ENSO Radiative Feedbacks and their Possibility as an Emergent Constraint

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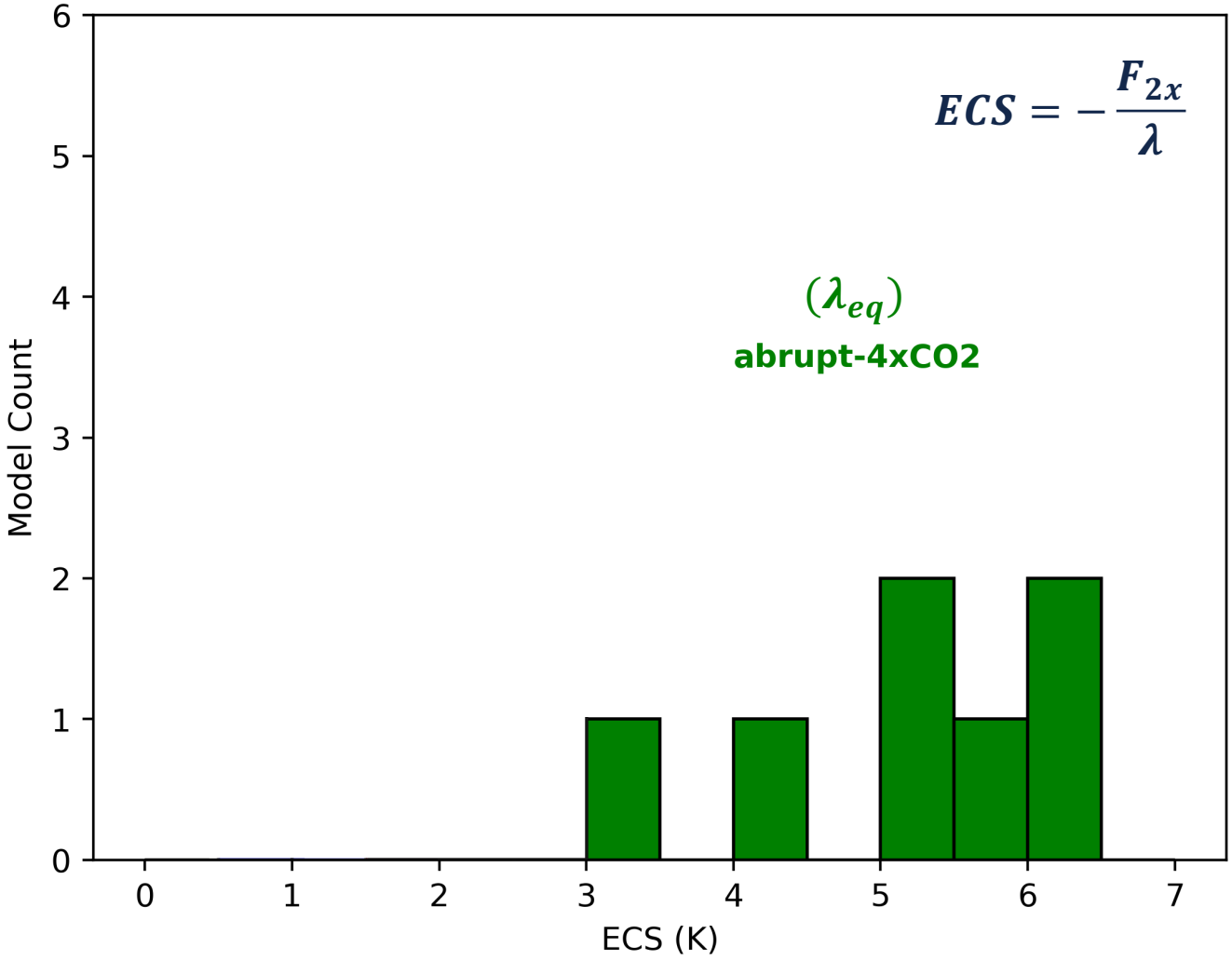
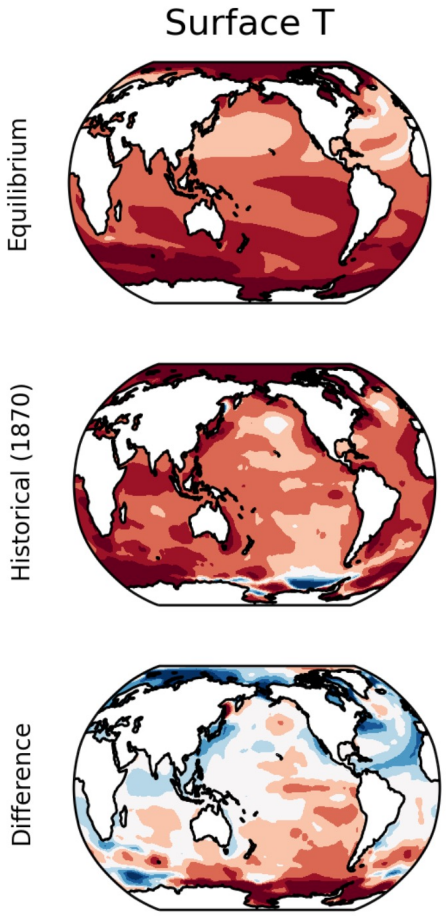
The Pattern Effect

