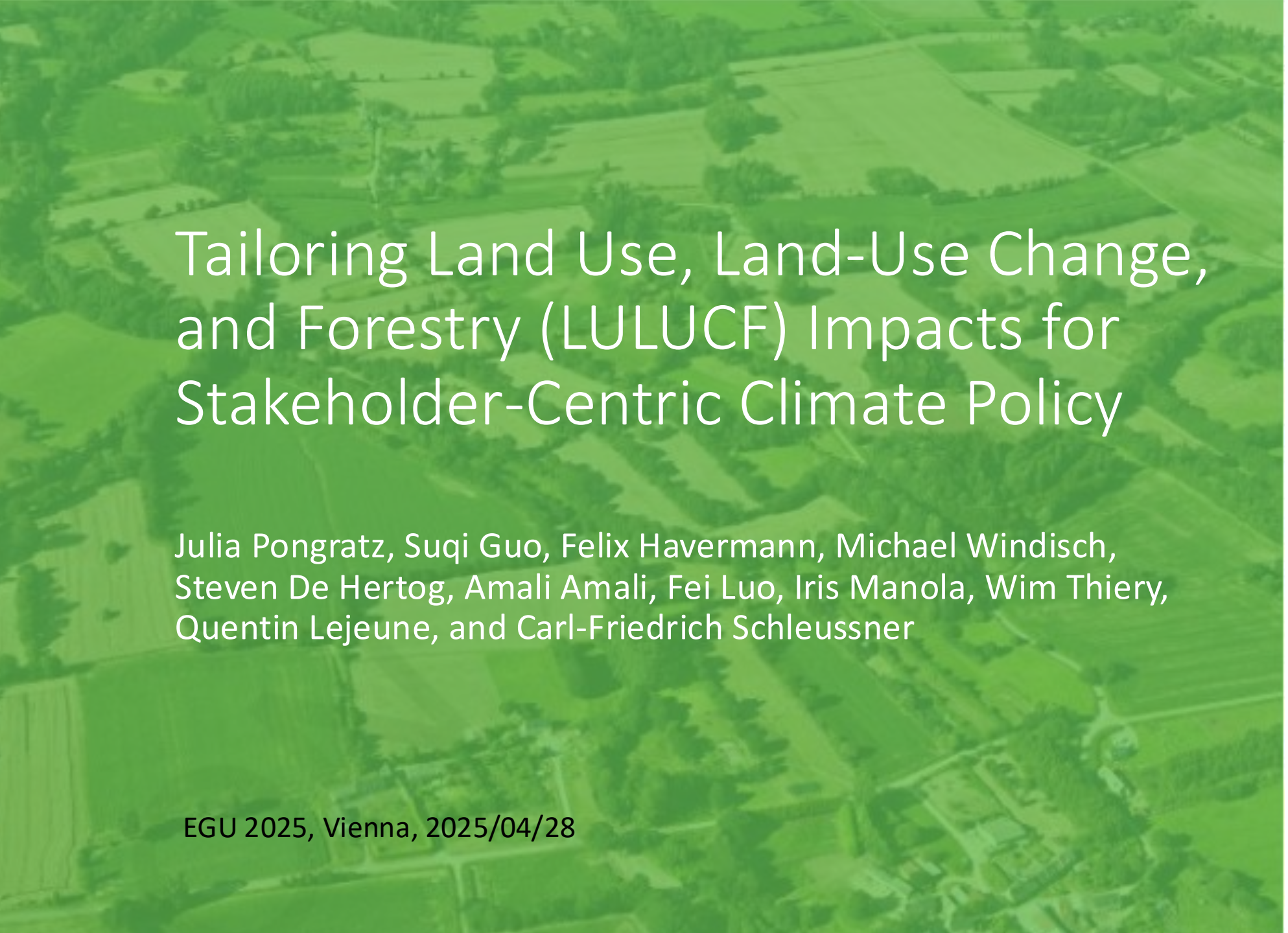

Tailoring Land Use, Land-Use Change, and Forestry (LULUCF) Impacts for Stakeholder-Centric Climate Policy

Julia Pongratz, Suqi Guo, Felix Havermann, Michael Windisch, Steven De Hertog, Amali Amali, Fei Luo, Iris Manola, Wim Thiery, Quentin Lejeune, and Carl-Friedrich Schleussner

EGU 2025, Vienna, 2025/04/28

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

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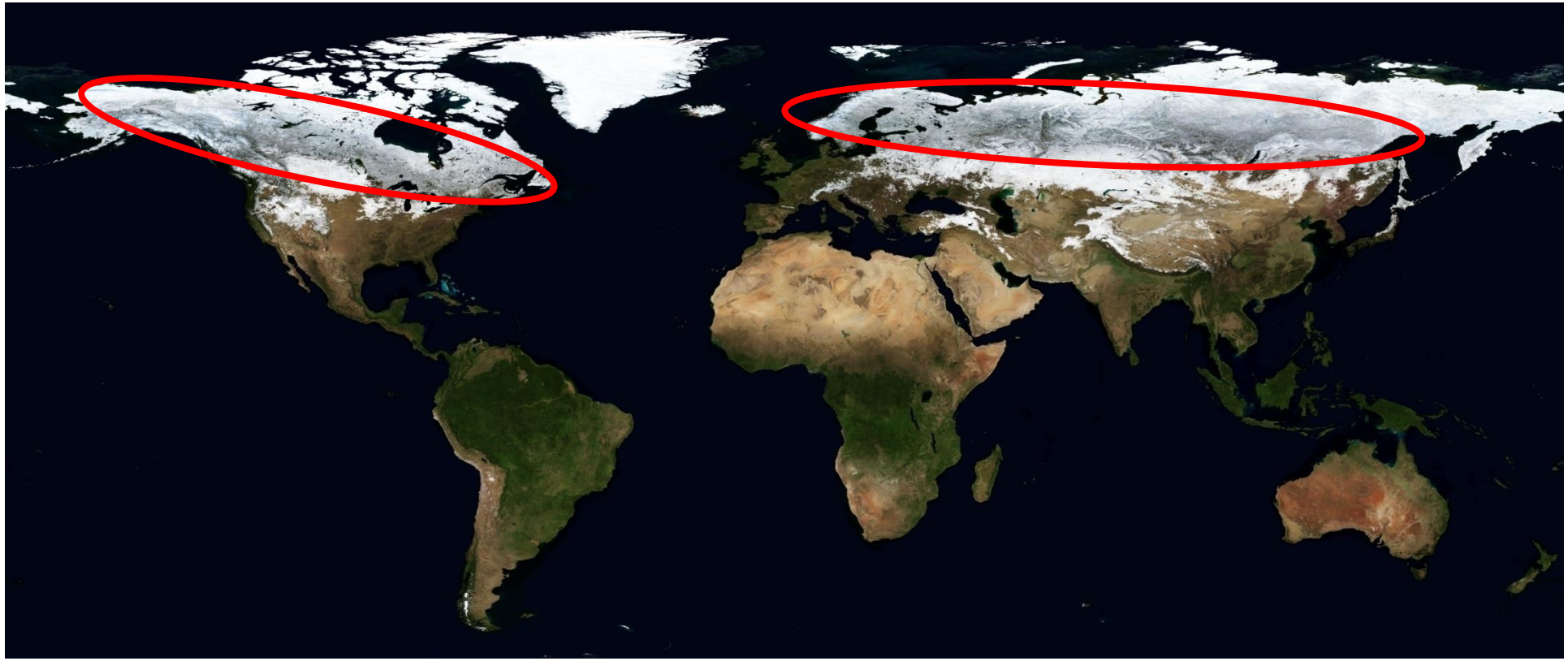
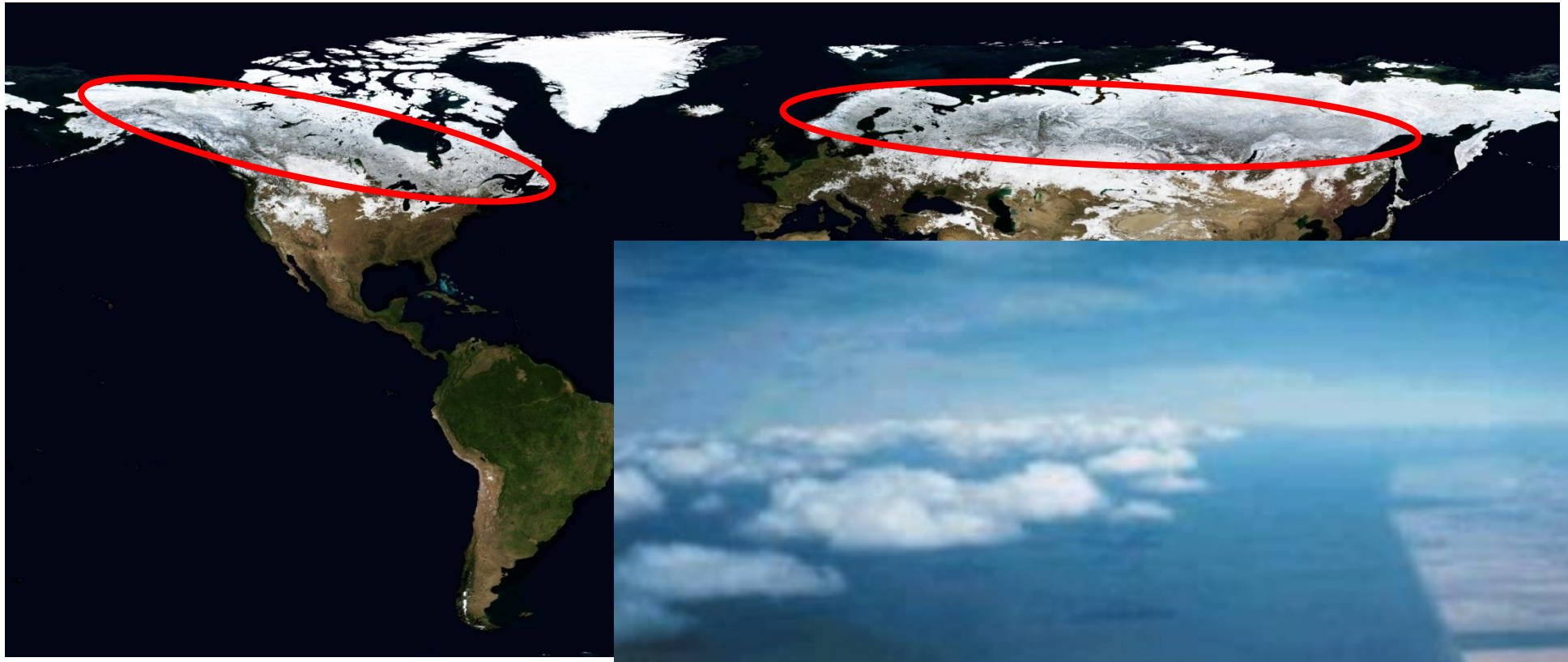
LAMA CLIMA
Land Management for Climate Mitigation and Adaptation

