Regional climate downscaling through the Antarctic-CORDEX project
Regional climate downscaling through the Antarctic-CORDEX project

Introduction

The Antarctic CORDEX (COordinated Regional Downscaling EXperiment) project was initiated by the World Climate Research Programme\(^1\) to develop regional climate downscaling of Antarctica to provide an accurate description of regional-to-local scale climate phenomena and their variability and changes. This project strengthens cooperation and knowledge exchange between polar climate modelling groups throughout the world, for delivering of these simulations. A coordinated set of simulations enables regional model inter-comparison studies, which are required to characterise uncertainties. Output from the project will also contribute to studies assessing the impact of climate change on Antarctica and the development of adaptation and mitigation strategies, which are required by a diverse range of stakeholders.

Why regional-scale understanding of Antarctica?

Detailed projections of how the Antarctic climate may evolve over the twenty-first century in response to anthropogenic forcing are urgently required by many users, in particular the glaciological and biological communities to produce improved projections of mass balance and the terrestrial ecosystem.

The melting of glacial ice from Antarctica is a cause of great concern for human society due to its potential impact on global sea level and thus the long-term viability of coastal communities. On a local scale it is also of importance to infrastructure of national Antarctic Programmes. The collapse of several Antarctic Peninsula ice shelves in recent decades has been strongly linked to rapid atmospheric warming causing an intensification of ice shelf surface melting, resulting in glacier-acceleration and sea level rise. The Antarctic Peninsula ice masses alone would raise global sea level by 20 cm if melted completely. However, if even a fraction of this were to melt it would make a significant contribution to the rate of sea level rise. To determine the future viability of the remaining Antarctic Peninsula ice shelves, high-resolution projections of daily surface temperature are required for the coming decades.

The West Antarctic Ice Sheet is currently the largest contributor to sea level rise from Antarctica. Within this sector, most attention has been directed towards glaciers draining into the Amundsen Sea, such as Pine Island Glacier. Together these glaciers and their catchment areas contain enough ice to raise global sea level by approximately 1.2 m. The influx of relatively warm circumpolar deep water along troughs that cross the Amundsen Sea continental shelf are thought to be the source of heat that drives the melt at the base of the floating ice shelves, resulting in loss of ice-shelf buttressing and consequent drawdown of grounded ice.

However, the highly variable flux of ocean heat that is delivered to the base of the ice shelves is strongly controlled by the interaction between the atmosphere and the ocean, and in particular the magnitude and direction of the local wind. Given that the performance of oceanographic models are highly sensitive to the atmospheric data used to force them, and that the processes affecting the atmosphere are tremendously complex and characterised by local-scale variability, a major challenge is therefore to acquire sufficient fine-scale data. Additionally, to develop projections of Antarctic mass balance requires understanding of the changes to its surface mass balance (i.e. the difference between accumulation and ablation), which varies extensively with highest accumulation rates over the Antarctic Peninsula and the coast of the West Antarctic Ice Sheet.

A major impediment to understanding the biological response to both natural environmental variability and superimposed anthropogenic change has been the widely different physical scales that biological researchers

---

\(^1\) The World Climate Research Programme is co-sponsored by WMO, the Intergovernmental Oceanographic Commission (IOC) and the International Council for Science (ICSU)
and climate modelling experts typically work at. Terrestrial organisms in the Antarctic operate at fine scales, e.g. representative of the islands, valleys and other terrestrial exposures that are typical in the Antarctic Peninsula. An important need is to define the environmental envelopes of both native and alien species, and hence be able to predict their potential distributions under current climates and how these may change under future scenarios. To achieve this, requires e.g. better estimates of seasonal surface temperature and precipitation changes on fine-scales.

One of the reasons why global climate models used for projections (e.g. from the Coupled Model Intercomparison Project (CMIP) version 5) are not directly fit for these purposes is because their coarse (300 km) grid spacing fails to capture the effects of local forcing such as the narrow and steep margins around the coastal margins of Antarctica, or the many narrow ice shelves that stretch along its coast. Moreover, global climate models usually lack a realistic representation of key physical processes, such as cloud microphysics, the necessary snow/ice/firn processes, or snow albedo evolution due to snow ageing.

**Dynamical downscaling**

Downscaling refers to taking information known at large-scales to make predictions at local scales. This can be done for climate information by dynamically downscaling global climate simulations or global atmospheric reanalysis using a regional climate model. As regional climate models are only applied to a limited domain, they can be used at a much higher spatial and temporal resolution than either global climate models or global atmospheric reanalysis. Consequently, they are much better able to represent the complex processes affecting the local meteorology of Antarctica, including polar mesocyclones, katabatic winds, marginal ice zone processes, clouds, atmospheric boundary layer, and topographic effects at the steep coastal margins. They have therefore proved an extremely valuable tool for providing physically-based atmospheric fields at regional-to-local scales. Figure 1 demonstrates that the polar optimised version of the Weather Research and Forecast (WRF) model at a grid-spacing of 5 km is able to capture the main aspects of local meteorology near Thwaites Glacier on the coast of West Antarctica, such as the diurnal variability of 2 m temperature, which is not captured by reanalysis.

**Simulations**

Antarctic-CORDEX consists of hindcast simulations from a range of regional climate models, driven by historical CMIP global climate model runs and atmospheric reanalysis. These simulations are evaluated against regional datasets. Regional downscaled projections are driven by CMIP scenario simulations for 2006-2100. Coordinating these simulations enables the project to produce multi-model ensembles, which can be used to characterise uncertainties. Promoting communication and knowledge exchange between groups also results in improved models and techniques.

![Figure 1: Ten-day time series of 3-hourly measurements of air temperature at 2 m (black) at Bear Peninsula (119.404W, 80.007S), which is nearby Thwaites Glacier, compared with corresponding output from the regional climate model Polar WRF at 5 km grid-spacing (red). Also shown is the corresponding time series from ERA-Interim atmospheric reanalysis data (blue), which is used to drive the Polar WRF simulation. Figure adapted from Deb et al. (2016).](image-url)
**Membership**

Membership of this programme currently numbers around ten groups, including from France (LGGE Grenoble), Belgium (University of Liege and University of Leuven), UK (British Antarctic Survey), Germany (University of Trier), Netherlands (Royal Netherlands Meteorological Institute), USA (Bryd Polar Research Center and New Mexico Institute of Mining and Technology), and Australia (Commonwealth Scientific and Industrial Research Organisation). **We welcome new members and would be happy to extend the involvement of this initiative to other groups worldwide.** Interest from end-users is also welcome to promote greater interaction with this community, and better support of impact/adaptation studies.

A joint meeting of Antarctic- and Arctic-CORDEX is to be held at the British Antarctic Survey, Cambridge, UK in October 2017.

**Further details**

Further details are available from the coordinator of Antarctic CORDEX, Dr Andrew Orr, at anmcr@bas.ac.uk or by going to: [http://www.climate-cryosphere.org/activities/targeted/polar-cordex/antarctic](http://www.climate-cryosphere.org/activities/targeted/polar-cordex/antarctic).

**Selected publications**