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The Antarctic Climate Change and the Environment (ACCE) Report: A Key Update

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Working Paper submitted by SCAR

Summary

This paper represents a major update of the original SCAR Antarctic Climate Change and the Environment (ACCE) report (Turner et al., 2009). It summarises subsequent advances in knowledge concerning how the climates of the Antarctic and Southern Ocean have changed in the past, how they might change in the future, and examines the associated impacts on the marine and terrestrial biota. The original ACCE report is available from: http://www.scar.org/publications/occasionals/acce.html.

Background

The Antarctic climate system varies on timescales from orbital (tens to hundreds of thousands of years), to millennial to sub-annual and is closely coupled to other parts of the global climate system. The ACCE report discussed these variations from the perspective of the geological record and the recent historical period of instrumental data, discussed the consequences for the biosphere, and documented the latest numerical model projections of changes into the future, taking into account human influence through the release of greenhouse gases and chlorofluorocarbons to the atmosphere. The report highlighted the large uncertainties in the vulnerability of the West Antarctic Ice Sheet (WAIS). The profound impact of the ozone hole on the Antarctic environment over the last 30 years, shielding the continent from much of the effect of global warming was noted.. However, over the next century ozone concentrations above the Antarctic are expected to recover and, if greenhouse gas atmospheric concentrations continue to increase at the present rate, temperatures across the continent are projected to increase by several degrees and sea ice will be reduced by about one third.

The Update

The original ACCE document contained 80 ‘key points’ that highlighted important climatic events affecting the Antarctic, documented the major changes, considered how the biota has been affected and gave estimates of future change. The SCAR ACCE Expert group (http://www.scar.org/researchgroups/acce/) worked on an update to these key points, incorporating material included in previous ATCM updates, making use of results emerging from activities associated with the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, and also rectifying some omissions identified in the original report, such as consideration of the impact of solar variability on the Antarctic climate. This update, which is much more comprehensive than previous updates (at around 20,000 words), has been published in the peer-reviewed journal Polar Record (http://journals.cambridge.org/action/displayJournal?jid=POL), and is also available as a Treaty Background Paper.

Highlights

1 Recent research has improved the reconciliation of the various satellite-derived estimates of changes in the mass of the Antarctic ice sheet and also estimated the contribution to sea level rise. It found that over the period 1992–2011 the Antarctic Peninsula, West Antarctica and East Antarctica have respectively

contributed +0.05 ± 0.04, +0.18 ± 0.07 and −0.04 ± 0.12 mm per year to global sea level rise. Combined this gives a contribution from the whole Antarctic ice sheet of +0.20 ± 0.15 mm per year, which compares to +0.39 ± 0.14 mm per year from the Greenland ice sheet.

2. Ice shelves along the Antarctic Peninsula have changed rapidly in recent decades, with episodes of retreat, breakup and collapse occurring on both sides. The overall reduction in total ice shelf area during the last five decades has recently been estimated to be over 28,000 km^2.

3. Since about 1980 the ozone hole has had a major impact on the climate of high southern latitudes, increasing the strength of the westerly winds over the Southern Ocean by 15-20%, slightly cooling much of the continent and decreasing the growth rate of plants. Despite the stronger westerlies there is no evidence of increased Antarctic Circumpolar Current transport.

4. Owing to the success of the Montreal Protocol, the amounts of ozone-depleting substances in the stratosphere are now decreasing by about 1% per year. As a result the size and depth of the ozone hole have stabilised, but are not yet decreasing. The interannual variability of the ozone hole remains largely controlled by meteorological factors in the stratosphere.

5. It has been forecast on empirical grounds that stratospheric ozone loss rates will begin to decline noticeably between 2017 and 2021 and that by the middle of the 21st century springtime concentrations of stratospheric ozone are expected to have significantly recovered and will have almost fully recovered by the end of the 21st century.

6. The large winter season warming on the western side of the Antarctic Peninsula has been traced to a decrease of sea ice just to the west of the Peninsula over the Bellingshausen Sea. It is unclear at present whether this change is a result of anthropogenic activity.