Land-atmosphere interactions are influenced by LULUCF



Land-atmosphere interactions are influenced by LULUCF



"Rabbit fence" in Australia (Lyons, *Meteor. Atmos. Physics*, 2002)

Land-atmosphere interactions are influenced by LULUCF

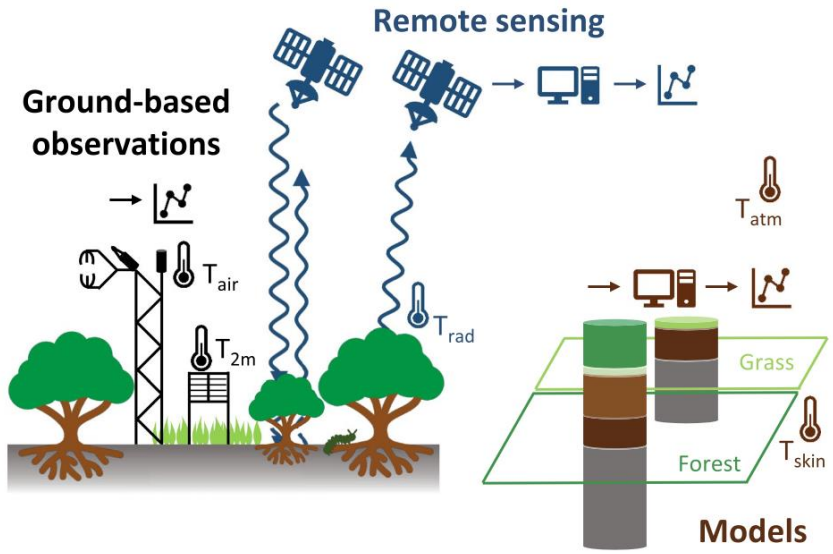
2021

Current Climate Change Reports
https://doi.org/10.1007/s40641-021-00178-y

VEGETATION AND CLIMATE CHANGE (M CLAUSSEN, SECTION EDITOR)

Land Use Effects on Climate: Current State, Recent Progress, and Emerging Topics

Julia Pongratz[1,2] · Clemens Schwingshackl[1] · Selma Bultan[1] · Wolfgang Obermeier[1] · Felix Havermann[1] · Suqi Guo[1]



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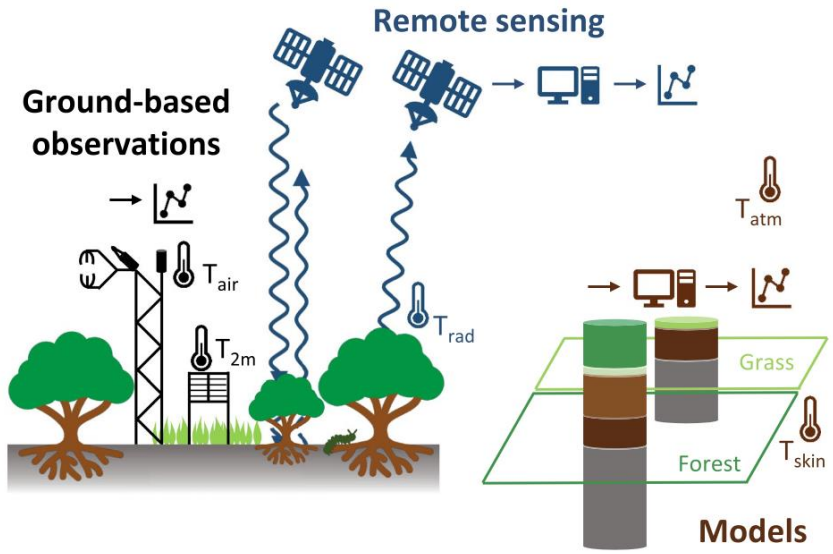
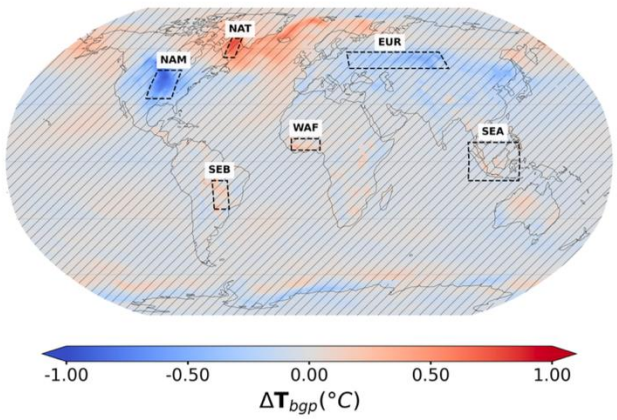


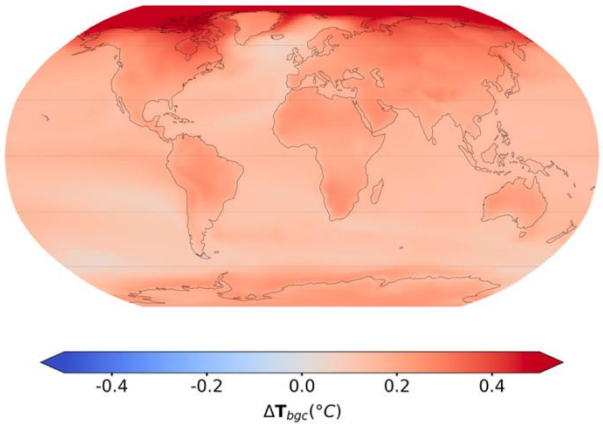
In press

EGUsphere Preprint repository

Biogeochemical versus biogeophysical temperature effects of historical land-use change in CMIP6

Amali A. Amali[1], Clemens Schwingshackl[1], Akihiko Ito[2], Alina Barbu[3], Christine Delire[3], Daniele Peano[4], David M. Lawrence[5], David Wårlind[6], Eddy Robertson[7], Edouard L. Davin[8,9,10], Elena Shevliakova[11], Ian N. Harman[12], Nicolas Vuichard[13], Paul A. Miller[6], Peter J. Lawrence[5], Tilo Ziehn[14], Tomohiro Hajima[15], Victor Brovkin[16,17], Yanwu Zhang[18], Vivek K. Arora[19], and Julia Pongratz[1,16]





Climate extremes are influenced by LULUCF

2010

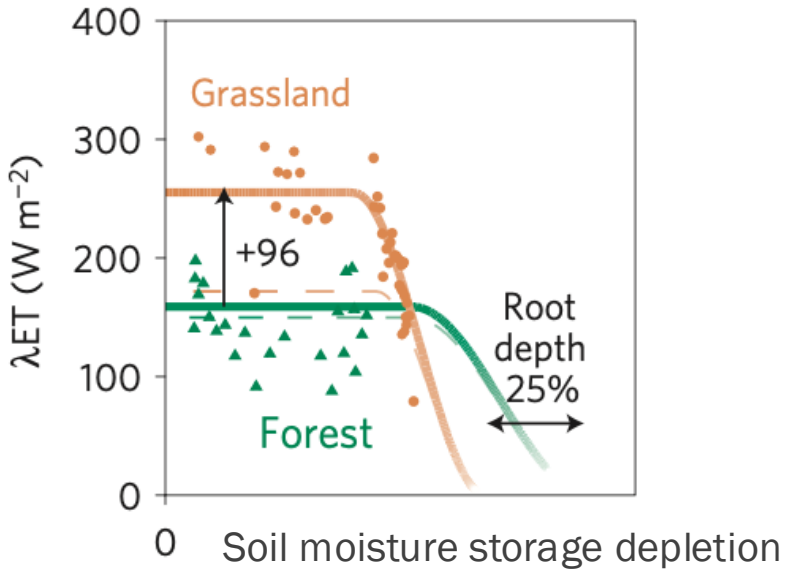
nature geoscience

ARTICLES

PUBLISHED ONLINE: 5 SEPTEMBER 2010 | DOI: 10.1038/NGEO950

Contrasting response of European forest and grassland energy exchange to heatwaves

Adriaan J. Teuling[1,2]*, Sonia I. Seneviratne[1]*, Reto Stöckli[3], Markus Reichstein[4], Eddy Moors[5], Philippe Ciais[6], Sebastiaan Luyssaert[6], Bart van den Hurk[7], Christof Ammann[8], Christian Bernhofer[9], Ebba Dellwik[10], Damiano Gianelle[11], Bert Gielen[12], Thomas Grünwald[9], Katja Klumpp[13], Leonardo Montagnani[14,15], Christine Moureaux[16], Matteo Sottocornola[11] and Georg Wohlfahrt[17]



