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Evaluating and Improving the Community Land Model's Sensitivity to Land Cover

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Both climate models and observations have shown the importance of biogeophysical effects of deforestation on local climate conditions. However, different land surface models show considerable discrepancies in simulating the biogeophysical effects of deforestation on surface fluxes and climate. In particular, the impact on turbulent heat fluxes is highly uncertain, resulting in diverging temperature impacts in current land surface models. Further, diurnal temperature changes induced by deforestation in most land surface models are in contradiction with observational evidence. Hence, this calls for a thorough evaluation of individual land surface models in terms of their ability of representing biogeophysical effects of deforestation.

In this study, we compare the local contrast between forest and open land (i.e. grassland and cropland) in albedo, daily average, maximum and minimum land surface temperature, and evapotranspiration (ET) in the Community Land Model 4.5 (CLM4.5) to corresponding observations. Based on MODIS datasets, we find that the albedo difference of forest minus open land is represented well by CLM4.5. The daily average and maximum land surface temperature differences of forest minus open land are qualitatively well captured by the model but tend to be biased positively in CLM4.5 compared to MODIS land surface temperature. Furthermore, the nighttime warming effect of forests in the mid-latitudes observed in MODIS data and in-situ measurement is absent in CLM4.5. Finally, we identify that the ET difference between forest and open land is underestimated in CLM4.5 compared to several independent observation-based ET products and with reversed sign for some regions, even when considering uncertainties in ET observations.

Based on these results, we explore four different aspects of the model which could be modified to alleviate the observed biases in ET: (1) root distribution, (2) formulation of plant water uptake, (3) light limitation of photosynthesis, and (4) maximum rate of carboxylation. A combination of these modifications can reduce the biases in ET and also daily average and maximum land surface temperature. Resolving these biases completely will require not only further improvements of model formulations, but also well-constrained ET observations for different land cover types.

Reference

Meier, R., Davin, E. L., Lejeune, Q., Hauser, M., Li, Y., Martens, B., Schultz, N. M., Sterling, S., and Thiery, W.: Evaluating and Improving the Community Land Model's Sensitivity to Land Cover, Biogeosciences Discuss., https://doi.org/10.5194/bg-2017-501, in review, 2018.