Accepted: 10 November 2020

DOI: 10.1111/geoj.12367

THEMED SECTION

WILEY

THE GJ Royal Geographical Society with IBG

Does the science criterion rest on thin ice?

Peder Roberts[1,2]

[1]Cultural Studies and Languages, University of Stavanger, Stavanger, Norway

[2]Division of History of Science, Technology and Environment, KTH Royal Institute of Technology, Stockholm, Sweden

Correspondence
Peder Roberts
Email: peder.w.roberts@uis.no

Funding information
European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme, Grant/Award Number: 716211

This paper explores whether a central plank of the Antarctic Treaty System (ATS) – the science criterion – is threatened by anthropogenic climate change. It begins by situating the origins of the ATS within the context of the International Geophysical Year (IGY), and the privileged position that science obtained within first the IGY and later the ATS. This extends to science functioning as the dominant currency through which states may ascend to the level of consultative parties (CPs), the highest level of authority within the ATS. Within this model Antarctica functions as a laboratory, a metaphor with a long history in Antarctica, reinforced by the Madrid Protocol and its strong focus on maintaining environmental boundaries and by a perception that Antarctica otherwise plays a minimal role in global affairs. Much of the research in Antarctica focuses on climate change and indeed has been important in establishing its scope and magnitude. But climate change also threatens both Antarctica itself and – by extension – the many low-lying areas of the world that would be affected by rising sea levels caused by melting Antarctic ice. Given Antarctica may no longer be so removed from the rest of the world, is this sufficient reason to revisit the centrality of science to legitimate participation in Antarctic governance? The paper considers alternatives to the current system, including assigning authority within the ATS to states affected by climate change. It concludes that while the science criterion remains viable, it rests on a moral as well as practical foundation that could be undermined if the right to authority over Antarctica remains disconnected from the actions that cause changes to the continent.

KEYWORDS
Antarctica, climate change, geopolitics, governance, justice, science

1 | INTRODUCTION

In 1988 the consultative parties to the Antarctic Treaty System (ATS) agreed on the painstakingly constructed Convention on the Regulation of Antarctic Mineral Resources (CRAMRA), a framework that would facilitate mining in Antarctica. But thanks in large part to regrets from Australia and France, the parties abandoned the convention even before it was signed. Instead they endorsed a Protocol on Environmental Protection to the Antarctic Treaty, widely known as the Madrid Protocol. The Protocol's combination of strenuous regulation of the Antarctic environment and vigorous nodding to green values symbolised an agreement that Antarctica was more than a continent for peace and science; it was a continent for environmental protection.

The primary motivation for abandoning CRAMRA in favour of the Madrid Protocol was to preserve a unique environment that should be safeguarded against the impacts of change that have marked other parts of the globe. But the rest of the world has changed Antarctica, and – perhaps more importantly – the world risks being changed substantially *by* Antarctica, thanks to melting ice shelves raising global sea levels and potentially altering ocean circulation patterns. The drivers of that change are a long way further north, but through the medium of Antarctica they become transformed into consequences that flow back toward lower latitudes.

The argument of this paper is that anthropogenic climate change poses a serious but underappreciated challenge to the current system of Antarctic governance. My focus is on the regime created by the "science criterion," through which scientific activity constitutes both the justification for human presence in Antarctica and the currency through which power within the ATS is legitimately obtained. I begin by sketching the historical roots of the ATS and the science criterion. I will take the central role of states as given, not because I want to argue that this is the optimal possible mode of governance for Antarctica or anywhere else, but because my concern is with the stability and durability of the system (cf. Kolers, 2012). Following scholars such as Grevsmühl (2019), I contend that the metaphor of Antarctica as a laboratory has been crucial in underpinning the legitimacy of this position. I consider how anthropogenic climate change challenges both the practical and the moral bases of this metaphor and suggest that regarding Antarctica as a conduit may also have value. I then consider the advantages and disadvantages of including the consequences of Antarctic ice melting in assessments of a state's right to participate in Antarctic governance, concluding that while a better alternative to the science criterion may not be in sight, the moral dimension of this convention – and hence part of its legitimacy – may well be challenged.

