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INTRODUCTION

The epistemology and politics of climate science

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Abstract

Historians of science have demonstrated the many ways in which science and politics are interrelated. The production of scientific knowledge, the organization of research and the application of science and technology are deeply intertwined with structures of power and governance. Climate science is a prime example to demonstrate the political qualities of science and the diversity of entanglements of science and politics. We argue that these entanglements have a wide range of meanings, such as scientists' political agendas and manoeuvres, the policies of scientific and funding institutions, the uses of science by corporate or state actors, and the political agency of science and technology, as well as public debates about them. To better capture the diversity of these entanglements, we suggest developing more fine-grained conceptual taxonomies or categories. As a possible starting point for further differentiation, we introduce the concepts *politics of science*, *science for policy* and *politics in science*. Next, we illustrate this conceptual differentiation using the history of weather and climate science as an example. Finally, we provide a short summary of the contributions to this special issue and their addition to the state of knowledge regarding the epistemology and politics of climate science.

> The politics of science is in essence no different from other politics. It is a bit more obscure and, it seems to me, usually better mannered, though perhaps it would be appropriate to borrow a line from Wordsworth and describe it as 'Nor harsh, nor grating, though of ample power to chasten and subdue.'[1]

The history of science has convincingly shown that science and politics are interrelated in many ways. Science has political qualities, and political contexts influence scientific development and understanding. Climate science is an obvious case, and historians have provided examples from many different periods and contexts. Climate knowledge served colonial exploitation and racist ideologies by associating racialized people in tropical climates with moral deficiency and low status. Not only did weather data serve scientific interests and practical needs in shipping, agriculture, forestry and water management, but also national meteorological services, weather information and national climatology contributed to nation building and the forging of national identity from the mid-nineteenth century onwards. In the twentieth century, the world wars and the Cold War made weather and climate knowledge a political priority, generating substantial funding for interests such

[1] Daniel S. Greenberg, *The Politics of Pure Science*, 2nd edn, Chicago: University of Chicago Press, 1999 (first published 1967), p. xxv.

as weather and climate modification, particularly in the USA. Since the 1970s, growing concern about global climate change has politicized climate science in new ways, laying the groundwork for one of the defining features of today's discourse.

Today, the goal of climate science is ostensibly to understand the climate system and provide knowledge to policymakers. At the same time, it operates under intense public and political scrutiny and is heavily influenced by political interests and agendas. The interactions between politics and climate science have shaped the dynamics and epistemology of the discipline significantly. However, the precise shape of this impact and the outcomes in different spheres of life and society remain open to investigation. A first opportunity to explore this topic arose from an invitation to organize a cross-cutting panel on the history, philosophy and sociology of Earth system science at one of the major climate-modelling conferences in 2017. This initiative resulted in a series of overview papers, including an article analysing historical perspectives on epistemology and politics in Earth system modelling.[2] The collection of articles we present in this special issue brings further cases and details and aims to broaden and deepen the historical understanding of the epistemology and politics of climate science also beyond the US context. It is based on a multi-panel symposium of the same title organized by the editors at the 10th Conference of the European Society for the History of Science in Brussels, 7–10 September 2022.

This special issue aims to emphasize the diversity of science–policy relations and the roles of politics in science, and to develop a conceptual differentiation with the help of the terms *politics of science*, *science for policy* and *politics in science*. In a first section of this introduction, we introduce and describe these concepts. In a second section, this conceptual differentiation will be applied and illustrated in the case of five examples in the history of climate science, revealing relations between the epistemology and the politics of climate science. A third section provides a short summary of the contributions to this special issue and what they add to the state of knowledge of the epistemology and politics of climate science.

'Politics' in the history of science and technology: towards differentiation

Steven Shapin and Simon Schaffer argued in their pathbreaking book *Leviathan and the Air-Pump* more than forty years ago that 'the problem of generating and protecting knowledge is a problem in politics, and, conversely … the problem of political order always involves solutions to the problem of knowledge'.[3] From their analysis of the conflict between Robert Boyle and Thomas Hobbes about the legitimacy of experimental practices to create scientific facts, they concluded that there are

> three senses in which we want to say that the history of science occupies the same terrain as the history of politics. First, scientific practitioners have created, selected, and maintained a polity within which they operate and make their intellectual product; second, the intellectual product made within that polity has become an element in political activity in the state; third, there is a conditional relationship between the nature of the polity occupied by scientific intellectuals and the nature of the wider polity.[4]

[2] Fourth International Conference on Earth System Modeling, 28 August–1 September 2017. See Simone Rödders, Matthias Heymann and Bjorn Stevens, 'Historical, philosophical and sociological perspectives on earth system modeling', *Journal of Advances in Earth System Modeling* (2020) 12(10), at https://doi.org/10.1029/2020MS002139; Matthias Heymann and Amy Dahan Dalmedico, 'Epistemology and politics in earth system modeling: historical perspectives', *Journal of Advances in Earth System Modeling* (2019) 11(5), pp. 1139–52.

[3] Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, Princeton, NJ: Princeton University Press, 1985, p. 21.

[4] Shapin and Schaffer, op. cit. (3), p. 332.

Historians of science and technology today generally agree that science and technology are not autonomous and independent spaces, but are dependent on and in many ways interact with politics and culture. The production of scientific facts, the organization of research and the application of science and technology are deeply entangled with structures of power and governance. Facts emerge not merely from observation and artefacts not merely from independent invention, but from the complex interplay of social authority, material devices and interpretive practices, demonstrating that politics is inherent to epistemic activity itself. Politics, on the other hand, is a broad and vague category. Expressions such as 'entanglements of science and politics', 'political qualities of science' and 'politics of science' comprise widely different meanings, including, for example, scientists' political agendas and manoeuvres, scientific and funding institutions' policies, corporate or state actors' uses of science, the political agency of science and technology, and political and public debates and controversies about science or scientific knowledge.

