for social relations and power dynamics.

As Mike Hulme explains convincingly, climate science alone is not enough to explain either how we think about climate or why global warming has led to such rancorous debates in recent decades.[4] Climate is an idea as much as it is measurable, quantifiable weather patterns. And these perceptions of climate have changed considerably over time, for distinct peoples, and in different places around the globe. There are even narratives of denial that can block climate change adaptation.[180] As such, it is necessary to approach climate, as Hulme does, by scrutinizing diverse meanings of science, economics, values, and international politics when trying to pinpoint people's perceptions of climate change.

One of the most prolific narratives is that of global warming crisis, which parallels the declensionist narrative embedded in modern environmentalism. Climate narratives—and indeed much climate history scholarship—perpetuates the environmentalist tale of tragedy, natural resource depletion, and catastrophic collapse that has long been at the heart of the environmental movement.[181] Moreover, the dominant view among both environmentalists and those striving to mitigate global warming today is that climate change has resulted from the capitalist economy and the industrialized nations that have been ruining the earth and depleting its natural resources through unregulated, irresponsible pollution. Many in the global warming community use this narrative implicitly or explicitly in their efforts to curb emissions by regulating industry and slowing capitalist consumption.

Recent research is increasingly challenging this narrative because of its inherent power dimensions that can further socio-economic and political inequality. Diana Liverman challenges what she identifies as three dominant global warming narratives: the crisis narrative, the differentiated responsibility narrative, and the market solutions narrative. These narratives serve some people more than others, they have directed too much attention to international treaties and north–south disagreements, and they also promote neoliberalism and other market-based solutions rather than offering distinct solutions outside past practices.[10] For example, historical narratives of vanishing glaciers—a common motif of climate change stories—often serve particular groups such as scientists, conservationists, and tourists rather than local residents or marginalized populations.[182] And in some cases, the way this narrative of melting glaciers creates a vision of glaciers as vanishing water towers—as has been done in mountain ranges worldwide—can empower certain groups like hydroelectric companies and large-scale irrigators (and thus disempower local residents), even though glacier retreat has serious hydrologic consequences for all these social groups.[1] But in other cases, local residents in Peru, for instance, have mobilized the global narrative of climate crisis and melting glaciers to fight for their rights to water against a multinational energy corporation and the effects of neoliberal privatization. Although these local Peruvians used collective action to seize control of a large reservoir from Duke Energy, they gained international attention and support in part because they broadcast a (correct) story of vulnerable populations struggling to maintain water supplies below disappearing glaciers.[183] Historical scholarship on climate can play a unique and important role here in uncovering this diversity of meanings, narratives, impacts, and responses to climate change. It is the job of historians not only to uncover these histories in the first place, but also to help push their conclusions into broader discussions about climate change today.

FROM THE PAST TO THE FUTURE

The existing climate historiography contains many excellent advances in climate reconstructions, social impacts and responses to climate change, the uses and abuses of climate science, and cultural perceptions and narratives. Climate reconstructions have helped not only to uncover past climate data but also to utilize diverse, often under-examined sources and archives that can enrich historical climatology, broaden understandings of the past, and improve historical methods. Research on social impacts of climate change shows the power of climate and non-human nature to shape historical processes. But the most recent studies are careful to attribute societal change such as social conflict, demographic changes, agricultural transformations, political shifts, and economic fluctuations to both human and climatic variables. Climate, the research shows, intersects with other human forces that must be contextualized through rigorous historical investigations alongside climate studies. The history of climate science demonstrates innovation in the evolution of climatology and climate knowledge, as well as ways in which climate science can be used directly or indirectly toward other agendas, which often facilitate expanded state or elite power. Recent work especially by anthropologists shows the value of combining historically produced TEK with western scientific studies. The outcome not only improves knowledge of climate change impacts but also leads to a more equitable sharing of knowledge (and thus power) between historically unequal groups. Finally, the scholarship on cultural constructions of

climate across diverse societies and periods shows how predominant climate ideas and narratives can influence policy discussions, economic plans, power dynamics, and social relations. Climate is as much cultural as it is scientific or atmospheric.

For all its achievements on diverse topics and approaches, as well as vast coverage of the world, the insights about human–climate interactions emerging from this climate history scholarship are barely present in public discussions of climate policy, mitigation, and adaptation. These public and policy discussions have instead tended to concentrate in two broad areas: (1) climate science and the changing atmosphere, especially temperature change, with a strong policy focus on mitigating future warming through the reduction of greenhouse gas emissions; and (2) the great debate between climate skeptics and believers, with 'believers' compiling ever increasing quantities of proof of anthropogenic climate change and skeptics offering much strong rhetoric to say humans are not responsible for warming. The second topic has, in my view, partially derailed more than a decade of scholarship as many researchers have focused simply on proving and re-proving anthropogenic influences on climate change, rather than working out the nuances of the climate system or devoting studies to people's experiences with and responses to climate change. In this way, the skeptics have exerted an inordinate influence on the direction of climate research. The emphasis on climate science and mitigation raised in the first point, on the other hand, stems both from a widespread cultural valuation for science over humanities and social science research. But it also results from the dearth of scholars in the humanities and social sciences—compared to the physical sciences—who actually do climate research. The end result is a relative shortage of research and public policy discussions about real people's lived experiences with climate and their perspectives and beliefs, as well as an understanding of what drives or impedes adaptation to climate change and a deeper appreciation of the societal forces—not just the environmental and climatic forces—that affect people's vulnerability to climate change.