2 | HOW SCIENCE BECAME THE DOMINANT ANTARCTIC CURRENCY

The ATS is the primary mechanism for Antarctic governance. It covers a bounded territory that has come to include both terrestrial and marine spaces. Eight states have historic sovereignty claims that have not been ceded, but rather frozen. Many scholars link the foundation of the ATS with the International Geophysical Year (1957–1958) (see among many others Bones, 2016; Howkins, 2017, pp. 130–66). An artefact of as well an exception to the tensions of the Cold War, the IGY – like the ATS – involved the USA and the USSR successfully advocating for a regime in which scientific activity conducted within the Antarctic would not be considered legally consequential in terms of sovereignty claims. In the short term this meant that a kind of "science Olympics" could be conducted, with the entire Antarctic continent open for competition (Dodds & Nuttall, 2016, pp. 72–73). Feats such as the Amundsen-Scott South Pole station, established by the USA, or the Soviet traverse to the Pole of Inaccessibility performed similar geopolitical work to the Sputnik launch in October 1957 or the US Navy-sponsored descent to the bottom of the Marianas Trench in January 1960.

In the long term the definition of science as the privileged form of activity in Antarctica became incorporated within the ATS. As Antonello (2019) has recently shown, wrangling continued about potential economic activity in Antarctica and its waters between 1959 and 1980. But in the absence of an indigenous population, and with little potential for economic activity and negligible military significance, Antarctica was a space where political aspirations could be inscribed on territory through the performance of science, as well as being known through the means of science, without the concomitant dimension of sovereignty. It is possible to look favourably on this arrangement without losing sight of the fact it also made science the means through which states competed as well as cooperated. A governance system built around science made sense for a territory where science was the most important activity.

In today's ATS, states cannot attain the status of consultative parties (CPs) – the highest level of decision-making power within the ATS – without demonstrated commitment to conducting science in Antarctica. Sociologist and philosopher of science Aant Elzinga has pioneered critical analysis of the science criterion. "Performing substantial scientific research as an entry ticket for new countries to manifest their presence and participate in the management of the Antarctic continent's future is key," he writes. "Science has a dual function, both advancing new knowledge and manifesting a country's serious interest and presence. Politics in this context is not a bad thing, but rather a good thing, an incentive to do good research that will, in turn, give a country clout at the decision-making table" (Elzinga, 2011, pp. 59–60). Elzinga's use of the term "performing" is neither pejorative nor incidental: doing (and being seen to be doing) is important in addition to knowing. Conducting science thus becomes a peculiarly meaningful way of establishing a legitimate connection with Antarctica. As Miller (2012) has argued, actions that are accorded historical significance build emotional bonds that can justify rights within a territory, something that I argue has occurred in Antarctica – and which has encouraged the retrospective desire to bring out the "scientific" aspect of early activities in order to better locate them within an overarching narrative.

Environmental protection is important in Antarctica also; the Madrid Protocol is proof of that. But is environmental protection congruent with science? The Greenpeace World Park campaign of the late 1980s and early 1990s had as its premise

that the ATS was *not* capable of enacting environmental protection for its own sake. The long history of science as a handmaiden to economic development has never really ended. Part of the resistance to CRAMRA from states in the developing world derived from a perception that the ATS was a colonial-era institution whose membership – defined in large part by commitment to scientific investigation of the continent – now hoped to carve up its resources among themselves (Dodds, 2010). Even in the age of the Madrid Protocol the focus has been on minimising human impacts on Antarctica by distinguishing between the necessary and the unnecessary, with science support justifying the construction and maintenance of considerable infrastructure.

The Madrid Protocol, with its focus on rigorous policing of intrusions on a demarcated space in the name of environmental purity, is nevertheless consistent with the view of Antarctica as a laboratory. Certain kinds of research can only be conducted in the Antarctic because the phenomena in question are endemic to the region (king penguins or the subglacial Lake Vostok). Other forms of research (such as aurora and airglow studies or glaciology) are not unique to Antarctica, but the continent provides excellent conditions in which to pursue them. Even in the years before the ATS it was widely recognised that studying Antarctica could reveal truths of broader significance. The Norwegian–British–Swedish Antarctic Expedition of 1949–1952 (NBSX) had as its emblematic justification measuring glacial recession in Queen Maud Land to determine if a global climatic improvement was underway (Roberts, 2011). And the IGY itself was premised on the idea that geophysical investigations ought to cover the whole globe and its atmosphere – extending into space. Is this not a good justification for maintaining the privileged position of science as it stands, particularly as the walls of the laboratory and the protocols for activity within are designed to ensure environmental control in the name of revealing scientific secrets?

