

CONTEXT

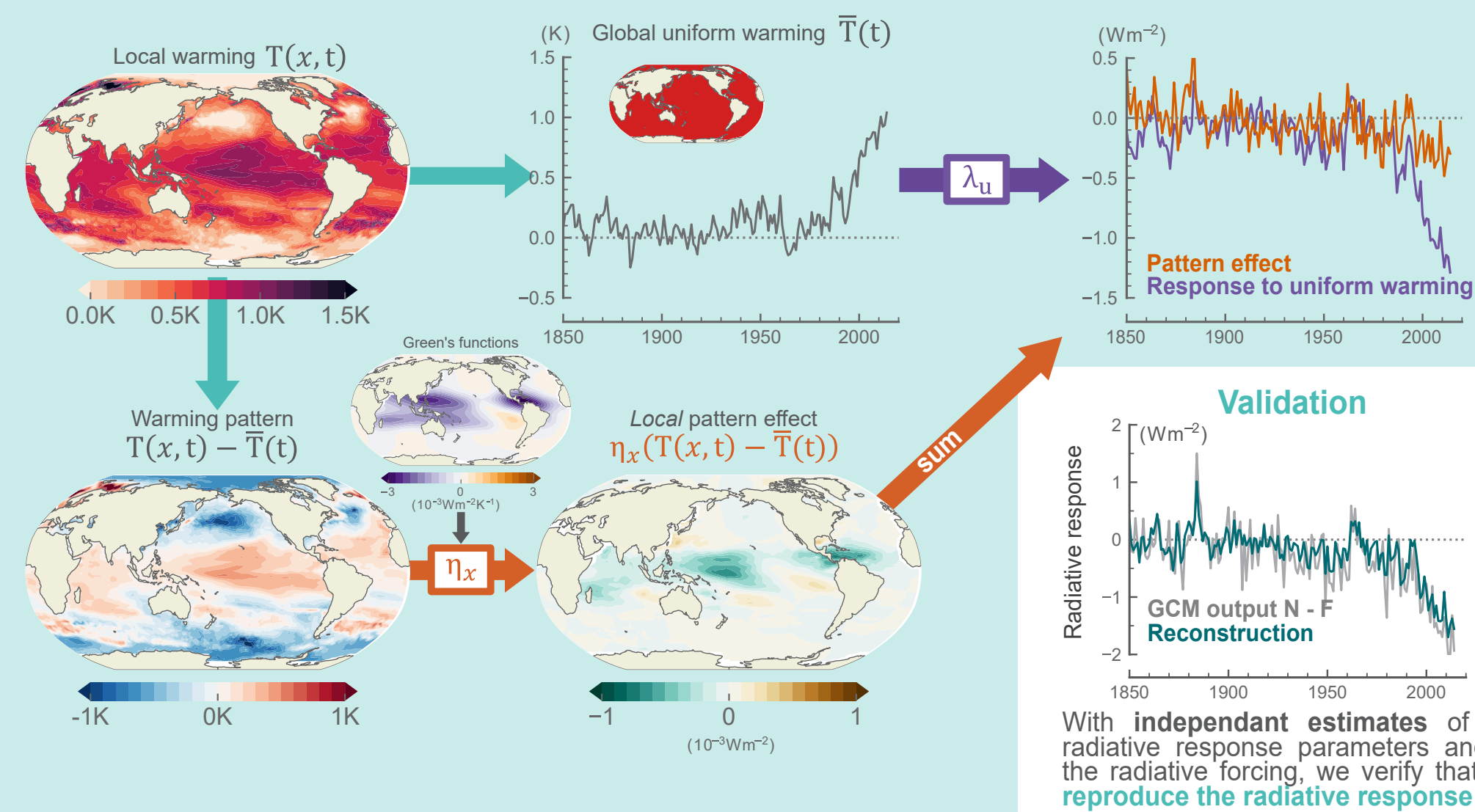
The spatial patterns of surface warming influence the Earth's response to radiative forcing as they affect climate feedbacks: **this is called the "pattern effect"**. While the latest generation of climate models accurately simulate global warming since the industrial revolution, recent studies highlight that they generally fail to replicate the observed warming patterns. These biases should translate into biases in the Earth energy imbalance, which eventually influences the rate of global warming. **In this study, we use a novel analytical method to explore such potential biases and to quantify the impact of the pattern effect on historical global warming.**

METHOD

The radiative response is computed **separately** on **global warming** and on **local warming patterns** using Green's functions coefficients.

$$dR(t) = \frac{\partial R}{\partial T} \bar{T}(t) + \sum_x \frac{\partial R}{\partial (T(x) - \bar{T})} (T(x) - \bar{T})$$

Response to global warming: $\lambda_u \bar{T}(t)$ Response to local SST pattern change: $\eta_x (T(x) - \bar{T})$



