

ADVANCED REVIEW

Climate and colonialism

Martin Mahony¹  | Georgina Endfield²¹School of Environmental Sciences, University of East Anglia, Norwich, UK²Faculty of Humanities and Social Sciences, University of Liverpool, Liverpool, UK**Correspondence**Martin Mahony, School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, UK.
Email: m.mahony@uea.ac.ukEdited by Matthias Heymann, Domain Editor,
and Mike Hulme, Editor-in-Chief

Recent years have seen a growth in scholarship on the intertwined histories of climate, science, and European imperialism. Scholarship has focused both on how the material realities of climate shaped colonial enterprises, and on how ideas about climate informed imperial ideologies. Historians have shown how European expansion was justified by its protagonists with theories of racial superiority, which were often closely tied to ideas of climatic determinism. Meanwhile, the colonial spaces established by European powers offered novel “laboratories” where ideas about acclimatization and climatic improvement could be tested on the ground. While historical scholarship has focused on how powerful ideas of climate informed imperial projects, emerging scholarship in environmental history, history of science, and historical geography focuses instead on the material and cognitive practices by which the climates of colonial spaces were made known and dealt with in fields such as forestry, agriculture, and human health. These heretofore rather disparate areas of historical research carry great contemporary relevance for studies of how climates and their changes have been understood, debated, and adapted to in the past.

This article is categorized under:

Climate, History, Society, Culture > Major Historical Eras

KEYWORDS

agriculture, colonialism, empire, environmental history, forests, health, history of climate

1 | INTRODUCTION

In its capacity to colonise the deepest recesses of the human mind, climate must surely constitute one of the world's most successful imperial projects (Livingstone, 2015, p. 937).

Contemporary narratives of climate change concern the anticipation of temporal change in the mean values and possible extremes of global climate. At a regional or local level, these visions of global, temporal change are often translated into spatial analogues—for example, arguments are made that the climate of Great Britain is set to transform at some future point into something like that of the present-day Mediterranean. Spatial analogues have proven popular techniques for constructing and communicating scenarios of future climate change, both within science and in wider cultural discourses (e.g., Jylhä et al., 2010). This cultural concern with the migration of “regional” climates also has a historical analogue, in the history of European encounters with foreign climates during the period of European colonial expansion. Here, it wasn't climates which were on the move (although debates about climate change were prominent in colonial settings—see below), but people—most notably soldiers, sailors, missionaries, administrators, settler farmers, and laborers in various forms of bondage. Significant debates ensued about human adaptation to new climates, about understanding, predicting and perhaps taming climatic variability, and about the relationships between climate and new, trans-global forms of economic production and exchange.

A number of authors have recently surveyed the value to be gained for contemporary studies of climate change, and societal responses to climate variability, from reconstructions of past climates, where information is gleaned from colonial records, diaries, ship logs, missionary records, and so on (Adamson & Nash, 2013; Allan et al., 2016; Carey, 2012). Others have begun to study the influence of climatic factors on colonial life and politics, such as hypothesized links between climate and violence (Papaioannou, 2016). However, along with these material reconstructions of climate variability and its impacts, it is vital to bear in mind historical changes in conceptualizations of climate itself, and their impacts on the conduct of colonialism (Locher & Fressoz, 2012).

A growing strand of historical scholarship is examining intersections between climate and empire: the ways in which ideas about climatic difference and superiority informed racist imperial ideologies; the everyday practices by which settlers and administrators sought to understand and deal with the new climates in which they dwelled; and efforts to develop more formal, scientific knowledges of colonial atmospheres. This article reviews this expanding field of scholarship, focusing on work which examines how colonists made knowledge about weather and climate and put it to use in the administration and inhabitation of colonial spaces. In the following section, we briefly review established historical work on the ideological aspects of climate and empire before looking more closely in the subsequent sections at emerging work on climate and the practices of colonialism.

As a set of ideas and images about fundamental differences between the Western “Self” and its alien “Other” (Said, 1979), imperialism was (and is) made manifest in a variety of different forms of colonialism—the practices of domination, exploitation, and administration of alien lands and peoples (Young, 2001). Our focus here will be on the “formal” European empires which emerged in the early modern period and persisted until the mid-twentieth century, albeit with a certain bias toward the British imperial world. However, we will not attend only to histories of state-backed colonial practitioners; imperialism and colonialism were also practiced through a variety of economic, religious, and humanitarian means (Lambert & Lester, 2004), and emerging historical scholarship is showing how ideas about weather and climate informed the thought and activities of actors engaged in these multiple instantiations of imperialism.

2 | IDEAS OF CLIMATE AND IDEAS OF EMPIRE

Climate is “as much a philosophical concept as a material entity” (Endfield & Randalls, 2014, p. 36). Throughout the 19th and early 20th centuries, climate represented an “exploitable hermeneutic resource” (Livingstone, 2000, p. 93) used by writers and colonists to frame colonial experience and to give meaning to cultural and environmental distinctiveness (Howell, 2015). “Climate” has, at various times, featured both as an index of weather, stabilizing its vicissitudes into a sense of spatial and temporal coherence, and as an agent, exercising decisive influence on the forms of life which live under its meteorological regime (Fleming & Jankovic, 2011). Climatic determinism has loomed large in the intellectual history of the western world, affording climate agency in the shaping of human health, race, productivity, culture, politics, and conflict (Arnold, 1996; Hulme, 2011; Livingstone, 2002). Classical theories of climate dating back to Hippocrates have been reworked to explain the distinctive racial, pathological, economic, and moral characteristics between different parts of the world. In a European imperial context, climatically determined differences between human “races” and cultures were central to Western European self-conceptions of an inherent superiority over other peoples, offering to early expansionists apparently scientific grounds for believing in their own imperial sense of cultural supremacy. Ideas of empire were intimately bound with ideas of climate—a relationship perhaps best epitomized by Montesquieu’s observation that the “empire of the climate is the first, the most powerful of all empires” (Montesquieu, cited in Livingstone, 2012, p. 91).

Early European encounters with the tropics, from the 15th century onwards, raised new questions about the origins and global migrations of plants, animals, and people. In the writings of the Christopher Columbus and his associates, “[c]limatic explanations were easily seized upon to explain cultural behaviour and differentiation” (Grove, 1995, p. 154). Climatic explanations of human difference were shaped by two key ideas, collectively referred to as the tropical paradox—that of tropical abundance, and that of differential mortality. The idea of tropical abundance held that tropical areas, with their hot, humid climates and rich soils, were highly biologically productive, and that little human work was required to grow subsistence crops. Travellers like Sir Walter Raleigh sent home reports of tropical inhabitants eating only that which “nature” brings forth, and luxuriating amid the redundancy of hard agricultural labor. These ideas, solidified in the 16th century, had lasting effects on imperial policies and practices, perhaps most notably in taxation schemes which were designed to compensate for the oversupply of cheap, productive land which was thought to keep local wages too high (Curtin, 1990). Such abundant lands were nonetheless attractive places to take control of and exploit. More deeply, Europeans began to wonder whether their inhabitants, apparently free from the consequences of the biblical Original Sin, could even be considered as part of the same human family. Theories of polygenesis began to ascribe different origins to the diversity of apparent racial groups, while the supposed relationship between climate and the necessity of labor contributed to new ideas about the inherent physical and cultural superiority of Europeans. The more testing, fickle climate and relative resource scarcity of Europe had, it

was theorized, shaped a more hardy, energetic people, capable of sophisticated social and technological innovations in their struggle with their environment.

The Tropics, in contrast, were constructed as places of moral degeneration, places that fostered indolence and laziness, echoing earlier hypotheses postulated as part of the *Querrelle d’Amerique*, the historical dispute between European and American intellectuals over the apparent antiquity of the Americas, the size and strength of its animal and plant populations relative to those of the Old World, and the moral, intellectual, and physical capacity of its populations (Gerbi, 1973). Intertwined climatic, racial, and moral ideologies provided an enduring moral and ethno-climatological frame of reference that influenced colonial attitudes, images, tropes, and metaphors and afforded travel writers and commentators a “unique framework within which to explore national and imperial identity” (Taylor-Brown, 2016, p. 306; on analogous Japanese colonial attitudes to tropical climates, see Zaiki & Tsukahara, 2007). Ideas about the nature of different climates also powerfully shaped the emerging geographies of European imperialism. Geographer William B. Meyer argues that early British colonists of North America saw in the southern Atlantic seaboard a region inevitably akin to the Mediterranean, and which could therefore correct Britain’s trade imbalances in popular products such as wine, olives, and rice, while also perhaps sating a rapacious mercantile appetite for precious metals which were believed more abundant under a warm sun (Meyer, 2000; White, 2015). The South, therefore, attracted a moneyed, aristocratic, conservative Anglican elite keen on exploiting these new agricultural potentials, in strong contrast to the religious nonconformists who settled the north east. It was this social response to an assumed southern climate which, Meyer argues, led to some of the distinct cultural traits of the southern United States, as opposed to the climate itself, to which the culture and politics of the regions have often been attributed (Meyer, 2000).

The radical differences of the tropical environments which Europeans explored and colonized—and the apparent differences of the people who inhabited them—were also encountered through the lens of differential mortality. Before the emergence and acceptance of germ theory and the new science of immunology, the very different reactions of different groups to tropical environments reinforced ideas of inherent racial differences. European travellers and settlers struggled against diseases to which the local population appeared to have an inherent immunity, while the converse destruction of many local populations upon European arrival, though occasionally attributed to the cruelty and savagery of the invaders, by the 17th century was seen as a divine act, clearing the way for European colonization of tropical lands (Curtin, 1990). We look more closely at the entanglements of racial and medical climatology below, tracing their lineages through later periods of colonization. In the next section, however, we turn to what historians of science have learned about how this concern for colonial climates shaped emerging infrastructures for climatic knowledge making.

3 | COLONIAL CLIMATOLOGY AND METEOROLOGY

The spread of European meteorological techniques to colonial settings largely followed two tracks. One track saw early explorers, soldiers, medics, missionaries and, later, administrators, taking with them thermometers, barometers, and other bits of meteorological kit, as the recording of weather was positioned as part of the practice of making strange new environments legible to European sciences and states. Another track, gaining momentum rather later, saw more organized and institutionalized efforts to coordinate meteorological observation across global space. Historians have recently started to reconstruct these processes, with White (2015) for example showing how early European settlers in North America made a number of intellectual breakthroughs which laid the foundations for the later emergence of climatology. Such histories are beginning to show how, like other colonial sciences, the sciences of climate were not simply “tools” of empire: along with related sciences of race and health, they did not just serve to help enact “a project already imagined,” but helped bring “into being the colonial project itself” (Seth, 2009, p. 375; see for example Baker, 2018; Greer, 2015).