A first objection to aligning science with environmental protection within the laboratory metaphor comes from the possibilities for scientific discovery that environmental change, even damage, might make possible. As Engelbertz et al. (2013, p. 12) have argued, dramatic loss of ice cover could in theory make Antarctica an equally interesting site for scientific research, irrespective of moral norms about environmental protection. There would still be science to do, and some of it might be equally relevant (if not more so) to understanding large-scale questions bearing on the world as a whole. Consider that the IGY arose within a context of burgeoning interest in the earth's upper atmosphere – knowledge that was enhanced by among other things studying the fallout patterns from nuclear tests in the Pacific Ocean (Rainger, 2004). The environmental damage that those tests caused was not inconsistent with gains to scientific understanding of fundamental atmospheric processes.

A second objection arises from the permeability of the laboratory walls. Consensus on the science criterion in 1959 reflected not only a positive valuation of science, but an assessment that practically all the other motivations for legitimate human presence in Antarctica were inconsequential. Importantly, it underplayed the phenomenon of teleconnection, by which changes in one part of the globe have consequences far away. Geophysical examples include the El Niño–Southern Oscillation events, in which local replacement of warm and moist air with cold and dry air in the Pacific produces significant climatic effects as far away as southern Africa. Teleconnections can also be anthropogenic, such as John R. McNeill's example of how a British demand for stable cotton supplies "inspired the large-scale replumbing of Egypt that culminated in the Aswan High Dam in the 1970s" (McNeill, 2019, p. 495). This is important because while the interconnected nature of global systems was clear already in the 1950s, there was considerably less appreciation of the agency of humans in driving those changes. The Swedish geographer Hans Ahlmann, whose climate change studies lay behind the NBSX, regarded the causes of those changes as natural and remained sceptical about human agency changing such large-scale processes (Sörlin, 2009).

3 | CONDUITS AND DAMS

Of course, the most important example of a teleconnection in the world today is ocean and air temperature rise caused by greenhouse gas emissions, in turn causing rising sea levels through the melting of polar ice sheets. Antarctica is both a site where knowledge about climate change is produced, and the most important source of the melting water that will raise sea levels in years to come through its massive continental ice sheets, far larger even than those of Greenland. Note the fundamental difference from the NBSX, which sought to measure glacial recession in Antarctica in order to measure climate change. The bare mountainsides that Ahlmann proposed using as indices of climate change have been replaced by calving ice shelves and thinning ice-sheets. The water released in these processes is a driver of change as much as an index of change. I therefore suggest that a major assumption behind the dominance of science as the currency of Antarctic power, that Antarctica has little impact on the rest of the world in economic or military-strategic terms and can thus safely be demarcated as a laboratory, is no longer true.

Could we then think of Antarctica as a conduit through which emissions become consequences, in addition to being a site where the consequences of emissions are revealed? The virtue of the conduit metaphor is that it focuses attention on flows through space. Rather than being a frozen mass (literally and politically) fringed by charismatic fauna, Antarctica becomes a dynamic space transformed by distant actions, with consequences far beyond the zone of the ATS. I am hesitant to assert that the conduit is always the more appropriate metaphor than the laboratory, given that the Antarctic continent is valued for its own sake and not simply as a reservoir of frozen water, a giant equivalent of a tailings dam (though it is also that). It could be argued that demarcation of Antarctica as a laboratory actually has increased value in a time of anthropogenic climate change, as a site where knowledge of vital importance to the world's future is produced. Nevertheless, the fact remains that Antarctica is no longer *just* a site for disembodied knowledge production, given that the very ice from which that knowledge comes is also a potentially existential threat for residents of low-lying states living far to the north.

If that conduit is to be dammed, then who should have the right to take the necessary decisions? Currently decisions regarding activities within the spatial remit of the ATS are taken by the CPs (at the time of writing they number 29) at annual Antarctic Treaty Consultative Meetings (ATCMs). As previously noted, attaining the status of CP requires "conducting substantial research activity there." Conducting science, and thus generating knowledge of the natural world (including the effects of climate change), is the best reason to have power over the space in which that work is conducted if the knowledge thus generated is considered more valuable than any other potential use of the continent. It may seem facile, but the simple fact that Antarctica is a territory *without* a population who might be entitled to exercise legitimate self-determination is crucial to legitimising the power of science within that space. This means no population with an inherent right to manage natural resources, something recognised by many scholars as a key justification for maintaining the control associated with self-determination (Miller, 2012; Moore, 2012).

