Mechanisms of the pattern effect in CAM6

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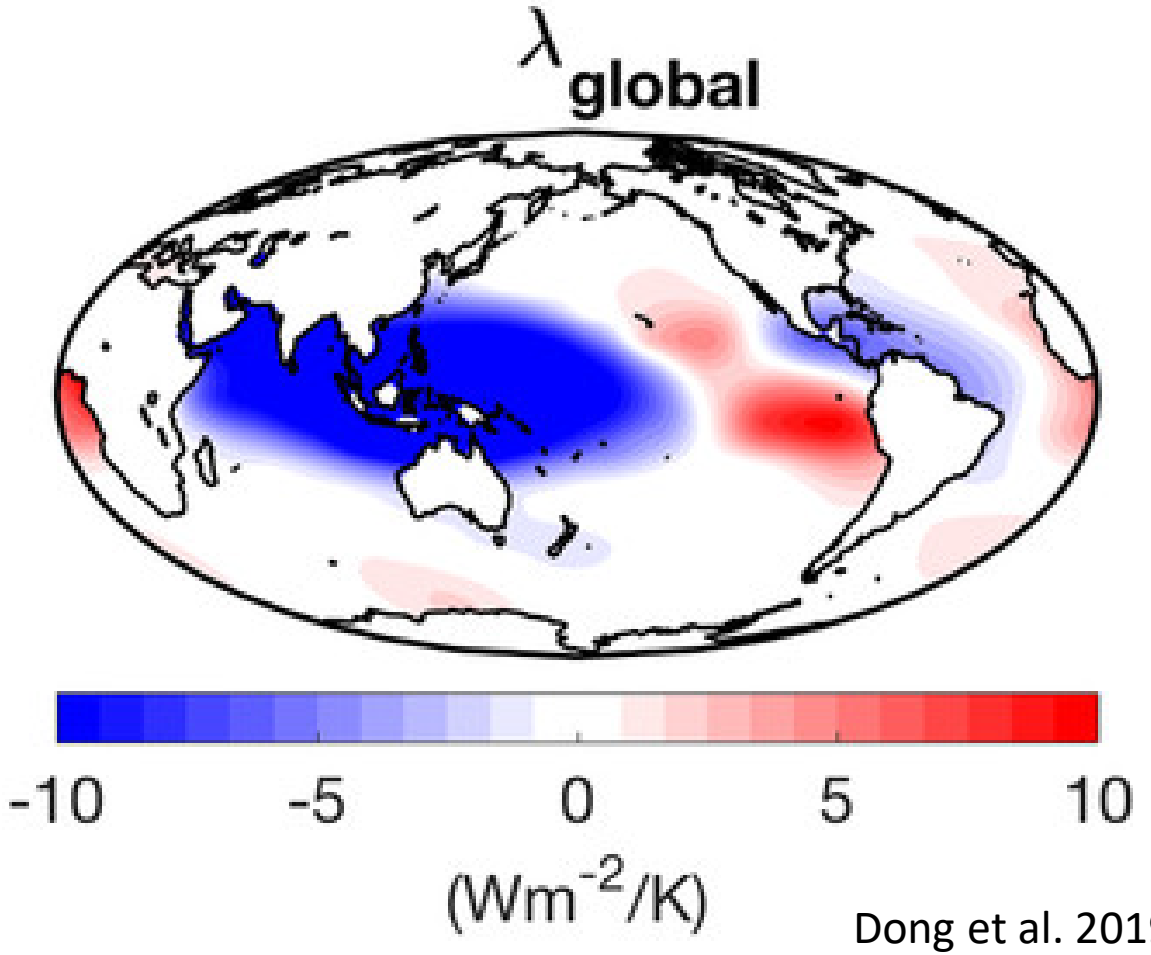
Funded by NOAA MAPP

The pattern effect relates the pattern of warming to radiative feedbacks

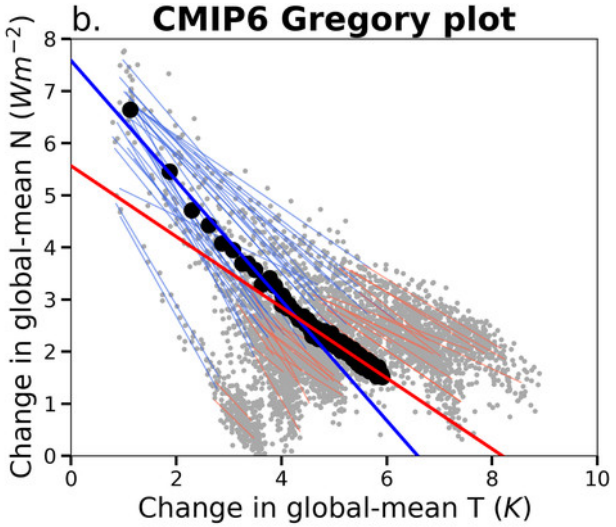
The figure shows the **global-mean radiative feedback for local SST warming**. The strong dependence of feedback on warming location explains why feedbacks are so sensitive to the *pattern of warming.*



