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Interactive ocean bathymetry and coastlines for simulating the last deglaciation with the Max Planck Institute Earth System Model (MPI-ESM)

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As ice sheets melt or grow, the flux of freshwater into the ocean changes and the bedrock adjusts due to isostatic adjustments, leading to variations in the bottom topography and the oceanic boundaries. For long-term integrations with large changes in the ice volume, it is therefore necessary to consider transient ocean bathymetry and coastlines. However, in most standard ESMs they are fixed throughout the simulations because the generation of a new ocean model bathymetry implies several levels of manual corrections. Hence, it is one of the main challenges in adequately simulating a complete glacial cycle with ESMs.

We present for the first time, a tool to allow for an automatic computation of bathymetry and land-sea mask changes during long-term climate simulations. It is applied within the Max Planck Institute ESM (MPI-ESM). The procedure includes the generation of the bathymetry file and the modification of the restart file to run the ocean component of MPI-ESM. Our approach guarantees the conservation of mass and tracers at global and regional scales.

We investigate the performance in simulating the ocean circulation when the interactive bathymetry and land-sea mask are implemented. Therefore, we compare two simulations of the last deglaciation with MPI-ESM. In the first run, the bathymetry and coastlines are automatically changed every 10 years. The ICE-6G reconstructions of ice thickness and topography are prescribed to compute both, the changes in the ocean floor and the freshwater fluxes into the ocean. In the second run, the bathymetry and land-sea mask are fixed to the Last Glacial Maximum condition (21kyrs BP). Both simulations are externally forced with solar insolation and greenhouse gas concentrations.

The presented modules constitute a powerful tool and a step forward towards a realistic simulation of the last deglaciation. We are currently continuing our efforts to combine single components into a fully coupled ice sheet-solid earth-climate model with interactive coastlines and topography, forced with only solar insolation and greenhouse gas concentrations.