

北京师范大学地理科学学部  
Faculty of Geographical Science BNU



EGU24-13869

# The biophysical and biogeochemical impacts of global forest cover changes on land surface temperature from 2001 to 2020

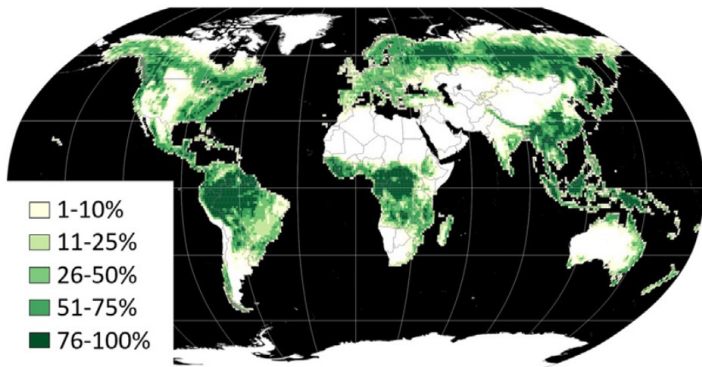
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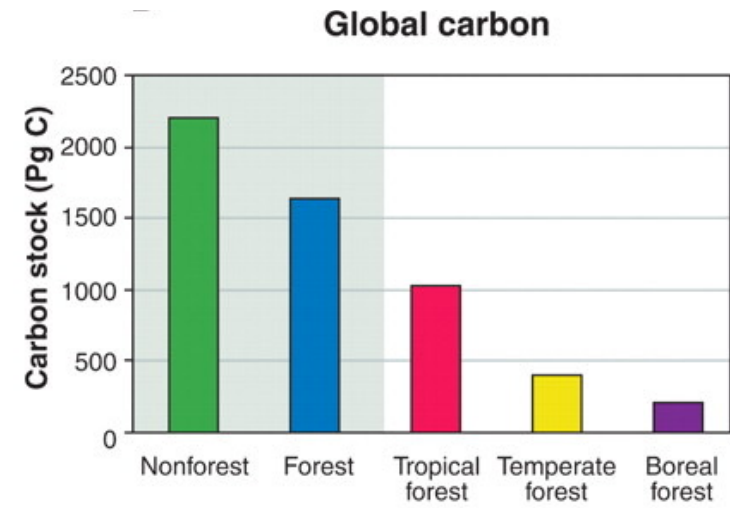
# 01 Background



Forest cover in 2000 (Potapov, 2022)

Biogeochemical effect  
(e.g., carbon cycle)

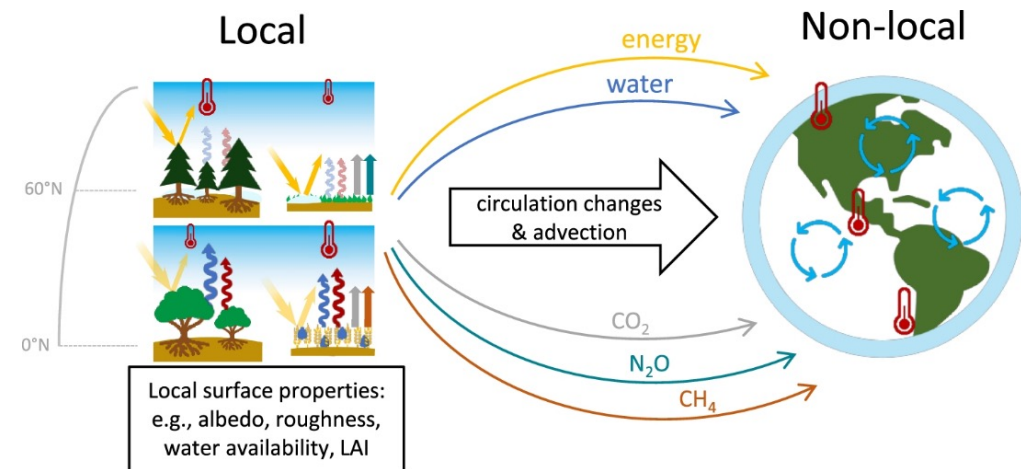
Biophysical effect  
(albedo, ET, roughness...)



Forest carbon stocks (Bonan, 2008)

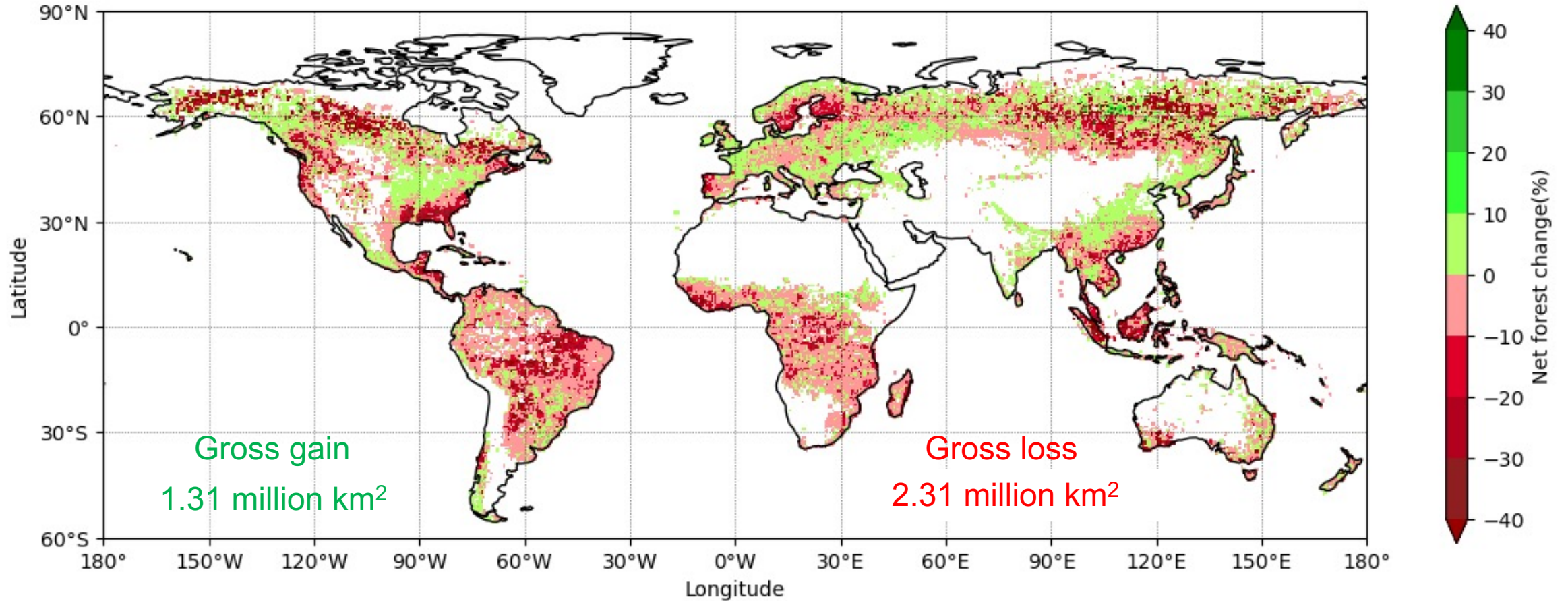
What are the **combined** biophysical and biogeochemical effects of forest cover change on temperature\* over the past two decades and their **tradeoff/synergy**?