These are precisely the kinds of issues that emerge from the climate history literature. Historians and others doing historical climatology have begun to extract lessons from the past. These are not simplistic and misplaced ideas about history repeating itself. Rather, they are insights related to some of the most pressing issues in today's climate conundrum: adaptation, vulnerability, resilience, policies, and the attribution of impacts. Historians show, for instance, that *adaptation* to climate change is not going to occur simply because we know more science. Adaptation occurs (or doesn't) because of social relations, power dynamics, available technologies, beliefs, religion, and narratives of the past and future. *Vulnerability* will not be reduced simply because we better understand climate-related sciences, such as the potential for stronger hurricanes or the trigger mechanism of an avalanche or the rate of future sea level rise. Science and technology help reduce vulnerability significantly, to be sure—and as history proves. But, to a large degree, economics explains why hundreds of thousands die in an earthquake in Haiti compared to dozens in the United States. Vulnerability, like adaptive capacity, has to do with social divisions, economic inequality, power imbalances, access to insurance, and religious beliefs that might put environmental processes in the hands of gods not people. Societal *resilience* is another key concept in climate discussions today that historical research shows was not necessarily based just on the best science. Rather, reactions to climate change were often just that: reactionary. Decision making was tied to a host of socio-economic, political, and cultural variables often unrelated to climate or knowledge of climate science. New climate *policies*—or signatures on old climate treaties—are not going to occur just because there is better science to quiet the skeptics. In fact, past government policies built on the day's state of the art climate science sometimes fed imperialist agendas or helped justify racism. Climate knowledge does not always lead to the 'right' solutions; different social groups are affected differently, sometimes negatively, even when governments apply that knowledge to policies. Finally, we will not pinpoint the causes of climate change *impacts* solely by studying science. Climate change impacts, history reveals, must be attributed to multiple intersecting variables, including both environmental and human forces.

Despite the clear need to bring people (and those who study human societies) into climate change research and planning, climate science and scientists continue to dominate policy discussions and climate assessments such as the IPCC. What all these points call for, then, is both an incorporation of historical insights into present-day climate discussions and an even stronger societal focus in historical climate studies. This means more social histories and cultural analyses of climate change to illuminate how real people respond to climate change and how social relations, power dynamics, and ideas affect those responses. Other scholars have also stressed the importance of societal analysis in climate research, whether it is McNeill's recommendation

to study vulnerability more profoundly, or Howe's plea for humanists to investigate narratives and think more deeply and critically about climate discourse, or Chakrabarty's call for a 'negative universal history' that examines inequality and power discrepancies of particular peoples, or Wood's proposition of 'eco-historicism' that involves 'thick' descriptions of human–ecological micro-contact, or Crate's suggestion for anthropologists to do 'climate ethnographies'.[9,11,16,153,184]

But public debate and policy discussions have not followed these paths to the people. Mike Hulme warns that, far from including people, western societies have instead returned to a form of climatic determinism—what he calls 'climate reductionism'—that denies the presence of people in future scenarios portrayed primarily through mathematical models.[185] This reductionist portrayal of the future, driven by the hegemony of mathematical models and predictive natural sciences, is not only problematic because it erases human beings and reduces the future to simplistic, predictable outcomes. These grand narratives also privilege certain social groups over others; they neglect the analysis of power and social relations, and they deny the geographies of inequality that exist worldwide and shape divergent perceptions, impacts, and responses to climate change.[10,184] They also forget that real people face a host of other risks in their lives, and that they have to make choices about the future based on this rich assemblage of competing social, economic, livelihood, health, political, and emotional risks that may, at certain times, be more critical.[186] The field of climate history, which long ago shed the strands of climatic determinism, has put people directly into the climate equation and uncovered the forces that affect human–climate dynamics. But the climate historiography could also push farther into social and cultural issues.

Climate history research should thus engage with social history and cultural analysis much more profoundly—and this would strengthen the scholarship not only on recent histories of global warming but also those on the distant past that also frequently gloss over social relations and power dynamics. Social history, in this case, means explicit and detailed consideration of the traditional categories of analysis: race, class, and gender. It means studying work and labor, the family, ethnicity, rural and urban history, social movements, and all other aspects of society that delve into issues of social relations and power dynamics. It is not enough to say that the poor and marginalized suffer disproportionately from climate change. Who exactly are the members of those groups? How and why are they most vulnerable—and since when? Are there examples where socio-economic and political inequalities were overcome to help societies adapt to climate change? If so, how and why did they achieve it? Do some people tell divergent stories about climate beyond crisis narratives of doom and catastrophe? How do everyday people experience everyday weather? Historical research has begun to answer these questions, but it could go much further. So far there have been relatively few in depth social histories of climate change. There have been very few gender histories of climate for any period or world region.[179] There are even fewer studies of youth or children and climate.[187] Tackling these topics and answering these questions would put real people more explicitly into climate studies of the past. It would also enrich current discussions about the future of climate change by focusing more directly on social relations, culture, and power.

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