Potential Future Climate Change Impacts on Afforestation and Reforestation

Sabine Mathesius, Fabian Stenzel, Dieter Gerten

INTRODUCTION

Future efforts to mitigate climate change could include large-scale afforestation and reforestation (A/R). However, it is not well understood how climate change would impact the carbon sequestration potential of A/R and thus the effectiveness of their mitigation potential over time. Here, we show the global impacts of the climate scenario SSP3-7.0 on the vegetation carbon of A/R forests (preliminary results), using the dynamic global vegetation model LPJmL5 and ISIMIP3b climate input data.

MODEL & FORCING

- A/R based on wood plantations (Braakhekke et al. 2019) in LPJmL5
- three wood plantation types: tropical, temperate, boreal
- prescribed wood plantation cover: 50% of each grid cell

CLIMATE SCENARIOS (2015-2100)

1) High-climate change: SSP3-7.0 (with increasing CO2 concentration)
2) SSP3-7.0 with constant CO2 (397 ppm)
3) Constant present-day climate and constant 397ppm-CO2 (reference run)

RESULTS

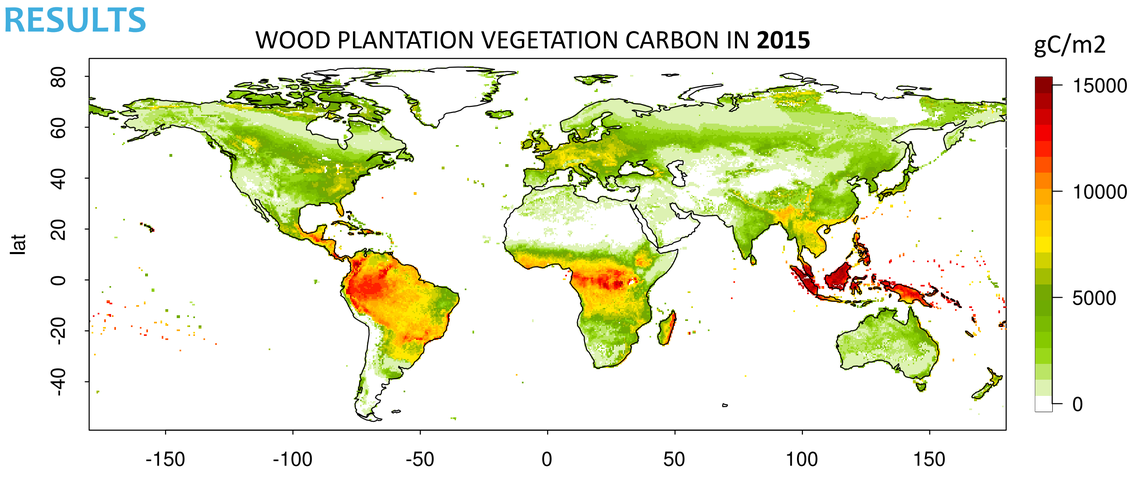

Figure 1. *Vegetation carbon of wood plantations in 2015, after historical simulation (under historical MPI-ESM1-2-HR climate) with constant prescribed wood plantation cover (50% of each grid cell, starting already in 1901).*

- Wood plantations after 114 years under historical climate: plantation trees are able to grow in most regions, with the highest biomass in the tropics (similar to natural PFTs, not shown)
- Note: Wood plantations not yet calibrated for LPJmL5! Productivity expected to increase substantially after calibration. These preliminary results serve to demonstrate the *qualitative* behavior.

