



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Coronavirus at the end of the world: Antarctica matters

Bob Frame^{*}, Alan D. Hemmings

Gateway Antarctica, University of Canterbury, Private Bag 4800, Christchurch, 8140, New Zealand



ARTICLE INFO

Keywords:

Antarctica
Coronavirus
COVID-19
Antarctic governance
Global change processes
Polar tourism

ABSTRACT

The potential impact of coronavirus in Antarctica through tourism and scientific research as well as the Antarctic Treaty System is reviewed over three time periods. In the short term, to April 2021, Antarctic tourism and field-based research will be severely reduced. The impact on Antarctic governance means that few, if any, international meetings will take place thereby leaving discussions on issues, such as fishing quotas, uncertain. Looking to the medium term, to April 2024, polar tourism is unlikely to have recovered and may face collapse unless alternatives are developed. Scientific research, organised through National Antarctic Programs could be reduced due to the economics of a global recession. Moving to a long-term view of six years or so, in terms of scientific activity, this will be highly dependent on the role and status of science in society following the pandemic and the extent to which science funding gets drawn into the economics of the recession. It is unlikely that cruise tourism will have regained its previous volumes though fishing, especially if food security becomes a major issue, is likely to increase pressure on environmental management mechanisms. Both these aspects will continue to put demands on the Antarctic Treaty System and its ability to respond to a fast changing global situation. In this latter sense, it could provide valuable lessons, and also learn from, for other global agreements such as climate change and biodiversity.

1. Introduction

Antarctica, as both a geographical and a geopolitical space, was given, understandably, very little attention around the early phase (January–April 2020) of the coronavirus disease (COVID-19) pandemic (WHO, 2020). Coverage either cast Antarctica as the one place untouched, or reported the plight of those trapped aboard cruise vessels and the subsequent confirmed COVID-19 infection (Hemmings & Frame, 2020). The broader implications in and around Antarctica and for the management of Antarctic affairs, and the global implications of any such Antarctic effects, were not publicly considered in this early phase. However, the relationship of such Antarctic effects with wider global effects of the pandemic, involving economic recession, internal challenges to state stability, geopolitics and the global order, alongside existing challenges in the Anthropocene (Liu, 2019; Stephens, 2018), pose questions over multiple time scales.¹

Here, we attempt a tentative, and necessarily time-bound overview of issues that COVID-19 poses for Antarctica and that have wider

implications. Our observations include both possible effects on human presence and activity in the Antarctic, and on possible effects on the international governance system for the Antarctic – i.e. our consideration covers both effects *in* Antarctica and in relation to Antarctica *but conducted elsewhere*. These remarks are organised into three notional time periods:

- *Short Term* – the one year period from April 2020 through the 2020/21 Antarctic summer operational season ending April 2021
- *Medium Term* – the three year period covering the three operational seasons 2021/22, 2022/23 and 2023/24, ending April 2024
- *Long Term* – the six year period beginning May 2024 and ending May 2030

Our reflections draw on publicly available sources across government (including National Antarctic Programmes), international agencies concerned with Antarctica, and media reports. We draw upon numerous discussions with government and other officials, scientists, and our own

^{*} Corresponding author.

E-mail addresses: research@frameworks.nz (B. Frame), alandhemmings@xtra.co.nz (A.D. Hemmings).

¹ Antarctica's future to 2100 had already been highlighted in the 2019 Intergovernmental Panel on Climate Change (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) which recommended the importance of long-term perspectives and the need for transformation of many existing institutions to address the complex challenges of effective mitigation and adaptation IPCC (2019).

understanding of the history, structure and modalities of Antarctic governance. The information sources drawn upon, and the state of affairs described in relation to this fast-moving topic, are those available up to 7 July 2020.² Our intent is to provide insights into how the inter-relationship between human endeavour, Antarctica and the global environment could be impacted by COVID-19. In so doing, we align this paper within strategic futures studies (Elsawah et al., 2020; Frame, 2018; Hemmings, 2020b; Hemmings & Frame, 2020; Liu, 2019). In each time frame, we examine scientific research, economic activity (tourism and fishing), and Antarctic governance.