\*Land surface temperature, LST



Effects of land cover (Julia Pongratz et al., 2021)

## 2.1 Results: Forest cover changes from 2000 to 2020

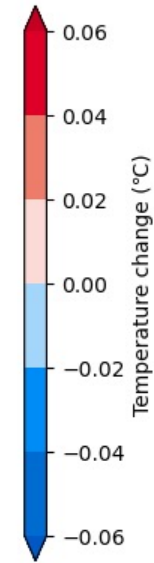
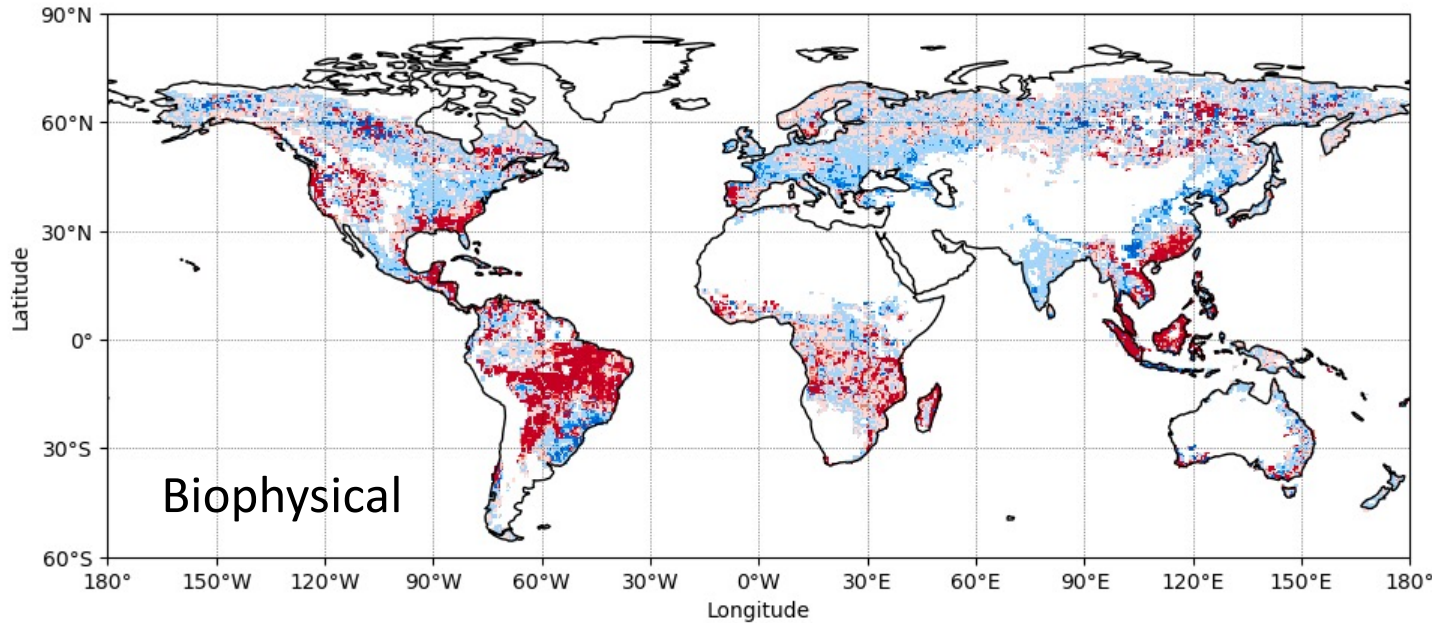


Net forest cover change: **loss of 1.00 million km<sup>2</sup>**

Area of **net gain (36%)**

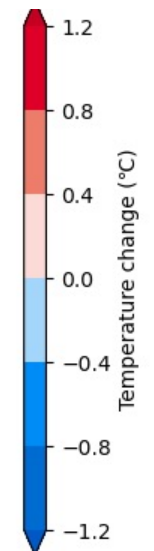
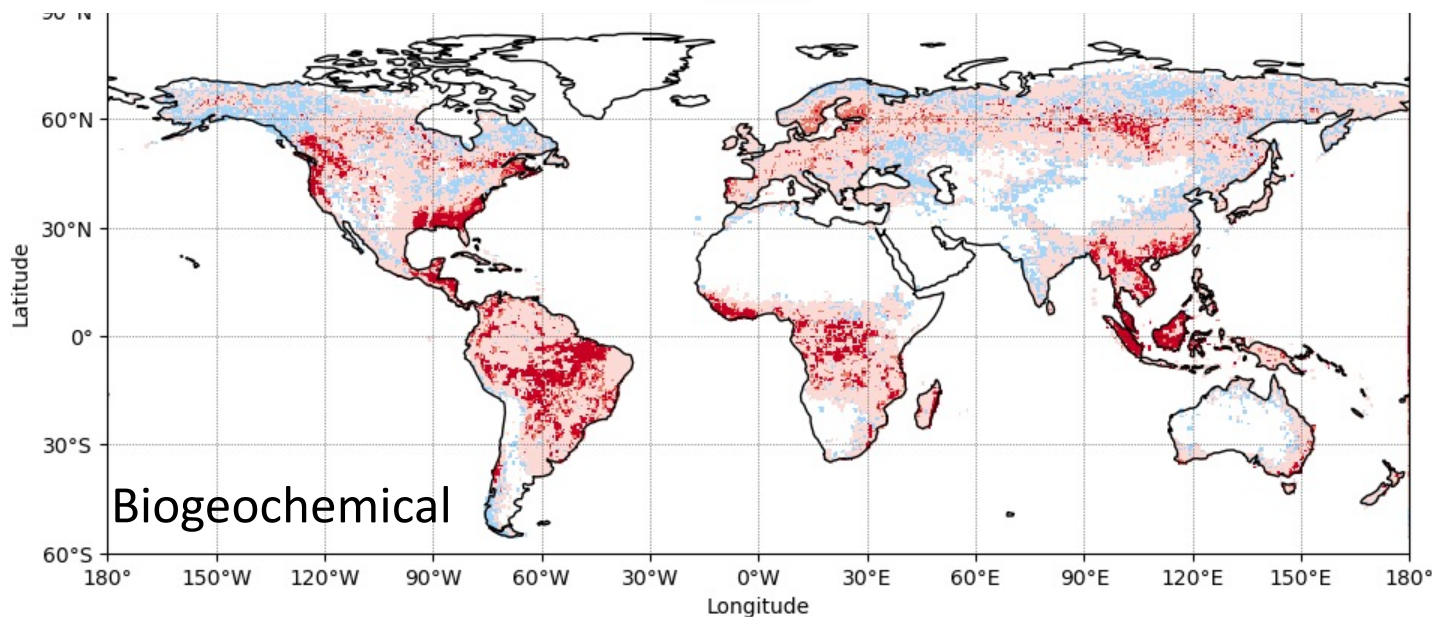
Area of **net loss (64%)**

## 2.2 Results: Biophysical and biogeochemical temperature effects



### Biophysical (BP)

- A global mean warming of **0.00225 °C**.
- Strong warming in tropical regions.

