EGU23-7422, updated on 17 Jan 2024
https://doi.org/10.5194/egusphere-egu23-7422
EGU General Assembly 2023

(Ir)reversibility of future Antarctic mass loss on multi-millennial timescales

Ann Kristin Klose[1,2], Violaine Coulon[3], Frank Pattyn[3], and Ricarda Winkelmann[1,2]
[1]FutureLab Earth Resilience in the Anthropocene, Earth System Analysis & Complexity Science, Potsdam Institute for Climate Impact Research, Potsdam, German
[2]Department of Physics and Astronomy, University of Potsdam, Potsdam, Germany
[3]Université libre de Bruxelles (ULB), Laboratoire de Glaciologie, Brussels, Belgium

Given the potentially high magnitudes and rates of future warming, the long-term evolution of the Antarctic Ice Sheet is highly uncertain. While recent projections under Representative Concentration Pathway 8.5 estimate the Antarctic sea-level contribution by the end of this century between -7.8 cm and 30.0 cm sea-level equivalent (Seroussi et al., 2020), sea-level might continue to rise for millennia to come due to ice sheet inertia, resulting in a substantially higher long-term committed sea-level change. In addition, potentially irreversible ice loss due to several self-amplifying feedback mechanisms may be triggered within the coming centuries, but evolves thereafter over longer timescales depending on the warming trajectory. It is therefore necessary to account for the timescale difference between forcing and ice sheet response in long-term sea-level projections by (i) determining the resulting gap between transient and committed sea-level contribution with respect to changing boundary conditions, (ii) testing the reversibility of large-scale ice sheet changes, as well as (iii) exploring the potential for safe overshoots of critical thresholds when reversing climate conditions from enhanced warming to present-day.

Here, we assess the sea-level contribution from mass balance changes of the Antarctic Ice Sheet on multi-millennial timescales, as well as ice loss reversibility. The Antarctic sea-level commitment is quantified using the Parallel Ice Sheet Model (PISM) and the fast Elementary Thermomechanical Ice Sheet (f.ETISh) model by fixing forcing conditions of warming trajectories from state-of-the-art climate models available from the sixth phase of the Coupled Model Intercomparison Project (CMIP6) at regular intervals in time. The ice sheet then evolves for several millennia under constant climate conditions. Finally, the climate forcing is reversed to present-day starting from different stages of ice sheet decline to test for the reversibility of ice loss.

Our results suggest that the Antarctic Ice Sheet may be committed to a strong grounding-line retreat or even a collapse of the West Antarctic Ice Sheet when keeping climate conditions constant at warming levels reached during this century. Fixing climate conditions later in time may additionally trigger a substantial decline of the East Antarctic Ice Sheet. We show that the reversibility of Antarctic ice loss as well as the potential for safe overshoots strongly depend on the timing of the reversal of the forcing.