

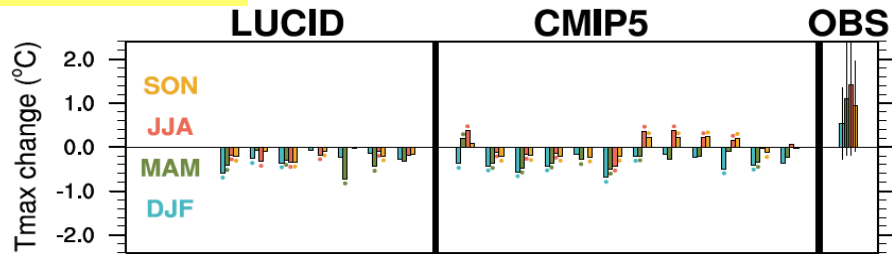
# Differing Responses in Diurnal Cycle of Land Surface and Air Temperature to Deforestation

David Benson, Liang Chen, Paul Dirmeyer

# Motivation

- Different temperature variables used in land-use impacts studies

## T2m (Tmax)



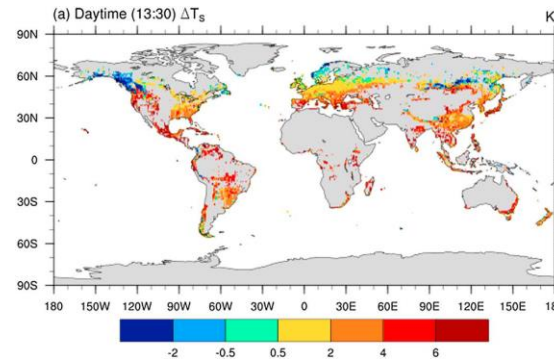
(Lejeune et al. 2017)

## Ts

$$\Delta T_s \approx \frac{\lambda_0}{1+f} \Delta S + \frac{-\lambda_0}{(1+f)^2} R_n \Delta f_1 + \frac{-\lambda_0}{(1+f)^2} R_n \Delta f_2 \quad (\text{Lee et al. 2011})$$

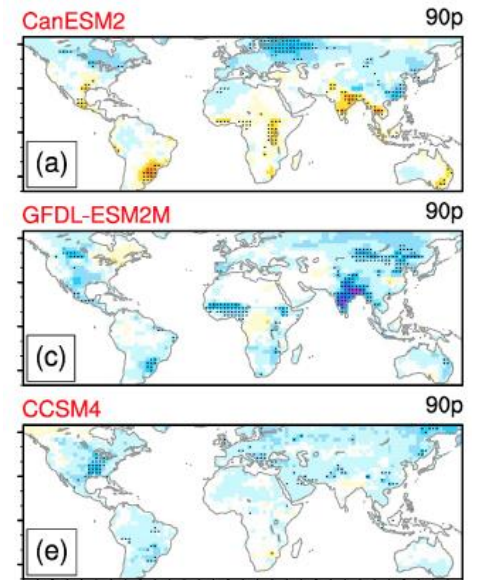
$$\Delta T_s = \frac{1}{4\sigma T_s^3} [-SW_{in} \Delta \alpha_s + (1 - \alpha_s) \Delta SW_{in} + \Delta LW_{in} - \Delta LE - \Delta H - \Delta G]. \quad (\text{Luyssaert et al. 2014})$$

## Ts daytime

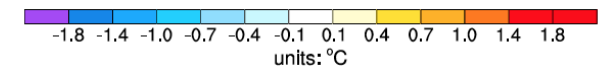


(Schultz et al. 2017)

