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The mark left by vegetation cover change on the Earth's surface energy balance from the satellite's perspective

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Land use and land cover change (LULCC) typically generate modifications in vegetation cover that can alter the radiative and non-radiative properties of the surface. Depending on where and when these changes occur, and on which biophysical process dominates, the resulting effect on the Earth's surface energy balance may either be a local warming or a local cooling. This local change in temperature is potentially much more perceptible by people as biophysical effects of LULCC, unlike biogeochemical ones, have an almost immediate response on the local climate. There is an increasing awareness that these biophysical effects should be accounted for in land-based mitigation plans. However, for a comprehensive evaluation of such plans it is necessary to have a spatially and seasonally explicit evaluation of how multiple vegetation transitions affect the different components of the surface energy balance.

Here we provide the first data-driven assessment of the potential local effect on the full surface energy balance of multiple vegetation transitions at global scale. All data are derived from satellite remote sensing observations, which are combined using a novel dedicated methodology optimized to disentangle the effect of mixed vegetation cover on the surface climate. The result is a multi-dimensional dataset providing global maps of the monthly change in the various fluxes for transitions amongst different ecosystems including grasslands, shrublands, cropland, savannas, various forest types (deciduous vs. evergreen, broadleaf vs. needleleaf) and wetlands.

We use this dataset to quantify the local perturbations in the surface energy balance generated by vegetation change from 2000 to 2015. The resulting synoptic effect in an average increase of 0.23 ± 0.03 C in local surface temperature where those vegetation changes occurred. Vegetation transitions behind this warming effect mainly relate to agricultural expansion in the tropics, where surface brightening and consequent reduction of net radiation does not counter-balance the increase in temperature associated with reduction in transpiration.

Beyond this evaluation of the mark that LULCC has left in the recent past, we expect that the spatialised estimates derived from satellite could find various other uses in the scientific and policy-making community. The dataset could become an important asset for integrated assessment modelling, but also for benchmarking and improving land-surface schemes and Earth system models. It could further serve as a baseline in the development of monitoring, reporting and verification (MRV) guidelines for the implementation of land-based biophysical climate mitigation and adaptation options, mirroring what is currently done for biogeochemical land-processes.