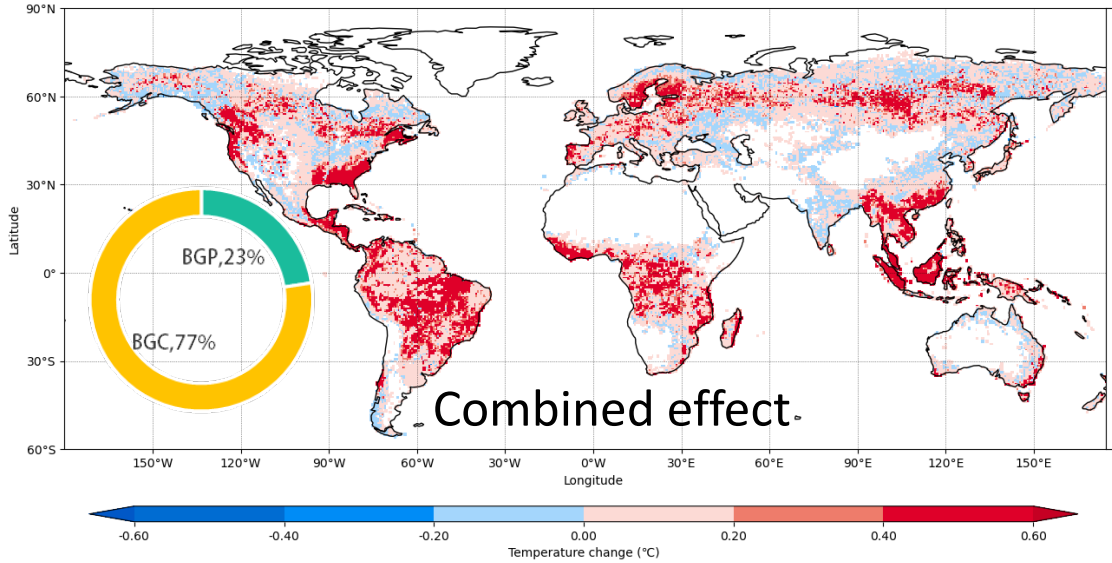


### Biogeochemical (BGC)

- Net carbon emission of 139 GtCO<sub>2</sub>e
- A global mean warming of **0.0593 °C**

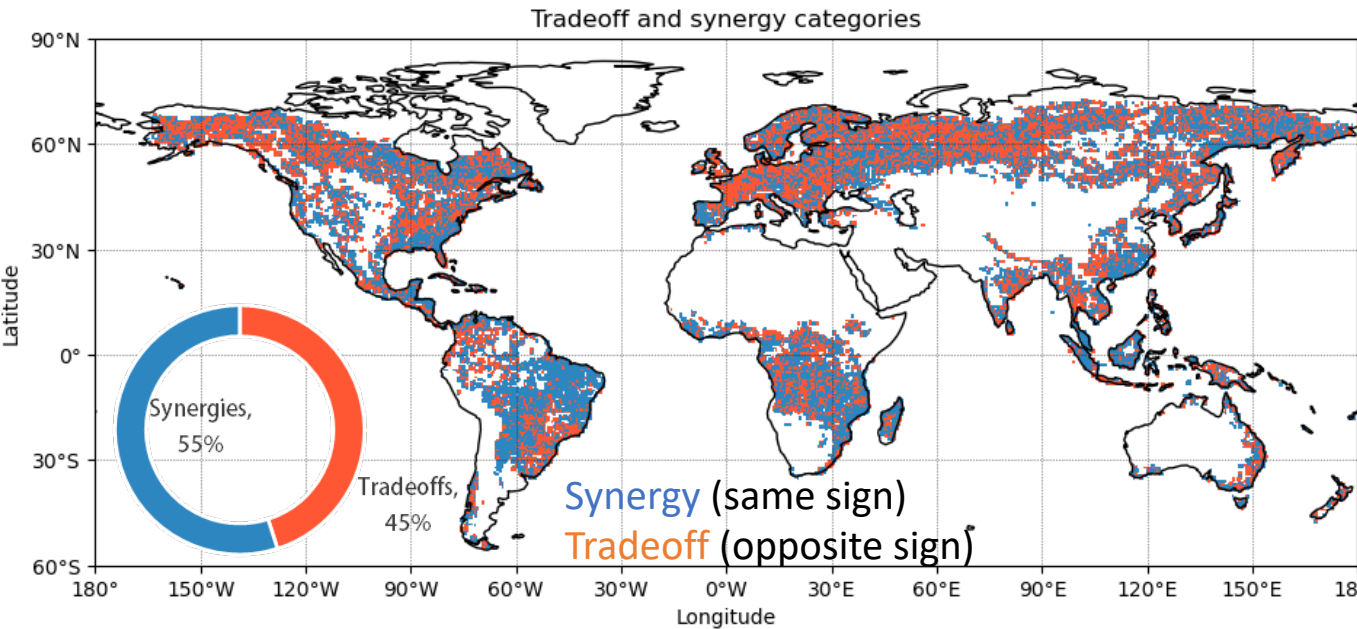
**BP+BGC Combined = 0.06155 °C**

# 2.3 Results: Tradeoff and synergy of biophysical and biogeochemical effects

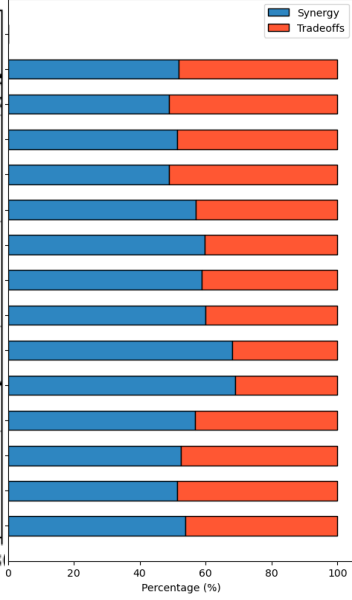


## Combined effect

- Biogeochemical (BGC) effects dominate temperature changes over 77% area



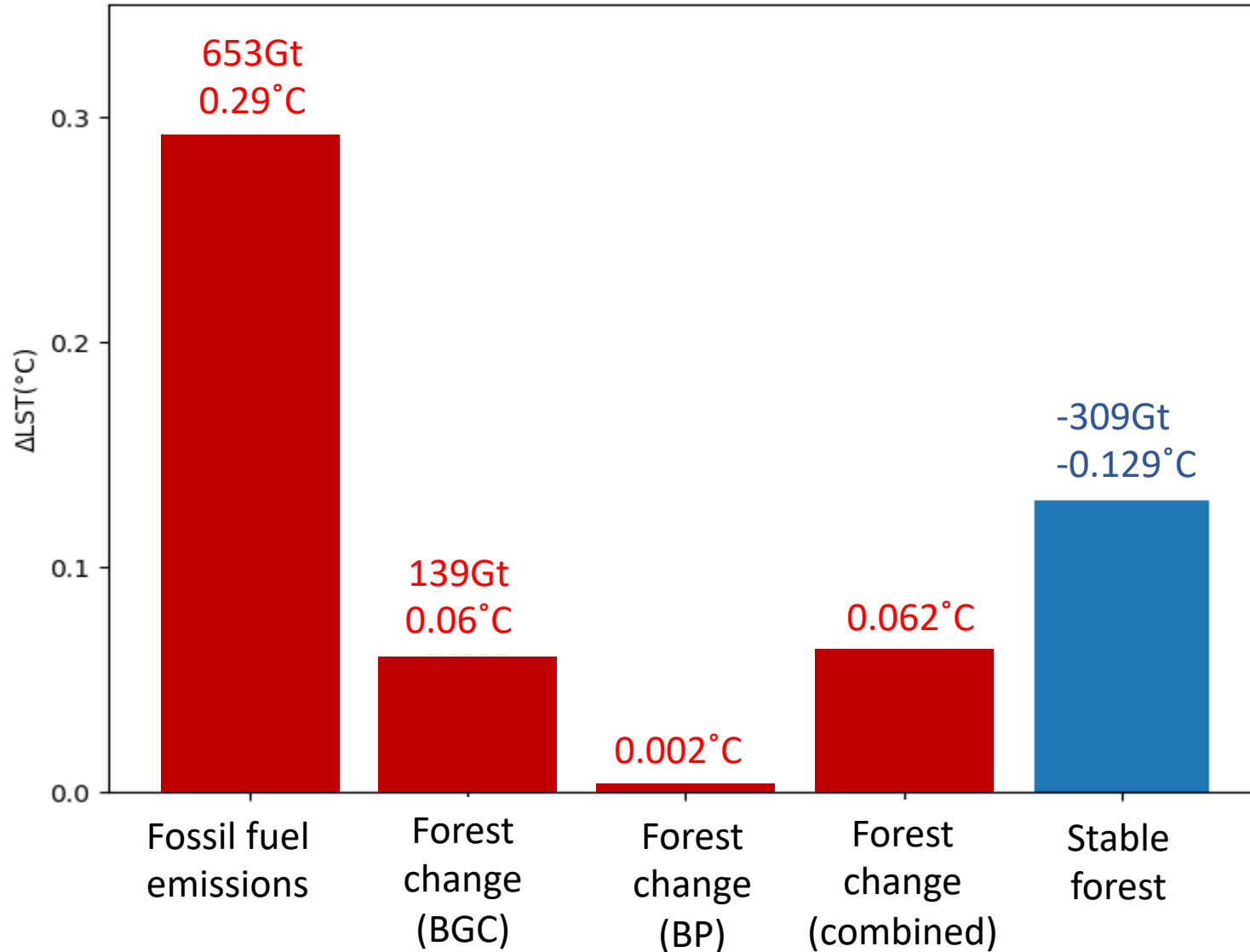
Synergy and Tradeoffs Percentages by Latitude



