Geophysical Research Abstracts
Vol. 13, EGU2011-3621, 2011
EGU General Assembly 2011

The interglacial carbon cycle

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Explaining the difference in carbon cycle dynamics (and hence atmospheric CO_2) between various interglacials is an elusive issue. Several biogeochemical mechanisms of different origin are involved in interglacial CO_2 dynamics, leading to a CO_2 release from the ocean (carbonate compensation, coral growth) compensated by a land carbon uptake (biomass and soil carbon buildup, peat accumulation). The balance between these fluxes of CO_2 is delicate and time-dependent, and it is not possible to provide firm constraints on these fluxes from proxy data. The best framework for quantification of all these mechanisms is an Earth System model that includes all necessary physical and biogeochemical components of the atmosphere, ocean, and land. To perform multi-millennial model integrations through the Holocene, Eemian, and MIS11, we use an earth system model of intermediate complexity, CLIMBER-2, coupled to the dynamic global vegetation model LPJ with a recently implemented module for boreal peatland dynamics.

During glacial-interglacial cycles, the carbon cycle never is in complete equilibrium due to a number of small but persistent fluxes such as terrestrial weathering. This complicates setting up interglacial experiments as the usual approach to start model integrations from an equilibrium state is not valid any more. In order to circumvent the problem of non-equilibrium initial conditions, the model is initialised with the oceanic biogeochemistry state taken from a transient simulation through the last glacial cycle with CLIMBER-2 only. In this simulation, the CLIMBER-2 model was run through the last glacial cycle with carbon cycle in "offline mode" as interactive components of the physical climate system (atmosphere, ocean, ice sheets) were driven by concentration of greenhouse gases reconstructed from ice cores.

Using these initial conditions, we performed coupled climate carbon cycle experiments for the Holocene, the Eemian and MIS11, driven by orbital forcing. Contrary to the results we published previously (Kleinen et al. 2010), peat accumulation was not prescribed, but rather determined dynamically, making this model setup applicable to previous interglacials as well. For the Holocene, our results resemble the carbon cycle dynamics as reconstructed from ice cores quite closely, both for atmospheric CO_2 and $\delta^{13}CO_2$. These experiments will be presented, analysing the role of different forcing mechanisms. The land surface appears to be an overall sink for CO_2, due to carbon accumulation in the soil, as well as peat accumulation, and oceanic contributions due to temperature and circulation changes are quite small. Finally, results for MIS11 and the Eemian will be shown.