Unpacking the potential:

How proposed reforestation scenarios shape global and regional temperature

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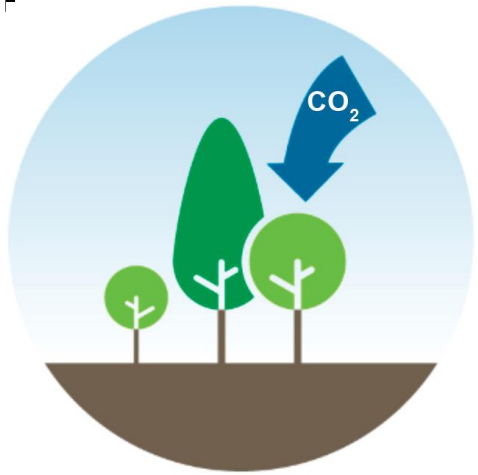
Introduction

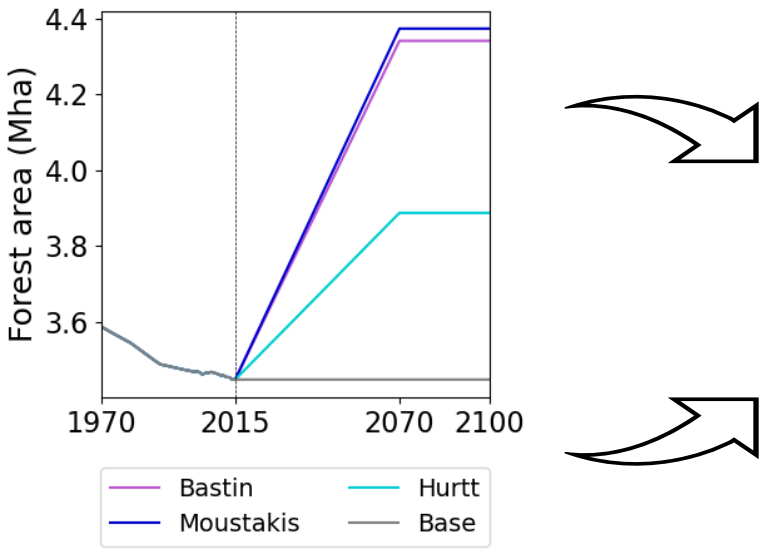
- Reforestation as a promising solution for carbon dioxide removal
- Proposed reforestation potential range from 150 to >1000 Mha
- Biogeochemical (BGC) and biogeophysical (BGP) effects of trees

➢ **No comparison of climate response across multiple reforestation potentials in fully-coupled ESM**



Simulations & Analysis

Input data



- SSP2-4.5 concentrations
- Baseline: fixed 2015 LC
- 3 reforestation potentials: Bastin, Moustakis, Hurtt

Bastin et al. 2019, Moustakis et al. 2024, Hurtt et al. 2020, Amali et al. 2024

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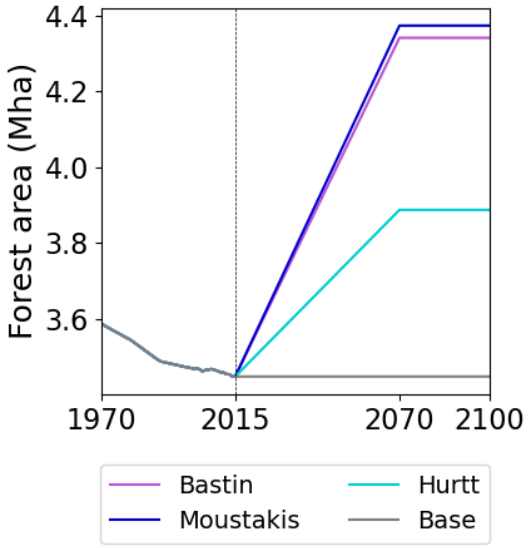
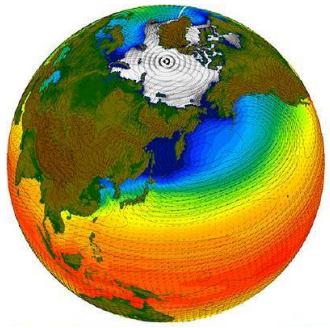


Fully-coupled CESM2



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- 5 ensemble members
- BGP simulated
- BGC calculated:

$$\Delta\bar{T}_{BGC} = -TCRE \cdot \bar{c}_{Land}$$

Bastin et al. 2019, Moustakis et al. 2024, Hurtt et al. 2020, Amali et al. 2024

Simulations & Analysis

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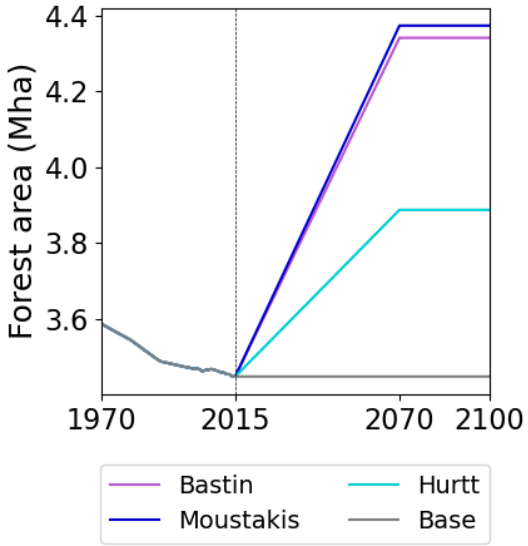

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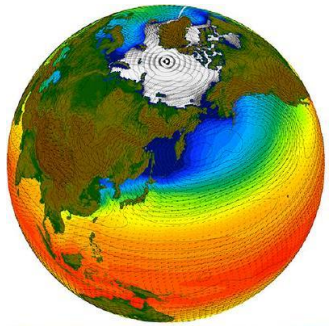