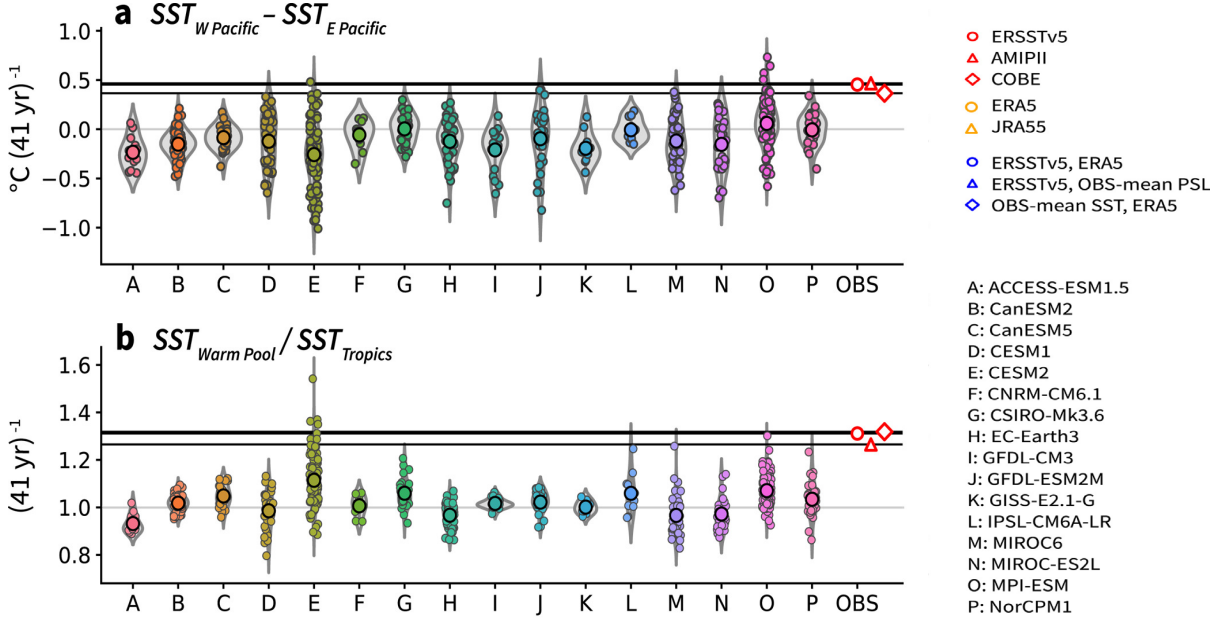
Dong et al. 2019, CAM4

The pattern effect has implications for…

Radiative feedbacks over time and **Biases in tropical SST pattern**



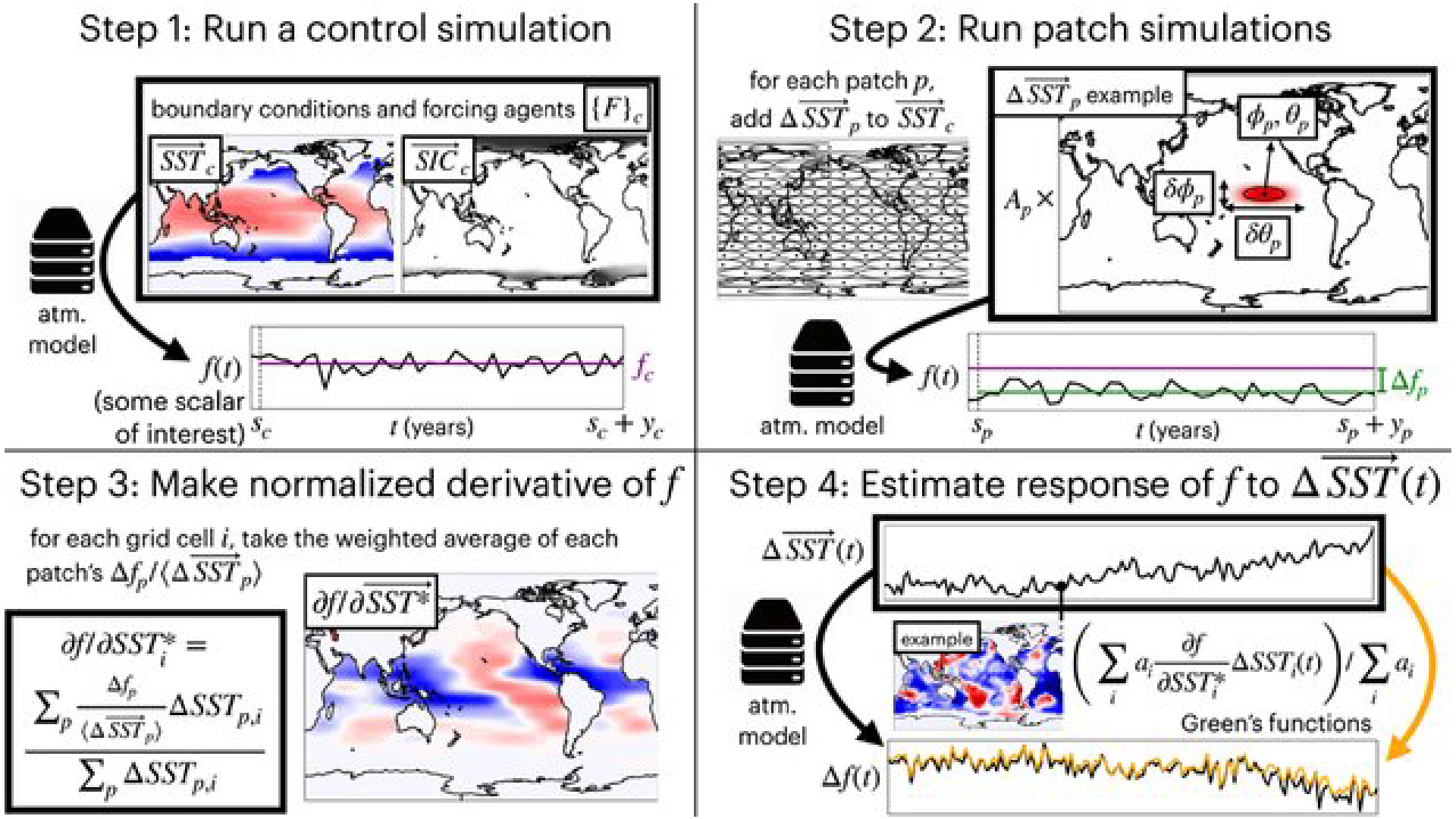
Dong et al. 2020, JCli



