Relocating meteorology

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Geographers, environmental historians, sociologists and historians of science have recently rediscovered the history of meteorology. They have recognized meteorology as a central, rather than peripheral discipline at the intersection of the relationship between science, environment, and society. Histories of nineteenth and twentieth century meteorology tell of great theoretical strides and pioneering individuals. However, they also increasingly focus on new questions, concerning, *inter alia*, the role of technology and material culture in meteorological knowledge production, the use of weather knowledges in the service of industrial, military, financial or agricultural interests, and the enduring significance of local cultures in the face of new emphases on global processes. Global and local at the same time, the history of meteorology is being re-articulated as the result of a plurality of histori*es* that still offer a largely uncharted territory to historical inquiry.

The field of history of meteorology is thus undergoing something of a renaissance. A number of recent works have shown how the disciplinary histories of the atmospheric sciences are germane not only to the practitioners and enthusiasts of those fields, but to wider, conceptual concerns across history of science and cognate disciplines. There is, no doubt, much to be said for the role of global anthropogenic climate change in bringing the political saliency and import of the atmospheric sciences to the attention of a broader readership. As projections of future climate invite increasingly radical societal action to avoid the worst consequences of environmental change, the complex imbrications of atmospheric science with politics, ideology and culture are being laid bare. Many are asking the question of how and why the atmospheric sciences became so 'politicised', while others embrace the observation that assuming a strict separation between science and politics *a priori* risks overlooking how these sciences have always been freighted not just with intellectual curiosity

and a will to truth, but also with political ambition and a will to power. The new power of the atmospheric sciences to structure everyday experiences (such as through the banality of the weather forecast) and to shape political imaginations and decisions in an age of climate change is one side of an emerging analytical coin. The other seeks to understand the flow of power and influence the other way, from society into science – to understand how and why particular forms of meteorology and climatology emerged in particular places and times, how these disciplines reflect the preoccupations of the societies from which they emerge, and how they were enrolled into political projects of control, domination, and perhaps even emancipation. With this special issue, we aim to build upon these analytic moves, and to push the field of history of meteorology a little further around what we detect as an emerging 'spatial turn'. By 'relocating meteorology', we aim to crystallise emerging historiographical trends, broaden the geographical reach of our histories, and advance innovative concepts for the development of the field in the future.

In this introduction, we lay out the intellectual rationale for this effort, and introduce how the subsequent papers in this issue contribute to the tasks which we see as currently sitting before the field. In the next section, we seek to deepen the question of why the history of meteorology suddenly appears so germane, and attractive to new students and researchers. In the subsequent section, we further sketch out the renewal of the field which we currently detect to be underway, before introducing how the papers which make up this issue contribute to the broader project of relocating meteorology. In the concluding section of this short essay, we reflect on where the field might go next, positing the project of relocating meteorology as a work in progress, but a work which can greatly contribute towards our understanding of the imbrications of space, knowledge and power in the atmospheric sciences and beyond.

Why the history of meteorology matters today

The most obvious place to start an account of why the history of meteorology matters, and matters now, is the growing prominence of climate as a source of cultural anxiety and political controversy. With concerns about anthropogenic climate change guiding the field, modern climatology "is burdened with the enormous challenge of delineating how climate relates to social and economic life".[1] This challenge is pursued through work which seeks to surgically isolate the elements of climatic trends which can be attributed to human agency, and through work which seeks to predict the impacts of future climatic shifts on the social and economic life of nations. Yet as a number of historians have shown, this confluence of thinking about climate and society is far from new. Indeed, the history of the sciences of the atmosphere suggests that studying climate "is always about studying society, vicariously or not".[2] Thus, in the current cultural and political atmosphere and in the face of the

[1] Fleming, J. R. and Jankovic, V. (2011) 'Revisiting Klima', *Osiris*, 26(1), p. 1.
[2] Fleming and Jankovic, 'Revisiting Klima', p. 10.

anthropocene, the history of meteorology is called upon to examine on the one hand the relationship between understandings of climate and society, and on the other how scientific evidence and truth-making claims about the weather are deeply entangled with broader cultural and political realms.

Intellectual histories of climate have shown how the concept has always been imbricated in discourses about the nature of human difference and about the ideal organisation of social life.[3] Crucially, these observations have started to inform work on the historical development of meteorological knowledge-making. Yet until recently, research into the intellectual genealogies of 'climate' and into the history of the atmospheric sciences had tended to proceed in some isolation by following individual theorists, national case studies, and isolated achievements. Following a broader transformation in the history of science and Science and Technology Studies (STS), the focus has shifted from scientific theories about the weather to meteorological practices, spaces, material and instrumental cultures. In short, new scholarship is showing more directly how the conduct of meteorology and climatology is deeply entangled with society.[4]