Globe-trotting mercantile and naval ships had long brought back to European metropolises observations of oceanic weather which started to be pieced together into new pictures of climatic patterns, not least of course the trade winds, which fundamentally shaped patterns of trade and exploration (Bankoff, 2017; Naylor, 2015; Schwartz, 2015; also Foxhall, 2010). In India and neighboring seas, early efforts to understand weather and climate were born of the demands of oceanic trade, of dealing with storms on land and at sea, and in India particularly, of reconciling imperial government with a monsoonal climate. For Grove, the year 1791 represents “the first occasion on which weather and agrarian observations made by scientific observers and others in the tropics were sufficiently elaborate and sufficiently coordinated...for some of the first speculations to be firmly made about global rather than regional climatic events” (Grove, 1998, p. 302). This was a product largely of the expanding reach of the East India Company (EIC), with new observations possible in colonies and trading posts across the globe, and by a number of EIC staffers who, inspired by the writings of Joseph Priestley and others, took with them a commitment to air and climate as vital elements of health, wellbeing and prosperity. By the 1810s, knowledge was circulating about simultaneous droughts in India, the Caribbean and the embryonic colonies of Australia (O’Brien, 2014a), with figures

such as EIC Governor of St Helena Alexander Beatson, formerly a military surveyor in India, becoming key nodes in new networks of meteorological knowledge production.

But this was all still subject to the interest and whims of enthusiastic individuals. The push for more coordinated observational efforts came later, as metropolitan savants expressed new enthusiasm for Baconian modes of thought and the collection of global climatic data in order to draw new inferences about the physical laws governing atmospheric processes. In 1836, Alexander von Humboldt urged the Royal Society to make better use of Britain's imperial reach in recording worldwide weather patterns (Brock, 1993). Historical attention has recently focused on the subsequent "magnetic crusade" of the 1840s, which saw the British establishing magnetic, meteorological, and tidal observatories at various key points around the empire, including Singapore, Bombay, the Cape of Good Hope, and Toronto. Sustained scholarly interest in this period has revealed how the cooperation of a variety of scientific, military, and commercial bodies was central to the imperial expansion of the "observatory sciences," and how a multitude of interests—few of them purely "scientific"—fed into the growth of imperial scientific endeavor (Aubin, Bigg, & Sibum, 2010; Carter, 2009; Cawood, 1979; Hall, 1990; Hunt, 1997; Locher, 2007; Marsden & Smith, 2007; Miller, 1986; Williamson, 2015).

Few of the observatories established during the Magnetic Crusade continued to function for long or continuous periods afterward (Williamson, 2015) and until the early 20th century, when the rise of international aviation saw meteorology become a crucial "infrastructural science" (Turner, 2010), only a limited number of European colonies had well-supported "weather services" (Mahony, 2016; Williamson & Wilkinson, 2017; for a brief but valuable discussion of the French colonies, see Duvergé, 1995). During the 19th century meteorological effort largely continued to follow shipping—Mauritius, for example, had a dedicated meteorological society from 1851 which compiled ship observations and, largely through the work of Charles Meldrum, ventured new hypotheses about the behavior of tropical cyclones (Island of Mauritius Meteorological Service, 1974). Such works of compilation continue to reward researchers, this time those endeavoring to reconstruct historical patterns of atmospheric circulation (Allan et al., 2016).

In the Australian colonies, meteorology was among the first sciences to be institutionalized, its practitioners serving "as important environmental interpreters for colonists and governments" (O'Gorman, 2014, p. 180). Antipodean meteorology is well recorded by historians, with institutional histories increasingly giving way to more nuanced accounts of the complex motivations behind meteorological knowledge production (O'Gorman, Beattie, & Henry, 2016). By the 1860s, all the Australian colonial governments had some form of institutionalized meteorology, and the rise of telegraphy meant that regional climates "took on abstract forms through isobar maps and statistical evaluations." In so doing, meteorologists "answered the calls of colonialism and modern science to know and categorize, and in so doing, control environments" (O'Gorman, 2014, p. 181). Further north, Zaiki and Tsukahara (2007) have shown how Japan's late 19th-century imperial expansion, conducted under a rubric of "scientific colonialism," was accompanied by a rapid expansion of meteorological observatories and an institutionalization of the science in imperial universities.

In New Zealand, formal meteorological observations began appearing in newspapers in the 1850s, displacing an earlier engagement with Maori weather knowledges and methods of foretelling, although evidence suggests that some of these methods—such as close observation of cloud formations—were picked up by settlers and continued to be used (Holland & Williams, 2014). Future research could profitably focus on these exchanges and hybridizations of knowledge within colonial "contact zones" (Pratt, 1991; Roberts, 2009). The evidentiary legacies of such knowledges, whether in the form of diaries, correspondence, or oral histories, are already being used to reconstruct regional and local climate change (Culver, 2014). The different ways in which people have been affected by and have coped with past climate variability is often embedded into local knowledge systems, passed down through generations in the form of memory, folklore, and cultural wisdom (Challinor et al., 2007). These knowledge systems afford crucial insights into climate-society interactions in the past, with important lessons for present-day debates about adaptation, vulnerability, and resilience (e.g., Endfield & Nash, 2002; Hannaford, Jones, & Bigg, 2015; Kelso & Vogel, 2015; Nash & Endfield, 2008; Nash & Grab, 2010).

Where reliable meteorological observations in the 19th century did exist, speculation about climatic cycles soon followed. Controversy reigned in Britain and India as to whether the periodic famines striking the latter could be understood through new methods of statistically analyzing sunspot cycles (Anderson, 2005; Porter, 1986, pp. 274–278). But the search for cycles was not just about anticipating fickle colonial climates. It was also an effort to make sense of an emerging global economy, shaped by the contours of European imperialism, and to understand how the new "national" economies of places like Australia and India fitted into the warp and weft of new global patterns of trade and profit. As Mirowski (1984, p.346) argues, William Stanley Jevons' work on sunspot cycles, often derided as an intellectual aberration, should instead be considered as part of a unified intellectual project to "portray the market as a 'natural' process, so that doubts about its efficacy would be assuaged, or at the very least, countered by scientific discourse." New understandings of a global climate system were being coproduced with new understandings of a global economy.

Katharine Anderson (2005) shows how for British meteorologists in 19th century India, the vast expanse of British-controlled territory offered the prospects of the kind of synoptic insights starting to be developed in continental North

America, as well as a proving ground for a new relationship between (meteorological) science and the state as “mutually reinforcing models of rational order”—a relationship at that time deeply troubled in Great Britain (Burton, 1986; Walker, 2012). In India, the practice of meteorology was seen as a hallmark of “civilised government,” and was suggestive of the kinds of administrative centralization then being sought in other areas of the British administration: “The atmosphere, like empire, required discipline on a monumental scale” (Anderson, 2005, p. 284). Meteorological observation techniques had spread across India, often following 19th century agricultural modernization schemes (Hazareesingh, 2012). By the late 19th century, the meteorological discipline described by Anderson—standardized observations, racial hierarchies of observers, globally circulating datasets—had been starting to yield results in the identification of large-scale atmospheric “teleconnections” (to use a later term) with relevance to the periodic failures of the Indian monsoon, with cooperation between meteorologists in India and Australia at the heart of new networks of data exchange and comparison (O’Brien, 2014a). But while 18th- and early 19th-century surgeon-naturalists like William Roxburgh were freely critical of the imperial power’s response to famine and climatic stress (Grove, 1998), the late 19th century effort to more precisely describe the atmospheric dynamics of monsoon failure and drought served, for Mike Davis, to help naturalize famine. If famine could be “scientifically” attributed to natural physical causes—as opposed to questions of political economy—the empire would be relieved of direct responsibility for India’s devastating famines, while also being emboldened in its efforts to understand, predict, and manage tropical environments (Davis, 2001).

Meteorology was, however, far from the preserve of imperial states. Insurance companies played a key role in producing and disseminating claims about the nature and salubrity of distant climates (Kneale & Randalls, 2014). Church missionaries, akin to other “non-scientific laymen who... travelled abroad,” were often derided by contemporaries as being “trained in dogmatics rather than in the methods of scientific investigation” (Baker, 1924, pp. 373–374; Harries, 2007). The missionary frontier, however, often ran “ahead of empire” (Barker, 2005, p. 86), and it follows that representatives of various missionary societies functioned as explorers as well as evangelists. They provided some of the earliest reports on distant environments and peoples, while their “long term residential topophilia” provided them with a unique, first-hand insight into the “physical and cultural geography of the landscapes that they inhabited” (Livingstone, 2005, p. 51). Missionaries, particularly Jesuits, were prominent proponents of meteorological science across the globe and their written legacies have begun to be used for material climatic reconstruction as well as for investigating prevailing climate theories and knowledge systems (Daston, 2008; Endfield & Nash, 2005, 2007; Harries, 2007; Lüdecke, 2005; Udías, 1996; White, 2015).

As Gregeory Cushman (2013) has shown, Jesuits in particular made major contributions to the understanding of phenomena such as tropical storms (also Udías, 1996). They were active hurricane forecasters in the Philippines and Cuba, where clashes of predictive authority with rival Spanish and American empires were frequent. However, Pietruska (2016) has recently demonstrated how in the Caribbean at the dawn of the 20th century, American meteorological hegemony was reasserted, largely under the guise of military security interests, but with practices quickly turning to agricultural intelligence and to the securing of profits for American investors. In the early 20th century, as understandings of global atmospheric patterns grew with the spread of telegraphic networks on the ground and under the sea, the rise of aviation saw renewed efforts to comprehend the atmosphere as a three-dimensional space which could be safely traversed by aeroplanes and airships. While the United States perhaps led the way in the establishment of aeronautical meteorology as a behind-the-scenes “infrastructural science” (Turner, 2010), British hopes that its empire could be tied together by a new network of airships and aeroplanes saw the establishment of new colonial meteorological services in places like British Malaya and British East Africa, often on a federal basis, as emphasis shifted from understanding regional agricultural climates to the provision of synoptic forecasts over wide areas (Mahony, 2016). In South America, neocolonial competition between American and German aviators created different patterns of meteorological expansion. The maritime meteorologists of the Deutsche Seewarte helped cement German dominance of South American aviation in the early interwar period, but this was soon subverted by the rise of Pan-American Airways and associated networks of private meteorological services (Cushman, 2005, 2006). The South Pacific represented another interwar “contact zone” between different national meteorological networks, with New Zealand’s weathermen appealing to the imperial metropole for help in establishing a comprehensive “all British” meteorological infrastructure in the Pacific. Expanded meteorological networks could open the airways to national conquest, while also guaranteeing expanded infrastructures of observation and communication which could be vital in times of war (Henry, 2014, 2017).

