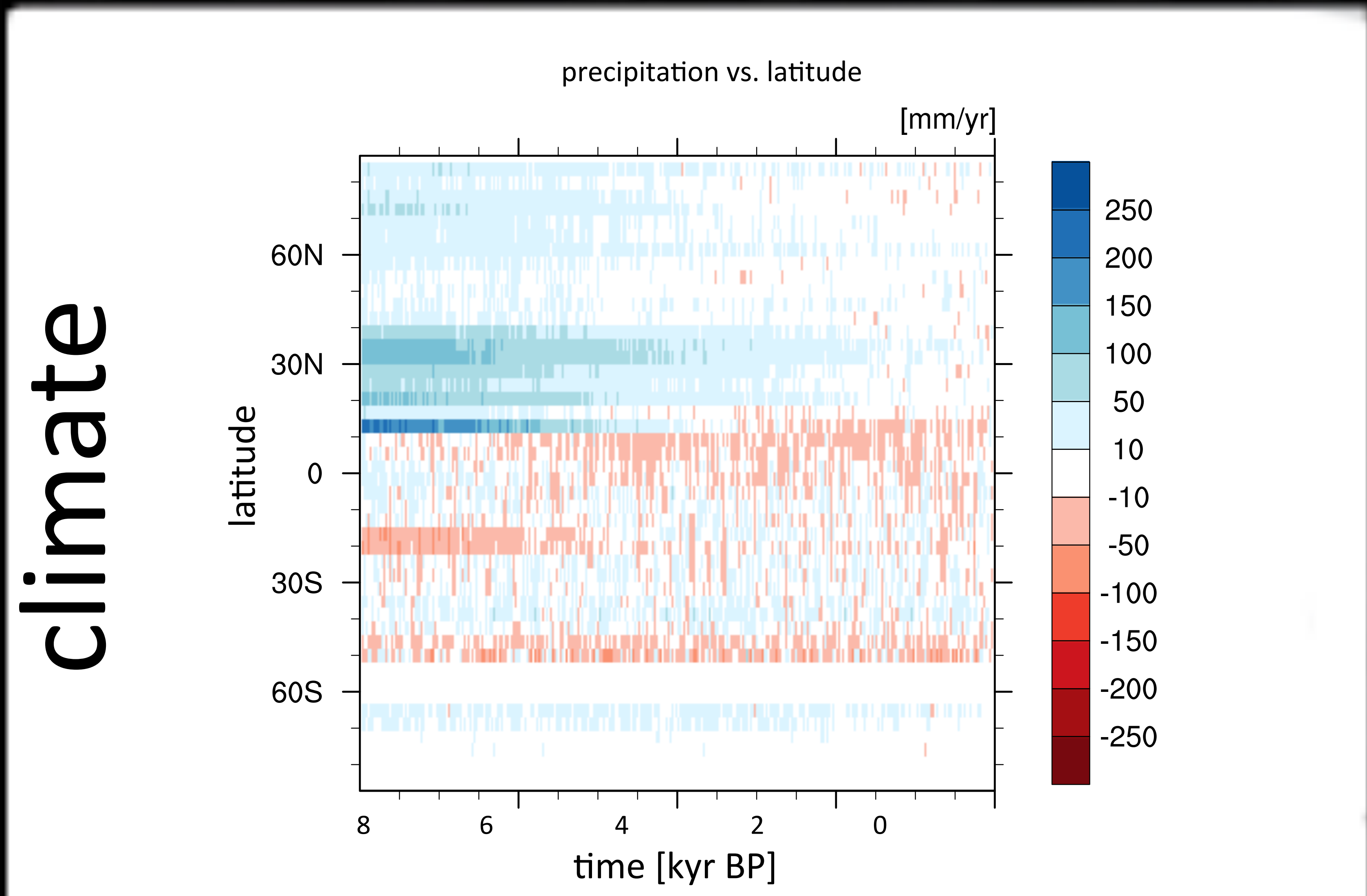
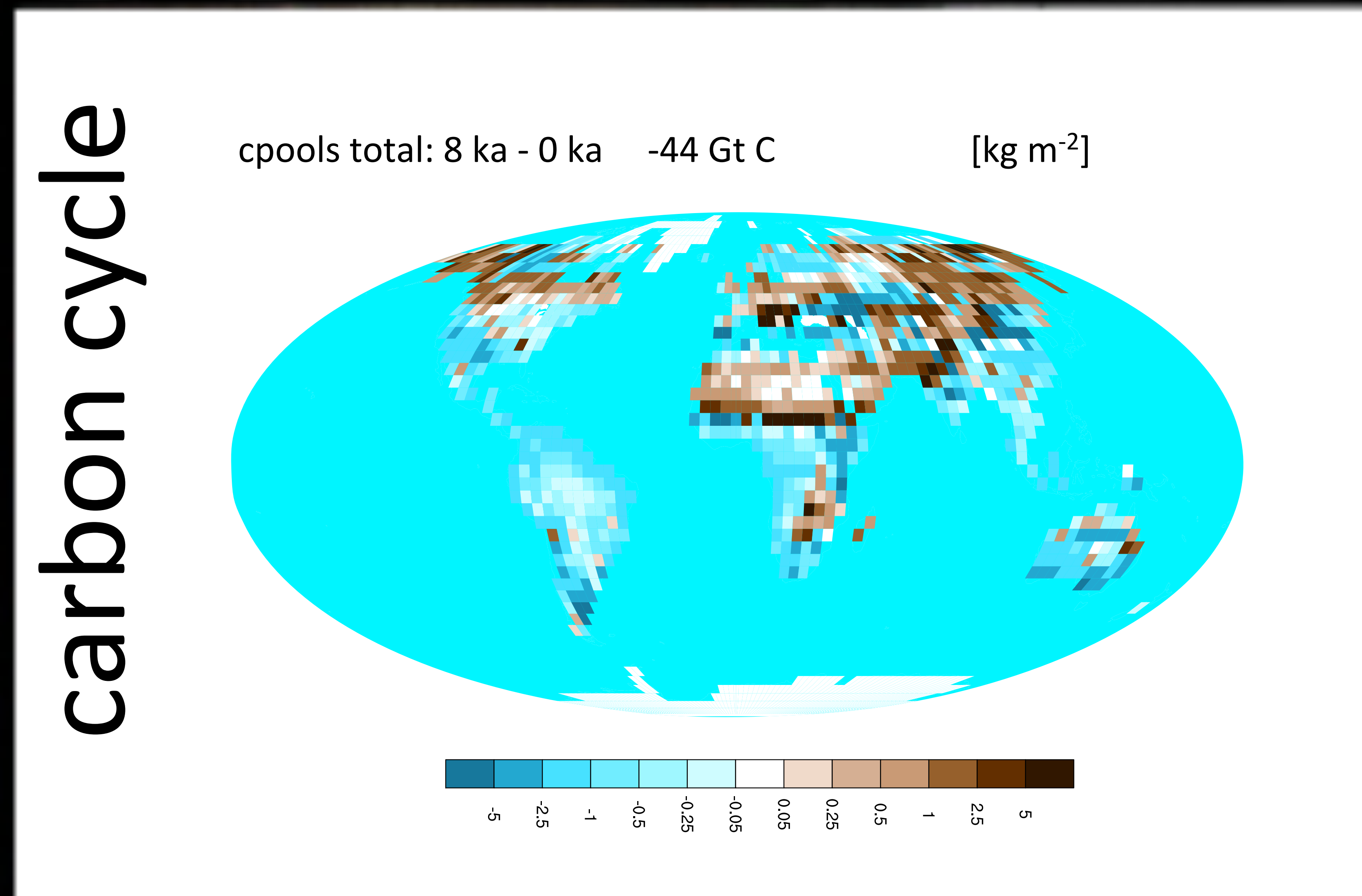