This journal issue intends to contribute to the reshaping of the historiography of meteorology by highlighting some of its most advanced current trends. The new interdisciplinary approach of science studies in recent decades has turned the history of meteorology into an ideal contact zone between the history and philosophy of science, geography, environmental history, anthropology and sociology of science. Such cross-fertilization is dramatically renewing the historiography of meteorological studies broadly conceived, to build a more inclusive history of meteorology that encompasses usually overlooked actors and sites of knowledge-production. The focus on pioneering individuals and institutional archives has been supplemented with a new interest in the wider co-evolution or 'co-production' of atmospheric science and society.[5]

Thus, understanding meteorology and climatology as co-produced with the social world adds a new answer to the question of why studying the history of meteorology matters today. If meteorology and climatology are not just sites where the rather arcane study of weather and climate has been pursued in quiet isolation from societal concerns and cultural forces, they become a mirror of the making of the modern world as an interconnected network of information, data and conceptual and anticipatory knowledge. While environmental historians might find it more intuitive to state that there is no history outside of the atmosphere that surrounds us, and that this atmosphere is by definition already global, the history of meteorology is newly discovering how we came to conceive of the "climate" as a global phenomenon, whose study required the involvement of central observatories,

[3] Ruth A Morgan, "Argument, Authority and Anxiety in the Atmospheric Sciences," *History of Meteorology* 6, no. January (2014): 14–16.

[4] David N. Livingstone, "Race, Space and Moral Climatology: Notes toward a Genealogy," *Journal of Historical Geography* 28, no. 2 (2002): 159–80; James Rodger Fleming, *Historical Perspectives on Climate Change* (Oxford: Oxford University Press, 2005); Mike Hulme, *Weathered: Cultures of Climate* (London: SAGE, 2016).

[5] On science-society co-production, see Sheila Jasanoff, ed. *States of Knowledge: The Co-Production of Science and Social Order*, (London: Routledge, 2004).

expansive networks of observations, and vast intellectual communities. Meteorology – as theory, practice, and intellectual or institutional concern – connected local savants, imperial intermediaries, indigenous communities, and scientific instruments. Ideas about the climate were shaped by this global endeavour. In short, the history of meteorology and climatology provide a crucial avenue to understand the social fabric of the making of the modern, globalised world.

In the past, meteorology was considered an ancillary science in the history physics and mathematics. Its relevance was apparent only once its techniques had been perfected, and predictive skill secured. Rather, the scientific disciplines concerned with the study of atmospheric phenomena are increasingly being seen as mirrors of the societies in which they have been embedded at different points in time. Rather than being singled out as a pitfall as in the past, the instability of the weather and the fluctuations of the climate make meteorology stand out because it exposes the "limits" of Enlightenment rationality and of human control over nature.[6] Thus, this new approach to the history of meteorology stands in close consort with our current sensitivity and understanding of how we transform the natural world through anthropogenic climate change, while humanity as a whole remains exposed to both the vehemence and fragility of the global atmosphere.

Studying the history of meteorology and climatology can provide important and consequential insights into societal attitudes to nature, into the cultural politics of human difference, and into the changing place of scientific knowledge and foreknowledge in the organisation of society and politics.

New spaces: "relocating meteorology" in new geographies of meteorological knowledge

This themed issue emphasizes the interdisciplinary, social, and spatial turn of emerging scholarship in the history of meteorology. It interrogates how ideas about the weather and climate intersected geographical spaces, scientific practices, and were shaped by the social world. The title of the issue "Relocating Meteorology" was inspired by Kapil Raj's influential work *Relocating Modern Science*, in which he called for a historiographical revolution in how we deal with the development of 'western' sciences, appealing for a shift in focus from processes of diffusion from metropole to periphery, towards models of circulation and intercultural encounter in the production of inherently hybrid forms of knowledge.[7]

We would suggest that historians of meteorology can profitably view the challenge of 'relocating meteorology' as both a call to question the geographical boundaries of our historical inquiries, but also as an invitation to examine various 'relocations' of meteorology

[6] See Jan Golinski, *British Weather and the Climate of Enlightenment* (Chicago: University of Chicago Press, 2007).
[7] Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650-1900* (Basingstoke: Palgrave Macmillan, 2007).

itself – the processes and practices through which meteorology 'travelled', found new audiences and users, and was woven into new social and environmental projects of world-making. In doing so, historians of meteorology can build on the spatial turn in the history of science, which has generated an important strand of scholarship on the historical geographies of science, concerned with the spatiality of the production and circulation of scientific knowledge.[8]