Wills et al. 2022, GRL

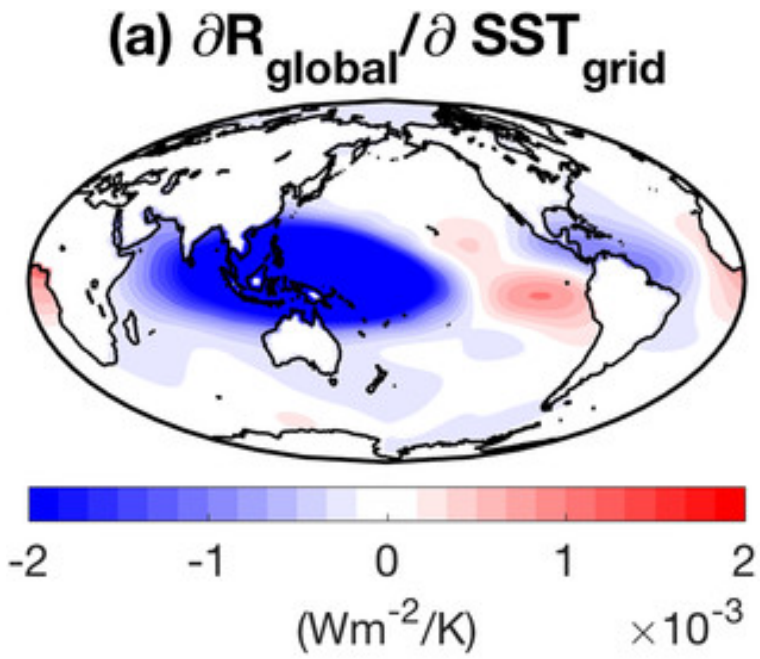
The pattern effect is evaluated using SST patch experiments

Bloch-Johnson et al. 2024, JCli



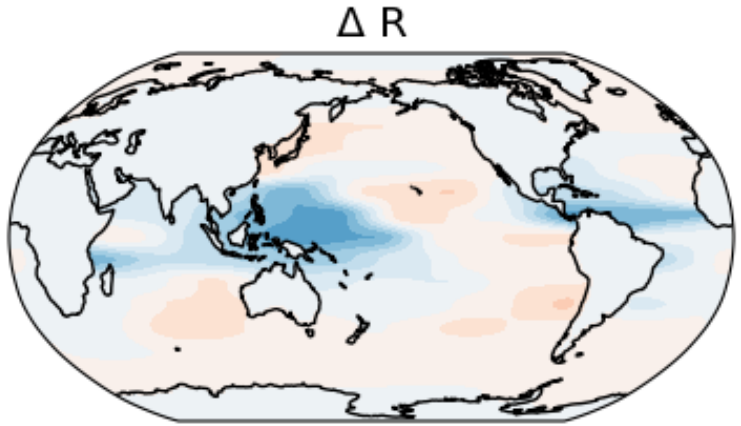
The West Pacific has a strong stabilizing influence