It is of course possible for the CPs to argue that their control over Antarctica is justified by the fact it has remained peaceful, (largely) undisturbed, and unexploited, evidence both of their own fitness to govern and of the fitness of the system through which they govern (including the science criterion). This position risks incorrectly identifying the system itself as the cause of that success, rather than the lack of challenges to it. Climate change poses just such a challenge, but despite awareness of the potential dangers to and through Antarctica, there has been a continued disconnection between the causes of Antarctic change and control over the continent itself. The West Antarctic Ice Shelf is threatened by Australian coal, Russian gas, and United States oil. Even if a moral argument were successfully made that the CPs have forfeited their legitimacy through their failure to preserve the sanctity of the laboratory, controlling Antarctica would be of limited utility without control over the mechanisms that drive environmental change in Antarctica. The correlation between CPs and major greenhouse gas emitters is sufficiently strong to suggest that this disparity will remain.

We can plausibly imagine a near-term future in which Antarctica melts substantially while the science conducted on the continent remains first-rate and its minerals remain economically unviable to exploit. Historian of science Robert Proctor has argued that good science is not always done by good people: Nazi science produced anti-smoking campaigns and sound cancer research in addition to horrific medical experiments and fraudulent racial science, to take but one extreme example (Proctor, 2000, especially pp. 248–278). The point is not that Nazism was any less evil because researchers working under its banner also produced some good public health research, but rather that it is dangerous to assign moral value to the producers of science based on the science itself. The current system might continue to facilitate good research backed by states whose actions have caused the site of the research to not only change, but to change in a manner that wreaks havoc. Science could continue to be functionally suitable as a measure of activity in Antarctica, but the moral authority that it carries would likely be challenged.

Could replacing the science criterion with some other justification for a privileged position at the Antarctic table lead to better results? Imagine a plan to reorient the ATS away from participation in Antarctic science, towards exposure to the effects of anthropogenic climate change. The states that are most affected by the consequences of change in Antarctica – Bangladesh, the Maldives, even Denmark – would have the power of decision-making within the ATS. Different permutations might be imagined, ranging from power being correlated to economic loss (states suffering most potential disadvantage) to power being a function of territorial loss (which need not necessarily correlate with economic loss). Conducting lots of science, even lots of very good science, would no longer be the decisive factor.

While the idea is attractive in principle, it risks replacing one problematic principle with another even more problematic principle. The moral authority of science within the ATS may be a product of historical circumstance. It is nevertheless widely recognised as a happy product, and the Madrid Protocol has joined it to values of environmental protection that are equally widely agreed to be morally admirable. And the claims to moral authority have been strengthened by concrete examples of scientific research that have contributed to knowledge about global environmental change, from the discovery of the ozone hole around Antarctica to glaciological and ice-core studies that reveal past and present climatic events, and

their effects. In the case of the ozone hole, findings from Antarctica influenced ameliorative measures, informing the Montreal Protocol, widely regarded as one of the most successful instruments of global environmental regulation.

Nor does it solve the problem of rising sea levels, given that it focuses on the symptom rather than the cause. Nine (2014) has argued in the case of rivers that when the consequences of resource use prevent states from exercising self-determination, joint political structures should be formed. The fundamental principle is "giving the threatened group a say in how the resources will be used" (Nine, 2014, p. 164). In the case of Antarctica, the very notion of a threatened group (of humans, at least) has only emerged with the rise of climate change as an issue. And while that group may be threatened by Antarctica, the remedy is not control over Antarctica, but rather control over the resources that effect change there. The key requirement of agency over resource exploitation is not met because the sources of emissions are not located within Antarctica, and hence apportioning control over a territorial unit does not prevent actions that flow from it. For Bangladesh to assert self-determination would involve preventing fossil fuel extraction and consumption outside Antarctica. States seeking to exercise control over their futures by averting sea-level rise would have extremely limited capacity to implement that control through the ATS, even if they were in charge of all decision-making within it. While plans have been sketched for geoengineering interventions that would anchor the major Antarctic ice sheets in place (Moore et al., 2018), these are not widely regarded as feasible.

