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Different temperature sensitivities to land use change in the RCPs

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Land use change in the CMIP5 Representative concentration pathways (RCPs) has both positive and negative changes in forest fraction and crop land cover, which is not related linearly to the amount of radiative forcing in the scenario. The Land-use and Climate Identification of robust impacts project (LUCID) clearly showed that in RCP2.6 and RCP8.5 it is unlikely that anthropogenic land use and land cover change (LULCC) will have a significant effect on global climate. However, the LUCID study only considered future scenarios of deforestation (RCP2.6 and RCP8.5). In contrast, the two 'middle' radiative forcing RCP scenarios (RPC4.5 and RCP6.0) have decreases in crop and pasture land projected over the century, resulting in very different LULCC scenarios compared to the two other RCPs.

Using an ensemble of simulations with and without land use changes in the Hadley Centre earth system model HadGEM2-ES, we compare the climatic effects of the LULCC in RCP4.5, RCP2.6 and RCP8.5. Although there is extensive land use change in all three RCPs considered here, the latitude at which the LULCC occurs is a crucial factor in whether the change has a climatic impact. We show that the mid to high latitude afforestation LULCC in RCP4.5 results in significant biogeophysical temperature differences over Eurasia and North America, compared to no LULCC. This contrasts with RCP2.6 and RCP8.5 where the significant areas of temperature change are much smaller from the predominantly tropical deforestation. While the carbon emissions mainly make up for the temperature changes at a global scale, there may be residual local effects due to LULCC in RCP4.5, especially with regard to extremes. We show that LULCC in RCP4.5 has an effect on the extremes of temperature, whereas RCP2.6 and RCP8.5 are less affected.

This work suggests that the different representations of LULCC in the RCPs result in different climate sensitivities to LULCC, which are not linear with the overall radiative forcing. Instead the sensitivity is related to the change in forest fraction at the mid to high latitudes. The scale, location, latitude, and type of LULCC change all affect whether there will be a significant temperature impact.