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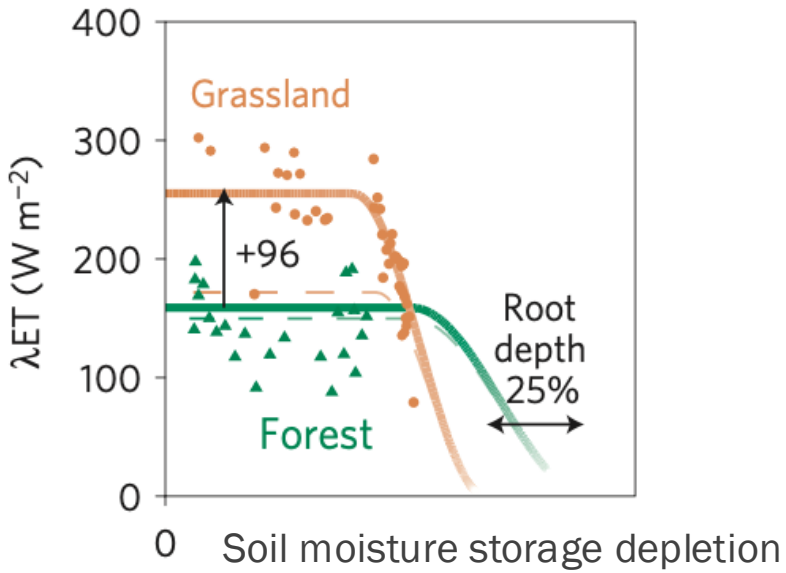


2017

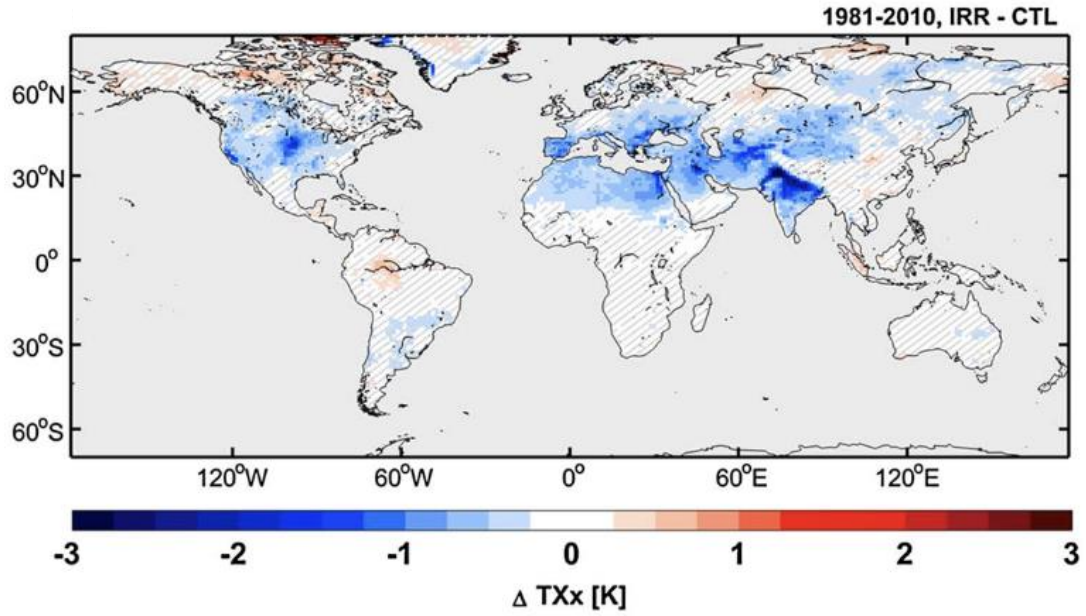
AGU PUBLICATIONS

JGR

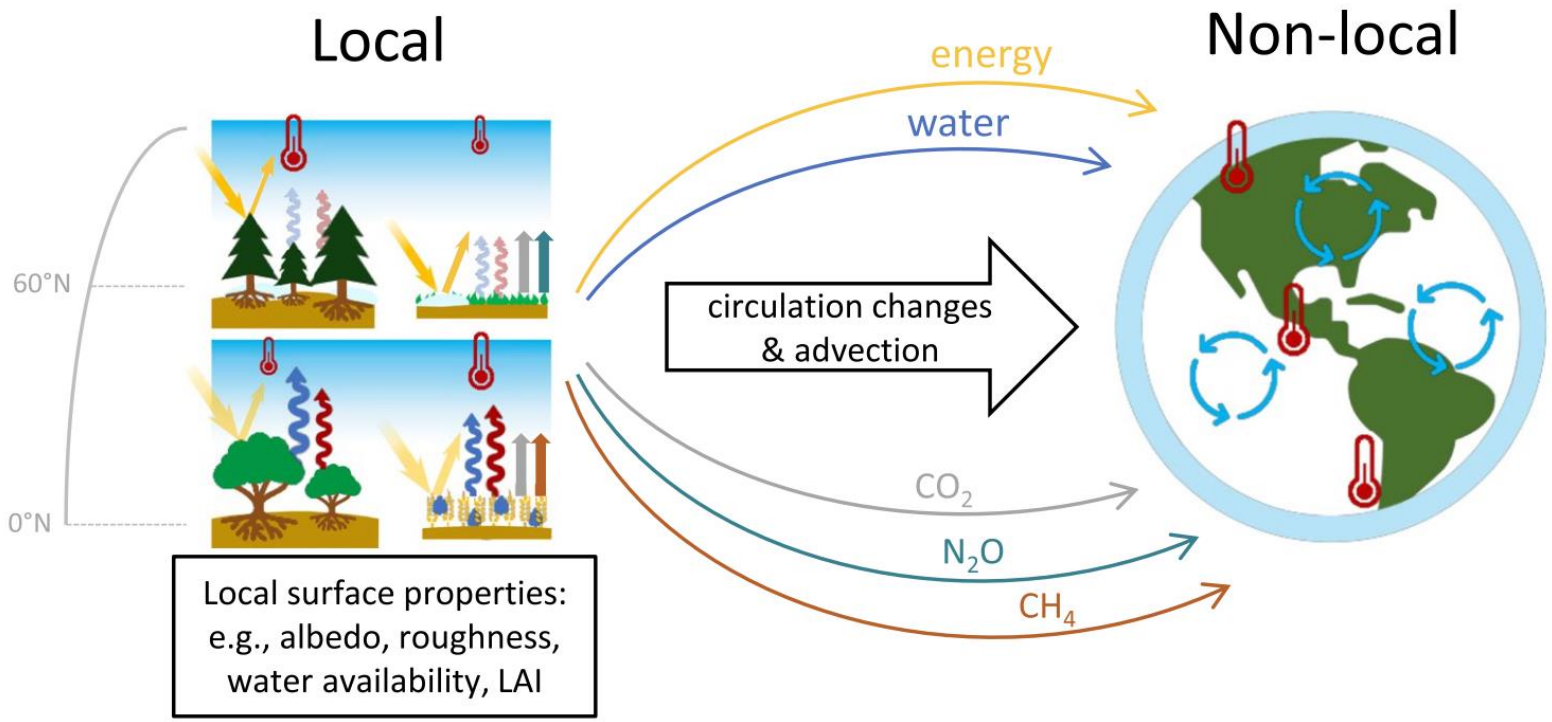
Journal of Geophysical Research: Atmospheres

Present-day irrigation mitigates heat extremes

Wim Thiery[1,2], Edouard L. Davin[1], David M. Lawrence[3], Annette L. Hirsch[1], Mathias Hauser[1], and Sonia I. Seneviratne[1]



Accounting for LULUCF impacts requires care

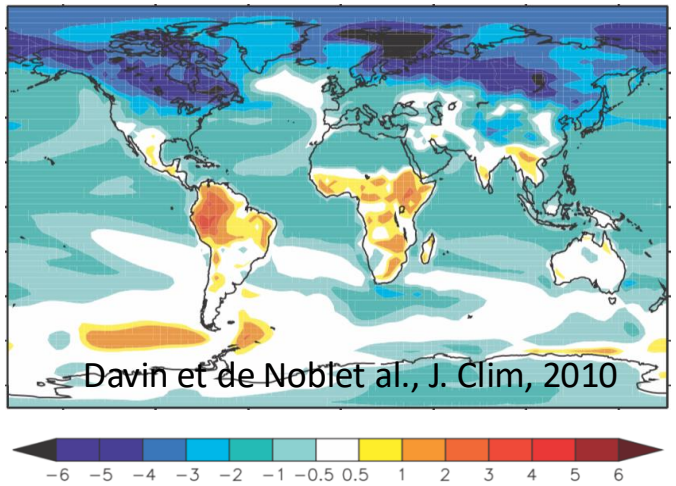


Pongratz et al., *Curr. Clim. Change Rev.*, 2021

Models had – wrongly! – been thought to be wrong

MODELS

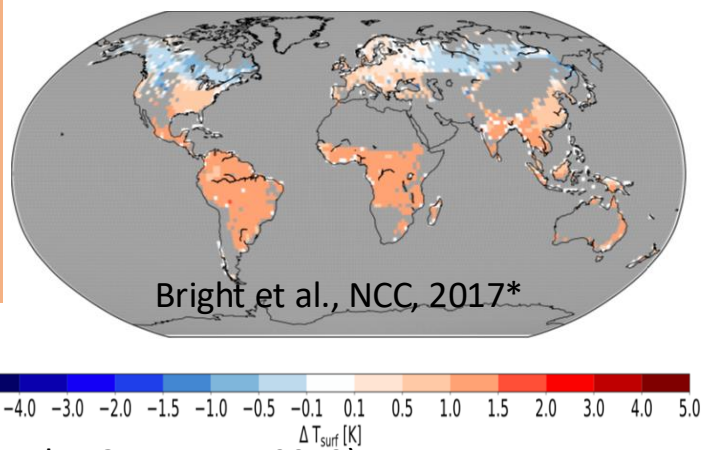
Modeled temperature change (K) by global deforestation



Models: **cooling** in boreal, but also temperate regions

OBSERVATIONS

Observed temperature change due to deforestation



Observations: cooling in boreal, **warming** in temperate regions

* (as shown by Winckler et al., *JGR-Atmos.*, 2019)

