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The role of history and strength of the oceanic forcing in sea-level projections from Antarctica with the Parallel Ice Sheet Model

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Mass loss from the Antarctic Ice Sheet constitutes the largest uncertainty in projections of future sea-level rise. Ocean-driven melting underneath the floating ice shelves and subsequent acceleration of the inland ice streams is the major reason for currently observed mass loss from Antarctica and is expected to become more important in the future. Here we show that for projections of future mass loss from the Antarctic Ice Sheet, it is essential (1) to better constrain the sensitivity of sub-shelf melt rates to ocean warming, and (2) to include the historic trajectory of the ice sheet. In particular, we find that while the ice-sheet response in simulations using the Parallel Ice Sheet Model is comparable to the median response of models in three Antarctic Ice Sheet Intercomparison projects – initMIP, LARMIP-2 and ISMIP6 – conducted with a range of ice-sheet models, the projected 21st century sea-level contribution differs significantly depending on these two factors. For the highest emission scenario RCP8.5, this leads to projected ice loss ranging from 1.4 to 4.3 cm of sea-level equivalent in the ISMIP6 simulations where the sub-shelf melt sensitivity is comparably low, opposed to a likely range of 9.2 to 35.9 cm using the exact same initial setup, but emulated from the LARMIP-2 experiments with a higher melt sensitivity based on oceanographic studies. Furthermore, using two initial states, one with and one without a previous historic simulation from 1850 to 2014, we show that while differences between the ice-sheet configurations in 2015 are marginal, the historic simulation increases the susceptibility of the ice sheet to ocean warming, thereby increasing mass loss from 2015 to 2100 by about 50%. Our results emphasize that the uncertainty that arises from the forcing is of the same order of magnitude as the ice-dynamic response for future sea-level projections.