Such work has showed how scientific knowledge derives meaning and authority not through its forcible detachment from context, but through a number of mutually sustaining interactions with local, national or regional cultures and political formations. While much of this work has focused on the history of the life sciences where, for instance, the cultural conditioning of responses to the challenges of evolutionary theory provides clear illustration of the geographical thesis,[9] this analytical approach is yet to fully make its mark in the history of the atmospheric sciences. As Livingstone remarks, a "fully fledged historical geography of the science of climate and climatic discourse more broadly construed…is a real *desideratum*".[10] Emerging work is starting to show more clearly how the sciences of weather and climate "cannot be divested from the circumstances surrounding its production, as regionalism, cultural difference, and local senses of belonging define vectors of research and even the basic meaning of climate".[11] Work by Jankovic[12] and Naylor[13] has done the most to develop these points. Emerging work on the practices and poetics of weather observation as a form of landscape dwelling, "where love of locality, prolonged residence, and a sense of parochial duty paid epistemic dividends",[14] can deepen this spatial turn, and trouble distinctions between professional science and amateur pastime.[15]

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[8] See for example David N. Livingstone, *Putting Science in Its Place: Geographies of Scientific Knowledge* (Chicago, IL: University of Chicago Press, 2003); Simon Naylor, "Introduction: Historical Geographies of Science – Places, Contexts, Cartographies," *The British Journal for the History of Science* 38, no. 1 (2005): 1–12; Richard C. Powell, "Geographies of Science: Histories, Localities, Practices, Futures," *Progress in Human Geography* 31, no. 3 (2007): 309–29; Diarmid A. Finnegan, "The Spatial Turn: Geographical Approaches in the History of Science," *Journal of the History of Biology* 41, no. 2 (2008): 369-388.

[9] See David N. Livingstone, *Dealing with Darwin: Place, Politics, and Rhetoric in Religious Engagements with Evolution* (Baltimore, MD: JHU Press, 2014).

[10] David N. Livingstone, "Reflections on the Cultural Spaces of Climate," *Climatic Change* 113, no. 1 (2012), p. 92.

[11] Fleming and Jankovic, 'Revisiting Klima', p. 11.

[12] Vladimir Jankovic, "The Place of Nature and the Nature of Place: The Chorographic Challenge to the History of British Provincial Science," *History of Science* 38, no. 1 (2000): 78–113; Vladimir Jankovic, "Science Migrations: Mesoscale Weather Prediction from Belgrade to Washington, 1970–2000," *Social Studies of Science* 34, no. 1 (2004): 45–75.

[13] Simon Naylor, "Nationalizing Provincial Weather: Meteorology in Nineteenth-Century Cornwall," *The British Journal for the History of Science* 39, no. 3 (2006): 407–33; Simon Naylor, "Log Books and the Law of Storms: Maritime Meteorology and the British Admiralty in the Nineteenth Century," *Isis* 106, no. 4 (2015): 771–97.

[14] David N. Livingstone, "Reading the Heavens, Planting the Earth: Cultures of British Science," *History Workshop Journal* 54, no. 54 (2000), p. 237

[15] Lucy Veale, Georgina Endfield, and Simon Naylor, "Knowing Weather in Place: The Helm Wind of Cross Fell," *Journal of Historical Geography* 45 (2014): 25–37; Endfield, G. H., & Morris, C. (2012). Exploring the role of the amateur in the production and circulation of meteorological knowledge. Climatic Change, 113(1), 69–89.

The project of 'relocating meteorology' entails also placing European meteorology in a broader, international, imperial, and global context. A great many histories of meteorology have focused on developments in various meteorological metropoles, and historians often remain prisoners of the boundaries of the nation-state and its centralized archives. Elapsing the distinction between colonial and metropolitan science, as recently emphasized in Hellen Tilley's *Africa as a Living Laboratory*, historians have started paying more attention to forms of hybrid, creole, and vernacular meteorology.[16] Katharine Anderson and Deborah Coen have also highlighted the importance of meteorology in the culture of Victorian England and the geographical imagination of the Austro-Hungarian empire respectively, indicating important new directions for an analysis of how the study of the weather was always part of much broader cultural phenomena.[17] The papers in this themed issue point to a qualitative shift in the history of meteorology, as they select local and national case studies as part of broader international and imperial transformations. Some of this work is starting to examine histories in locations more distant from the centres of western wealth and power, to highlight the centrality of such places to understanding both the power of locality, and the contingency of globality, in the history of meteorology.

It is no coincidence that several papers focus on the entanglement between meteorology and European empires. European colonies are increasingly attracting the attention of historians of meteorology, permitting examination of trans-national networks of intellectual exchange, and of how theories and practices changed, adapted, and hybridised as they spread from meteorological metropoles.[18] In the spirit of Raj's "Relocating Modern Science," such work often overturns diffusionist models of the history of science, which view sciences of the colonial 'periphery' as pale imitations of metropolitan science.[19] Following the pioneering work of Richard Grove,[20] we are beginning to get a fuller picture of how the 'infrastructural

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[16] Tilley, Helen. *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870-1950* (Chicago: University of Chicago Press, 2011); Cushman, Gregory T. "Humboldtian Science, Creole Meteorology, and the Discovery of Human-Caused Climate Change in South America." *Osiris* 26, no. 1 (2011): 16–44.