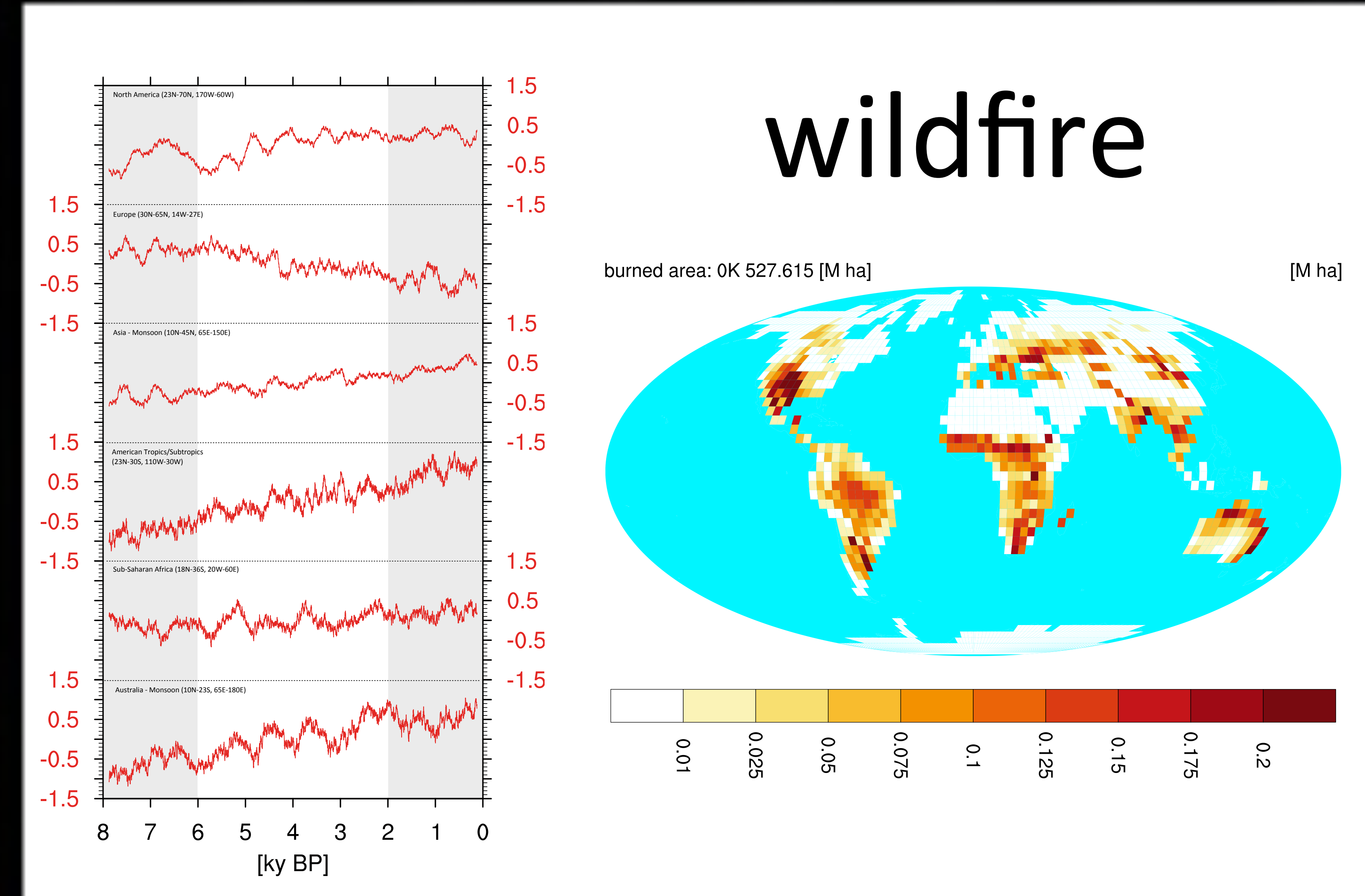
Land biosphere dynamics during the present and the last interglacials