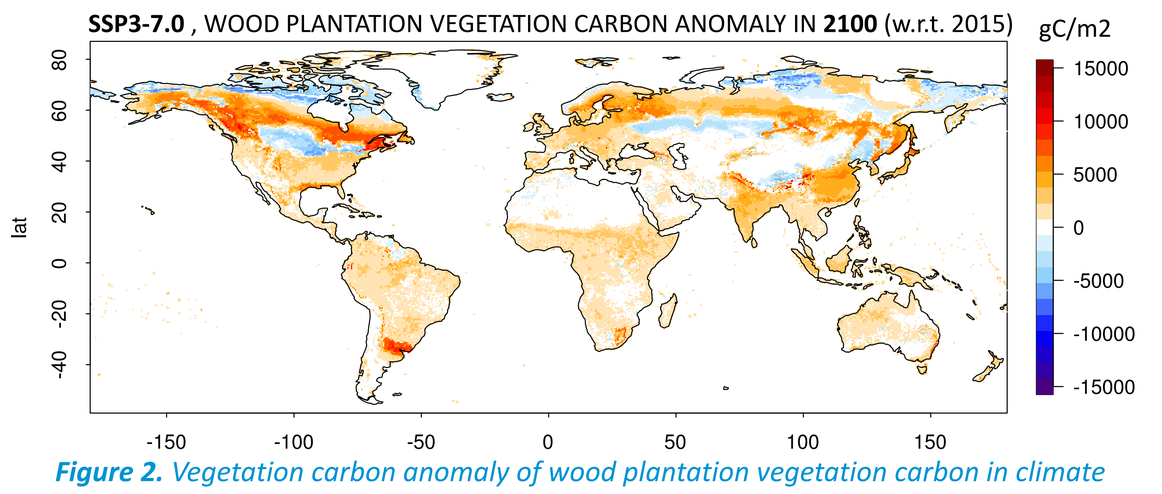

Figure 2. *Vegetation carbon anomaly of wood plantation vegetation carbon in climate scenario SSP3-7.0 (ISIMIP3b bias-corrected MPI-ESM1-2-HR).*

- In 2100: diverse spatial pattern of vegetation carbon anomalies with respect to 2015
- Increase partly because wood plantation trees were not yet in equilibrium by 2015 – to remove this factor, we also calculated the difference from a reference run under constant climate, resulting in significantly lower anomalies (see Fig. 3)
- Decrease in vegetation carbon in large regions North of 40N, where boreal needleleaved evergreen trees are the dominant wood plantation tree type

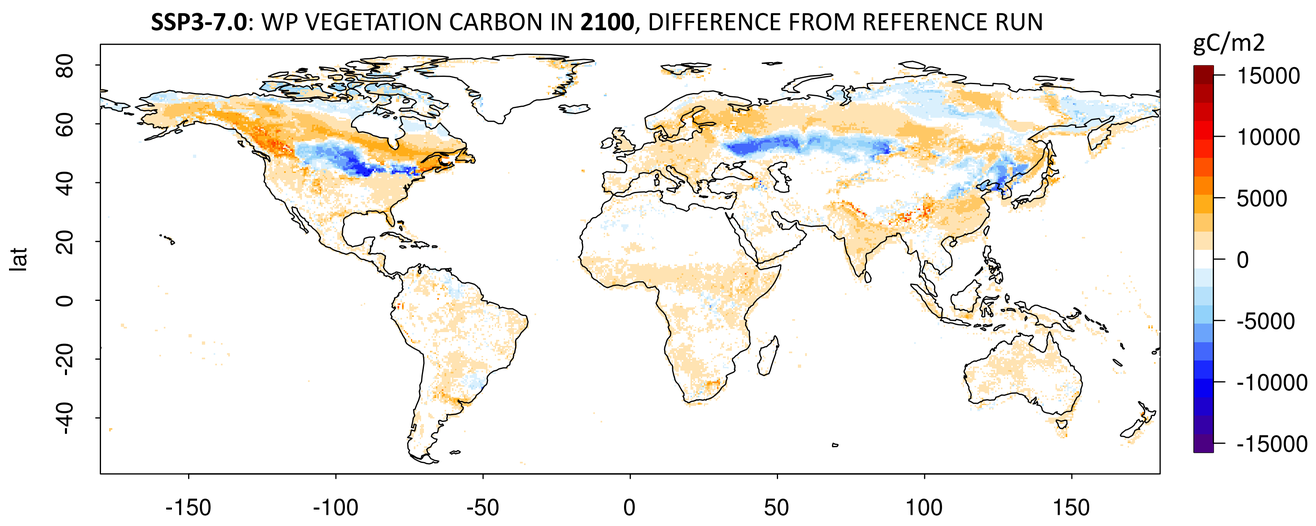

Figure 3. *WP vegetation carbon difference between simulation with SSP3-7.0 climate & SSP3-7.0 CO2 and simulation with constant present-day climate & constant CO2, both in year 2100.*

