Climatic effects of land use and large-scale deforestation in Earth System Models

*Victor Brovkin[1], Lena Boysen[1], Julia Pongratz[1]

1. Max Planck Institute for Meteorology

Processes in terrestrial ecosystems, to a large extent, are controlled by climate and CO_2 concentration. In turn, geographical distribution of vegetation cover strongly affects heat, moisture, and momentum fluxes between land surface and atmosphere (biogeophysical effects). Anthropogenic land use and land cover changes (LULCC) are now included into Earth System Models (ESMs) in the form of historical and hypothetical future scenarios as a forcing in the Coupled Model Intercomparison project, phase 6 (CMIP6). A propagation of climatic effects from land to the ocean in ESMs allows to investigate a global climate response to LULCC in addition to analysis of local effects over deforested land.

One complication in the analysis of global climatic effects of historical and future LULCC scenarios is their relatively small amplitude. To increase the signal-to-noise ratio, the Land Use Model Intercomparison Project (LUMIP) suggested an idealized deforestation simulation following a prototype of 1%-CO_2 increase experiment commonly used in CMIPs. The idealized experiment allows to investigate –in a harmonized way across models –a response of land surface biophysics and climate to a large-scale deforestation of 20 million km^2 distributed over the most forested parts of globe. The forest is removed linearly over a period of 50 years, with an additional 30 years with no specified change in forest cover. Boundary conditions such as CO_2 concentration and other forcings are kept at the pre-industrial level.

First analysis of MPI-ESM simulations reveals statistically significant increases in tropical and decreases in boreal near-surface air temperatures along with uniform decreases of precipitation in regions of deforestation. Interestingly, temperature changes develop from the centre (first 10-30 years) to the margins of deforestation (after 40 years), e.g. in the Amazon region, hinting to the influence of non-local land cover impacts on climate that add to the local deforestation signal. Detectability of burned area shows opposite pattern, with robust increase in fire developing first at the edge and then in the centre of deforestation areas, presumably indicating an importance of vegetation-fire feedback. Effects of idealized and historical land use changes on terrestrial carbon cycle will be discussed in details.

Keywords: land use, Earth System Models, climate change, carbon cycle