## T2m (TX90P)



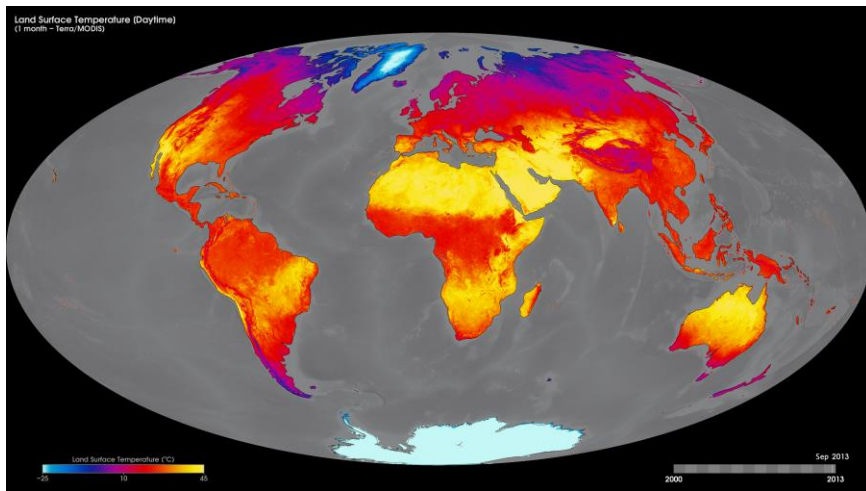
CMIP5 land use only – piControl



(Li et al. 2018)

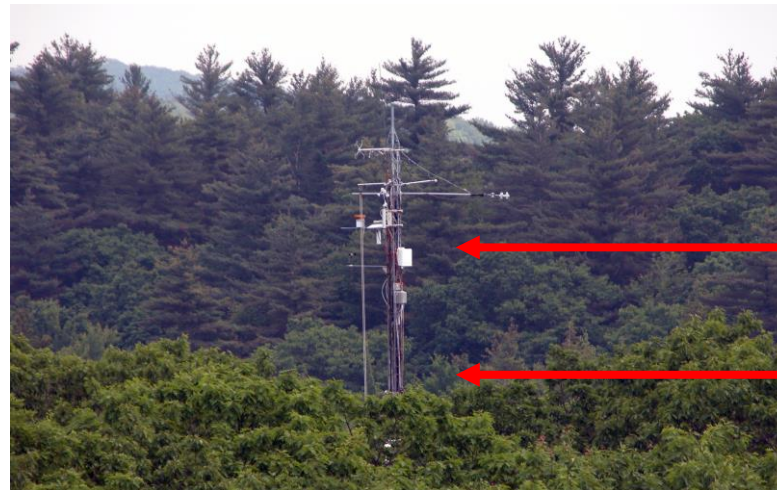
# Research question

- Are there consistent changes between  $T_s$  and  $T_{2m}$  in response to historical deforestation in the climate models?



MODIS Monthly Daytime Land-Surface Temperature (09/2013)

Source: <https://svs.gsfc.nasa.gov/30373>



Near surface air temperature (commonly 2 meters above the apparent sink for sensible heat,  $T_{2m}$ )

*versus*

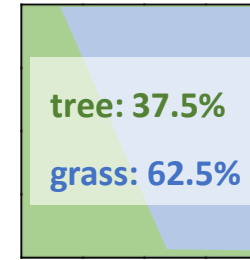
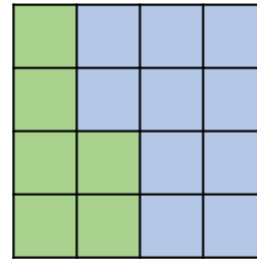
land surface temperature (or skin temperature,  $T_s$ )

Source: <http://crd.lbl.gov/news-and-publications/news/2012/department-of-energy-s-investment-ensures-ameriflux-data-for-all/>

