Ice Sheet Instability, Long-term Sea-level Rise, and Southern Ocean Acidification: Time for Coordinated Action by Antarctic Treaty Parties

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**Information Paper submitted by ASOC**

Summary

In addressing climate change, the main focus of Antarctic Treaty System bodies has been ecosystem impacts on Antarctica and the Southern Ocean. However, it is time these bodies began to address more directly the impacts of these changes on the entire planet, as current research makes clear that these will be massive, catastrophic, essentially permanent and potentially rapid; especially with current rates of CO2 increase in the atmosphere, primarily from fossil fuel use. The ATCM should charge the Secretariat and successive Chairs of the ATCM and/or the CEP with exploring ways to bring this science and its policy implications to greater public and political attention, including at COP-27 in Egypt in November 2022. ATCPs should do likewise, and re-examine their Nationally Determined Contributions (NDCs) in light of the non-adaptable impacts, on both national and global levels, of irreversible Antarctic change.

Introduction

Traditionally, the Antarctic Treaty System has focused its climate change work on documenting the impacts of global warming on Antarctic continental and Southern Ocean marine ecosystems. As research on ice sheet and Southern Ocean dynamics has expanded exponentially over the past two decades however, it has become apparent that these have strong implications for climate ambition, in particular the need to avoid overshoot of the Paris Agreement temperature limit of 1.5°C, and especially 2°C. This is because peak temperatures, and CO2 concentration levels in the atmosphere largely set the risk of irreversible ice sheet collapse and resulting sea-level rise, as well as Southern Ocean acidification. The narrative of climate change in Antarctica today is therefore no longer solely one of the impacts on the region itself; but of the massive global impacts from a rapidly changing Antarctica causing essentially permanent sea-level rise, as well as other impacts due to loss of Southern Ocean keystone species from essentially permanent acidification. The IPCC, in its 2022 Sixth Assessment (AR6), characterized these impending changes, absent rapid emissions reductions, as “beyond the limits of adaptation.”[[1]](#footnote-1)

Converging Models and Ancient Records of Antarctic Sea-level Rise

Antarctica holds enough ice to raise current global sea level by 58 meters. Exponentially expanding research, especially over the past two decades shows that the risks of non-reversible melting processes increase as temperature and rates of warming rise, affecting the stability of buttressing ice shelves and the marine-based portions of the ice sheet. While this primarily affects the West Antarctic Ice Sheet (WAIS), parts of East Antarctica are similarly marine-based and therefore vulnerable.[[2]](#footnote-2) Together, these portions of the ice sheet may hold up to 20 meters of global sea-level rise (SLR). While still limited to a few studies, this recent, more sophisticated modeling that takes into account the physical properties of the ice sheet also shows their collapse may be unexpectedly rapid. This could lead to annual rates of 5 cm SLR by the middle of the next century; and 10 meters total by 2300 from Antarctica alone; findings noted as a matter of concern in IPCC AR6.[[3]](#footnote-3)

While these figures may at first seem extreme, they track well with the paleo-climactic record. In Earth’s past, warming of even 1°C above pre-industrial levels resulted in very different coastlines than those of today, at 3-6 meters above contemporary; and 12-20 meters at 2°C.[[4]](#footnote-4) The rate of change, and ability to adapt to swings in sea levels and flooding is also important. Here again, Earth’s past indicates that we should have a high level of concern. While some of these past changes occurred over thousands of years, there have also been periods where extremely fast sea-level rises (up to 4 meters per century) occurred due to rapid ice sheet collapse. Termed “melt-water pulses”, the last of these took place 14,000 years ago: when global sea levels rose between 15–18 meters in just 350 years, likely when the Laurentide Ice Sheet over Canada collapsed.

Improving Models and Observations of Ice Sheet Loss

Today, much of the WAIS sits over a vast archipelago of islands separated by extremely deep ocean basins. Its ice rests on marine sediments that are up to 4 km below sea level, sloping downwards toward its center. As warm water melts the edges of the ice sheet, it retreats into these deep ocean basins, exposing more and more of the underside of the ice sheet to warming waters. This rapidly forces further melting and eventually causes the ice sheet to become unstable. That process, known as Marine Ice Sheet Instability, may cause rapid ice sheet loss to occur over a few centuries or less. Similar conditions exist in parts of East Antarctica and have become far better documented on the continent through coordinated scientific efforts over the past five years.[[5]](#footnote-5)

Ice shelves also play a strong role in stabilizing much of the Antarctic ice sheet, buttressing (holding back) the land-based ice behind. Once an ice shelf disappears, as has occurred on the Antarctic Peninsula as well as Greenland, the outlet glaciers from the main ice sheet may speed up their discharge of ice into the ocean by several times. Once collapsed, ice shelves rarely re-form. On Greenland and the Antarctic Peninsula, there is no observed record of an ice shelf returning even under a period of colder atmospheric temperatures, likely because the warmer surrounding ocean waters prevent ice shelf restoration.

