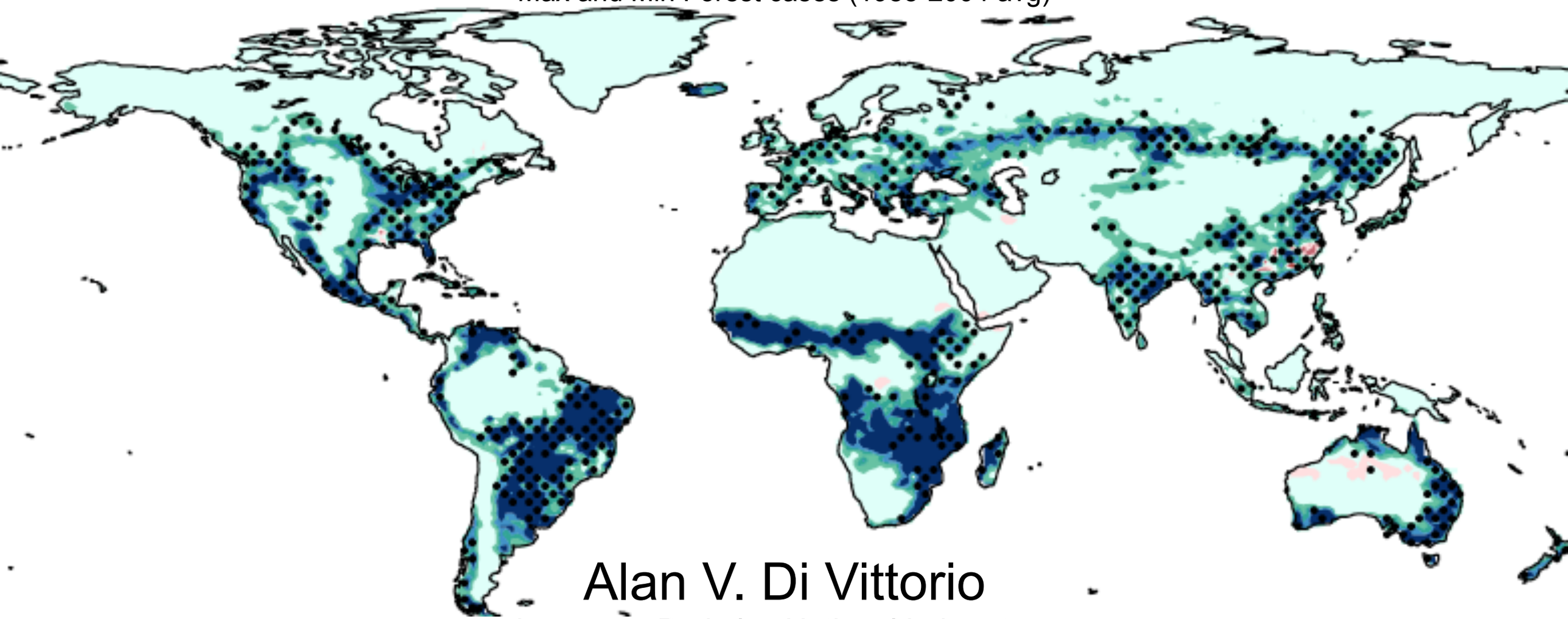
Substantial effects of land cover uncertainty on carbon and climate projections

Difference in forest area between
Max and Min Forest cases (1985-2004 avg)



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LMWG/BGCWG/SDWG Meeting
1 March 2017

With special thanks
to the iESM team

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Earth Systems and Society Program

OAK RIDGE National Laboratory

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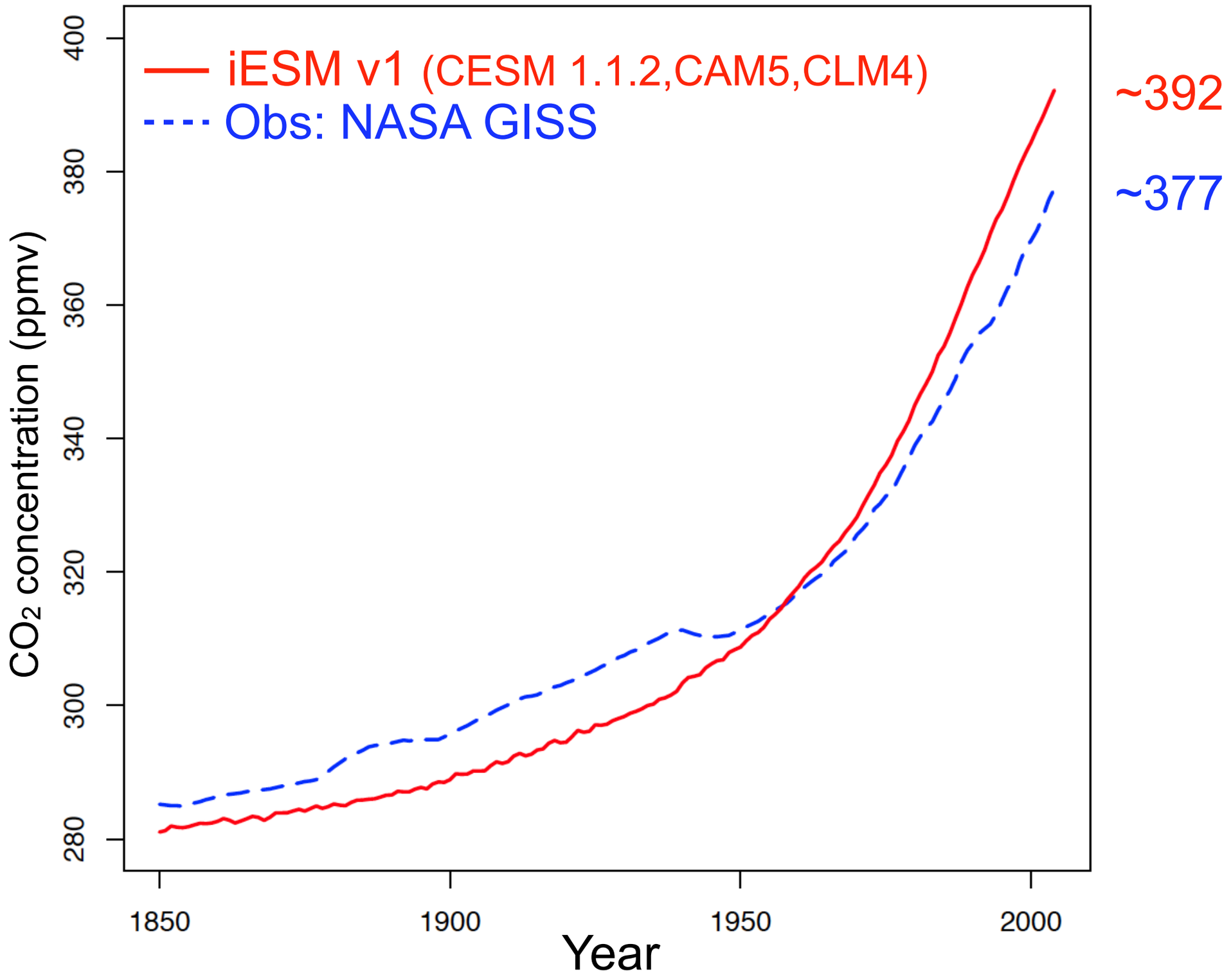
~15 ppmv CO_2 bias in 2004