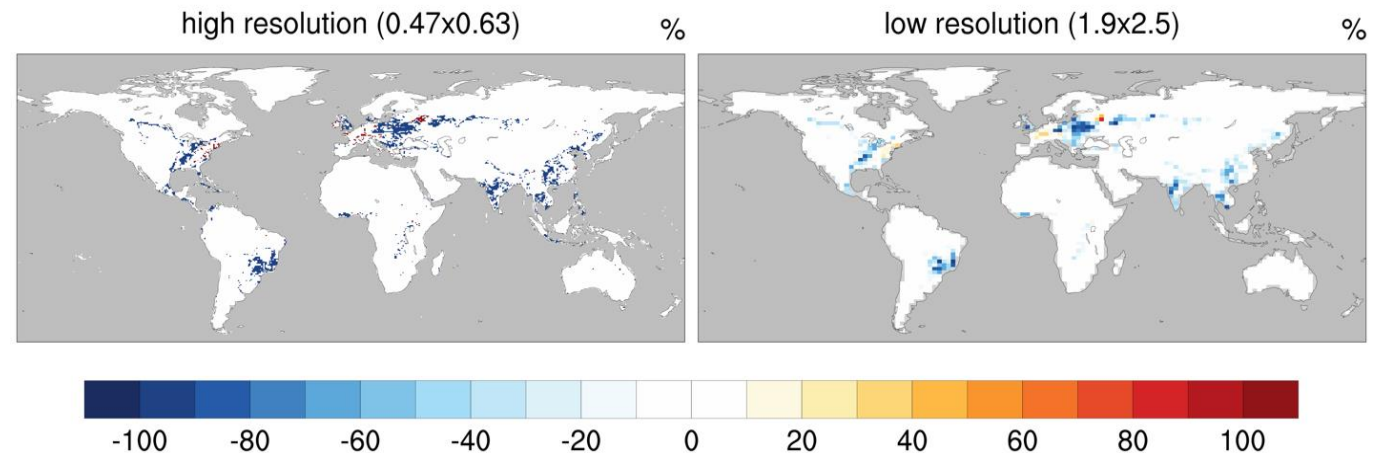
# Data and methods

- CESM historical deforestation simulations (using **CLM4** and **CLM5**)

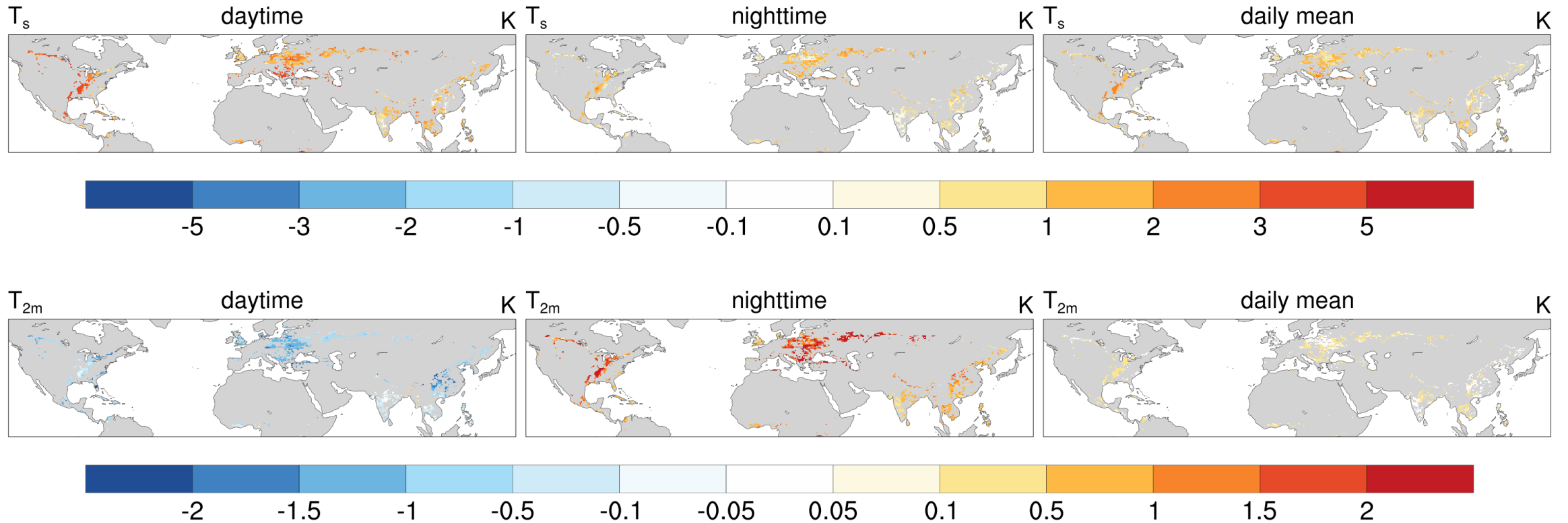
- high-res explicit ( $0.47^{\circ} \times 0.63^{\circ}$ )
- low-res ( $1.9^{\circ} \times 2.5^{\circ}$ )
- Compset: *F2000climo*



