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Contribution of the land-use forcing to the increase in risk of warm extreme events since 1850 over North America from constrained CMIP5 simulations

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During the industrial period, large areas of North America experienced a reduction in forest cover and an expansion of agricultural areas. There is indication that this has affected the intensity and frequency of temperature extremes through changes in biophysical land surface properties (Christidis et al., 2013, Pitman et al., 2012). However, it has never been addressed in the context of a multi-model transient experiment ensemble. Here we intend to constrain CMIP5 models with observations in order to assess the contribution of historical land-cover changes (LCC) to changes in the risk of warm extreme events over North America.

We have retained only six models from the CMIP5 ensemble that can reproduce the local warming effect of deforestation during daytime, which was identified in present-day observations of the impact of deforestation on mean summer temperature (Lee et al, 2011). As for its observed cooling effect during nighttime, we kept the sole model that is able to simulate it. Using a framework derived from the Fraction of Attributable Risk methodology, we have then quantified by how much the increase in risk of getting a particular extreme event driven by increased greenhouse gas concentrations (GHG) was damped or amplified over areas which were largely affected by LCC, compared to surrounding ones that experienced few LCC over the same period. We find that the constrained model ensemble indicates an amplification by between 10 and more than 100% by local LCC of the increase in risk of occurrence of a warm extreme event corresponding to the 90th percentile during the pre-industrial period, depending on the model. This amplification factor gets higher for more extreme events, rising to at least 20% for the 995th permille. Regarding nighttime temperatures, the retained model indicates that historical LCC have locally more than cancelled the effect of increased GHG concentrations on the frequency of warm extreme events corresponding to between the 90th percentile and the 995th permille, leading to a slight decrease in their risk of occurrence.

Christidis, N., P. A. Stott, G. C. Hegerl, and R. A. Betts, The role of land use change in the recent warming of daily extreme temperatures (2013), Geophysical Research Letters, 40, 589-594
Pitman, A. J., et al., Effects of land cover change on temperature and rainfall extremes in multi-model ensemble simulations (2012), Earth System Dynamics, 3, 213-231
Lee, X., et al., Observed increase in local cooling effect of deforestation at higher latitudes (2011), Nature, 479, 384-387