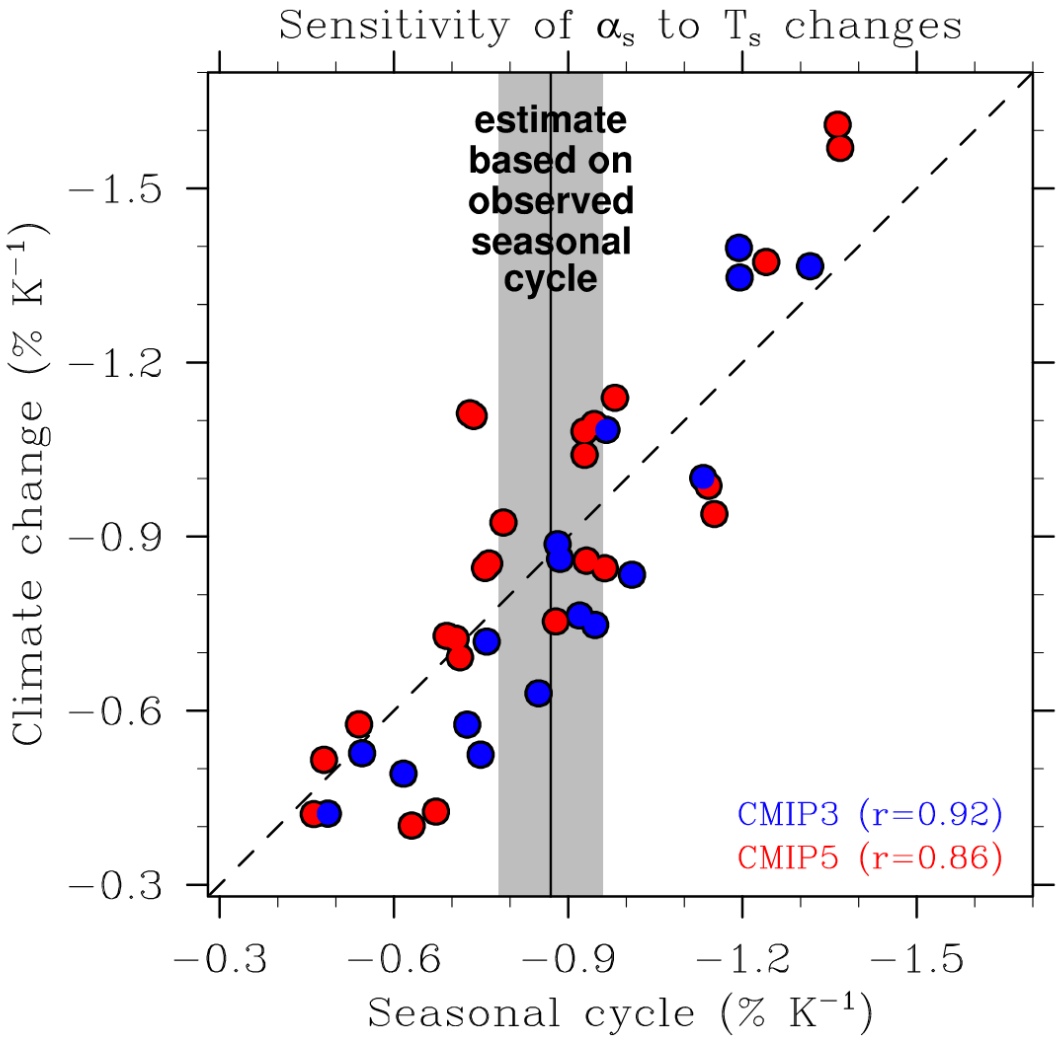




Emergent Constraints

