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Long-term Consequences of anthropogenic CO2 Emissions simulated with a complex Earth System Model

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A new complex earth system model consisting of an AGCM, an OGCM, a 3-dimensional ice sheet model, a marine biogeochemistry model and a dynamic vegetation model was used to study the long-term response to anthropogenic carbon emissions with ensemble simulations. The prescribed emissions follow standard IPCC emissions up to 2100. After 2100 an exponential decrease of the emissions was assumed. The North Atlantic overturning collapsed in the high emission scenario simulations. In the low emission scenario only a temporary weakening of the deep water formation in the North Atlantic is predicted. The moderate emission scenario brings the system close to its bifurcation point, with 3 out of 5 runs leading to a collapsed North Atlantic overturning circulation. The atmospheric moisture transports are the main cause of the collapsed deep water formation. The formation of AABW is temporarily reduced/suppressed in all simulations as well, but recovers again. The collapse of the NADW formation has only a small effect on the simulated atmospheric CO2 concentration. The volume of the Greenland ice sheet is reduced, but its contribution to global mean sea level is almost cancelled by the growth of the Antarctic ice sheet due to enhanced snow fall. The modifications of the high latitude freshwater input due to the simulated changes in mass balance of the ice sheet are one order of magnitude smaller than the changes due to atmospheric moisture transport. After year 3000 the global mean surface temperature was almost constant due to the compensating effects of decreasing atmospheric CO2 concentrations due to oceanic uptake and delayed response to increasing atmospheric CO2 concentrations before.