We incorporate the multilinear radiative response in a **two-layer energy balance model** to quantify the impact of the pattern effect on global warming.

$$\begin{cases} \text{Surface+ mixed-layer ocean} & C \frac{dT}{dt}(t) - \lambda_u \bar{T}(t) - \gamma(\bar{T}(t) - \bar{T}_0(t)) = F(t) + P(t) \\ \text{Deep ocean} & C_0 \frac{dT_0}{dt}(t) - \gamma(\bar{T}(t) - \bar{T}_0(t)) = 0 \end{cases}$$

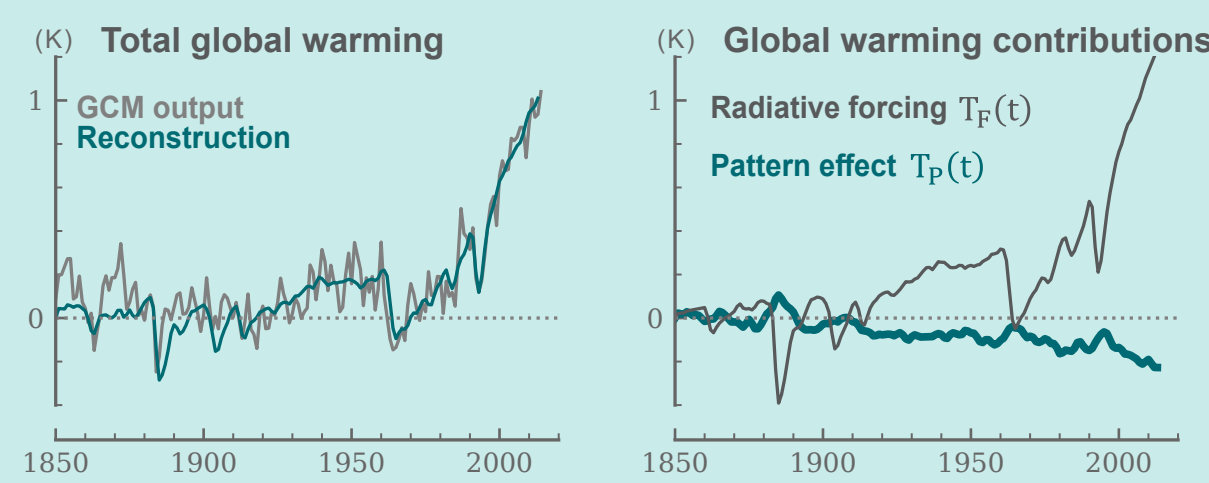
Heat storage Climate feedbacks Heat exchange Forcing terms