## Synergy and tradeoff

- Synergy** between BP and BGC in 55% of forest change area
- Tradeoff** in 45% area, and increases at higher latitudes

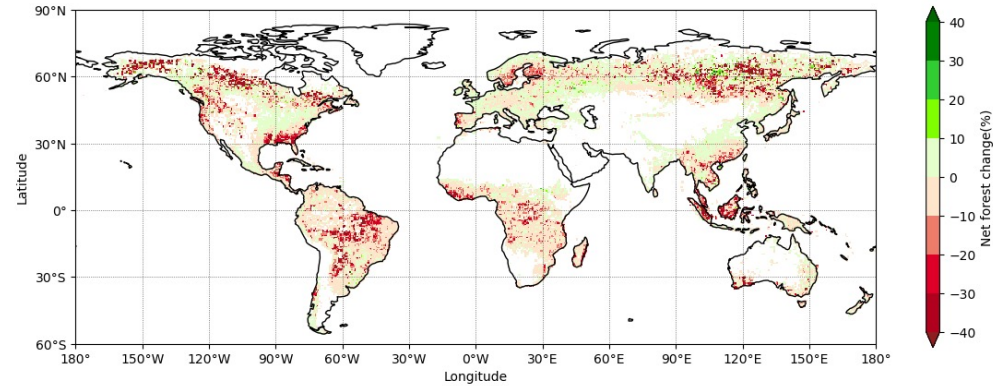
# 03 Summary



- Global forest changes contribute **0.062°C** warming from both biophysical and biogeochemical effects (**27%** of fossil fuel warming) from 2001-2020
- Stable forests **counteract** the warming by **-0.13°C**.

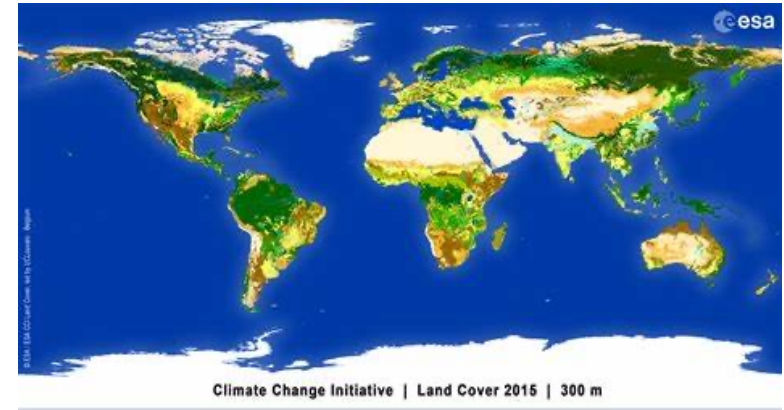
Thanks for your attention!  
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# 04 Method: quantify biophysical effect



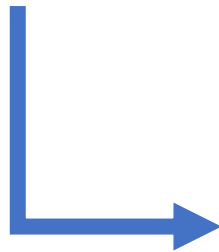
Global Forest Change Data (Potapov et al. 2022)  
**Forest cover change**

+

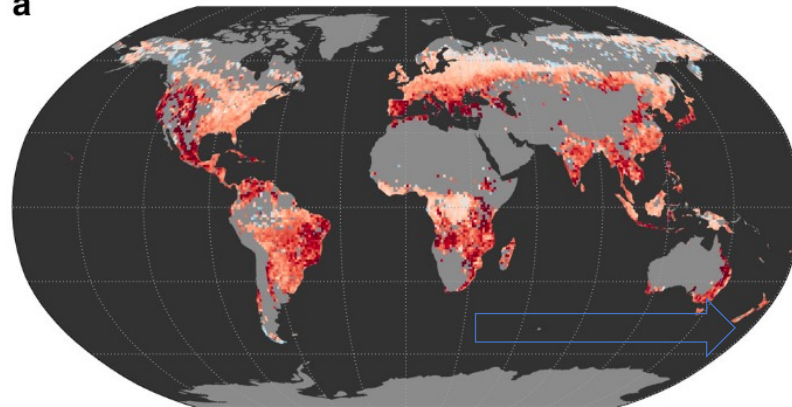


ESA CCI Land cover data

Forest land conversions



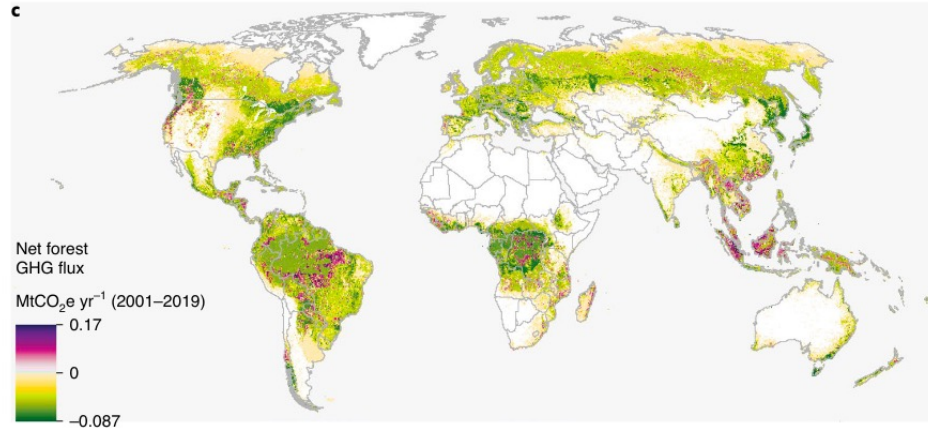
a



Potential biophysical effects of vegetation change  
(Duveiller et al 2018)

