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Carbon sequestration potential and climatic effects of reforestation in an Earth system model

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Studies on the global climatic effects of afforestation have mainly focused on the carbon sequestration potential of plausible scenarios while neglecting biogeophysical effects or were based on highly idealised afforestation scenarios. Here we assess the reduction potential for the atmospheric CO_2 concentration and possible consequences for the global climate of following a strong reforestation scenario during this century taking into account both biogeochemical and biogeophysical effects. We perform simulations using the Max Planck Institute for Meteorology Earth System Model (MPI-ESM), forced by anthropogenic emissions according to the Representative Concentration Pathway (RCP) 8.5, but using land use transitions according to RCP 4.5. Thereby we are able to isolate the effects of land use changes in this scenario in which agricultural intensification leads to abandonment of agricultural areas and a regrowth of forest of about 8 million km^2 in our model. We find that this reforestation reduces the atmospheric CO_2 concentration by about 85 ppm by the end of the century as compared to RCP 8.5. This value is higher than previous estimates for plausible reforestation scenarios, mostly because the CO_2 fertilisation effect on the terrestrial vegetation has not been accounted for in previous studies. Due to the lower CO_2 concentration the global mean temperature increase is reduced by about 0.27 K. Regionally the simulated effect may exceed 2 K, but the largest annual mean cooling signal occurs in only sparsely populated regions. Concerning temperature extremes, however, the effect can also be large in densely populated areas, mostly caused by local biogeophysical effects of the vegetation changes. Thus, we conclude that the mitigation potential of reforestation is higher than previously thought, the need for adaptation in many regions of the world is still strong, but temperature extremes may be reduced.