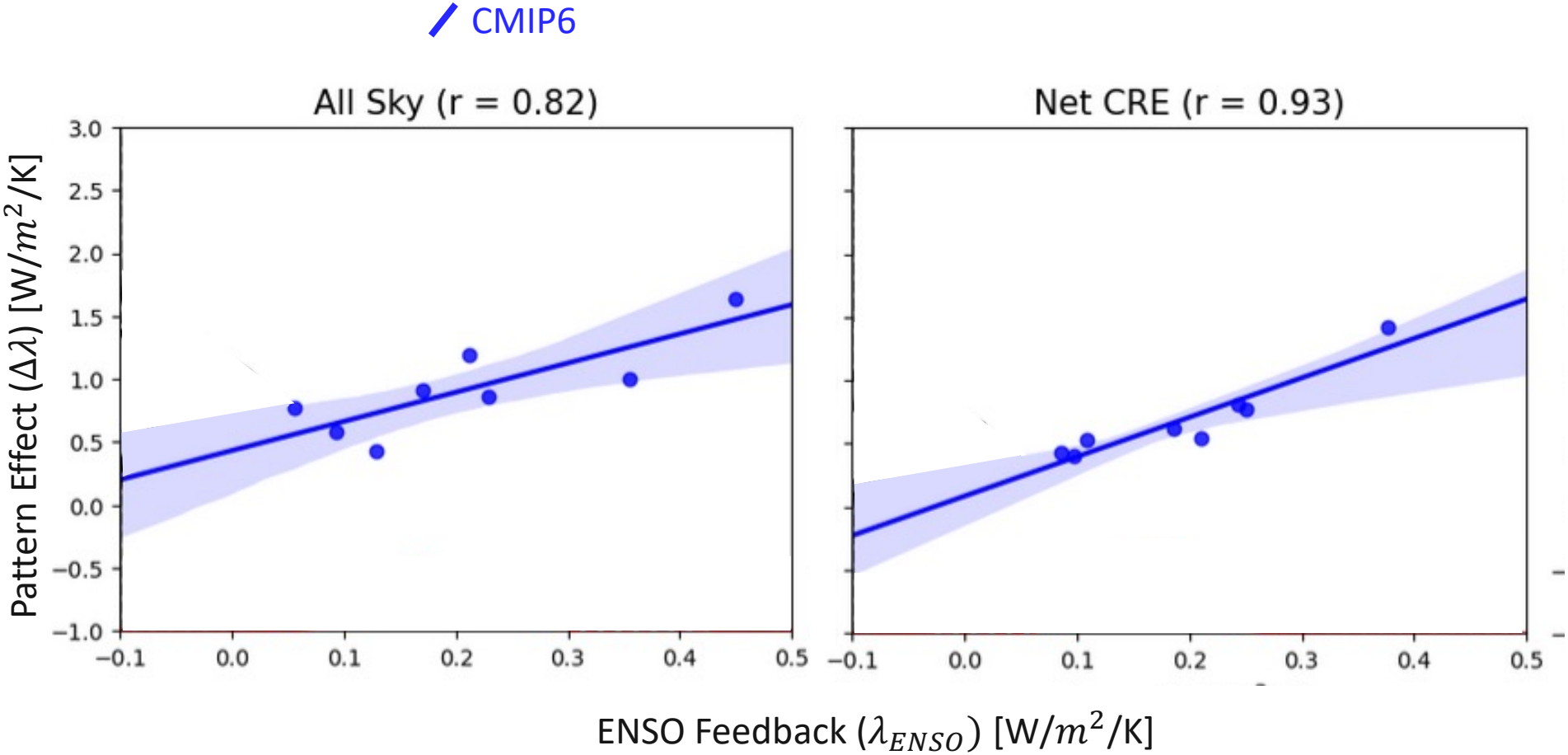
Emergent constraint:

