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The Challenge of Present Day and Future Climate in Antarctica: An Intercomparison of Regional Climate Models

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The coldest, driest and windiest continent has potential to add significantly to global sea level under a warming climate which makes it essential to be able to monitor and model the atmosphere – ocean - ice sheet system accurately. Unfortunately, Antarctica presents significant challenges for regional climate models including a necessarily large domain, few observations and a strong sensitivity to ocean conditions as well as large uncertainties propagated from global climate models (GCMs) used as forcing. The CORDEX ensemble of regional climate models (RCMs) allows us to compare the performance of different regional models and to begin to disentangle the important processes that will improve regional climate projections. In this study we use data from six field stations and compare several regional climate models for the Antarctic Domain including the Unified Model, HIRHAM5, HadRM3Pv1, MARv3.6, RACMO$_2$.1Pv1 and RACMO$_2$.3p2.

A common set-up of models forced with the ERA-Interim climate reanalysis allows us to explore inter-model differences for the period 1980 -2015. We also compare high and low resolution model runs (0.11°and 0.44°) as well as those with and without upper boundary relaxation and with and without sophisticated snow models at the surface. To explore the importance of global climate model forcing on the lateral and lower boundary we also compare HIRHAM5 and RACMO$_2$.1Pv1 with forcing from the global climate model EC-Earth running historical, RCP 4.5 and RCP 8.5 scenario runs for the 21st century. We calculate the surface mass budget (SMB) of Antarctica from precipitation, evaporation/sublimation and runoff and explore the implications of future climate change. While under the present day regional climate models show similar values and interannual variability, there is a strong resolution dependence on estimates of SMB. All scenarios show a significant temperature increase between 1.1 °C and 4.4°C for the future. Evaluation runs from the two HIRHAM5s, RACMO$_2$.3p2 and MARv3.6 give a mean surface mass balance from 1979-2015 of 2660 GT yr +/- 200 GT
while RACMO$_2$.1Pv1 and HadRM3Pv1 show a lower SMB. For future projections of SMB, accurate and detailed surface snow models are crucial in estimating the relative amounts of runoff and refreezing but significant decadal scale variability as well as differences between ensemble members from the same GCM shows that forcing from the global models remains the largest source of uncertainty in future estimates of SMB.