CAM4



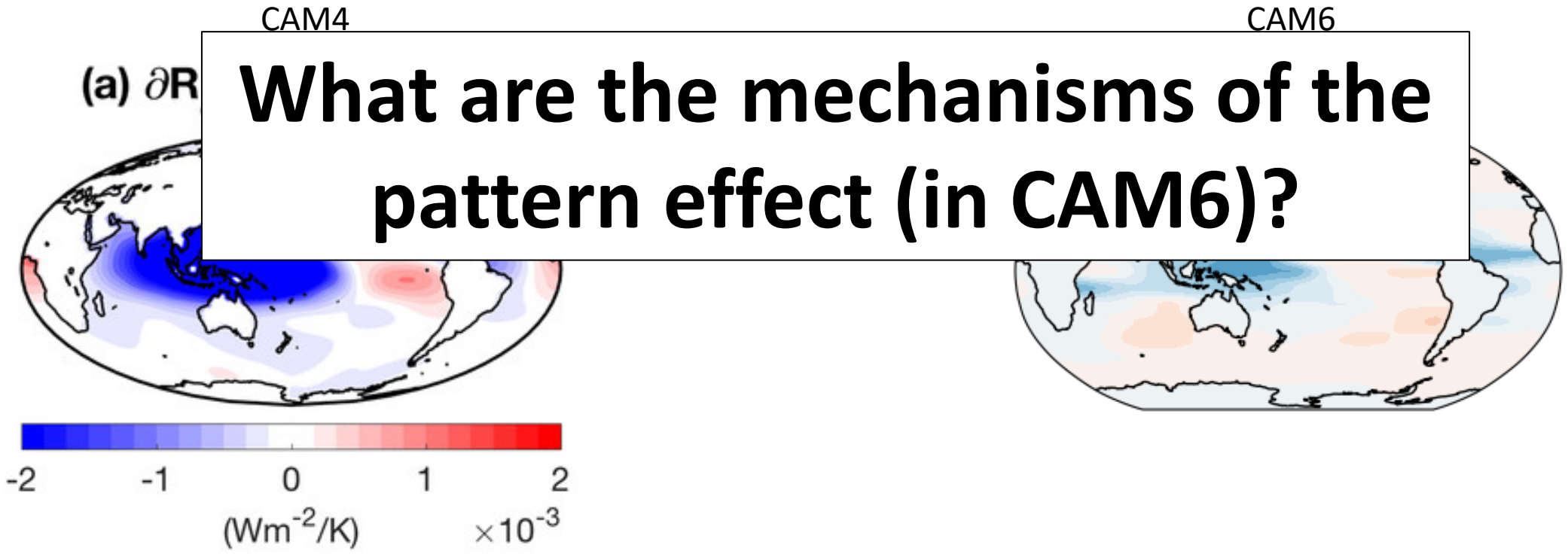
Dong et al. 2019

CAM6



Different plotting conventions, for qualitative assessment only!

The West Pacific has a strong stabilizing influence

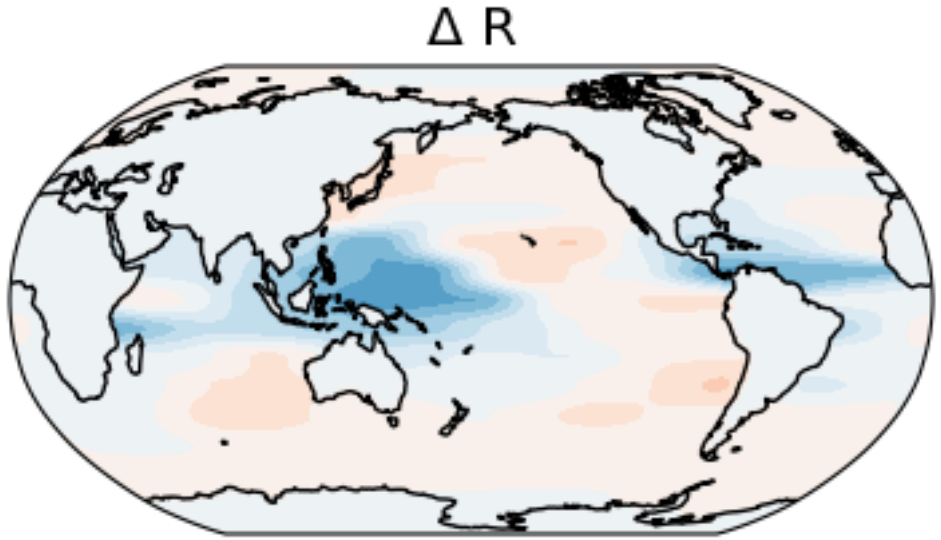


What are the mechanisms of the pattern effect (in CAM6)?

Dong et al. 2019

Different plotting conventions, for qualitative assessment only!

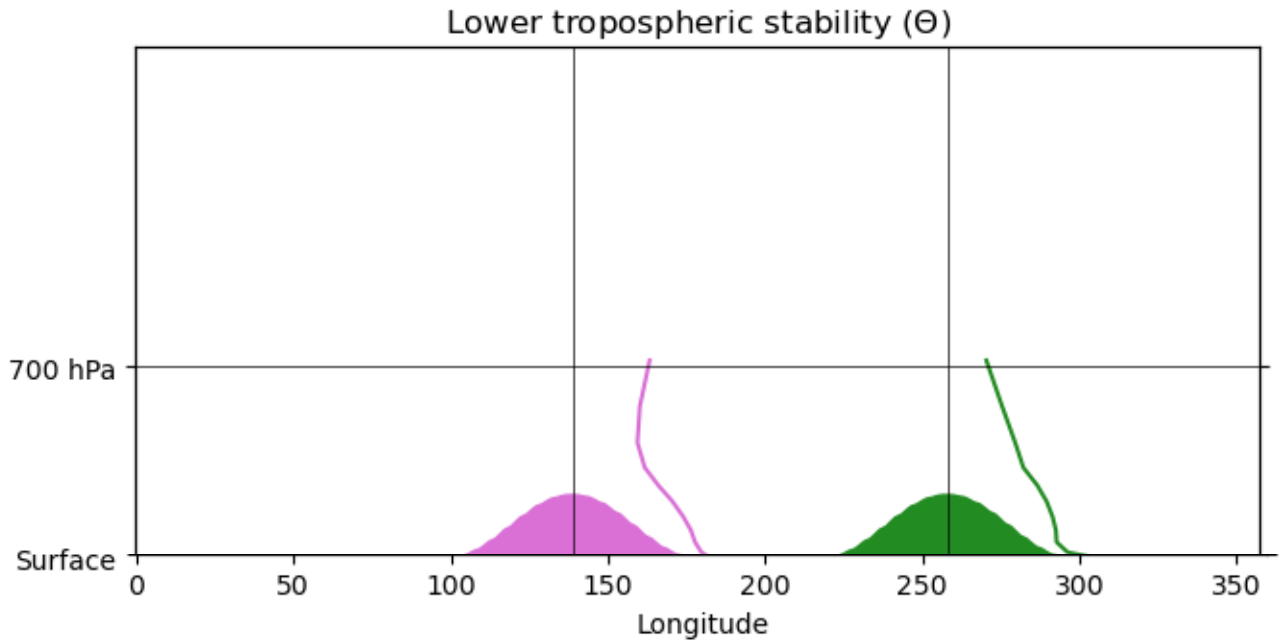
How is global-mean ΔR influenced by SST anomalies?