physically-explainable relationship between intermodel variations in some current *observable* climate quantity and future projections of it can be combined with an observational estimate to constrain the future projections.

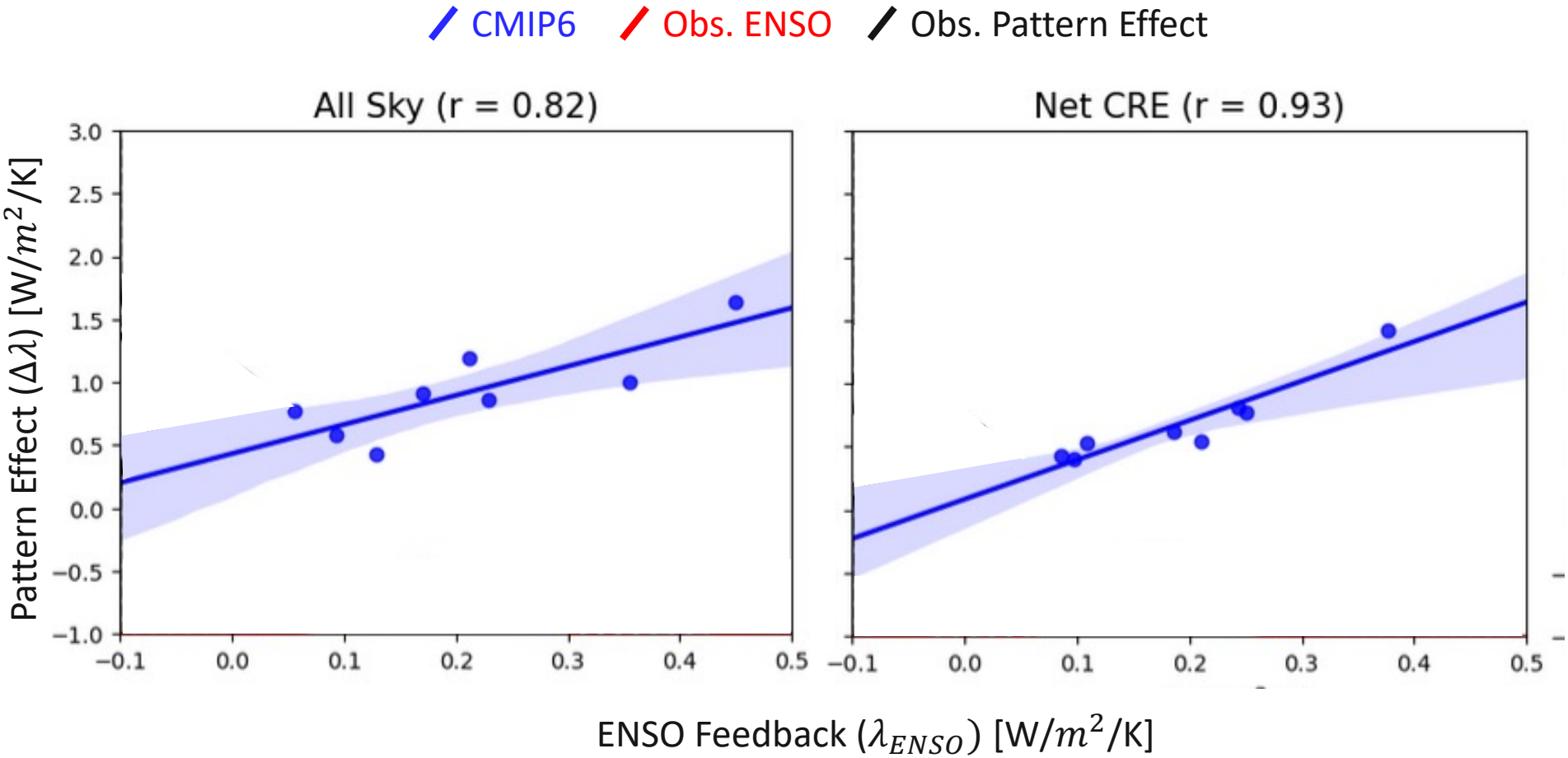


Klein & Hall (2015)

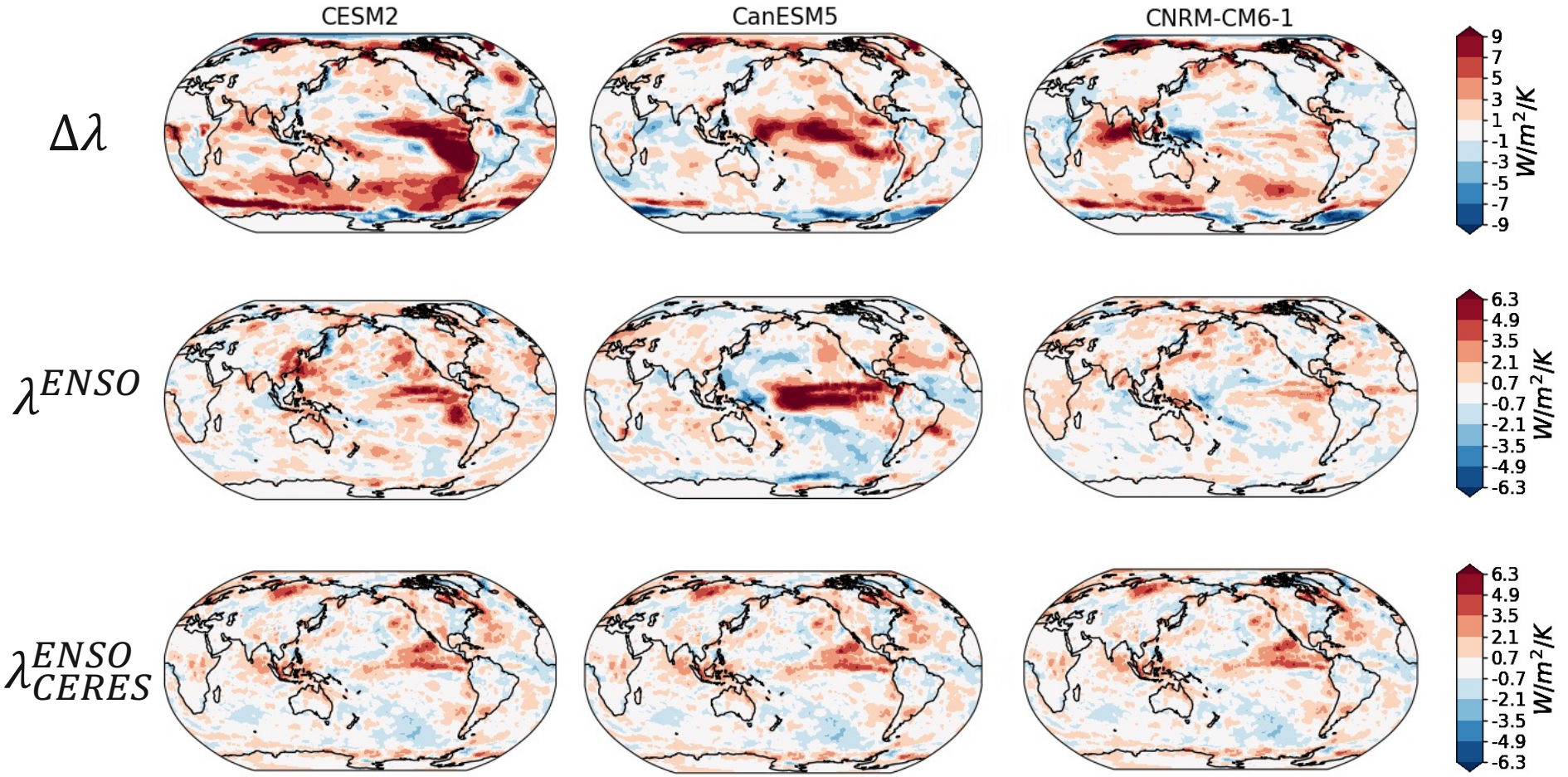
ENSO – A Pattern Effect Analog?