We suggest developing more fine-grained conceptual taxonomies or categories to capture the diversity of meanings or types of science–politics relations. As a starting point for such an endeavour, we propose a differentiation of types of these relations, which can be labelled *politics of science*, *science for policy* and *politics in science*. Although these categories do not have clear boundaries, remain vague and to some degree overlap, we believe that they offer a way forward to deepening the understanding of the diversity of science–policy relations.

The *politics of science* comprises a broad range of activities and developments, in which actors of all sorts aim at promoting specific scientific and/or political interests and developments or produce intendedly or unintendedly political effects. This category includes, for example, activities such as lobbying for specific scientific projects or institutions and research directions or lobbying against specific types of science and scientific practices. Daniel S. Greenberg specified this category as follows: 'The politics is in the people, institutions and processes that determine what is to be researched, by whom, where, under what circumstances, and, finally, what is to be done with the results.'[5] It includes the politics of state agencies, military institutions and corporate and public actors and activists in supporting and shaping or undermining and obstructing science and scientific knowledge. This category captures the interactions of political and scientific ideas and ideologies. Examples comprise how colonial science contributed to constructing racial hierarchies, controlling colonized land and people, and facilitating and justifying global empire building and exploitation.[6] It would include considerations of how Soviet socialism shaped science in the Soviet Union (and Chinese socialism in China).[7] It would also cover the way in which Cold

[5] Greenberg, op. cit. (1), p. xxv.

[6] E.g. Helen Tilley, *Africa as a Living Laboratory: Empire, Development, and the Problem of Scientific Knowledge, 1870–1950*, Chicago: University of Chicago Press, 2011; David Arnold, *Colonizing the Body: State Medicine and Epidemic Disease in Nineteenth-Century India*, Berkeley: University of California Press, 1993; Richard Drayton, *Nature's Government: Science, Imperial Britain, and the 'Improvement' of the World*, New Haven, CT: Yale University Press, 2000; Londa Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World*, Cambridge, MA: Harvard University Press, 2004.

[7] Classic references on Soviet science are Loren R. Graham, *Science in Russia and the Soviet Union: A Short History*, Cambridge: Cambridge University Press, 1993; Paul R. Josephson, *Physics and Politics in Revolutionary Russia*, Berkeley: University of California Press, 1991; Nikolai Krementsov, *Stalinist Science*, Princeton, NJ: Princeton University Press, 1997; Slava Gerovitch, *From Newspeak to Cyberspeak: A History of Soviet Cybernetics*, Cambridge, MA: MIT Press, 2002. On a Chinese case see e.g. Rachel S. Core, *Tuberculosis Control and Institutional Change in Shanghai, 1911–2011*, Hong Kong: Hong Kong University Press, 2023. See also the review by Léa Delmaire, 'Fighting a social disease in a socialist way', *Metascience* (2025) 34, pp. 243–5.

War ideologies, military funding and international relations structured scientific priorities in the USA.[8]

The concept of *science for policy* describes relations in which actors of all sorts refer to, develop, build, support or use science with the aim of furthering political goals, whether these goals directly relate to the science in question or not. Examples would be the support or uses of science and technology for specific state interests such as national security, territorial control, nation building and international diplomacy by state or other actors. Recently, for example, the concept of science diplomacy, which can be regarded a special case of *science for policy*, has gained significant attention.[9] Likewise, it includes the use of science or scientists by corporate or public actors to provide guidance and help promote specific political goals. A whole industry of science-based consulting in economic, health, environmental and other sectors has emerged to support or justify policies and decision making.[10]

Politics in science, finally, describes political activities and relations within science or scientific institutions to pursue scientific or other interests. It comprises a large range of negotiation processes about scientific practices, norms and values; the building of institutional frameworks; community building; and the definition of directions and priorities. This category puts emphasis on the political character of everyday interactions and decision making within scientific communities and institutions and includes the negotiation of values and creation of procedures regarding practices in community building and maintenance, the distribution of funds, quality control, evaluation processes, publication standards, the building of status and authority, codes of conduct and research integrity, patronage, gatekeeping and, generally, the governance of science. While political processes internal to scientific institutions are not autonomous, depend on broader political contexts and are, as Greenberg suggested, 'in essence no different from other politics', they

[8] E.g. Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America*, Cambridge, MA: Harvard University Press, 1978; Stuart W. Leslie, *The Cold War and American Science: The Military–Industrial–Academic Complex at MIT and Stanford*, New York: Columbia University Press, 1993; Noam Chomsky et al., *The Cold War and the University: Toward an Intellectual History of the Postwar Years*, New York: The New Press, 1997; Jessica Wang, *American Science in an Age of Anxiety: Scientists, Anticommunism, and the Cold War*, Chapel Hill: University of North Carolina Press, 1999; Ronald E. Doel, 'Constituting the postwar earth sciences: the military's influence on the environmental sciences in the United States after 1945', *Social Studies of Science* (2003) 33(5), pp. 635–66; John Krige, *American Hegemony and the Postwar Reconstruction of Science in Europe*, Cambridge, MA: MIT Press, 2006.

[9] In this special issue, Matthias Heymann's 'Science diplomacy and politics: building the Global Atmospheric Research Program' provides a short discussion of science diplomacy. For more extensive accounts see Royal Society/AAAS, *New Frontiers in Science Diplomacy: Navigating the Changing Balance of Power*, London: The Royal Society, 2010; Simone Turchetti, Matthew Adamson, Giulia Rispoli *et al.*, 'Introduction: just Needham to Nixon? On writing the history of "science diplomacy"', *Historical Studies in the Natural Sciences* (2020) 50(4), pp. 323–39; Sam Robinson, Matthew Adamson, Gordon Barrett *et al.*, 'The globalization of science diplomacy in the early 1970s: a historical exploration,' *Science & Public Policy* (2023) 50(4), pp. 749–58. A recent example is Johannes Mattes and Cécile Philippe, 'Crossing boundaries, forging unity: nuclear medicine and science diplomacy in Cold War Europe', *BJHS* (2025) 58(3), pp. 503–27.