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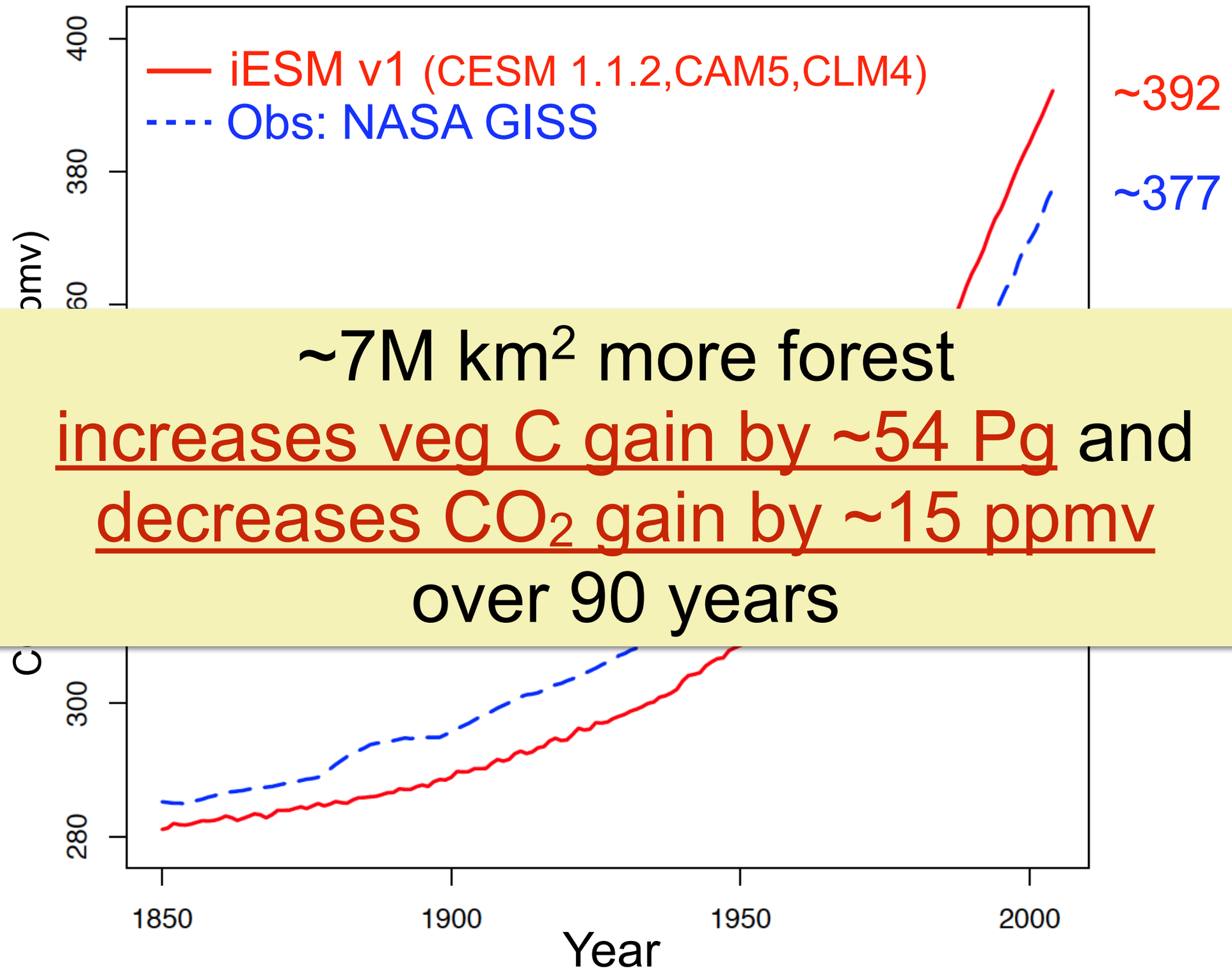


