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The ocean response to changes of the Greenland Ice sheet in a warming climate

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During recent decades, increased and highly variable mass loss from the Greenland ice sheet has been observed, implying that the ice sheet can respond to changes in ocean and atmospheric conditions on annual to decadal time scales. Changes in ice sheet topography and increased mass loss into the ocean may impact large scale atmosphere and ocean circulation. Therefore, coupling of ice sheet and climate models, to explicitly include the processes and feedbacks of ice sheet changes, is needed to improve the understanding of ice sheet-climate interactions.

Here, we present results from the coupled ice sheet-climate model system, EC-Earth-PISM. The model consists of the atmosphere, ocean and sea-ice model system EC-Earth, two-way coupled to the Parallel Ice Sheet Model, PISM. The surface mass balance (SMB) is calculated within EC-Earth, from the precipitation, evaporation and surface melt of snow and ice, to ensure conservation of mass and energy. The ice sheet model, PISM, calculates ice dynamical changes in ice discharge and basal melt as well as changes in ice extent and thickness. Idealized climate change experiments have been performed starting from pre-industrial conditions for a) constant forcing (pre-industrial control); b) abruptly quadrupling the CO_2 concentration; and c) gradually increasing the CO_2 concentration by 1% per year until $4xCO_2$ is reached. All three experiments are run for 350 years.

Our results show a significant impact of the interactive ice sheet component on heat and fresh water fluxes into the Arctic and North Atlantic Oceans. The interactive ice sheet causes freshening of the Arctic Ocean and affects deep water formation, resulting in a significant delay of the recovery of the Atlantic Meridional Overturning Circulation (AMOC) in the coupled $4xCO_2$ experiments, when compared with uncoupled experiments.