This upscaling of interwar climatology and meteorology was not, however, universal. The collapse of the Austro-Hungarian Empire following World War I saw the spatial horizons of Austrian meteorologists and climatologists shrink accordingly. While Austrian imperial climatology had accorded with a broader imperial epistemology of seeking unity in diversity (Coen, 2016), climatology in the Austrian republic focused on new, smaller-scale targets—the microclimates of mountain resorts and the “artificial climates” of cities and spaces of work (Coen, 2006). The Austrian case provides further evidence for how the evolution of meteorology and climatology in different places was shaped by local and trans-local structures of political power, the spatial coordinates of atmospheric knowledge making shaped by the spatialities of rule

(Coen, 2011; cf. Lehmann, 2017). The multinational history of polar meteorology and climatology likewise illuminates this dynamic of coproduction between science and sovereignty (Doel, Friedman, Lajus, Sörlin, & Wråkberg, 2014; Howkins, 2008, 2011; Lajus & Sörlin, 2014; Turchetti, Naylor, Dean, Siegert, 2008).

4 | THE COLONY AS LABORATORY

European colonies were spaces where new forms of political, social, economic, and environmental order could be tried out, “living laboratories” where expectation, experimentation, and experience collided in efforts to remake the world (Tilley, 2011). In this section, we review work which has examined how imported understandings of climate clashed with lived experience, how assumed relationships between climate, health, and place were transformed by the colonial enterprise, and how experiments in agriculture and forestry spawned new knowledges of climate.

4.1 | Imported understandings

Despite the significance of formal meteorological knowledge-making, colonial life was often shaped more fundamentally by more vernacular knowledges of climate. The imagined geographies of imperial spaces and their climates were frequently at odds with reality and lived experience (Livingstone, 1999, 2000; White, 2015). Recent work by Australasian environmental historians, for example, had shed new light on how expectations of colonial climates often differed radically—and consequentially—from reality (Beattie, 2011; Beattie, O’Gorman, & Henry, 2014; Fenby, 2015). In New Zealand, the country’s potential to be a “neo-Europe,” based on a similar climate, rubbed up against the slow realization of very different meteorological particularities (Beattie, 2003, 2014; Holland & Williams, 2014; Holland, Wood, & Dixon, 2009). Early settlement boosters in New South Wales promoted a climate and soils which would be familiar to the British, and which were ready for easy taming by both farmers and convicts. But expectations of a British-style climate led to serious misconceptions and maladaptation to extremes. A dry period from 1790 to 1793 motivated settlement along the Hawkesbury River valley, which then suffered repeated flood devastation when rains returned, while British definitions of drought, such as a month without rain, did not sit easily with the new climate, wherein drought would later come to be defined as a sustained period of low rainfall impacting upon environment and society (Gergis, Garden, & Fenby, 2010; Meinig, 1962). Fenby, Garden, and Gergis (2014, p. 50) suggest that “Persistently comparing Australian climate with the familiar climate of England hampered colonists’ ability to understand weather in the new continent.” In the meantime, settlers to Australia’s northern coast brought with them conceptions of a “clockwork” climate, switching between two seasons with a predictable regularity that greatly contradicted local aboriginal concepts of seasonality, and, in retrospect, climatological data (O’Brien, 2014b). Similar processes of hopes and expectations dashed by colonial experience were at work in Western Australia. Ruth Morgan, through her study of narrative accounts of the 1914 drought in Western Australia, reveals the persistence of a “pioneer mythology” of resilience and adaptation that overlooked other more poignant stories of loss and deprivation linked to drought (Morgan, 2014, 2017). Like in the United States (Meyer, 2000), the hardships of coming to terms with a new climate shaped emerging senses of national identity, contributing for example to “a growing nationalist literary and artistic tradition that portrayed pioneering hardship as fundamental to the development of a sense of national character” (Garden, 2014, p. 72; also Berland, 1993).

4.2 | Climate, health, and place

Geographical discussions of climate matters in the 19th and early 20th centuries were linked to issues of empire, ethnicity, and also health (Edmond, 2005; Jankovic, 2006; Livingstone, 1999). Moral discourses linking ethnic constitution to regional climatic characteristics (Curtin, 1964; Driver, 2004; Driver & Yeoh, 2000; Kennedy, 1990; Livingstone, 2000; Naraindas, 1996) were interwoven with theories of European acclimatization or the ability of European civilization to adapt to “alien” environments (Howell, 2015; Livingstone, 1987; Osborne, 2000). Certain aspects of the climate were thought to have a particularly deleterious effect on the health of Europeans. The heat, sun, and supposed humidity then associated with the tropics was cited as a major reason for “southern sickliness” (Kupperman, 1984, p. 213). Fears abounded that prolonged residences in such environments would result not only in physical deterioration, particularly among women and children (Bell, 1993), but would also cultivate a “low sense of morality” (Livingstone, 2002, p. 168).

Anticipative pathological geographies of the first half of the 19th century positioned many parts of European empires as being among the most inauspicious for human development and among the most hazardous for European constitutions (Kneale & Randalls, 2014; Naraindas, 1996; Wheeler, 1999). But the colonies also represented testing grounds for debates about acclimatization, health, and wellbeing (Osborne, 2000). For much of the 19th century, for example, the link between climate and disease was “absolute,” and so it was essential that the climates of new realms were understood first and

foremost (Kupperman, 1984, p. 238). Facts were collected by colonial enterprises about the state of health of individuals and after a time, and no doubt reflecting concerns over the rapidity with which their employees were invalidated, inferences between health and factors such as weather, work, diet, and exposure were drawn (Endfield, 2011).

Savage (2004) has highlighted, however, how engagement with other parts of the world resulted in the identification of favorable and unfavorable, healthy and unhealthy locations, comprehended on the basis of similarities or differences to the temperate world. Imperial discourses effectively “normalized” the environmental characteristics of other places against the measured standard of the temperate zone. Perceived variations in salubrity were recognized with different latitudes and topography. Some countries such as West Africa or New Guinea were identified as “the white man’s grave” (Eves, 2005; Mathe-Shires, 2001), and tropical plains generally became associated with disease and pestilence. Central, eastern, and southern Africa were considered more favorable. Cooler, more temperate mountain regions were also considered to be more favorable for European constitutions, a recognized differentiation that contributed to the development of a perceived spatially-varied pathological geography or “medical topography” (Harrison, 1996). Medical officer and topographer J Grier-son for example, writing in the *Transactions of the Medical and Physical Society of Calcutta*, in relation to health problems which had disabled his regiment, identified variable levels of salubrity across South Asia accounting for patterns of ill health among his troops, both indigenous and British (Jepson, 2004).

This dehomogenization of empire in pathological terms brought opportunity as well as threat. Some colonies or topographic features within colonies began to be identified as places offering “climate therapy” for those invalidated back home through old world disease or indeed those whose health had been diminished elsewhere in the colonies. Much has been written, for example, on the development of hill stations in India, the Caribbean highlands and various parts of Africa (e.g., Adamson, 2012; Carey, 2011; Kenny, 1995; Njoh, 2008), and mountainous regions in the tropics generally were recognized as key sanatoria for some of the world’s most problematic diseases (Carey, 2014). By the second half of the 19th century, temporary stays in some colonial destinations such as Australia, New Zealand, and the Cape Colony also offered a retreat from degenerative diseases such as tuberculosis, then associated with crowded urban environments in Europe (Bell, 1993). In her study of domestic healthcare in colonial New Zealand, Joanna Bishop notes how that particular British colony “appeared to be the antithesis to the diseases ravaging the British Isles” and was “promoted as an inherently healthy land” whose climate was considered to be beneficial to the British constitution (Bishop, 2014, p. 5). Recent work in the Americas has highlighted how the city of Jauja in Peru served a similar function, and “was one of the most acclaimed places to cure the disease through climate therapy” (Carey 2014, p. 796). As Carey (2014, p. 798) shows, “various constructions of climate were appropriated and used by various groups- not only physicians promoting the health benefits of high elevation Andean climate - but also politicians, entrepreneurs, the Lima elite and economic developers seeking scientific justification for their endeavours in the Andes.” Recent research, however, has also highlighted the importance of health in motivating European emigration from colony to colony, for example, from the unhealthy tropical plains of India to Australia, New Zealand, and South Africa (Beattie, 2012). Hill stations across Australia and New Zealand in particular became places where the public health of British administrators and military personnel could be restored through seasonal furlough and, as Beattie (2012, p. 105) notes, “officials in Australia’s fledgling colonies, along with those in New Zealand and South Africa, clamoured to attract wealthy white settlers from India,” commonly sounding “a note of alarm by playing on the dangers of India’s climate while reassuring migrants of their own colony’s salubrity.”

Cartographers, surveyors, and medical topographers all played a key role in constructing understanding about imperial spaces, identifying localities for optimizing acclimatization, and selecting landscapes which could offer opportunities for European adaptation to climates and tropical environments in colonial possessions (Jepson, 2004, p. 140). This offered an important “counterpoint to the metropolitan scientific community in London” (Jepson, 2004, p. 145) through local field observation and experience. Indeed, as Johnston (2013, p. 443) has recently indicated, the more nuanced appreciation of the pathological geography of place in the colonies helped influence the locations and layouts of towns, cities, and residences.

As the extent of imperial investment overseas expanded through the second half of 19th century, so did the body of medical texts, guides, and manuals offering advice for the colonist, be they soldiers, emigrants, laborers, or officials, on what to eat, what to wear, and where and how to live. Ryan Johnson highlights how “everyone from scientists and physicians to missionaries and administrators was bombarded with relentless advertising and abundant advice about the outfit needed to preserve health in a tropical climate.” Studying this “advice” affords insight into the changing understandings of, and attitudes toward, the health implications of living and working in the colonies, and highlights how commodity cultures reinforced imperial stereotyping. The so-called Tabloid medicine chests were regarded as “must have” pieces of travelling equipment, while manufacturers’ propaganda for these items served to reinforce images of the tropical colonies as pestilential, highlighting disease to be the “worst menace” in the tropics. The Tabloid chest, however, was marketed as not only rendering travellers “safe,” but also—like the hill stations—to mark them out as being “superior in Britain’s tropical possessions” (Johnson, 2008, pp. 71–72). In fact, with a progressive shift from monogenic to polygenic thinking, it became important to use European material culture to mark out and identify the distinction between colonizer and colonized, “legitimizing the rule of

a few over many” (Johnson, 2008, p. 73). Recent work by Howell et al. (2013) has focused on the hitherto little studied role of British nurses working in colonial locations and the way in which “the tools” of personal as well as public “hygiene” were used to create “physical and cultural boundaries around her white patients and herself, setting colonists apart from their colonial setting” (p. 338).