We evaluate three proposed mechanisms of the pattern effect

- 1. Change in lower-tropospheric stability
- 2. Change in Walker circulation strength
- 3. Circus tent

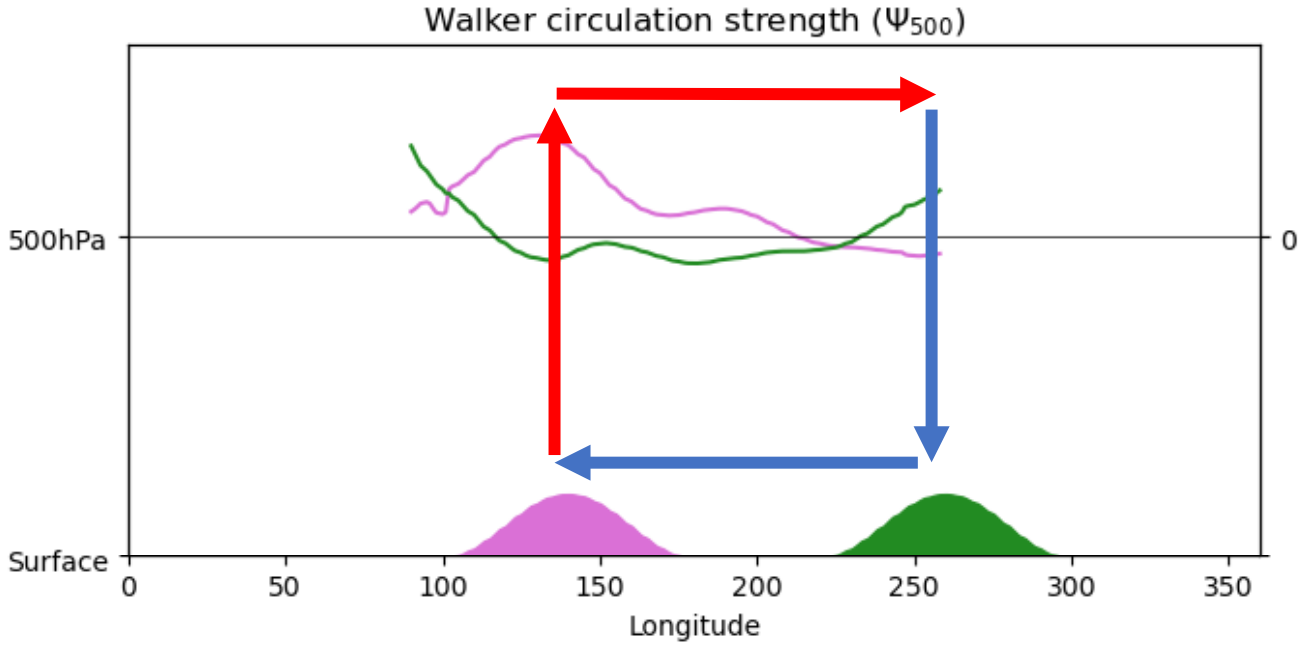
1. Change in lower-tropospheric stability: low cloud cover is decreased by a weaker inversion, a more negative cloud feedback



West Pacific SST patch East Pacific SST patch

Change in LTS ($\theta_{700} - \theta_s$) averaged over 60°S to 60°N

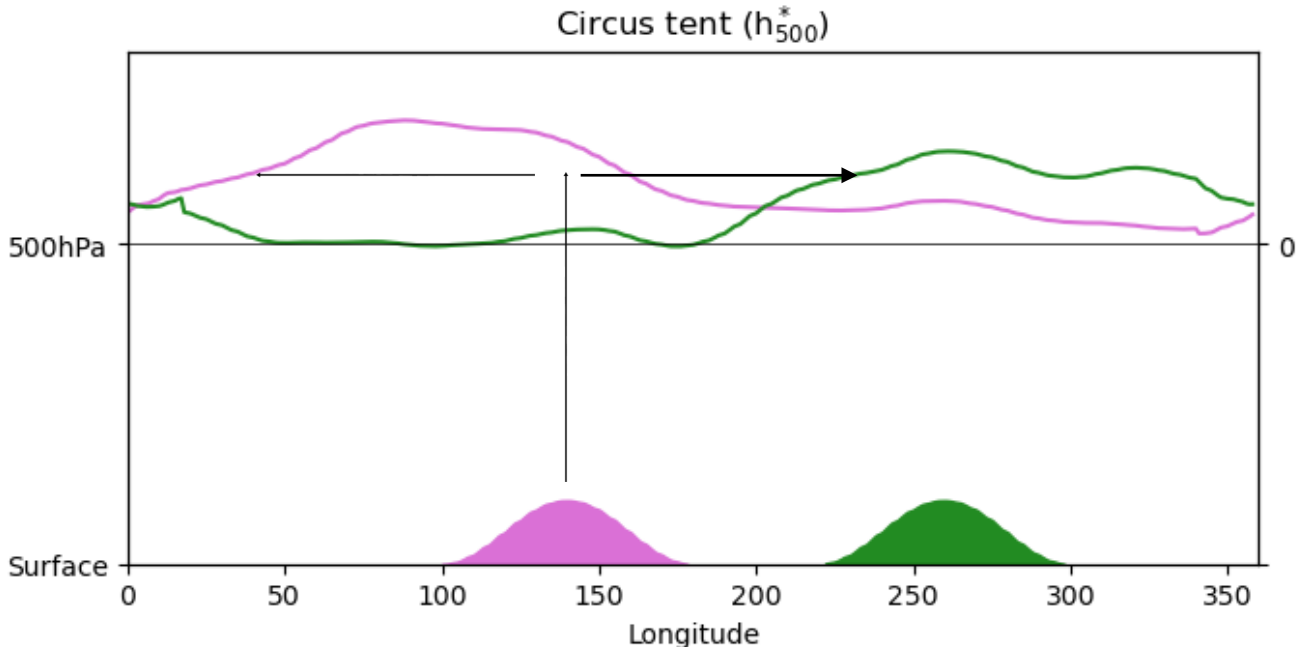
2. Change in Walker circulation strength: zonal-overturning circulation with ascent over the tropical west Pacific and subsidence over the tropical east Pacific



