Project: **891**

Project title: **Forest management in the Earth system**

Project lead: **Julia Pongratz**

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1. Introduction

The main aim of this project is to better understand the role of land use change for and in a changing climate. About one quarter of the ice-free land surface has undergone anthropogenic land cover change (i.e., a change in vegetation type, such as clearing of forest for agricultural expansion), and a further half is under land management (such as wood harvest). While the effects of land cover change have been simulated to be substantial on the global scale (e.g., Pongratz et al. 2010), a recent study has shown that the effects of land management are of similar magnitude locally as those from land cover change (Luyssaert et al. 2014). Therefore, Earth system models are now moving towards including land management aspects. Here we report on the first steps towards representing forest management in JSBACH / MPI-ESM / ICON, in addition to novel results on the mechanisms underlying anthropogenic land cover change.

2. Separating local and non-local effects of deforestation

Land use change affects local climate directly by changes in surface properties, such as altering surface albedo, but also affects climate remotely via changes in atmospheric composition and circulation, in particular for scenarios of global land use change. Earlier studies of climatic effects of global land use change lacked the ability to separate local and non-local effects, hindering our understanding of underlying mechanisms and the ability to attribute climate change to land use change of a certain location. We have developed a method that allows this separation and could show that (1) local effects of deforestation are largely independent of the background land use scenario, making them a promising set of variables to compare effects across scenarios, models and observations, (2) non-local effects, in the case of idealized, near-complete deforestation, can be as large as local effects, and (3) that the underlying mechanisms differ between local and non-local effects. These findings are particularly important in view of the Coupled Model Intercomparison Project 6 (CMIP6), in which both realistic and idealized land use change scenarios will be compared.

3. Simulating adaptive wood harvest in a changing climate

So far (e.g., in CMIP5), land use has been prescribed externally to Earth system models, ignoring that land use decisions depend on the state of the vegetation, which in turn depends on the state of the climate system. We extended JSBACH to simulate wood harvest interactively with climate, by defining target levels of carbon densities (here: sustained yields, i.e. carbon densities are not allowed to fall below present-day levels) and simulating harvest rates in dependence of the actually available biomass. We find that simulated sustained-yield harvest rates are substantially larger than the harvest rates assumed in the CMIP5 land use scenarios (Hurtt et al. 2011) and strongly vary with climate change (Fig. 1). Yet most Integrated Assessment Models constructing the land use scenarios used in Earth system modeling do not account for climate and CO2 effects on vegetation. Our findings highlight the need for accounting for climate change impacts on land use in climate modeling.

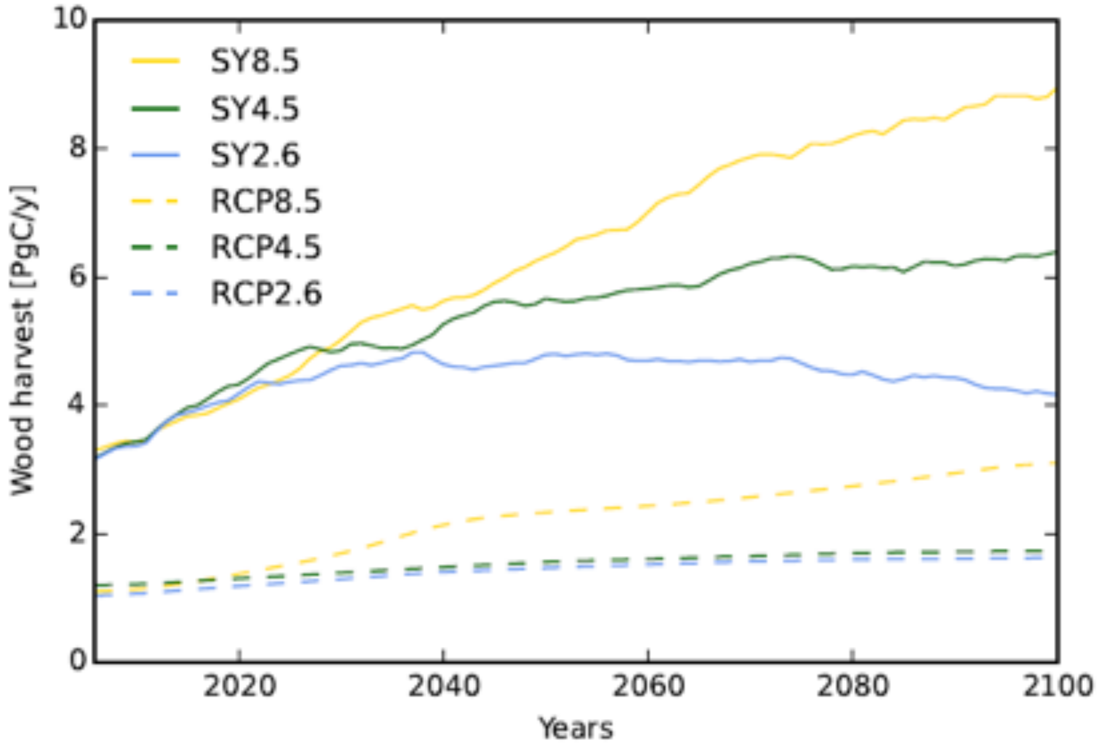

Figure 1: Potential wood harvest rates ("SY"; for climates under three representative concentration pathways (van Vuuren et al., 2011)) simulated by JSBACH for a prescribed target vegetation carbon density (here of year 2005) are substantially higher and more responsive to the climate evolution than wood harvest rates prescribed by Integrated Assessment Models ("RCP").

4. Towards a forest management module in JSBACH / MPI-ESM

The current representation of forests in JSBACH always assumes a mature forest, in terms of productivity, despite the fact much of the world's forest is young due to past or continuous forest management. We have taken the first steps towards a better representation of forest management in JSBACH (and ICON-les) by replacing the maximum leaf area, previously a prescribed parameter dependent only on the plant functional type, with an interactive simulation of leaf area. In ongoing simulations, leaf area is now determined in dependence of the carbon stocks and is thus able to capture the slow regrowth of forest.

5. Contribution to international model intercomparison projects (MIPs)

Recent studies have highlighted the large spread that exists in the simulated carbon stock changes due to land use change in state-of-the-art Earth system models (Brovkin et al. 2013), making land use emissions the most uncertain component of the global carbon cycle. Therefore, to better understand JSBACH's capability to simulate land use effects on the global carbon cycle we deemed it crucial for JSBACH to join a long-standing MIP of the Global Carbon Project, TRENDY ("Trends in the global carbon cycle"). For the first time, JSBACH now participates in the annual assessments of the global carbon budget (LeQuere et al. subm.).

References

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