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The climate feedbacks of the Greenland ice sheet as simulated in EC-Earth coupled with an ice sheet model

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A new global climate model system incorporated with the component of the Greenland ice sheet has been developed recently to study the interaction of the Greenland ice sheet with the climate system. The model system consists of the global climate model, EC-Earth, coupled with the Parallel Ice Sheet Model (PISM). To establish a physically sound coupling, the EC-Earth surface physical parameterization is adapted to the land ice surface with improved snow albedo parameterization and snow thermal flux over land surface covered with ice. The surface mass balance (SMB) over land ice resulting from the precipitation, the surface evaporation, and the melting of snow and ice is computed within the EC-Earth as forcing to PISM to ensure accuracy and conservation of mass and energy. The coupling then involves using the OASIS coupler to exchange surface temperature and the accumulated SMB of the EC-Earth, with the consequent PISM simulated ice sheet conditions such as ice extent and thickness, and the discharge from the ice sheet. The PISM is initialized using the standard paleo-climatological spin-up of 125k years followed by forcing of the EC-Earth preindustrial climate to reach an equilibrium state with the model preindustrial climate.

The coupled EC-Earth/PISM system is integrated under the preindustrial condition until it has reached the quasi-stationary state for a considerable long period (PI-CTRL). To study the interaction of the Greenland ice sheet, an experiment with idealized 1% CO_2 per year increase from the atmospheric CO_2 at preindustrial level to four-times CO_2 are performed for 300 years (i.e. stabilized at 4xCO_2 for 160 years). The evolution of Greenland ice sheet under 4xCO_2 forcing and its impact on the climate system are investigated and compared with that in the PI-CTRL. Freshwater flux from the Greenland ice sheet melt and discharge to the North Atlantic basin and its role on the change of the strength of the North Atlantic Meridional Overturning Circulation are analyzed. The regional climate changes associated with the dynamic and thermodynamic effect of the Greenland ice sheet change are also quantified.