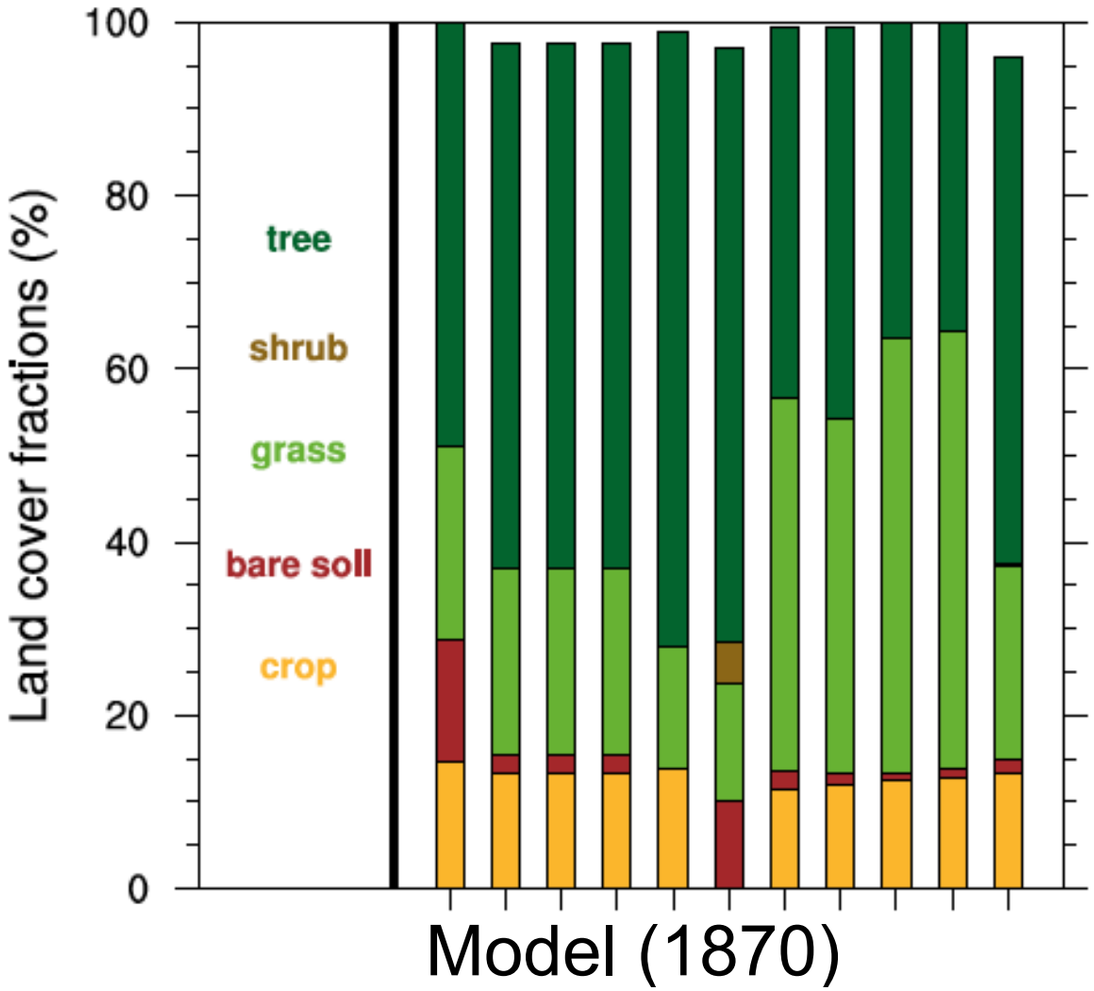
~7M km^2 more forest

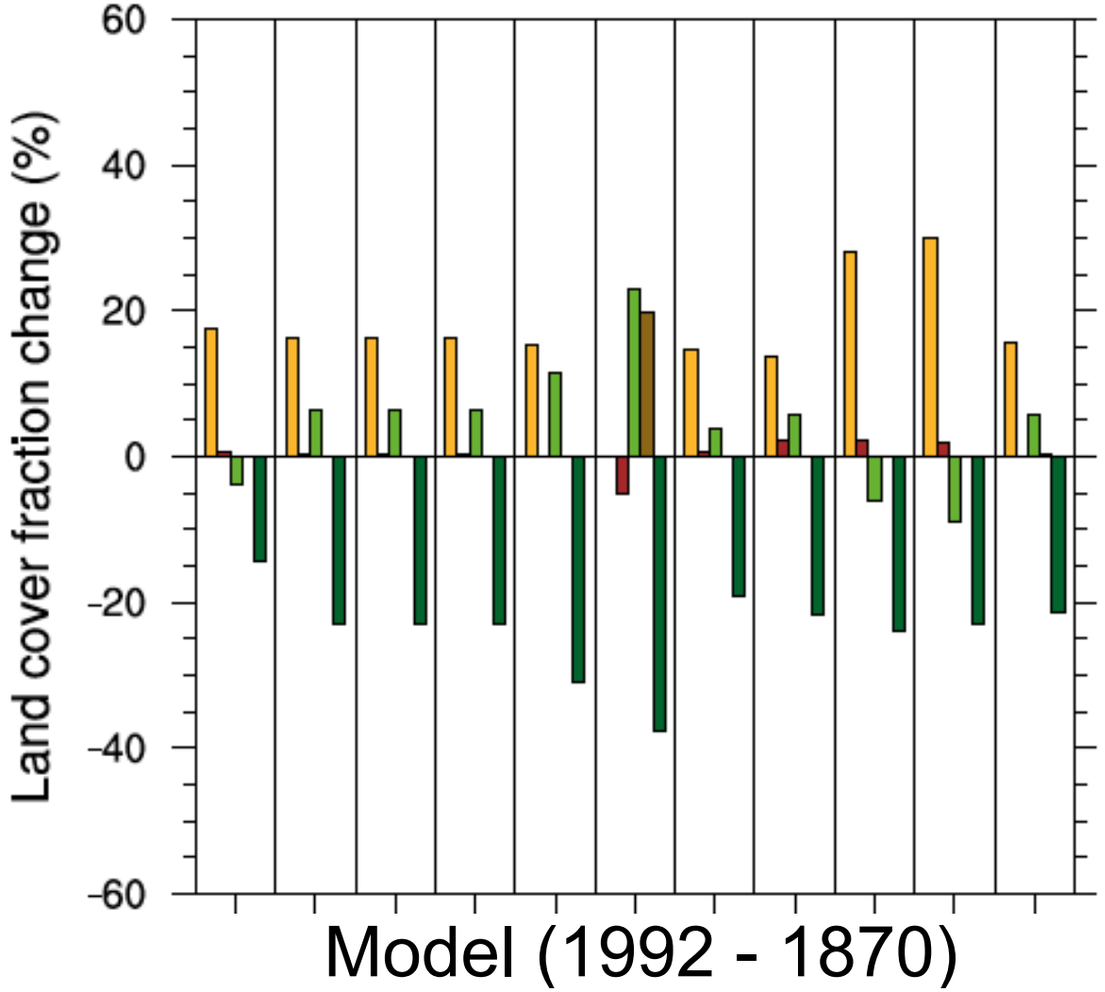
increases veg C gain by ~54 Pg and

decreases CO_2 gain by ~15 ppmv

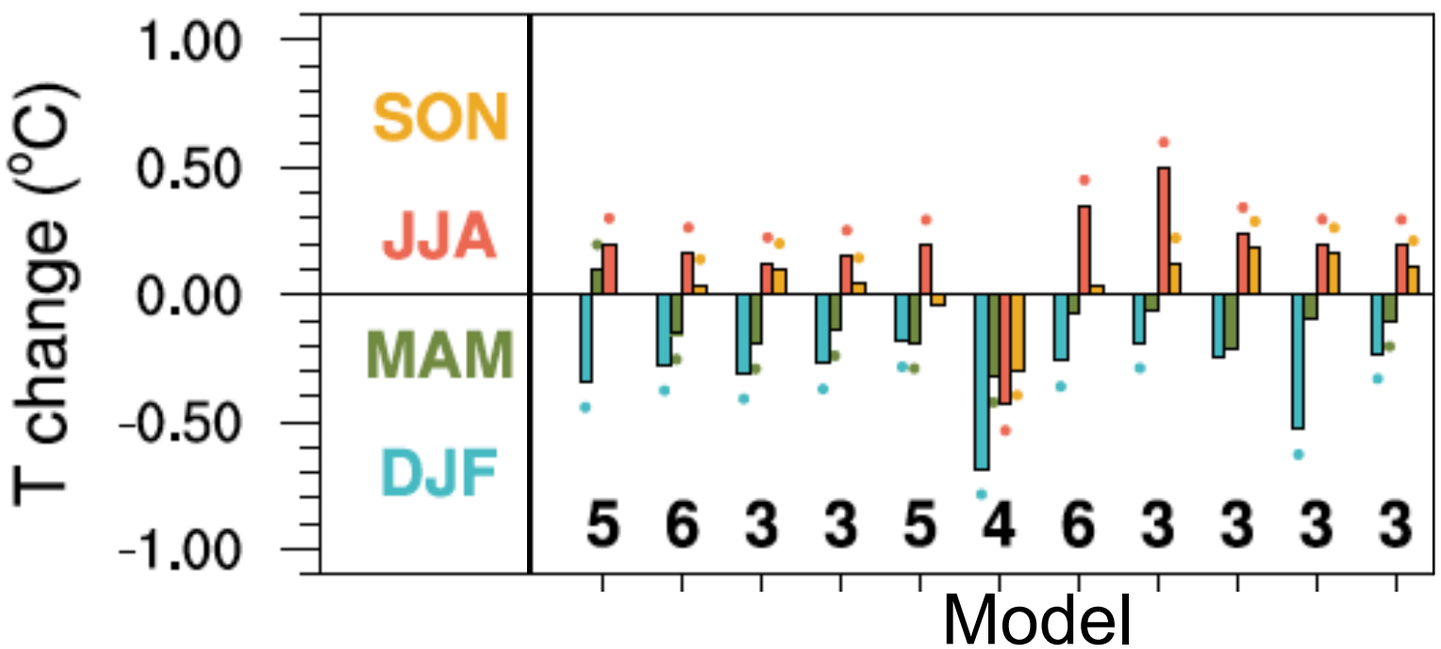
over 90 years

Different CMIP5 LULC/C can obscure LULC/C change effects on regional climate





North America
1974-2004 minus 1862-1891
(Lejeune et al., 2017)



- What is the contribution of land cover uncertainty to simulated carbon cycle uncertainty?

- How does the land cover-driven carbon uncertainty compare to the effects of CO_2 concentration, nitrogen deposition, and climate?

- What are the effects of land cover uncertainty on local/regional climate?

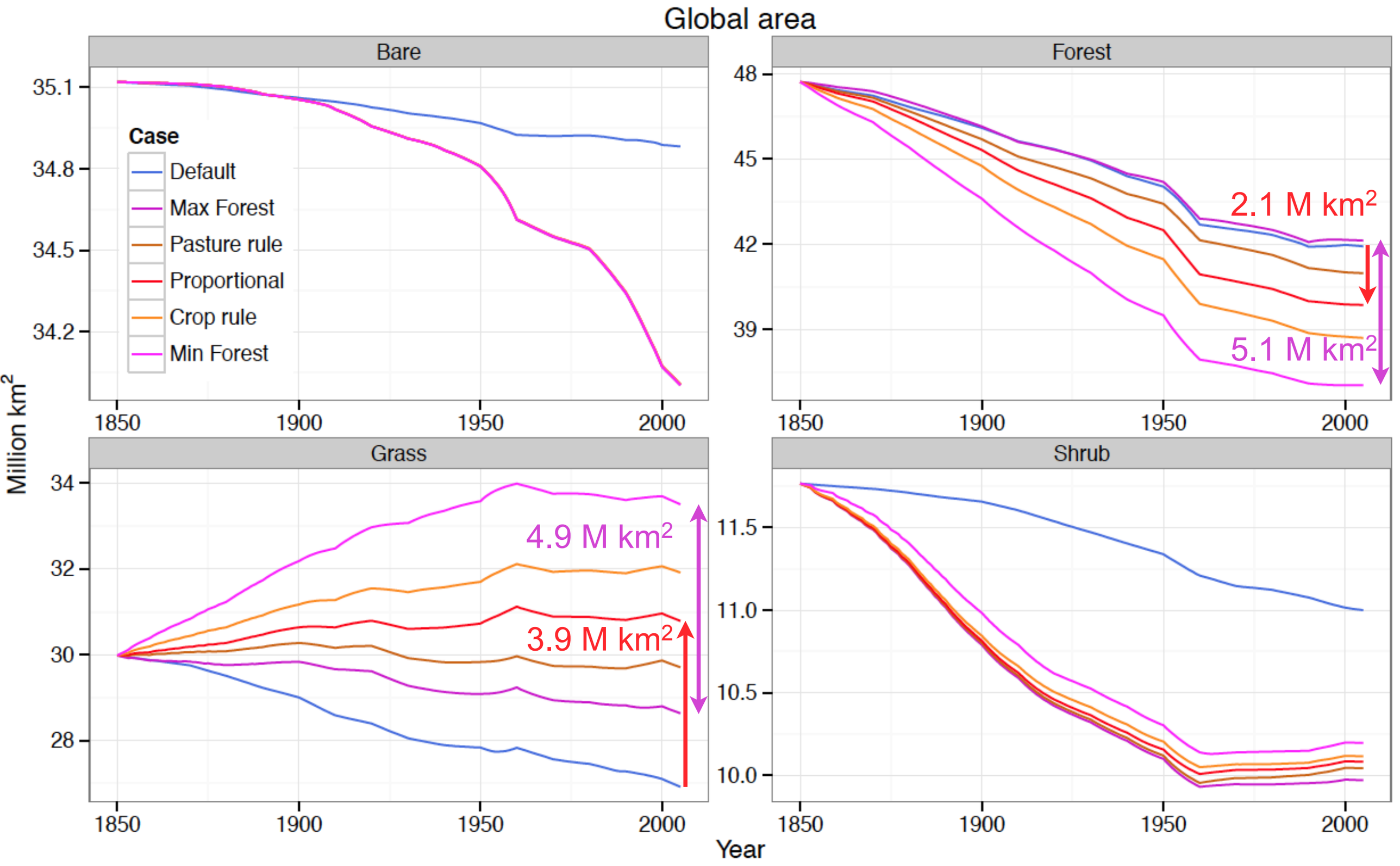
iESM-CLM simulations: 1850 - 2004

- Identical CMIP5 land use inputs (* indicates fully coupled sim)