Creating distinction and superiority in the colonies became more important throughout the second half of the 19th century and was manifest not only in clothing and medicine, but also lifestyles and the built environment which the colonists created. Chang and King (2011) identify a genealogy in the development of distinctive tropical architecture which is inextricably linked to shifting climatic, racial, and medical discourses. Three “moments” are identified. In pre-19th century India, for example, tropicalized stereotypes focused on “adaptation and transculturation,” whereby indigenous concepts and initiatives, such as the bungalow, and interior mechanisms for “climate control” such as verandahs and punkhas were adapted by European colonists. By the early 19th century, with an erosion of the “previous reverence for indigenous knowledge,” there was a shift toward a metropolitan-designed tropical architecture that sought to protect Europeans from miasmatic threats, symbolically also addressing the “widespread anxieties about the degeneration of white bodies in the Tropics” by establishing “a visible assurance of the colonists’ cultural identity” and a separation and distance from indigenous practices and ways of life. This phase coincides with “bodily interventions” linked to colonial clothing. Planning policies likewise found expression as instruments of power, domination, and social control in urban space in colonial Africa (Njoh, 2008). By the early 20th century, however, new developments saw sanitary and housing improvements which were not restricted to European colonists but their employees too, albeit “not out of benevolence but because of economic calculations” - the workers being central to tropical economic production. Designs themselves were still heavily influenced by long standing climatic medical theories, despite the advent of germ theory around the turn of the 20th century (Chang & King, 2011, p. 295). Indeed, while these discourses are very mobile from the 18th through to the 20th century, they do all privilege climate as a key influence.

4.3 | Climate, agriculture, and forestry

Colonial expansion was intimately linked to the transfer and acclimatization of plants (Crosby, 2015; Osborne, 2000; Ross, 2017) and these transfers were always accompanied by circulating ideas, knowledge, and scientific techniques (Beattie, Melillo, & O’Gorman, 2015; Flikke, 2016). Toward the end of the 18th century, for example, important innovations took place in colonial agriculture and a new network of botanical gardens emerged which played a central role in the ecological and agricultural transformations of the European empires. Botanical gardens had emerged in early modern Europe to support both an expanding medical profession and theological missions of recreating the lost Garden of Eden (Prest, 1988). Imperial botanic gardens, however, were pivotal to the plant exchanges and scientific developments that resulted in the introduction of new plantation crops in the colonies (Brockway, 1979, p. 450; Drayton, 2000). The establishment of the Calcutta Botanic Garden in 1787 was motivated in large part by the wish to gather together drought-resistant types of popular crops, and to then distribute them to regions threatened by famine (Grove, 1995). The Botanic Garden was a means of building resilience to a capricious climate, and thus of shoring up the legitimacy of the colonial state. Nonetheless, key figures in the network of imperial and colonial gardens were often the most vociferous critics of the environmental impacts of colonial rule (Grove, 1998; see also Cushman, 2011).

Botanic gardens were sites of experimentation in acclimatization and played a key role in generating and disseminating useful scientific information worldwide on a hitherto unprecedented scale (Osborne, 1994). There were similarly ambitious experimental arboreta and plantations across many colonies and the types of trees introduced to colonial landscapes provide additional insight into prevailing climatic and medical understandings. As Bishop notes for New Zealand, for example, nurserymen, botanists, agriculturalists, and gardeners introduced medicinal plants and many popular species used regularly by British practitioners, such as dandelion, plantain, and dock, naturalized easily and readily in their new environment (2014, p. 10). Botanists believed “eucalypts helped to cure malaria and other tropical diseases by both draining swamps because of their vigorous growth and through the secretion of their scented powerful oils which subscribers to the miasmatic theory of disease believed would kill malaria” (Bennett, 2011a, p. 269). The olfactory benefits addressed concerns over noxious miasmas while providing, as Flikke (2016, p. 25) notes, “airborne ‘paths’ which promised physical restoration, health and well-being as settlers negotiated the treacherous alien terrain with an eye to the ground and nose to the air” (see also Ingold, 2010). Not surprisingly, eucalyptus trees were “a ubiquitous presence on many southern Indian hill stations,” but were also introduced to hill stations elsewhere in New Zealand and Australia as a result of their health giving properties (Beattie, 2012, p. 114). Towards the end of the 19th century, scientific forestry and forest conservation policies were emerging across the European empires, supported by a range of ideological rationales. In a dominant European colonial imaginary, for example, treeless landscapes were considered a sign of cultural inferiority, despite the fact that around the same time, the “shrinking forests of Europe were taken as a sign of European technological and cultural superiority” (Flikke, 2016, p. 22). The drive to conserve forests among colonial governments was motivated to a large extent by desiccation theory and the belief that forest

protection and planting would “improve” local climates (Barton, 2002; Davis, 2004; Grove, 1995), along with the economic imperatives of administrations keen to monopolize and maximize revenues from forested lands (Bennett, 2015; Rajan, 2006). As well as new revenue streams, colonial forestry gave rise to new knowledges of climate. Environmental historian Brett Bennett has argued that 19th century foresters in Australia and South Africa saw climate as the key factor in experiments with new trees, often to the ridicule of their European contemporaries. The mantra “fit the tree to the climate” arguably dictated the Cape Colony’s forestry policy at the turn of the century, with figures such as David Ernest Hutchins, C.-B. McNaughton, and Harold Fulcher Swain developing new techniques of comparative climatology to elucidate, for example, which Australian species might best be grown in different regions of South Africa (Barton & Bennett, 2011; Bennett, 2011b). This comparative approach had long been at the core of colonial knowledge making: “According to James Hector, the [New Zealand] government scientist, the principal aim of collating standardised meteorological observations was to facilitate comparison of the New Zealand climate with that of other countries” (Holland & Williams, 2014, p. 87). While earlier forms of settlement and agricultural policy in the British Dominions had been motivated in part by ideas of climatic similarity between Britain and her new possessions, by the early 20th century ideas of climatic equivalence were emerging between colonies and dominions themselves, informed by these comparative climatologies. In 1924, C.C. Robertson of the Research Branch of the Cape Colony’s Department of Forestry was sent to Australia to investigate the provenance of imported eucalyptus species growing in South Africa and returned with a map that “transposed the latitudes of each country onto each other”, intended to help Cape foresters “visualise more clearly how the two countries’ climates potentially overlapped” and thus identify “climatically matched” species (Bennett, 2011a, p. 276).

But efforts to reconcile colonial expansion with climatic conditions were not just about the simple production and application of knowledge. They were often characterized by struggles over scientific and political authority. For example, in mid-19th century South Australia, the “rainfall line” drawn by government surveyor G.W. Goyder became a lightning rod for disagreements over the place of expert knowledge in government policy. Goyder’s line, which marked a zone of decreasing rainfall reliability, was swept up into arguments about demarcations between agricultural and pastoral land uses, amid pressure to expand permanent settlement and farming and in the context of ideas that settled farming would enhance rainfall levels (Douglas, 2014). By the late 1870s “the whole concept of any rigid ‘nature’s’ limit was being replaced by the idea that man’s actions could and/or were overcoming nature’s deficiencies” (Meinig, 1961, p. 212). But by the early 1880s, Goyder had apparently been vindicated. Yields fell, rain never followed the plough, and drought took hold again. As Donald W. Meinig and Kirsty Douglas have both shown, the epistemic struggles over land and climate in South Australia were also struggles over the rights of a colonial government to regulate settler behavior, over the relative authority of climatological, ecological, and agricultural expertise, and over the relative power of official expertise as opposed to “folk experimentation” in new landscapes. Then, as now, debating climate and climate change was also to debate the rights of experts and governments to draw lines and limits around people’s behavior.

5 | COLONIAL CLIMATE CHANGE

If colonies functioned as a kind of laboratory, then the ability of humans to directly influence the climate was one of the chief objects of observation and experimentation. In colonial America, the vagaries and extremes of climate were often attributed to divine intervention, from God punishing early settlers for their deviations, to Almighty assistance—with fogs or rain storms—in the War of Independence. But a shift from religious to secular interpretations of climatic processes accompanied America’s rejection of British rule. The poet and politician Joel Barlow identified in *The Columbiad* the limiting forces of climate, of flood and frost, with the yoke of British imperial rule, and exclaimed that political independence would also mean freedom for Americans “to conquer the land and the atmosphere,” to put the genius of science to work in taming the climate in which the young nation would emerge triumphant (Meyer, 2000, p. 41; also Golinski, 2007). In so doing, Barlow touched upon a number of debates about the potential of climate not just to shape human affairs, but for human actions to shape climate.

As historians Christoph Bonneuil and Jean-Baptiste Frescoz (2015, p. 176) have recently argued, “European colonial expansion played a key role in the emergence of reflection on anthropic climate change.” As the European powers expanded in all directions of the compass, new questions were raised about why climates on similar latitudes could be so different, most notably on opposite sides of the Atlantic, and crucially whether humans had any hand in making them so (Cushman, 2011; Fleming, 2005; Kupperman, 1982; Meyer, 2000; White, 2015). Much debate revolved around the links between forests and climate, and the possible impacts of deforestation on climates at local, continental, and even global scales. Some understood the seemingly moderate, benign climate of north-western Europe as being a product of centuries of deforestation, and this informed a drive to “improve” the seemingly more capricious climate of eastern North America through the large-scale felling of forests and the drainage of swamps. Early European settlers struggled to understand the causes of north-eastern

North America's harsh and volatile climate according to classical ideas of latitudinal gradation. While a number of boosters sought to play down the hardships of the New England winters and the sweltering summers of the southern colonies, others reasoned that the European climate had been tempered by millennia of deforestation and cultivation, while the North American continent remained raw and untamed. John Evelyn, a councilor of the Royal Society, argued in his 1664 work *Sylva* that the high humidity levels of North America and Ireland, and their associated negative effects on settler health, could be attributed to the dense forests, which attract rainfall and mists. Cutting these forests would moderate the rainfall and improve the soils and airs—a process which he argued was already underway in New England following just a few decades of settlement (Fleming, 2005). These ideas of climatic improvement became central to the colonial enterprise, resting as it did on claims that Europeans had a right, even a duty, to “civilize” both barbarous peoples and wild nature (Golinski, 2007; Siiskonen, 2015). With John Locke promoting cultivation as the hallmark of the relation between land and property, climatic improvement took a central place in the ideological underpinnings of European expansion (Thompson, 1980).

These arguments were not uncontested. Vogel (2011) reports correspondence in the *Transactions of the Royal Society* which challenged claims of anthropogenic warming in the North American colonies, citing similar temperature trends in Ireland—a colony then “lying fallow after the Cromwellian Wars and the difficulties of the Stewart Restoration” (p. 116), with processes of land clearance and deforestation going into reverse. Historians of this period have paid only modest attention to the knowledge-making practices which underpinned these claims and counterclaims of climatic change. This is partly a function of available sources—personal observations and testimony jostled for authority in the early modern period, before the rise of coordinated, instrumental meteorology and climatology. Our histories of knowledge practices are therefore largely limited to later periods when questions of scientific method came to the fore in settler engagements with colonial climates. Important questions remain: how certain accounts of foreign or changing climates acquired authority while others did not; how personal, bodily experience intersected with proto-scientific forms of observation and recording (Matson, 2017); and the effects of changing publication practices on the cultural circuits through which climatic claims travelled across continents and oceans.

