

The neglected nonlocal climate effects of deforestation

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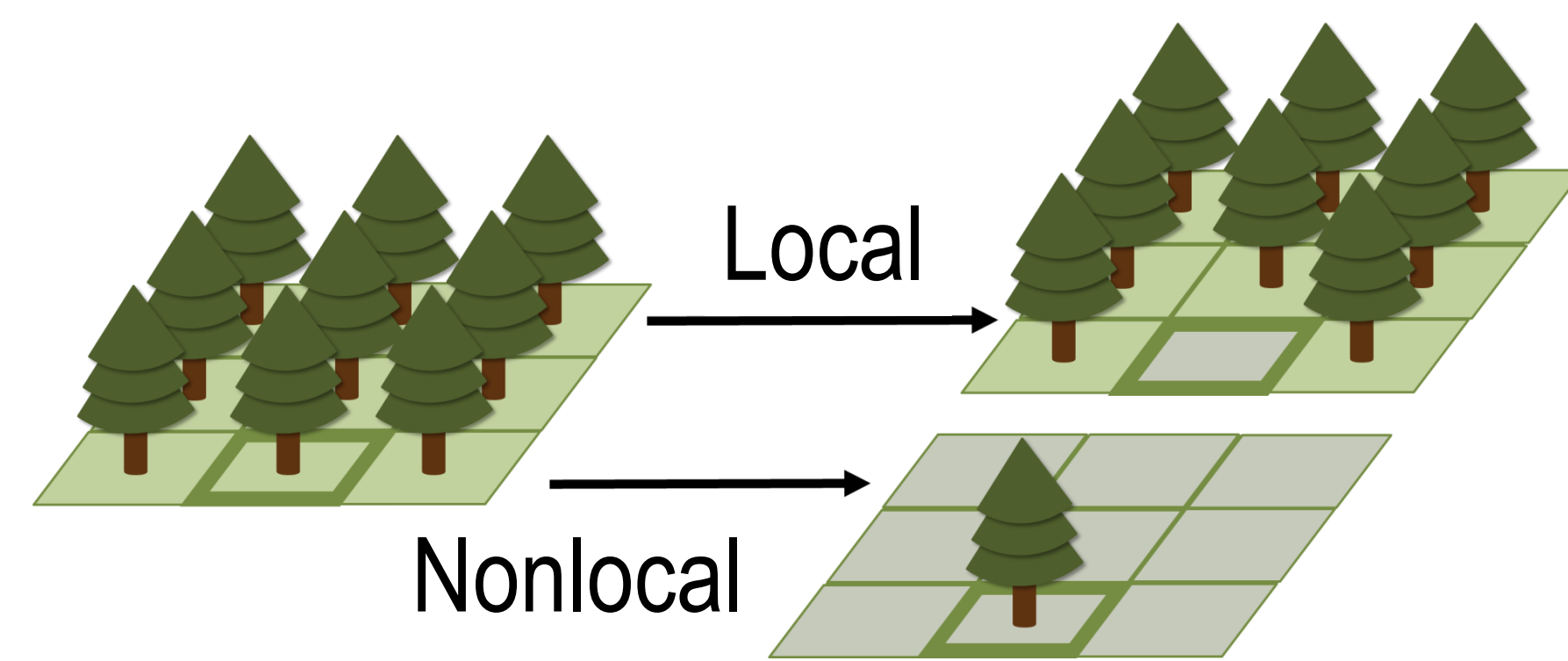
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Key points

The nonlocal biogeophysical effects should not be neglected

- Deforestation affects climate both locally and in remote regions.
- Cooling due to increased albedo is essentially nonlocal.
- Nonlocal cooling is even stronger than local warming when globally averaged.
- This nonlocal cooling is not captured in observations.

Local / nonlocal effects



Local biogeophysical effects impact only deforested boxes:

- Via changes in albedo, evapotranspiration efficiency, roughness.

