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Modelled vs. reconstructed past fire dynamics - how can we compare?

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Fire is an important process that affects climate through changes in CO_2 emissions, albedo, and aerosols (Ward et al. 2012). Fire-history reconstructions from charcoal accumulations in sediment indicate that biomass burning has increased since the Last Glacial Maximum (Power et al. 2008; Marlon et al. 2013). Recent comparisons with transient climate model output suggest that this increase in global ?re activity is linked primarily to variations in temperature and secondarily to variations in precipitation (Daniau et al. 2012).

In this study, we discuss the best way to compare global ?re model output with charcoal records. Fire models generate quantitative output for burned area and fire-related emissions of CO_2, whereas charcoal data indicate relative changes in biomass burning for specific regions and time periods only. However, models can be used to relate trends in charcoal data to trends in quantitative changes in burned area or fire carbon emissions. Charcoal records are often reported as Z-scores (Power et al. 2008). Since Z-scores are non-linear power transformations of charcoal influxes, we must evaluate if, for example, a two-fold increase in the standardized charcoal reconstruction corresponds to a 2- or 200-fold increase in the area burned. In our study we apply the Z-score metric to the model output. This allows us to test how well the model can quantitatively reproduce the charcoal-based reconstructions and how Z-score metrics affect the statistics of model output.

The Global Charcoal Database (GCD version 2.5; www.gpwg.org/gpwgdb.html) is used to determine regional and global paleofire trends from 218 sedimentary charcoal records covering part or all of the last 8 ka BP. To retrieve regional and global composites of changes in fire activity over the Holocene the time series of Z-scores are linearly averaged to achieve regional composites.

A coupled climate–carbon cycle model, CLIMBA (Brücher et al. 2014), is used for this study. It consists of the CLIMBER-2 Earth system model of intermediate complexity and the JSBACH land component of the Max Planck Institute Earth System Model. The fire algorithm in JSBACH assumes a constant annual lightning cycle as the sole fire ignition mechanism (Arora and Boer 2005). To eliminate data processing differences as a source for potential discrepancies, the processing of both reconstructed and modeled data, including e.g. normalisation with respect to a given base period and aggregation of time series was done in exactly the same way. Here, we compare the aggregated time series on a hemispheric and regional scale.