Tim Brücher, Victor Brovkin, and Veronika Gayler

Max Planck Institut f. Meteorology, Germany (tim.bruecher@zmaw.de)







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summary

Transient, 8000 years spanning experiments starting at the Mid-Holocene (8 ka BP: 8000 years before present) until the preindustrial era (0 ka) are performed to analyze the changes in vegetation distribution, carbon storage on land, and disturbance processes (wildfire).

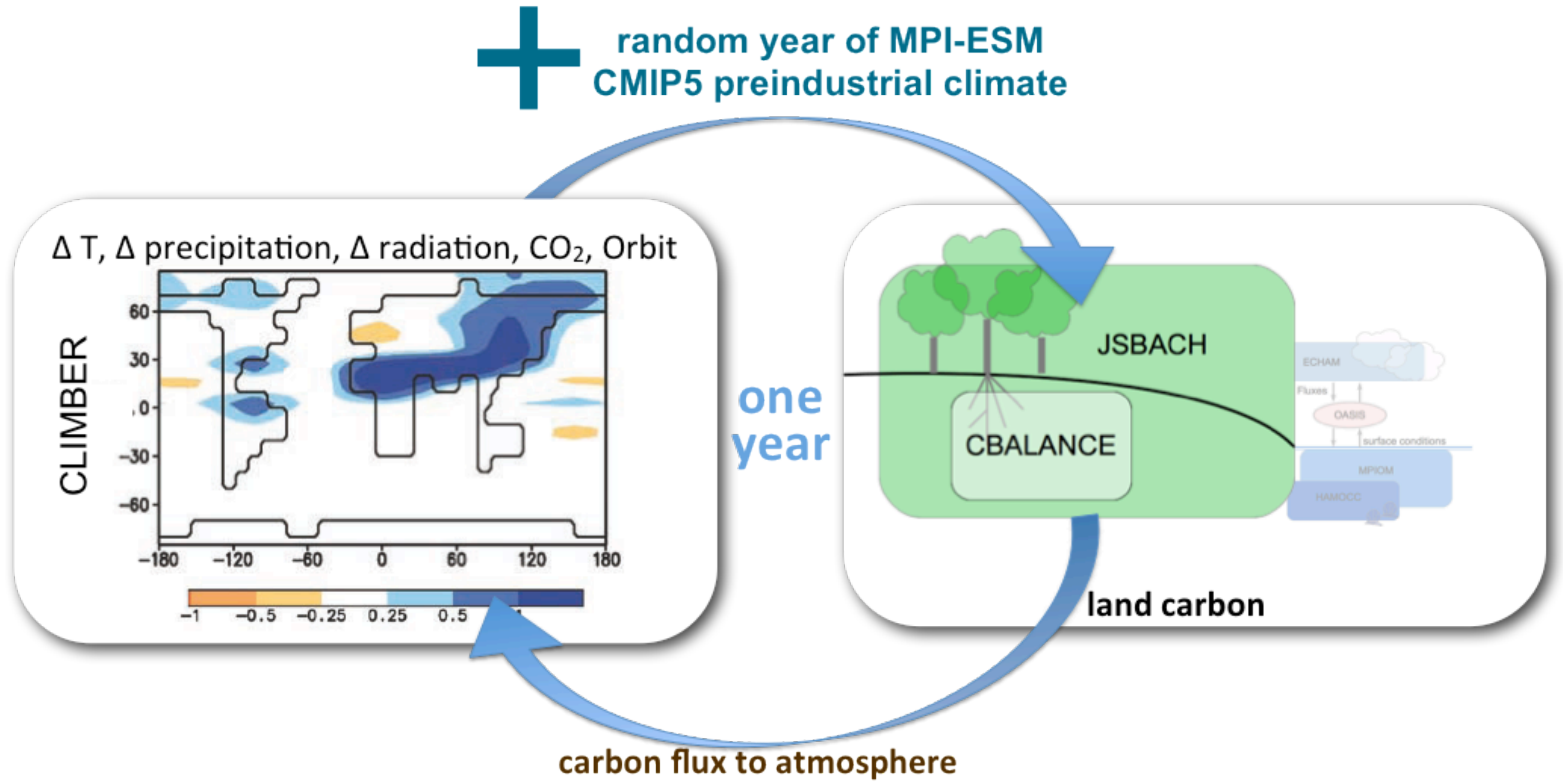
While the atmosphere and ocean processes are simulated on a coarse resolution by CLIMBER, the land processes are simulated at higher resolution with JSBACH. It is shown, that changes in secondary processes such as natural fire disturbance range at the same order of magnitude as simulated differences in the land carbon. Hence it is crucial to add further components of the carbon cycle such as CH_4 emissions and peat accumulation to get a complete picture. Recent studies with JSBACH show that during the last 6000 years the boreal wetland CH_4 emissions were slightly increased (Schuldt et al., 2013).

outlook

Further transient simulations will be performed to get estimates on the un-certainties of the underlying dynamics of the carbon storage. These experiments will include different landuse as well as peatland CO_2 emission scenarios during the Holocene to provide a range of possibilities of anthropogenic and natural impacts on the Holocene climate and CO_2 dynamics.

Schuldt RJ et al. (2013) Modelling Holocene carbon accumulation and methane emissions of boreal wetlands. An Earth System Model approach, *Biogeosciences*.