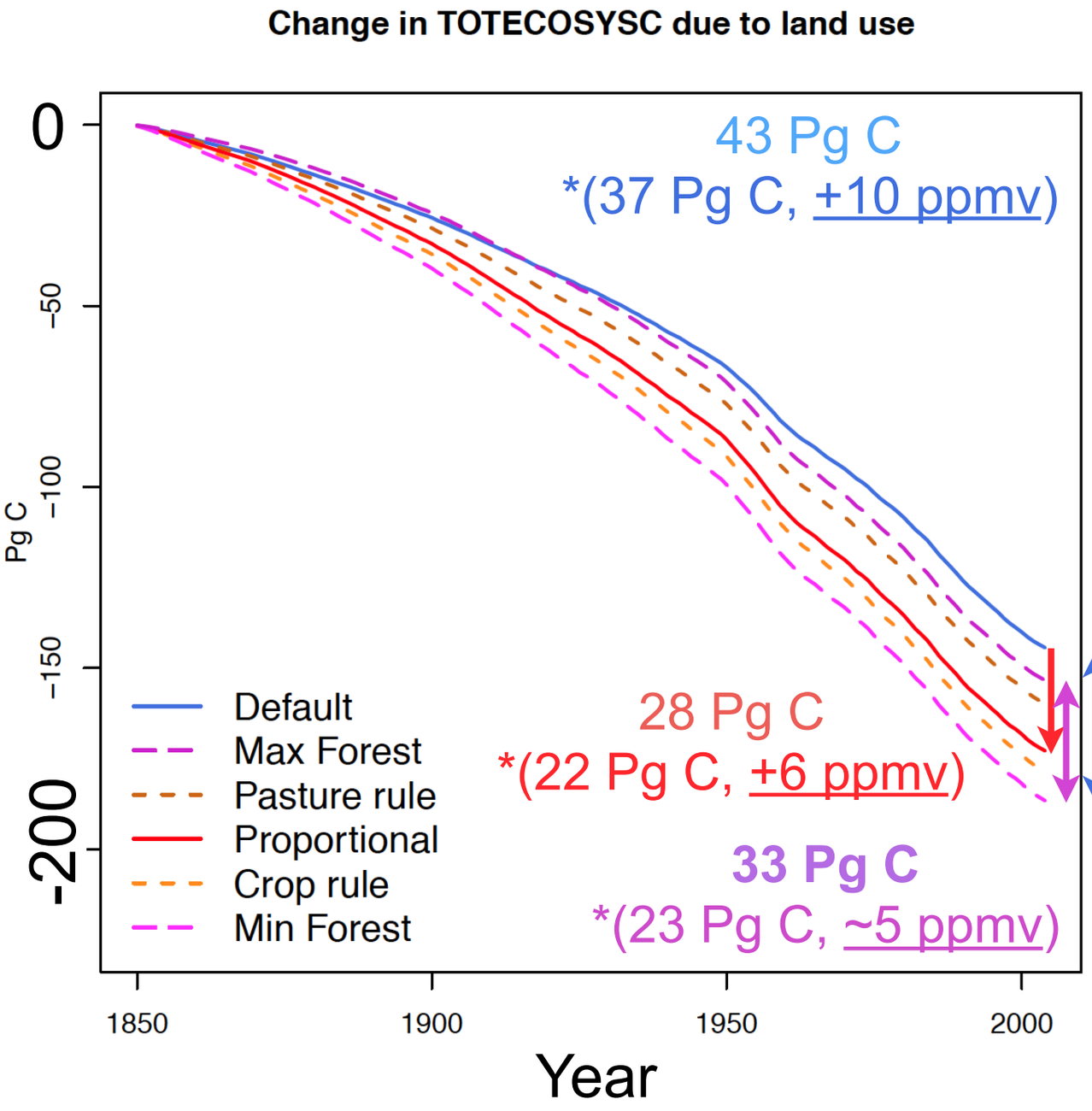
Case	LULCC Reference	LULCC assumptions
No LULCC	Constant 1850	No conversion
Default*	Year 2000	Proportional to PFTs
Max forest*	Previous year	Δ Pasture/crop maximizes forest area
Pasture rule*	Previous year	+ Pasture replaces grass/shrub PFTs first
Proportional*	Previous year	Proportional to PFTs; accounts for pasture
Crop rule	Previous year	+ Crop replaces tree PFTs first
Min Forest*	Previous year	Δ Pasture/crop minimizes forest area
Prop constant CO_2	Previous year	Proportional to PFTs (max/min forest also)
Prop const CO_2/clim	Previous year	Proportional to PFTs (max/min forest also)
Prop const N dep	Previous year	Proportional to PFTs (max/min forest also)

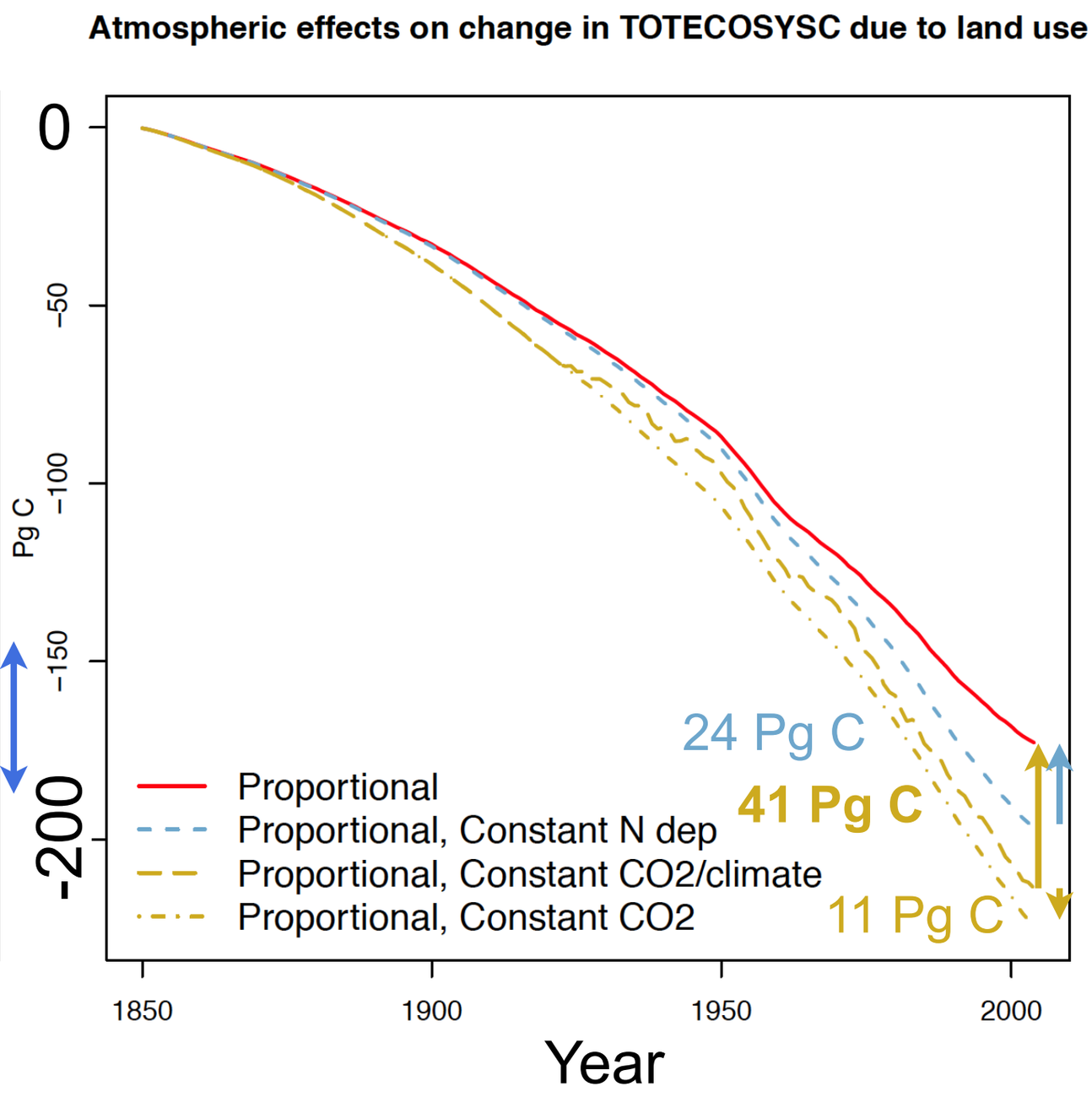
- Atmosphere: CRU-NCEP, transient CO_2, N deposition, and aerosols