2. Short term (April 2020–April 2021)

By early April 2020, most National Antarctic Programmes (NAPs) had, fortunately, ended their operating season, changed over personnel and most aircraft and ships had departed Antarctica. Stations had locked down for their usual Antarctic winter isolation until around December 2020. There were no reports of infection at Antarctic stations, and none have been reported since. Again, fortunate, since medical capacity is limited, and any external medical aid entails complicated logistics. Whilst most Antarctic stations are isolated from each other, some are clustered (COMNAP, 2017). New Zealand's Scott Base and the enormous US McMurdo Station on Ross Island are walking distance apart; there are three year-round stations close together in East Antarctica's Larsemann Hills³; and seven year-round stations in relative proximity on King George Island off the Antarctic Peninsula.⁴ Here, infection would pose additional challenges of isolation to prevent spread between stations. A few programmes with good air capabilities conduct mid-winter and spring supply drops or landings, which require care to minimise risks of infection introduction. Elsewhere in the Antarctic, risk may be lower still. However, given a global pandemic, and the necessary connectivity of Antarctic operations each summer, nowhere, not even Antarctica, can ever be entirely risk-free.

Whilst elsewhere Antarctic tourism activities were finished by early March, operations in the Antarctic Peninsula (via the Gateway Cities Ushuaia and Punta Arenas)⁵ continued into April. High levels of COVID-19 infection occurred on at least one returning cruise vessel, the *Greg Mortimer* (Ing et al., 2020), thereby posing a risk that transmission might have occurred in the Peninsula, although as noted above, there have been no reports from Antarctic stations.

There is likely to be little significant Antarctic fieldwork in the 2020/21 Antarctic summer season (Antarctica New Zealand, 2020; Australian Antarctic Division, 2020; British Antarctic Survey, 2020; National Science Foundation, 2020; South African National Antarctic Programme, 2020), although research using remote sensing, datasets already collected, and long-term monitoring primarily from Antarctic stations should continue.⁶ Looking to the end of the next Antarctic summer season (i.e. April 2021), to the extent that Antarctic operations continue there will be particular concern to avoid or minimise COVID-19 infection risk. Although the immediate focus will be on avoiding human infection,

² Information on the impact of the pandemic on the Arctic and the Antarctic is given at <http://polarconnection.org/coronavirus-and-the-polar-regions/>.

³ Stations operated by China, India and Russia.

⁴ Stations operated by Brazil, Chile, China, Poland, Russia, South Korea and Uruguay.

⁵ There are five Gateway Cities to Antarctica globally: Ushuaia (Argentina), Punta Arenas (Chile), Cape Town (South Africa), Hobart (Australia) and Christchurch (New Zealand).

⁶ For a sense of the likely situation see statements from the US, Australian, UK and South African NAPs (Antarctica New Zealand, 2020; Australian Antarctic Division, 2020; British Antarctic Survey, 2020; National Science Foundation, 2020; South African National Antarctic Programme, 2020).

⁷ In the USA, cases are being recorded by the National Veterinary Services Laboratories https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/SA_One_Health/sars-cov-2-animals-us.

evidence of transmission (reverse zoonosis) to big cats (New York Times, 2020) points to a potential need to minimise risks to Antarctic biota, and seals in particular [(Kerry & Riddle, 2009); 15-21].⁷ Accordingly, in addition to extraordinary precautions to prevent transmission through station resupply and personnel change-overs, perhaps requiring screening of inbound people, even the limited field work possible will need to ensure no risk to native biota. All the indications are that there will be significant reductions in multinational projects and field operations – a mainstay of normal Antarctic science – in order to manage risk, given a global environment where different states may be at different places on COVID-19 management. Antarctic Gateway states will be heavily invested, not only because of their concern about domestic exposure risk, through transit and because their hospitals are likely to receive any Antarctic cases, but because they are the states responsible for air and maritime rescue coordination sectors that reach down into the Antarctic (COMNAP, 2008a).