CLIMBER - JSBACH

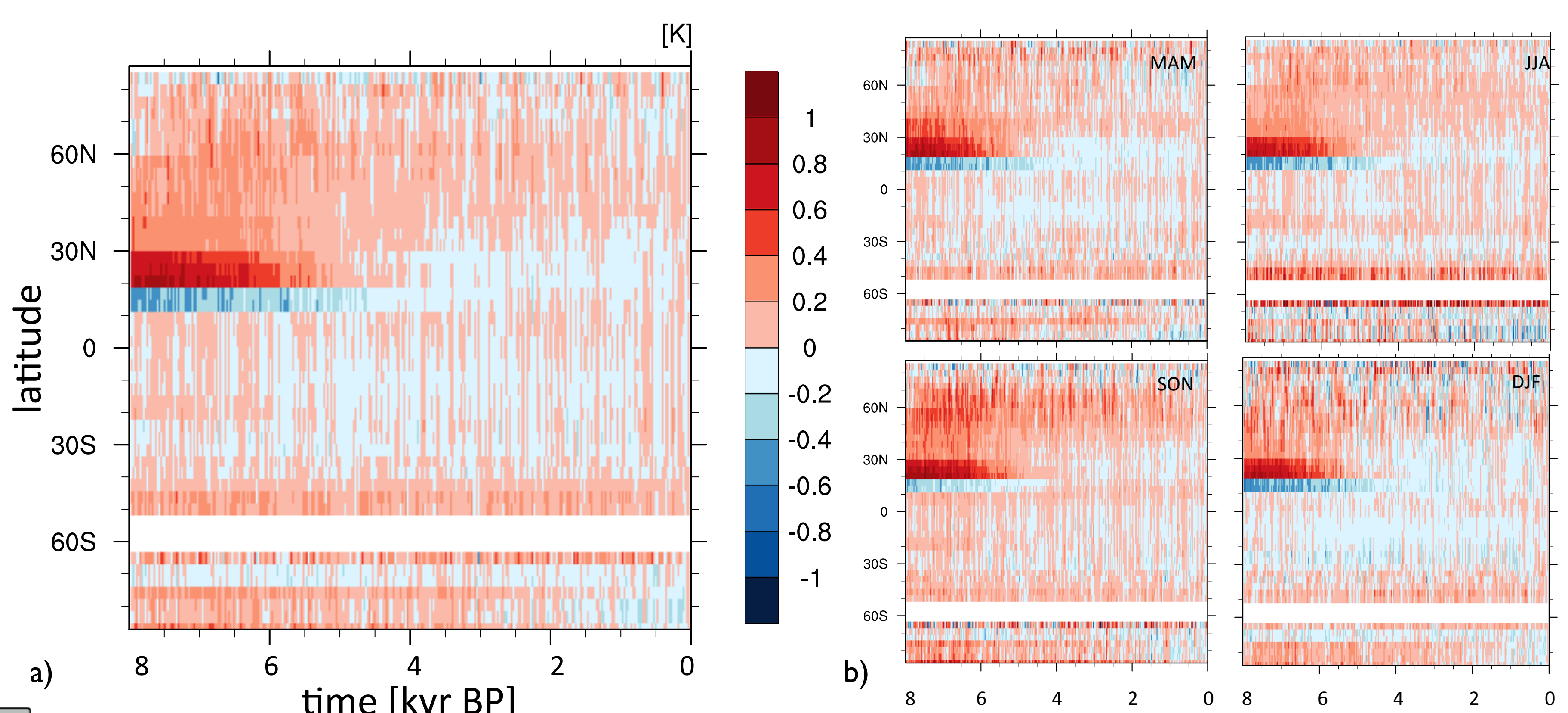


A new climate-carbon cycle model is used, which is the asynchronously coupled EMIC (Earth System Model of Intermediate Complexity) CLIMBER-2 (Ganopolski et al., 2001) and the land component JSBACH of the Max-Planck Earth System Model (MPI-ESM) described by Raddatz et al. (2007).

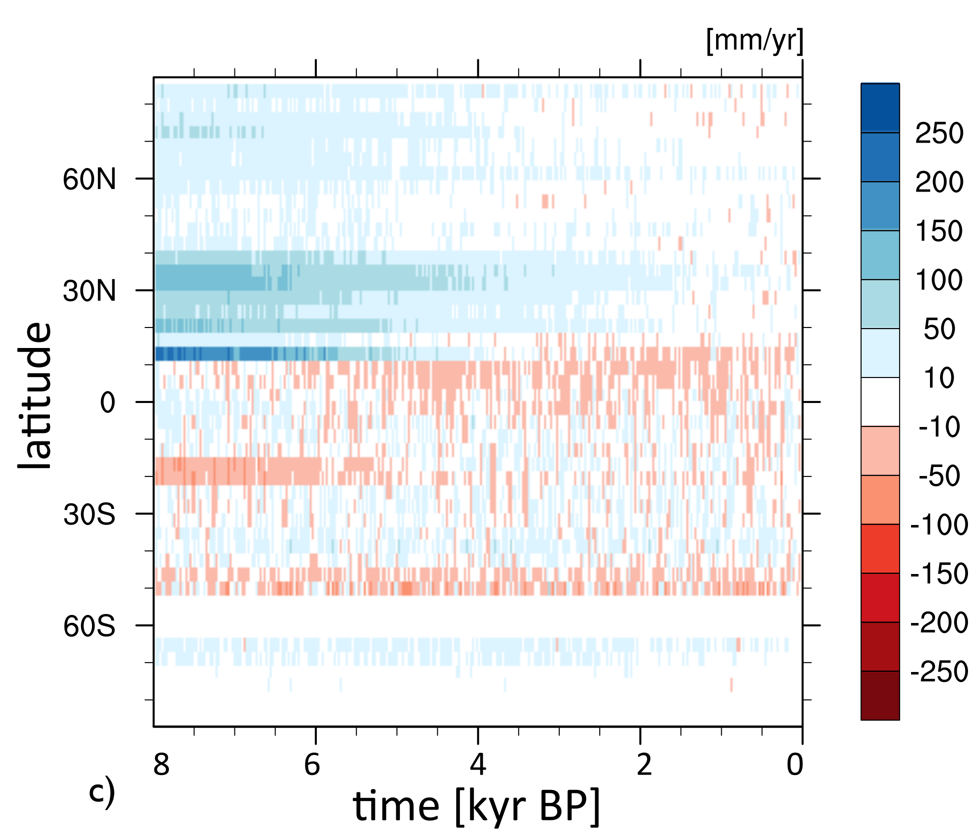
Ganopolski A et al. (2001) CLIMBER-2: a climate system model of intermediate complexity. Part II: model sensitivity, *Climate Dynamics*, **17**: 735-751
Raddatz T et al. (2007) Will the tropical land biosphere dominate the climate-carbon cycle feedback during the twenty-first century?, *Climate Dynamics,*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

transient climate changes

temperature vs. latitude



precipitation vs. latitude



Modeled changes in temperature (Figs. a+b) and precipitation (Fig. c) within the 8000 years. Shown are anomalies to preindustrial climate. The dominant feature shows the wetter conditions in the tropics during the Holocene (Fig. c) and linked with cooler temperatures (Fig a). The changes in the temperature are biggest during summer and autumn (Fig. b).