[10] Classic examples investigating scientific experts as policy advisers are Kevles, op. cit. (8); Sheila Jasanoff, *The Fifth Branch: Science Advisers as Policymakers*, Cambridge, MA: Harvard University Press, 1990; Theodore M. Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*, Princeton, NJ: Princeton University Press, 1995; Paul N. Edwards and Stephen H. Schneider, 'Self-governance and peer review in science-for-policy', in Clark A. Miller and Paul N. Edwards (eds.), *Changing the Atmosphere: Expert Knowledge and Environmental Governance*, Cambridge, MA: MIT Press, 2001, pp. 219–46. See also Roger A. Pielke, *The Honest Broker: Making Sense of Science in Policy and Politics*, Cambridge: Cambridge University Press, 2007; and Matthias Heymann, Gabriele Gramelsberger and Martin Mahoney (eds.), *Cultures of Prediction in Atmospheric and Climate Science: Epistemic and Cultural Shifts in Computer-Based Modelling and Simulation*, New York: Routledge, 2017.

still reveal idiosyncratic, domain-specific challenges and features that deserve attention in the history of science.[11]

An obvious objection to this differentiation of categories may be that instances of science–politics relations are not easily to be clearly assigned to one of these categories but fit more or even all of them. This objection, however, does not invalidate the attempt at differentiation. Science–politics entanglements are usually complex and may involve elements and features that could best be captured and analysed by several of these categories. Cold War science, for example, involved elements of *science for policy*, with state institutions financing research activities for political purposes. At the same time, scientific actors or institutions were engaged in the *politics of science* by catering to political goals for pursuing their own scientific interests. In addition, new state-funding opportunities gave rise to competition among scientific institutions and disciplines, which provoked *politics in science*, for example heated discussions about scientific priorities. The contribution by Heymann in this special issue gives an example of such a case. So these categories do not only serve to construct order in the diversity of science–politics relations, but also offer a tool for analysis of the complexity of such relations, as well as for the construction of a diversity of narratives about such relations, for example by focusing on different actors, processes or contexts. In the next section the categories *politics of science*, *science for policy*, and *politics in science* will be further illustrated with historical examples in the epistemology and politics of climate research.

Epistemology and politics in the history of climate research

A famous and notorious example of the *politics of climate science* is the long-standing intellectual tradition of climate determinism, the claim that climate exerts a dominant influence on human societies, shaping physiology, character, economic performance, moral behaviour and political organization. Since ancient times, climate determinism proliferated time and again, with significant authority. Knowledge of climates was used by Hippocrates and Aristotle to explain the pre-eminence of ancient Greece through reference to its favourable climate.[12] It was also used by eighteenth-century thinkers such as Charles-Louis Baron de Montesquieu and David Hume to account for the evolution of civilization and the shaping of political systems, personal energy, morality and societal character.[13] Likewise, climate determinism became an important idea in the colonial endeavours of European empires, who relied on climatic theories to justify hierarchical global orders. Colonial medicine attributed disease susceptibility to 'tropical climates' and constructed notions of racial difference tied to climate and environment. Imperial geographers used climate to explain

[11] To this category could be counted as diverse contributions as Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society*, Cambridge, MA: Harvard University Press, 1987; Frank Greenaway, *Science International: A History of the International Council of Scientific Unions*, Cambridge: Cambridge University Press, 1996; Allan A. Needell, *Science, Cold War, and the American State: Lloyd V. Berkner and the Balance of Professional Ideals*, Amsterdam: Harwood Academic Publishers, 2000; Aileen Fyfe and Noah Moxham, 'The history of peer review', in Jürgen Renn (ed.), *The Oxford Handbook of the History of Science*, Oxford: Oxford University Press, 2020, pp. 297–318; Lorraine Daston, *Rivals: How Scientists Learned to Cooperate*, New York: Columbia Global Reports, 2023. See also the review by Mitchell Ash, 'Lorraine Daston on the internal politics of science', *Metascience* (2025) 34, pp. 187–90.

[12] Hippocrates, *On Airs, Waters, and Places* (ca. 400 BCE), trans. Francis Adams, in The Internet Classics Archive, at https://classics.mit.edu/Hippocrates/airwatpl.html (last accessed 25 November 2025). See also Genevieve Miller, '"Airs, waters, and places" in history', *Journal of the History of Medicine and Allied Sciences* (1962) 17, pp. 129–40.

[13] Charles Louis de Secondat, Baron de Montesquieu, *De l'esprit des loix*, Geneva: Barilot & Fils, 1748. The book has the subtitle: 'ou du Rapport que les loix doivent avoir avec la constitution de chaque gouvernement, les moeurs, le climat, la religion, le commerce, &c'. See also Jan Golinski, *British Weather and the Climate of Enlightenment*, Chicago: University of Chicago Press, 2007, pp. 173–84; James R. Fleming, *Historical Perspectives on Climate Change*, New York: Oxford University Press, 1998, pp. 12–17.

why colonized peoples allegedly lacked industriousness or rational capacity. Conversely, the knowledge demand and ideological needs of colonizers fostered disciplines such as colonial geography, climatology and medicine to deliver appropriate theories.[14]

The early twentieth century brought a peak of academic climate determinism in geography, anthropology and racial science. A widely read proponent such as Ellsworth Huntington popularized sweeping arguments about climate as the primary cause of social and racial difference. He linked temperature and humidity to energy, productivity, intelligence, social progress and national success, asserting that temperate climates – especially those of Northern Europe and North America – favour 'civilization'.[15] About hundred years later, in the early twenty-first century, climate determinism resurfaced in new forms, often called neo-environmental determinism or climate reductionism. Scholars in security studies, migration research and civil society organizations framed climate change as a driver of conflict, migration and state failure.[16] Recently, David N. Livingstone, Mike Hulme and others have offered a strong critique of such narratives for oversimplifying complex sociopolitical processes and examined how climatic arguments were mobilized for political ends.[17] Climate determinism, in its diverse configurations and contexts, inspired and justified by climate knowledge and instrumentalized for political interests and ideologies, represents a conspicuous example of *politics of science*.