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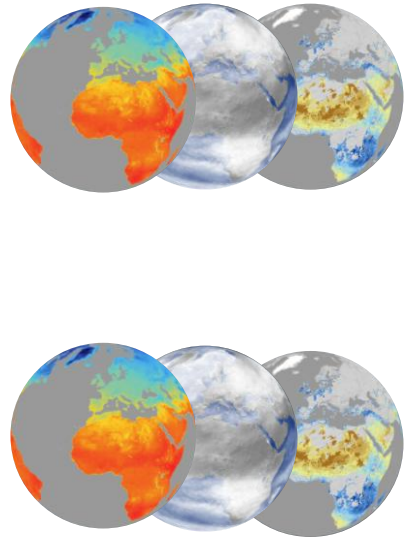
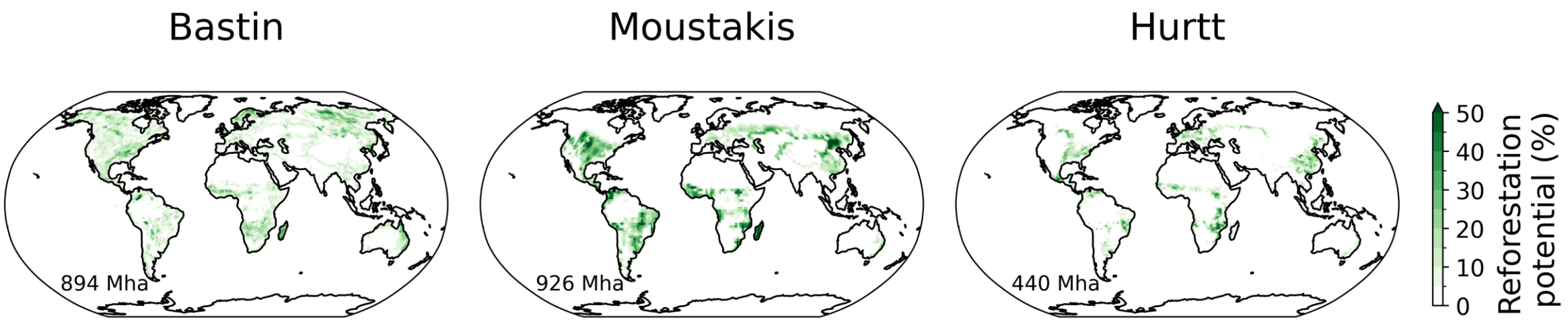
Research focus



1. Global BGP and BGC temperature changes
2. Regional BGP temperature patterns

Bastin et al. 2019, Moustakis et al. 2024, Hurtt et al. 2020, Amali et al. 2024

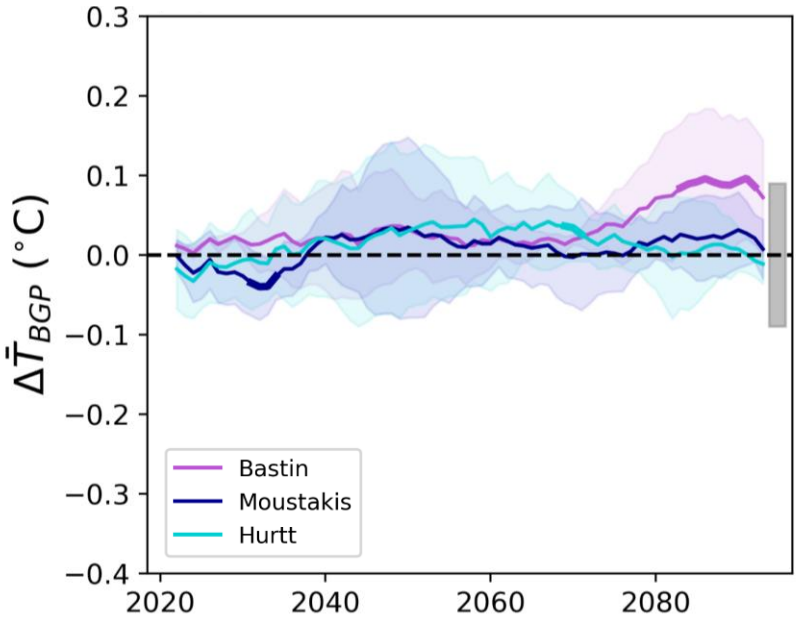
Large differences in reforestation potentials



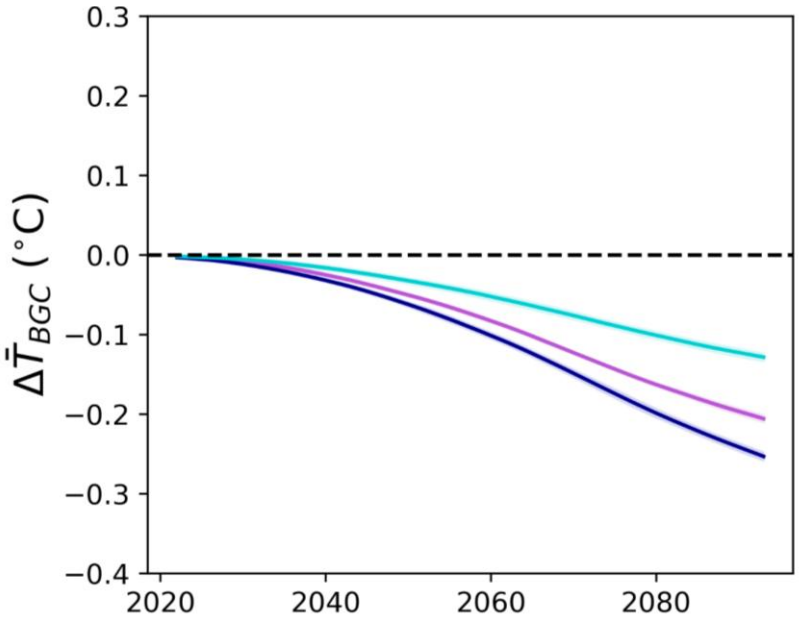
- Similar reforestation placement in e.g., Amazonia, Congo, eastern USA
- Large differences in reforestation in high latitudes & total reforestation area