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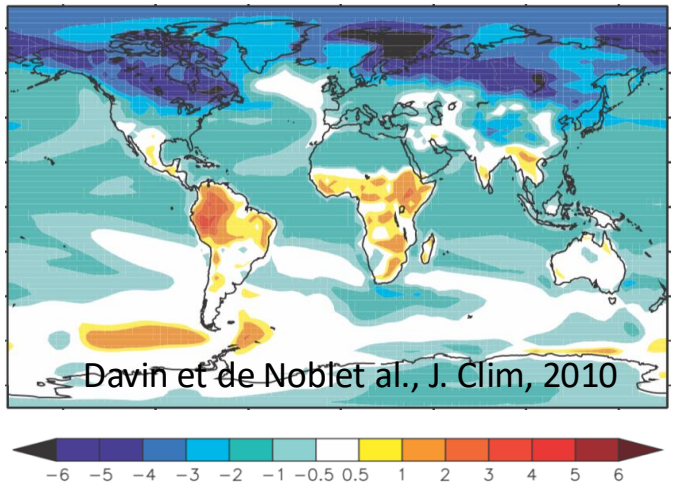

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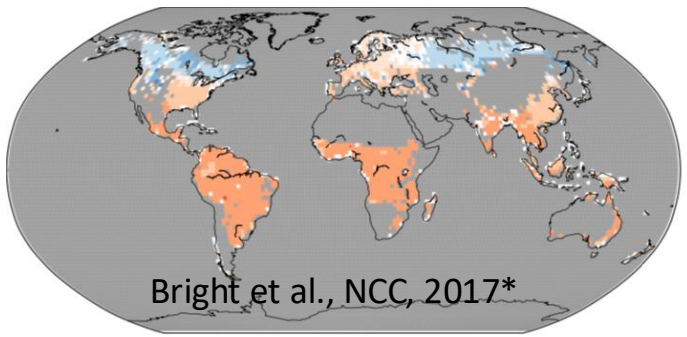

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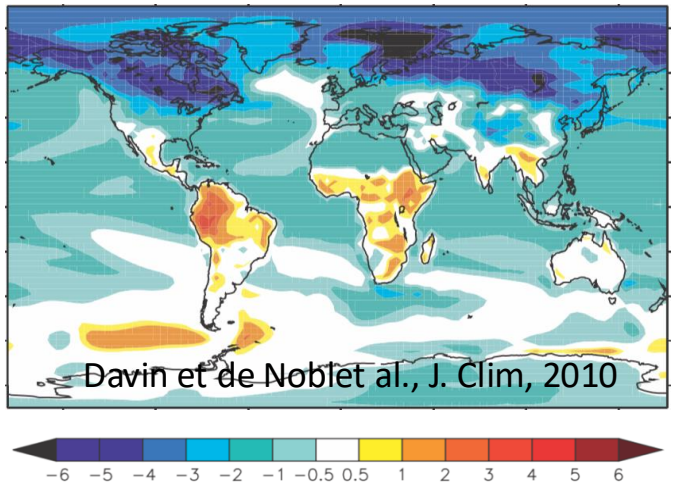


Models: **cooling** in boreal, but also temperate regions

Local + non-local effects

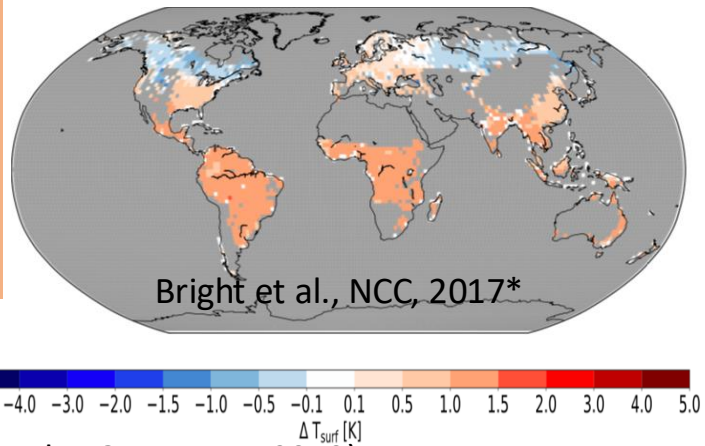
Reconciled by Earth system model:

Non-local effects add a cooling.

(Winckler et al., *Geophys. Res. Lett.*, 2018)

OBSERVATIONS

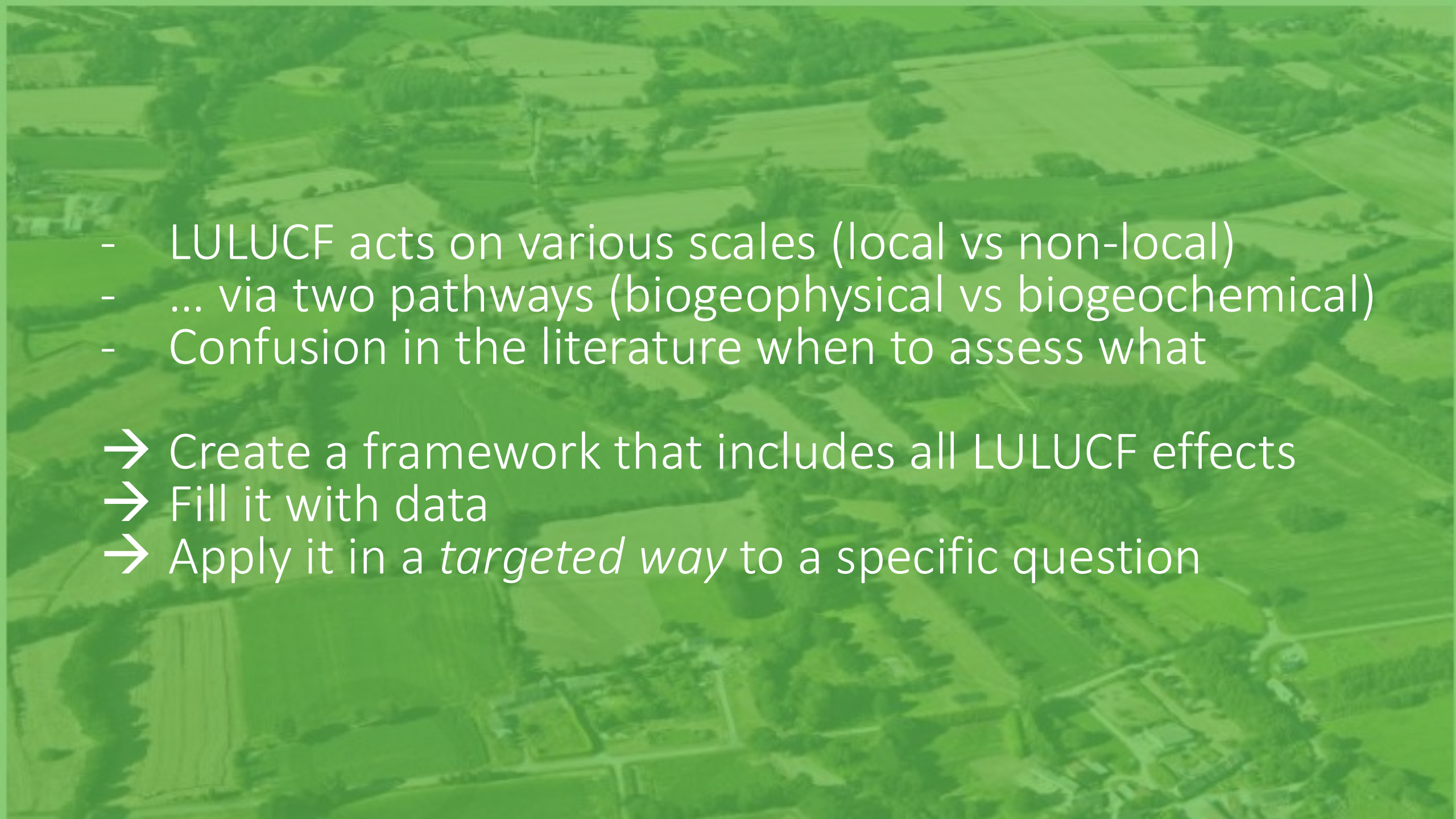
Observed temperature change due to deforestation



Observations: cooling in boreal, **warming** in temperate regions

Local effects only

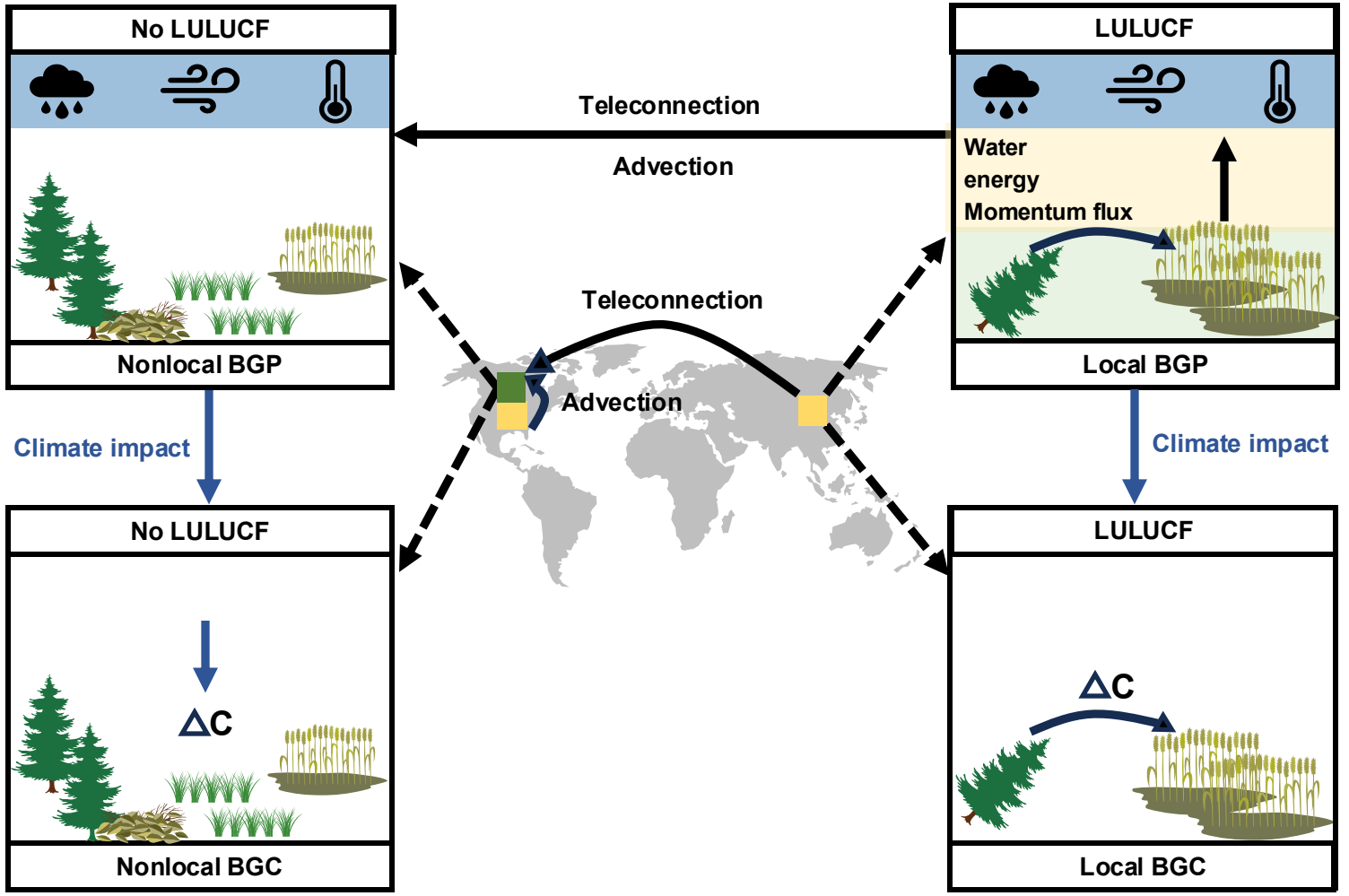
* (as shown by Winckler et al., *JGR-Atmos.*, 2019)