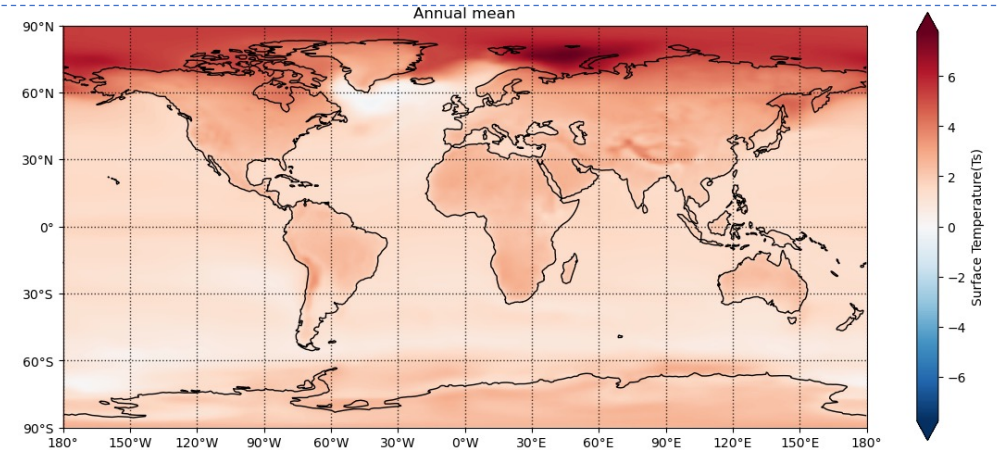
Biophysical effects on  
LST

# 04 Method: quantify biogeochemical effect



Forest greenhouse gas net flux (Harris et al. 2021)  
Forest carbon fluxes

+



Transient climate response to emissions  
CMIP5 (Windisch et al 2021)



Biogeochemical  
effect on global LST

Area Scaling



Biogeochemical  
effect on local LST



# 04 Method: quantify biogeochemical effect

$$\Delta T_{\text{global}} = AF \times E \times \text{TCRE} \quad (1)$$

$$\Delta T_{\text{global}} = \Delta T_{\text{local}} \times A_{\text{grid}} / A_{\text{sfc}} \quad (2)$$

$$\Delta T_{\text{local}} = AF \times E \times \text{TCRE} \times A_{\text{sfc}} / A_{\text{grid}} \quad (3)$$

AF: airborne fraction, 0.5

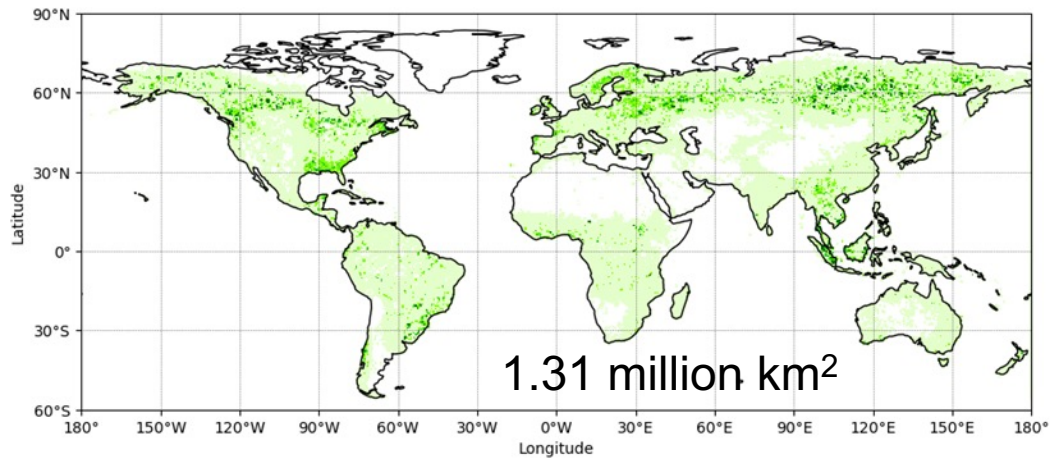
E: CO<sub>2</sub> flux of a grid (unit: GtCO<sub>2</sub>)

TCRE: surface temperature response to CO<sub>2</sub> emission (unit: °C/GtCO<sub>2</sub>); e.g., 2.01°C/2233.66 GtCO<sub>2</sub>

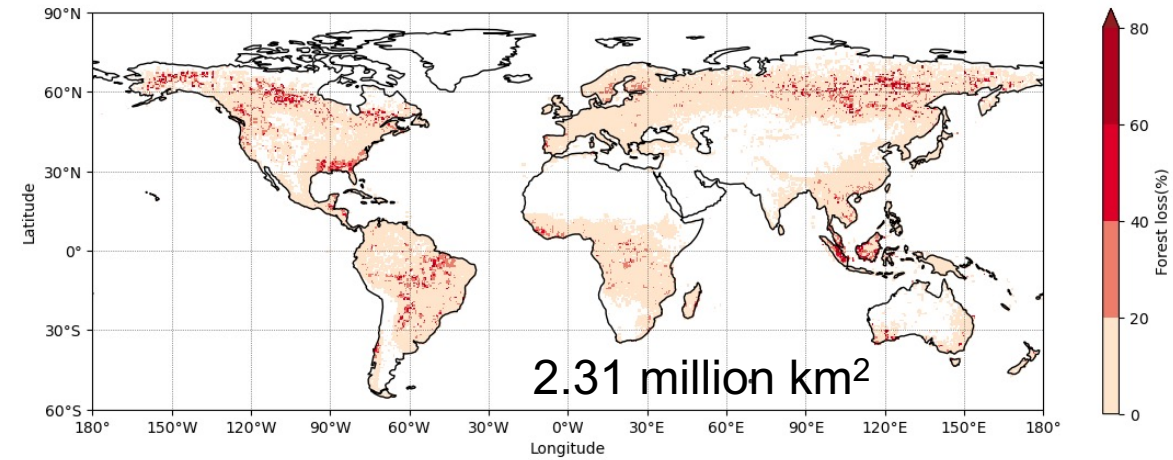
A<sub>sfc</sub>: Earth surface area = 5.1 \* 10<sup>8</sup> km<sup>2</sup>

A<sub>grid</sub>: Grid area

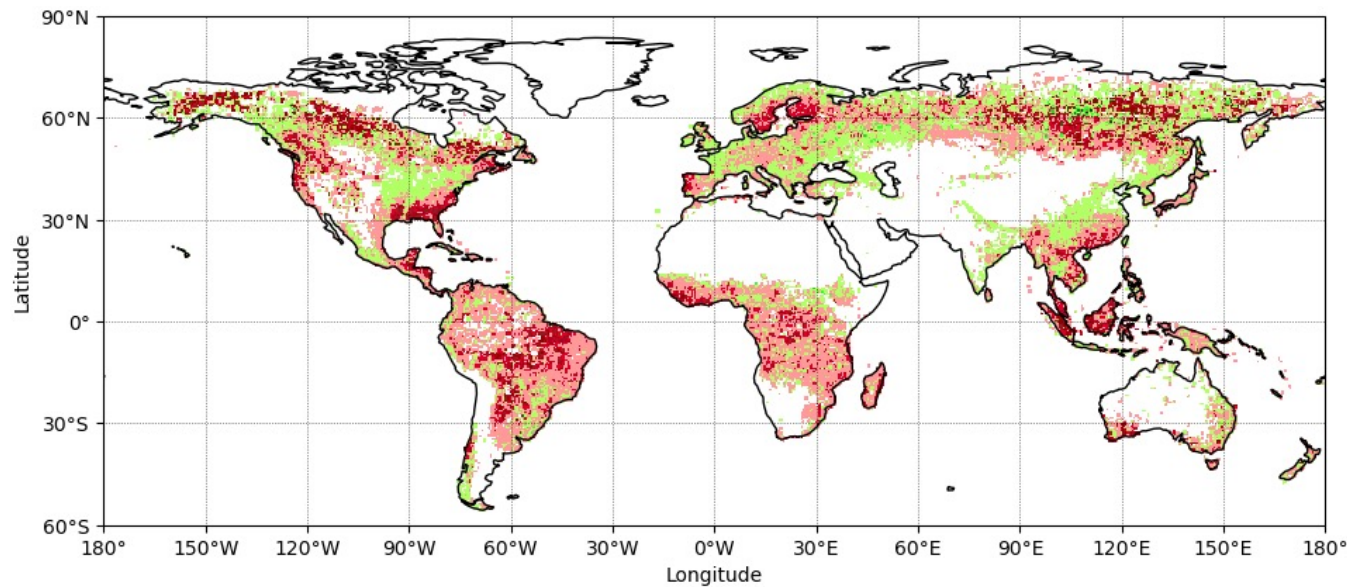
# 2.1 Results: Forest cover changes from 2000 to 2020