While debates about forests and anthropogenic climate change predate the European settlement of North America, and are traceable to antiquity (Hughes, 1985), the climate-forest issue arguably only became a coherent body of thought in the 18th century. John Woodward's development of the concept of transpiration in the late 17th century, and its later refinement by Stephen Hales and Count Buffon, undergirded new concerns about the links between forest vegetation and the atmosphere (Grove, 1995). While in North America deforestation was seen for a long time as a way of improving the climate, elsewhere forests came to be seen more favorably. As regulators of the exchanges of moisture between land and atmosphere, forests had the effect of usefully drying wet regions, and of bringing moisture to otherwise dry areas. In this view, deforestation represented a rupture in the natural and providential order of things, and climatic protection was cited as one of the major motivations behind early efforts at forest protection in Europeans colonies and territories such as St. Helena, Mauritius, India, and New Zealand (Barton, 2002; Beattie, 2003; Ross, 2017). Bonneuil and Fressoz (2015, p. 179) suggested that “From the 1820s on, a powerful discourse of what could be called ‘climatic orientalism’ warned the European states against deforestation and climate change by recalling the ruins of brilliant civilizations now surrounded by desert.” Forest conservation could preserve rainfall, prevent flooding and soil erosion, and thus ensure the sustainability of civilizational dominance.

In 19th century Australia, newspapers expressed general support for the theory that forests shaped local climates and should thus be conserved. From 1870s, Indian foresters began to arrive in Australasia as they took up jobs in emerging forestry bureaucracies, and they shaped environmental debates in profound ways (Barton, 2002; Beattie, 2011). But dissenting voices also started to emerge, whether from settlers who subscribed to “rain follows the plough” (Douglas, 2014), or from those who advocated, echoing earlier North Americans, deforestation for climatic improvement in more temperate zones like Tasmania. However, the emerging meteorological establishment began to challenge ideas of human influence, leading to epistemological conflicts over the best way to make sense of a changing climate—close meteorological monitoring, of the kind seemingly practiced by the German Forestry Service from 1875, or place-based historical knowledge of changing landscapes (Legg, 2014).

In the mid-19th century, there was still little support for forest conservation in Britain's colonies forthcoming from London, but the initiative of the likes of John Croumbie Brown, Colonial Botanist at the Cape Colony, saw local legislation put forward on conservation measures (Beinart, 2008; Siiskonen, 2015). In Dhawar in western India, where meteorological observation had expanded during the 1850s alongside experiments with new cotton varieties, concerns about the local climatic effects of rapid deforestation, and about the sensitivity of imported cotton strains to climatic stress, combined to produce new modes of governmental intervention in the environment. Alexander Gibson, Superintendent of the Dapuri Botanic Garden in Poona, drew on the experiences of local farmers to argue that the climate was becoming drier and more hostile. Gibson would go on to become Conservator of Forests for the Bombay Presidency, an institute set up as part of a wider move toward climate protection, but he soon found his conservationist instincts met with an often contrary demand from the colonial government for timber revenue (Hazareesingh, 2012). Nonetheless, “climate theories that explained how forest lands

affected rainfall, along with soil preservation, water flow, animal life, and the preservation of a variety of forest flora and fauna made forestry the most pressing environmental issue of the late 19th and early 20th centuries” (Barton, 2002, p. 9).

5.1 | Climate control

Climatic variability was a constant cause for concern for both indigenous societies and European colonists. Both groups, however, comprehended and responded to this variability within the frameworks of their own climatic philosophy. The imperial positioning of climate within what Livingstone (1991, 1995, 2002) has referred to as a “moral economy,” for example, and particularly the association of drought with wayward indigenous practices, has been discussed elsewhere (Davis, 2004, 2007; Endfield & Nash, 2002). Indigenous societies in many parts of colonial Africa, however, conceptualized and responded to climatic variability within their own ethno-climatic frame of reference. Rainmaking ceremonies were among a number of key drought responses among indigenous communities in central southern Africa (Landau, 1993, p. 3), even if such practices were considered by early colonial settlers, specifically missionaries, to be indicative of heathen superstition and, as such, a barrier to the civilizing mission.

From the colonists’ side, anxieties about extreme climates, and their apparent changeability, combined with imperial confidence in human power over nature to inform a number of fantasies of climatic control. The German architect Herman Sörgel’s scheme for the damming of the Mediterranean and the engineering of African climates is a particularly noteworthy example of a colonial dream of climate control which, although never realized, gained great cultural traction and was reworked for a variety of political contexts—the Weimar Republic, the Third Reich, and the Cold War. Dubbed *Atlantropa*, the scheme would drain the Mediterranean, sourcing near infinite hydroelectric power from dams at Gibraltar, Port Said and Gallipoli, would check the apparent expansion of the Sahara (Davis, 2016) and, through the construction of gigantic lakes further south, would open up new lands—with moderated climates—to European settlement. This engineering of African climates and environments was reasoned to be a way of ensuring continued European domination of the continent, while the infinite supply of electricity was expected to bring peace and cultural and economic renewal to a united Europe (Lehmann, 2016). This pairing of environmental anxiety and boundless technological optimism, and political cosmopolitanism with racist imperialism, built upon earlier French ambitions to flood large portions of the Sahara and moderate the climate (Davis, 2007; Heffernan, 1990; Létolle & Bendjoudi, 1997; Marcot, 2003), and echoed others’ plans to “rewater” the Kalahari (e.g., McKittrick, 2015, 2017; Schwarz, 1920).

When attempts to control colonial climates did emerge in practice, they were usually on a more modest scale. A long drought in Queensland between 1895 and 1903 saw government meteorologist Clement Wragge attempt cloud seeding with artillery guns (Garden, 2014; Powell, 1991), but in late 19th century North Otago, New Zealand, official meteorologists were rather more circumspect about such experiments. Anxieties about a dearth of rainfall led to a curious set of locally funded rainmaking efforts, which frequently put in conflict popular opinion, religious ideologies of environmental stewardship, and a professionalizing meteorological establishment keen to establish its credentials as an authoritative science, distinct from popular prophesy and from folk remedies for drought (Beattie, 2014; also Henry, 2015). While early 20th century meteorologists showed their status anxiety through very public denunciations of climate control schemes, the early Cold War revival of weather modification, particularly rainmaking, saw techniques and theories flow from American scientists like Irving Langmuir (see Fleming, 2010) to places like India and South Africa. Efforts to revive the British government’s infamously famished “groundnut scheme” in Tanganyika by shooting silver iodide bombs at passing clouds (Mahony, in review) nonetheless paled in comparison to contemporary American efforts to divert hurricanes with nuclear weapons—just one indicator perhaps of the shifting loci of western imperial power in the post-war period, and harbingers of the even more ambitious geoengineering ideas which would emerge a few decades later (Fleming, 2010; Harper, 2017).

6 | CONCLUSION

This review has illustrated how climate theories have been used ideologically, politically, and practically in a variety of colonial contexts “to promote the transformation of nature for human benefits, to qualify spaces and segregate races, to govern populations, and sometimes denounce environmental transformation” (Locher & Fressoz, 2012, p. 581). However, recent historical work has also highlighted the malleability of climate theory in colonial contexts over time and space. Furthermore, we have observed how an earlier scholarly interest in the ideological aspects of climatic and imperial thought has recently been supplemented by a new emphasis on the practices of colonial life and rule. Historians and historical geographers have shed new light on practices of climatic knowledge making in the colonies, taking the history of meteorology and climatology out of the global North and showing how those sciences developed in the cultural and epistemological contact zones of the European empires. New scholarship on climate, health, and place is showing how despite the rise of germ theory in the late

19th century, climate theories proved to be pervasive, and concerns about climate continued to inform the practice of colonial medicine and architecture. In the fields of agriculture and forestry, new historical work has shown how colonists sought to work with and adapt to local climates, often through lessons drawn from intercolonial networks of information exchange.

Much historical interest has recently fallen on colonial ideas about climate change. While we would caution against this work simply being oriented around a quest for antecedents of more recent concerns about global climate change, this scholarship nonetheless shows important historical continuities with the present, not least in struggles over the role of experts and governments in identifying and responding to environmental changes, and in the troublesome links between efforts to regulate environments and to regulate human conduct. Furthermore, this history shows the Janus-faced capacities of scientific knowledge to both naturalize structures of power and domination, and to serve as a vector of resistance. Colonial designs on deliberate climatic improvement likewise provide cautionary tales for today's aspiring geoengineers.

Significant gaps remain in this scholarship though, not least work on contexts outside of the major British Dominions, and indeed outside of the Anglosphere. Little is known about the history of meteorology and climatology in French, German, or Portuguese colonies for instance, although such work is starting to emerge (see Mahony and Caglioti, 2017). Furthermore, a recent turn in imperial history toward examining the circuits of material, economic, and scientific exchange between—as well as within—empires offers a useful lens for examining the histories of atmospheric science beyond national frames of reference (see Lester, 2006, 2015). More work is also required on contacts between settler and indigenous knowledges of climate, and on the processes of exchange by which hybrid forms of expertise and practice emerged at the nexus of diverse cultural groups, scientific communities, and imperial formations. Recent work on the “go-betweens” and cultural translators who shaped imperial practices and encounters points to one way of finessing bipartite and core-periphery models of imperial relationships (Raj, 2016), with promising implications for how we construct histories of climate and colonialism. Nonetheless, scholarship on climate, colonialism and empire is a burgeoning and exciting field which has much to offer not only students of imperial and environmental history, but also students of modern-day climate politics.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

RELATED WIREs ARTICLES

[The evolution of climate ideas and knowledge](#)

[Climate and history: A critical review of historical climatology and climate change historiography](#)

ORCID

Martin Mahony  <http://orcid.org/0000-0002-6377-413X>

FURTHER READING

Fleming, J. R. (2005). *Historical perspectives on climate change*. Oxford, England: Oxford University Press [already in ref list though].

Hulme, M. (2016). *Weathered: Cultures of climate*. London, England: Sage.

