Modeled land vegetation and carbon during Interglacials

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summary

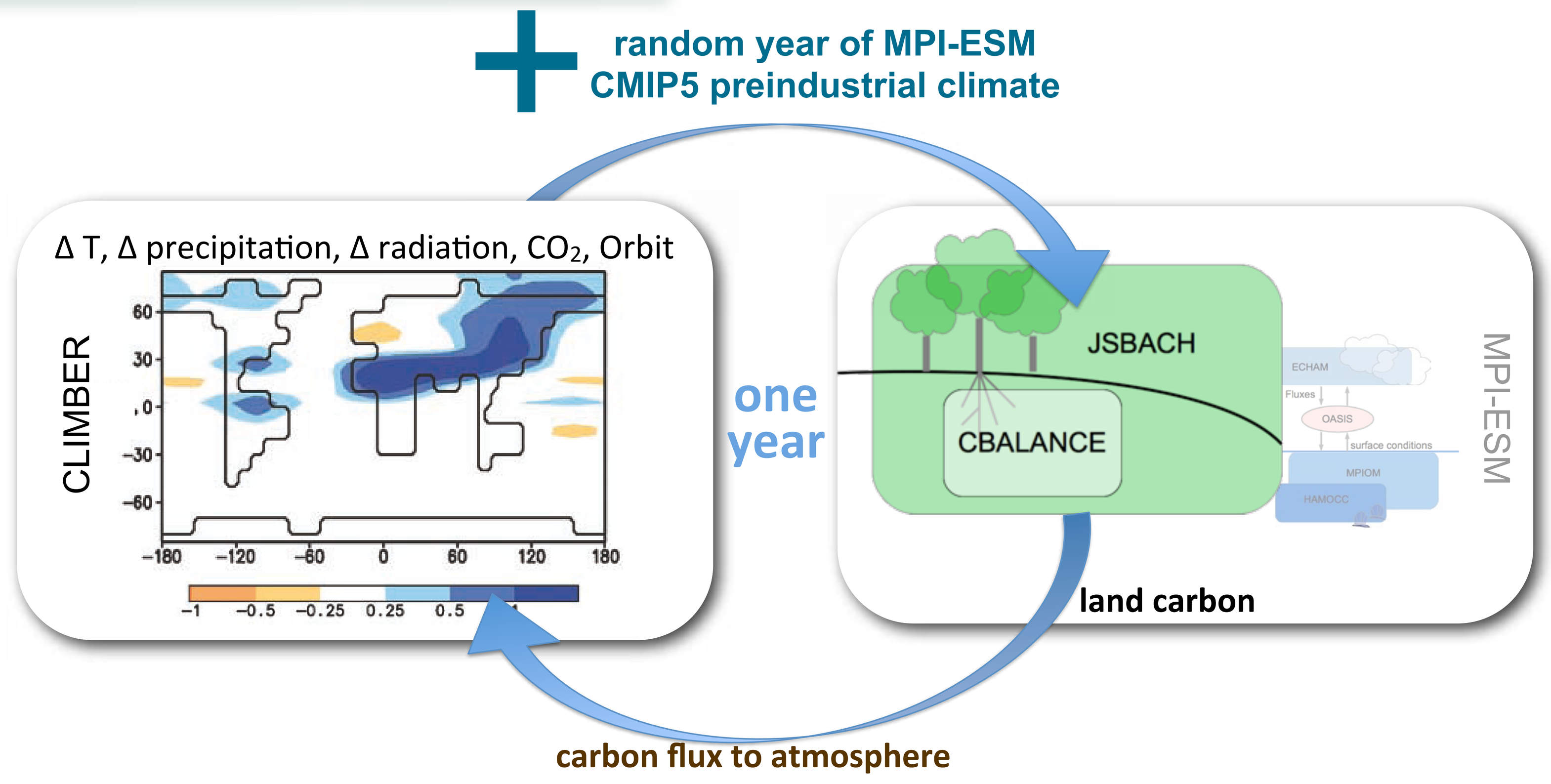
Time slice experiments for pre-industrial climate, Holocene, and the Eemian are performed to analyze the vegetation distribution, carbon storage on land, and disturbance processes for different climate states. While the atmosphere and ocean processes are simulated on a coarse resolution by CLIMBER, the land processes are simulated at higher resolution. It is shown, that changes in secondary processes like natural fire activity ranges at the same order of magnitude as simulated differences in the land carbon for the Eemian and pre-industrial climate.