A second example, largely fitting the category of *science for policy*, is the establishment of meteorological services. In the late eighteenth century, late Enlightenment governments and economic, agricultural and patriotic societies in many countries in Europe sponsored instrumental meteorological observation networks not only for the aim of a better understanding of weather and climate but also to help improve agriculture and public-health practices and policies.[18] In the nineteenth century, meteorology and climatology flourished

[14] Sam White, 'Unpuzzling American climate: New World experience and the foundations of a new science', *Isis* (2015) 106(3), pp. 544–66; Ruth Morgan, 'Climate and empire in the nineteenth century', in Sam White, Christian Pfister and Franz Mauelshagen (eds.), *Palgrave Handbook of Climate History*, New York: Palgrave MacMillan, 2018, pp. 589–603; Philipp N. Lehmann, 'Losing the field: Franz Thorbecke and (post-)colonial climatology in Germany', *History of Meteorology* (2017) 8, pp. 145–58; Martin Mahony and Georgina Endfield, 'Climate and colonialism', *WIREs Climate Change* (2018) 9(2), at https://doi.org/10.1002/wcc.510; David N. Livingstone, *The Empire of Climate: A History of an Idea*, Princeton, NJ: Princeton University Press, 2024; Philip Curtin, *Migration and Mortality in Africa and the Atlantic World*, London: Routledge, 2001; David Arnold, *The Problem of Nature: Environment, Culture and European Expansion*, Oxford: Blackwell, 1996; Mark Harrison, *Climates and Constitutions: Health, Race, Environment and British Imperialism in India, 1600–1850*, Oxford: Oxford University Press, 1999.

[15] Ellsworth Huntington, *Civilization and Climate*, New Haven: Yale University Press, 1915. See also Fleming, op. cit. (13), pp. 95–106. Other influential contributors to climate and environmental determinism were Ellen Churchill Semple, *Influences of Geographic Environment*, New York: Henry Holt, 1911; and Thomas Griffith Taylor, *Environment, Race, and Migration*, Chicago: University of Chicago Press, 1937.

[16] E.g. Thomas F. Homer-Dixon, *Environment, Scarcity, and Violence*, Princeton, NJ: Princeton University Press, 1999; Chris D. Thomas *et al.*, 'Extinction risk from climate change', *Nature* (2004) 427, pp. 145–8; Christian Aid Report, *The Climate of Poverty: Facts, Fears and Hope*, London: Christian Aid, 2006. CNA Military Advisory Board, *National Security and the Accelerating Risks of Climate Change Report*, Alexandria: CNA Corporation, 2007. David D. Zhang, Jane Zhang, Harry F. Lee and Yuan-qing He, 'Climate change and war frequency in eastern China over the last millennium', *Human Ecology* (2007) 35(4), pp. 403–14; Jon Barnett and W. Neil Adger, 'Climate change, human security and violent conflict', *Political Geography* (2007) 26(6), pp. 639–55; Christian Parenti, *Tropic of Chaos: Climate Change and the New Geography of Violence*, New York: Nation Books, 2011.

[17] Livingstone, op. cit. (14). Mike Hulme, 'Reducing the future to climate: a story of climate determinism and reductionism', *Osiris* (2011) 26(1), pp. 245–66; Mike Hulme, *Weathered: Cultures of Climate*, London: Sage, 2017; Betsy Hartmann, *The Climate Change and Security Discourse: A Critical Overview*, London: Routledge, 2010; Jan Selby and Clemens Hoffmann, 'Rethinking climate change, conflict and security', *Geopolitics* (2014) 19(4), pp. 747–56.

[18] Theodore S. Feldman, 'The history of meteorology, 1750–1800: a study in the quantification of experimental physics', dissertation, University of California, Berkeley, 1983, pp. 230–76; Feldman, 'Late enlightenment meteorology', in Tore Frängsmyr, John L. Heilbron and Robin E. Rider (eds.), *The Quantifying Spirit in the Eighteenth Century*, Berkeley: University of California Press, 1990, pp. 143–77; Caroline C. Hannaway, 'The Société royale de médecine

with the emergence of the nation state and in the age of imperialism. Industrialization, population growth, nation-building efforts and burgeoning colonial ambitions created new demands for climatic knowledge.[19] Since the mid-nineteenth century, national weather services were founded in many countries to improve weather and climate knowledge and support state policies. Weather data did not only serve scientific interests and practical needs in medicine, shipping, agriculture, forestry and water management. National weather services, weather information and descriptive accounts of national climatology also contributed to nation-building and the forging of national identity.

In Norway, for example, climatology (and the geosciences in general) became an important national symbol after independence from Denmark in 1814. In the Habsburg Empire, meteorology and climatology helped to connect the many different peoples and lands of the empire (which included, for example, Austria, Hungary, Bohemia, Moravia and Galicia) and contributed to a sense of national coherence and identity.[20] Likewise, weather stations in the colonies served meteorological knowledge production and as symbols and means of imperial domination. During the early Cold War, Denmark and the USA invested strongly in the operation of weather stations in Greenland to maintain sovereignty (Denmark) and gain full control (USA) of the contested Arctic island as a stronghold against the Soviet Union, another instance of using *science for policy*. Networks of weather stations represented centralized state infrastructure, symbolizing and consolidating state control through continuous presence and the observation, registration and inventory of weather and climate.[21]