Bastin et al. 2019, Moustakis et al. 2024, Hurtt et al. 2020

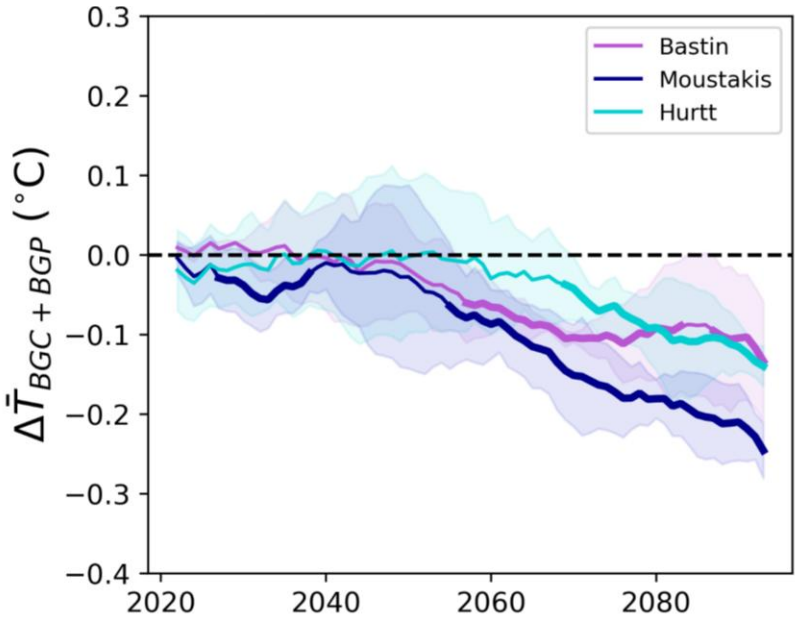
Similar global cooling with less reforestation



Biogeophysical:
BGP warming in Bastin towards end of century

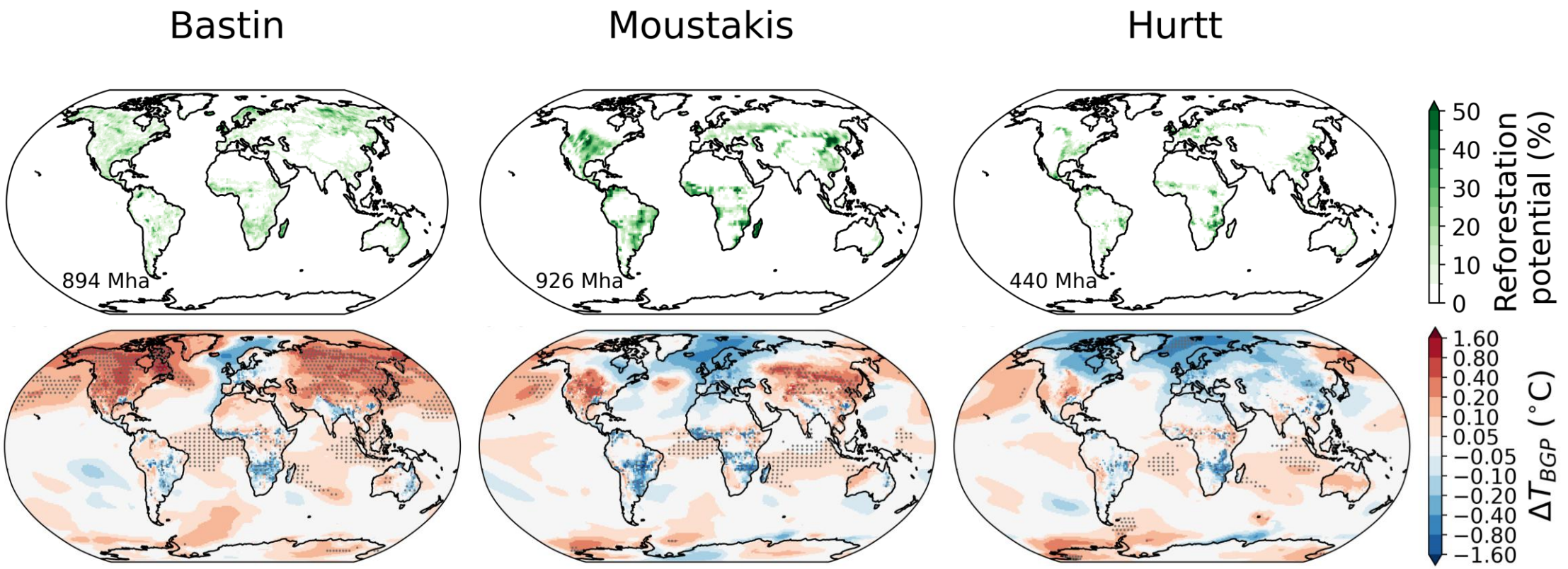


Biogeochemical:
Global BGC cooling for all 3 datasets



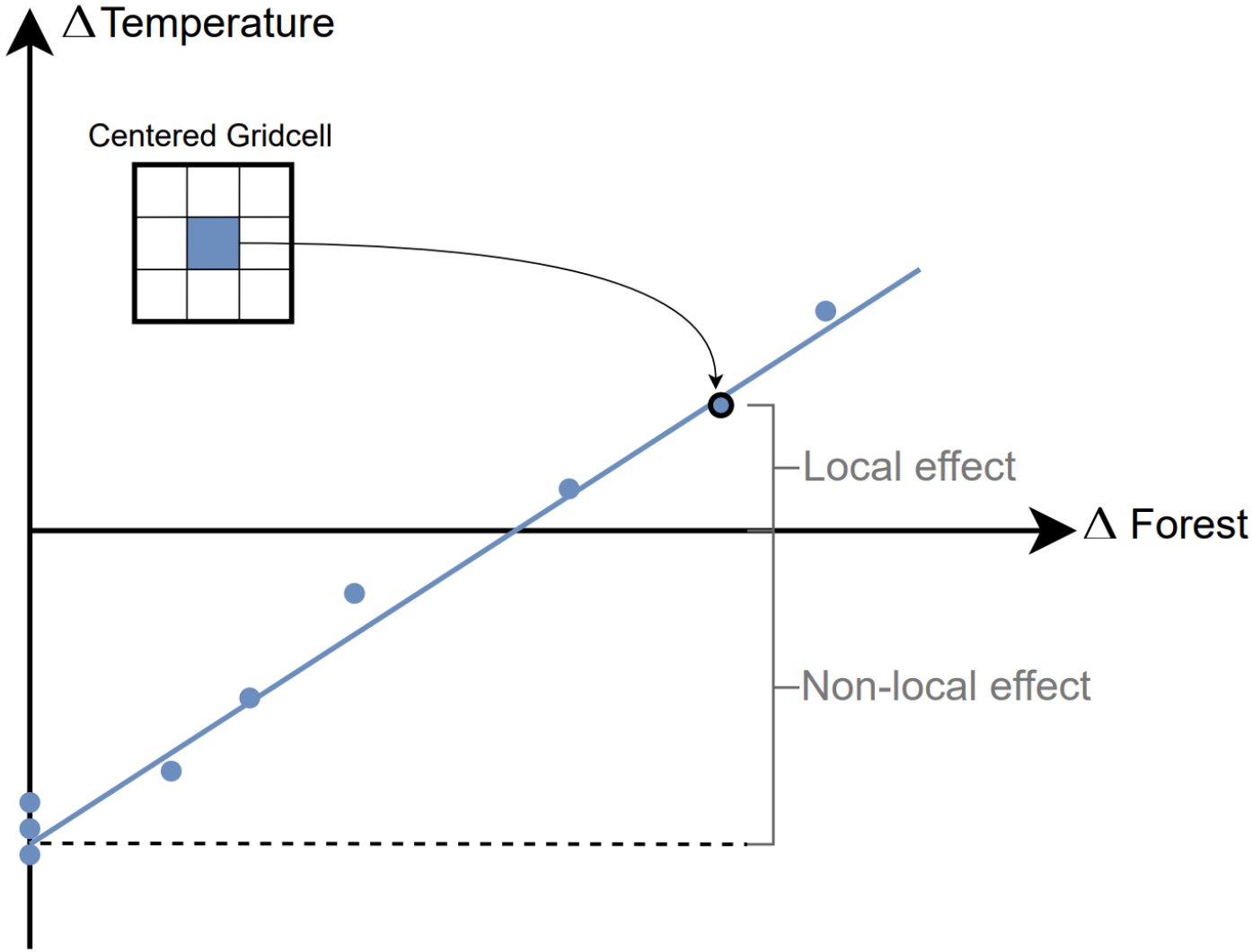
Net global cooling of 0.25°C (Moustakis) and 0.13°C (Bastin & Hurtt)