For Antarctic governance, some significant effects of COVID-19 are evident. The Antarctic is governed by a number of international legal instruments developed under the umbrella of the 1959 Antarctic Treaty (Hemmings, 2018a; Rothwell & Hemmings, 2020). The resulting Antarctic Treaty System (ATS) is organised around two annual diplomatic meetings: the Antarctic Treaty Consultative Meeting (ATCM) and the meeting of the Commission for the Conservation of Antarctic Marine Living Resources (Commission). In essence, the ATCM deals with activity on the continent and tourism and the Commission deals with fishing. Both diplomatic meetings are accompanied by numerous technical advisory meetings which provide critical input for political decision-making. Decision-making in both fora is through consensus of the parties in attendance.

In 2020, the ATCM due to be held in Helsinki from late May was cancelled because of COVID-19 (Secretariat of the Antarctic Treaty, 2020a). Finland did not offer to host a delayed or virtual ATCM, and so the next meeting is the one planned for Paris, France around the middle of 2021 (i.e. after the next Antarctic summer has passed). Given the nature of decision-making at the ATCM (Hemmings, 2020b), there has been no formal capacity to collectively agree any response in relation to COVID-19, such as prohibiting ship visits to stations, exchanging data on risk management, considering risk and precautionary measures in relation to Antarctic wildlife before the next Antarctic summer. It is striking that the very body charged with management of the Antarctic appeared to have no capacity to collectively act remotely. In June, parties began to consult through an online forum, but as yet this appears not to have involved any formal decision-making, which appears to be reserved to the Paris ATCM in the usual manner (Secretariat of the Antarctic Treaty, 2020b).

It seems likely that the second meeting in late October 2020 in Hobart (the Commission) will be cancelled given that the three working group meetings to take place in Japan and India have already been cancelled.⁸ The working group on 'Fish Stock Assessment', which underpins the Commission's subsequent allocation of catches between states and statistical areas through Conservation Measures, remains scheduled for mid-October in Hobart, as are the Scientific Committee and Commission meetings later in October.⁹ But, at this point it seems unlikely that delegations will be willing or able to travel to Hobart from capitals all over the globe. Discussions are currently underway about options for conducting these meetings virtually, with consideration being given to a reduced agenda of essential items progressed through rolling online sessions of two to three hours duration. Many details, including scheduling to share the burden of time-zone difficulties equitably, and the

⁸ At 7 July 2020, this was still scheduled on <https://www.ccamlr.org/en/meetings-and-publications/meetings-publications>. The three Working Groups have been cancelled.

⁹ <https://www.ccamlr.org/en/wg-fsa-2020>; <https://www.ccamlr.org/en/sc-camlr-39> and <https://www.ccamlr.org/en/ccamlr-39>.

question of whether sessions can or should be conducted with simultaneous translation into the four official languages – or only in English – remain to be confirmed¹⁰. Given states have, globally, viewed fishing activities (like agriculture) as an essential activity, there is widespread expectation that fishing activities in the CCAMLR Area will proceed at close to normal levels. Thus, CCAMLR Members apparently attach importance to being able to make decisions on catch allocation through the virtual arrangements¹¹. However, questions then arise whether it is possible to safely place observers aboard fishing vessels and or conduct challenge inspections in the Southern Ocean before COVID-19 is contained globally or vaccination available.

Assuming that it proves possible to convene the Commission and allow decision-making remotely, a new working precedent across the ATS will have been set. Note that even with several months lead-time this was not considered possible for the earlier ATCM. It remains to be seen whether an in-person ATCM in Paris is possible in 2021. If not, another virtual meeting may be necessary. An alternative to a virtual meeting - for ATCM or CCAMLR Commission meetings – might be a meeting elsewhere (perhaps New York, subject to its condition), where all participating states already have high-level permanent diplomatic representatives thereby avoiding the need for further travel (Hemmings, 2020b).

The challenges here are of course common to most diplomatic meetings since the declaration of the pandemic. Numerous meetings occurring even later the putative dates for the Commission meeting, most notably the November COP 26 UN Climate Change Conference in Glasgow in November 2020,¹² have already been postponed into 2021.

