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CO_2 and CH_4 during recent interglacials

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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, $CaCO_3$ sedimentation) 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 various interglacials, 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 peatland dynamics and methane emissions.

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. Tropical peatlands were initialised in a similar manner from an integration of LPJ through the last glacial cycle.

Using these initial conditions, we used CLIMBER2-LPJ to perform interactively coupled climate carbon cycle experiments for the Holocene and the Eemian, as well as Marine Isotope Stages 11 and 13, driven by orbital forcing and prescribed ice sheets. For the Holocene, our results resemble the carbon cycle dynamics as reconstructed from ice cores quite closely, both for atmospheric CO_2 and $\delta^{13}CO_2$. In addition, Holocene CH_4 emissions follow similar trends to CH_4 concentration reconstructions.

We present results from these simulations, analysing the evolution of the carbon cycle in these modelled interglacials, and how it compares to results from ice cores.