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Simulated biogeochemical effects of idealized land cover and land management changes

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Land cover and land management (LCLM) changes are important sources and sinks for anthropogenic CO_2 fluxes. Current earth system models (ESMs) are capable to simulate the globally most sensitive LCLM changes (strong effects or large spatial extent in the earth system) such as de- and afforestation, wood harvest and irrigation, however, a comprehensive analysis between these ESMs is still absent. The present study aims to quantify the biogeochemical effects of forest cover changes, wood harvesting and irrigation of croplands on the global carbon cycle.

Therefore, we conducted coupled atmosphere-ocean-land experiments of idealized global deforestation with and without cropland irrigation as well as global re-/afforestation with and without wood harvest over a 150-year period under present day solar and trace gas forcing. All experiments were simulated by three different ESMs (MPI-ESM, EC-EARTH and CESM) to quantify inter-model uncertainty and potentially uncover specific model biases. The analysis focuses on the transient response of land carbon fluxes and pools after an abrupt LCLM practice change, in order to track the emergence of signals that could potentially mitigate climate change. Additionally, we want to unravel model differences concerning the temporal dynamics of LCLM change effects. Since greenhouse gases (GHG) concentration is kept constant at present-day level, the climate changes here arise from the biogeophysical effects of LCLM changes. We use a checkerboard approach to separate local and non-local components of the climate changes as proposed by Winckler et al., 2017, i.e. we separate the changes in climate induced locally by the LCLM changes from those induced remotely by advection and changes in atmospheric circulation.

First results with the MPI-ESM show that immediate global deforestation starting from present-day land-use distribution causes a 824 GtC loss of the total land carbon pool throughout the simulation period of 150 years, about 46% of which stem from tropical regions (17°S–17°N). Land

carbon stocks are not balanced until the end of the simulation, which indicates that the land will continue to emit CO_2 to the atmosphere and a long-term commitment by deforestation for climate change. Non-local effects lead to a loss of 26 GtC from land, again with largest losses found for the tropical regions. Even though it is a small part compared to the total loss (local plus non-local effect), it reveals potentially substantial consequences that LCLM changes at large scale can have unintendedly on other regions, including remote pristine ones, through biogeophysical climate change.