- LULUCF acts on various scales (local vs non-local)
- … via two pathways (biogeophysical vs biogeochemical)
- Confusion in the literature when to assess what

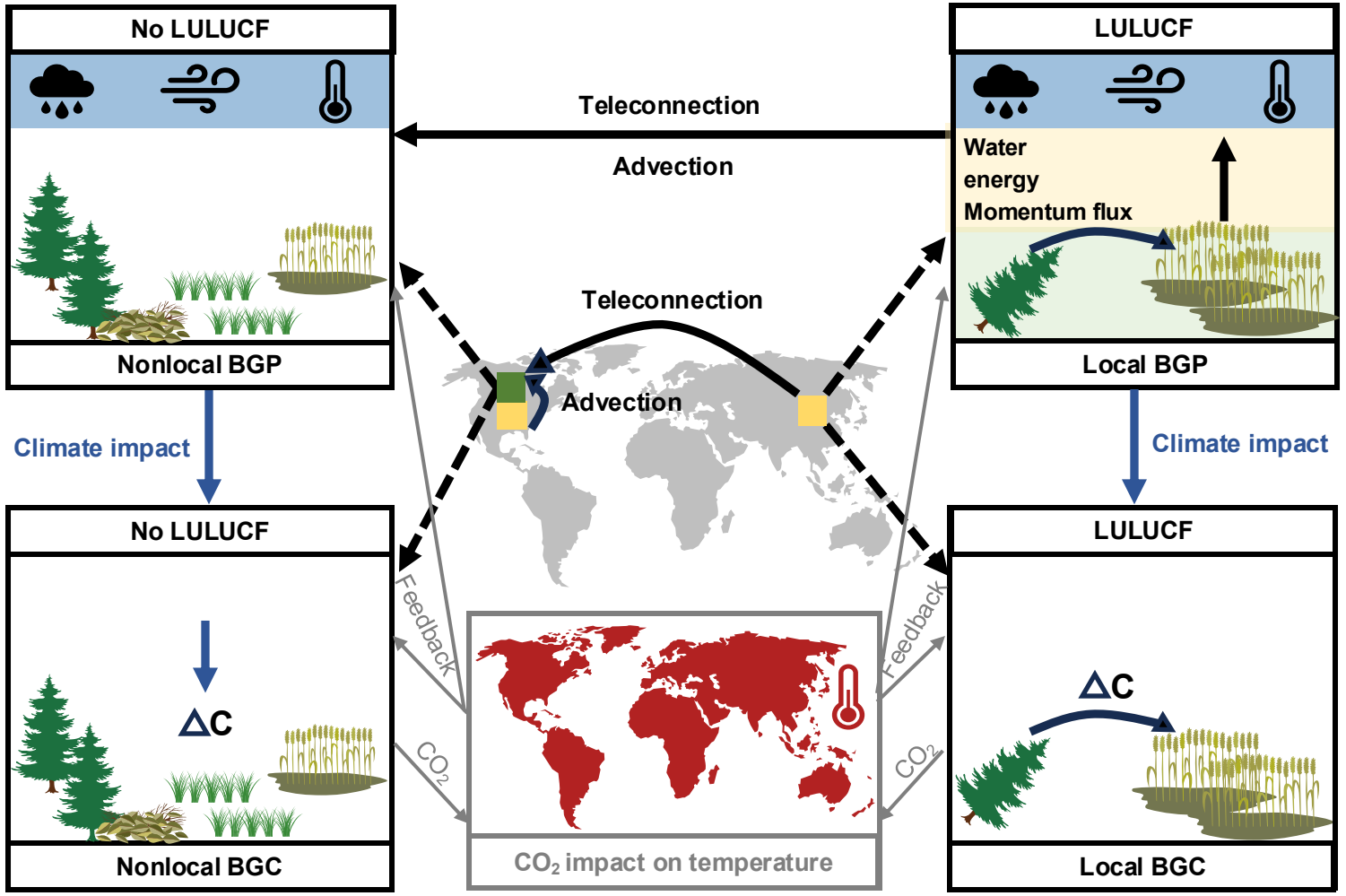
→ Create a framework that includes all LULUCF effects
→ Fill it with data
→ Apply it in a *targeted way* to a specific question

Systematizing scales and pathways



Guo et al., in prep.

Systematizing scales and pathways



Guo et al., in prep.

Filling in gaps in the framework

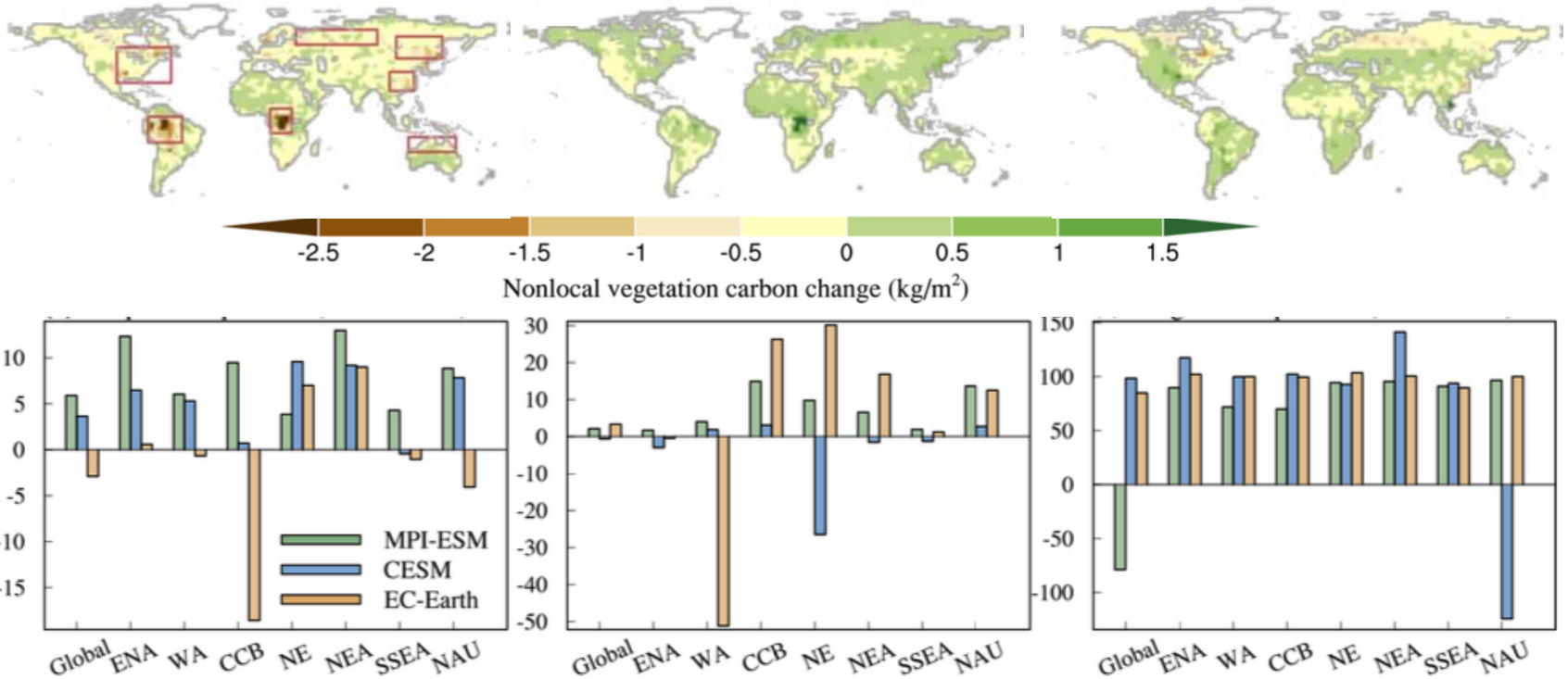
In press

EGUsphere Preprint repository

Remote carbon cycle changes are overlooked impacts of land-cover and land management changes

Suqi Guo[1], Felix Havermann[1], Steven J. De Hertog[2,3], Fei Luo[4,5,6], Iris Manola[4], Thomas Raddatz[7], Hongmei Li[7,8,9], Wim Thiery[2], Quentin Lejeune[10], Carl-Friedrich Schleussner[10,11,12], David Wårlind[13], Lars Nieradzik[13], Julia Pongratz[1,7]

Cropland expansion | Afforestation | Irrigation expansion



(Examplary results from MPI Earth System Model)

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Filling the framework with data