Reforestation location drives regional BGP pattern



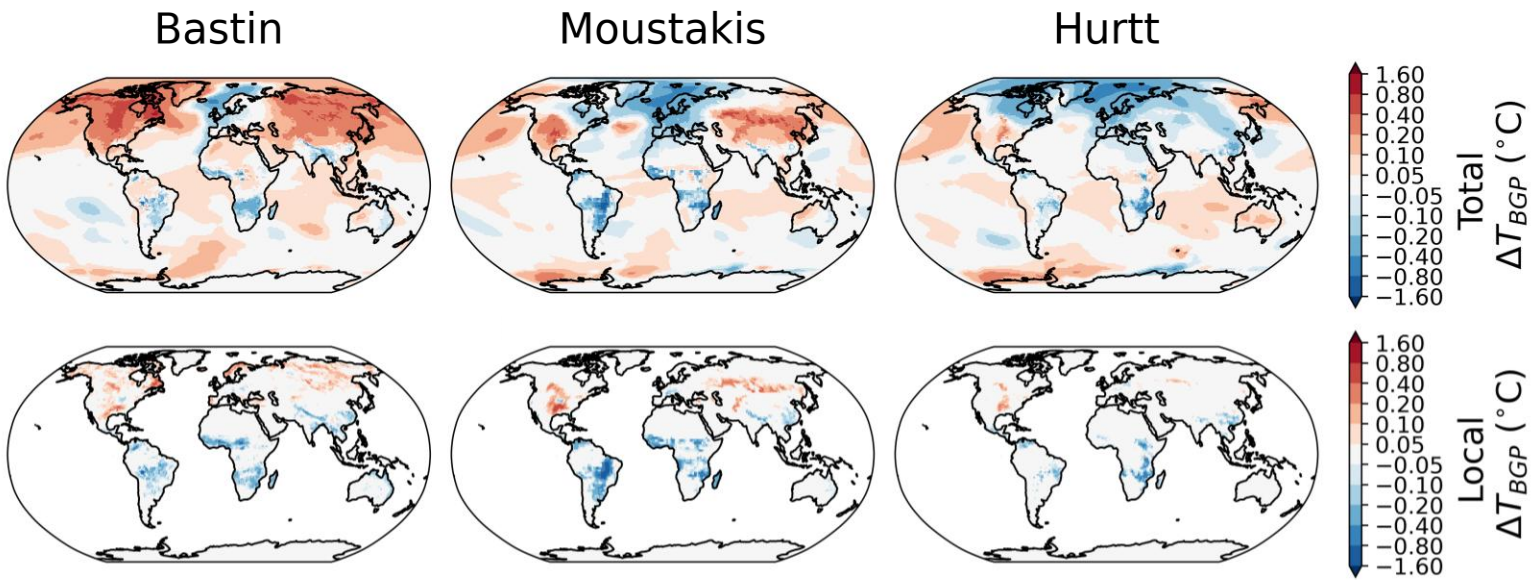
- Consistent cooling over tropical land, Europe and Norwegian Sea
- Large differences in temperature responses in high-latitude regions