Related is a third example, the development of weather forecasting in the nineteenth century, which involved *politics in science* in addition to *science for policy* and the *politics of science*. Reliable weather forecasts were one of the foremost desires of sailors, farmers and many others. Since the late eighteenth century, the rising availability of weather data nurtured the hope of scientific weather prediction. Scientists set high standards for prediction, guided by the ideal of astronomy. Weather and climate, however, proved complex phenomena, and meteorology remained far from that ideal. The tasks and purposes of the Prussian Meteorological Service, founded in 1847, for example, did not include weather forecasting, as the state of science was considered insufficient. Its director, Wilhelm Mahlmann, called

and Epidemics in the Ancien Régime', *Bulletin of the History of Medicine* (1972) 46, pp. 257–73; Hulb J. Zuidervaart, 'An eighteenth-century medical–meteorological society in the Netherlands: an investigation of early organization, instrumentation and quantification', *BJHS* (2005) 38(4), pp. 379–410, and (2006) 39(1), pp. 49–66; Golinski, op. cit. (13), pp. 137–50. David C. Cassidy, 'Meteorology in Mannheim: the Palatine Meteorological Society, 1780–1795', *Sudhoffs Archiv* (1985) 69(1), pp. 8–25; Linda Richter, *Semiotik, Physik, Organik: Eine Geschichte des Wissens vom Wetter (1750–1850)*, Frankfurt am Main: Campus, 2019. Aitor Anduaga, *Politics, Statistics and Weather Forecasting, 1840–1910: Taming the Weather*, Abingdon: Routledge, 2020; Katharine Anderson, *Predicting the Weather*, Chicago: University of Chicago Press, 2005.

[19] Morgan, op. cit. (14).

[20] Yngve Nielsen and Magnus Vollset, *Vinden Dreier, Meteorologiens historie i Norge*, Oslo: Spartacus forlag/Scandinavian Academic Press, 2016; Deborah R. Coen, *Climate in Motion: Science, Empire, and the Problem of Scale*, Chicago: University of Chicago Press, 2018. For the case of England see also Anderson, op. cit. (18); and Peter Moore, *The Weather Experiment: The Pioneers Who Sought to See the Future*, London: Chatto & Windus, 2015. For the case of France see Fabien Locher, *Le savant et la tempête: Etudier l'atmosphère et prévoir le temps au XIXe siècle*, Rennes: Presses universitaires de Rennes, 2008. For the case of Switzerland see Franziska Hupfer, *Das Wetter der Nation: Meteorologie, Klimatologie und der schweizerische Bundesstaat, 1860–1914*, Zurich: Chronos, 2019.

[21] E.g. Martin Mahony and Georgina Endfield, 'Climate and colonialism', *WIREs Climate Change* (2018) 9(2), at https://doi.org/10.1002/wcc.510; Fiona Williamson and Vladimir Jankovic, 'A question of scale: making meteorological knowledge and nation in Imperial Asia', *History of Meteorology* (2020) 9, pp. 1–9; Matthias Heymann, 'In search of control: Arctic weather stations in the early Cold War', in Ronald E. Doel, Kristine C. Harper and Matthias Heymann (eds.), *Exploring Greenland: Cold War Science and Technology on Ice*, New York: Palgrave MacMillan, 2016, pp. 75–98.

it *Meteoromantie*, a shortcut for meteorological prophecy.[22] When Robert FitzRoy, director of the Meteorological Department in England, built up a system of daily weather forecasts for five British regions in 1861, a sharp scientific controversy ensued with FitzRoy being blamed because his forecasts did not meet scientific standards. After FitzRoy's suicide in May 1865, the Royal Society stepped in with severe criticism, and the British government cancelled forecasts and storm warnings.[23] It was a matter of *politics in science* that put strong pressures on FitzRoy and caused the discontinuation of the service he had established.

A public outcry, however, forced the reluctant Royal Society to reconsider weather forecasting. After a few years, a new system was established, based on the reading of 'synoptic charts'. This turn of events is deeply ironic, first because FitzRoy had introduced synoptic charts in 1863 for a weather map representing comprehensive weather data, and second because the authority of weather forecasting 'was now closely linked … to the heart of the scientific establishment, the Royal Society'.[24] While scientifically controversial, national weather services in many countries adopted synoptic weather forecasting in the following years and decades.[25] It became common practice, though it was considered an art rather than a science. State interests in weather forecasting had forced this pragmatism, an example of both the *politics of science* (political intervention in the authority of scientific standards) and *science for policy* (weather forecasting for serving state interests).

A fourth example regards the establishment of weather and climate modelling in the second half of the twentieth century, which also involved science–politics entanglements in all suggested categories. The second half of the twentieth century saw a radical shift in the understanding of weather and climate. The conditions of the Second World War and the early Cold War provided science and technology with new tools, such as computers, rockets, satellites and systems science, and dressed it with previously unseen authority, resources and expectations. US Cold War interests resonated well with the promises of meteorologists. After the Second World War, the mathematician John von Neumann and the meteorologist Carl Gustav Rossby proved well versed in the *politics of science*. They recognized the new opportunities in meteorology and boldly sold the prospect of controlling the atmosphere through science-based weather forecasting and weather and climate modification – powerful arguments in an era of military rivalry and geopolitical ambition. The Navy's Office of Research and Invention provided funding for the so-called Meteorology Project, in which a team of young scientists, led by von Neumann and coached by Rossby, used for the first time a digital computer to master extremely complex calculations for approximate solutions of the physical equations governing the atmosphere (which had no analytical solution). Based on this approach, they developed computer-based weather forecasting and paved the way for the rapid rise of computer-based numerical weather prediction and climate modelling.[26]

22 Richter, op. cit. (18), pp. 268–71. Wilhelm Mahlmann, 'Meteoromantie', in E.F. August und F.W. Barentin (eds.), *Handwörterbuch der Chemie und Physik*, vol. 3, Berlin: M. Simon, 1850, pp. 155–7.