7. Reconstructions of surface temperature for West Antarctica suggest that it has warmed markedly over the last 50 years with the Siple region identified as one of the most rapidly warming areas on Earth. These changes have been linked to sea surface temperature increases across the tropical Pacific Ocean.

8. Over the period 1979–2010 the sea ice over the Southern Ocean as a whole showed a positive trend in the annual mean of 1.3% per decade. The trends in ice concentration have been linked to trends in ice motion, with wind-driven changes in ice advection being the dominant factor although it has recently been suggested that the contribution of fresh meltwater to the ocean from the ice sheets has played a part. The extent of Antarctic sea ice reached a new record maximum for the satellite era in 2012.

9. Ongoing responses of the marine ecosystem to climate change include: a shift in phyto- and bacterioplankton from larger to smaller species; a shrinking of Adélie and Gentoo penguin populations; shifts in the range of Southern elephant seal populations to the south, and decreases in the north of their range; low breeding success of Emperor penguins in East Antarctica due to changes in the food-chain and sea-ice extent; assumed up-slope migration of king crabs as the continental slope waters have warmed; and different rates of response to the climate-induced ice-shelf disintegration of benthic and pelagic systems.

10. Terrestrial and freshwater ecosystems have likewise shown a range of rapid and sensitive responses to different aspects of environmental change. The most general responses, where warming combined with increased availability of liquid water are experienced, have been for local-scale increases in populations, biomass and community complexity involving the native invertebrates and plants. However, specific instances of ‘negative’ responses, for example as a result of exhaustion of local meltwater sources, or increased desiccation stress through decreases in relative humidity, have also been described. Other direct human impacts, particularly through physical damage to habitats and the introduction of non-native organisms, provide a greater level of threat to parts of the Antarctic terrestrial environment than does current climate change *per se*, though interactions among them are likely to be important

Concluding Remarks

The climate of the high latitude areas is more variable than that of tropical or mid-latitude regions and has experienced a wide range of conditions over the last few million years. The snapshot available of the climate during the instrumental period is limited in the long history of the continent, and separation of natural climate variability from anthropogenic influences is difficult. However, the effects of increased greenhouse gases and decreases in stratospheric ozone are already evident. The effects of the expected increase in greenhouses gases over the next century, if they continue to rise at the current rate, will be remarkable because of their speed, and because of polar amplification of the global warming signal. It should be borne in mind that equally rapid change was also typical in past deglaciations, for example 20,000 years ago at the end of the Last Glacial Maximum. Removal of the surface cooling effect of the ozone hole as it diminishes in extent will accelerate the increase in surface temperature. Reasonably broad estimates may be made of how quantities such as temperature, precipitation, acidification of the ocean and sea ice extent might change, and the possible impacts on marine and terrestrial biota considered. How the large ice sheets of Antarctica will respond cannot yet be predicted with confidence, but observed recent rapid changes give cause for concern - especially for the stability of parts of West Antarctica.

Recommendations

SCAR recommends that the CEP and Treaty Parties:

1. Encourage SCAR and Treaty Parties to engage with the United Nations Framework Convention on Climate Change (UNFCCC) and Intergovernmental Panel on Climate Change (IPCC) to ensure that climate change issues in the Antarctic and Southern Ocean are fully considered and that both bodies are made aware of the outcomes of the ACCE report and associated updates;

2. Focus efforts on implementing the recommendations outlined by the Antarctic Treaty Meeting of Experts (ATME) on climate change and implications for Antarctic management and governance (2010);

3. Convey the key points of the ACCE updated report more broadly to ensure awareness of the critical role of Antarctica and the Southern Ocean in the climate system and the importance of associated impacts on the region.

Reference

Turner, J., Bindschadler, R. A., Convey, P., di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D. A., Mayewski, P. A., and Summerhayes, C. P. 2009. Antarctic Climate Change and the Environment , 526. Cambridge, Scientific Committee on Antarctic Research.