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Transient Forcing Impacts on the Freshwater Balance in Polar Regions

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The hydrological cycle is of fundamental importance for the climate system and increasing attention is being payed to this topic by both observational and model studies. Nevertheless, a comprehensive understanding of the interaction between the hydrological cycle and climate change is still missing – especially in polar regions. To assess changes of the hydrological cycle in polar regions we use a series of simulations with the Community Climate System Model version 3 (CCSM3) from NCAR. Starting from different initial conditions an ensemble of four transient simulations from 1500 to 2100 (with natural forcing and the SRES scenario A2 from 2000 to 2100) is generated. Thereby future changes are placed in the context of the pre-industrial climate (1500-1870). These long ensemble simulations enable us to assess changes on the basis of a robust data set and to present an extended analysis of the results presented at the 2009 assembly. We found the freshwater cycle and budget in the polar regions to vary little during the pre-industrial period, while the simulations project substantial changes as a response to the increasing greenhouse gas concentrations in the future. These changes in polar regions occur in a temporally and spatially non-uniform way and exert a strong feedback on lower latitudes. In the Arctic region the freshwater import increases stronger than the export, transforming the Arctic Ocean from a freshwater source to a sink with a decreasing density and a rising sea surface height. Discharge from rivers dominates these freshwater budget changes. The Southern Ocean, on the other hand, loses freshwater due to the fact that oceanic export exceeds atmospheric import of freshwater. In the Northern Hemisphere distinct changes of the freshwater discharge through ocean passages to adjacent ocean basins are identified which alter deep-water formation and consequently the Atlantic Meridional Overturning Circulation. The latter is decreasing by about 20% until the end of the 21st century. In the Southern Hemisphere, local modifications in sea ice production and other ocean surface freshwater forcing cause changes in deep-water formation. Based on these projections, substantial changes in the distribution of water masses on hemispheric scale are expected for the 21st and subsequent centuries.