Extreme Modern Era Rates of CO2 and Temperature Rise

Significantly, the observed human-induced global temperature rises over recent decades, now unequivocally attributed by the Inter-government Panel on Climate Change largely to human greenhouse gas emissions[[6]](#footnote-6), is much faster than anything documented in the Earth’s past. CO2 increases in the last 50 years are 200 times greater than during the end of the last Ice Age and period of rapid meltwater SLR 14,000 years ago. This means that future rates of ice sheet loss and SLR could increase even further beyond the acceleration that has been observed over the past few decades, and potentially be more rapid than at any other time in at least the past 130,000 years.

This record from Earth’s past indicates that the gradient between 1°C and 2°C of warming holds high levels of risk for human societies on a global level. Today’s better understanding of ice sheet behavior, especially interactions between the ice and surrounding warming oceans informs us that ice sheet collapse and potentially rapid SLR cannot be ruled out.

Irreversible Ecosystem Impacts of Rapid CO2 Rise from Southern Ocean Acidification

In addition to ice sheet loss from anthropogenic warming, the rise in CO2 has led to levels of ocean acidification unprecedented in at least the past 3 million years. The Southern Ocean has absorbed up to 40% of anthropogenic CO2 emissions from fossil fuel use over the past two centuries, thereby performing an invaluable ecosystem service by slowing global warming. This is because its colder and fresher waters take up CO2 more readily than the mid-latitude and tropical oceans (a process also observed in the Arctic). However, this has come at a high cost, as both polar oceans have become the most acidic on the planet.

Shell damage to pteropods (a small shelled invertebrate at the base of the food chain) from corrosive waters was observed in samples from scattered regions of the Southern Ocean as early as 2008[[7]](#footnote-7), when CO2 levels were still below 400ppm. At today’s 420ppm, these regions and observations of shell damage are expanding rapidly at both poles.

Should atmospheric CO2 levels reach 450ppm – which at current rates of CO2 increase given lack of concrete action on fossil fuel use, will occur in just 11 years – it is believed[[8]](#footnote-8) that these regions of higher acidity in the Southern Ocean will have significant impacts on the ability of all species to reproduce, whether through acidification impacts on the shelled organisms at the base of most food chains, or directly from the additional pressures of warming waters from continued atmospheric heating; and less saline waters due to continued ice sheet melt. Invasive species from lower latitudes will add to pressures on native Southern Ocean marine and marine-dependent species. Higher still atmospheric levels of CO2, beyond 450ppm will cause non-survivable levels of acidification to spread northwards, including into the southwestern Atlantic, home to the largest concentrations of Antarctic krill.

Ocean acidification is an essentially non-reversible process on any human timescale. The corrosive waters caused by CO2 absorption will persist 30-50,000 years before pH levels can return to those of today. The level of acidification, in other words, will be set entirely by peak CO2 levels in the atmosphere; stabilize only when CO2 levels decrease; but then take thousands of years to return to survivable levels. Should CO2 levels continue to rise, a mass extinction event in the Southern Ocean becomes unavoidable.[[9]](#footnote-9) In addition to loss of endemic Antarctic species and ecosystems, this will have far-reaching negative impacts on global fisheries and food production.

Recommendations

The ramifications of fast-evolving Antarctic science, and its clear communication by ATCM bodies and ATCPs should comprise a matter of highest concern to the Treaty System. Specifically:

* ATCPs should work to bring these scientific findings to strong global attention at the 27th Conference of Parties (COP-27) of the United Nations Framework Convention on Climate Change (UNFCCC) in Sharm-al-Sheikh, Egypt in November 2022; and at COP-28 in Dubai, United Arab Emirates, especially in light of the vulnerability of both host nations to even moderate levels of SLR.[[10]](#footnote-10)
* ATCPs should further re-examine and revise their own NDCs in light of the non-adaptable impacts, on both national and global levels, of irreversible Antarctic change.
* Future ATCMs should regularly consider developments in Antarctic science that have implications for global impacts and limits of national adaptation by ATCPs and other governments, including consideration of potential inputs from ATCMs into other appropriate forums.
* The ATCM should agree on ways to bring this science and its policy implications to greater public and political attention at future COPs, for example by charging the Secretariat, CEP or successive Chairs of the ATCM to do so.
* The ATCM might also request SCAR officially to represent Antarctica at each COP, in light of the reality that this 10% of Earth’s land mass otherwise is unrepresented within the Framework Convention.

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9. IPCC, 2019: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press. [↑](#footnote-ref-9)
10. Egypt is extremely vulnerable to rising sea levels. Much of the Nile Delta is lost with just 1 meter of SLR; near-complete loss of agricultural lands occurs along the Nile well above Cairo at 10 meters SLR due to flooding and salinization. In the UAE, most of the host city Dubai, including its busy international airport will be under water at 3 meters SLR. [↑](#footnote-ref-10)