changes in tree PFTs  
from 1850 to 2000 in  
CLM4

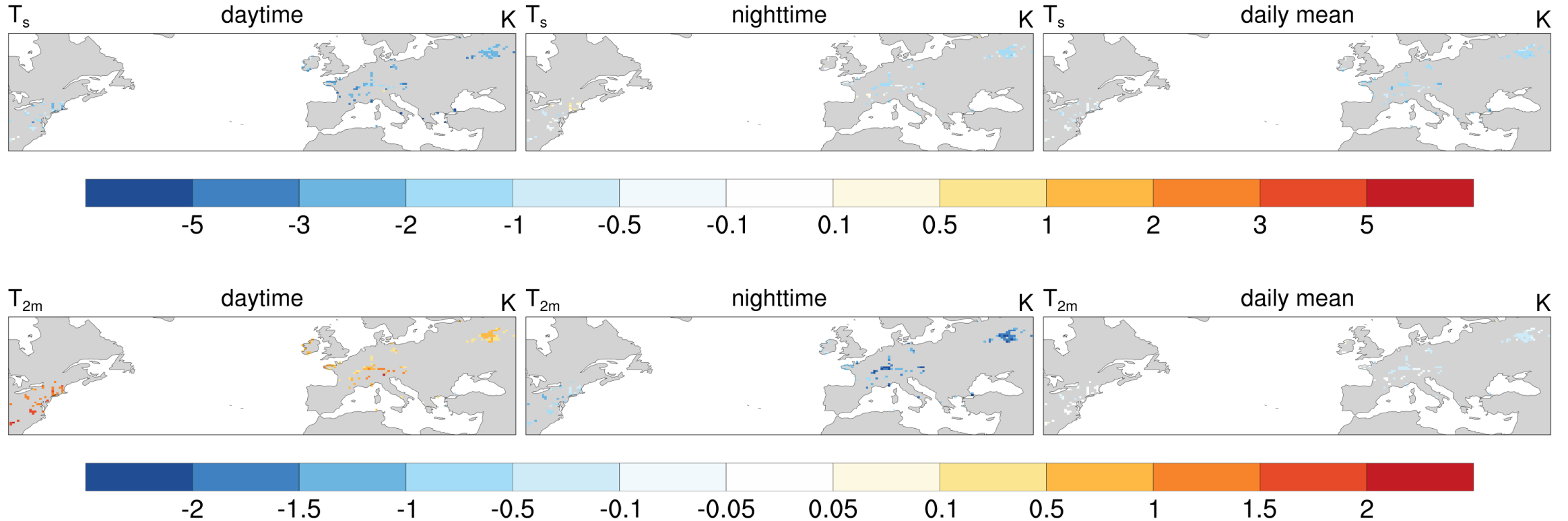


# Deforestation-induced temperature changes in CLM4



Opposite signs of changes in the daily maximum land surface temperature and 2-m air temperature

# Afforestation-induced temperature changes in CLM4



Opposite signs of changes in the daily maximum land surface temperature and 2-m air temperature

