Geophysical Research Abstracts
Vol. 19, EGU2017-9331, 2017
EGU General Assembly 2017

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 (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. It is still unclear how the nonlocal effects depend on the spatial scale of deforestation, and whether they still compensate the local warming in a more realistic spatial distribution of deforestation.

To investigate this, we use a fully coupled climate model and separate local and nonlocal effects of deforestation in three steps: Starting from a forest world, we simulate deforestation in one out of four grid boxes using a regular spatial pattern and increase the number of deforestation grid boxes step-wise up to three out of four boxes in subsequent simulations. To compare these idealized spatial distributions of deforestation to a more realistic case, we separate local and nonlocal effects in a simulation where deforestation is applied in regions where it occurred historically.
We find that the nonlocal effects scale nearly linearly with the number of deforested grid boxes, and the spatial distribution of the nonlocal effects is similar for the regular spatial distribution of deforestation and the more realistic pattern. Globally averaged, the deforestation-induced warming of the local effects is counteracted by the nonlocal effects, which are about three times as strong as the local effects (up to 0.1K local warming versus -0.3K nonlocal cooling). Thus, the nonlocal effects are more cooling than the local effects are warming, and this is valid not only for idealized simulations of large-scale deforestation, but also for a more realistic deforestation scenario.
We conclude that the local effects of deforestation only yield an 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.