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vegetation cover and carbon dynamics

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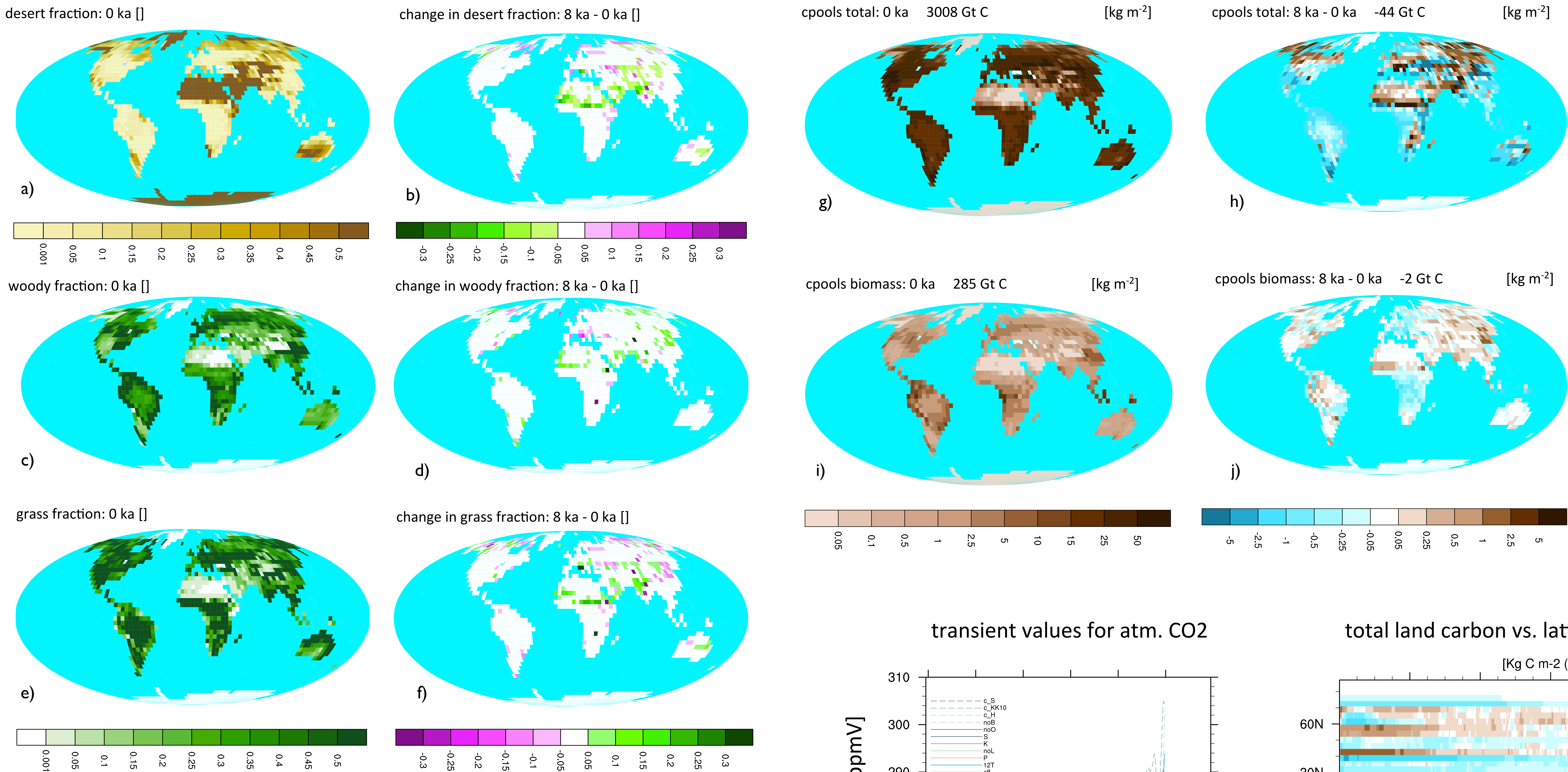
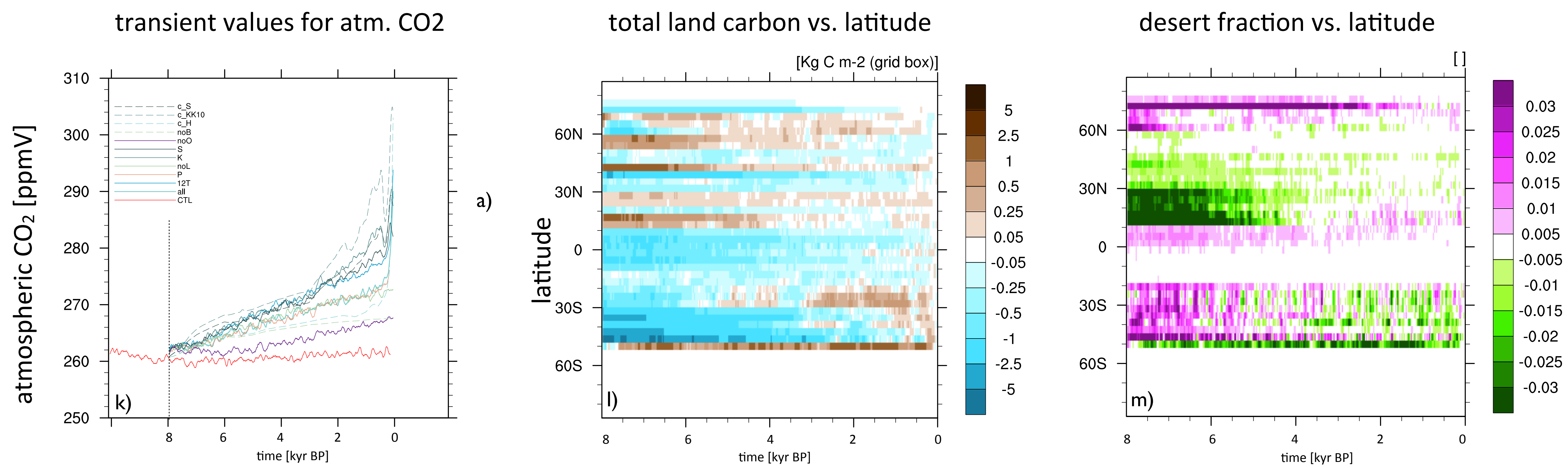