3. Medium term (May 2021–April 2024)

Global media coverage made much of the apparent environmental recovery during the shutdown of significant swathes of human activity in the early phase of the pandemic – clearer skies, reduced emissions, cetaceans reappearing in waterways. Yet Antarctica is not the location of industrial activity, nor subject to activity whose halting would stimulate comparable transformations. Even after two years of appreciably reduced human activity, equivalent transformations are unlikely to be discernible.

For NAPs, the Council of Managers of National Antarctic Programs (COMNAP), whose purpose is “to develop and promote best practice in managing the support of scientific research in Antarctica”, will be critical (COMNAP, 2008b). For many (perhaps most) NAPs, operational constraints due to domestic lockdowns, reduced finances,¹³ and/or redirection of national efforts to reduce the impacts of a COVID-19 induced economic recession,¹⁴ may be significant. States may reduce programmes, or defer station rebuilds or equipment acquisition. At the extreme, we may see some states unable to sustain their programmes over the coming years, and consequential station evacuation or decommissioning.

Worldwide, cruise tourism has struggled as a result of COVID-19 (Rothwell, 2020; OECD, 2020). Indeed, some cruises have been disasters in terms of passengers infected and transmission ashore and one has triggered a Commission of Inquiry.¹⁵ Large global tourism companies are decommissioning ships and plans, so the global conveyor belt of large vessel tourism will largely shut down. So, recovery of the cruise industry

in general may be difficult and protracted. Specialist Antarctic tourism companies face additional difficulties and may collapse under the pressure of COVID-19. Most passengers travel long distances by air to participate in Antarctic cruises. Even as international travel resumes, it is likely to prove difficult, exposed to great uncertainties and involve ongoing onerous border controls and possibly quarantine requirements. Antarctic tourism vessels are likely to face difficulties in gaining port access for embarkation and disembarkation, and often are homeported in the northern hemisphere. These considerations, coupled with depressed global economic circumstances and, inter alia, travel insurance difficulties, suggest that the impact may well exceed the effects on Antarctic tourism of the 2007/08 Global Financial Crisis (GFC), recovery from which took a decade [(Netherlands & New Zealand, 2019): Figure 2].

The picture in relation to fishing activity depends upon whether catch levels can be assigned in 2020 or early 2021, and regularly thereafter, and whether transit through metropolitan ports is allowed.

The implications for Antarctic governance in the medium term are dependent on three interlocking factors: the manner in which global institutions and individual states respond to the pandemic and the consequences of this for the functioning of wider international systems and global order; the severity of the economic consequences of the pandemic – e.g. how deep a recession follows; and the particular in-area issues that the pandemic initiates or amplifies (whether in relation to the biophysical Antarctic or the geopolitical Antarctic space). As we move to the long-term these factors become interlinked with both scientific research and economic activity.

4. Long term (May 2024 to April 2030)

The impacts from COVID-19, notably contraction of NAPs and tourism activity, seem likely to resonate through Antarctic affairs for years. This may usher in wider structural changes in Antarctic activity and governance over the longer term. Prediction is, of course, impossible. Yet exploring scenario processes for socio-environmental systems using scenario processes is a rigorous and well-established means of supporting decision-making (Elsawah et al., 2020). It is a process that is gaining traction within Antarctic studies through expertise developed for climate change (Ebi et al., 2014; O’Neill et al., 2017). To structure this, we will expand the three aspects discussed under the Short- and Medium-Term perspectives, namely science, economic activity and governance to include other categories for Antarctica recently developed which build on an architecture developed for climate change scenarios (Frame, 2020; Rintoul et al., 2018).

4.1. Scientific research

Could crises emerge around the viability of Antarctic stations encourage station sharing or international Antarctic stations (Hemmings, 2011)? Might some states disappear from Antarctic engagement for shorter, or possibly longer, periods? Are different ways of working and acquiring data through, for example, shared remote platforms (robots, drones, buoys and satellites) possible? Accordingly, might an overall reduction in Antarctic research volume be offset by greater international integration and technology usage over the next five plus years? A complication here could be transformation of the regional order if (say) the United States’ role as one of the major drivers of research declines and another single state (say China) (Brady, 2017; Liu, 2019), or a diverse group of states become more active in Antarctica.