Could the right to exercise power within the ATS be more strongly linked to refraining from contributing to environmental change in Antarctica? Mancilla's (2015) argument concerning the asymmetric distribution of harms and goods from natural phenomena located within sovereign territory prompts reflection on the moral bases for such distributions. I suggest that in the case of Antarctica – where states have asserted rights to exert authority through science – it is worth contemplating a stronger connection between causes and consequences. States that conduct lots of good science while pumping greenhouse gases into the atmosphere might be charged with robbing Peter to pay Paul, and thus find their status within the ATS diminished. The specific right to participate in governance of Antarctica would thus be linked to the more general responsibility to minimise harms that originate within the boundaries of individual states. Moore (2012) has argued that even a conception of natural resource rights as belonging to states does not dictate full authority over the exploitation of those resources (see also Nine, 2014).

If the right of states to dispose of resources may be limited for reasons of overriding international importance – such as the catastrophic effects of rising sea levels – then the right of an individual state to participate in Antarctic governance may be placed in the category of rights that would be forfeited were those overriding reasons not respected. This would entail a loss of prestige, which has been a key factor in continuing the costly process of conducting research in Antarctica over the years. But in light of the transactional approach to international relations taken by many states at the time of writing, the loss of influence in Antarctica might be seen as relief from a pointless burden. Chile and Argentina, which claim privileged rights based on geographical and historical affinities, would also be highly unlikely to accept any system in which they were sidelined or minimised. Loss of authority within the existing system might well lead to extra-systemic demands for a new system altogether.

A further objection derives from the difficulty of identifying a uniform class of affected parties. Rising sea levels are the most important consequence of climate change, but ocean currents may also be significantly affected. Should Norway be entitled to additional authority because a weakening of the Gulf Stream could make its comparatively temperate coasts more like icy East Greenland? Studies suggest that global temperature increases above 1.5°C will have disproportionate effects on the poor (King & Harrington, 2018). This would require consensus among the class of affected states on remedial measures, which could be difficult if some affected states do not regard preventing fossil fuel extraction as inherently inimical to their interests. Take the case of Greenland, which has pushed ahead with auctioning oil leases despite the effects of climate change on the territory, in large part because the oil extracted from Greenland would make a substantial difference to the local economy (Government of Greenland, 2014). Such issues become even more complex considering the difficulty of definitively sourcing all harms arising from climate change to Antarctica, given that the Greenland ice sheet will also contribute to changes.

4 | CONCLUSION

It is tempting to draw an analogy between the ATS and the United Nations, in which the anachronistic composition of the Security Council persists at least in part because opening fundamental questions about the system as a whole might well lead to its dissolution. There is much less reason to fear a tiger without teeth. Does that in itself constitute grounds for not interfering with a system that has proven surprisingly flexible and resilient over 60 years?

Perhaps, but a latent threat to the legitimacy of the ATS exists as long as the assumption underpinning the system is that there is no greater benefit to humanity from Antarctica than conducting research. This is where I come back to the laboratory and the conduit. The laboratory metaphor may have had its day in terms of differentiating between the controlled inside and the uncontrolled outside, but it might yet do good work by drawing critical attention to the issue of boundaries. Rigorous policing of Antarctica's borders from environmental threats, as demanded by the Madrid Protocol, is now plainly inadequate given the effects of climate change – and doubly so when the threat can be transmitted onward through the consequences of melting.

To take meaningful steps to control emissions, and to reduce change in and from Antarctica, would be a statement of intent that a continent reserved for science and peace cannot be allowed to become a conduit for conflict and destruction. Otherwise the moral standing of the system risks erosion even if the CPs continue to diligently and creatively conduct quality research in Antarctica. If the magnitude of harms caused by Antarctic ice sheets melting is as great as predicted, it will be entirely fair to ask why the states which contributed most to that melting also retained privileged positions at the Antarctic decision-making table all along.

ACKNOWLEDGEMENTS

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No. 716211 - GRETPOL). The author wishes to thank Alejandra Mancilla and two anonymous referees for their constructive and helpful comments. The paper was prepared in conjunction with the workshop under the project "Political Philosophy Looks to Antarctica" financed by the Research Council of Norway (grant number 14446).

FUNDING INFORMATION

European Research Council (ERC) [grant agreement No. 716211 – GRETPOL].

DATA AVAILABILITY STATEMENT

No new data were created for this paper.

ORCID

Peder Roberts https://orcid.org/0000-0002-0019-8251

REFERENCES

Antonello, A. (2019). *The greening of Antarctica: Assembling an international environment*. Oxford, UK: Oxford University Press.

Bones, S. (2016). SCAR as a healing process? Reflections on science and polar politics in the cold war and beyond: The case of Norway. In P. Roberts, L.-M. van der Watt, & A. Howkins (eds.), *Antarctica and the humanities* (pp. 231–250). New York, NY: Palgrave Macmillan.

