Climate-carbon cycle model response to freshwater discharge into the North Atlantic

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Response of a coupled climate-carbon cycle model to freshwater discharge into the North Atlantic is investigated with regard to cold reversals caused by meltwater from northern continental ice sheets such as the Younger Dryas during the last deglaciation. The extreme case in which the North Atlantic thermohaline circulation ceases in several decades is discussed. In the preindustrial case, northern severe cooling is reproduced by the collapse of the Atlantic northward heat transport, and land carbon decreases due to decrease in net primary production (NPP) by the cooling or precipitation decrease, resulting in decrease in global air temperature and increase in atmospheric carbon dioxide (CO2) concentration. The atmospheric CO2 increase by the land carbon decrease is consistent with a previous terrestrial vegetation model study (Scholze et al. 2003) and a minimum in ice core delta13CO2 during the Younger Dryas (Smith et al. 1999). The atmospheric CO2 increase in our model is less than 10 ppmv consistent with the paleoclimatic records at the beginning of the Younger Dryas. This small increase results from the compensation between changes in CO2 sources and sinks of the land and ocean carbon cycles such as the decrease in both NPP and soil respiration by the cooling. In the postindustrial case with fossil fuel CO2 emission, the same anomalies as the preindustrial case are found in the climate and the land carbon cycle in comparison with the control experiment without the freshwater discharge. After the termination of the freshwater discharge, the cold anomaly is globally reduced by the intense greenhouse effect of the increasing atmospheric CO2 on the order of 2000 ppmv, despite the weak thermohaline circulation in the North Atlantic. In contrast to the preindustrial case, the atmospheric CO2 concentration about 90 ppmv higher than the control experiment is caused mostly by the decrease in the ocean carbon uptake, which results from the decrease in the transport of anthropogenic carbon into the deep ocean by the collapse of the North Atlantic thermohaline circulation. The model results show the fact that there can be a case in the earth system where we can see a decoupling between two environmental variables, air temperature and atmospheric CO2, that normally correlate with each other. (Obata 2007 J.Climate)