Mowing window regression for local/non-local



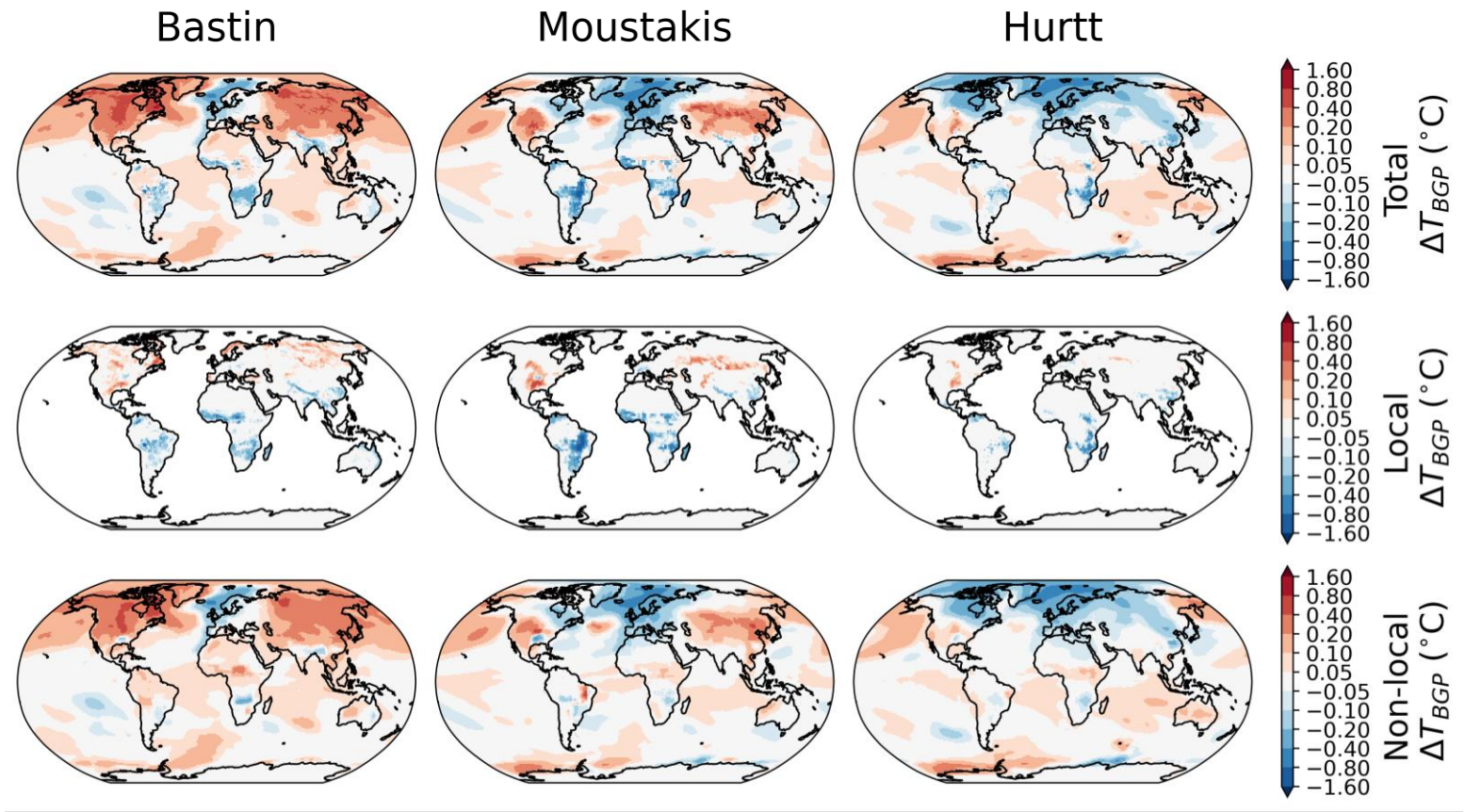
Gao et al. 2017,
Lejeune et al. 2018

Non-local effects govern temperature differences



- Consistent local tropical cooling and high-latitude warming

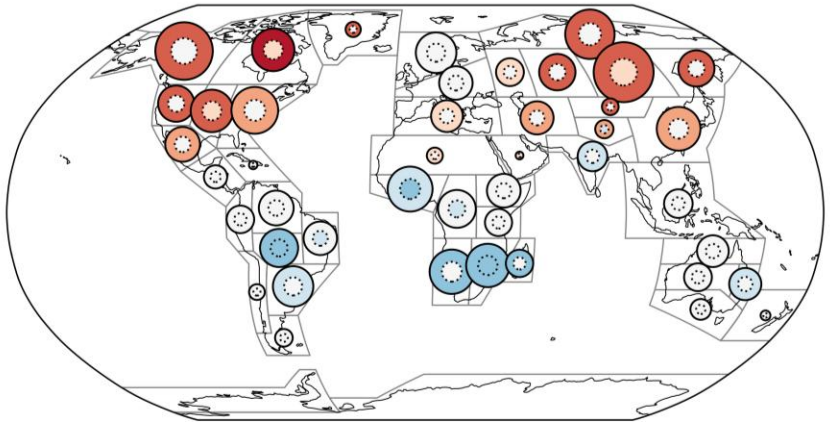
Non-local effects govern temperature differences



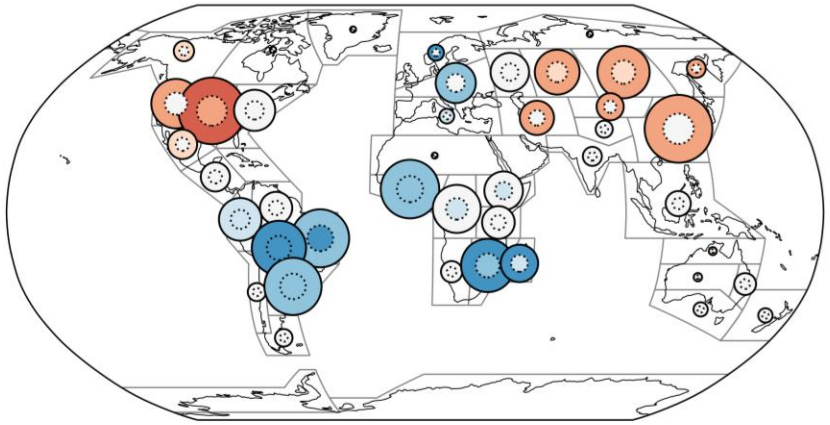
- Consistent local tropical cooling and high-latitude warming
- Different reforestation patterns induce wide range of non-local effects