Within the large scientific effort undertaken in Antarctica (Kennicutt et al., 2019), there are many highly complex ‘Big Science’ programmes seeking fundamental knowledge including most notably¹⁶: climatology,

¹⁶ ‘Big science’ refers here to projects of scale and complexity, which generally entail interdisciplinarity and involve large numbers of scientists and support personnel, often from multiple agencies and states, and may extend over several years or be effectively ongoing.

¹⁰ Personal Communication to ADH from government officials 23 June 2020.
¹¹ *ibid.*

¹² <https://unfccc.int/news/cop26-postponed>.

¹³ The vulnerability of Antarctic activities to economic crises is well demonstrated by the case of Ecuador, due to host the ATCM in 2018, having to abandon that for domestic financial reasons (Hemmings, 2018a).

¹⁴ Some national Antarctic programmes are components of state agencies with broader national responsibilities.

¹⁵ Namely ‘The Special Commission of Inquiry into the Ruby Princess’ <https://www.rubyprincessinquiry.nsw.gov.au/>.

geology and glaciology. Together these contribute, inter alia, to our understanding of global change processes. If, however, one or two seasons of climatological field work are lost, there are Long Term consequences including gaps in the small number of long-term climate records. To get to the point where climate changes can be definitively attributed to anthropogenic causes, models and the observations that the models are compared to need to be further improved. Put simply, gaps in long-term datasets cannot be recovered (McDonald & Cairns, 2020). Of greater impact is the possibility of severe cuts to NAPs as a consequence of tactical budget re-allocations to fund measures to counter what is being portrayed as a significant economic recession (World Economic Forum, 2020). This might occur on both a runaway climate change scenario (perhaps RCP 6/SSP5 in the parlance of the Intergovernmental Panel on Climate Change) (Ebi et al., 2014; O'Neill et al., 2017) or, perhaps counter-intuitively under a quite different scenario where climate change adaptation, rather than mitigation, is seen as a global priority to stimulate a New Green Deal as a means of negotiating out of a Depression. While the latter may feel unworldly in 2020, it is not infeasible in 2025 as a response to a global economic crisis.

A critical factor for Antarctic research may be how science itself comes out of a global pandemic whose understanding and resolution seems utterly dependent upon its effective deployment. If effective scientifically-informed COVID-19 responses reverses recent inclinations to adopt populist, parochial and essentially non-scientific 'explanations', and reinvigorates rational, evidence-based and integrated approaches to human challenges and aspiration, then a revisualisation of Antarctica as a place in which to conduct vital international scientific research – most obviously in relation to anthropogenic climate change – is in prospect. A spinoff from this might also be a boost in confidence around a particular basis to Antarctic diplomacy, what is termed 'Science Diplomacy'. Whilst not a mainstream approach to diplomacy, it is a construct greatly favoured within the Antarctic science community itself (Berkmann et al., 2011) and has recently been invoked more generally in the context of COVID-19 (Gluckman & Turekian, 2020).

Bundled up in this is a case for 'science' to be more inclusive, in order to engage more intensely with complexity. This will require much more inter- and *trans*-disciplinary research (across social sciences and humanities as well as the physical sciences) working on long-term solutions to 'wicked' problems (Saltelli & Funtowicz, 2017; Waltner-Toews et al., 2020). However, stressed post pandemic, states may disparage such approaches and insist that the proper focus of research is reinvigorating traditional economic activity.

4.2. Economic activity

There are two major elements here, tourism and fishing, though consideration of the longer term impacts relating to bioprospecting, marine biodiversity and minerals remains outside our current scope (Chaturvedi, 2018).

4.2.1. Tourism

An economic-induced transformation from an activity based on ships and "expedition cruising" to one predicated on aircraft has significant implications for infrastructure including airstrips, hotels and smaller vessels for "fly-sail" activities. There might be a recovery to essentially the present tourism model over a five-to ten-year period as we saw with the GFC, particularly given the recent surge of new polar vessels. Alternatively, there could be a strong drive to accelerate innovative forms, for example virtual tourism, where Antarctica services more explicitly the notion of a subliminal experience, an unworldly *other*, a remote continent of the imagination. Tourism, in summary, might either return to a business-as-usual model but with heavily reduced numbers over 10 years, or migrate to highly innovative, currently barely imaginable, form of touristic experience in which Antarctica has a new form of cultural heritage that is pertinent to an emerging new global perspective. Tourism may therefore go various ways: essentially decline for a decade or more

before resuming its present form and levels; transform to conventional air-supported mass tourism; or evolve into something entirely novel.