West Pacific SST patch East Pacific SST patch

Change in maximum streamfunction between 90°E to 240°E, where streamfunction is averaged over 5°S to 5°N

3. Circus tent: change in free-tropospheric MSE* is proportional to inversion strength and effectively communicated horizontally via gravity waves

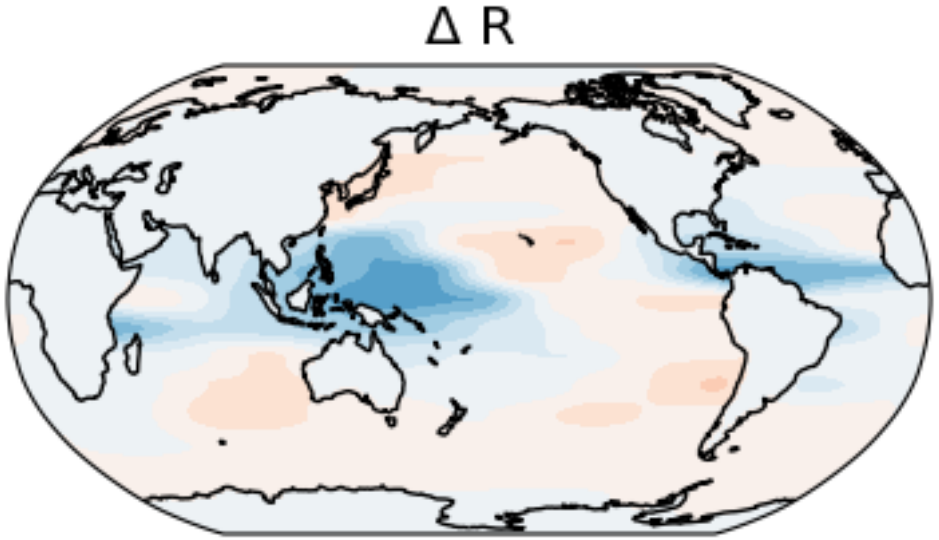


West Pacific SST patch East Pacific SST patch

Change in free-tropospheric saturation MSE averaged over 30°S to 30°N

We decompose the radiative responses using a regularized regression across the seasonal cycle

$$\Delta R \approx r_1 \Delta LTS + r_2 \Delta WC + r_3 \Delta h^*_{500}$$



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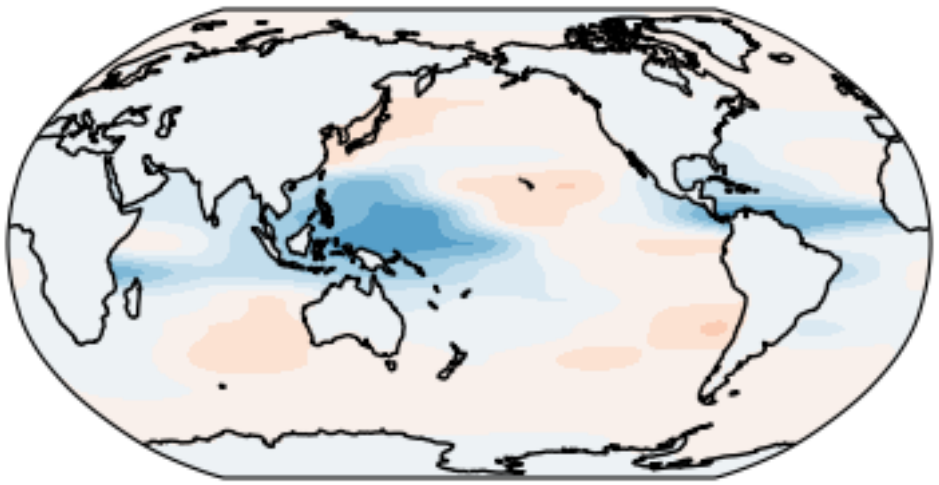
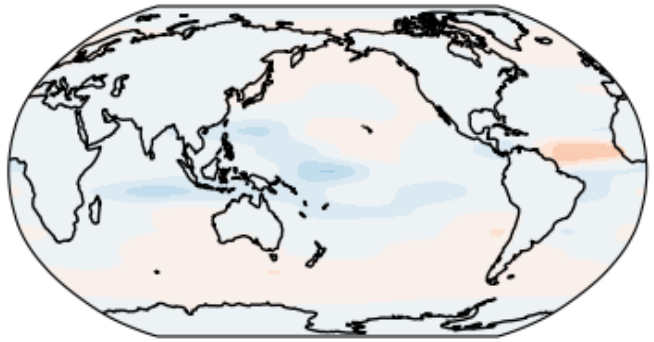
Δ R