Reforestation regions for climate change mitigation

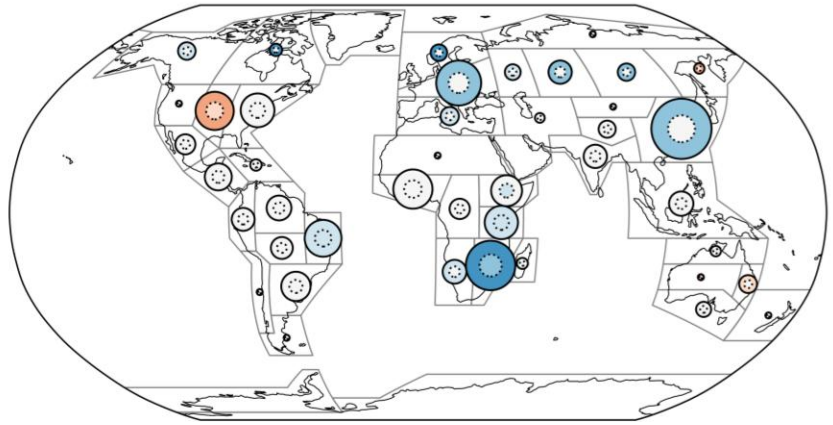
Bastin

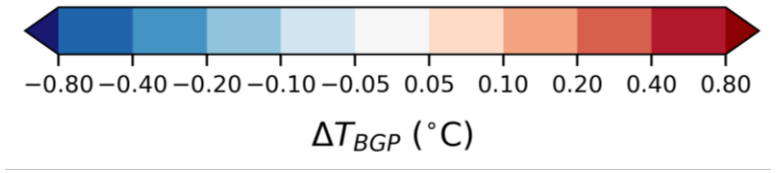


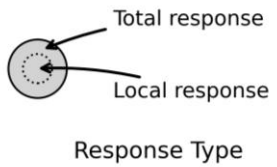
Moustakis



Hurtt







Reforestation regions for climate change mitigation

Bastin

Moustakis

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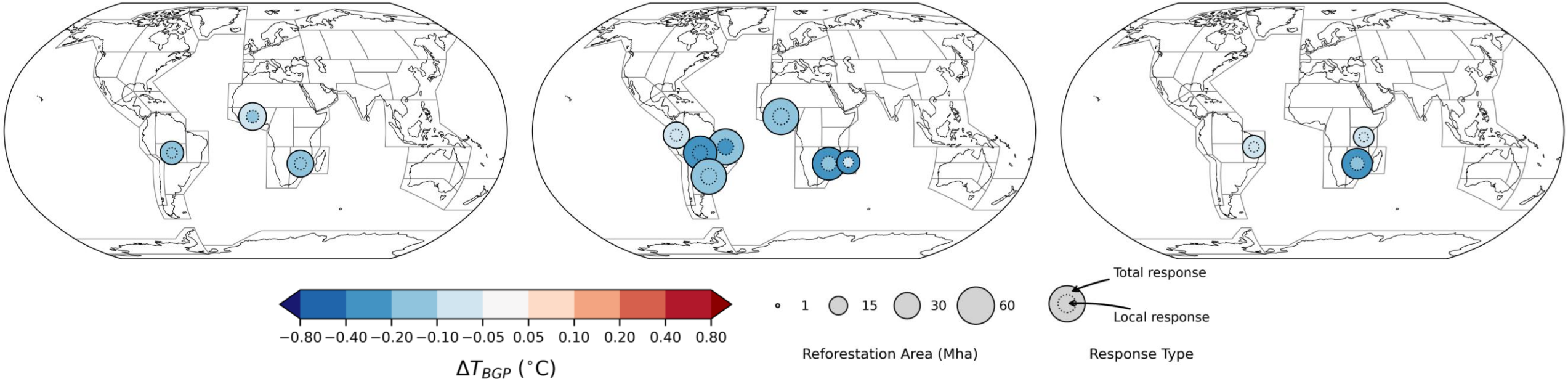

Reforestation leads to local temperature reduction

Reforestation regions for climate change mitigation

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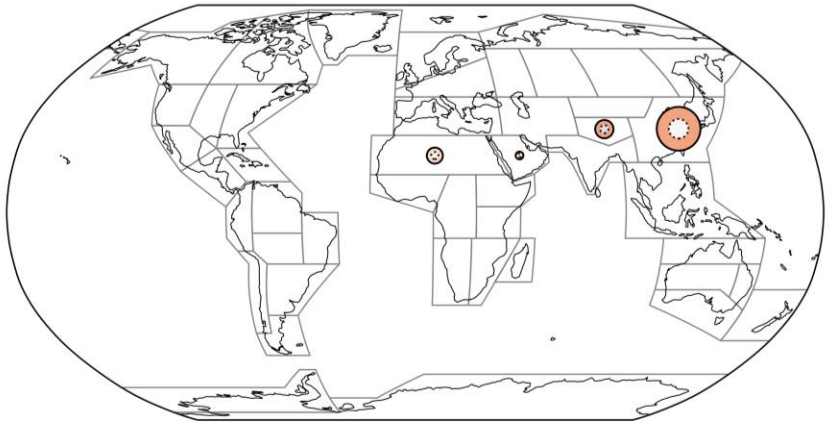
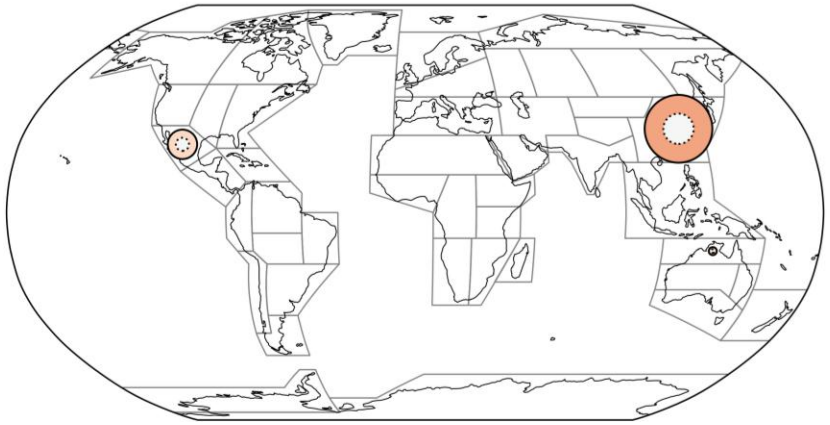
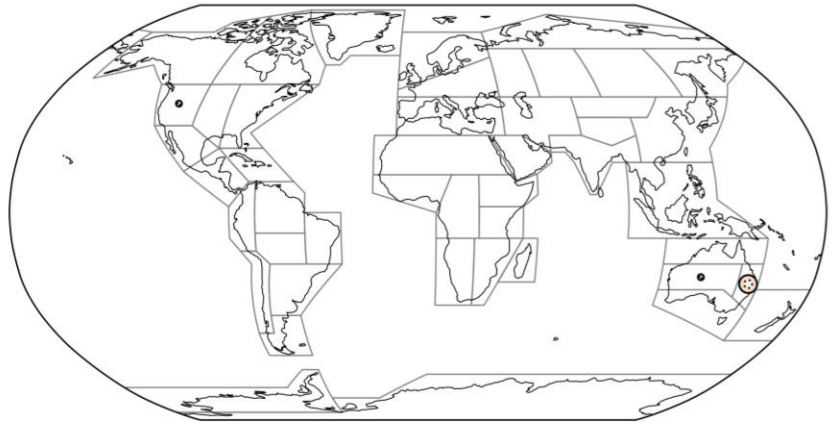
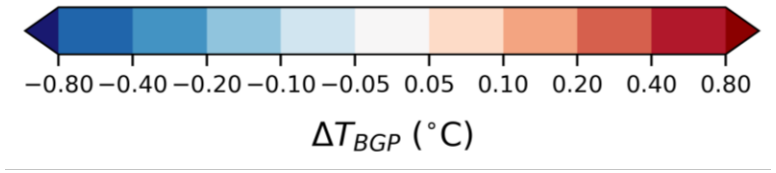
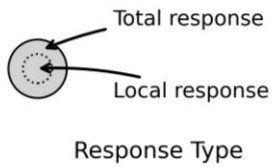