4.2.2. Fishing

Food security may emerge as a critical post-COVID-19 issue (FAO, 2020). So long as a mechanism for catch allocation is available, fishing in Antarctic waters will proceed. The questions becomes whether there are pressures to lift catches beyond the levels that scientific analysis could support, and whether balancing environmental management mechanisms – such as marine protected areas – come under further pressure.

4.3. Antarctic governance

The ATS has many strengths, not least its formal persistence over seven decades. However, it is arguable that it has always suffered from a structural hollowness; and that this has worsened in the three decades since the adoption of its last major instrument (Hemmings, 2018b). If these are valid concerns, then one might consider what effect COVID-19 may have on its shape and vitality. The issues include not only which states (and other actors) remain formally engaged but which become the effective drivers of whatever it is that the ATS is or becomes. Already, some Western media are alleging that particular states (invariably China and Russia) are "taking advantage" of the pandemic to advance their Antarctic interests (Feiger & Wilkson, 2020). COVID-19 has, it seems, reinforced already evident regional tensions. At the institutional level, if we assume that in the short to medium term the ATS (like other international instruments and regimes) has developed through necessity some mechanisms for remote or virtual operation and decision-making, is there ever a 'snap-back' to the old mechanisms? If there is not, then the (presently unscoped) issues around what this means for, inter alia, substantive decision-making, access, transparency and institutional capture, will warrant attention.

5. Concluding comments

How the wider global order is affected by the pandemic and its aftermath feeds back into the Antarctic question. It must be a possibility that whereas the ending of the Cold War did not fundamentally alter the nature of the regime ushered in by the Antarctic Treaty at the height of that Cold War, the trauma to the global economic system and wider international norms delivered by COVID-19 might do so. The shape of the ATS post pandemic may well influence attitudes to the acceptability of future resource exploitation – most obviously whether the present prohibition of mineral resource activities is ever lifted, but in relation to conventional marine harvesting (fishing), the treatment of biodiversity and Antarctic tourism, and constraining strategic competition in the region (Hemmings, 2020a). Across all of these, there are unresolved questions of acceptability-in-principle, levels of activity, modes of regulation, beneficiaries and benefit sharing; and the balancing of use against environmental values and rights. If COVID-19 has a silver lining – and in the midst of it one cannot tell – and structural change in human behaviour results, where better place for early reflection of this than the Antarctic?

