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Modelling the long-term impact of surface warming on Greenland ice sheet mass loss

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Projections of future sea level changes require understanding of the response of the Greenland ice sheet to future climate change. Numerous feedbacks between the ice sheet and the climate system mean that comprehensive model setups are required to simulate the concurrent ice sheet and climate changes. Here, the ice sheet response to a warming climate has been studied using a model setup consisting of an earth system model (EC-Earth) interactively coupled to an ice sheet model (PISM). The coupled system has been employed for a 1400-year simulation forced by historical radiative forcing from 1850 onward continued along an extended RCP8.5 scenario to beyond year 3200.

The simulation reveals that the rate of mass loss from the Greenland ice sheet increases substantially after 2100. The mass loss hereafter continues at a steady rate, even as the warming rate gradually levels off. As the coupled setup does not include the direct impact of oceanic forcing, the mass loss is due to the combination of a negative surface mass balance and a dynamic response to the surface warming. Increased melt exceeds regional precipitation increases in the surface mass balance, while the surface warming increases the enthalpy (per unit volume) of the ice sheet potentially impacting the rheology and thereby the ice flow.

The relative roles of the surface mass balance changes and the dynamic response of the ice flow are further investigated using additional ice sheet model sensitivity experiments, where the ice sheet is forced by the time-varying surface mass balance from the coupled model. We aim to quantify the impact of the simulated surface warming on the ice flow by means of a hybrid simulation where the ice sheet is forced by the surface mass balance from the coupled setup while keeping the ice surface temperature constant. This allows for assessment of the impact of the surface mass balance change, isolated from the dynamical response to the warming surface.