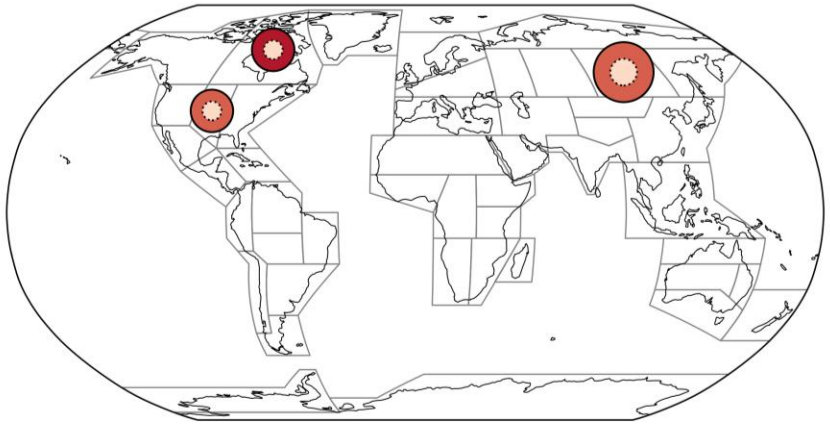


Reforestation leads to local temperature reduction

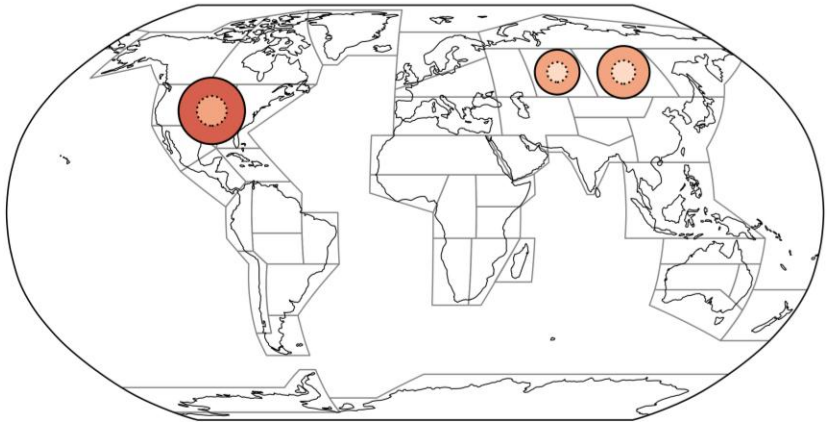
Reforestation still beneficial as local cooling can mitigate non-local warming or, in the absence, provide direct local cooling benefits

Reforestation regions for climate change mitigation

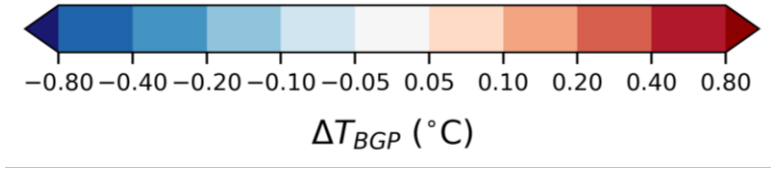
Bastin

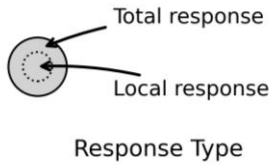


Moustakis



Hurtt

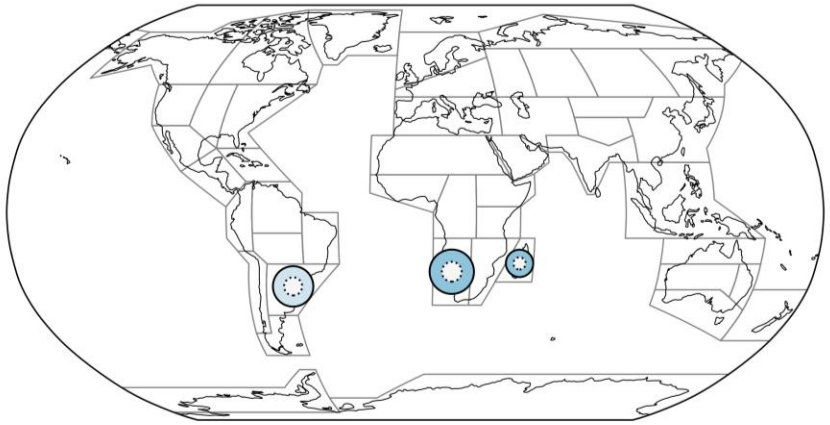




- Reforestation leads to local temperature reduction
- Reforestation still beneficial as local cooling can mitigate non-local warming or, in the absence, provide direct local cooling benefits
- Reforestation would have no overall (BGP+BGC) effect or could be climatically detrimental

Reforestation regions for climate change mitigation

Bastin



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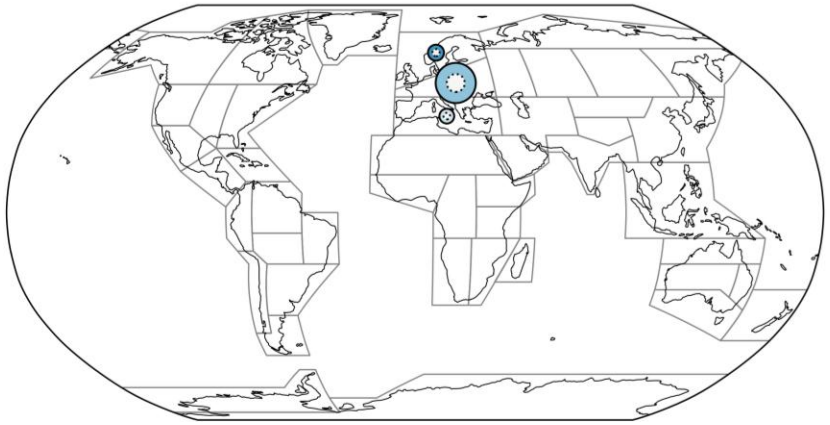