[17] Coen, Deborah R. "Imperial Climatographies from Tyrol to Turkestan." *Osiris* 26, no. 1 (2011): 45–65. Anderson, Katharine. *Predicting the Weather: Victorians and the Science of Meteorology*, (Chicago, IL: University of Chicago Press, 2005).

[18] James Beattie, Emily O'Gorman, and Matthew Henry, *Climate, Science, and Colonization: Histories from Australia and New Zealand* (Basingstoke: Palgrave Macmillan, 2014); Fiona Williamson, "Weathering the Empire: Meteorological Research in the Early British Straits Settlements," *The British Journal for the History of Science* 48, no. 3 (2015): 475–92; Martin Mahony, "For an Empire of 'all Types of Climate': Meteorology as an Imperial Science," *Journal of Historical Geography* 51 (2016): 29–39; Angelo Matteo Caglioti, *Meteorological Imperialism. Climate Science, Environment, and Empire in Liberal and Fascist Italy (1870-1940)*, PhD diss. (University of California, Berkeley, 2017).

[19] George Basalla, "The Spread of Western Science," *Science* 156, no. 3775 (1967): 611–22; Lewis Pyenson, *Civilizing Mission: Exact Sciences and French Overseas Expansion, 1830-1940* (Baltimore, MD: Johns Hopkins University Press, 1993).

[20] Richard H. Grove, "The East India Company, the Raj and the El Nino: The Critical Role Played by Colonial Scientists in Establishing the Mechanisms of Global Climate Teleconnections 1770-1930," in *Nature & The Orient*, ed. Richard H. Grove, Vinita Damodaran, and Satpal Sangwan (Oxford: Oxford University Press, 1998), 301–23.

globalism'[21] of meteorology was built upon a polycentric geography of meteorological initiative, with the science shaping up differently in different places, according to thoroughly local concerns and pre-occupations.[22] Further work in this vein can bring "into sharper focus the ways in which theory and practice, science and society, intellectual projects and imperial ventures have interpenetrated", thus enriching not only the historiography of meteorology, but of science and empire more broadly.[23] In the same way that European colonial empires helped create the world we inhabit today, meteorology became an infrastructural and networked science shaped by imperial interconnections.

"Relocating meteorology" as opening new sites and discovering new actors

The project of 'relocating meteorology' geographically opens a new set of opportunities for the study of both new sites and new actors. Early path-breaking work on the history and sociology of the natural sciences focused on the rarefied spaces of the laboratory.[24] More recently, the *field* has come into focus as a new object of historical and geographical investigation.[25] Robert Kohler's work on the contested positioning of the field between landscape and labscape has been formative here, and has opened up a range of questions concerning how field sites are delineated, how their natural unruliness may or may not be tamed, and how they furnish their investigators with authority.[26] While meteorology may not be classically understood as a field science, it is a science whose history illustrates several moments when the distinctions between observatory and field become blurred, or contested. Field campaigns and explorations of new territory usually involved meteorological observations, and prior to the establishment of extended, permanent observational infrastructures, meteorological knowledge production in colonial settings relied on the periodic forays of scientists, administrators or soldiers into the outside world. More conceptually, Simon Naylor has suggested that spaces such as islands have functioned as meteorological field sites, where scientific authority was gained through long periods of

[21] Paul N. Edwards, "Meteorology as Infrastructural Globalism," *Osiris* 21, no. 1 (2006): 229–50.
[22] Matthew Henry, "'Inspired Divination': Mapping the Boundaries of Meteorological Credibility in New Zealand, 1920–1939," *Journal of Historical Geography* 50, (2015): 66–75; Chris O'Brien, "Deliberate Confusions," *History of Meteorology* 6 (2014): 17–34; Gregory T. Cushman, "The Imperial Politics of Hurricane Prediction: From Calcutta and Havana to Manila and Galveston, 1839-1900," in *Nation-States and the Global Environment*, ed. Mark Lawrence, Erika Bsumek, and David Kinkela (Oxford: Oxford University Press, 2013), 137–62.
[23] Livingstone, "Reading the Heavens, Planting the Earth: Cultures of British Science," p. 240.
[24] Steven Shapin and Simon Schaffer, *Leviathan and the Air Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, NJ: Princeton University Press, 1985); Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton, NJ: Princeton University Press, 1979).
[25] See Isla Forsyth, "The More-than-Human Geographies of Field Science," *Geography Compass* 7, no. 8 (2013): 527–39; Robert E. Kohler and Jeremy Vetter, "The Field," in *A Companion to the History of Science*, ed. Bernard Lightman (Oxford: Wiley, 2016), 282–95.
[26] Robert E. Kohler, *Landscapes and Labscapes: Exploring the Lab-Field Border in Biology*, (Chicago, IL: University of Chicago Press, 2002).

