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Past and future impact of land use on the carbon cycle and climate

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The impact of land use on the carbon cycle and the climate is assessed using the Bern Carbon Cycle-Climate model that includes a version of the LPJ dynamic global vegetation model with a land use module. The land use module is driven by maps of global cropland, pasture and urban areas. Historical land use data are taken from the HYDE3 dataset (Goldewijk 2006, personal communication); future land use scenarios with corresponding greenhouse gas emission scenarios were developed at the International Institute of Applied Systems Analysis (IIASA), based on the SRES storylines A2, B1, and B2. The model calculates atmospheric CO2 and carbon fluxes as modified by land use, whereas land use feedbacks on climate via albedo and the water cycle are not considered. Land use causes a loss (or prevents uptake) of 188 Gt of terrestrial carbon between 1700 and 2000 relative to a simulation without land use, and 103 to 211 Gt over the 21st century, depending on the scenario. The inclusion of land use improves the ability of the model to reproduce historical atmospheric CO2 and reconstructed global biospheric carbon uptake as compared to a simulation without land use. The comparison suggests that the model overestimates the role of pasture. In simulations that only consider croplands, the land use impact is 84 GtC until 2000 and 46 to 144 GtC for the 21st century. When CO2 fertilisation is turned off, land use impact is 250 GtC until 2000 (113 GtC without pasture) and 35 to 51 GtC for the 21st century (25-43 GtC without pasture). The large differences observed in the future between different scenarios when fertilisation is active, are due to different atmospheric CO2 levels driven mainly by fossil emissions, and not land use change. Thus, CO2 fertilisation strongly affects land use impacts through the enhancement of CO2 uptake in natural forests, creating terrestrial carbon sinks that are largely lost when natural lands are converted. This is a lasting effect not correlated to the rate of land use change, but to the extent of existing cropland, which we characterise with the concept of land use

commitment, i.e. the carbon loss over the 21st century in a simulation without further land use change after 2000. This amounts to 80 to 150 GtC, and 25 to 56 GtC in a simulation without pastures, highlighting the potential importance of this legacy in comparison to possible future land use changes.