Livingstone, D.N. *The empire of climate*, series for BBC Radio 4. Retrieved from <http://www.bbc.co.uk/programmes/b00wfhgg/episodes/player>

REFERENCES

- Adamson, G. C. D. (2012). “The languor of the hot weather”: Everyday perspectives on weather and climate in colonial Bombay, 1819–1828. *Journal of Historical Geography*, 38(2), 143–154.
- Adamson, G. C. D., & Nash, D. J. (2013). Long-term variability in the date of monsoon onset over western India. *Climate Dynamics*, 40(11–12), 2589–2603.
- Allan, R., et al. (2016). Toward integrated historical climate research: The example of atmospheric circulation reconstructions over the Earth. *WIREs Climate Change*, 7(2), 164–174.
- Anderson, K. (2005). *Predicting the weather: Victorians and the science of meteorology*. Chicago, IL: University of Chicago Press.
- Arnold, D. (1996). *The problem of nature: Environment, culture and European expansion*. Oxford, England: Wiley.
- Aubin, D., Bigg, C., & Sibum, H. O. (2010). In D. Aubin, C. Bigg, & H. O. Sibum (Eds.), *The heavens on Earth: Observatories and astronomy in nineteenth century science and culture*. London, England: Duke University Press.
- Baker, A. G. (1924). Enlisting the missionary in research work. *The Journal of Religion*, 4(4), 372–382.
- Baker, Z. (2018). Meteorological frontiers: Climate knowledge, the West, and U.S. statecraft, 1800–1850. (PhD thesis). University of California, Davis, CA.
- Bankoff, G. (2017). Aeolian empires: The influence of winds and currents on European maritime expansion in the days of sail. *Environment and History*, 23(2), 163–196.
- Barton, G. A. (2002). *Empire forestry and the origins of environmentalism*. Cambridge, England: Cambridge University Press.
- Barton, G. A., & Bennett, B. M. (2011). Edward Harold Fulcher Swain's vision of Forest modernity. *Intellectual History Review*, 21(2), 135–150.

- Beattie, J. (2003). Environmental anxiety in New Zealand, 1840–1941: Climate change, soil erosion, sand drift, flooding and Forest conservation. *Environment and History*, 9(4), 379–392.
- Beattie, J. (2011). *Empire and environmental anxiety: Health, science, art and conservation in South Asia and Australasia, 1800–1920*. Basingstoke, England: Palgrave.
- Beattie, J. (2012). Imperial landscapes of health: Place, plants and people between India and Australia, 1800s–1900s. *Health and History*, 14(1), 100–120.
- Beattie, J. (2014). Science, religion, and drought: Rainmaking experiments and prayers in North Otago, 1889–1911. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 137–155). Basingstoke, England: Palgrave Macmillan.
- Beattie, J., Mellilo, E., & O’Gorman, E. (2015). *Eco-cultural networks and the British Empire: New views on environmental history*. London, England: Bloomsbury Academic.
- Beattie, J., O’Gorman, E., & Henry, M. (2014). *Climate, science, and colonization: Histories from Australia and New Zealand*. Basingstoke, England: Palgrave Macmillan.
- Beinart, W. (2008). *The rise of conservation in South Africa: Settlers, livestock, and the environment 1770–1950*. Oxford, England: Oxford University Press.
- Bell, M. (1993). “The pestilence that walketh in darkness”. Imperial health, gender and images of South Africa c. 1880–1910. *Transaction of the Institute of British Geographers*, 18(3), 327–341.
- Bennett, B. (2015). *Plantations and protected areas: A global history of Forest management*. Cambridge, MA: MIT Press.
- Bennett, B. M. (2011a). Naturalising Australian trees in South Africa: Climate, exotics and experimentation. *Journal of Southern African Studies*, 37(2), 265–280.
- Bennett, B. M. (2011b). The consolidation and reconfiguration of “British” networks of science, 1800–1970. In B. M. Bennett & J. M. Hodge (Eds.), *Science and empire: Knowledge and networks of science across the British Empire, 1800–1970* (pp. 30–43). Basingstoke, England: Palgrave Macmillan.
- Berland, J. (1993). Weathering the north: Climate, colonialism, and the mediated body. In V. Blundell, J. Shepherd, & I. Taylor (Eds.), *Relocating Cultural Studies* (pp. 207–225). London, England: Routledge.
- Bishop, J. L. (2014). *The role of medicinal plants in New Zealand’s Settler Medical Culture, 1850s–1920s*. (PhD thesis). Hamilton, New Zealand, University of Waikato.
- Bonneuil, C., & Fressoz, J. (2015). *The shock of the Anthropocene*. London, England: Verso.
- Brock, W. H. (1993). Humboldt and the British: A note on the character of British science. *Annals of Science*. Taylor & Francis Group, 50(4), 365–372.
- Brockway, L. H. (1979). Science and colonial expansion: The role of the British Royal Botanic Gardens. *American Ethnologist*, 6(3), 449–465.
- Burton, J. (1986). Robert FitzRoy and the early history of the meteorological office. *The British Journal for the History of Science*, 19(2), 147–176.
- Carey, M. (2011). Inventing Caribbean climates: How science, medicine, and tourism changed tropical weather from deadly to healthy. *Osiris*, 26(26), 129–141.
- Carey, M. (2012). Climate and history: A critical review of historical climatology and climate change historiography. *WIREs Climate Change*. Wiley, 3(3), 233–249.
- Carey, M. (2014). Climate, medicine, and Peruvian health resorts. *Science, Technology & Human Values*, 39(6), 795–818.
- Carter, C. R. (2009). *Magnetic fever: Global imperialism and empiricism in the nineteenth century*. Philadelphia, PA: American Philosophical Society.
- Cawood, J. (1979). The magnetic crusade: Science and politics in early Victorian Britain. *Isis*, 70(4), 492–518.
- Challinor, A., et al. (2007). Assessing the vulnerability of food crop systems in Africa to climate change. *Climatic Change*, 83(3), 381–399.
- Chang, J. H., & King, A. D. (2011). Towards a genealogy of tropical architecture: Historical fragments of power-knowledge, built environment and climate in the British colonial territories. *Singapore Journal of Tropical Geography*, 32(3), 283–300.
- Coen, D. R. (2006). Scaling down: The “Austrian” climate between empire and republic. In J. R. Fleming, V. Janković, & D. R. Coen (Eds.), *Intimate universality: Local and global themes in the history of weather and climate* (pp. 115–140). Sagamore Beach, MA: Science History Publications/USA.
- Coen, D. R. (2011). Imperial climatographies from Tyrol to Turkestan. *Osiris*, 26(1), 45–65.
- Coen, D. R. (2016). Seeing planetary change, down to the smallest wildflower. In J. Graham (Ed.), *Climates: Architecture and the planetary imaginary* (pp. 34–39). Zurich, Switzerland: Lars Müller Publishers.
- Crosby, A. W. (2015). *Ecological imperialism: The biological expansion of Europe, 900–1900* (2nd ed.). Cambridge, England: Cambridge University Press.
- Culver, L. (2014). Seeing climate through culture. *Environmental History*, 19(2), 311–318.
- Curtin, P. D. (1964). *The image of Africa: British ideas and action, 1780–1850*. Madison, WI: University of Wisconsin Press.
- Curtin, P. D. (1990). The environment beyond Europe and the European theory of empire. *Journal of World History*, 1(2), 131–150.
- Cushman, G. T. (2005). Bergen south: The Americanization of the meteorology profession in Latin America during world war II. In S. Emeis & C. Ludecke (Eds.), *From Beaufort to Bjerknes and beyond: Critical perspectives on observing, analyzing, and predicting weather and climate* (pp. 197–213). Augsburg, Germany: Rauner.
- Cushman, G. T. (2006). The struggle over Airways in the Americas, 1919–1945: Atmospheric science, aviation technology, and neocolonialism. In J. R. Fleming, V. Janković, & D. R. Coen (Eds.), *Intimate universality: Local and global themes in the history of weather and climate* (pp. 175–222). Sagamore Beach, MA: Science History.
- Cushman, G. T. (2011). Humboldtian science, creole meteorology, and the discovery of human-caused climate change in South America. *Osiris*, 26(1), 16–44.
- Cushman, G. T. (2013). The imperial politics of hurricane prediction: From Calcutta and Havana to Manila and Galveston, 1839–1900. In M. Lawrence, E. Bsumek, & D. Kinkela (Eds.), *Nation-states and the global environment* (pp. 137–162). Oxford, England: Oxford University Press.
- Daston, L. (2008). Unruly weather: Natural law confronts natural variability. In L. Daston & M. Stolleis (Eds.), *Natural law and law of nature in early modern Europe: Jurisprudence, theology, moral and natural philosophy* (pp. 233–248). Aldershot, England: Ashgate.
- Davis, D. K. (2004). Desert “wastes” of the Maghreb: Desertification narratives in French colonial environmental history of North Africa. *Cultural Geographies*, 11(4), 359–387.
- Davis, D. K. (2007). *Resurrecting the granary of Rome: Environmental history and French colonial expansion in North Africa*. Athens, OH: Ohio University Press.
- Davis, D. K. (2016). *The arid lands: History, power, knowledge*. Cambridge, MA: MIT Press.
- Davis, M. (2001). *Late Victorian holocausts: El Niño famines and the making of the third world*. London, England: Verso.
- Doel, R. E., Friedman, R. M., Lajus, J., Sörlin, S., & Wråkberg, U. (2014). Strategic Arctic science: National interests in building natural knowledge—Interwar era through the cold war. *Journal of Historical Geography*, 44, 60–80.
- Douglas, K. (2014). “For the sake of a little grass”: A comparative history of settler science and environmental limits in South Australia. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 99–118). Basingstoke, England: Palgrave Macmillan.
- Drayton, R. H. (2000). *Nature’s government: Science, imperial Britain, and the ‘improvement’ of the world*. New Haven, CT: Yale University Press.
- Driver, F. (2004). Imagining the tropics: Views and visions of the tropical world. *Singapore Journal of Tropical Geography*, 25(1), 1–17.
- Driver, F., & Yeoh, B. S. A. (2000). Constructing the tropics: Introduction. *Singapore Journal of Tropical Geography*, 21(1), 1–5.
- Duvergé, P. (1995). Le Service météorologique colonial. *La Meteorologie*, April, pp. 46–51.
- Edmond, R. (2005). Returning fears: Tropical disease and the metropolis. In F. Driver & L. Martins (Eds.), *Tropical visions in an age of empire* (pp. 175–194). Chicago, IL: Chicago University Press.
- Endfield, G., & Randall, S. (2014). Climate and empire. In J. Beattie, E. Mellilo, & E. O’Gorman (Eds.), *Eco-cultural networks and the British empire new views on environmental history* (pp. 21–43). London, England: Bloomsbury.

