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Vegetation and land carbon feedbacks in the high-resolution transient Holocene simulations using the MPI Earth system model

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Plants influence climate through changes in the land surface biophysics (albedo, transpiration) and concentrations of the atmospheric greenhouse gases. One of the interesting periods to investigate a climatic role of terrestrial biosphere is the Holocene, when, despite of the relatively steady global climate, the atmospheric CO_2 grew by about 20 ppm from 7 kyr BP to pre-industrial. We use a new setup of the Max Planck Institute Earth System Model MPI-ESM1 consisting of the latest version of the atmospheric model ECHAM6, including the land surface model JSBACH3 with carbon cycle and vegetation dynamics, coupled to the ocean circulation model MPI-OM, which includes the HAMOCC model of ocean biogeochemistry. The model has been run for several simulations over the Holocene period of the last 8000 years under the forcing data sets of orbital insolation, atmospheric greenhouse gases, volcanic aerosols, solar irradiance and stratospheric ozone, as well as land-use changes. In response to this forcing, the land carbon storage increased by about 60 PgC between 8 and 4 kyr BP, stayed relatively constant until 2 kyr BP, and decreased by about 90 PgC by 1850 AD due to land use changes. Vegetation and soil carbon changes significantly affected atmospheric CO_2 during the periods of strong volcanic eruptions. In response to the eruption-caused cooling, the land initially stores more carbon as respiration decreases, but then it releases even more carbon due to productivity decrease. This decadal- scale variability helps to quantify the vegetation and land carbon feedbacks during the past periods when the temporal resolution of the ice-core CO_2 record is not sufficient to capture fast CO_2 variations. From a set of Holocene simulations with prescribed or interactive atmospheric CO_2, we get estimates of climate-carbon feedback useful for future climate studies.

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