23 Jim Burton, 'Robert FitzRoy and the early history of the Meteorological Office', *BJHS* (1986) 19(2), pp. 147–76; Anderson, op. cit. (18), pp. 112–30; Moore, op. cit. (20), pp. 228–315; Matthias Heymann, 'Weather and climate modeling and the perils of prediction', in Theodore Arabatzis, Stathis Arapostathis, Iraklis Katsaloulis and Aristotle Tympas (eds.), *The Perils and Promises of Prediction: Historical and Epistemological Perspectives*, Cham: Springer Nature, 2026, pp. 143–58.

24 Katherine Anderson, 'Practical science: meteorology and the forecasting controversy in mid-Victorian Britain', dissertation, Northwestern University, 1994, pp. 301–2.

25 Anduaga, op. cit. (18), pp. 298–320, and pp. 112–29 on Fitzroy's introduction of the term 'synoptic'; Anderson, op. cit. (18), pp. 128–9.

26 Kristine C. Harper, *Weather by the Numbers: The Genesis of Modern Meteorology*, Cambridge, MA: MIT Press, 2008. Frederik Nebeker, *Calculating the Weather: Meteorology in the 20th Century*, San Diego: Academic Press, 1995, pp. 135–72; Paul N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*, Cambridge, MA: MIT Press, 2010.

'Weather and climate modification', which leading scientists and policymakers actively promoted, became a predominant political formula and the common label for weather and climate research in the USA for the next twenty years.[27] Rising flows of (mostly military) funding for weather and climate prediction (and possibly modification) served the powerful logic of *science for policy* in the Cold War competition with the Soviet Union, while, from the perspective of leading scientists and science administrators, it may rather be labelled the result of the *politics of science*. It facilitated significant scientific accomplishments, such as the development of computer-based, numerical weather models for weather forecasting and general circulation models (GCMs) for climate modelling and simulation, which revolutionized weather services as well as climate sciences.[28]

Weather and climate modelling and simulation pioneered the rise of computer-based simulation science, which also caused significant *politics in science*. Computer models of the atmosphere were characterized by many simplifications, and scientists knew that they were not realistic; it could not even be established with any certainty how far from the actual behaviour of the atmosphere these models were. Especially in the case of complex climate models, the issue of uncertainty generated much debate among scientists, with a few even opposing their use, such as British climatologist Hubert Lamb.[29] The issue became particularly salient when climate models served to predict the long-term consequences of rising greenhouse gas emissions. Empirically oriented scientists, such as world-renowned climatologist Helmut Erich Landsberg, shared concerns about the credibility of science, when wide-ranging claims were drawn from uncertain models. The successes, practicality and increasing demand of this kind of modelling and simulation work, however, outlived these concerns and arguably led to a gradual softening of epistemic standards and norms in computer simulation science. First, this approach caused the alleviation of strict shared norms of accuracy and rigour that clashed with the simplifications and pragmatic assumptions in models. Second, it led to the overriding of the norm of reticence – as some scientists expressed it – by going public with the results of knowingly uncertain science. Both these shifts represented a significant result of the *politics in climate science* during the 1970s and 1980s. They opened the possibility of further politicization and paved the way for the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988.[30]

A final example is related to the work of the IPCC and its repercussions. Public and political concern about climate change in the late twentieth century created a strong demand of *science for policy*. The IPCC had the task of establishing a scientific consensus about the state of knowledge about climate change and produce projections about future climate to

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[27] Kristine C. Harper, *Make It Rain: State Control of the Atmosphere in Twentieth-Century America*, Chicago: University of Chicago Press, 2017; Ronald E. Doel and Kristine C. Harper, 'Prometheus unleashed: science as a diplomatic weapon in the Lyndon B. Johnson administration', *Osiris* (2006) 21, pp. 66–85. See also the contribution by Matthias Heymann, 'Science diplomacy and politics: building the Global Atmospheric Research Program', in this special issue.

[28] Edwards, op. cit. (26); Heymann, Gramelsberger and Mahoney, op. cit. (10); Matthias Heymann and Dania Achermann, 'From climatology to climate science in the 20th century', in White, Pfister and Mauelshagen, op. cit. (14), pp. 607–34.

[29] Janet Martin-Nielsen, 'Ways of knowing climate: Hubert H. Lamb and climate research in the UK', *WIREs Climate Change* (2015) 6, pp. 465–77; Martin-Nielsen, 'A new climate: Hubert H. Lamb and boundary work at the UK Meteorological Office', in Heymann, Gramelsberger and Mahoney, op. cit. (10), pp. 85–99.

[30] Gabriel D. Henderson, 'The dilemma of reticence: Helmut Landsberg, Stephen Schneider, and public communication of climate risk, 1971–1976', *History of Meteorology* (2014) 6, pp. 53–78; Matthias Heymann and Nils Randlev Hundebøl, 'From heuristic to predictive: making climate models political instruments', in Heymann, Gramelsberger and Mahoney, op. cit. (10), pp. 100–19; Matthias Heymann, 'Knowledge production with climate models: on the power of a "weak" type of knowledge', in Moritz Epple, A. Imhausen and F. Müller (eds.) *Weak Knowledge: Forms, Functions, and Dynamics*, Frankfurt am Main: Campus, 2019, pp. 321–50; Heymann, op. cit. (23).

serve policy demands. The relevance of the IPCC, however, proved much broader than serving *science for policy*. First, the importance of climate change and the institutionalization of the IPCC helped channel ample amounts of funding to climate science and expand the discipline as well as its modelling efforts tremendously. Models expanded in complexity to become Earth system models and capture both climatic impacts from greenhouse gases and feedback process from oceans, cryosphere and biosphere. Second, the strong demand for climate projections, on the other hand, redefined priorities in climate science with a strong focus on the application of climate models to simulating projections, which became a key effort. Third, political demand pushed an expansion of the modelling paradigm into the realm of the social and economic sciences with the development of so-called integrated assessment models (IAMs) that made use of the data produced by Earth system models to evaluate the effect of economic and environmental policies on environmental and climate change and its social and economic impacts. The IPCC manifested the emergence of a new model-based regime of expertise and dressed the integrated modelling regime with social and political authority. Fourth, it contributed to making climate science a matter of public debate and to shaping public perceptions and political discourse about climate change.[31]