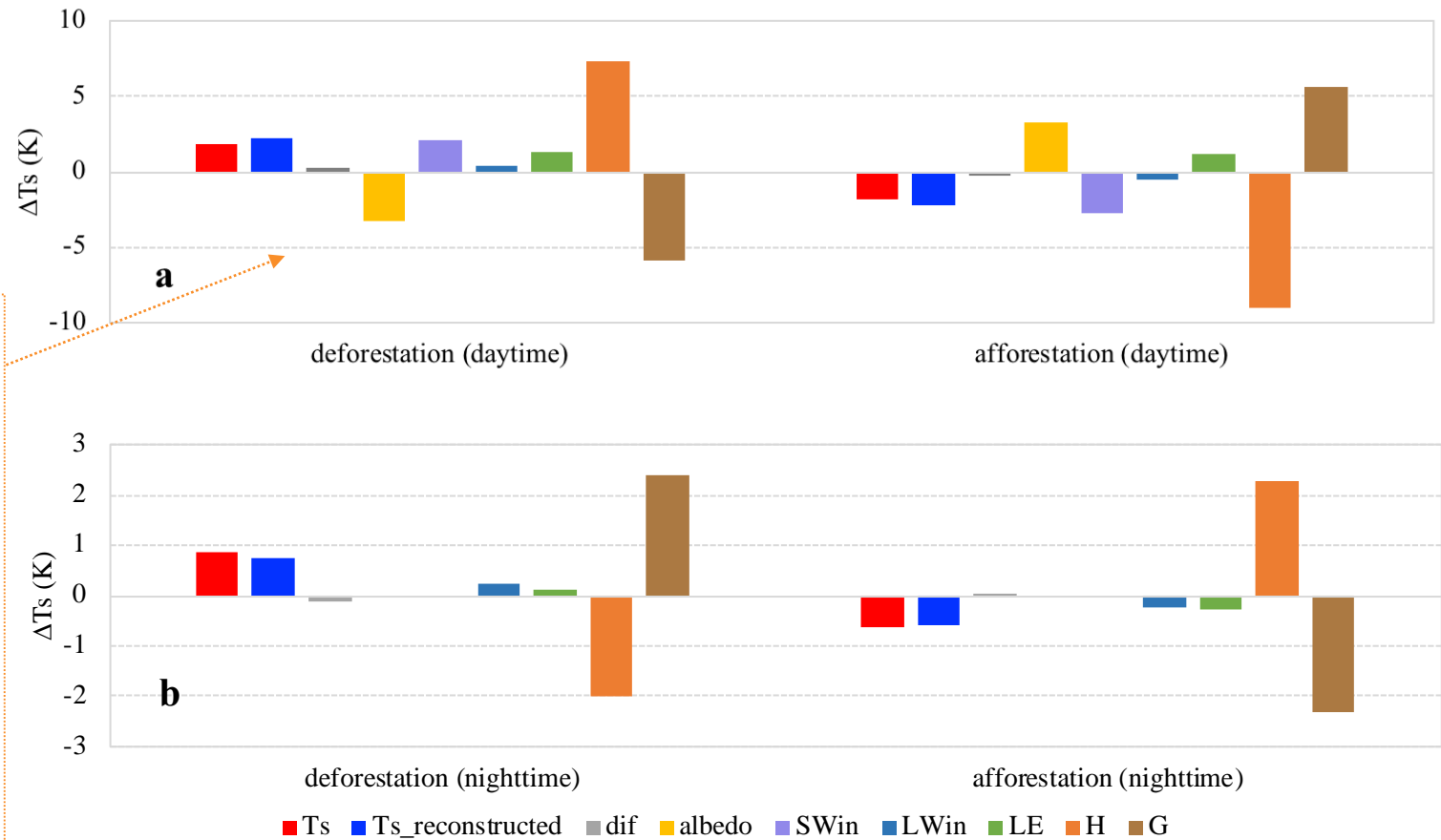
# $T_s$ decomposition (CLM4)

$$\Delta T_s = \frac{1}{4\sigma T_s^3} [-SW_{in}\Delta\alpha_s + (1 - \alpha_s)\Delta SW_{in} + \Delta LW_{in} - \Delta LE - \Delta H - \Delta G].$$

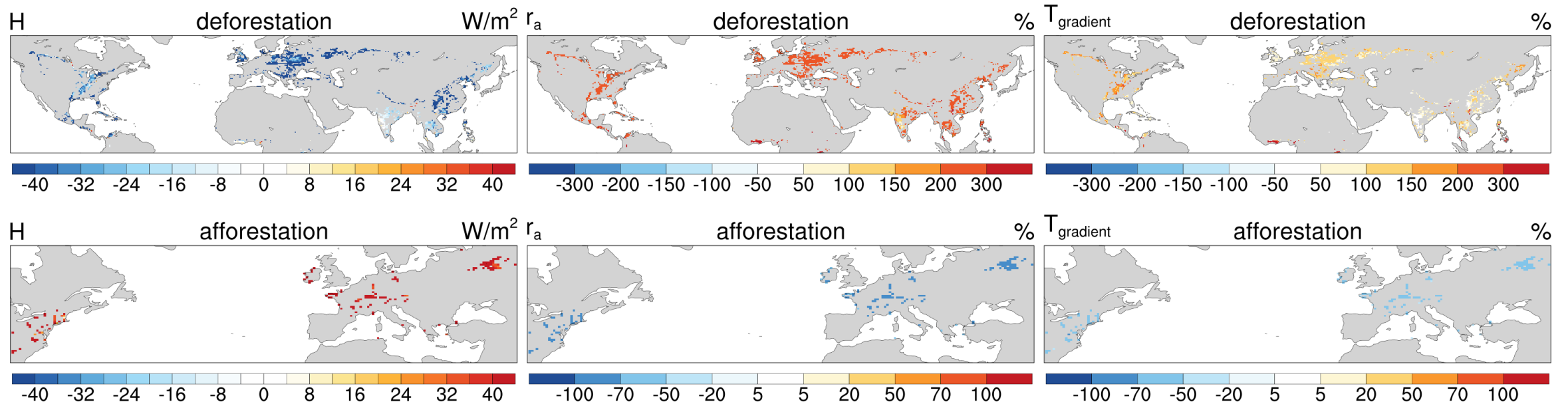
(Luyssaert et al. 2014)

