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Modeling ice sheet – solid earth – climate interactions during deglaciation

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We study the interactions of ice sheets with the other components of the climate system in a new modeling system that encompasses a wide range of interactions between ice sheets, their mass balance, the solid Earth and the climate. Forcing the model with increasing greenhouse gas concentrations allows us to study the full interactions of the different climate system components and thus deepen our understanding of the processes relevant during deglaciation.

The system consists of the modified Parallel Ice Sheet Model (mPISM), the VIscoelastic Lithosphere and MAntle model (VILMA), and the Max Planck Institute Earth System Model (MPI-ESM). The surface mass balance of the ice sheets is computed with an energy balance model, shelf basal melt from temperature and salinity of the adjacent ocean. By applying VILMA, sea-level change due to ice loads is calculated considering surface deformation, eustasy and geoid change. In MPI-ESM, glaciers, topography, rivers, coastlines and bathymetry adapt to changes in ice sheets and topography. The model system is forced only with transient orbital parameters and greenhouse gas concentrations.

In our experiments, the retreating ice sheets leave behind vast periglacial lakes and marginal seas. Gigantic ice sheet surges into these basins lead to the formation of large ice shelves with low surface elevations causing strong melt. Where the basins are connected to the open ocean, basal melt and calving increase the ice loss at the shelves. Over time, the retarded sea-level response shrinks the periglacial basins again. This study presents first experiments that include the full range of interactions between ice sheets, solid Earth, atmosphere and ocean circulation.