- Any data (in-situ, remote sensing, …) can be used, but only modeling will provide non-local effects
- LAMACLIMA provided estimates of all (local and non-local, biogeophysical and biogeochemical) effects for various land management changes

In press

EGUsphere Preprint repository

Remote carbon cycle changes are overlooked impacts of land-cover and land management changes

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Earth Syst. Dynam., 13, 1305–1350, 2022
https://doi.org/10.5194/esd-13-1305-2022

Earth System Dynamics
Open Access
EGU

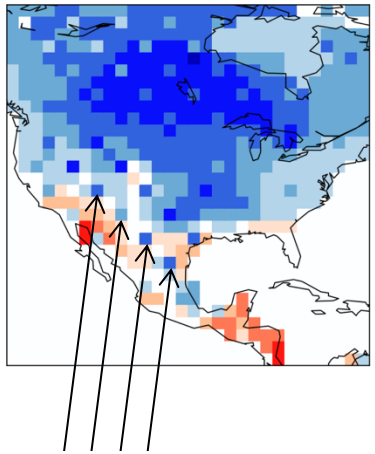
The biogeophysical effects of idealized land cover and land management changes in Earth system models

Steven J. De Hertog[1], Felix Havermann[2], Inne Vanderkelen[1], Suqi Guo[2], Fei Luo[3,4], Iris Manola[3], Dim Coumou[3,4], Edouard L. Davin[5,6], Gregory Duveiller[7], Quentin Lejeune[8], Julia Pongratz[2,9], Carl-Friedrich Schleussner[8], Sonia I. Seneviratne[6], and Wim Thiery[1]

Approach for separating local and non-local effects

Method: Winckler, Reick, and Pongratz, *J. Clim.*, 2017

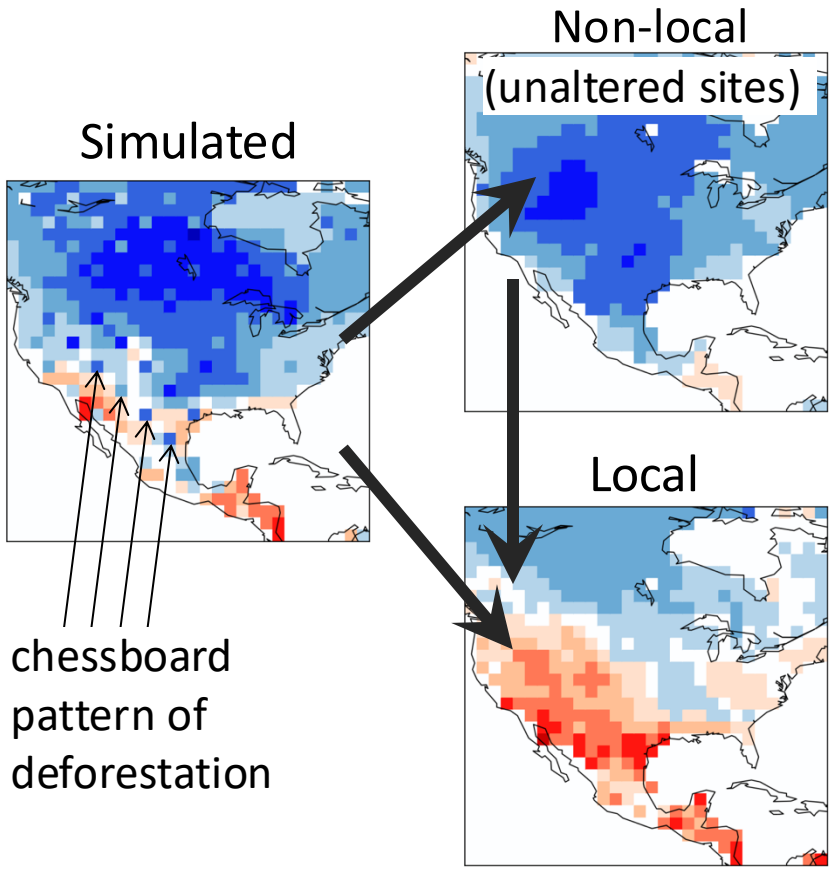
Simulated



chessboard pattern of deforestation

Approach for separating local and non-local effects

Method: Winckler, Reick, and Pongratz, *J. Clim.*, 2017



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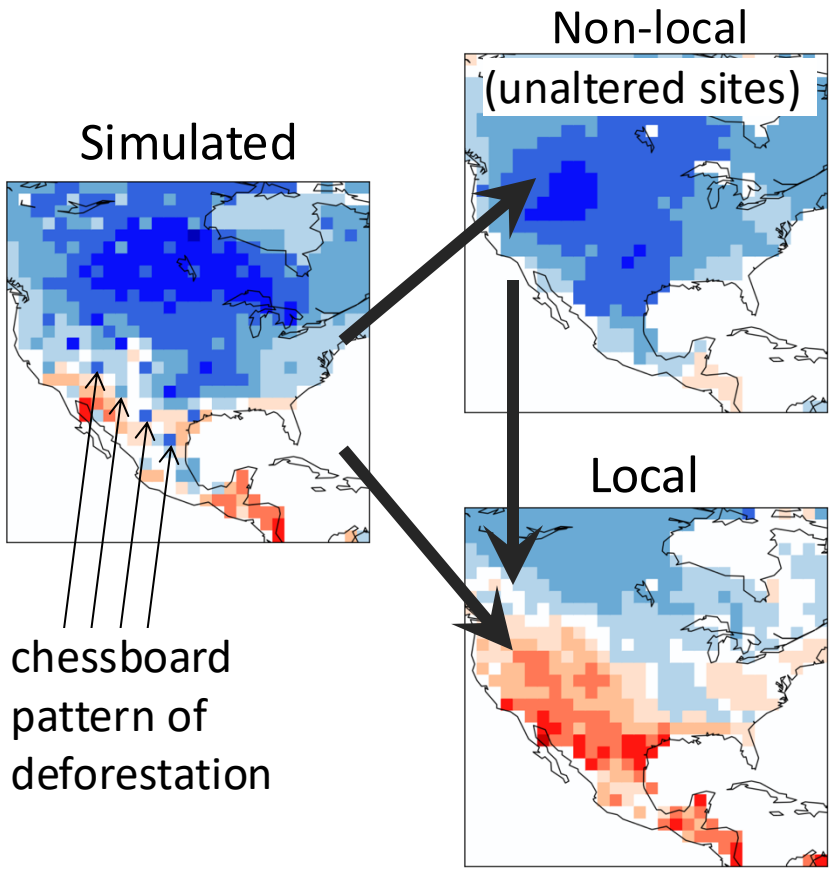
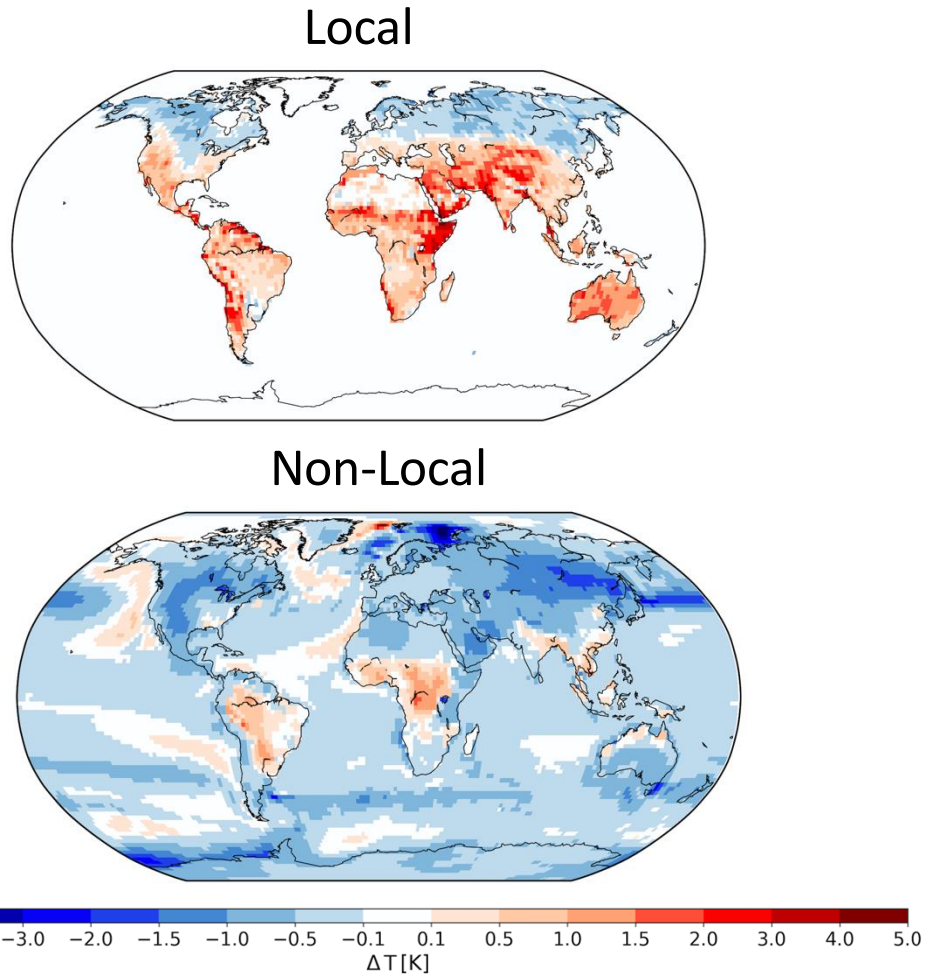
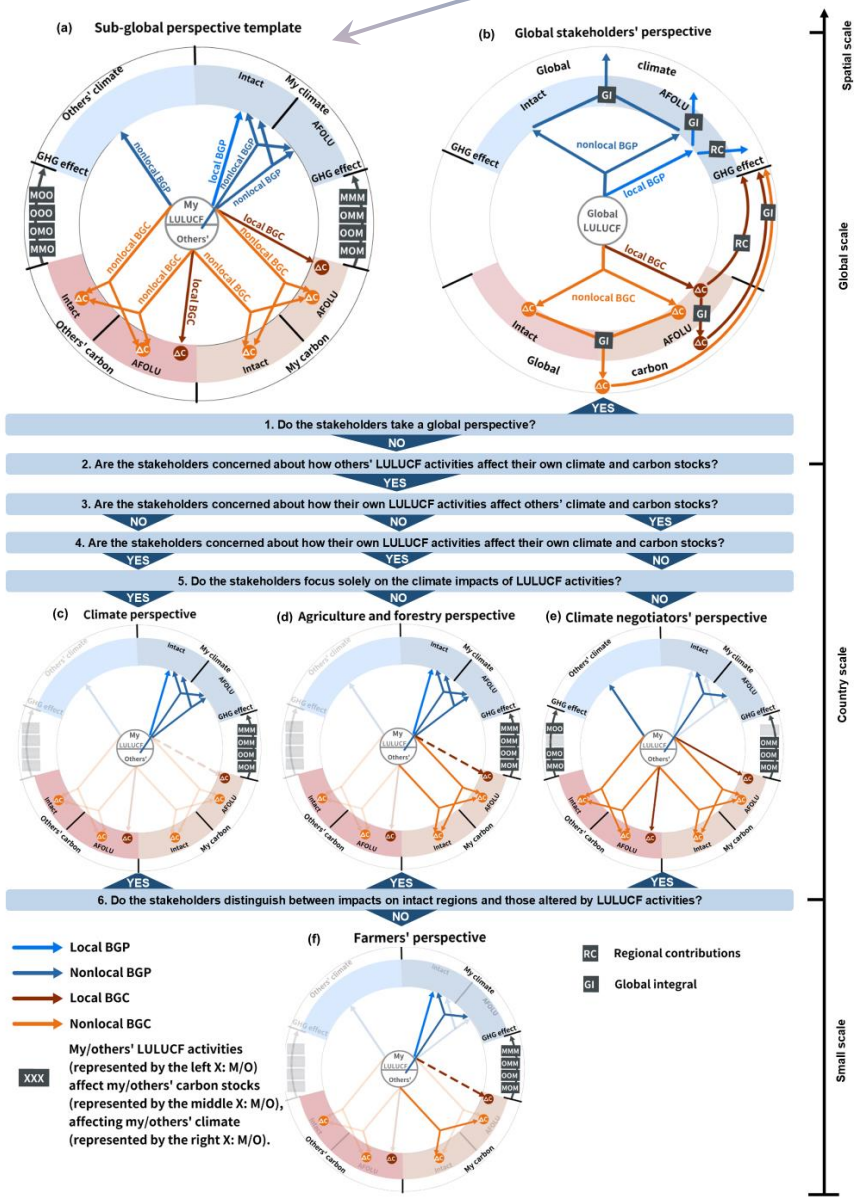