outlook

Hence it is crucial to add further components of the carbon cycle such as boreal wetland emissions and peat accumulation to get a complete picture. Recent studies with JSBACH show, that during the last 6000 years the boreal wetland emissions increased by app. two TgCH4 yr^{-1} (Schuldt et al., 2012). Using a model setup such as CLIMBER-JSBACH gives the possibilities to resolve heterogeneous and sub-scale processes within the biosphere and perform simulations on long time scales.
Transient simulations will be performed to fill the gap between the time slices to understand the underlying dynamics of the carbon storage. Experiments including different landuse scenarios during the Holocene will provide a range of uncertainty of the human impact on the Holocene climate and CO_2 dynamics.

Schuldt RJ et al. (2012) Modelling Holocene carbon accumulation and methane emissions of boreal wetlands. An Earth System Model approach, *Biogeosciences Discussions*, accepted.

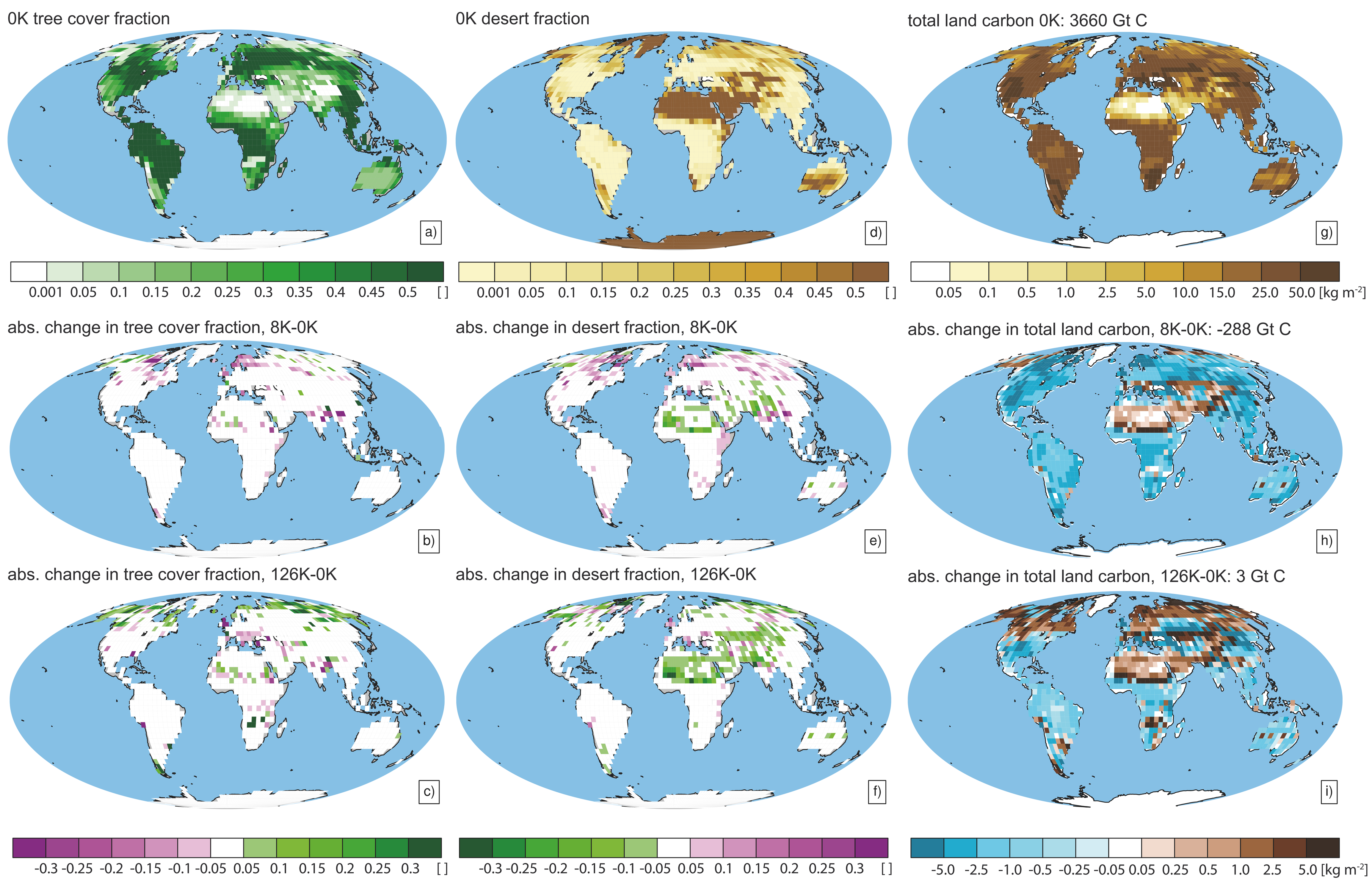
CLIMBER - JSBACH



