Land-atmosphere carbon isotope fluxes during interglacials

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summary

Understanding carbon cycle and climate dynamics in the past is crucial to project climate and CO_2 changes in the future. To quantify a role of terrestrial mechanisms in atmospheric $\delta^{13}CO_2$ changes in the past, a model of ^{13}C discrimination during terrestrial biogeochemical processes is added to the land surface module JSBACH of the MPI Earth System Model (MPI-ESM). The parametrisation of fractionation processes for C_3 and C_4 plants is an extension of the theory by Lloyd & Farquhar (1994) and Wingate et al. (2007). The ^{13}C model component simulates land-atmosphere carbon isotope exchanges on sub-daily time scale.

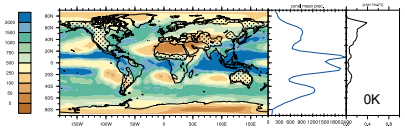
We present a JSBACH model study focusing on the last two interglacials Holocene (last 6000 yrs. BP, 6K) and the Eemian (125.000 yrs. BP, 125K) . The climate forcing is taken from MPI-ESM simulation based on a constant atmospheric CO_2 concentration of 280 ppm and an orbital forcing following the PMIP-2 exercises (Fischer and Jungclaus,2010 & 2011). Here we show the present day distribution of observed and modeled $\delta^{13}C$ as well as its change in interglacial climates. The difference in the spatial distribution is mainly correlated to changes in the C_4 vegetation cover.

Fischer & Jungclaus, Climate of the Past, **6**(2), p.155-168, 2010.
Lloyd & Farquhar, *Oecologia* **99**(3-4), p. 201-215,1994.

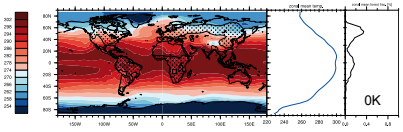
Fischer & Jungclaus, Clim. Past Discuss., **7**, p. 463–483, 2011
Wingate et al., Plant, Cell & Environment **30**(5), p. 600–616, May 2007.

climate

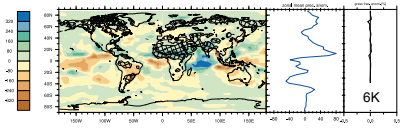
0K: yearly precipitation [mm]; grass frac. > 35% (shaded)

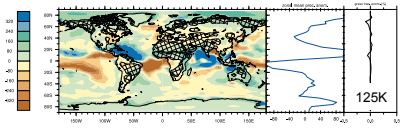


0K: yearly mean temperature [K]; forest frac. > 35% (shaded)

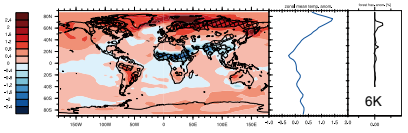


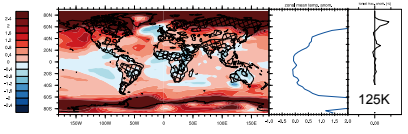
anomaly to reference period (0K) in yearly precipitation [mm] and grass frac. (> 35% shaded)





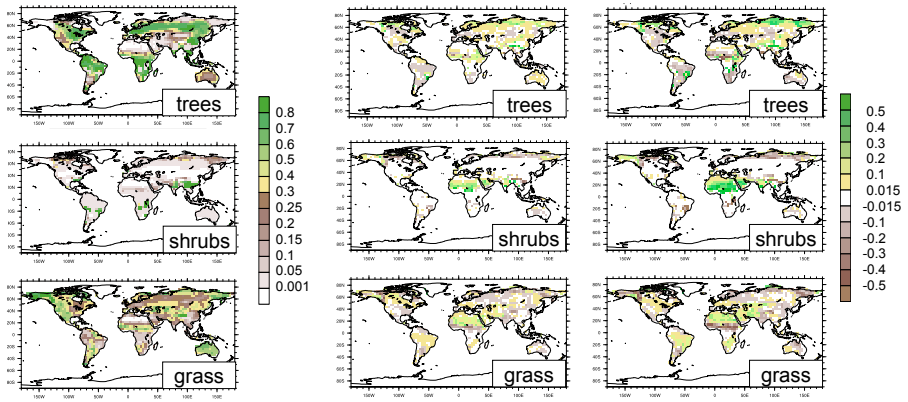
anomaly to reference period (0K) in yearly mean temperature [K] and forest fraction (> 5% shaded)





At regional scale and annual mean, the climate (e.g. precipitation and 2m temperature) is changing significantly and these changes are most pronounced at a seasonal basis (not shown here). On the global, annual mean scale, the changes are small.

vegetation cover

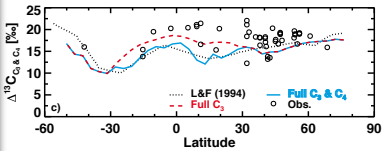


From MPI-ESM simulations for Eemian and Holocene including a dynamical vegetation scheme, the cover fractions for eight different plant function types are derived and used as a boundary condition for the land component.

Striking is the simulated expansion of boreal and tropical forests replacing grassland simulated for both interglacials.

At a first glance, 125K and 6K patterns are looking similar but they are more pronounced in the warmer 125K case.

carbon isotopes



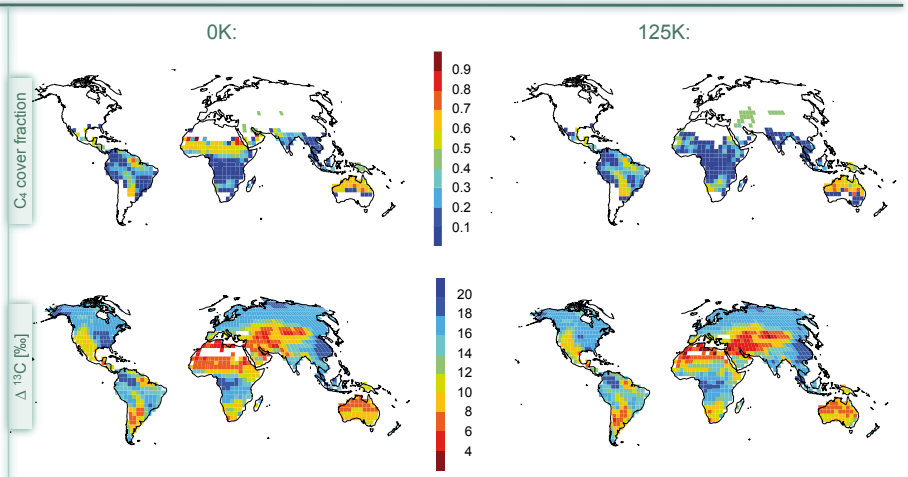
Simulated (blue + red lines) annual latitudinal mean of ^{13}C discrimination of photosynthesis compared to model estimates (black lines) by Lloyd & Farquhar (1994) and observed ecosystem discriminations (circles, Buchmann & Kaplan, 2001).

Buchmann & Kaplan, *Global Biogeochemical Cycles in the Climate System*, p. 253-265 Academic Press, 2001.

Lloyd & Farquhar, *Oecologia* **99**(3-4), p. 201-215,1994.

Δ ^{13}C [‰]	0K	6K	125K
C_3	16.71	15.00	15.02
C_4	3.38	3.37	3.31
all plants	14.97	15.00	16.70

Global mean values for ^{13}C discrimination of photosynthesis for C_3, C_4, and all plants.



Multiyear annual mean of ^{13}C discrimination of photosynthesis and the location of C_4 grasses for present day and the last Interglacial. Differences in Δ ^{13}C between these periods are small in areas with differences in the C_4 - cover fraction.

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