Result (global deforestation): Surface temperature change



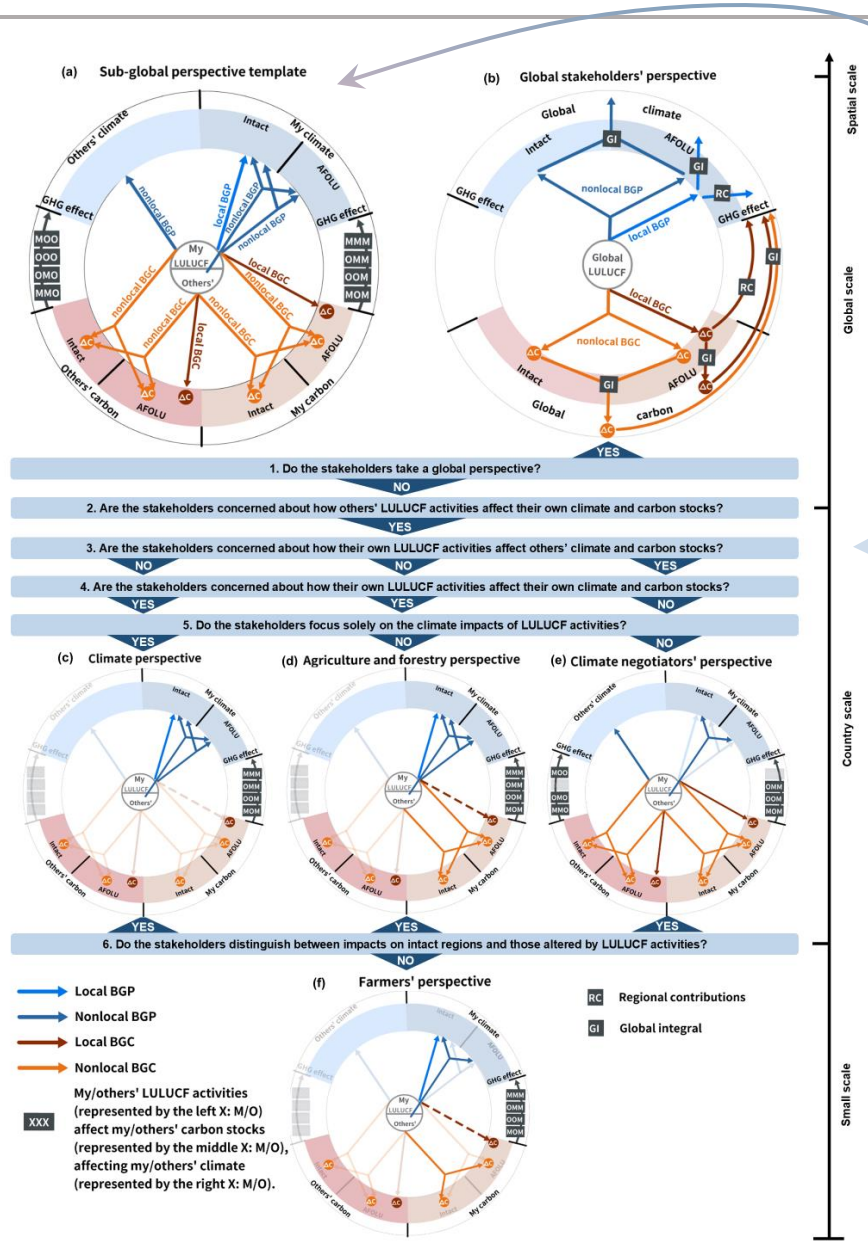
Framework for identifying different perspectives



Guo et al., in prep.

Systematization of all LULUCF impacts

Framework for identifying different perspectives



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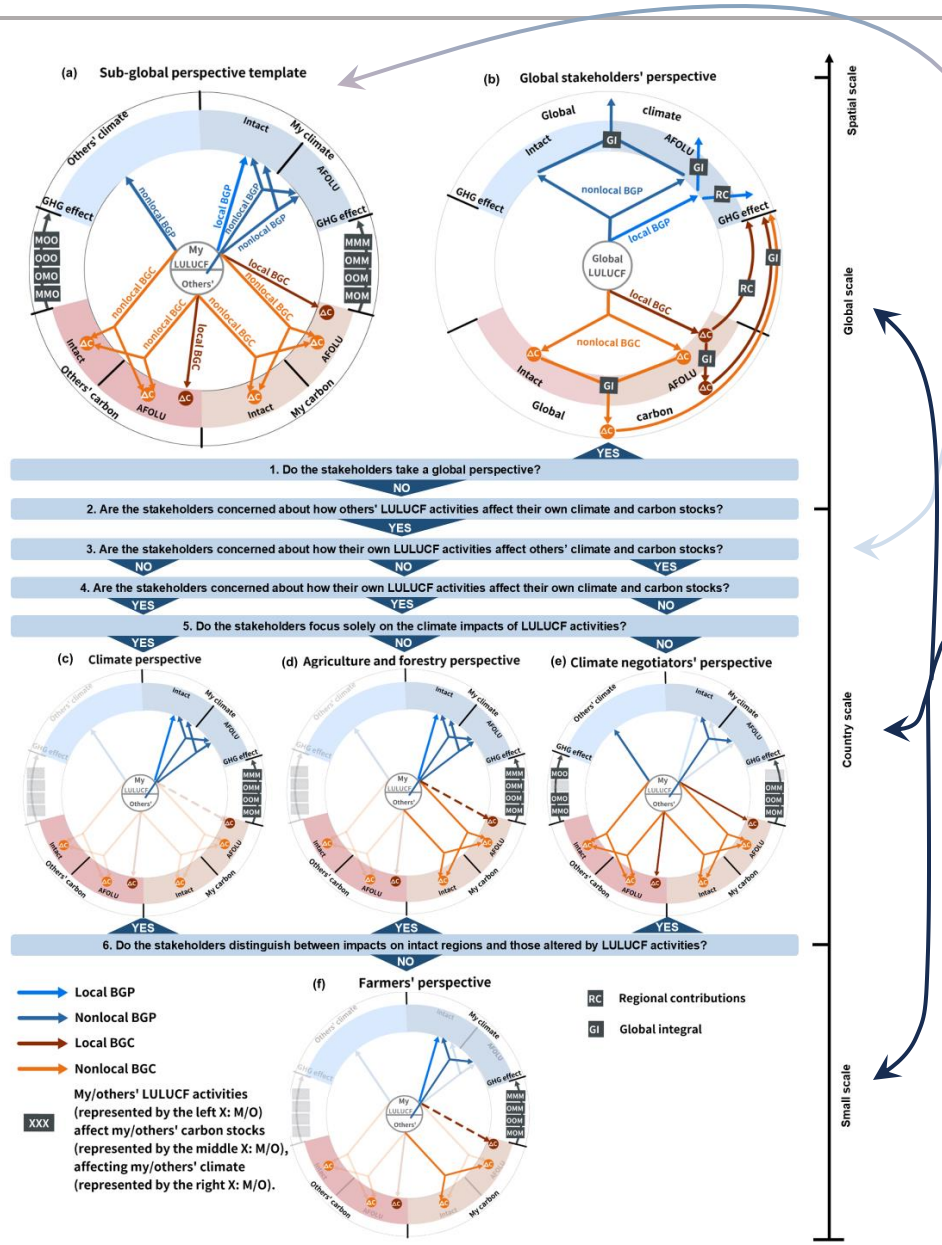
Systematization of all LULUCF impacts

