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Global scale interactions between forest and climate

T. J. Raddatz (1), V. Brovkin (1), C. H. Reick (1), M. Claussen (1,2), and V. Gayler (1)

(1) Max Planck Institute for Meteorology, Land in the Earth System, Hamburg, Germany (thomas.raddatz@zmaw.de), (2) Meteorological Institute, University Hamburg, Germany

Large-scale biogeophysical interactions between forests and climate are explored using the Earth System Model of the Max Planck Institute for Meteorology (MPI-ESM) that includes interactive atmosphere, ocean, and vegetation modules. In two sensitivity simulations, vegetation cover of the entire ice-free land surface is either prescribed as grassland or forest, in order to quantify a quasi-equilibrium response of the atmosphere and ocean to altered land surface boundary conditions. After 400 years of model integration, the global mean annual surface temperature increases by 0.8°C in the forest simulation and declines by 0.3°C in the grassland simulation in comparison to the simulation with a mixed potential vegetation cover. Thereafter, vegetation cover is allowed to respond interactively to climate. After subsequent 300 years, the grass cover simulation converges to the same state as the control run, while the forest simulation is still out of equilibrium. The asymmetry between the two simulations could be explained by a faster tree establishment relative to the climate-induced mortality. Nevertheless, an ongoing trend towards the initial conditions in the forest simulation suggests that no multiple climate-forest states exist in the current version of MPI-ESM.

An additional simulation with an artificial vegetation cover that has the albedo of forest, but all other properties as grassland, reveals that albedo is the main driver of the global climate signal. Differences in transpiration between forest and grassland have only a minor impact on the global climate, dampening the climate signals induced by the albedo effect only slightly.