Consequences:
The pattern effect acts as an additional forcing

$$T(t) = T_F(t) + T_P(t)$$

Global warming caused by the radiative forcing

Global warming caused by changing warming patterns

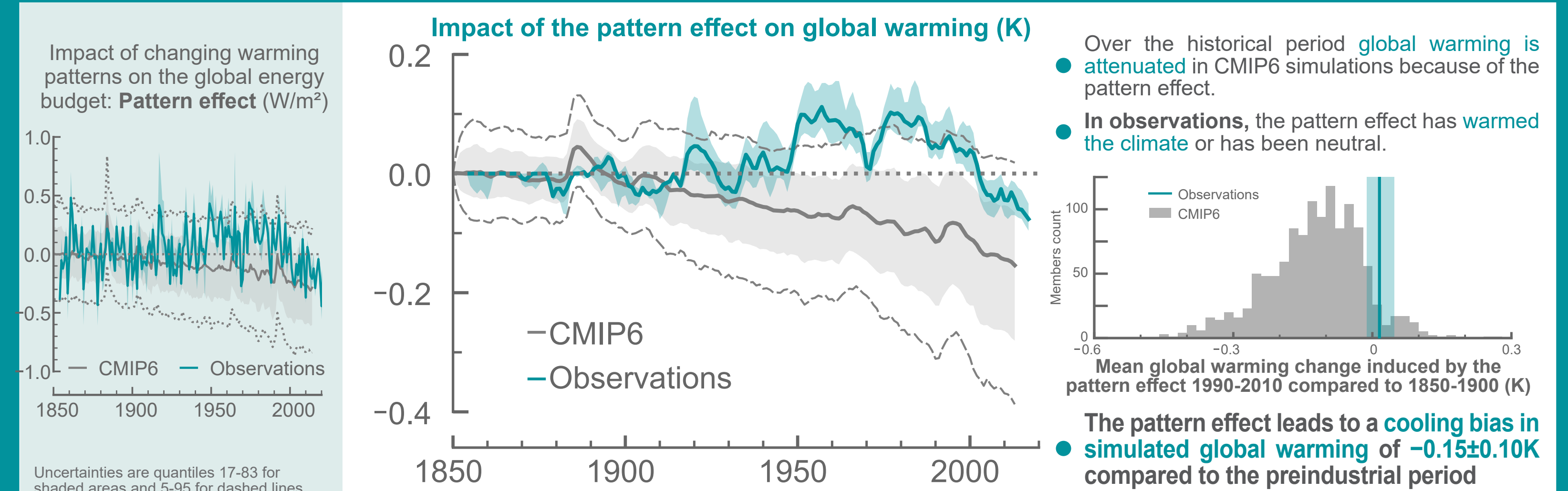


DATA

50 CMIP6 models 3 Green's functions (CAM4, CAM5, GFDL-CM4)
409 ensemble members 4 Observational products (HadiSST, ERSSTv5, COBE, AMIP)

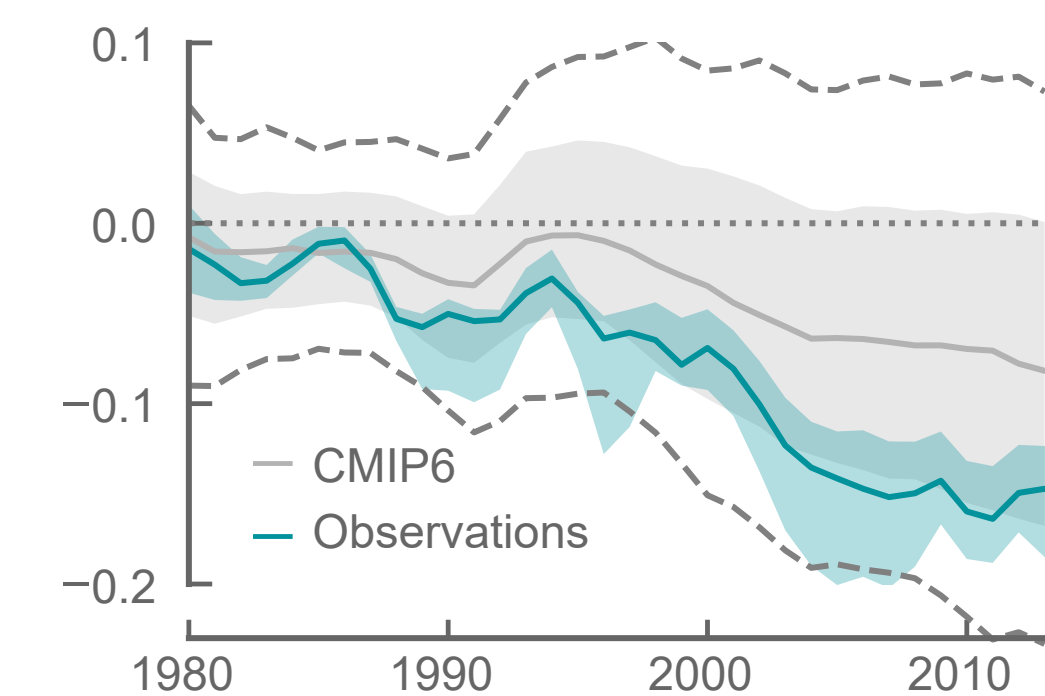
RESULTS

Over the full historical period, the pattern effect has reduced global warming in climate model simulations but not in observations

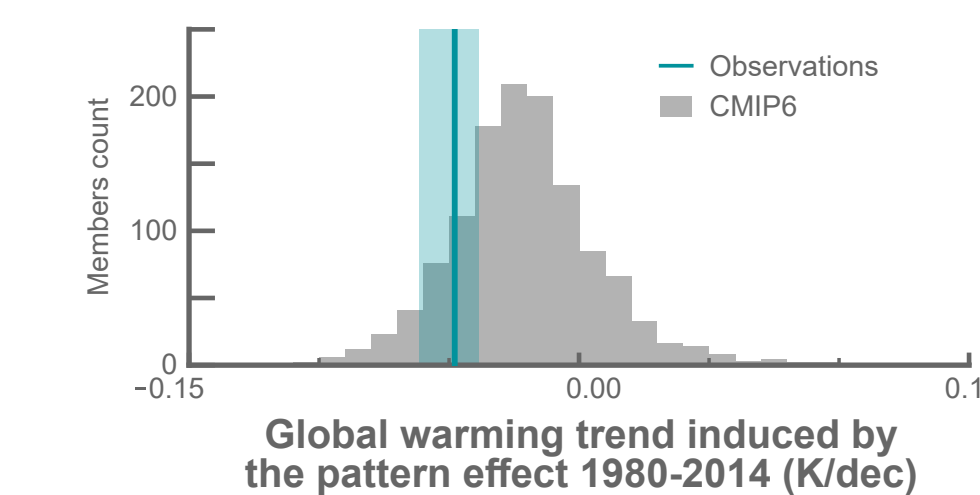


The pattern effect has reduced global warming more in observations than in climate models only since the 1980s