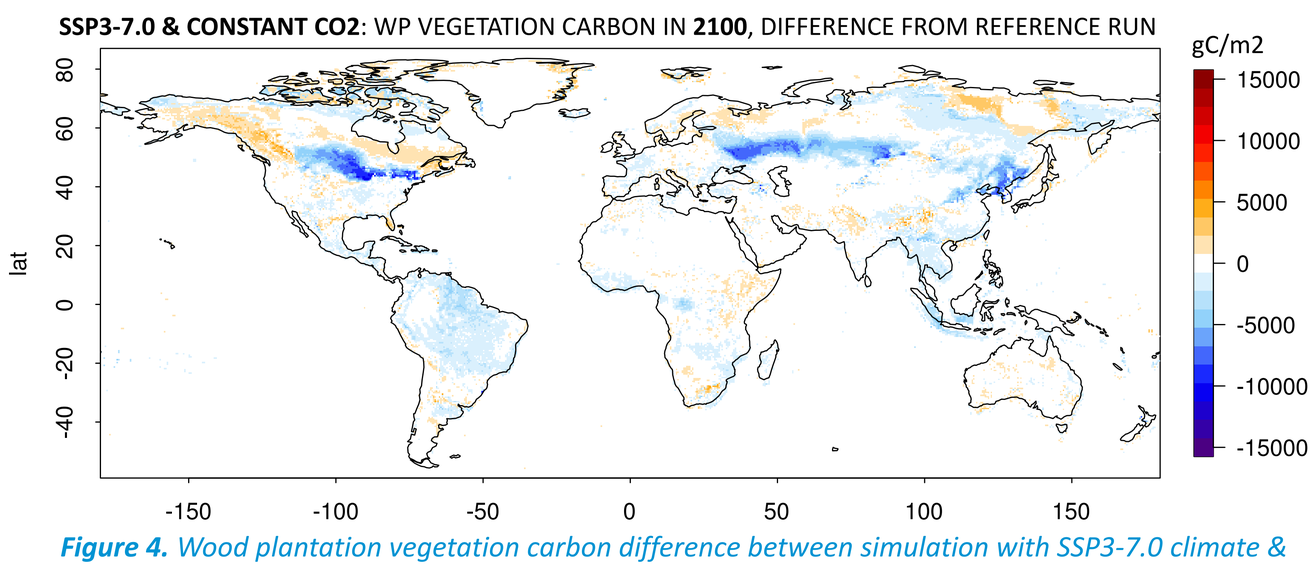

Figure 4. *Wood plantation vegetation carbon difference between simulation with SSP3-7.0 climate & constant CO2 and simulation with constant present-day climate & constant CO2, both in year 2100.*

CLIMATE IMPACTS WITH / WITHOUT CO2 FERTILIZATION

- In many regions, wood plantations benefit from *combined effect* of temperature increase, precipitation changes and CO2 increase in the high-climate change scenario SSP3-7.0 (see Fig. 3)
- Strong decrease in Northern continental interior regions, likely caused by reduced precipitation and reduced soil moisture
- In scenario with SSP3-7.0 climate and constant CO2 (Fig. 4), the overall climate impact on wood plantations is negative, with positive exceptions mainly occurring in high latitudes, where productivity increases largely due to warming
- Note: CO2 fertilization effect under high CO2 concentrations comes with high uncertainty and might be overestimated in LPJmL and other models, thus analyses of climate impacts without (or lower) CO2 fertilization effect are important to get a better understanding of potential climate risks

OUTLOOK

- **Calibration** of wood plantations in LPJmL5. followed by quantitative analyses of **carbon sequestration potential** under climate change
- Analyses of **drought effects** on carbon dioxide removal potential of A/R
- **Model intercomparison study** on climate impacts on A/R and BECCS (LPJmL, JSBACH, LPJ-GUESS)
- Analyses of **forest management** potential for carbon dioxide removal

CONTACT
sabine.mathesius@pik-potsdam.de

REFERENCES
Braakhekke, M. C., Doelman, J. C., Baas, P., Müller, C., Schaphoff, S., Stehfest, E., & Van Vuuren, D. P. (2019). Modeling forest plantations for carbon uptake with the LPJmL dynamic global vegetation model. *Earth System Dynamics*, *10*(4), 617-630.

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