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Response of an idealized ice-sheet-shelf system to mass-preserving forcing

Johannes Feldmann (1), Ronja Reese (1,2), Anders Levermann (1,2,3)

(1) Potsdam Institute for Climate Impact Research, Potsdam, Germany, (2) Institute of Physics, University of Potsdam, Potsdam, Germany, (3) LDEO, Columbia University, New York, USA

Surface accumulation and sub-ice-shelf melting are key drivers for the flow dynamics of the Antarctic Ice Sheet and are most likely to change under future warming which leads to 1) higher snowfall and 2) stronger melting below ice shelves. Here we carry out conceptual simulations in which an equilibrium ice-sheet-shelf system is perturbed such that the increased sub-shelf melting is compensated by enhanced snowfall. Although the net surface mass balance of the whole system remains unchanged, the redistribution of mass leads to a dynamic response of the ice sheet due to changes in ice-shelf backstress and ice discharge. In particular, we show that such forcing can lead to the counter-intuitive situation of a retreating ice sheet which gains mass, thus having a negative sea-level contribution. The ice-sheet evolution is investigated for varying magnitude of mass redistribution and values of relevant parameters that affect ice properties and bed geometry. Special focus is given to the pattern of the applied melt perturbation (central vs. lateral and confined vs. distributed ice-shelf melt). The qualitative ice-sheet response is found to be independent of all these parameters. Furthermore, we examine the response in ice-shelf backstress to the perturbation with respect to changes in the ice-shelf length and mean ice-shelf thickness, respectively. Our analysis reveals that the thickness change has significantly more influence than the length change.