In short, the science-for-policy approach of the IPCC engendered much *politics of science* (and *politics in science*) in many dimensions and a co-construction of science and politics.[32] Climate science profited from a multiplication of resources, of workforce and of public attention. Climate scientists and their practices, on the other hand, moved into public light and under public scrutiny like never before, which demanded new communication strategies and skills. Another element of the *politics of science* became fully visible only in the 2000s. Climate science's close policy link to (and dependence on) political demands and funding increasingly pushed a development that many scientists experienced as a dispossession of their modelling tools and loss of control. Since about the 2000s, the integrated model-based regime of expertise increasingly encouraged political actors to pursue and investigate technical solutions to climate change, such as geoengineering and so-called negative emissions technologies (NETs), which remove carbon from the atmosphere on a large scale. Between 2010 and 2015, as greenhouse gas emissions continued to rise, a series of increasingly optimistic decarbonization scenarios were published by the IPCC, which mainly relied on NETs. The historic international climate agreement at the Paris conference in December 2015 to limit the increase of global mean temperature to 1.5 °C instead of 2 °C relied on IPCC projections based on large-scale application of these so far unavailable, unproven and potentially risky strategies. Scientists were shocked to realize that the model-based regime of expertise now seemed to serve the propagation of technical solutions rather than political strategies for emission reductions.[33]

[31] Lisette van Beek, Maarten Hajer, Peter Pelzer, Detlef van Vuuren and Christophe Cassen, 'Anticipating futures through models: the rise of integrated assessment modelling in the climate science–policy interface since 1970', *Global Environmental Change* (2020) 65, 102191, at https://doi.org/10.1016/j.gloenvcha.2020.102191; Heymann and Dahan Dalmedico, op. cit. (2).

[32] Silke Beck and Martin Mahony, 'The IPCC and the new map of science and politics', *WIREs Climate Change* (2018), e547, at https://doi.org/10.1002/wcc.547; Clark A. Miller and Paul N. Edwards (eds.), *Changing the Atmosphere: Expert Knowledge and Environmental Governance*, Cambridge, MA: MIT Press, 2001; Heymann and Dahan Dalmedico, op. cit. (2); Duncan McLaren and Nils Marcusson, 'The co-evolution of technological promises, modelling, policies and climate change targets', *Nature Climate Change* (2020) 10, pp. 392–7.

[33] Kevin Anderson, 'Duality in climate science', *Nature Geosciences* (2015) 8, pp. 898–900; Wim Carton, '"Fixing" climate change by mortgaging the future: negative emissions, spatiotemporal fixes, and the political economy of delay', *Antipode* (2019) 51(3), pp. 750–69; McLaren and Marcusson, op. cit. (32); Heymann and Dahan Dalmedico, op. cit. (2), pp. 1147–8.

Broadening the agenda: diversity and variability in global climate science

The set of articles in this issue will broaden and deepen understanding of the multiple and complex relationships between epistemology and politics in climate science and challenge narrow standard narratives. The articles add to the existing literature in several ways. They focus on the post-war period, which has received less attention in the historiography of climate research than, for example, the nineteenth century or the early twentieth. Second, they broaden previously US-centred narratives by focusing on a variety of world regions and national and international research efforts. They show that the political and cultural contexts vary, and the relationships between politics and science play out in different ways. Third, while much of the literature on recent climate science focuses on the history of global climate change and climate modelling and simulation, this set of articles adds analysis and narratives on diverse climatological disciplines and issues, including, for example, bioclimatology, palaeoclimatology and colonial meteorology. The articles address issues such as the role of interests and the authority of scientific and political actors (including, for example, largely neglected actors such as journal editors and journalists) and the political boundary work in determining climatological research directions, the role of technology, and the perceptions, interpretations, visions and political rhetoric of scientists in national and international science diplomacy and public policy efforts.

Fiona Williamson's article examines how meteorology in Malaya and Singapore from 1940 to 1960 was fundamentally shaped by war, occupation and colonial military priorities. Originally a civil service focused on aviation and routine forecasting, the British colonizers rapidly militarized the Malayan Meteorological Service during the Second World War to support British air operations, before it was dismantled during the Japanese invasion. After the war, meteorological infrastructure was only slowly rebuilt. When the Malayan Emergency – the anti-British national liberation guerilla war by the Malayan National Liberation Army (MNLA) – began in 1948, the service once again became essential to military operations for providing forecasts for air strikes, reconnaissance, supply drops and jungle warfare. Williamson shows that the British *politics of science* focused scientific priorities, staffing and resources on strategic military needs and colonial interests. Meteorology played a more central role in colonial governance than in investigating tropical weather and climate and addressing local civilian concerns. This entanglement of science, empire and warfare in decades of conflict left a lasting imprint on tropical meteorology in South East Asia.

Lucie Gerber explores in her article how scientists at the French Centre national de la recherche scientifique (CNRS) imagined and used the 'phytotron', a controlled-climate laboratory at Gif-sur-Yvette built in the 1950s, as an experimental research facility to help modernize plant production and agricultural productivity in France and in drylands of colonial North Africa. Plant physiologists at Gif treated climate as a manipulable complex of factors – such as light, temperature, humidity and so on – and investigated plant responses to combinations of these factors. They focused on the temporal dependencies of plant growth on climatic factors at daily and seasonal timescales for optimizing the timing of interventions in agriculture and horticulture. The phytotron was also sold as an 'accelerator' of plant growth by allowing intervention in the timing of climate-sensitive biological events, which could help to define the delimitation and extension of a plant's productive area and even allow unused climatic resources to be tapped by adapting agriculture to deserts. Gerber's account reveals the *politics of science* of ambitious scientists, who adopted Cold War science and modernization ideologies to promote their visions of biological big science. While phytotron research continued until its closure in 1988, it suffered from the neglect of soil biology and ecological complexity, as well as from institutional and financial constraints, and never lived up to its promise.