Nonlocal biogeophysical effects impact all boxes:

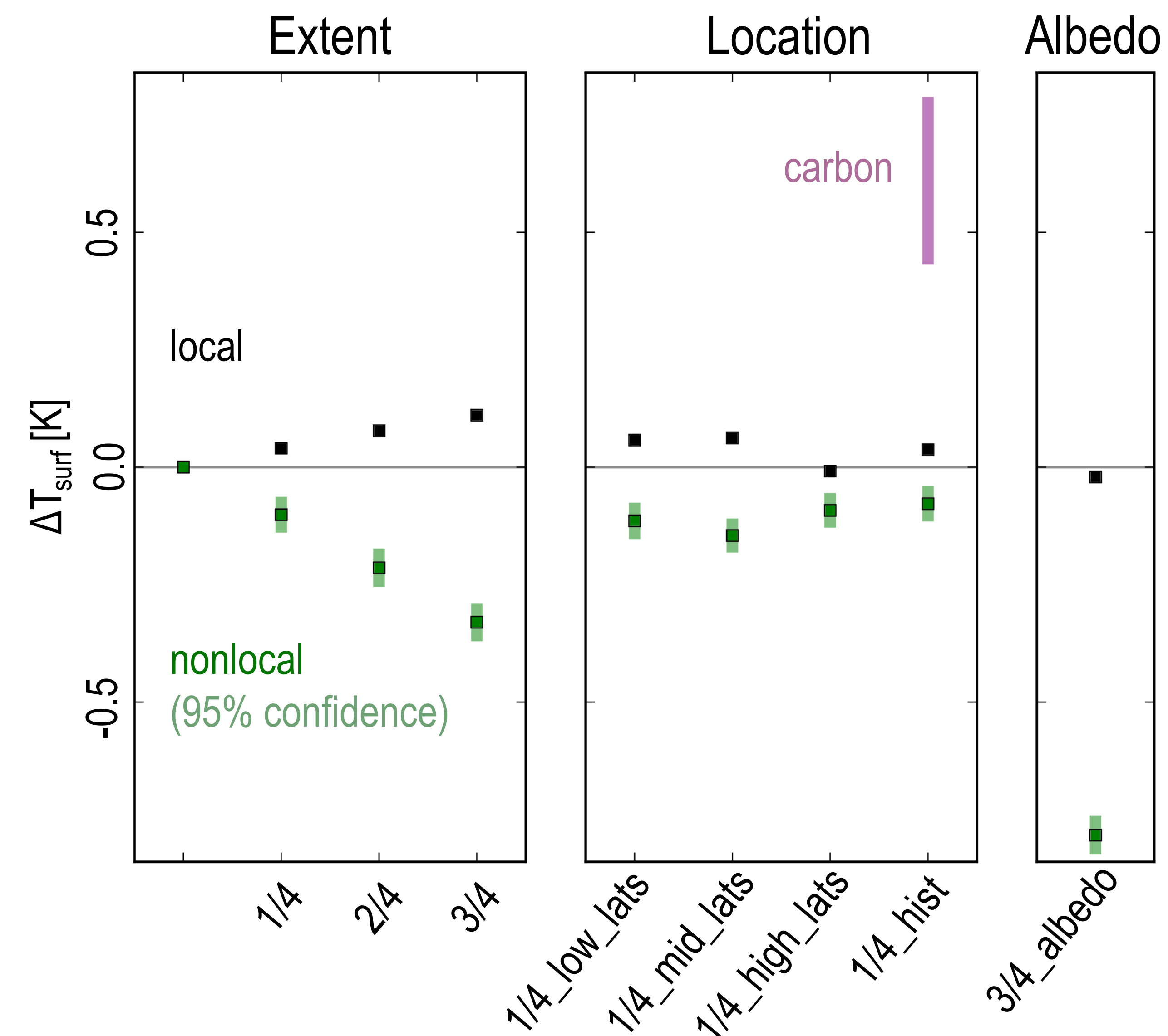
- Induced, e.g., by advection or changes in circulation.

Motivation

Nonlocal effects are potentially relevant for climate mitigation policies. However, there are substantial research gaps:

- How do the nonlocal effects depend on the **extent** and **location** of deforestation?
- What is the role of **albedo** for the nonlocal effects?
- Can the nonlocal effects explain the apparent mismatch between deforestation-induced warming (observations) and cooling (models)?