- Endfield, G. H. (2011). The mission. In J. Agnew & D. N. Livingstone (Eds.), *The Sage handbook of geographical knowledge* (pp. 202–216). London, England: Sage.
- Endfield, G. H., & Nash, D. J. (2002). Drought, desiccation and discourse: Missionary correspondence and nineteenth-century climate change in central southern Africa. *The Geographical Journal*, 168(1), 33–47.
- Endfield, G. H., & Nash, D. J. (2005). “Happy is the bride the rain falls on”: 1 climate, health and “the woman question” in nineteenth-century missionary documentation. *Transactions of the Institute of British Geographers*, 30(3), 368–386.
- Endfield, G. H., & Nash, D. J. (2007). “A good site for health”: Missionaries and the pathological geography of central southern Africa. *Singapore Journal of Tropical Geography*, 28, 142–157.
- Eves, R. (2005). Ethnic and racial studies unsettling settler colonialism: Debates over climate and colonization in new Guinea, 1875–1914. *Ethnic and Racial Studies*, 28(2), 304–330.
- Fenby, C. (2015). “Seven lean years, seven fat years”: Climate theory in Australia, 1820–1830. *History of Meteorology*, 7, 25–38.
- Fenby, C., Garden, D., & Gergis, J. (2014). “The usual weather in new South Wales is uncommonly bright and clear...equal to the finest summer day in England”: Flood and drought in new South Wales, 1788–1815. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 43–59). Basingstoke, England: Palgrave Macmillan.
- Fleming, J. R. (2005). *Historical perspectives on climate change*. Oxford, England: Oxford University Press.
- Fleming, J. R. (2010). *Fixing the sky: The checkered history of weather and climate control*. New York, NY: Columbia University Press.
- Fleming, J. R., & Jankovic, V. (2011). Introduction: Revisiting Klima. *Osiris*, 26(1), 1–15.
- Flikke, R. (2016). South African eucalypts: Health, trees, and atmospheres in the colonial contact zone. *Geoforum*, 76, 20–27.
- Foxhall, K. (2010). Interpreting the tropical Atlantic climate: Diaries from the mid-nineteenth-century Australian voyage. *Weather, Climate, and Society*, 2, 91–102.
- Garden, D. (2014). Extreme weather and ENSO: Their social and cultural ramifications in New Zealand and Australia in the 1890s. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 61–80). Basingstoke, England: Palgrave Macmillan.
- Gerbi, A. (1973). *The dispute of the new world: The history of a polemic, 1750–1900*. Pittsburgh, PA: University of Pittsburgh Press.
- Gergis, J., Garden, D., & Fenby, C. (2010). The influence of climate on the first European settlement of Australia: A comparison of weather journals, documentary data and palaeoclimate records, 1788–1793. *Environmental History*, 15(3), 485–507.
- Golinski, J. (2007). American climate and the civilization of nature. In J. Delbourgo & N. Dew (Eds.), *Science and empire in the Atlantic world* (pp. 153–174). London, England: Taylor & Francis.
- Greer, K. (2015). Zoogeography and imperial defence: Tracing the contours of the Nearctic region in the temperate North Atlantic, 1838–1880s. *Geoforum*, 65, 454–464.
- Grove, R. H. (1995). *Green imperialism: Colonial expansion, Tropical Island Edens and the origins of environmentalism, 1600–1860*. Cambridge, England: Cambridge University Press.
- Grove, R. H. (1998). The East India company, the Raj and the El Niño: The critical role played by colonial scientists in establishing the mechanisms of global climate Teleconnections 1770–1930. In R. H. Grove, V. Damodaran, & S. Sangwan (Eds.), *Nature and the Orient* (pp. 301–323). Oxford, England: Oxford University Press.
- Hall, M. B. (1990). The inductive sciences in nineteenth-century England. In T. H. Levere & W. R. Shea (Eds.), *Nature, experiment, and the sciences* (pp. 225–247). Amsterdam, the Netherlands: Springer Netherlands.
- Hannaford, M. J., Jones, J. M., & Bigg, G. R. (2015). Early-nineteenth-century southern African precipitation reconstructions from ships’ logbooks. *The Holocene*, 25(2), 379–390.
- Harper, K. (2017). *Make it rain: State control of the atmosphere in twentieth-century America*. Chicago, IL: University of Chicago Press.
- Harries, P. (2007). *Butterflies and barbarians: Swiss missionaries and systems of knowledge in South-East Africa*. Athens, OH: Ohio University Press.
- Harrison, M. (1996). “The tender frame of man”: Disease, climate and racial difference in India and the West Indies, 1760–1860. *Bulletin of the History of Medicine*, 70(1), 68–93.
- Hazareesingh, S. (2012). Cotton, climate and colonialism in Dharwar, western India, 1840–1880. *Journal of Historical Geography*, 38(1), 1–17.
- Heffernan, M. (1990). Bringing the desert to bloom: French ambitions in the Sahara during the late nineteenth century—The strange case of la mer interieure. In D. E. Cosgrove & G. E. Petts (Eds.), *Water, engineering and landscape: Water control and landscape transformation in the modern period* (pp. 94–114). London, England: Belhaven Press.
- Henry, M. (2014). Australasian airspace: Meteorology, and the practical geopolitics of Australasian airspace, 1935–1940. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 233–250). Basingstoke, England: Palgrave Macmillan.
- Henry, M. (2015). “Inspired divination”: Mapping the boundaries of meteorological credibility in New Zealand, 1920–1939. *Journal of Historical Geography*. Elsevier Ltd, 50, 66–75.
- Henry, M. (2017). Assembling meteorology: Balloons, leaking gas, and colonial relations in the making of new atmospheres. *Journal of the Royal Society of New Zealand*, 47(2), 162–168.
- Holland, P., & Williams, J. (2014). Pioneer settlers recognizing and responding to the climatic challenges of southern New Zealand. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 81–96). Basingstoke, England: Palgrave Macmillan.
- Holland, P., Wood, V., & Dixon, P. (2009). Learning about the weather in early colonial New Zealand. *Weather and Climate*, 29, 3–23.
- Howell, J. (2015). *Exploring Victorian travel literature: Disease, race and climate*. Edinburgh, England: Edinburgh University Press.
- Howell, J., et al. (2013). Nursing the tropics: Nurses as agents of imperial hygiene. *Journal of Public Health*, 35(2), 338–341.
- Howkins, A. (2008). Political meteorology: Weather, climate, and the contest for Antarctic sovereignty, 1939–1959. *History of Meteorology*, 4, 27–40.
- Howkins, A. (2011). Melting empires? Climate change and politics in Antarctica since the international geophysical year. *Osiris*, 26, 180–197.
- Hughes, J. D. (1985). Theophrastus as ecologist. *Environmental Review*, 9(4), 296–306.
- Hulme, M. (2011). Reducing the future to climate: A story of climate determinism and reductionism. *Osiris*, 26(1), 245–266.
- Hunt, B. J. (1997). Doing science in a global empire: Cable telegraphy and electrical physics in Victorian Britain. In B. Lightman (Ed.), *Victorian science in context* (pp. 312–333). Chicago, IL: University of Chicago Press.
- Ingold, T. (2010). Footprints through the weather world: Walking, breathing, knowing. *Journal of the Royal Anthropological Institute*, 16(1), 121–139.
- Island of Mauritius Meteorological Service. (1974). *Meteorology in Mauritius, 1774–1974*. Vacoas, Mauritius: Island of Mauritius Meteorological Service.
- Jankovic, V. (2006). The last resort: A British perspective on the medical south, 1815–1870. *Journal of Intercultural Studies*, 27(3), 271–298.
- Jepson, W. (2004). Of soil, situation, and Salubrity: Medical topography and medical officers in early nineteenth-century British India. *Historical Geography*, 32, 137–155.
- Johnson, R. (2008). Tabloid brand medicine chests: Selling health and hygiene for the British tropical colonies. *Science as Culture*, 17(3), 249–268.
- Johnston, K. (2013). The constitution of empire: Place and bodily health in the eighteenth-century Atlantic. *Atlantic Studies*, 10(4), 443–466.
- Jylhä, K., Tuomenvirta, H., Ruosteenoja, K., Niemi-Hugaerts, H., Keisu, K., & Karhu, J. A. (2010). Observed and projected future shifts of climatic zones in Europe and their use to visualize climate change information. *Weather, Climate, and Society*, 2(2), 148–167.