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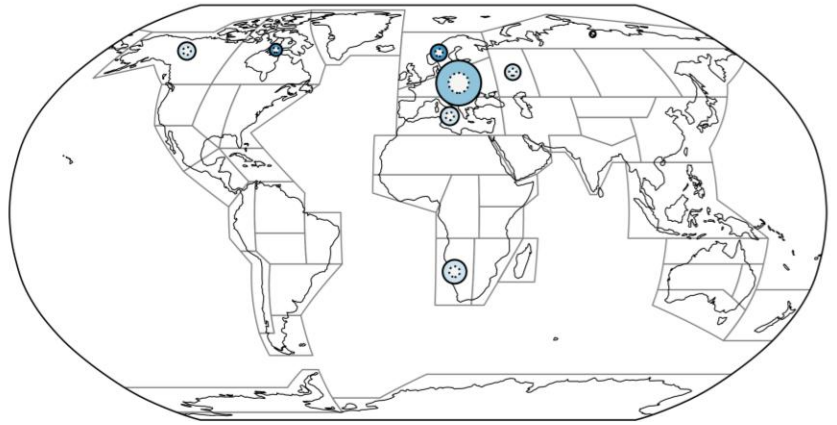

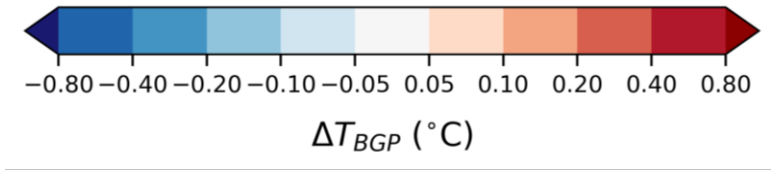

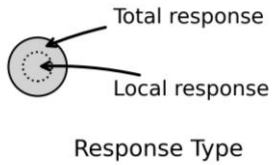

- Reforestation leads to local temperature reduction
- Reforestation still beneficial as local cooling can mitigate non-local warming or, in the absence, provide direct local cooling benefits
- Reforestation would have no overall (BGP+BGC) effect or could be climatically detrimental
- Reforestation in other areas benefit them but not a reliable climate strategy

Reforestation regions for climate change mitigation

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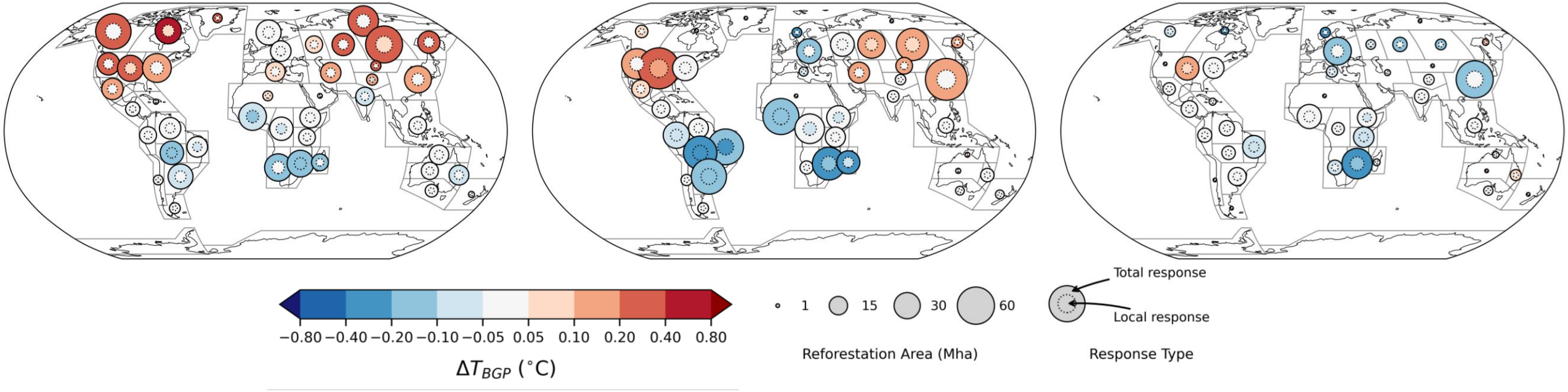
Moustakis

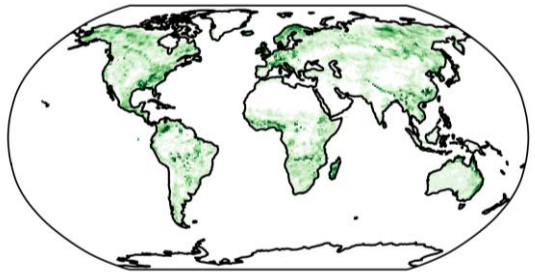
Hurtt



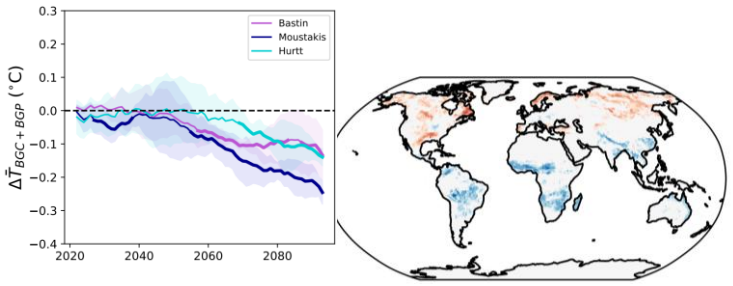
- Recommended to reforest in tropics (e.g., Amazonia, SE Africa) and subtropics (e.g., East Asia)
- Not recommended to reforest in higher latitudes (e.g., Central North America, E. Siberia)

Summary

Reforestation scenarios shape global and regional temperature outcomes
Fahrenbach et al. (preprint, accepted)

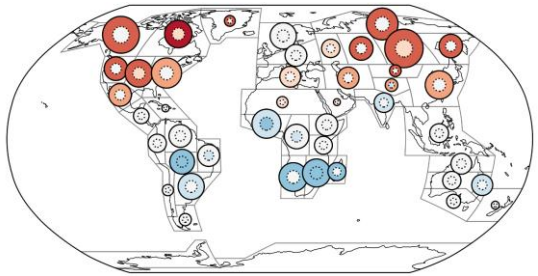


Novel ESM Study: First study comparing temperature responses across 3 reforestation potentials



Less is more: Same net global cooling with 450 Mha less reforestation

Latitudinal Trade-offs: Tropical and subtropical reforestation maximize cooling; high-latitude planting can trigger local BGP warming



Beyond Carbon: Mitigation policies must consider BGP effects alongside carbon uptake

Support Not Replace: Large-scale reforestation offers cooling of 0.25°C, helpful to support but not replace decarbonisation

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