Dodds, K. (2010). Governing Antarctica: Contemporary challenges and the enduring legacy of the 1959 Antarctic treaty. *Global Policy*, *1*, 108–115. https://doi.org/10.1111/j.1758-5899.2009.00006.x

Dodds, K., & Nuttall, M. (2016). *The scramble for the poles: The geopolitics of the Arctic and the Antarctic (Polity)*. Cambridge, UK: Polity Press.

Elzinga, A. (2011). Origin and limitations of the Antarctic treaty. In P. A. Berkman, M. A. Lang, D. W. H. Walton, & O. R. Young (Eds.), *Science diplomacy: Antarctica, science, and the governance of international spaces* (pp. 59–68). Washington, DC: Smithsonian Press.

Engelbertz, S., Liggett, D., & Steel, G. (2013). Value theory for an Antarctic case study. In D. Liggett, & A. D. Hemmings (Eds.), *Exploring Antarctic values gateway Antarctica special Publications Series 1301, 9–21*.

Government of Greenland (2014). *Greenland's oil and mineral strategy 2014-2018*. Retrieved from https://naalakkersuisut.gl/~/media/Nanoq/Files/Publications/Raastof/ENG/Greenland%20oil%20and%20mineral%20strategy%202014-2018_ENG.pdf

Grevsmühl, S. (2019). Laboratory metaphors in Antarctic history: From nature to space. In J. Herzberg, F. Torma, & C. Kehrt (Eds.), *Ice and snow in the cold war: Histories of extreme climatic environments* (pp. 211–235). New York, NY; Oxford, UK: Berghahn.

Howkins, A. (2017). *Frozen empires: an environmental history of the Antarctic Peninsula*. Oxford, UK: Oxford University Press.

King, A. D., & Harrington, L. J. (2018). The inequality of climate change from 1.5 to 2°C of global warming. *Geophysical Research Letters*, *45*, 5030–5033. https://doi.org/10.1029/2018GL078430

Kolers, A. (2012). Justice, territory and natural resources. *Political Studies*, *60*, 269–286. https://doi.org/10.1111/j.1467-9248.2011.00933.x

Mancilla, A. (2015). The volcanic asymmetry or the question of permanent sovereignty over natural disasters. *Journal of Political Philosophy*, *23*, 192–212. https://doi.org/10.1111/jopp.12038

McNeill, J. R. (2019). Cheap energy and ecological teleconnections of the industrial revolution, 1780–1920. *Environmental History*, *24*, 463–533. https://doi.org/10.1093/envhis/emz006

Miller, D. (2012). Territorial rights: Concept and justification. *Political Studies*, *60*, 252–268. https://doi.org/10.1111/j.1467-9248.2011.00911.x

Moore, J. C., Gladstone, R., Zwinger, T., & Wolovick, M. (2018). Geoengineer polar glaciers to slow sea-level rise. *Nature*, *555*, 303–305. https://doi.org/10.1038/d41586-018-03036-4

Moore, M. (2012). Natural resources, territorial rights, and global distributive justice. *Political Theory*, *40*, 84–107. https://doi.org/10.1177/0090591711426999

Nine, C. (2014). When affected interests demand joint self-determination: learning from rivers. *International Theory*, *6*, 157–174. https://doi.org/10.1017/S1752971914000086

Proctor, R. (2000). *The Nazi war on cancer*. Princeton, NJ: Princeton University Press.

Rainger, R. (2004). 'A wonderful oceanographic tool': The atomic bomb, radioactivity, and the development of American oceanography. In H. Rozwadowski, & D. Van Keuren (Eds.), *The machine in Neptune's garden: Historical perspectives on technology and the marine environment* (pp. 93–131). Sagamore Beach, MA: Science History Publications.

Roberts, P. (2011). *The European Antarctic: Science and strategy in Scandinavia and the British Empire*. New York, NY: Palgrave Macmillan.

Sörlin, S. (2009). Narratives and counter-narratives of climate change: North Atlantic glaciology and meteorology ca. 1930–1955. *Journal of Historical Geography*, *35*, 237–255. https://doi.org/10.1016/j.jhg.2008.09.003

How to cite this article: Roberts P. Does the science criterion rest on thin ice?. *Geogr J*. 2020;00:1–7. https://doi.org/10.1111/geoj.12367