## Deforestation (daytime):

- cooling effects of increased **albedo** are well balanced by warming effects of incoming radiation
- non-radiative effects (mainly by decreased **sensible heat flux**) play a more important role in the  $T_s$  change.



# Relationship between the changes in $T_s$ and $T_{2m}$ (CLM4)



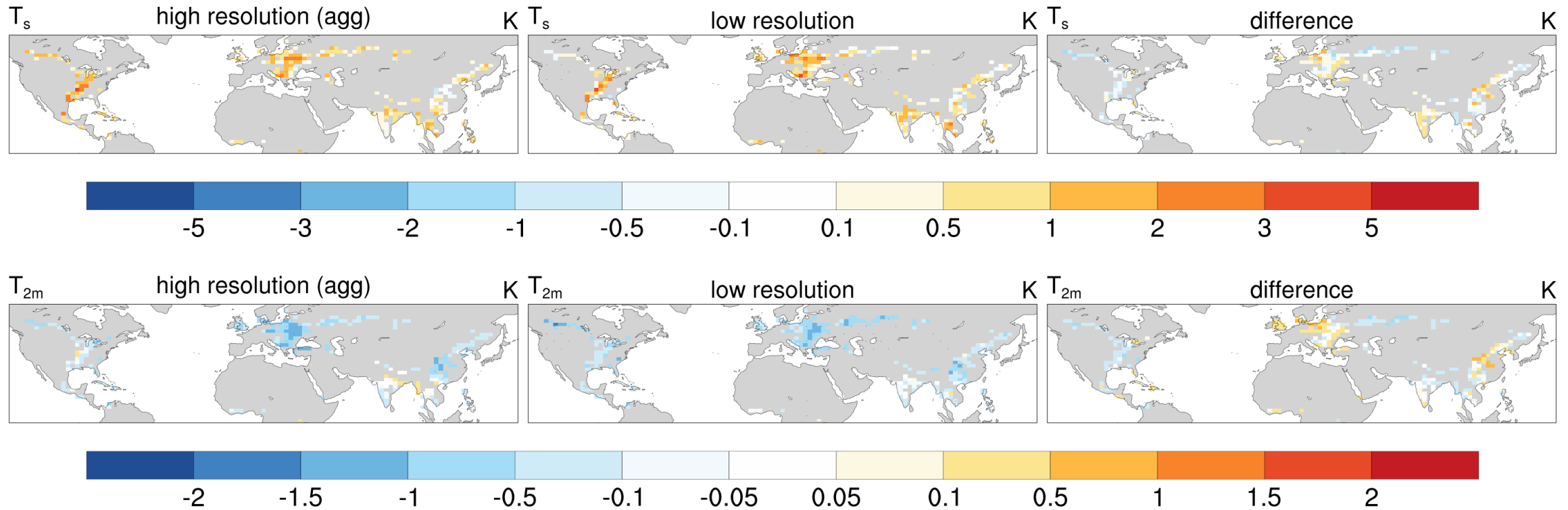
Deforestation: **increased  $T_s$  and a larger temperature gradient vs. increased aerodynamic resistance**

increased aerodynamic resistance dominates and hinders the heat being transferred efficiently to the air, resulting in decreased sensible heat flux and cooler air.



