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Representing Icebergs In A Fully Coupled Climate Model

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Changes in the global climate during past and current times strongly impact the Polar Regions, which in turn affect the global climate due to several mechanisms, such as albedo, topography, ablation and ice discharge. Icebergs are an important part of the climate system as they interact with the ocean, atmosphere and cryosphere. Several approaches have been taken to incorporate iceberg calving into numerical models under different climate forcings. The studies done so far have in common that the icebergs were moved by reconstructed or modelled forcing fields and that the initial size distribution of the icebergs was prescribed according to present day observations. Hence, uncertainties in the forcing fields and in the parameterization of the iceberg size may alter the results.
To investigate the impact of the background forcing (atmosphere, ocean) and the pre-defined size distribution on the icebergs and consequently on the Northern hemisphere climate and the Greenland ice sheet, we have coupled an earth system model of intermediate complexity (iLOVECLIM, Roche et al., 2013) to an ice sheet/ice shelf model (GRISLI, Ritz et al., 2001) and an iceberg module (Jongma et al., 2009; Bügelmayer et al., 2014).
Using this set-up, we performed 15 sensitivity experiments that differ in the applied forcing (atmosphere, ocean), the applied boundary conditions (pre-industrial, 4xCO_2, 1/4 x CO_2) and the initial size distribution of the icebergs. In the presented study only the Greenland ice sheet is considered.
We find that, under pre-industrial conditions, the atmospheric forcing pushes the icebergs further away from their calving sites and further into the North Atlantic, whereas the ocean currents transport the bergs along the Greenland coast and southward along the Canadian coast. Although the purely atmospheric-forced bergs cause warmer oceanic conditions than the oceanic-driven bergs, the overall effect on climate and the resulting ice sheet due to variations in the iceberg melt fluxes are small.
Under equilibrated pre-industrial conditions, the generation of only small or big icebergs, instead of icebergs of all size classes, has a negligible effect on the Greenland ice sheet. Yet, under a warming climate (4xCO_2) the implementation of only small or big bergs, compared to all size classes, causes a thicker ice sheet at the margins after 1000 model years. Also during a colder climate (1/4 x CO_2) the generation of only small or big bergs allows for a wider spread extension of the Greenland ice sheet.

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