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Biogeophysical effects of idealised land cover and land management changes on the climate

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Land cover and land management (LCLM) changes have been highlighted for their critical role in low-end warming scenarios, both in terms of global mitigation and local adaptation. Yet the overall potential of LCLM options and their combination is still poorly understood. Here we model the climatic effects of four LCLM options using three state-of-the-art Earth system models, including the Community Earth System Model (CESM), the Max Planck Institute Earth System Model (MPI-ESM) and the European Consortium Earth System Model (EC-EARTH). The considered LCLM options represent idealized conditions:(i) a fully afforested world, (ii) a fully deforested world, (ii) a fully afforested world with extensive wood harvesting, and (iv) a fully deforested world with extensive irrigation. In these idealized sensitivity experiments, ran under present-day climate conditions, the effects of the different LCLM strategies represent an upper bound of the potential for global mitigation and local adaptation. To disentangle the local and non-local effects from the LCLM changes, a checkerboard perturbation, as proposed by Winckler et al. (2017) is applied.

Our first results show that deforestation leads to a pronounced warming in 2m air temperature in CESM over most regions, being most pronounced in the tropics (up to 4°C). In contrast, in the boreal regions of North America and Asia, deforestation causes a ~1°C cooling in 2m air temperature. In CESM, the local effect seems to dominate the temperature response from deforestation, while the resulting non-local effect overall has a smaller magnitude. This contrasts to the effect from afforestation, of which the non-local component dominates the 2m air temperature signal. Afforestation indeed shows a strong local cooling in the tropics and a slight local warming in the temperate and boreal regions, yet, the local cooling is regionally offset by a global, non-local warming of up to 2 °C. In a next step, we will extend this analysis to the ensemble of Earth system models and increase our process-based understanding of these results and their implications on hot extremes as well as the effects on other temperature metrics (surface

temperature and temperature of the lowest level of atmospheric column). Finally, we will perform a subgrid-scale comparison of the effects of LCLM on temperature.

References:

Winckler, J., Reick, C.H., Pongratz, J., 2017. Robust identification of local biogeophysical effects of land-cover change in a global climate model, American Meteorological society, 30(2), DOI: 10.1175/JCLI-D-16-0067.1