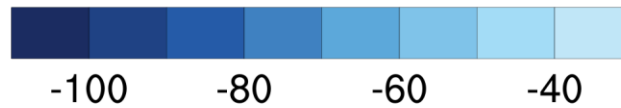
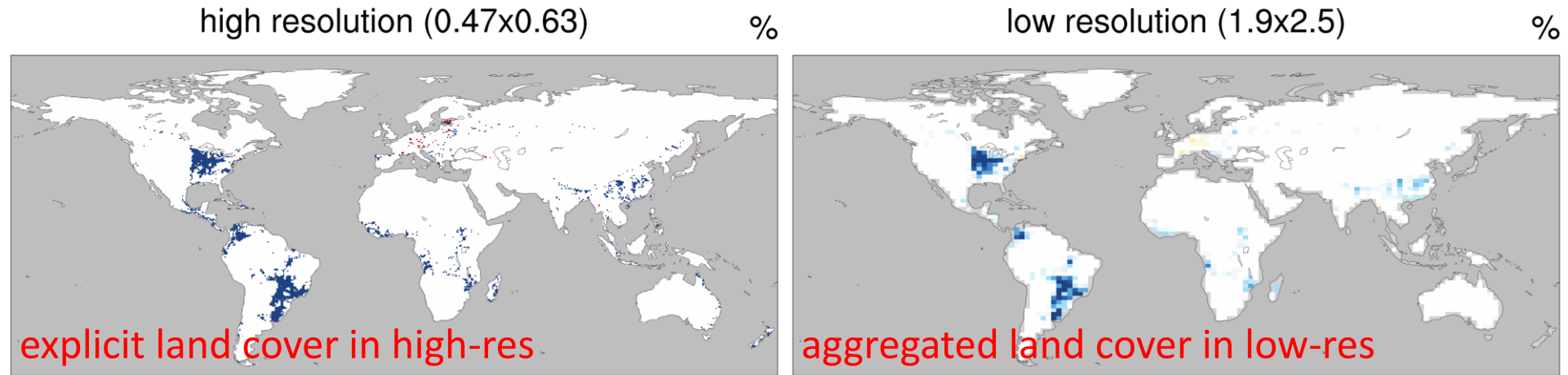
# Resolution dependency? (CLM4)

No

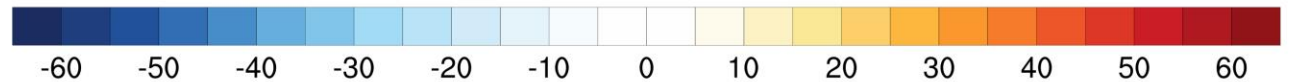
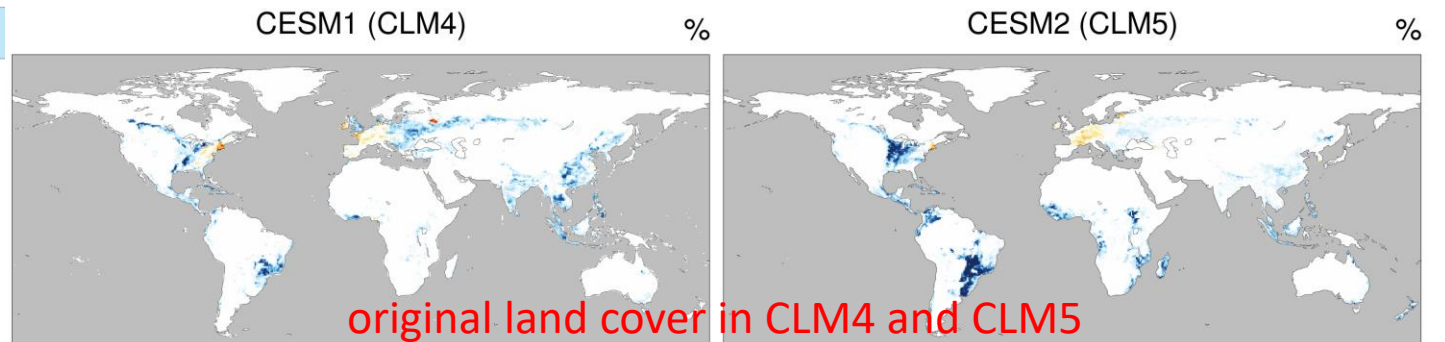


Increased  $T_s$  and decreased  $T_{2m}$  after deforestation are manifested in both high-resolution and low-resolution experiments.

