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# Interacting melt-elevation and glacial isostatic adjustment feedbacks allow for distinct dynamic regimes of the Greenland Ice Sheet

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Interacting feedbacks play an important role in governing the stability of the Greenland Ice Sheet under global warming. Here we study the interaction between the positive melt-elevation feedback and the negative feedback from glacial isostatic adjustment (GIA), and how they affect the ice volume of the Greenland Ice Sheet on long time scales. We therefore use the Parallel Ice Sheet Model (PISM) coupled to a simple solid Earth model (Lingle-Clark) in idealized step-warming experiments. Our results suggest that for warming levels above 2°C, Greenland could become essentially ice-free on the long-term, mainly as a result of surface melting and acceleration of ice flow. The negative GIA feedback can mitigate ice losses and promote a partial recovery of the ice volume.

Exploring the full factorial parameter space which determines the relative strength of the two feedbacks reveals that four distinct dynamic regimes are possible: from stabilization, via recovery and self-sustained oscillations to the irreversible collapse of the Greenland Ice Sheet. In the recovery regime an initial ice loss is reversed and the ice volume stabilized at 61-93% of the present day volume. For certain combinations of temperature increase, atmospheric lapse rate and Earth mantle viscosity, the interaction of the GIA feedback and the melt-elevation feedback leads to self-sustained, long-term oscillations in ice-sheet volume with oscillation periods of tens to hundreds of thousands of years and oscillation amplitudes between 15-70% of present-day ice volume. This oscillatory regime reveals a possible mode of internal climatic variability in the Earth system on time scales on the order of 100,000 years that may be excited by or synchronized with orbital forcing or interact with glacial cycles and other slow modes of variability.