Gross forest cover gain



Gross forest cover loss

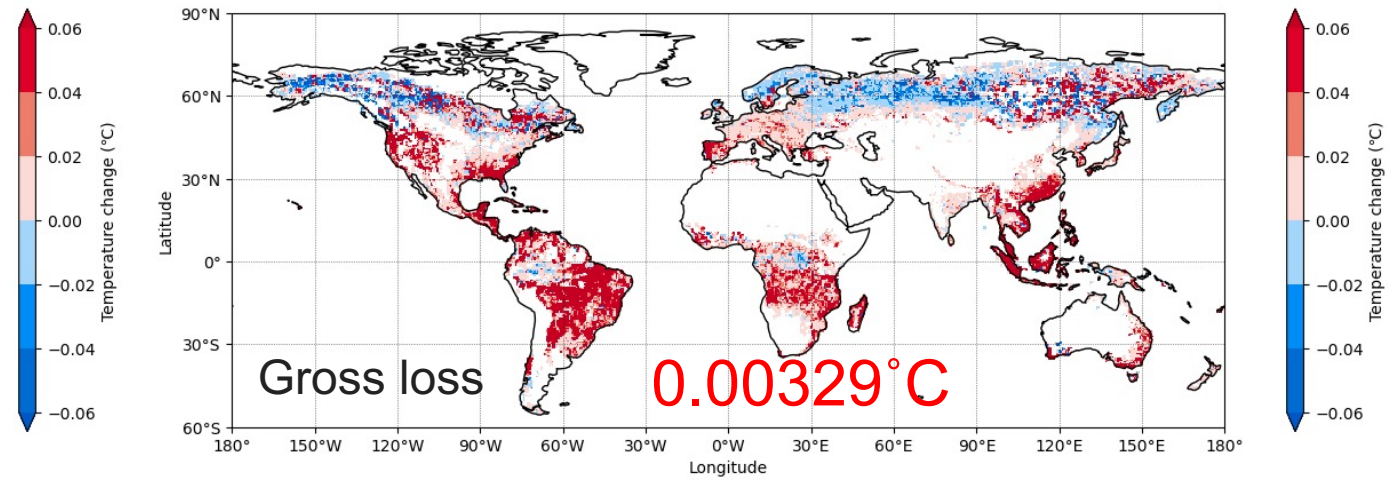
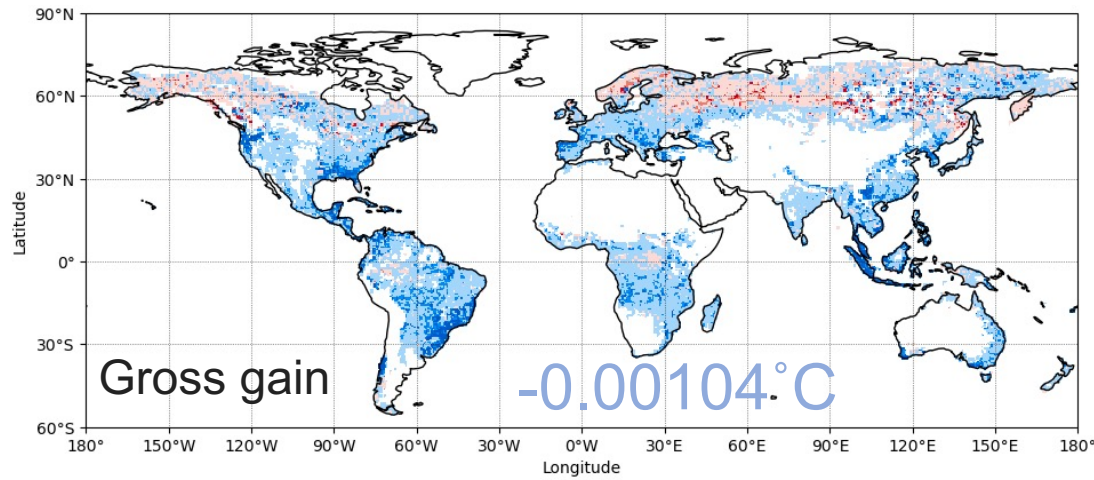


Net gain area (36%)

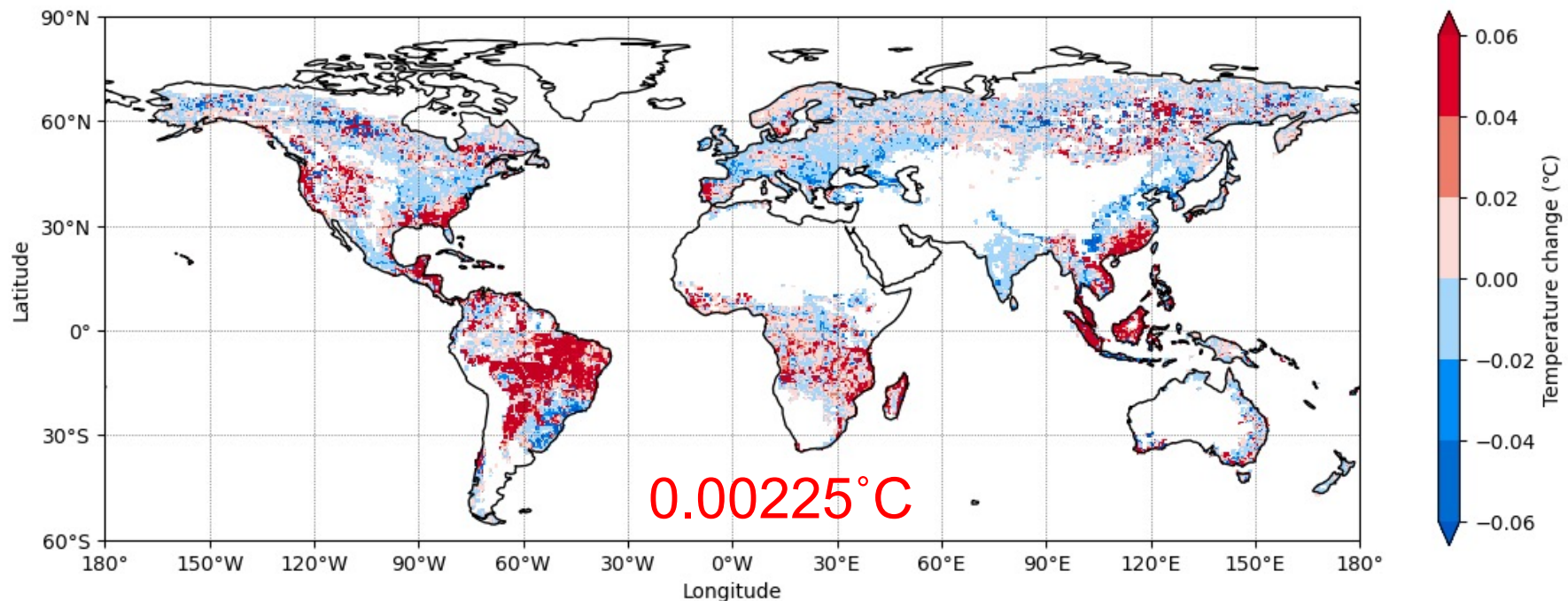
Net forest cover change

Net loss area (64%)

