Response of the Antarctic Ice Sheet to increased ice-shelf oceanic melting

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A numerical ice sheet-shelf model is used to simulate the large-scale response of the Antarctic Ice Sheet to prescribed future increases in oceanic melting at the base of floating ice shelves. The model is driven forward in time starting from modern conditions, with either step-function or time-dependent perturbations in parameterized sub-ice oceanic melt rates that crudely represent possible ranges due to future anthropogenic warming.

In some runs, changes to Antarctic precipitation and surface melt are also simply prescribed. It is found that with melt rates under the interiors of large shelves increased to ~2 m/y or more (from modern 0.1 m/y), drastic grounding line retreat in the Ross, Ronne and Pine Island/Thwaites embayments leads to collapse of nearly all marine West Antarctic ice. The time scale of collapse depends on the magnitude of oceanic melt: ~1500 years for 2 m/y, and ~300 years for “infinite” melt (no floating ice). The WAIS collapse causes ~3 m of global sea-level rise. However, the net Antarctic contribution is modified by expected future changes in surface mass balance, especially increased East Antarctic snowfall which significantly reduces the net sea-level rise. In simulations with time-dependent forcing peaking at 2200 AD and then decaying exponentially to represent the natural uptake of anthropogenic CO_2, WAIS still largely collapses for peak oceanic melt rates of ~4 m/y or more, and the re-growth of WAIS towards its modern state is delayed by the CO_2 tail and takes longer than 20,000 years.