A new climate-carbon cycle model is used, which is the asynchronously coupled EMIC (Earth System Model of Intermediate Complexity) CLIMBER-2 (Ganopolski et al., 2001) and the land component JSBACH of the Max-Planck Earth System Model (MPI-ESM) described by Raddatz et al. (2007).

Ganopolski A et al. (2001) CLIMBER-2: a climate system model of intermediate complexity. Part II: model sensitivity, *Climate Dynamics*, **17**: 735-751
Raddatz T et al. (2007) Will the tropical land biosphere dominate the climate-carbon cycle feedback during the twenty-first century?, *Climate Dynamics*, **29**: 565–574

vegetation cover and land carbon



Modeled vegetation and carbon storage (kg m^{-2}) for pre-industrial climate (0 ka, top row), and its anomalies for mid-Holocene (8 ka BP, middle row), and the Eemian (126 ka BP bottom). Shown are values for tree cover fraction (left column), desert fraction (middle column), and the total land carbon storage (Gt, right column).

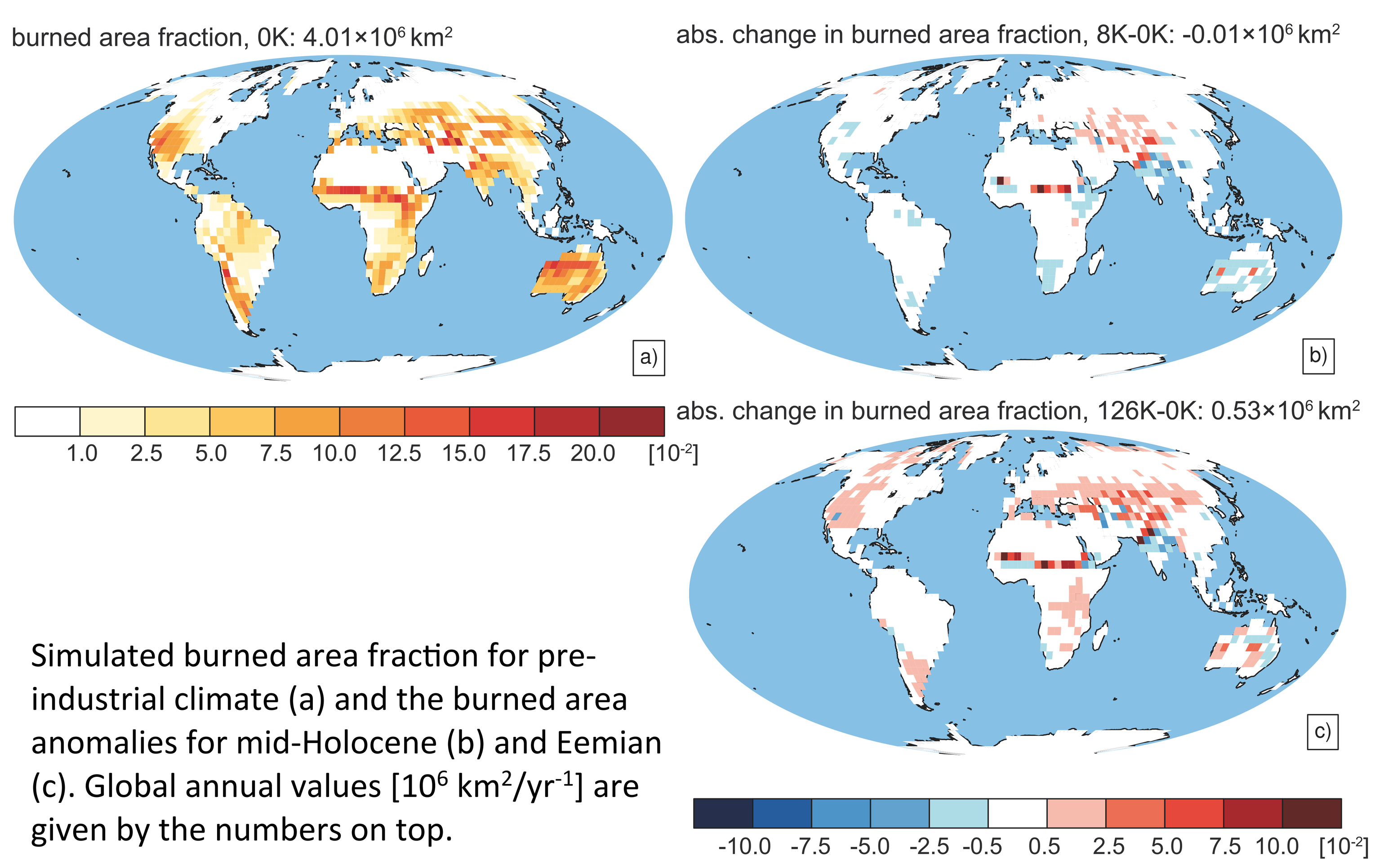
Following ice core reconstructions (Elsig et al., 2009, Lourantou et al., 2010), the atmospheric CO_2 concentration was prescribed at 280 ppm for pre-industrial climate, 260 ppm for 8 ka BP, and 276 ppm for 126 ka BP.