## 2.2 Results: Biophysical temperature effects of net forest change

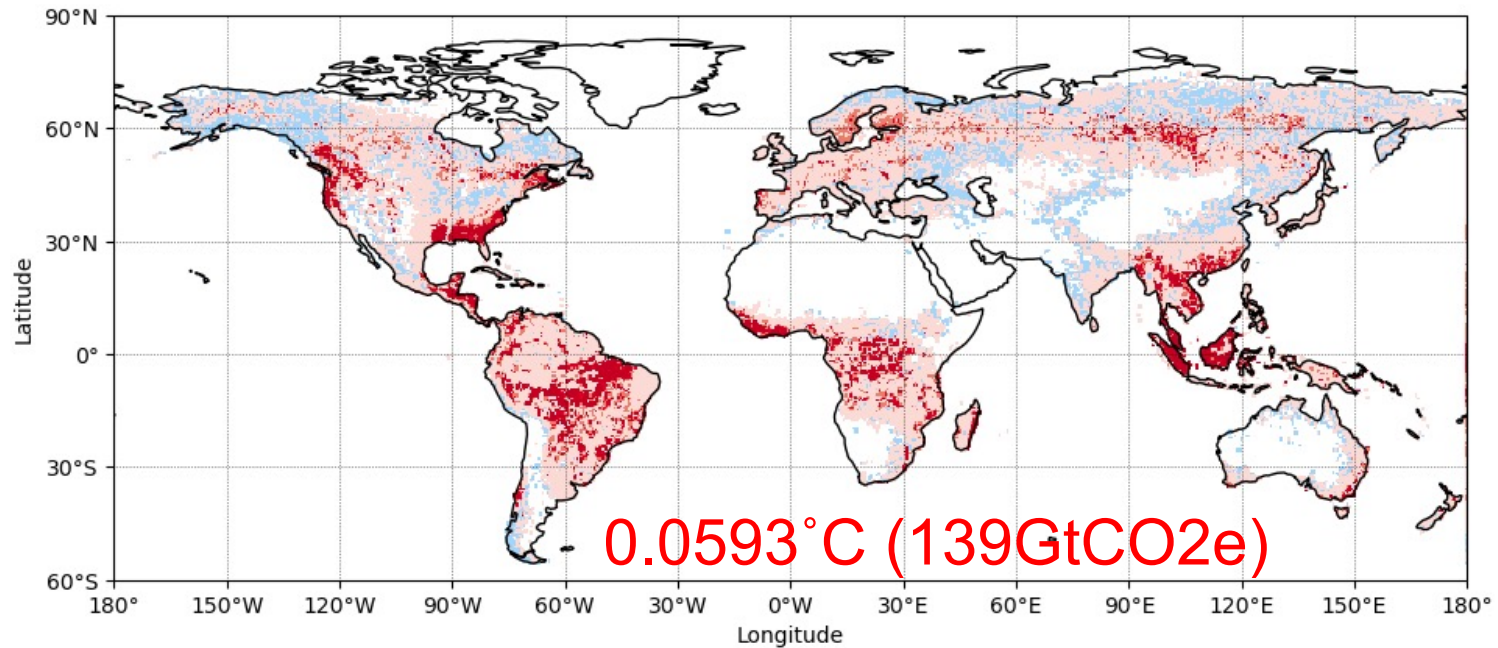
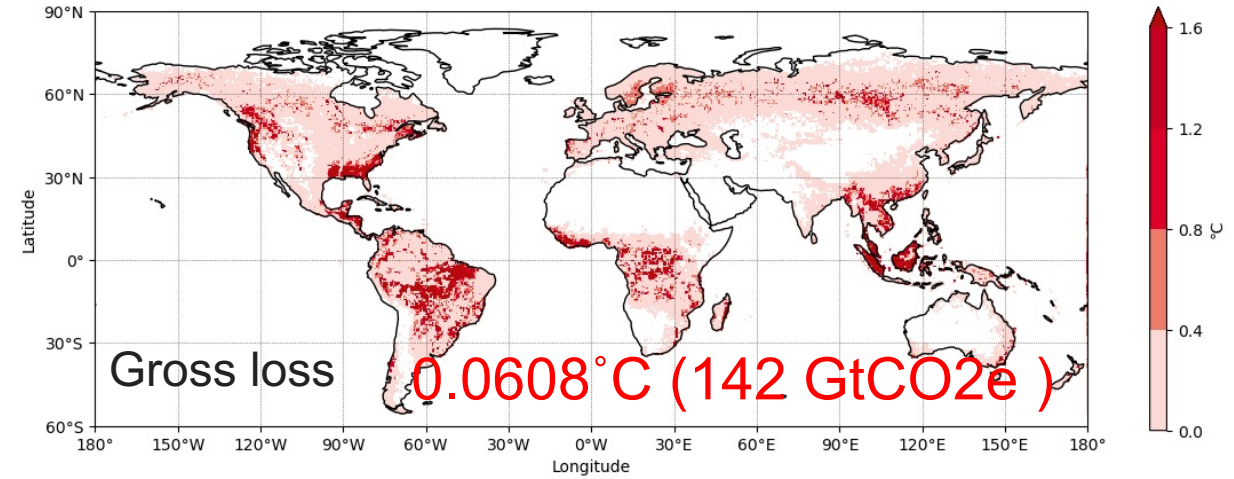
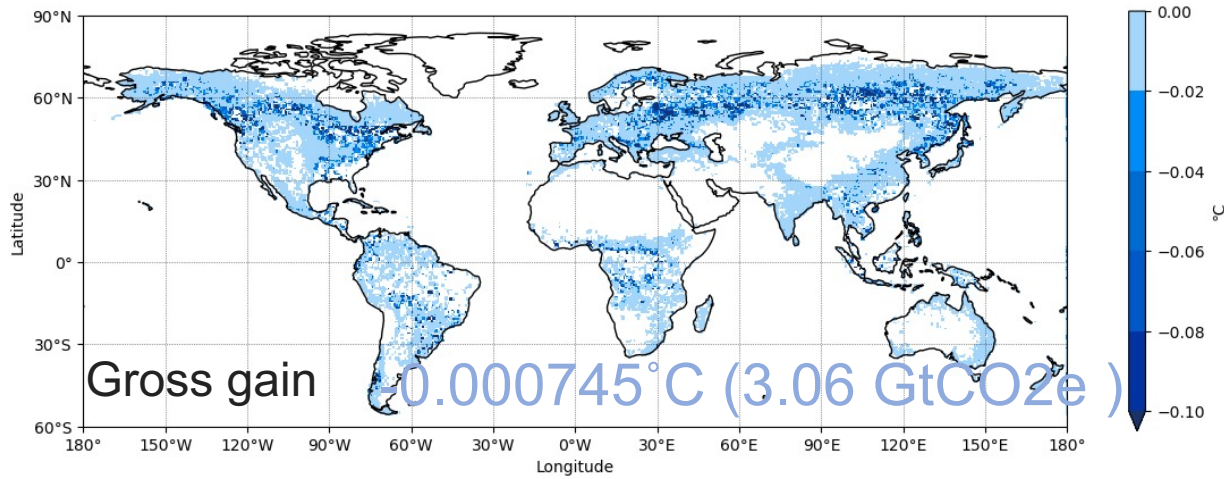


Strong biophysical warming in tropical regions



A global warming of  $0.00225^{\circ}\text{C} = -0.00104^{\circ}\text{C} + 0.00329^{\circ}\text{C}$