CRedit authorship contribution statement

Bob Frame: Writing - original draft, Writing - review & editing. **Alan D. Hemmings:** Writing - original draft, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Antarctica New Zealand. (2020). Covid-19 impacts Platform funded research field season, <https://www.antarcticnz.govt.nz/media/news/june-update>, 3 July 2020.
- Australian Antarctic Division. (2020). Changes for Australian Antarctic Program to keep the icy continent free of COVID-19. <https://www.antarctica.gov.au/news/2020/changes-for-australian-antarctic-program-covid-19/>.
- Berkmann, P. A., Lang, M. A., Walton, D. W. H., & Young, O. R. (Eds.). (2011). *Science diplomacy: Antarctica, science, and the governance of international spaces*. Washington DC: Smithsonian Institution Scholarly Press.
- Brady, A.-M. (2017). *China as a polar great power*. Washington DC and New York: Woodrow Wilson Center Press and Cambridge University Press. <https://doi.org/10.1017/9781316832004>
- British Antarctic Survey. (2020). 'Responding to the COVID-19 pandemic', 9 June 2020 https://www.bas.ac.uk/media-post/british-antarctic-survey-season-plan-for-2020-21/?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news;
- Chaturvedi, S. (2018). The future of Antarctica: Minerals, bioprospecting, and fisheries. In M. Nuttall, T. R. Christensen, & M. Siegert (Eds.), *Routledge handbook of the polar regions*. London: Routledge.
- COMNAP. (2017). *Antarctic station catalogue*. Christchurch: COMNAP Secretariat.
- COMNAP. (2008a). https://www.comnap.aq/documents/D8552_29_Air_and_Sea_Route_Map.pdf.
- COMNAP. (2008b). <https://www.comnap.aq/documents/comnap-constitution-adopt-ed-04-july-2008.pdf>.
- Ebi, K. L., Kram, T., van Vuuren, D. P., et al. (2014). A new toolkit for developing scenarios for climate change research and policy analysis. *Environment: Science and Policy for Sustainable Development*, 56, 6–16. <https://doi.org/10.1080/00139157.2014.881692>
- Elsawah, S., Hamilton, S., Jakeman, T., Rothman, D., Schweizer, V., Trutnevtey, E., et al. (2020). Scenario processes for socio-environmental systems analysis of futures: A review of recent efforts and a salient research agenda for supporting decision making. *The Science of the Total Environment*. <https://doi.org/10.1016/j.scitotenv.2020.138393>, 138393.
- FAO. (2020). *How is COVID-19 affecting the fisheries and aquaculture food systems*. <https://doi.org/10.4060/ca8637en>. Rome.
- Feiger, L., & Wilkson, M. (2020). The countries taking advantage of Antarctica during the pandemic. *The Atlantic*. <https://www.theatlantic.com/politics/archive/2020/05/antarctica-great-power-competition-australia-united-states-britain-russia-china-arctic/611674/>.
- Frame, B. (2020). 'Towards an Antarctic scenarios integrated framework'. *The Polar Journal*, 10(2). <https://doi.org/10.1080/2154896X.2020.1757822>
- Frame, B. (2018). New Zealand, new futures, new thinking? *Futures*, 100, 45–55. <https://doi.org/10.1016/j.futures.2018.04.005>
- Gluckman, P., & Turekian, V. (2020). Rebooting science diplomacy in the context of COVID-19. In *Issues in science and technology*. <https://issues.org/rebooting-science-diplomacy-in-the-context-of-covid-19-lessons-from-the-cold-war/>.
- Hemmings, A. D. (2011). Why did we get an international space station before an international Antarctic station? *The Polar Journal*, 1, 5–16.
- Hemmings, A. D. (2018a). The Antarctic Treaty System. *New Zealand Yearbook of International Law*, 16, 362–370.
- Hemmings, A. D. (2018b). The hollowing of Antarctic governance. In P. S. Goel, R. Ravindra, & S. Chattopadhyay (Eds.), *Science and geopolitics of the white World: Arctic-Antarctic-Himalaya*. Cham: Springer.
- Hemmings, A. D. (2020a). 'Challenges to substantive demilitarisation in the Antarctic Treaty area. *The Yearbook of Polar Law*, 12.
- Hemmings, A. D. (2020b). Antarctic governance in a time of coronavirus. *ANZSIL Perspective*, 13, 3–5. pdf <https://www.anzsil.org.au/resources/Documents/ANZSIL%20PERSPECTIVE%20MAY%202020%20FINAL%20.pdf>.
- Hemmings, A. D., & Frame, B. (2020). Antarctica's latest challenge: Coronavirus. In G. Foscarini (Ed.), *Antarctic resolution*. Baden, Switzerland: Lars Müller Publishers.