5.1 Million km^2 range in forest area by 2005

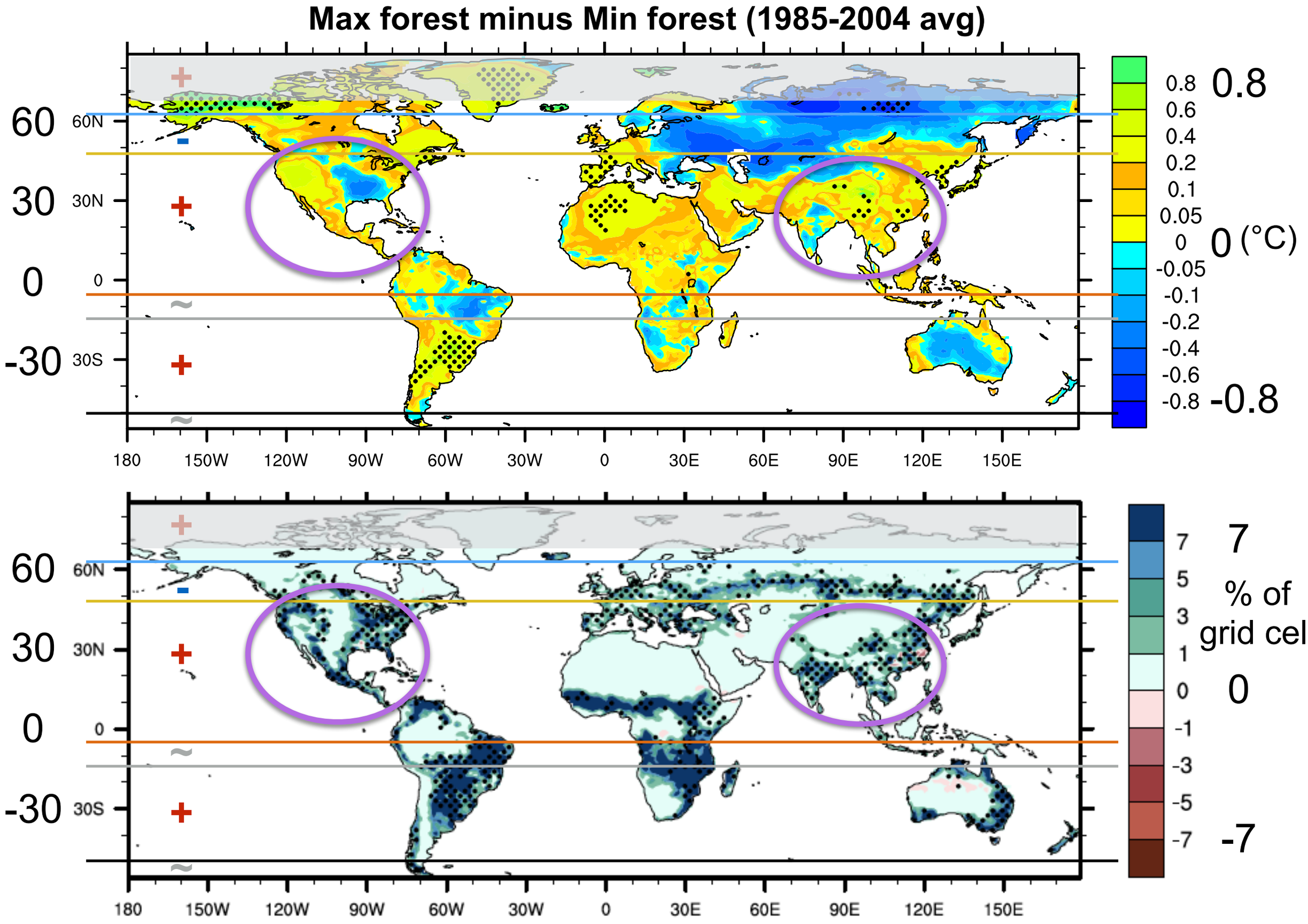


LC uncertainty substantially affects total ecosystem carbon (Pg C)