dwelling and watchful observation.[27] Furthermore, while much historical analysis of field sites has focused on their definition and expansion on a horizontal plane, an emerging interest in the vertical as a dimension of vision, practice and mobility "takes us away from human habitation into depths and heights in which no one lives (for long) yet which are vital to global economy and polity".[28] It takes us into what Siobhan Carroll labels the 'atopia' of the atmosphere – a space of cultural-economic circulation and ambition, which nonetheless evades attempts at territorial control and domination; an example of Spivak's 'planetary' spaces, radically other, which can freely "undo, arrest, deviate or destroy human systems of global circulation with which they become associated".[29]

In meteorology, engaging with the three-dimensional space of the atmosphere means engaging with objects and processes that are lively and highly mobile, rather than phenomena which are limited to particular places. The 'field' thus becomes something more akin to "a moving assemblage of people, place, and practice, rather than a static and well-defined arena of scientific surveillance".[30] Studies of the historical geographies of scientific knowledge are frequently presented in a register of horizontal movement: circulation, diffusion, migration, expansion; often coupled with the 'flat' ontologies of actor-network theory, or with the historiographies of European advance across two-dimensional maps of imperial geography. The vertical dimension, as both an object of knowledge and a space of practice, has been largely absent from this spatializing gaze.[31] The history of meteorology is an ideal subject with which to explore not just the horizontal expansion and mobility of the sciences, but also their engagements, whether practical or conceptual, with questions of depth, height and volume. Recent moves in political geography and international relations to understand how power works through the production, delineation and control of three-dimensional atmospheric spaces points to an important role for historians of the atmospheric sciences in examining the co-production of three-dimensional knowledge and power.[32]

Thinking beyond human actors can likewise offer new analytical possibilities. This might mean engaging more readily with the agency of flora and fauna in the development of knowledges of climate.[33] Technology has of course played a crucial role in driving developments in meteorology, shaping new practices and opening new fields of atmospheric

[27] Naylor, "Log Books and the Law of Storms: Maritime Meteorology and the British Admiralty in the Nineteenth Century," p. 788.
[28] Kohler and Vetter, "The Field," p. 287-8
[29] Siobhan Carroll, *An Empire of Air and Water: Uncolonizable Space in the British Imagination, 1750-1850* (Philadelphia, PA: University of Pennsylvania Press, 2015), p.7; Gayatri Chakravorty Spivak, *Death of a Discipline* (New York: Columbia University Press, 2003).
[30] Martin Mahony and Samuel Randalls, "Weather, climate and the geographical imagination", in Mahony, M. and Randalls, S. eds., *Weather, Climate and the Geographical Imagination: Placing Atmospheric Knowledges*. University of Pittsburgh Press, forthcoming.
[31] Michael S. Reidy, "The Most Recent Orogeny: Verticality and Why Mountains Matter," *Historical Studies in the Natural Sciences* 47, no. 4 (2017): 578–87.
[32] See for example Stuart Elden, "Secure the Volume: Vertical Geopolitics and the Depth of Power," *Political Geography* 34 (2013): 35–51.
[33] Kirsten Greer, "Zoogeography and Imperial Defence: Tracing the Contours of the Nearctic Region in the Temperate North Atlantic, 1838–1880s," *Geoforum* 65 (2015): 454–64.

vision.[34] Knowledges of weather and climate have also played key roles in the development of broader socio-technical systems, most notably perhaps in the case of aviation where, functioning as what Roger Turner calls an 'infrastructural science', meteorology quietly participated in the construction of the atmosphere as a traversable space, amid new practices and cultures of observation, forecasting, and risk management.[35] There is however much more to be learned about these 'hidden' aspects of meteorology, and about the mutual transformations of meteorological science and broader socio-technical systems and spaces.

The project of 'relocating meteorology' allows us to open out to new sites of knowledge production and to discover new actors in the history of the discipline. Theory-builders and institution-builders tend to dominate our histories of meteorology. Yet new questions are increasingly being asked, particularly in this journal, about how a broader range of actors contributed to the production of knowledge of weather and climate. How did agriculturalists, engineers, insurance clerks, colonists, military personnel, aviators, medics and others produce new forms of knowledge and put them to work?[36] To what extent can we characterise meteorology and climatology as products of encounter and exchange between diverse social and cultural groups? And what do such questions mean for how we think about issues of authority and credibility in the history of the atmospheric sciences?[37]

Renewing the field

The papers offered in this themed issue contribute to this broader renewal of the field in a number of ways. Rather than with centralized European observatories, we begin in the 'Middle Border' region of the United States, with Joseph Giacomelli developing the notion of 'vernacular climatology' to describe the product of ongoing "negotiations between academics, bureaucrats, technocrats, volunteer observers, agriculturalists, newspapermen, and others", each concerned with contesting the legitimacy of the emerging sciences of weather and climate, and with questions of scale and locality at the heart of efforts to establish any semblance of scientific credibility.[38] Pushing further west, Kelsey Matson examines the place of the Yellowstone region at the intersection of new concerns about atmospheric electricity, healthful climates and nationhood, crucially situating the human body as an historically