Dania Achermann's contribution focuses on the role of isotope analysis in the development of climate research. She argues that regional political and cultural contexts outside the Anglo-American countries have also played a significant part in the shaping of ice core palaeoclimatology and climate science. By zooming in on the history of a radiocarbon laboratory in Switzerland, her contribution shows that the national and cultural importance of nuclear physics and glaciology facilitated the emergence of such a laboratory of international standing. The article highlights a particularly significant aspect of the *politics of science*. State funding for nuclear research in the 1950s served Switzerland's goal of keeping up with the international state of research. This enabled the establishment of the carbon-14 laboratory in the first place. At the same time, narratives of Swiss identity contributed to governmental support for glaciology. Based on the desire for international integration after a long period of isolation, international projects such as polar expeditions enjoyed broad political support. By shifting its research objectives from nuclear physics to archaeology, glaciology and, ultimately, climate science, the laboratory also engaged in *politics in science*. While funding for carbon-14 dating decreased, carbon dioxide emerged as a highly relevant political and scientific topic in the 1970s, on which the laboratory could build, and through which it could secure its further existence as a palaeoclimate research institution. This case study demonstrates that also the *politics of other sciences* had a significant impact on the epistemology of climate science.

Matthias Heymann traces the origins of the Global Atmospheric Research Program (GARP), showing how, between about 1961 and 1967, scientists and political actors worked to build what became the largest international atmospheric-science collaboration programme. GARP was launched in 1967 by the World Meteorological Organization (WMO) together with the International Council of Scientific Unions (ICSU) with the aim of coordinating global atmospheric observations, improving computer-based numerical weather forecasting and advancing climate science. The starting point for developing GARP was US president John F. Kennedy's call for international cooperation in atmospheric and space research in 1961, an example of *science for policy* for the purpose of international diplomacy to ease Cold War tensions. Kennedy's diplomatic initiative opened an attractive window of opportunity for scientists, who pursued their own *politics of science* in successfully negotiating political support for an international programme. Competition within science for funding and support between disciplines and research areas, research establishments and weather services, and between nations, required careful negotiations within ICSU led by Bert Bolin. Bolin successfully orchestrated the *politics in science* over several years that eventually helped to produce consensus and define the directions and details of the research programme.

By investigating historical correspondence between influential climatologists (notably Hubert Lamb) and editors of major journals during 1973 and 1974, Robert Naylor and Eleanor Shaw show that journal editors played a crucial and underappreciated role in shaping how early climate change was discussed in public and scientific media in the 1970s. During that decade there was a debate between climate modellers using computer-based atmospheric simulations, which suggested the possibility of future warming, and climatologists such as Hubert Lamb, who investigated long-term past climatic history based on empirical weather data. Editors at high-profile journals (like *Nature, The Ecologist*, the *UNESCO Courier* and *Development Forum*) acted as gatekeepers, deciding which voices and messages reached broader audiences. Lamb's correspondence with editors reveals how editors helped package climate change messages into forms that resonated better with prevailing environmental, political and social concerns. Naylor and Shaw argue that early climate change narratives were not purely the outcome of scientific consensus but were co-constructed by editors who pursued their own *politics of science* by adjusting arguments to fit existing discourses. This effort helped raise attention to and the status of climate change in public and policy arenas by the late 1970s.

Carolina Granado examines the role of Bert Bolin, the first chair of the Intergovernmental Panel on Climate Change (IPCC), in shaping how the IPCC was established, how its scientific assessments were communicated, and how it gained legitimacy during the early years of international climate negotiations. She argues that Bolin served as a mediator between climate science producers (scientists) and users (governments and corporations), which involved selecting which scientific findings to highlight to political actors and framing climate change as a policy-relevant problem. At the same time, his leadership helped to institutionalize the IPCC by building trust in its scientific authority through 'boundary work' and maintaining a clear but strategically positioned boundary between science and policy to maximize credibility. With evolving political and social contexts, Bolin's role adapted over time. When the IPCC came under attack in the early 1990s, he aimed to protect its authority by addressing criticisms. He included sceptical scientists in the assessment process, emphasized its objectivity and rigour, and promoted wider acceptance of climate science. The article demonstrates the importance of Bolin's diplomatic skills in the *politics of science*. Scientific authority did not arise from data, models and scientific assessments, but was crafted through careful framing, selection and communication strategies.

Conclusion

There is agreement among historians about the importance of science–politics relations in the history of climate science. Notably, in recent decades, few disciplines have experienced politicization to an extent similar to that of climate science. It is not easy to grasp and understand what this exactly means and whether (or not) this factor differentiates climate science from other scientific disciplines. This special issue aims to broaden and deepen our understanding of the *diversity* of science–politics relations and entanglements in climate science, with a focus on the history of post-war climate science. Case studies from British Malaya (Malaysia since 1963), France, Switzerland and the UK, and the international efforts of the Global Atmospheric Research Program and the IPCC, add new insights and details about the role of colonial interests, modernization tales, national identity, editor policies and the political 'boundary work' of scientists in a diversity of research domains and political and social contexts. These cases show and further corroborate that epistemology and the politics of climate science are linked and interact in many diverse, sometimes neglected, sometimes overlooked, ways that deserve attention. These cases also suggest that reflection and discussion about more fine-grained analytical tools may help to order, analyse, disentangle and make sense of the diverse forms and formats of relations of politics and climate science. As a starting point for such discussion and further academic work in the history of science we suggest a basic differentiation between the categories *science for policy*, the *politics of science* and *politics in science*.

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