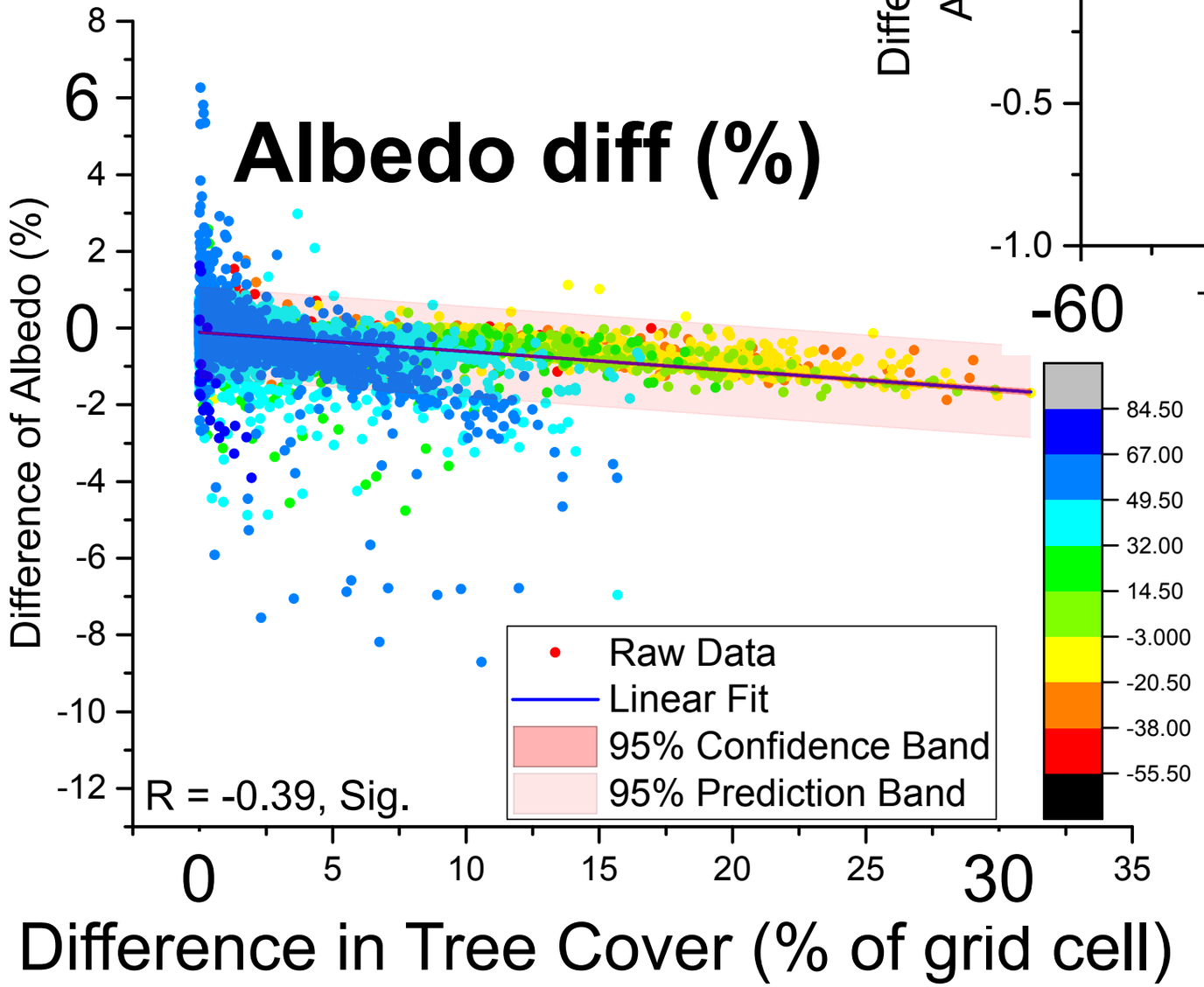


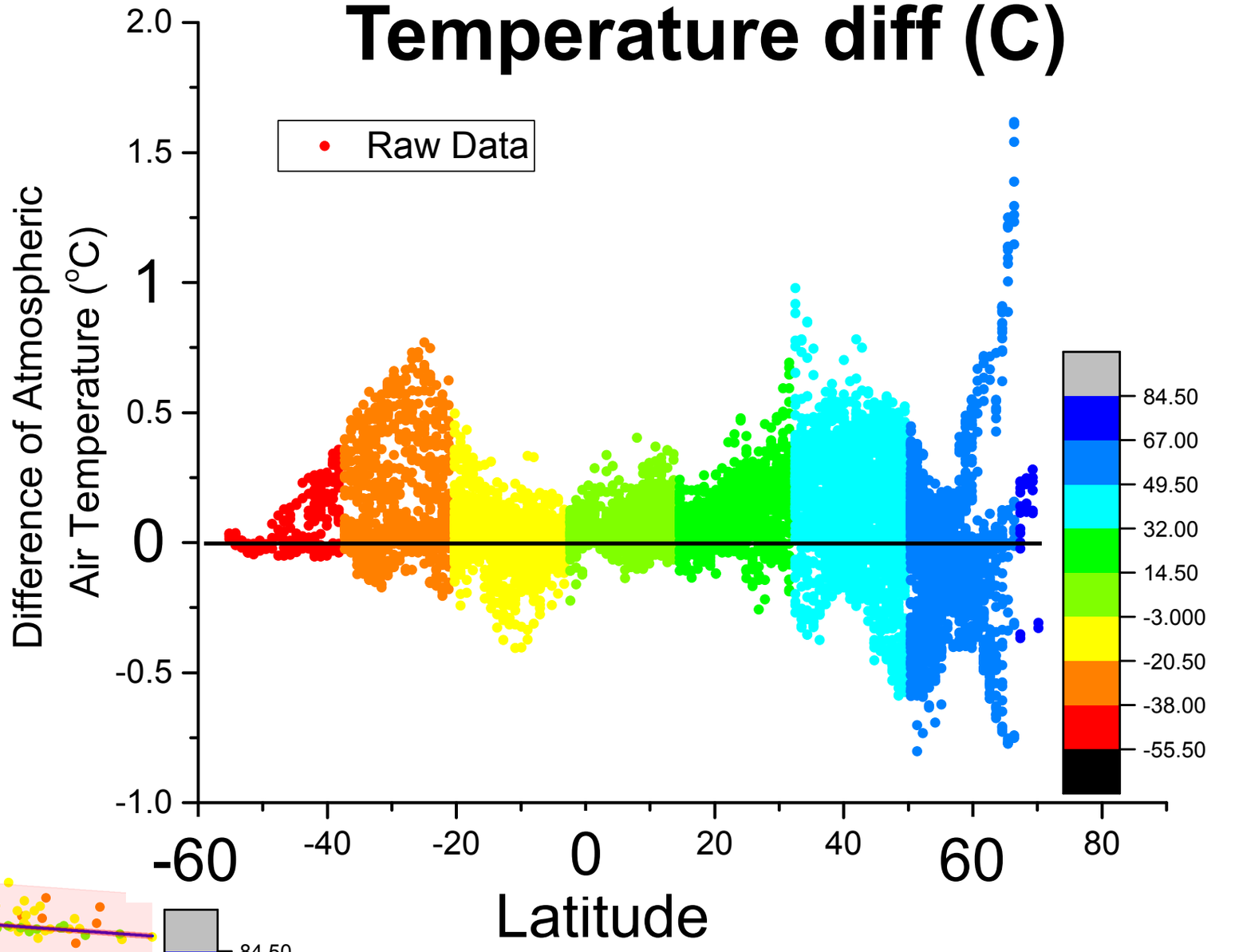


Regional dependence of climate impacts



What drives temperature sign?





Max Forest minus Min Forest
(1985-2004 avg)
(tree diff > 0)

