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The Role of Biomass Heat Storage on the Dampening Effect of Forests on Diurnal Temperature Variations

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Remote sensing and in-situ observations have revealed a dampened diurnal temperature cycle in forests compared to other land cover types such as grassland at most locations on earth (Lee et al., 2011; Li et al., 2015; Vanden Broucke et al., 2015; Duveiller et al. 2018). This feature is missing in all of the LUCID and CMIP5 climate models (Lejeune et al., 2017). In particular, the origin of the nighttime warming effect by forests is poorly understood up to now. A possible candidate for alleviating these biases are heat storage fluxes in and out of the biomass. These fluxes are observed to reach a diurnal amplitude of up to 100 W/m^2 (e.g. Dos Michiles et al., 2008) and have therefore the potential to increase nighttime temperatures and decrease daytime temperatures in forests significantly.

We incorporated a biomass heat storage scheme into the state-of-the-art land surface model CLM5.0. Results from global-scale simulations show that, compared to the configuration not including biomass heat storage, nighttime temperatures are increased by more than 1 K in densely forested areas, thereby improving the agreement with remote sensing observations. During daytime, the biomass heat storage induces a reduction of the turbulent heat fluxes leading to a smaller cooling effect.

Overall our results indicate that biomass heat storage is a crucial process that is missing from most current global climate models, with potentially critical implications about their ability to capture the biogeophysical effect of forest changes and forest management, even more so when investigating land use change effects on temperature extremes. In a next step, we will investigate how this process affects the dynamics of the boundary layer in simulations that are coupled to the atmosphere, using the regional climate model COSMO-CLM2 over Europe and Switzerland.

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