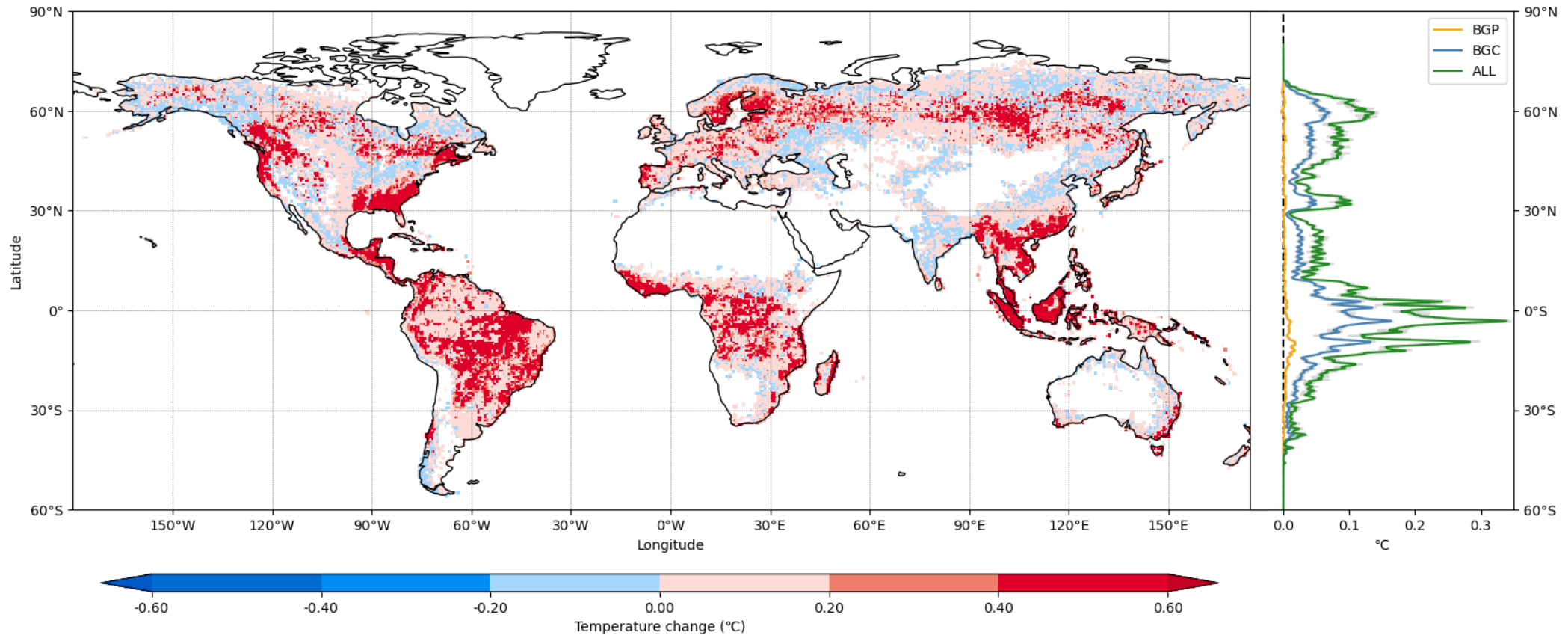
## 2.3 Biogeochemical temperature effects of net forest change



Temperature change (°C)

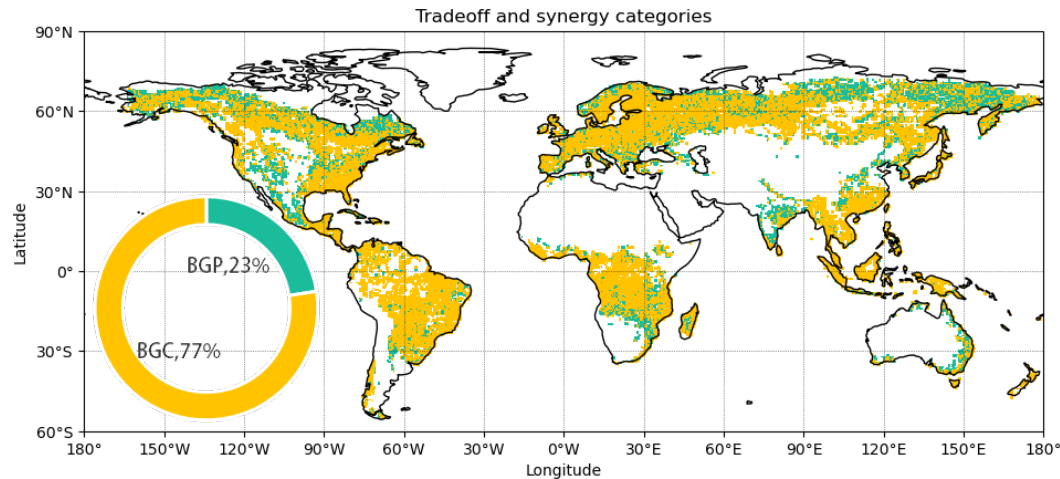
A global mean warming of 0.0593°C

## 2.4 The combined biogeochemical and biophysical effects

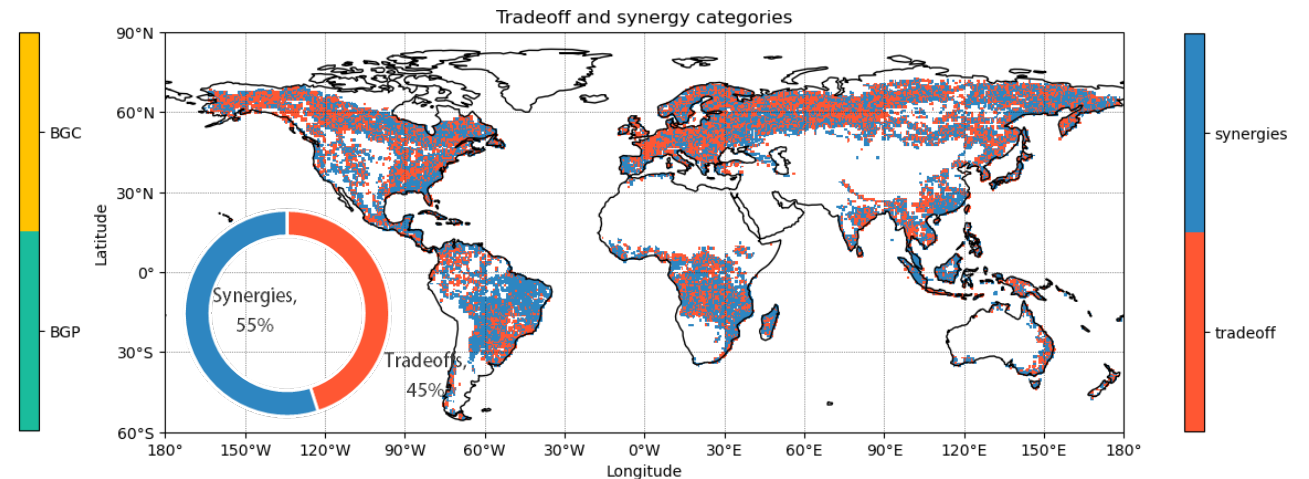


- A global mean :  $0.06155^{\circ}\text{C}$  (combined) =  $0.00225^{\circ}\text{C}$  (biophysical) +  $0.0593^{\circ}\text{C}$  (biogeochemical)

## 2.5 Tradeoff and synergy between biophysical and biogeochemical effects



Dominant distribution map of biophysical and biogeochemical effects



Tradeoffs and synergies classification

- **Biogeochemical effects** dominate the temperature changes in most of the global regions (77%)
- **The synergies** between biophysical and biogeochemical processes are mainly found in the southeastern United States and the Amazon region, while **tradeoffs** are distributed in the northern forest areas and along the eastern coast of South America.