Sensible heat may dominate latent heat

Max Forest minus Min Forest
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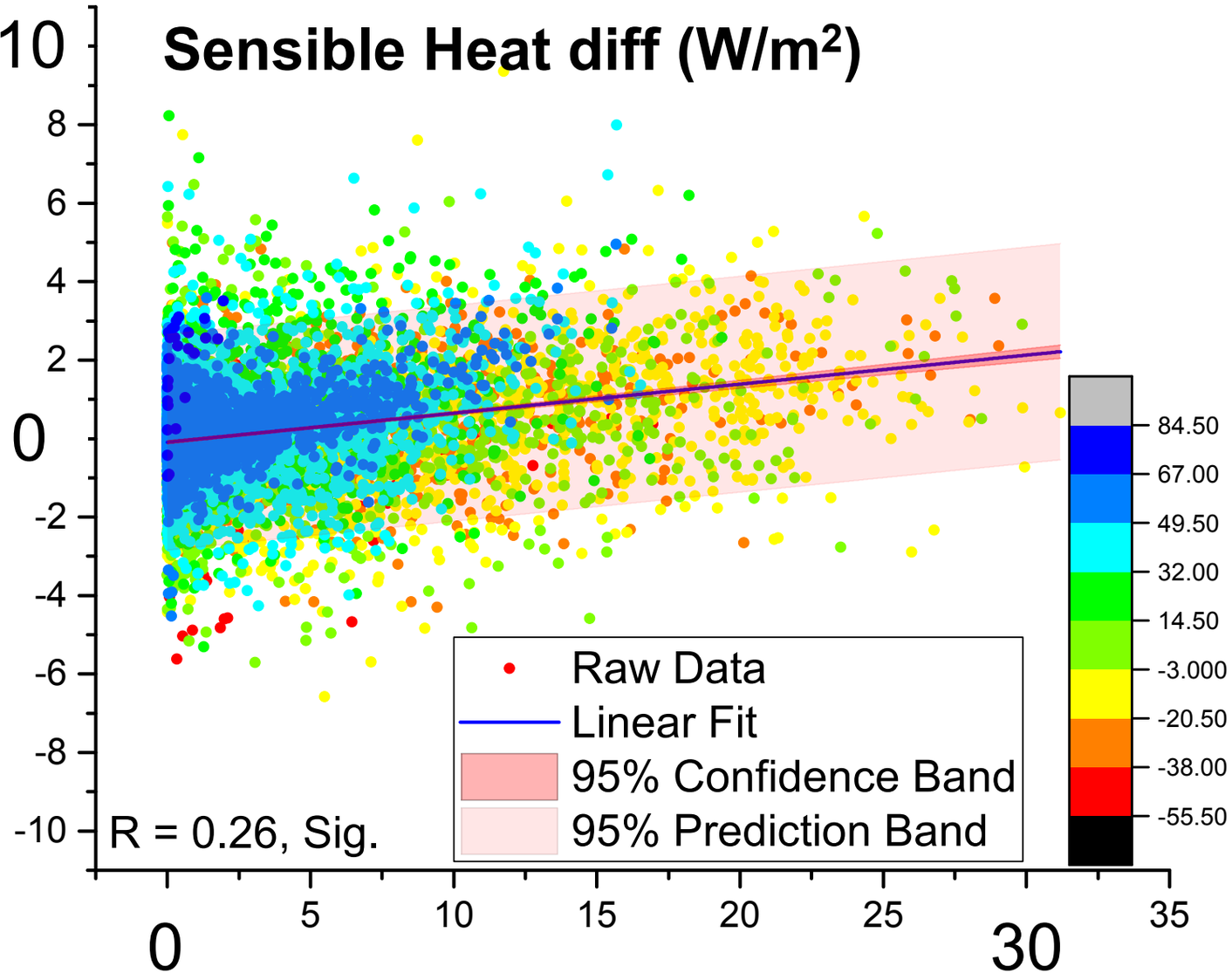
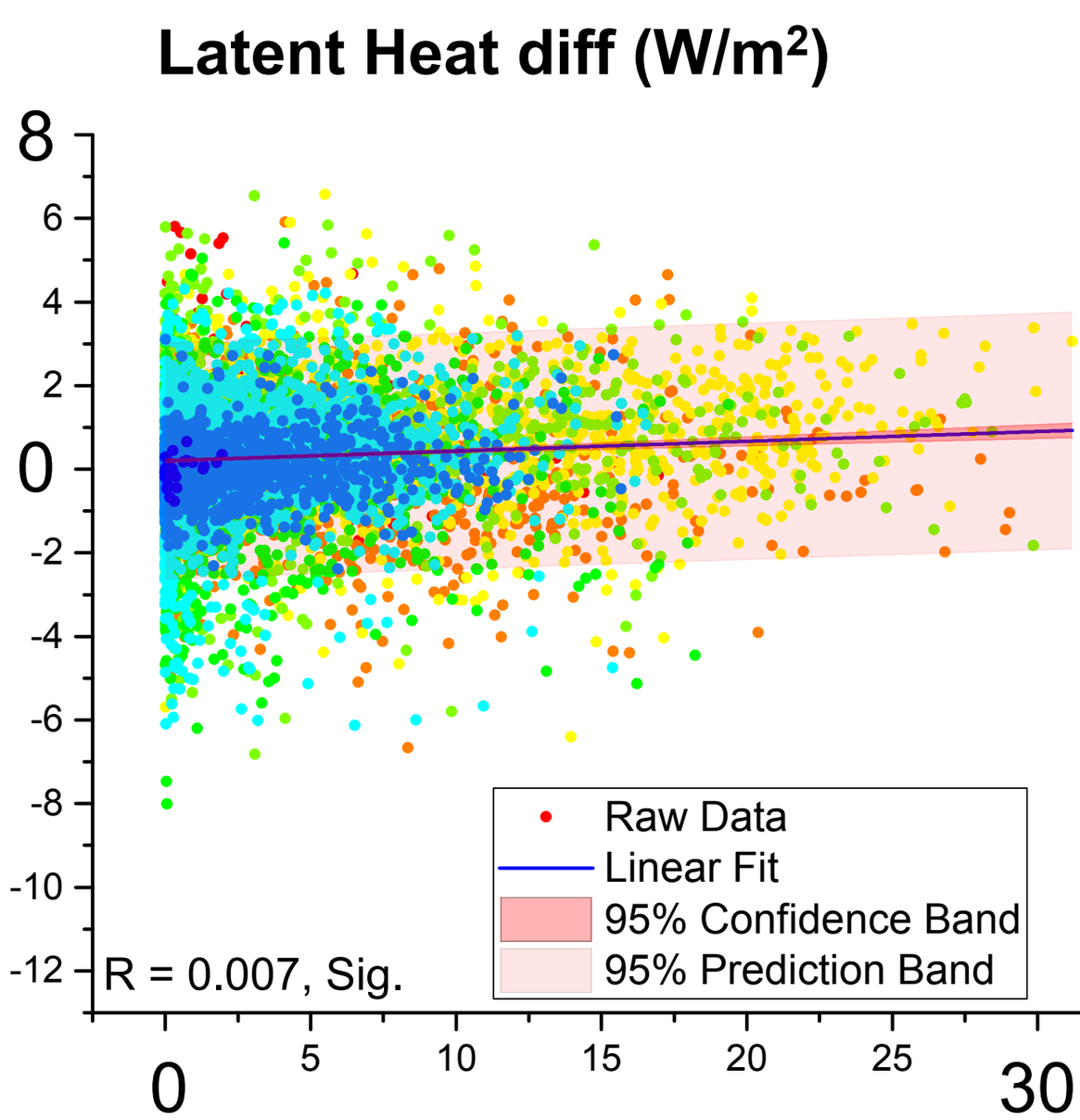
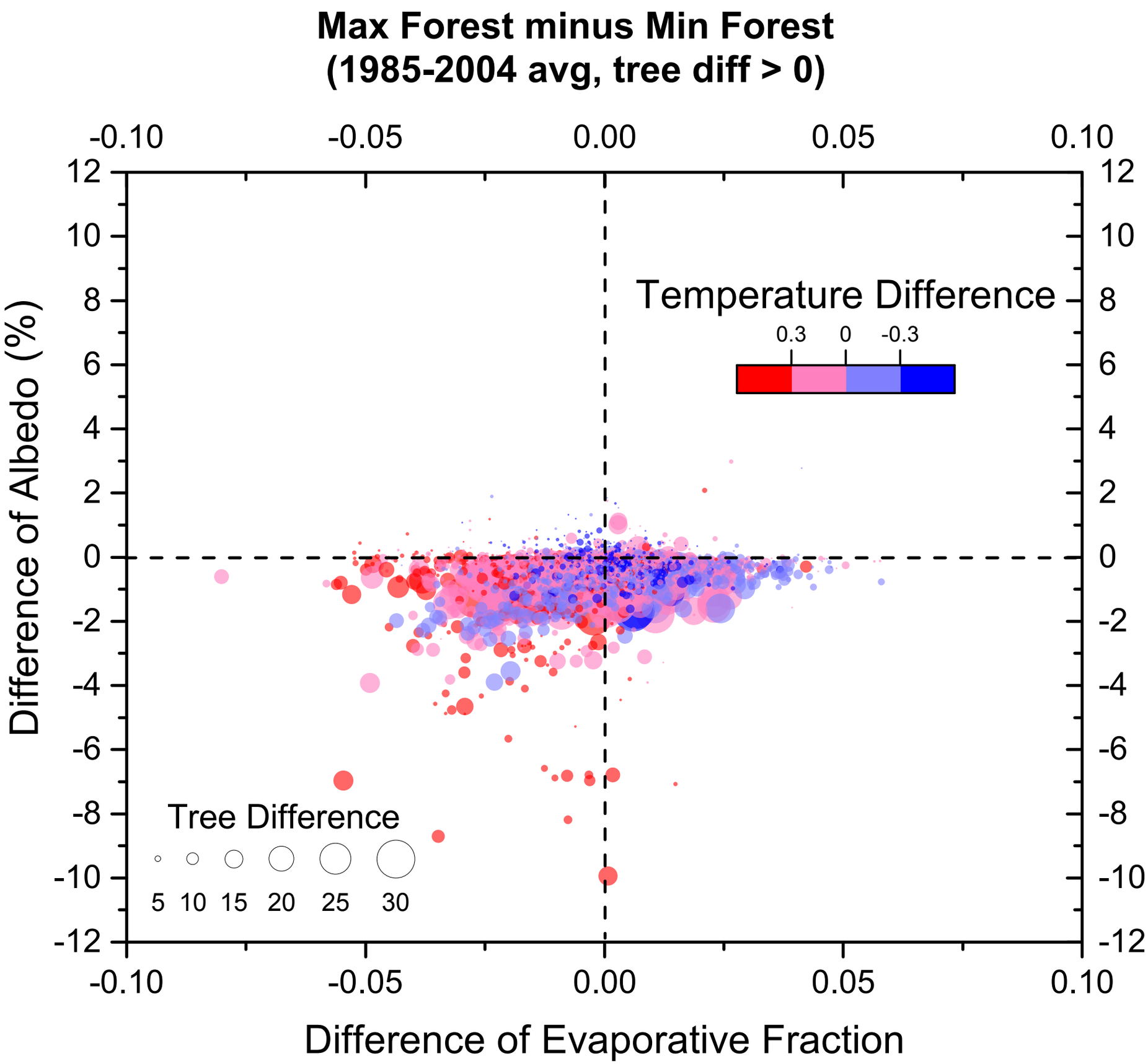




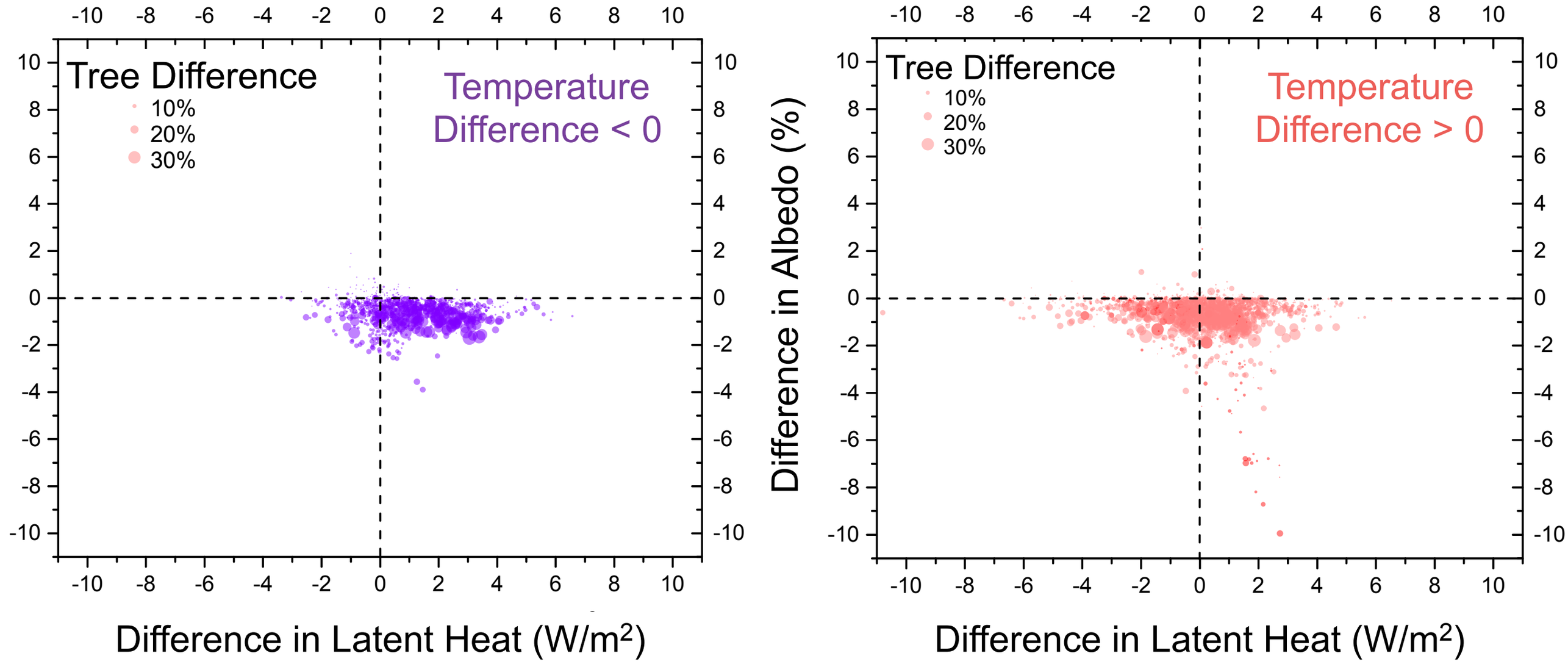
Difference in Tree cover (% of grid cell)