- Kelso, C., & Vogel, C. (2015). Diversity to decline-livelihood adaptations of the Namaqua Khoikhoi (1800–1900). *Global Environmental Change*, 35, 254–268.
- Kennedy, D. (1990). The perils of the midday sun: Climatic anxieties in the colonial tropics. In J. M. MacKenzie (Ed.), *Imperialism and the natural world* (pp. 118–140). Manchester, England: Manchester University Press.
- Kenny, J. (1995). Climate, race, and imperial authority: The symbolic landscape of the British Hill station in India. *Annals of the Association of American Geographers*, 85(4), 694–714.
- Kneale, J., & Randalls, S. (2014). Invisible atmospheric Knowledges in British insurance companies, 1830–1914. *History of Meteorology*, 6, 35–52.
- Kupperman, K. O. (1982). The puzzle of the American climate in the early colonial period. *American Historical Review*, 87(5), 1262–1289.
- Kupperman, K. O. (1984). Fear of hot climates in the Anglo-American colonial experience. *The William and Mary Quarterly*, 41(2), 213–240.
- Lajus, J., & Sörlin, S. (2014). Melting the glacial curtain: The politics of Scandinavian–Soviet networks in the geophysical field sciences between two polar years, 1932/33–1957/58. *Journal of Historical Geography*, 44, 44–59.
- Lambert, D., & Lester, A. (2004). Geographies of colonial philanthropy. *Progress in Human Geography*, 28(3), 320–341.
- Landau, P. S. (1993). When rain falls: Rainmaking and Community in a Tswana Village, c. 1870 to recent times. *The International Journal of African Historical Studies*, 26(1), 1–30.
- Legg, S. (2014). Debating the climatological role of forests in Australia, 1827–1949: A survey of the popular press. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 119–136). Basingstoke, England: Palgrave Macmillan.
- Lehmann, P. N. (2016). Infinite power to change the world: Hydroelectricity and engineered climate change in the Atlantropa project. *American Historical Review*, 121(1), 70–100.
- Lehmann, P. N. (2017). Losing the field: Franz Thorbecke and (post-) colonial climatology in Germany. *History of Meteorology*, 8, 145–158.
- Lester, A. (2006). Imperial circuits and networks: Geographies of the British Empire. *History Compass*, 4(1), 124–141.
- Lester, A. (2015). Commentary: New directions for historical geographies of colonialism. *New Zealand Geographer*, 71(3), 120–123.
- Létolle, R., & Bendjoudi, H. (1997). *Histoires d’une mer au Sahara: utopies et politiques*. Paris: Harmattan.
- Livingstone, D. N. (1987). Human acclimatization: Perspectives on a contested field of inquiry in science, medicine and geography. *History of Science*, 25(4), 359–394.
- Livingstone, D. N. (1991). The moral discourse of climate: Historical considerations on race, place and virtue. *Journal of Historical Geography*, 17(4), 413–434.
- Livingstone, D. N. (1995). The polity of nature: Representation, virtue, strategy. *Ecumene*, 2(4), 353–377.
- Livingstone, D. N. (1999). Tropical climate and moral hygiene: The anatomy of a Victorian debate. *British Journal for the History of Science*, 32(112 Pt 1), 93–110.
- Livingstone, D. N. (2000). Tropical hermeneutics: Fragments for a historical narrative: An afterword. *Singapore Journal of Tropical Geography*, 21(1), 93–98. <https://doi.org/10.1111/1467-9493.00066>
- Livingstone, D. N. (2002). Race, space and moral climatology: Notes toward a genealogy. *Journal of Historical Geography*, 28(2), 159–180.
- Livingstone, D. N. (2005). Scientific enquiry and the missionary enterprise. In R. Finnegan (Ed.), *Participating in knowledge society. Researchers beyond the university walls* (pp. 50–64). Basingstoke, England: Palgrave.
- Livingstone, D. N. (2012). Reflections on the cultural spaces of climate. *Climatic Change*, 113(1), 91–93.
- Livingstone, D. N. (2015). Review of Jessica Howell, exploring Victorian travel literature: Disease, race and climate. *Social History of Medicine*, 28(4), 937–938.
- Locher, F. (2007). The observatory, the land-based ship and the crusades: Earth sciences in European context, 1830–50. *British Journal for the History of Science*, 40(147), 491–504.
- Locher, F., & Fressoz, J. (2012). Modernity’s frail climate: A climate history of environmental reflexivity. *Critical Inquiry*, 38(3), 579–598.
- Lüdecke, C. (2005). East meets west: Meteorological observations of the Moravians in Greenland and Labrador since the 18th century. *History of Meteorology*, 2, 123–131.
- Mahony, M. (2016). For an empire of “all types of climate”: Meteorology as an imperial science. *Journal of Historical Geography*, 51, 29–39.
- Mahony, M. (in review). Weather, climate and the colonial imagination: Spaces of meteorology at the end of empire. In M. Mahony & S. Randalls (Eds.), *Weather, climate and the geographical imagination*. Pittsburgh, PN: University of Pittsburgh Press.
- Mahony, M., & Caglioti, A.M. (2017). Relocating meteorology. *History of Meteorology*, 8, 1–14.
- Marcot, J.-L. (2003). *Une mer au Sahara: Mirages de la colonisation—Algérie et Tunisie (1869–1887)*. Paris, France: La Différence.
- Marsden, B., & Smith, C. (2007). *Engineering empires: A cultural history of Technology in Nineteenth-Century Britain*. Basingstoke, England: Palgrave.
- Mathe-Shires, L. (2001). Imperial nightmares: The British image of “the deadly climate” of West Africa, c. 1840–74. *European Review of History*, 8(2), 486–500.
- Matson, K. (2017). “The Ozone of Patriotism”: Meteorology, electricity, and the body in the nineteenth-century Yellowstone region. *History of Meteorology*, 8, 35–53.
- McKittrick, M. (2015). An empire of rivers: The scheme to flood the Kalahari, 1919–1945. *Journal of Southern African Studies*, 41(3, SI), 485–504.
- McKittrick, M. (2017). Theories of “reprecipitation” and climate change in the settler colonial world. *History of Meteorology*, 8, 74–94.
- Meinig, D. W. (1961). Goyder’s line of rainfall: The role of a geographical concept in south Australian land policy and agricultural settlement. *Agricultural History*, 35(4), 207–214.
- Meinig, D. W. (1962). *On the margins of the good Earth: The South Australian wheat frontier 1869–1884*. Chicago, IL: Association of American Geographers.
- Meyer, W. B. (2000). *Americans and their weather*. Oxford, England: Oxford University Press.
- Miller, D. P. (1986). The revival of the physical sciences in Britain, 1815–1840. *Isis*, 2, 107–134.
- Mirowski, P. (1984). Macroeconomic instability and the “natural” processes in early neoclassical economics. *The Journal of Economic History*, 44(2), 345–354.
- Morgan, R. A. (2014). Farming on the fringe: Agriculture and climate variability in the Western Australian Wheat Belt, 1890s to 1980s. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 159–176). Basingstoke, England: Palgrave.
- Morgan, R. A. (2017). On the home front: Australians and the 1914 drought. In G. Endfield & L. Veale (Eds.), *Cultural histories, memories and extreme weather: A historical geography perspective* (pp. 34–54). London, England: Routledge.
- Naraindas, H. (1996). Poisons, putrescence and the weather: A genealogy of the advent of tropical medicine. *Contributions to Indian Sociology*, 30(1), 1–35.
- Nash, D. J., & Endfield, G. H. (2008). “Splendid rains have fallen”: Links between El Niño and rainfall variability in the Kalahari, 1840–1900. *Climatic Change*, 86(3–4), 257–290.
- Nash, D. J., & Grab, S. W. (2010). “A sky of brass and burning winds”: Documentary evidence of rainfall variability in the Kingdom of Lesotho, Southern Africa, 1824–1900. *Climatic Change*, 101, 617–653.
- Naylor, S. (2015). Log books and the law of storms: Maritime meteorology and the British admiralty in the nineteenth century. *Isis*, 106(4), 771–797.
- Njoh, A. J. (2008). Colonial philosophies, urban space, and racial segregation in British and French colonial Africa. *Journal of Black Studies*, 38(4), 579–599.
- O’Brien, C. (2014a). Deliberate confusions. *History of Meteorology*, 6, 17–34.
- O’Brien, C. (2014b). Imported understandings: Calendars, weather, and climate in tropical Australia, 1870s–1940s. In J. Beattie, E. O’Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 195–212). Basingstoke, England: Palgrave Macmillan.

- O'Gorman, E. (2014). "Soothsaying" or "science"? H.C. Russell, meteorology, and environmental knowledge of rivers in colonial Australia. In J. Beattie, E. O'Gorman, & M. Henry (Eds.), *Climate, science, and colonization: Histories from Australia and New Zealand* (pp. 177–194). Basingstoke, England: Palgrave Macmillan.
- O'Gorman, E., Beattie, J., & Henry, M. (2016). Histories of climate, science, and colonization in Australia and New Zealand, 1800–1945. *WIREs Climate Change*, 7(6), 893–909.
- Osborne, M. A. (1994). *Nature, the exotic, and the science of French colonialism*. Bloomington, IN: Indiana University Press.
- Osborne, M. A. (2000). Acclimatizing the world: A history of the paradigmatic colonial science. *Osiris*, 15, 135–151.
- Papaioannou, K. J. (2016). Climate shocks and conflict: Evidence from colonial Nigeria. *Political Geography*, 50, 33–47.
- Pietruska, J. L. (2016). Hurricanes, crops, and capital: The meteorological infrastructure of American empire in the West Indies. *The Journal of the Gilded Age and Progressive Era*, 15(4), 418–445.
- Porter, T. M. (1986). *The rise of statistical thinking, 1820–1900*. Princeton, NJ: Princeton University Press.
- Powell, J. M. (1991). *Plains of promise, rivers of destiny: Water management and the development of Queensland 1824–1990*. J. M. Powell—Version details—Trove. Brisbane, Australia: Boolarong.
- Pratt, M. L. (1991). Arts of the contact zone. *Profession*, 91, 33–40.
- Prest, J. (1988). *The garden of Eden: The botanic garden and the re-creation of paradise*. New Haven, CT: Yale University Press.
- Raj, K. (2016). Go-betweens, travelers, and cultural translators. In B. Lightman (Ed.), *A companion to the history of science* (pp. 39–57). Chichester, England: Wiley.
- Rajan, S. R. (2006). *Modernizing nature: Forestry and imperial eco-development 1800–1950*. Oxford, England: Oxford University Press.
- Roberts, L. (2009). Situating science in global history: Local exchanges and networks of circulation. *Itinerario*, 33(1), 9–30.
- Ross, C. (2017). *Ecology and power in the age of empire: Europe and the transformation of the tropical world*. Oxford, England: Oxford University Press.
- Said, E. W. (1979). *Orientalism*. New York, NY: Vintage Books.
- Savage, V. R. (2004). Tropicality imagined and experienced. *Singapore Journal of Tropical Geography*, 25(1), 26–31.
- Schwartz, S. B. (2015). *Sea of storms: A history of hurricanes in the Greater Caribbean from Columbus to Katrina*. Princeton, NJ: Princeton University Press.
- Schwarz, E. H. L. (1920). *The Kalahari; or, Thirstland redemption*. Oxford, England: Blackwell.
- Seth, S. (2009). Putting knowledge in its place: Science, colonialism, and the postcolonial. *Postcolonial Studies*, 12(4), 373–388.
- Siiskonen, H. O. (2015). The concept of climate improvement: Colonialism and environment in German South West Africa. *Environment and History*, 21, 281–302.
- Taylor-Brown, E. (2016). Review of Jessica Howell, exploring Victorian travel literature: Disease, race and climate. *Studies in Travel Writing*, 20(3), 306–308.
- Thompson, K. (1980). Forests and climate change in America: Some early views. *Climatic Change*, 3, 47–64.
- Tilley, H. (2011). *Africa as a living laboratory: Empire, development, and the problem of scientific knowledge, 1870–1950*. Chicago, IL: University of Chicago Press.
- Turchetti, S., Naylor, S., Dean, K., & Siegert, M. (2008). On thick ice: Scientific internationalism and Antarctic affairs, 1957–1980. *History and Technology*, 24(4), 351–376.
- Turner, R. (2010). *Weathering Heights: The emergence of aeronautical meteorology as an infrastructural science*. Philadelphia, PA: University of Pennsylvania.
- Udías, A. (1996). 'Jesuits' contribution to meteorology. *Bulletin of the American Meteorological Society*, 77(10), 2307–2315.
- Vogel, B. (2011). The letter from Dublin: Climate change, colonialism, and the Royal Society in the seventeenth century. *Osiris*, 26(1), 111–128.
- Walker, M. (2012). *History of the meteorological office*. Cambridge, England: Cambridge University Press.
- Wheeler, R. (1999). Limited visions of Africa: Geographies of savagery and civility in early eighteenth century narratives. In J. Duncan & D. Gregory (Eds.), *Writes of passage: Reading travel writing* (pp. 14–48). London, England: Routledge.
- White, S. (2015). Unpuzzling American climate: New world experience and the foundations of a new science. *Isis*, 106(3), 544–566.
- Williamson, F. (2015). Weathering the empire: Meteorological research in the early British straits settlements. *The British Journal for the History of Science*, 48(3), 475–492.
- Williamson, F., & Wilkinson, C. (2017). Asian Extremes: Experience, Exchange and Meteorological Knowledge in Hong Kong and Singapore c.1840–1939. *History of Meteorology*, 8, 159–178.
- Young, R. J. C. (2001). *Postcolonialism: An historical introduction*. Oxford: Blackwell.
- Zaiki, M., & Tsukahara, T. (2007). Meteorology on the southern frontier of Japan's empire: Ogasawara Kazuo at Taihoku Imperial University. *East Asian Science, Technology and Society*, 1(2), 183–203.

How to cite this article: Mahony M, Endfield G. Climate and colonialism. *WIREs Clim Change*. 2018;9:e510.
<https://doi.org/10.1002/wcc.510>