Investigating the nonlocal effects



Set-up:

- Left: Complete deforestation in 1/4, 2/4 and 3/4 of all land boxes, spatially homogeneous distribution of deforestation.
- Middle: Extent of deforestation like 1/4, but only in the low, mid, or high latitudes and near historically deforested regions. Magnitude of carbon warming estimated using a bookkeeping approach [5] and the transient response to cumulative emissions [6].
- Right: Changes in areas of 3/4, only albedo is changed to grass while other surface properties of trees remain.

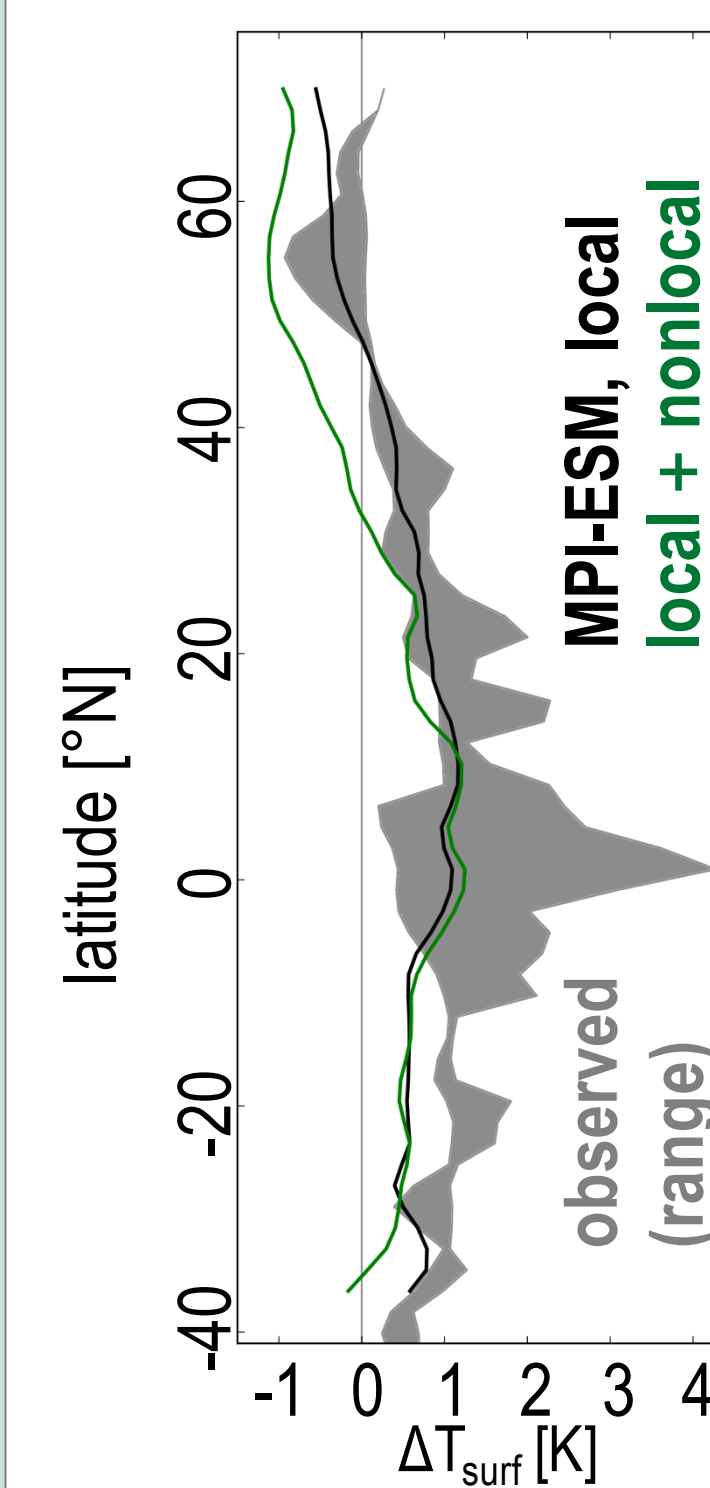
Nonlocal effects depend on extent and location of deforestation

- Nonlocal cooling is stronger than local warming (local : nonlocal = 1 : -3 for homogeneous spatial deforestation).
- Nonlocal effects scale linearly with number of deforestation boxes.
- Nonlocal cooling occurs also for low-latitude deforestation and a more realistic distribution of deforestation ('hist').
- The overall effect of deforestation is likely still warming because of carbon release.

