The neglected nonlocal biogeophysical effects of deforestation

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Local and nonlocal bigeophysical effects of deforestation

Local effects:
- Affect only deforested locations.
- Can be inferred from observations. \cite{Li2015, Alkama2016, Bright2017}

Nonlocal effects:
- Affect also nearby and remote locations, e.g. via advection.
- Cannot be inferred from observations.
- Potentially strong impacts \cite{Swann2012, Devaraju2015}

In climate models: both local AND nonlocal effects.
Separating nonlocal and local effects [Winckler et al., J. Clim., 2017]

Nonlocal effects:
From locations without deforestation

Local effects:
Simulated minus nonlocal

Here: ‘effects’ = changes in surface temperature
Local effects in the MPI-ESM largely agree with observations

Observations: Li et al. (2015), Alkama & Cescatti (2016), Bright et al. (2017)
Nonlocal effects prohibit consistent comparison to observations

Observations: Li et al. (2015), Alkama & Cescatti (2016), Bright et al. (2017)
Investigating the nonlocal effects

Guiding questions:

- Nonlocal effects only for large-scale deforestation?
- Where are nonlocal effects triggered?
- How are the nonlocal effects triggered?
Nonlocal effects depend on the areal extent of deforestation

- Simulations: Spatially homogeneous deforestation pattern, increase number of deforestation grid cells
- Ratio of globally averaged local/nonlocal = 1/-3
- Nonlocal effects scale linearly with number of deforested grid cells
Investigating the nonlocal effects

Guiding questions:

- Nonlocal effects only for large-scale deforestation?
- Where are nonlocal effects triggered?
- How are the nonlocal effects triggered?
Where are the nonlocal effects triggered?

- Simulations: Deforest fixed areal extent, but in different regions.
- 1/-3 ratio also for deforestation near historically deforested areas.
- Nonlocal cooling triggered by deforestation in all three latitude bands.
Where are the nonlocal effects triggered?
Investigating the nonlocal effects

Guiding questions:

- Nonlocal effects only for large-scale deforestation?
- Where are nonlocal effects triggered?
- How are the nonlocal effects triggered?
How are the nonlocal effects triggered?

- Simulations: Change only one surface property.
- Change in surface albedo responsible for nonlocal cooling.
- Cooling largely excluded from the local effects.
Not only biogeophysical effects matter

Biogeophysical effects are only part of the climate response
Nonlocal effects across models

Obtain nonlocal effects from existing simulations of plausible deforestation:

- Isolate local effects as in [Lejeune et al., 2017]
- Nonlocal = simulated – local effects.

→ Nonlocal cooling across models?
Nonlocal effects across models
Summary and conclusions

- Local effects alone – and thus observations – only yield an incomplete picture.

- On global mean, biogeophysical nonlocal cooling may be stronger than local warming.

- Climate models are essential to better understand and quantify the nonlocal effects.

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References

- Separation of local and nonlocal effects:

- Observations:
  Li, Y. et al., 2015, Nat. Commun., doi: 10.1038/ncomms7603

- Estimate of the effect of land carbon loss:
  Gillett, N. et al., 2013, J. Clim., doi: 10.1175/JCLI-D-12-00476.1
Why are nonlocal effects excluded from observations?

Difference: 2K
Why are nonlocal effects excluded from observations?

The difference between forest and grass locations is unaffected by deforestation elsewhere.