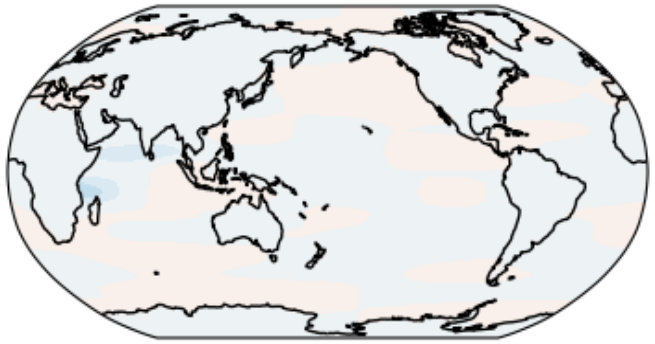
$r_1 \Delta LTS$

Lower tropospheric stability



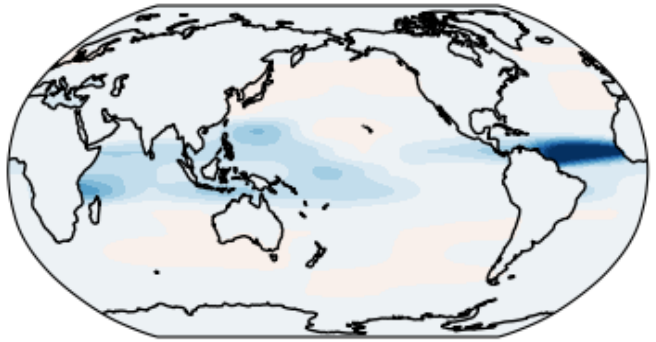
$r_2 \Delta WC$

Walker circulation



$r_3 \Delta h^*_{500}$

Circus tent



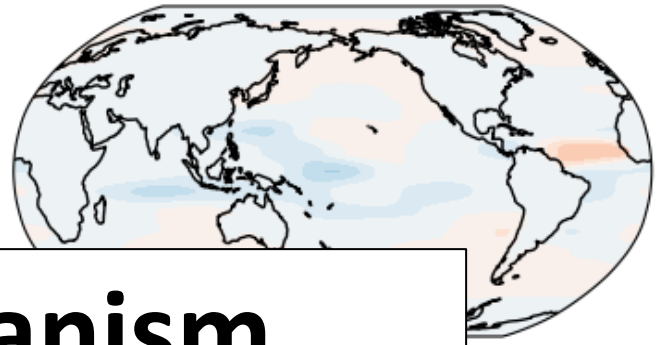
We decompose the radiative responses using a regul
across