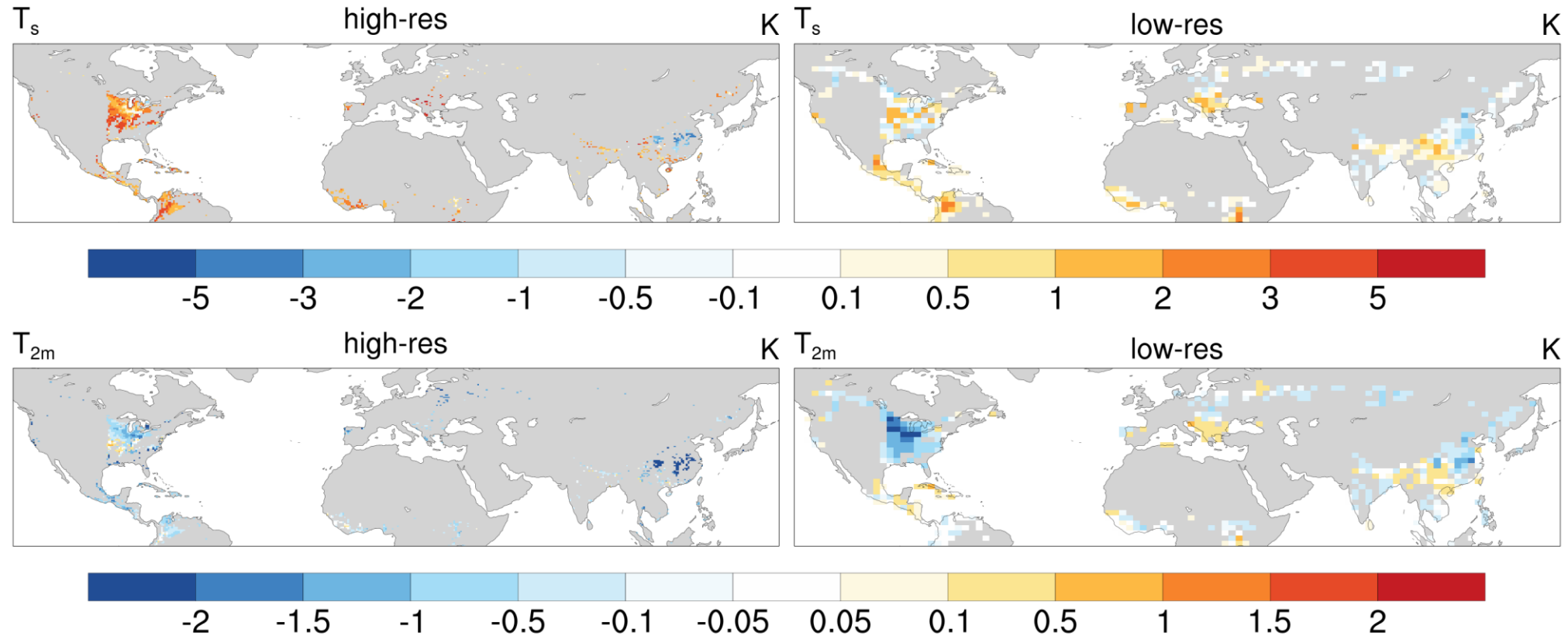
# Historical deforestation in CLM5



Note: There is quite a difference in land cover data and LULCC between CLM4 and CLM5.



# Deforestation-induced temperature changes in CLM5



**Opposite signs** of changes in  $T_s$  and  $T_{2m}$  after deforestation are shown in both high-resolution and low-resolution experiments.

# Summary

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- The discrepancies between  $T_{2m}$  and  $T_s$  suggest that the relationship between deforestation and hot extremes can be swayed by the choice of temperature variables
- Climate models provide both temperature variables, and care should be taken to ensure consistency when comparing to observational studies.
- More work should be focused on understanding the diurnal cycle of deforestation-induced climate changes.

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Thank you!