Albedo vs Evaporative Fraction



Latent heat and temperature

Max Forest minus Min Forest
(1985-2004 avg, tree diff > 0)



Summary

- Land cover uncertainty contributes ~5 ppmv uncertainty to CO_2 concentration
  - This is about 1/3 of original bias

- Land cover uncertainty can contribute on the order of 1 degree to temperature uncertainty
  - This is on the order of LULCC-attributed effects
  - Regional dependence
  - Sensible heat vs albedo vs latent heat?
  - Local vs distributed

- LULCC-driven uncertainty is reducible
  - LULCC is an integrated process

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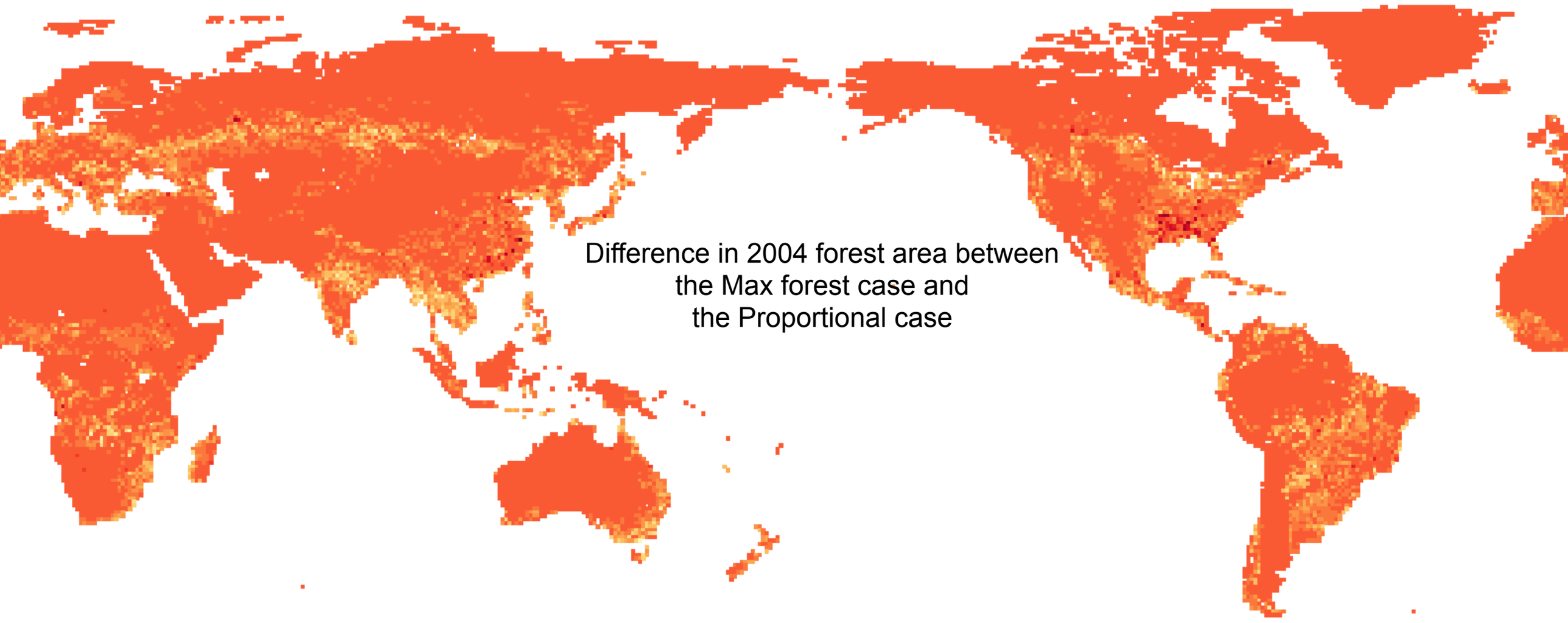
Questions?



This work is supported by the Director, Office of Science, Office of Biological and Environmental Research of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231 as part of the Integrated Assessment Research and Earth System Modeling Programs.

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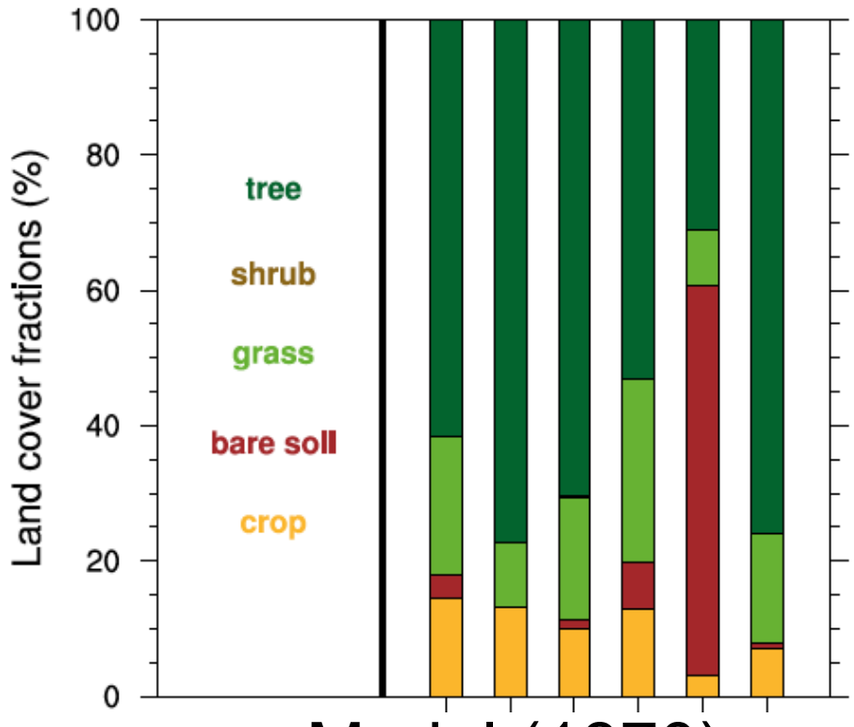
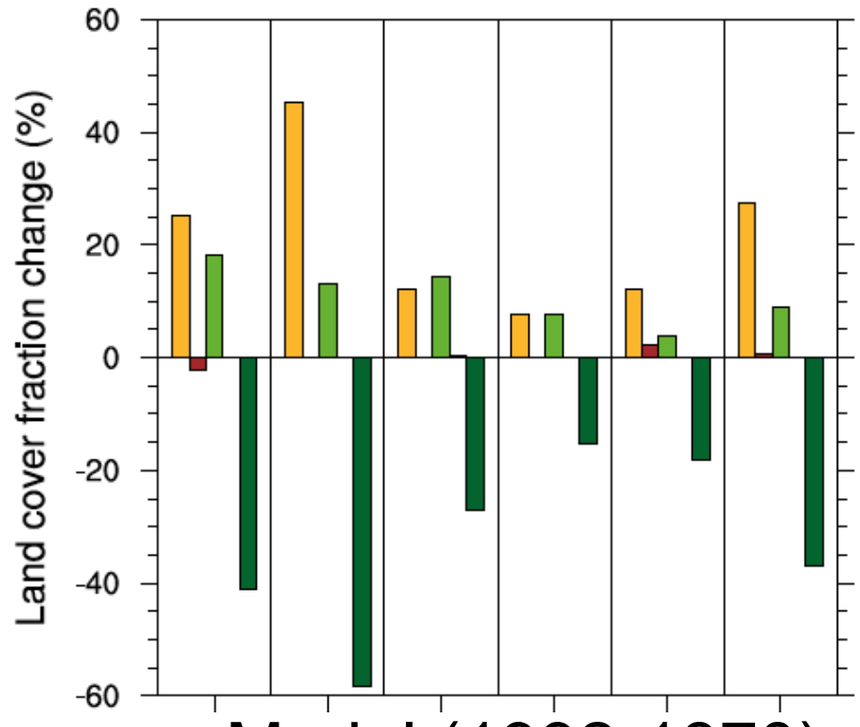
Different LUCID LULC/C can obscure LULC/C change effects on regional climate





Model (1870)

Model (1992-1870)

North America
1974-2004
minus
1862-1891
(Lejeune et al., 2017)