[34] James R. Fleming, *Inventing Atmospheric Science: Bjerknes, Rossby, Wexler, and the Foundations of Modern Meteorology* (Cambridge, MA: MIT Press, 2016).
[35] Roger Turner, "Weathering Heights: The Emergence of Aeronautical Meteorology as an Infrastructural Science" (PhD thesis, University of Pennsylvania, 2010).
[36] James Kneale and Samuel Randalls, "Invisible Atmospheric Knowledges in British Insurance Companies , 1830-1914," *History of Meteorology* 6 (2014): 35–52; Vladimir Janković, "Working with Weather: Atmospheric Resources, Climate Variability and the Rise of Industrial Meteorology, 1950 – 2010," *History of Meteorology* 7 (2015): 98–111.
[37] Morgan, "Argument, Authority and Anxiety in the Atmospheric Sciences." *History of Meteorology* 6 (2014): 14-16.
[38] Joseph Giacomelli, "Unsettling Gilded-Age Science: Vernacular Climatology and Meteorology in the 'Middle Border'," *History of Meteorology* 8 (2017): 15–34.

important instrument in sensing and registering meteorological phenomena.[39] Thus, this paper opens new research directions in the history of meteorology by connecting it with an emerging interest in the history of the body as a site of knowledge production.

Our attention then turns to north-west Europe – paradoxically perhaps, given the region's centrality to extant accounts of meteorology's history. Yet Kevin Donnelly makes the provocative case that despite its geographic centrality, the city of Brussels was decidedly marginal in terms of early nineteenth century scientific culture. He suggests that this marginality, and the peculiar political and economic context of Belgium, allowed Adolph Quetelet to position the city as a hub for a nascent meteorological internationalism, which endures in various forms to this day. The curiosities of Belgian society likewise provided the raw materials for Quetelet's new approach to social statistics which, Donnelly suggests, was crucial in the emergence of a non-deterministic conception of a global climate system.[40] Thus, Donnelly highlights the making of nineteenth century internationalism as a new site and cultural infrastructure for the production of scientific knowledge, which allowed Quetelet to shake up the scientific hierarchies of positivist scientific culture.

We then move more concertedly into the 'margins' of European meteorological endeavour and its colonial frontiers. Meredith McKittrick offers an important new history of the trans-imperial circulation of the controversial idea of 'reprecipitation', which informed a number of colonial schemes to modify the dry climates of colonial possessions. While a lot of scholarly attention has recently fallen on apparent prefigurations of current concerns over climate change and modification, McKittrick points to the "limitations of reading the history of meteorology and climatology 'backwards,' by looking for the precursors of ideas that are now widely accepted". Doing so risks obscuring "significant realms of scientific and popular debate from historians' view". Instead, she suggests that historians of meteorology pay equal attention to the progenitors of ideas which we may appear now as dead-ends or non-starters, in order to understand historically- and spatially-situated meteorological cultures in all their variety and fullness.[41]

We subsequently turn to three case studies from the history of German meteorology from the late-nineteenth to the mid-twentieth century – a country which, despite boasting a number of meteorological pioneers and being the powerhouse of nineteenth to twentieth century continental Europe, has been underrepresented so far in English-speaking historiography. All three papers deal with the shifting imperial contexts which shaped the development of German meteorology. Robert-Jan Wille reconstructs the horizontal and vertical expansion of meteorological practice through Wladimir Köppen's aerology, showing how the developing contours of German national and imperial power shaped the evolution of a world-wide network for studying the atmosphere in three dimensions. Penelope K. Hardy

[39] Kelsey Matson, "The Ozone of Patriotism": Meteorology, Electricity, and the Body in the Nineteenth-Century Yellowstone Region," *History of Meteorology* 8 (2017): 35–53.
[40] Kevin Donnelly, "Redeeming Belgian Science: Periodic Phenomena and Global Physics in Brussels, 1825-1853" *History of Meteorology* 8 (2017): 54–73.
[41] Meredith McKittrick, "Theories of "Reprecipitation" and Climate Change in the Settler Colonial World," *History of Meteorology* 8 (2017): 74–94.

picks up the baton to illustrate how in interwar Germany, with its empire taken away, national pride was re-asserted through oceanic expeditions which sought to re-inscribe German geophysical might onto the map of international and imperial science. Finally, Philipp Lehmann examines the terrestrial repercussions of Germany's post-imperial moment, showing how the loss of colonial field sites shaped the evolution of climatological ideas, and contributed to a growing emphasis on regional particularity and 'colonial revisionism' amid a broader "postcolonial longing for the overseas field" within German geography.[42] Together, these papers innovatively constitute an exemplary contribution of how to write global histories of national scientific communities, by placing the history of German meteorology in the imperial context of international competition.