Modeled vegetation fraction (Fig. a-f) and carbon storage [kg m^{-2}] (Fig. g-j) for pre-industrial climate (0 ka BP; Fig. a,c,e + g,i), and its anomalies for the mid-Holocene (8 ka BP; Fig. b,d,f + h,j). Shown are values for desert, woody and grass fraction as well as the total and biomass carbon separately.

Please note:
Shown are maps from the scenario without land use emissions (experiment noL, see below) to be consistent with the carbon cycle, as the scenario is implemented by the use of carbon fluxes and no underlying maps are used.



What happens due to the applied forcing?

- The CO_2 concentration evolves Fig. k) close to ice-core reconstructions during the 8000 years (Monnin, 2004).
- The African and Asian Monsoon systems are stronger during the Mid-Holocene, which leads to a widespread greening that is also reflected in a gain of land carbon (see also pre. slide)
- GPP increases over the course of the Holocene due to an increase of atmospheric CO_2.

Monnin E et al. (2004) Evidence for substantial accumulation rate variability in Antarctica during the Holocene, through synchronization of CO_2 in the Taylor Dome, Dome C and DML ice cores. Earth and Planetary Science Letters, **224**, 45-54

Experiment setup: The experimental setup it shown in the table to the right. The scenarios count for different model setups to include **orbital forcing**, **land use emissions**, **peat**, and **biosphere**. This setup allows to perform a separation method afterwards to disentangle the effect of the different forcings. Experiments starting with `c_` are correspondent *CLIMBER-only* simulations not coupled to JSBACH.

	Ini 8K	CTL	All	12T	noB	P	noL	K	S	noO
Orbit	8K	8K	dyn.	dyn.	dyn.	dyn.	dyn.	dyn.	dyn.	8K
CO2	260 ppmV	dyn.	dyn.	dyn.	dyn.	dyn.	dyn.	dyn.	dyn.	dyn.
Atm. d13C	-6.4‰	-6.4‰	-6.4‰	-6.4‰	-6.4‰	-6.4‰	-6.4‰	-6.4‰	-6.4‰	-6.4‰
biosphere		X	X	X	-	X	X	X	X	X
SWA1-Veksei			X		X	X	X	X	X	X
SWA2-Opdyke				X						
Peat1 - no		X	X	X	X		X	X	X	X
Peat2 - Kleinen						X				
LU-1 Hyde		X	X	X	X	X				X
LU-2 KK10								X		
LU-3 Stocker									X	