What happens due to the applied forcing?

- The two interglacials' anomaly patterns agree in their shape, but differ in magnitude.
- During the interglacials the boreal forest (Fig. b+c) is partly increased by up to 30% and especially regions affected by the African and Asian monsoon system show a widespread area of greening (Fig. 1e+f), as precipitation is much higher. These zones are the dominant ones, where a gain of land carbon can be identified (Fig. h+i).
- Due to lower atmospheric CO_2 level at 8 ka, the reduced CO_2 fertilization leads to lower carbon storage in comparison with 0k. This effect dominates the climate change effect.
- A further simulation for the mid-Holocene at 280 ppm to calculate the net effect of climate and orbital forcing was carried out and shows 5 Gt higher carbon storage on land than during the Eemian (not shown).

Elsig J et al. (2009) Stable isotope constraints on Holocene carbon cycle changes from an Antarctic ice core, *Nature*, **461**: 507-510.
Lourantou A et al. (2010) Changes in atmospheric CO_2 and its carbon isotopic ratio during the penultimate deglaciation, *Quaternary Science Reviews*, **29**: 1983-1992

burned area



Simulated burned area fraction for pre-industrial climate (a) and the burned area anomalies for mid-Holocene (b) and Eemian (c). Global annual values [10^6 km^2/yr^{-1}] are given by the numbers on top.

Windbreak and fire are implemented as disturbances within JSBACH; they both affect the carbon cycle, although not significantly.

- Burned area during preindustrial climate is about 4×10^6 km^{2}yr^{-1} with hotspots in Africa, Australia, and southwest America (Fig. a).
- Anomalies for the mid-Holocene and Eemian agree in their patterns (Fig. b-c).
- During the Eemian global burned area is slightly higher (+ 0.5×10^6 km^{2}yr^{-1}).
- Mid-Holocene @ 280 ppm: close to Eemian values as an effect of higher fuel load, even the climate is relatively cooler during the Holocene.
- Carbon Emissions: 2.5 Gt yr^{-1} for pre-industrial conditions, but app. 7% less during the mid-Holocene (similar burned area), and app. 10% higher during the Eemian (25% increase of burned area and reduced carbon in biomass).
- Charcoal reconstructions (site level data) show opposite trend since the Last Glacial Maximum (Power et al., 2008).
- Land use is not included, experiments don't cover the last century with its strong increase in fire activity.

Power MJ et al. (2008) Changes in fire regimes since the Last Glacial Maximum: an assessment based on a global synthesis and analysis of charcoal data, Climate Dynamics, **30**: 887-907

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