Similar imperial and colonial themes are present in Fiona Williamson and Clive Wilkinson's paper on the development of meteorology in Singapore and Hong Kong in the late-nineteenth and early-twentieth century. Their comparative analysis shows convincingly how the differential development of meteorology in different colonial settings was shaped not just by different atmospheric conditions, but by different political and economic contexts. The work contributes to a growing scholarship on meteorology in the region, where contact between different imperial and cultural formations shaped a set of unstable, rivalrous scientific networks, which nonetheless produced important contributions to meteorological theory and practice.[43] We then fly south to another outpost of 'British' meteorology, with Matthew Henry examining the role of meteorology in the interwar development of Australia-New Zealand air routes. Henry highlights the challenges of trans-colonial cooperation, as efforts were made to standardise practices and procedures, amid attempts to gain credibility amongst a crucial set of users of meteorological information – pilots. The paper is a further illustration of the often-unacknowledged centrality of meteorology in the production of three-dimensional airspace, and contributes to an increasingly vibrant and sophisticated historiography of Australasian meteorology.[44]

Finally, we return to a major meteorological metropole, to illustrate how the project of 'relocating meteorology' can inform and transform the study of major centres of political power and scientific influence in Europe. Janet-Martin Nielsen offers an important analysis of the significance of new technologies in relocating meteorology as a public- and service-oriented science in post-war Britain. Focusing on the establishment of numerical weather prediction at the Meteorological Office, Nielsen describes anxieties to establish and perform the objectivity of meteorological science – to not just produce better predictions, but to demonstrate their basis in the machinic objectivity of the computer simulation. Nielsen's is

[42] Robert-Jan Wille, "Colonizing the Free Atmosphere: Wladimir Köppen's 'Aerology', the German Maritime Observatory, and the Emergence of a Trans-Imperial Network of Weather Balloons and Kites, 1873-1906," *History of Meteorology* 8 (2017): 95–123; Penelope K. Hardy, "Meteorology as Nationalism on the German Atlantic Expedition, 1925-1927," *History of Meteorology* 8 (2017): 124–144; Philipp Lehmann, Losing the Field: Franz Thorbecke and (Post-)Colonial Climatology in Germany," *History of Meteorology* 8 (2017): 145–158.

[43] Fiona Williamson and Clive Wilkinson, "Asian Extremes: Experience, Exchange and Meteorological Knowledge in Hong Kong and Singapore c.1840-1939," *History of Meteorology* 8 (2017): 159–178.

[44] Matthew Henry, "Assembling the Weather: Expertise, Authority and the Negotiation of trans-Tasman Aviation Forecasts" *History of Meteorology* 8 (2017): 179–201.

thus an important study of how notions of modernity, uncertainty and injurious subjectivity have shaped key transitions in meteorological practice, and have informed enduring concerns about the science's predictive abilities and social utility which are laced through so many of the preceding analyses. As such, it is a fitting – if seemingly geographical paradoxical – way to conclude our efforts here to relocate meteorology.[45]

We are pleased to also include a special supplementary section offered by James R. Fleming. His short text accompanies an historical film from 1960s Soviet Russia, which proffered a vision of a future 2017 where continental-scale climate control has re-shaped global environments and national fortunes.[46] It is fitting to revisit such a vision in the year of its prophesised becoming, and to use it to point the way to other geographies and cultures which are as-yet underrepresented in the historiography of meteorology and climatology.

What next? Relocating meteorology as a work-in-Progress

As with all historiographical manifestos and intellectual projects, 'relocating meteorology' is more an open-ended frontier than an accomplished achievement. The selection of about ten papers can hardly do justice to the current renewal of the field nor saturate the future directions which may be pursued. There is still a lot of work to be done by historians willing to undertake new challenges of the field.

The history of meteorology remains a largely Euro-centric business, despite our effort to examine the making of meteorology amid the contact zones between European empires and the rest of the world. While the historiography of North America and the Caribbean is rapidly developing, we still do not have complete accounts of the history of meteorology in vast regions of the world, such as in Asia, Africa, Latin America, the Pacific World and the Middle East. There has been an emergent interest in the history of exploration of glaciers, poles, and mountains like the Alps in histories of European meteorology, but large parts of Europe itself remain overlooked, such as southern and eastern Europe. Even France has remained somewhat marginal, with the exception of Fabien Locher's work.[47]

A major challenge to a truly global history of meteorology is the national organization of meteorological archives in the twentieth century, which erases the international and interconnected nature of meteorology in the nineteenth century – and before. Hopefully, it is no longer a distant utopia to think of intersecting meteorological archives by building on emerging techniques in the digital humanities for the preservation and analysis of archival materials across the world. This could become an interesting arena of future development of the field at the intersection of digital and environmental humanities.