Impact of the pattern effect on global warming (K)



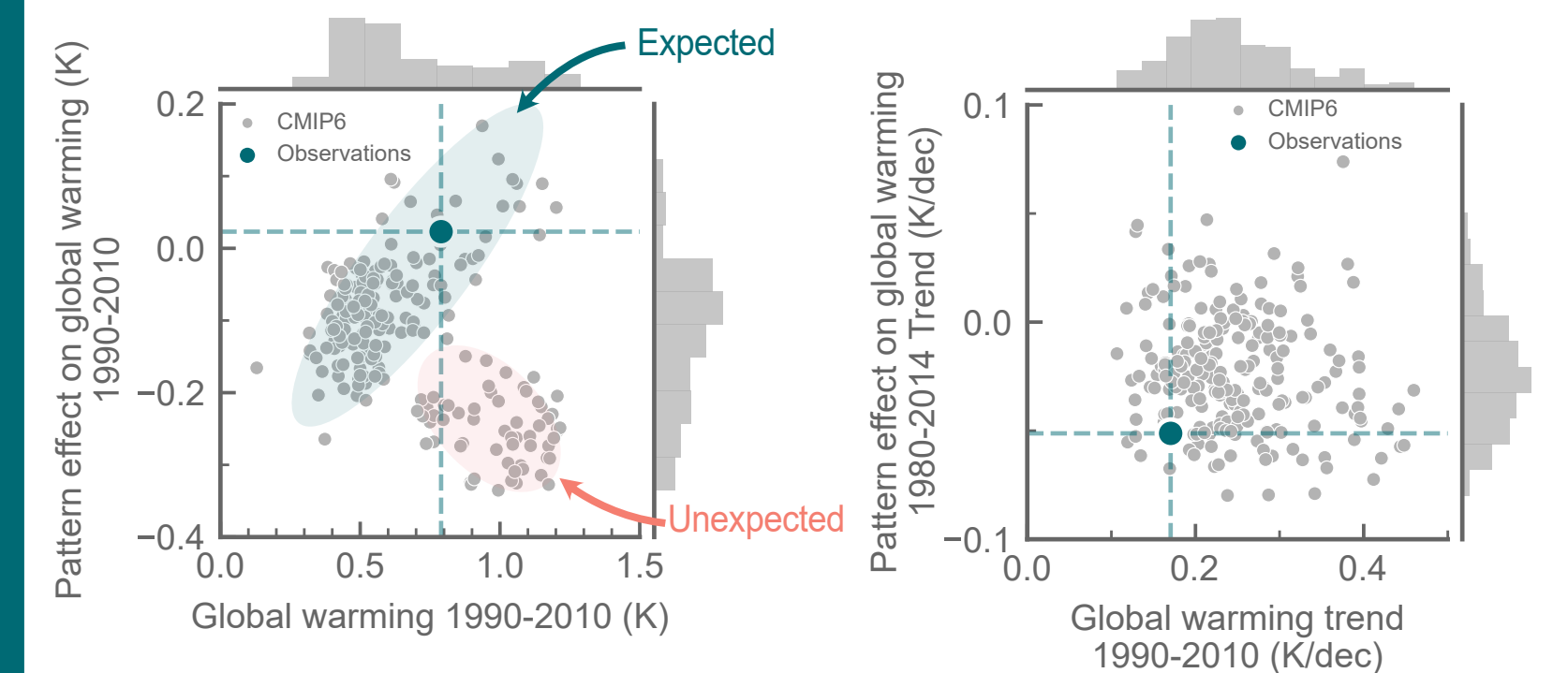
When referenced in 1980, the pattern effect reduces global warming in observations more than in climate models.



The cooling trend since 1980 induced by the pattern effect that is stronger in observations than climate models is only part of the story !

CONSEQUENCES

Our analysis has two consequences **1.** historical simulations should have less overall global warming than observations, and **2.** historical simulations should show a stronger global warming rate since the 1980s.



1. Is not always the case ! Another issue may be compensating for this: **problem with the radiative response to uniform warming?**

2. Might be the case: CMIP6 models generally show stronger global warming trends since the 1980s than observations

MORE INFOS

Contact me at r.guilcas@outlook.com

Read a **paper** on the decomposition of the radiative response in Journal of Climate: Meyssignac, Guillaume-Castel & Roca

Read a **preprint** on the method to quantify how the pattern effect affects global transient warming: Guillaume-Castel & Meyssignac

Meyssignac, B., Guillaume-Castel, R., & Roca, R. (2023). Revisiting the global energy budget dynamics with a multivariate Earth energy balance model to account for the warming pattern effect. Journal of Climate, 36(23), 8113-8126.