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Increased uncertainty in Land-Use change impacts on temperature due to Global Warming in CMIP6-LUMIP experiments

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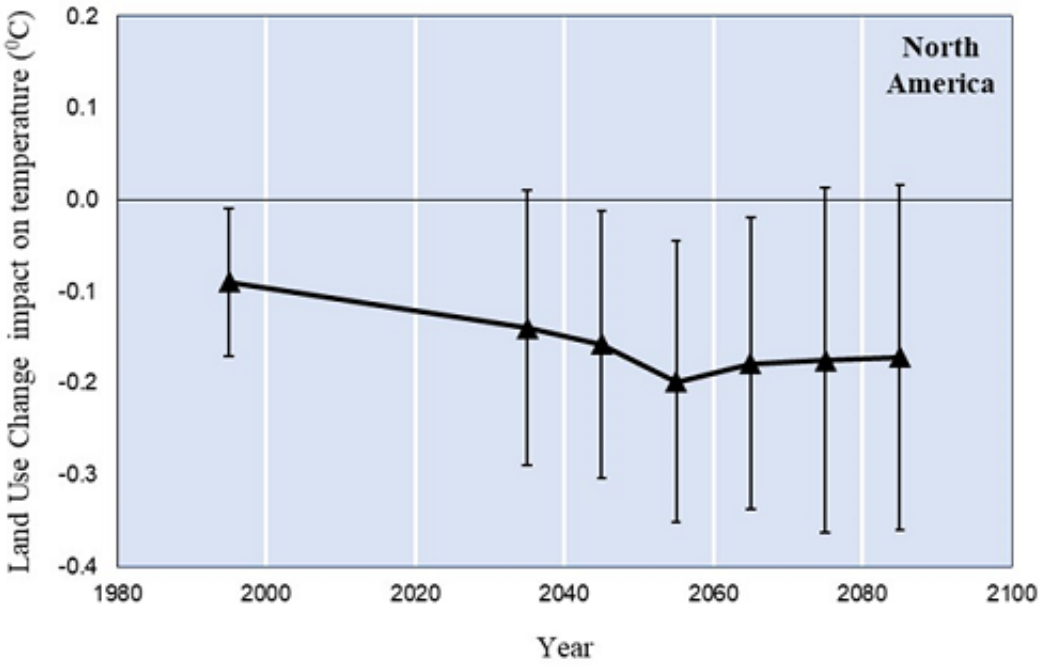
Land-use change (LU) is a major regional climate forcing that affects carbon-water-energy fluxes and, therefore, near-surface air temperature. Although there are uncertainties in LU impacts in the historical climate, there is a growing consensus towards a cooling influence in the mid-latitudes. However, how a drier and warmer land surface condition in the future climate can change the LU impacts are not investigated well.

We use a comprehensive set of five coupled climate models from the CMIP6-LUMIP project to assess the changing influence of the LU change. We use two methodologies: (1) direct method – where LU impacts are estimated by subtracting the 'no-LU' climate experiment from the control experiment that includes LU, and (2) Kumar et al., 2013 (K13) method where LU impacts are estimated by comparing climate change impacts between LU and no-LU neighboring regions.

First, we compared the LU impacts in the historical climate and between the direct method and K13 methods using the multi-model analysis. In the North America LU change region, the direct method shows a cooling impact of (-0.14 ± 0.13°C). The K13 methods show a smaller cooling impact (-0.09 ± 0.08°C). In terms of energy balance, the direct method shows a reduction of net shortwave radiation (-0.82 ± 0.91 watts/m^2) the K13 method shows a cleaner result of (-1.25 ± 0.60 watts/m^2), as expected. We suspect that a more substantial influence of the LU change in the direct method is due to large-scale circulation driven response or due to the internal variability that has been canceled out in the K13 method.

Next, we extend the K13 method to assess the LU impacts in the future climate. Direct methods are not available for the future climate experiment in CMIP6-LUMIP datasets. We find that a cooling impact of LU change has become statistically insignificant in the future climate (-0.17 ± 0.19°C). A similar influence is also found in the reduction of the net shortwave radiation (-1.92 ± 3.34 watts/m^2). We also found that climate change impacts on temperature are an order of magnitude greater than LU impact in the future climate. Hence, we hypothesize that higher warming has contributed to the larger uncertainty in LU impacts. We will also discuss LU impacts in Eurasia and Indian subcontinent.



Reference

Kumar, S., Dirmeyer, P. A., Merwade, V., DelSole, T., Adams, J. M., & Niyogi, D. (2013). Land use/cover change impacts in CMIP5 climate simulations: A new methodology and 21st century challenges. Journal of Geophysical Research: Atmospheres, 118(12), 6337-6353.