Decision tree to identify perspective

Framework for identifying different perspectives



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Decision tree to identify perspective

Different scales (global, country, field scale)

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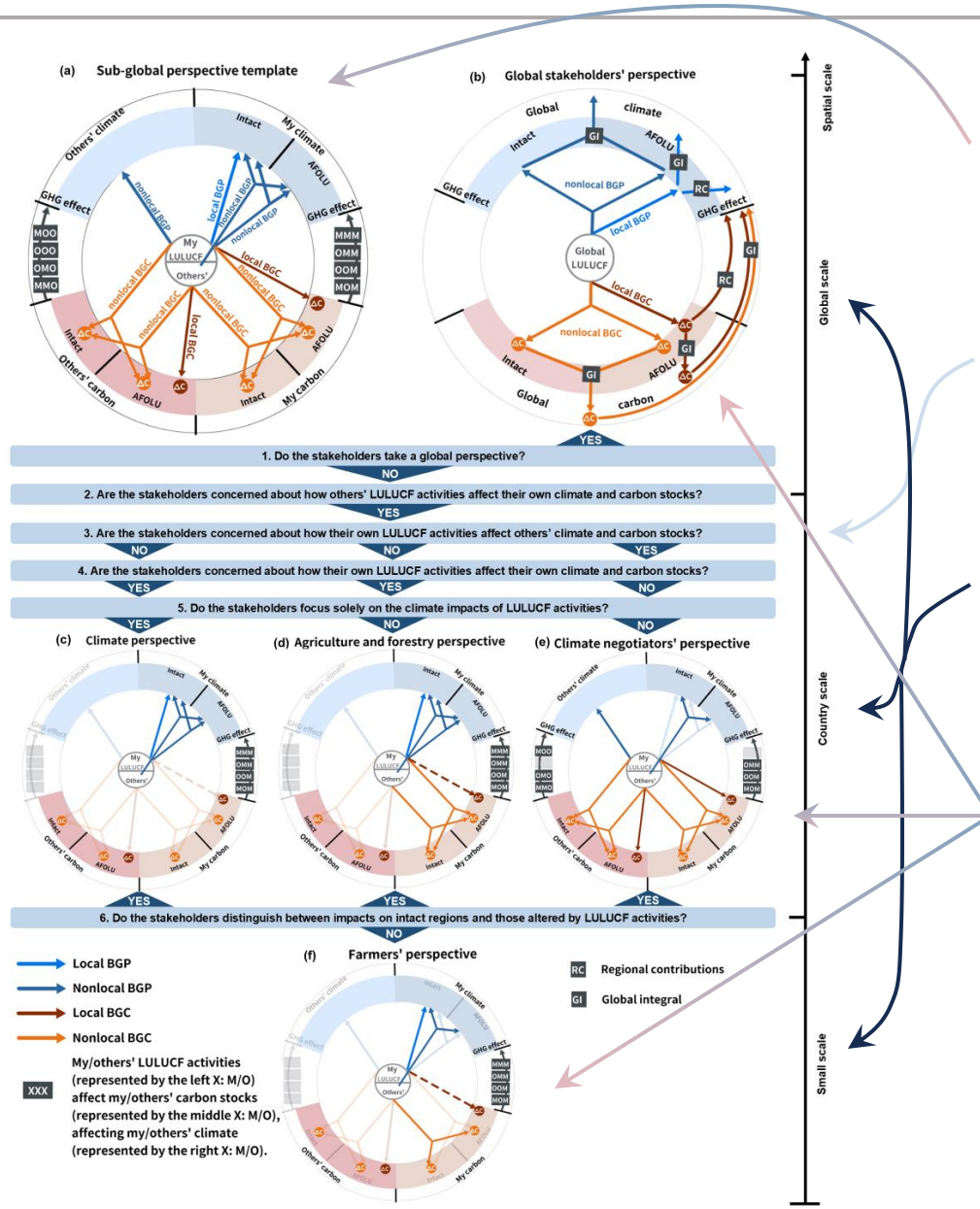


Guo et al., in prep.

Systematization of all LULUCF impacts

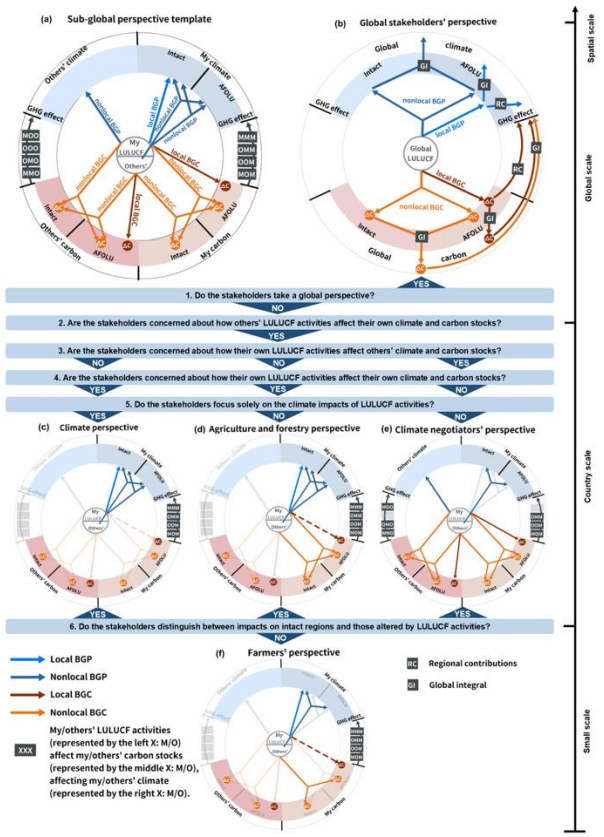
Decision tree to identify perspective

Different scales (global, country, field scale)

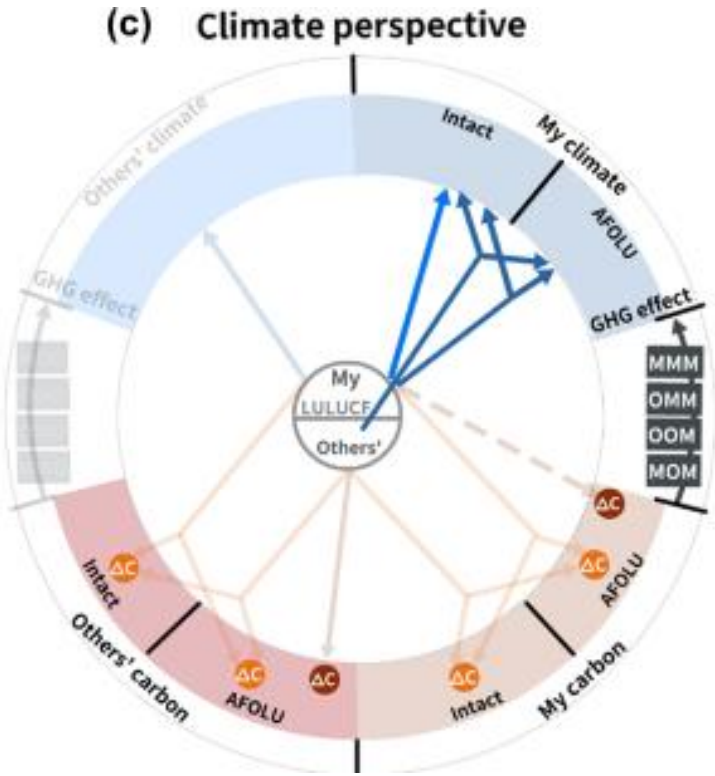
Various outcomes of which impacts need to be considered

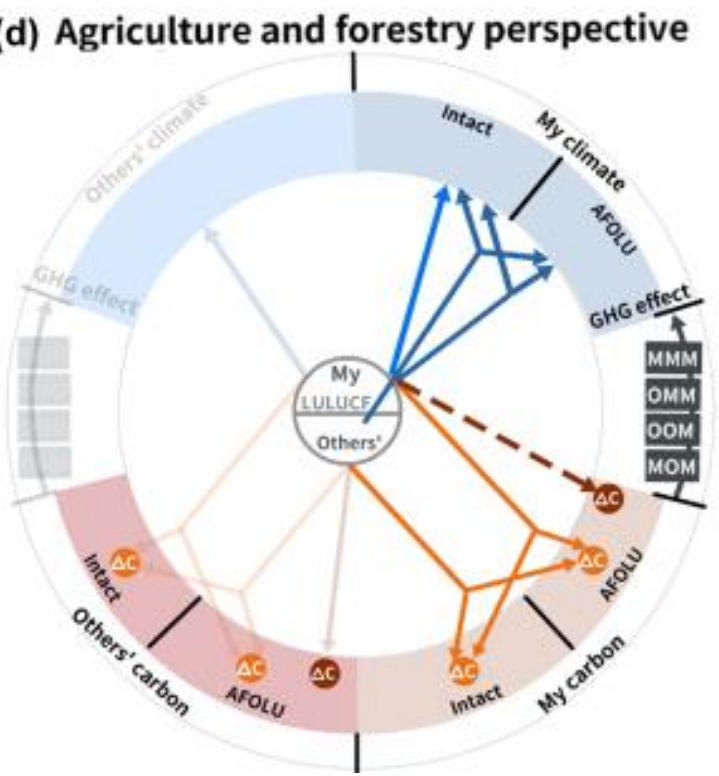
Framework for identifying different perspectives

Guo et al., in prep.



Two examples:





Conclusion on assessing the LULUCF impacts for climate policies

- Current political focus has been mostly on **greenhouse gas fluxes** – which ignores partly massive **biogeophysical effects** on climate mean and extremes
- The complexity across pathways and **scales (local vs non-local)** is high for LULUCF
- LAMACLIMA provided a **systematic framework** to address the needs of a large variety of questions (**"stakeholder perspectives"**)
- Outlook:
  - Incorporate data on more LULUCF practices, under more climate scenarios
  - Iterate with stakeholders and incorporate their variables of concern (such as specific climate extremes)