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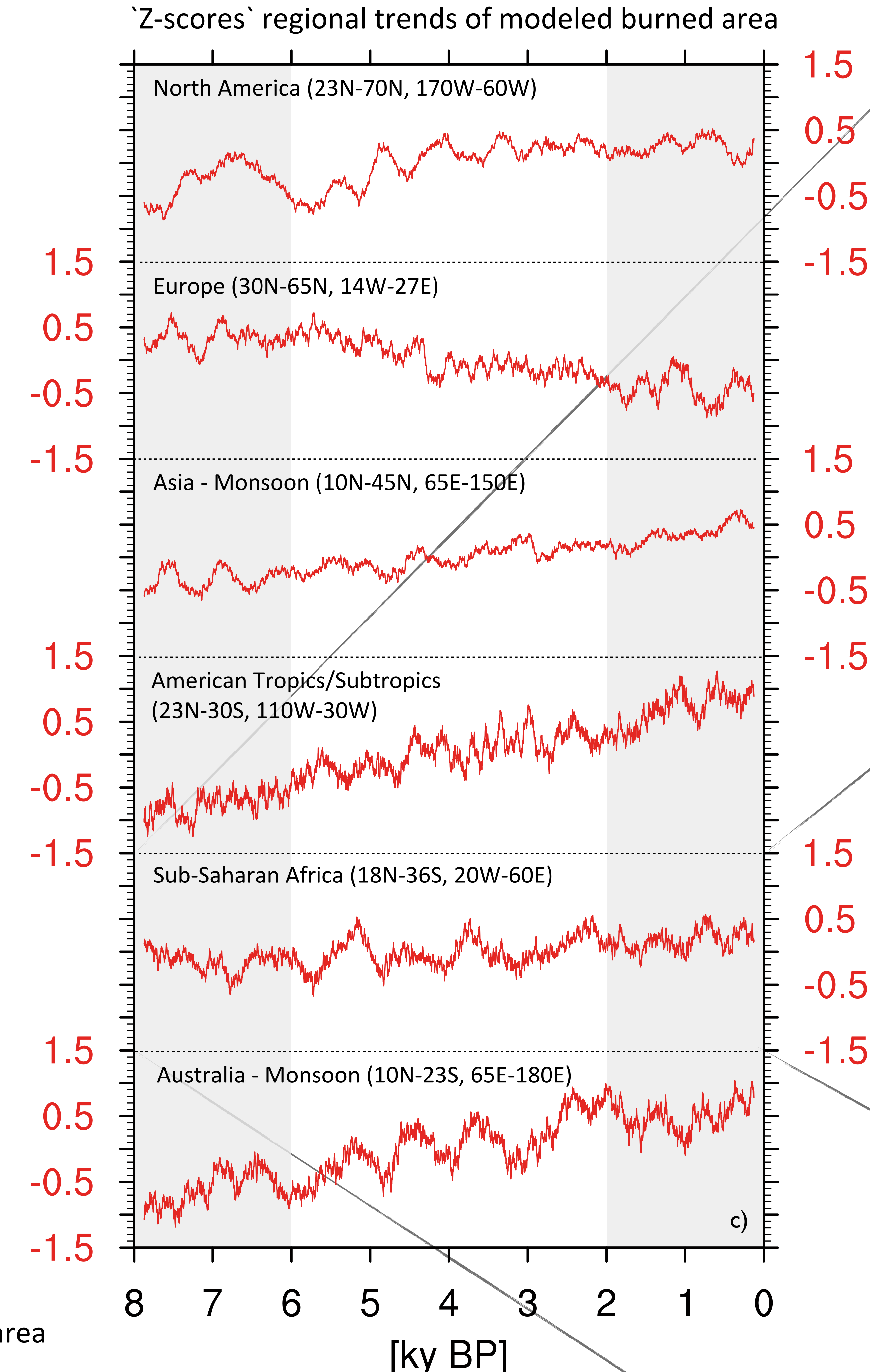
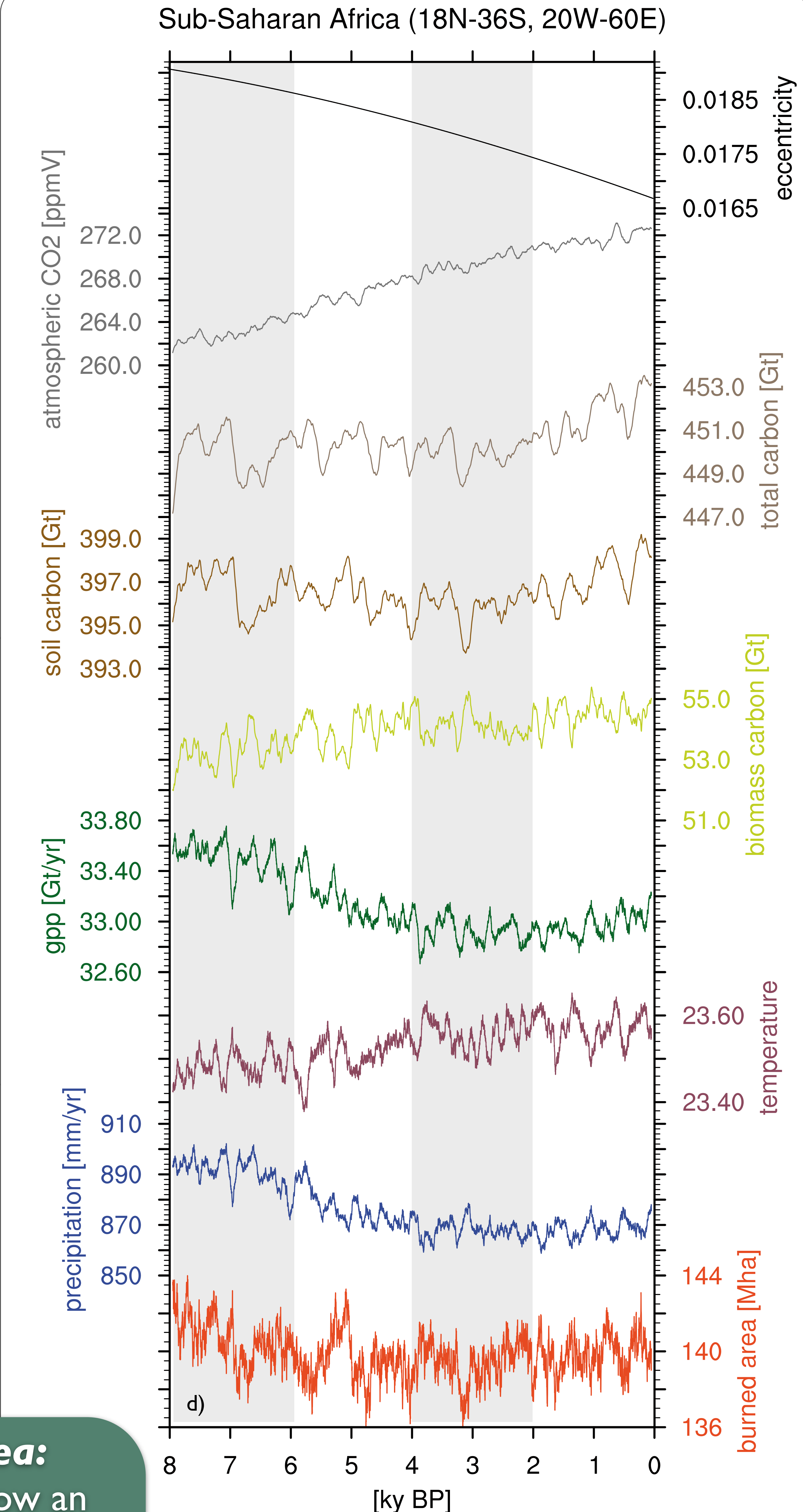
disturbance

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 5.3×10^6 km^2yr^{-1} with hotspots in Africa, Australia, and southwest America (Fig. a). It is higher at 8 ka BP by app. 14×10^4 km^2yr^{-1} (app. 2%; Fig. b).
- Wildfire emissions: 6.1 Gt yr^{-1} for pre-industrial conditions (0 ka BP), and app. 4.6% less during the mid-Holocene (8 ka BP) despite of a slightly higher burned area.
- Global trend of a monotonic increase after the Last Glacial Maximum in Z-score transformed burned area (Power et al., 2008) in most of the regions is captured.
- *`Z-scores`* regional modeled trends of burned area during the Holocene agree partly to charcoal reconstructions (site level data) but show different strength of increases / decreases (Marlon et al., 2013).
- Since land use changes were not included in the simulations, an anthropogenic increase in fire activity during the last few centuries is not captured.