Role of changes in surface albedo

- The increase in albedo is responsible for the deforestation-induced biogeophysical cooling.
- Locally, this cooling is partly compensated for by changes in the sensible and latent heat fluxes (not shown).
- The albedo-induced cooling is mainly included in the nonlocal effects.
- Thus models may seem to cool stronger than observations.

Model vs. observations

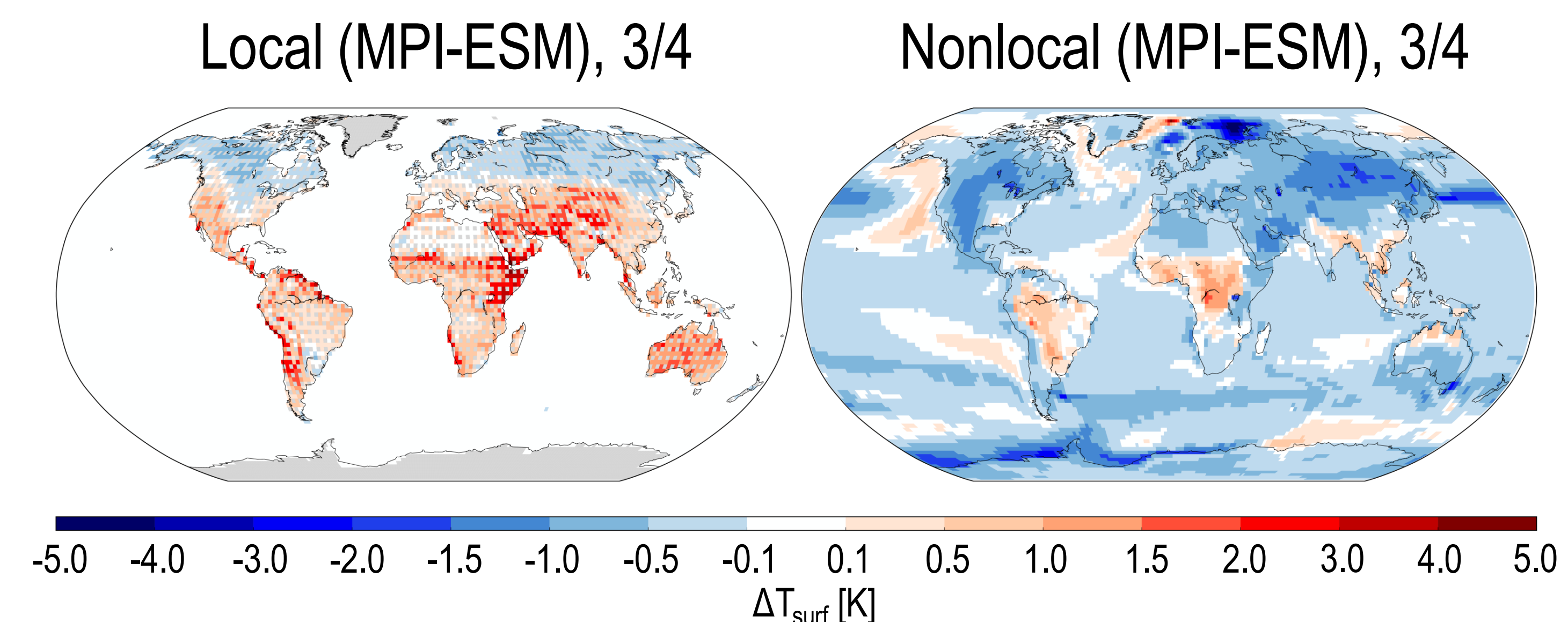


Local effects

- Observations based on in situ (FluxNet) [2] or satellite (MODIS) data [3,4]
- MPI-ESM: Local effects as in [1] within the range of independent observations

Nonlocal effects

- Not captured by observations, and thus contribute to mismatch with simulated effects.



References:

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