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Antarctic Climate Change and the Environment: A Decadal Synopsis

Research Imperatives

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Summary

A major update by SCAR to the Antarctic Climate Change and the Environment report has been compiled. Given the wide scope of Antarctic research, but the climate-change focus of this updated report, here we make recommendations for the most significant and urgent research required for the region. The recommendations focus on changes in the region that have significant implications for the Earth System and for society, and on the expected impacts of climate change on the region's biodiversity.

Background

Science forms a foundation for human activity in the Antarctic. The preamble to the Antarctic Treaty acknowledges the *substantial contributions to scientific knowledge resulting from international cooperation in scientific investigation in Antarctica*. The Consultative Parties have repeatedly emphasized the value of scientific research in the region: through the Protocol on Environmental Protection, in Resolution 7 of 2019 (ATCM XLII), and in the 2021 Paris Declaration on the occasion of the Sixtieth Anniversary of the entry into force of the Antarctic Treaty and on the Thirtieth anniversary of the signing of the 1991 Madrid Protocol on Environmental Protection to the Antarctic Treaty.

The Consultative Parties have also repeatedly recognised the importance of research to understand the implications of the effects of climate change both on the Antarctic environment and globally. In the Santiago Declaration at ATCM XXXIX, the Consultative Parties reaffirmed *their intention to work together to better understand changes to the Antarctic climate and to actively seek ways to address the effects of climate change on the Antarctic environment and dependent and associated ecosystems*. They did so again in Resolution 8 of 2021 at ATCM XLIII, where they recommended that their governments *support their National Antarctic Programmes and SCAR in their ongoing efforts to undertake research about climate change and its impacts, and to communicate the implications for Antarctica, both within the Antarctic Treaty System and internationally*. These intentions were also communicated broadly through the Paris Declaration.

That Declaration also reaffirms the Consultative Parties' *commitment to work together to better understand changes to the Antarctic climate and to implement actions consistent with the Paris Agreement's goals, with a view to limiting the adverse impacts of climate change on the Antarctic environment and dependent and associated ecosystems, protecting ecosystems, and improving Antarctica's resilience to climate change*.

ATCM XLIV IP72 *Antarctic Climate Change and the Environment: A Decadal Synopsis and Recommendations for Action* sets out the evidence for climate change impacts on the Antarctic environment, forecasts how these will continue into the future under various scenarios, and what the implications in turn are for other components of the Earth System, including humans and nature. This decadal synopsis is based predominantly on the Sixth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC), which in turn are founded on an extensive body of research, including by scientists working on or in Antarctica and the Southern Ocean and/or their connections to the Earth System. ATCM XLIV WP30 *Antarctic Climate Change and the Environment: A Decadal Synopsis. Findings and Policy Recommendations* summarises the key findings of the report and provides a series of policy recommendations derived from these findings.

The *Antarctic Climate Change and the Environment: A Decadal Synopsis and Recommendations for Action* submitted to this ATCM, and the reports of the IPCC, hold critical messages on research imperatives for the Parties and for all of those conducting research in, from, on and about the Antarctic and Southern Ocean.

Research Recommendations

Given the wide scope of Antarctic research, but the climate change focus of the *Antarctic Climate Change and the Environment: A Decadal Synopsis and Recommendations for Action* report, here we make recommendations on the most significant and urgent research needed. Given the climate change focus of this report, the recommendations focus on changes in the region that have significant implications for the Earth System and for society, and on the expected impacts of climate change on the region's biodiversity.

SCAR encourages the Parties to support the following research recommendations, especially by conveying these research imperatives to their National Antarctic Programs and to civil society:

1. Further support the research required to reduce uncertainty about the future of the region and its impact on the Earth System and to identify commensurate management responses. Integrated, international and targeted long-term monitoring programs and observatories are among the most important for reducing uncertainty and for understanding the likely impacts of mitigation and adaptation responses.
2. Urgently reduce uncertainty about the current and future behaviour of the Antarctic Ice Sheet. The current observation network, especially for the hydrology and conditions at the base of the ice sheet, and the temperature and bathymetry of ice shelf cavities, coastal regions and the continental shelf, is inadequate to fully anticipate change and understand the risks of ice shelf collapse, loss of buttressing and rapid ice sheet mass loss in the coming decades. An international effort is urgently required to address this. A major exploration is required of key (unexplored) ice shelves and upstream glaciers using direct access techniques, ocean and airborne robotics, icebreaking ships, aircraft and space-borne remote sensing and other means to understand the ablation regime of the Antarctic ice sheet along the periphery; how it has changed in the past, is currently changing and will change in the future; and how this will drive rapid ice-mass loss and sea-level rise from Antarctica.
3. Understand how changes in atmospheric circulation drive changes in ocean currents around Antarctica and the advection of ocean heat onto the continental shelf, into the ice shelf cavities and in contact with the glaciers, and the influence of melt water feedbacks.
4. Determine what the contribution will be of the Antarctic ice sheet to future sea-level rise and reduce uncertainties in projections of the rate and magnitude of that contribution, and effectively communicate the impacts and risks with stakeholders and users.
5. Account for and develop a detailed process-based understanding of the contemporary annual-to-decadal time-scale trends in the Antarctic climate system. How climate change and variability in the high southern latitudes, with the Southern Annular Mode as the primary driver of variability, are connected to lower latitudes, including the tropical oceans and monsoon systems, and will respond to ongoing changes to the ozone hole and to other anthropogenic forcing, is critical for improved climate projections and anticipation of extreme climate events.

6. Determine why the properties and volume of Antarctic Bottom Water are changing, and what the consequences are for global ocean circulation and climate.
7. Establish which species, ecosystems and food webs are most vulnerable in the Southern Ocean, how they are likely to change, and which organisms are most likely to go extinct and over what period, as a consequence of climate change and local interactions such as with non-native species.
8. Determine how increases in marine living resource harvesting in the context of climate change impacts will impact harvested, associated and dependent species in contrast with other groups, as well as Southern Ocean biogeochemical cycles.
9. Establish which terrestrial ecosystems and food webs are most vulnerable, how they are likely to change, and which organisms are most likely to decline and/or to go extinct and over what time period, as a consequence of climate change and local interactions such as with non-native species.