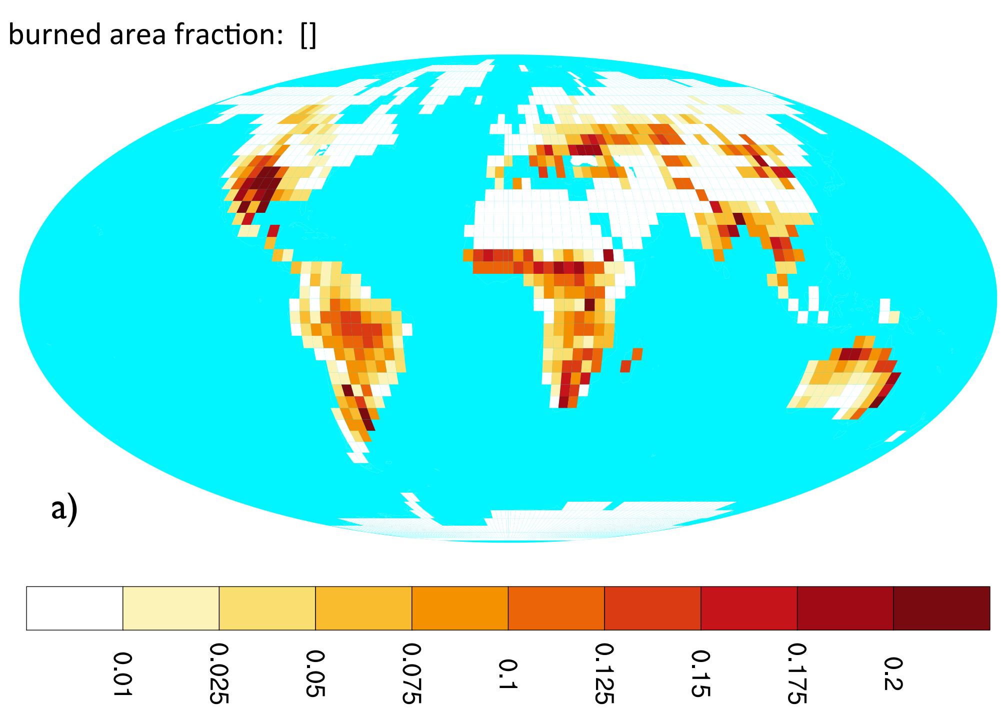
Power MJ et al. (2008) Changes in fire regimes since the Last Glacial Maximum: an assessment based on a global synthesis and analysis of charcoal data, Climate Dynamics, **30**: 887-907
Marlon JR et al. (2013) Global biomass burning: a synthesis and review of Holocene paleofire records and their controls, Quaternary Science Reviews, *accepted*



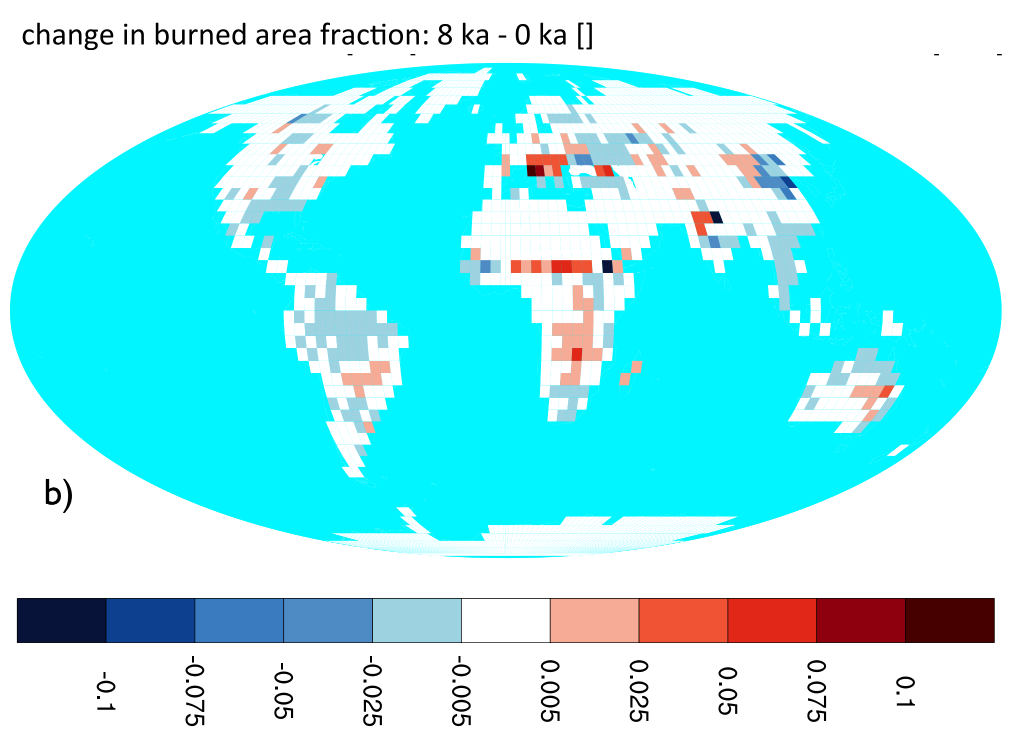


Z-scores vs. burned area:
Z-score transformed data show an increase in fire activity, but modeled burned area points to a slight decrease in burned area.

pre-industrial fire activity at 0 ka BP



changes in burned area



further reading about LIG

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