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[45] Janet Martin-Nielsen, "Scientific forecasting? Performing objectivity at the UK's Meteorological Office, 1960s-1970s," *History of Meteorology* 8 (2017): 202–221.
[46] James R. Fleming, "In the Year 2017: A Soviet Fantasy of the Future," *History of Meteorology* 8 (2017): 222–224.
[47] Locher, Fabien. *Le savant et la tempête: étudier l'atmosphère et prévoir le temps au XIXe siècle* (Rennes: Presses Universitaires de Rennes, 2008).

As work on the colonial histories of meteorology and climatology accelerates, it is vital that imperial narratives of the inexorable, beneficent spread of western science and technology are not simply reproduced. Few studies of colonial meteorology have yet offered full analyses of how European meteorological ideas and practices interacted with indigenous knowledge systems. In part this seems to be because the story was often one of European scientists simply ignoring local knowledges of weather and climate, often to the detriment of European agricultural fortunes.[48] Efforts to manipulate the climate of European colonies have offered interesting insights into the status anxieties of meteorologists who sought to distance themselves from the 'superstitions' of both settler and indigenous populations.[49] Yet tracing more subtle interactions between different knowledge systems, and recovering voices expunged from institutional archives, will require methodological innovation.

A great deal of innovation in the history of meteorology can come from the intersection between environmental history and STS, two fields that are increasingly converging.[50] In this respect, several questions remain to be answered: What was the role of natural environments in the processes of transmission and transformation of climate knowledge? What was the role of the circulation of standardised forms, instruments and data in the production of infrastructural networks and new environments? How did these systems become sites of contestation over scientific authority, trustworthiness and risk? Following the broader circulation of technologies, resources, and the intermediaries that made them possible may permit new answers to the question of the enduring importance of space and place in the history of meteorology.

One such way into such dynamics may be to investigate the lives and careers of not only the institution-builders and the knowledge-leaders, but of those who were drawn into the ranks of those institutions from a range of cultural backgrounds, performing the monotonous work of observation and data processing, feeding local weather into the centres of colonial climatic calculation.[51] Following the 'traces'[52] of such lives may offer a richer picture of the development of meteorology and climatology in the contact zones of European imperial expansion.[53] And in order to develop a more expansive understanding of "meteorology," a great deal of work is necessary to reveal the role of such cultural intermediaries, middle men and women, and their role in the broader development of meteorological knowledge. A truly "relocated" history of meteorology will not be complete until we fully understand how

[48] Chris O'Brien, "Imported Understandings: Calendars, Weather, and Climate in Tropical Australia, 1870s-1940s," in *Climate, Science, and Colonization: Histories from Australia and New Zealand*, ed. James Beattie, Emily O'Gorman, and Matthew Henry (Basingstoke: Palgrave Macmillan, 2014), 195–212.
[49] James Beattie, "Science, Religion, and Drought: Rainmaking Experiments and Prayers in North Otago, 1889-1911," in *Climate, Science, and Colonization: Histories from Australia and New Zealand*, ed. James Beattie, Emily O'Gorman, and Matthew Henry (Basingstoke: Palgrave Macmillan, 2014), 137–55.
[50] Sara B. Pritchard, Finn Arne Jorgensen, and Dolly Jorgensen, eds. *New Natures: Joining Environmental History with Science and Technology Studies* (Pittsburgh: University of Pittsburgh Press, 2013).
[51] Such work would build upon extant literature on the role of the 'technician' in the history of science. See Steven Shapin, "The Invisible Technician," *American Scientist* 77, no. 6 (1989): 554–63; Rob Iliffe, "Technicians," *Notes and Records of the Royal Society* 62 (2008): 3–16.
[52] On biography in the archival margins, see Cheryl McGeachan, "Historical Geography II: Traces Remain," *Progress in Human Geography*, 2016, 1–14.
[53] Mary Louise Pratt, "Arts of the Contact Zone," *Profession*, 1991, 33–40.

European weather knowledge has been shaped by the wider forces of empire, race, gender, class and religious belief. The historical relocation of meteorology was not just a function of the expansion of formal state power. Religious bodies, missionaries, soldiers, medics and various others contributed to the expansion of meteorological networks, and further work is required to understand these groups, their interactions, conflicts, and 'intermediaries'.[54] In developing such work, we can continue to decentre the nation-state as the subject and unit of our analyses, to build a more inclusive and global history of meteorology.

[54] Cushman, "The Imperial Politics of Hurricane Prediction: From Calcutta and Havana to Manila and Galveston, 1839-1900"; Jamie L. Pietruska, "Hurricanes, Crops, and Capital: The Meteorological Infrastructure of American Empire in the West Indies," *The Journal of the Gilded Age and Progressive Era* 15, no. 4 (2016): 418–45.