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Environmental impact of forest versus grassland in a coupled land-atmosphere system

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Grassland and forest interact differently with the atmospheric boundary layer (ABL), but the impact of these differences is difficult to quantify from observations. Here, instead, we use a simplified model of the soil-vegetation-atmosphere continuum to investigate how grassland and forest behave differently under a range of climate conditions (i.e. varying levels of soil moisture and initial temperature). The model includes a slab model for the ABL, the Penman-Monteith equation for solving the surface energy balance and a two-layer force-restore soil model.

Our results indicate that under wet conditions, the higher net radiation and stronger coupling facilitate higher evapotranspiration from forest. Under dry conditions, however, there is a strong positive feedback between increased vapor pressure deficit and reduced evapotranspiration over forests. The increased sensible heat flux causes deeper boundary layers, higher temperatures, and lower vapor pressure deficit. This feedback might explain why evapotranspiration from forests does not increase at the same rate as evapotranspiration from grasslands during drought periods characterized by high levels of radiation and high temperatures. The findings are evaluated against a recent synthesis of flux-tower observations in the FLUXNET-La Thuile database (Teuling et al., Nature Geoscience, 2010).