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Combined biogeophysical and biogeochemical effects of large-scale forest cover changes in the MPI earth system model

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Afforestation and reforestation have become popular instruments of climate mitigation policy, as forests are known to store large quantities of carbon. However, they also modify the fluxes of energy, water and momentum at the land surface. Previous studies have shown that these biogeophysical effects can counteract the carbon drawdown and, in boreal latitudes, even overcompensate it due to large albedo differences between forest canopy and snow. Our study investigates the role forest cover plays for global climate by conducting deforestation and afforestation experiments with the earth system model of the Max Planck Institute for Meteorology (MPI-ESM). Complete deforestation of the tropics (18.75° S - 15° N) exerts a global warming of 0.4 °C due to an increase in CO_2 concentration by initially 60 ppm and a decrease in evapotranspiration in the deforested areas. In the northern latitudes (45° N - 90° N), complete deforestation exerts a global cooling of 0.25 °C after 100 years, while afforestation leads to an equally large warming, despite the counteracting changes in CO_2 concentration. Earlier model studies are qualitatively confirmed by these findings. As the response of temperature as well as terrestrial carbon pools is not of equal sign at every land cell, considering forests as cooling in the tropics and warming in high latitudes seems to be true only for the spatial mean, but not on a local scale.