- Ing, A. J., Cocks, C., & Green, J. P. (2020). COVID-19: In the footsteps of Ernest Shackleton. *Thorax*. <https://doi.org/10.1136/thoraxjnl-2020-215091>
- IPCC. (2019). In H.-O. Pörtner, D. C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, & N. M. Weyer (Eds.), *Special report on the Ocean and Cryosphere in a changing climate*. https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/07_SROCC_Ch03_FINAL.pdf.
- Kennicutt, M. C., II, Bromwich, D., Liggett, D., Njåstad, B., Peck, L., Rintoul, S. R., et al. (2019). Sustained Antarctic research: A 21st century imperative. *One Earth*, 1(1), 95–113.
- Kerry, K. R., & Riddle, M. J. (2009). *Health of Antarctic wildlife: A challenge for science and policy*. Dordrecht: Springer.
- Liu, N. (2019). Rising China and Antarctic futures in the Anthropocene. In M. Lim (Ed.), *Charting environmental law futures in the Anthropocene*. Singapore: Springer.
- McDonald, A. J., & Cairns, L. H. (2020). A new method to evaluate reanalyses using synoptic patterns: An example application in the Ross Sea/Ross Ice Shelf region. *Earth and Space Science*, 7, Article e2019EA000794. <https://doi.org/10.1029/2019EA000794>
- National Science Foundation. (2020). Update: USAP plans for upcoming Antarctic season', 11 June 2020; https://www.nsf.gov/news/news_summ.jsp?cntn_id=300743&org=OPP.
- Netherlands, & New Zealand. (2019). Proactive management of Antarctic tourism: Time for a fresh approach. In *Information paper 26 tabled at the 42nd Antarctic Treaty Consultative Meeting*. Prague. ATS.
- New York Times. (2020). Bronx zoo tiger is sick with the coronavirus. <https://www.nytimes.com/2020/04/06/nyregion/bronx-zoo-tiger-coronavirus.html>.
- OECD. (2020). Tourism policy responses to the coronavirus (COVID-19). <https://www.oecd.org/coronavirus/policy-responses/tourism-policy-responses-to-the-coronavirus-covid-19-6466aa20/>.
- O'Neill, B. C., Krieger, E., Ebi, K. L., et al. (2017). The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. *Global Environmental Change*, 42, 169–180. <https://doi.org/10.1016/j.gloenvcha.2015.01.004>
- Rintoul, S. R., Chown, S. L., DeConto, R. M., England, M. H., Fricker, H. A., et al. (2018). Choosing the future of Antarctica. *Nature*, 558, 233–241.
- Rothwell, D. (2020). *International law and cruise ships: Sailing into stormy waters*. Lawyers Weekly. <https://www.lawyersweekly.com.au/sme-law/28155-international-law-and-cruise-ships-sailing-into-stormy-waters>.
- Rothwell, D. R., & Hemmings, A. D. (2020). Evolution of A Polar law. In K. N. Scott, & D. Vanderzwaag (Eds.), *Research handbook on polar law*. Cheltenham, UK: Edward Elgar.
- Saltelli, A., & Funtowicz, S. (2017). What is science's crisis really about? *Futures*, 91, 5–11.
- Secretariat of the Antarctic Treaty. (2020a). *Cancellation of ATCM XLIII – CEP XXIII*. News and Events. <https://ats.aq/devph/en/news/176>.
- Secretariat of the Antarctic Treaty. (2020b). *Next steps following cancellation of ATCM XLIII – CEP XXII in Finland*. News and Events. <https://www.ats.aq/devph/en/news/179>.
- South African National Antarctic Programme. (2020). (June 23, 2020) SANAP Collaboration during COVID-19 – An Online Presence. <https://www.sanap.ac.za/saunday-science-space-science-aurora-australis>.
- Stephens, T. (2018). 'The Antarctic Treaty System and the Anthropocene', *The Polar Journal* 8(1) 29-43, [10.1080/2154896X.2018.1468630](https://doi.org/10.1080/2154896X.2018.1468630)
- Waltner-Toews, D., Biggeri, A., De Marchi, B., Funtowicz, S., Giampietro, M., O'Connor, M., Ravetz, J., & Sluijs, J. (2020). Post-normal pandemics: Why covid-19 requires a new approach to science. *Discover Society*. <https://steps-centre.org/blog/postnormal-pandemics-why-covid-19-requires-a-new-approach-to-science/>.
- WHO. (2020). https://www.who.int/health-topics/coronavirus#tab=tab_1.
- World Economic Forum. (2020). Emerging priorities and principles for managing the global economic impact of COVID-19. <https://www.weforum.org/whitepapers/emerging-priorities-and-principles-for-managing-the-global-economic-impact-of-covid-19>.