Antarctica 2300 (ISMIP6) Projections

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Summary

The Ice Sheet Model Intercomparison Project (ISMIP6, Nowicki et al., 2016) is a crucial part of the World Climate Research Programme’s Climate Model Intercomparison Project Phase 6 (CMIP6), which focuses on ice sheets. The goal of ISMIP6 is to provide processed-based projections of ice sheet contribution to sea-level rise for the 21st century (Nowicki et al., 2020; Goelzer et al., 2020; Seroussi et al., 2020), and to assess the uncertainties associated with these projections and their origins. It is also essential to consider ice sheet projections beyond the 21st century, as instability mechanisms have the potential to rapidly destabilize ice sheets, and several regions may reach tipping points, potentially leading to much larger sea level contributions. ISMIP6 Antarctica 2300 Projections is a continuation of the successful ISMIP6 project, and extends previous simulations to 2300, using climate forcings from both CMIP5 and CMIP6 under different scenarios.

***Protocol and experiments***

Fourteen experiments are forced with evolving climate conditions from Global Climate Models (GCMs). These experiments are based on 5 different CMIP5 and CMIP6 GCMs and most are based on a high carbon emission scenario (RCP 8.5 and SSP5-8.5). The majority of experiments are forced with climate conditions (atmospheric and oceanic conditions) simulated by GCMs until 2300, but a few simulations are based on repeated forcings from the end of the 21st century. In this case, conditions from 2080 to 2100 are repeated for the following two century. In order to avoid repeating the same interannual patterns, annual conditions are selected randomly from the 2080-2100 period to create forcing for the entire length of the experiments. The same selection is used by all ice flow models to ensure they are forced with similar conditions. Additionally, two experiments use a low carbon emission scenario (RC P2.6 or SSP1-2.6) and four experiments introduce ice shelf collapse that happens when ice shelves experience elevated amounts of liquid water at their surface for a period of ten years or more (Trusel et al., 2015).

Similar to the philosophy adopted for initMIP-Antarctica (Seroussi et al., 2019) and ISMIP6 Antarctica projections (Seroussi et al., 2020), there are no constraints on the method or datasets used to initialize ice sheet models. The exact initialization date is also left to the discretion of individual modeling groups, so the historical experiment length varies among groups (some groups start directly at the beginning of 2015 and therefore did not submit a historical run). The resulting ensemble includes a variety of model resolutions, stress balance approximations, and initialization methods, representative of the diversity of the ice sheet modeling community for more details on participating models. 16 international groups submitted experiments using 13 different ice flow models, resulting in a total of 45 sets of experiments.

***Antarctic contribution to sea level rise***

ISMIP6 Antarctica 2300 Projections results show a contribution to sea level rise by 2100 consistent with previous ISMIP6 efforts despite the ensemble of models being slightly different from the one in Seroussi et al. (2020). The Antarctic ice loss and its contribution to sea level increases rapidly after 2100 to reach up to 4.2 meters of global mean sea level rise by 2300 (see Fig.1). However, some simulations suggest a mass gain that continues beyond the 21st century, leading to an overall sea level fall of up to 0.8 meters by 2300. Simulations forced by CCSM4 cause the least amount of mass loss, due to the increased snow precipitations in East Antarctica, while simulations forced with CESM2, HadGEM and UKESM suggest relatively similar amounts of sea level change. Additional experiments (not shown) performed with repeated forcings from the end of the 21st century show significantly less sea level contribution, up to 1 meter less sea level rise, while experiments including ice shelf collapse show a notable increase in sea level rise contribution, up to 1 additional meter sea level rise by 2300 for the most extreme cases.



Figure 1: Change in ice volume above floatation (left y-axis) and sea level equivalent (right y-axis) between 2015 and 2300 from all ice flow models. Experiments are forced with simulated climate conditions from CCSM4 (blue), HadGEM (red), CESM2 (yellow) and UKESM (green) until 2300. No ice shelf collapse is included in these experiments. Adapted from Seroussi et al. (in prep.)

Our results demonstrate the large uncertainty coming from both ice flow models as well forcings from climate models (Barthel et al., 2020). They suggest that continued development and improvements are needed to both enhance the reliability of ice flow models, as well as to provide accurate projections of climate evolution in polar regions in the 21st century and beyond.

**In conclusion it is essential for all Treaty Parties to consider ice sheet projections beyond the 21st century, as instability mechanisms have the potential to rapidly destabilize ice sheets, and several regions may reach tipping points, potentially leading to much larger sea level contributions and a commitment to multi-meter (intergenerational) sea-level rise.**

***Membership***

The ISMIP6 consist of ice flow modelers as well as physical oceanographers, atmospheric scientist, climate modelers, and data scientist from 11 countries over 4 continents. We welcome new members and would be happy to extend the involvement of this initiative to other interested groups worldwide.

***Further details***

More information is available on <https://www.climate-cryosphere.org/wiki/index.php?title=ISMIP6_wiki_page> or by contacting ISMIP6 at [ismip6@gmail.com](mailto:ismip6@gmail.com). ISMIP6 is supported by the Climate and Cryosphere (CliC) initiative.

***References***

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