Geophysical Research Abstracts
Vol. 13, EGU2011-10636-1, 2011
EGU General Assembly 2011

Fingerprints of changes in the terrestrial carbon cycle in response to large reorganizations in ocean circulation

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CO_2 and carbon cycle changes in the land, ocean and atmosphere are investigated using the comprehensive carbon cycle-climate model NCAR CSM1.4-carbon. Ensemble simulations are forced with freshwater perturbations applied at the North Atlantic and Southern Ocean deep water formation sites under pre-industrial climate conditions. As a result, the Atlantic Meridional Overturning Circulation reduces in each experiment to varying degrees. The physical climate fields show changes that are well documented in the literature but there is a clear distinction between northern and southern perturbations. Changes in the physical variables affect, in return, the land and ocean biogeochemical cycles and cause a reduction, or an increase, in the atmospheric CO_2 by up to 20 ppmv, depending on the location of the perturbation. In the case of a North Atlantic perturbation, the land biosphere reacts with a strong reduction in carbon stocks in some tropical locations and in high northern latitudes. In contrast, land carbon stocks tend to increase in response to a southern perturbation. The ocean is generally a sink of carbon although large re-organizations occur throughout various basins. The response of the land biosphere is strongest in the tropical regions due to a shift of the Intertropical Convergence Zone. The carbon fingerprints of this shift, either to the south or to the north depending on where the freshwater is applied, can be found most clearly in South America. For this reason, a compilation of various paleoclimate proxy records of Younger Dryas precipitation changes are compared with our model results.