The circus tent mechanism dominates in most regions

$$\Delta R \approx r_1 \Delta LTS + r_2 \Delta WC + r_3 \Delta h^*_{500}$$

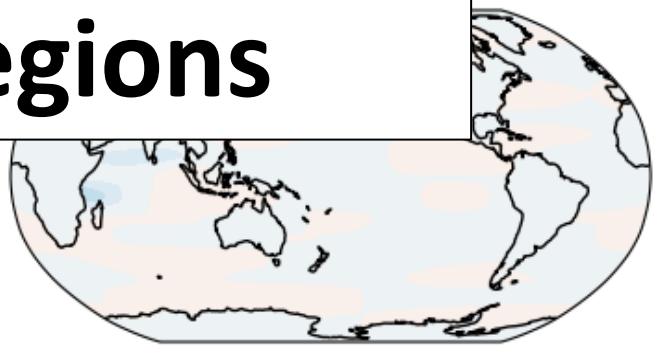
Lower tropospheric stability

$r_1 \Delta LTS$

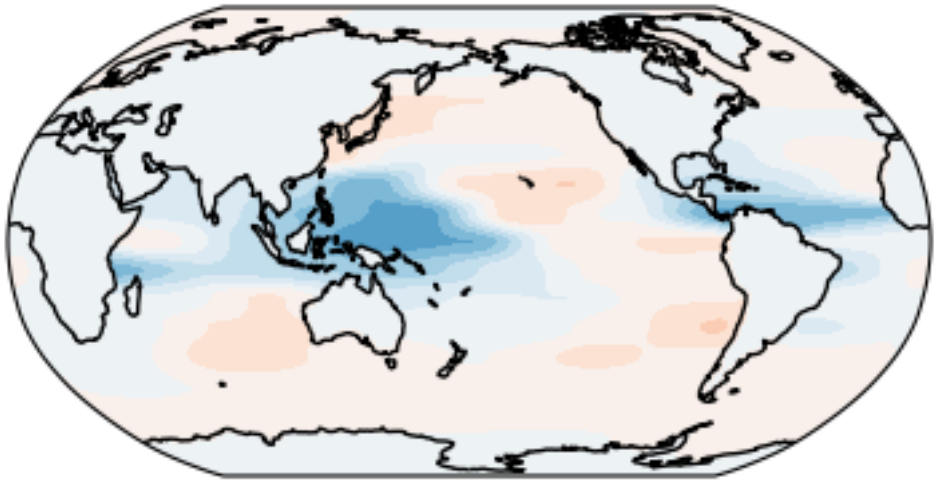


n

$r_2 \Delta WC$

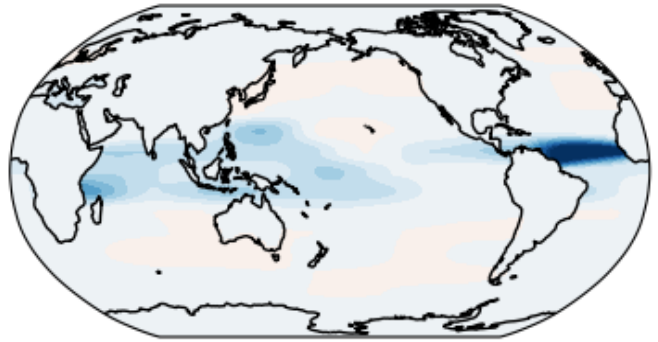


Δ R

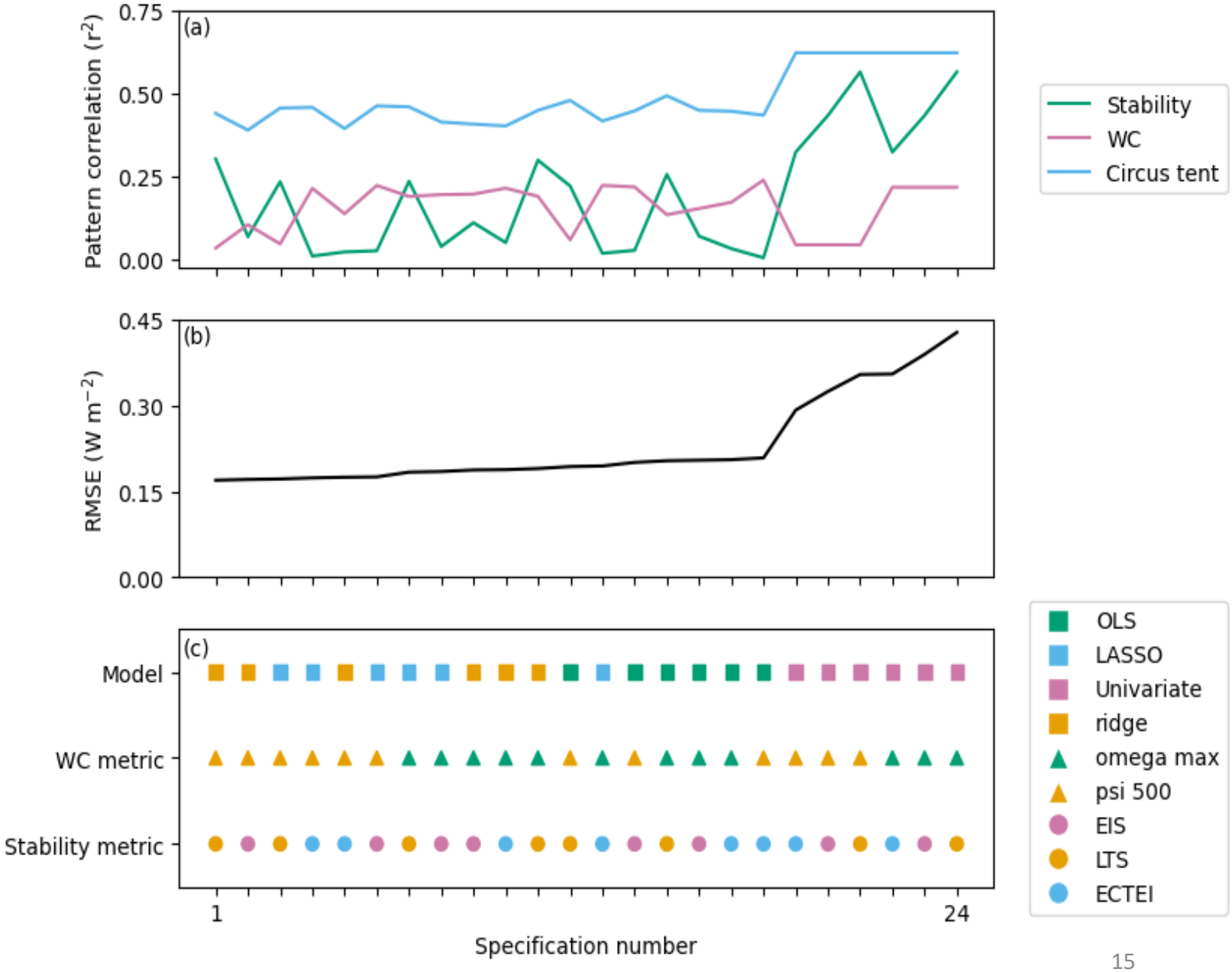


Circus tent

$r_3 \Delta h^*_{500}$



We compare different “specifications” of the regression model. The circus tent mechanism dominates robustly



Summary

- The pattern effect relates the pattern of warming to radiative feedbacks
- We decompose the pattern effect in CAM6 into three mechanisms
- The circus tent mechanism dominates (robustly)

We compare different “specifications” of the regression model. The circus tent mechanism dominates robustly