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The neglected nonlocal effects of deforestation

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Deforestation changes surface temperature locally via biogeophysical effects by changing the water, energy and momentum balance. Adding to these locally induced changes (local effects), deforestation at a given location can cause changes in temperature elsewhere via advection and changes in circulation (nonlocal effects). Most previous studies have not considered local and nonlocal effects separately, but investigated the total (local plus nonlocal) effects, for which global deforestation was found to cause a global mean cooling. Recent modeling and observational studies focused on the isolated local effects: The local effects are relevant for local living conditions, and they can be obtained from in-situ and satellite observations. Observational studies suggest that the local effects of potential deforestation cause a warming when averaged globally.
This contrast between local warming and total cooling indicates that the nonlocal effects of deforestation are causing a cooling and thus counteract the local effects. However, this hypothesis of a cooling nonlocal could not be tested in previous studies because the nonlocal effects could not be isolated. It was further unclear how the nonlocal effects depend on the areal extent and spatial distribution of deforestation. To investigate this, we use a fully coupled climate model and separate local and nonlocal effects of deforestation in separate simulations with varying areal extent and spatial distribution of deforestation.

We find that, when globally averaged, local effects are counteracted by the nonlocal effects (up to 0.1K local warming versus -0.3K nonlocal cooling). The nonlocal cooling scales linearly with the number of deforested grid boxes, so this 1:-3 relationship is valid also for smaller-scale deforestation. Furthermore, the nonlocal cooling is apparent also for a more realistic spatial distribution of deforestation. The nonlocal effects of low-latitude deforestation are more ambivalent: Within the deforested low-latitude regions, we obtain a warming due to changes in precipitation and cloudiness. However, low-latitude deforestation is cooling the extratropics, and thus the global mean nonlocal effect is cooling even for low-latitude deforestation.
We conclude that the local effects of deforestation –and thus also the observations– yield a highly incomplete picture of the total climate effects by biogeophysical pathways. While the local effects capture the direct climatic response at the site of deforestation, the nonlocal effects have to be included if the biogeophysical effects of deforestation are considered for an implementation in climate policies.