ENSO – A Pattern Effect Analog?



ENSO – A Pattern Effect Analog?



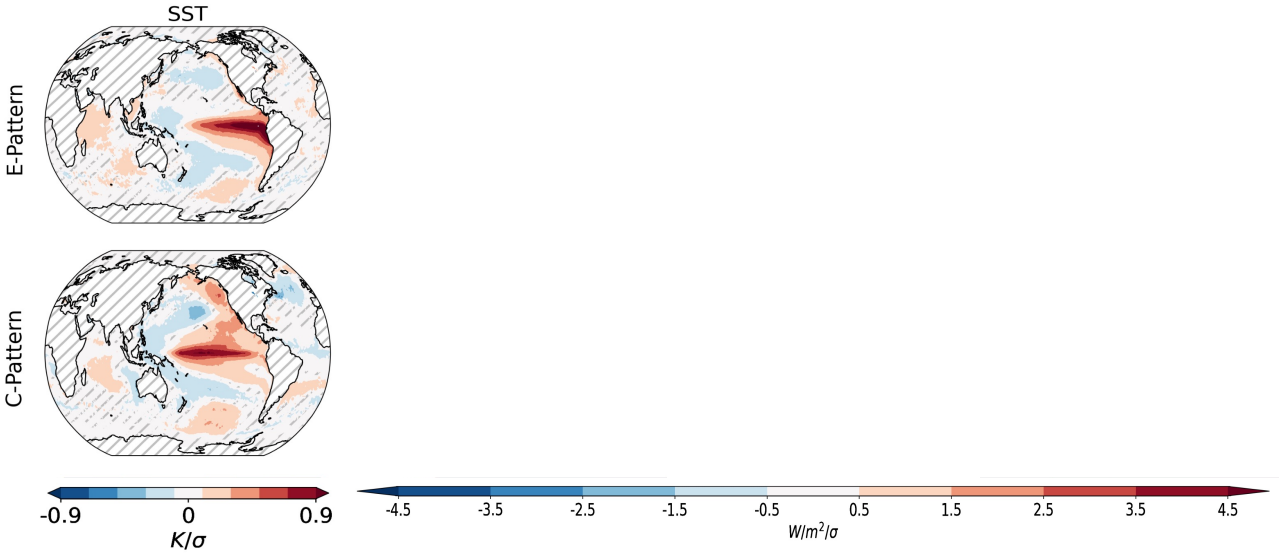
Strong *EP* $\Delta\lambda_C$ = Strong *EP* $\lambda_{C,ENSO}$

Strong *CP* $\Delta\lambda_C$ = Strong *CP* $\lambda_{C,ENSO}$

Weak $\Delta\lambda_C$ = Weak $\lambda_{C,ENSO}$

Observational Radiation Patterns

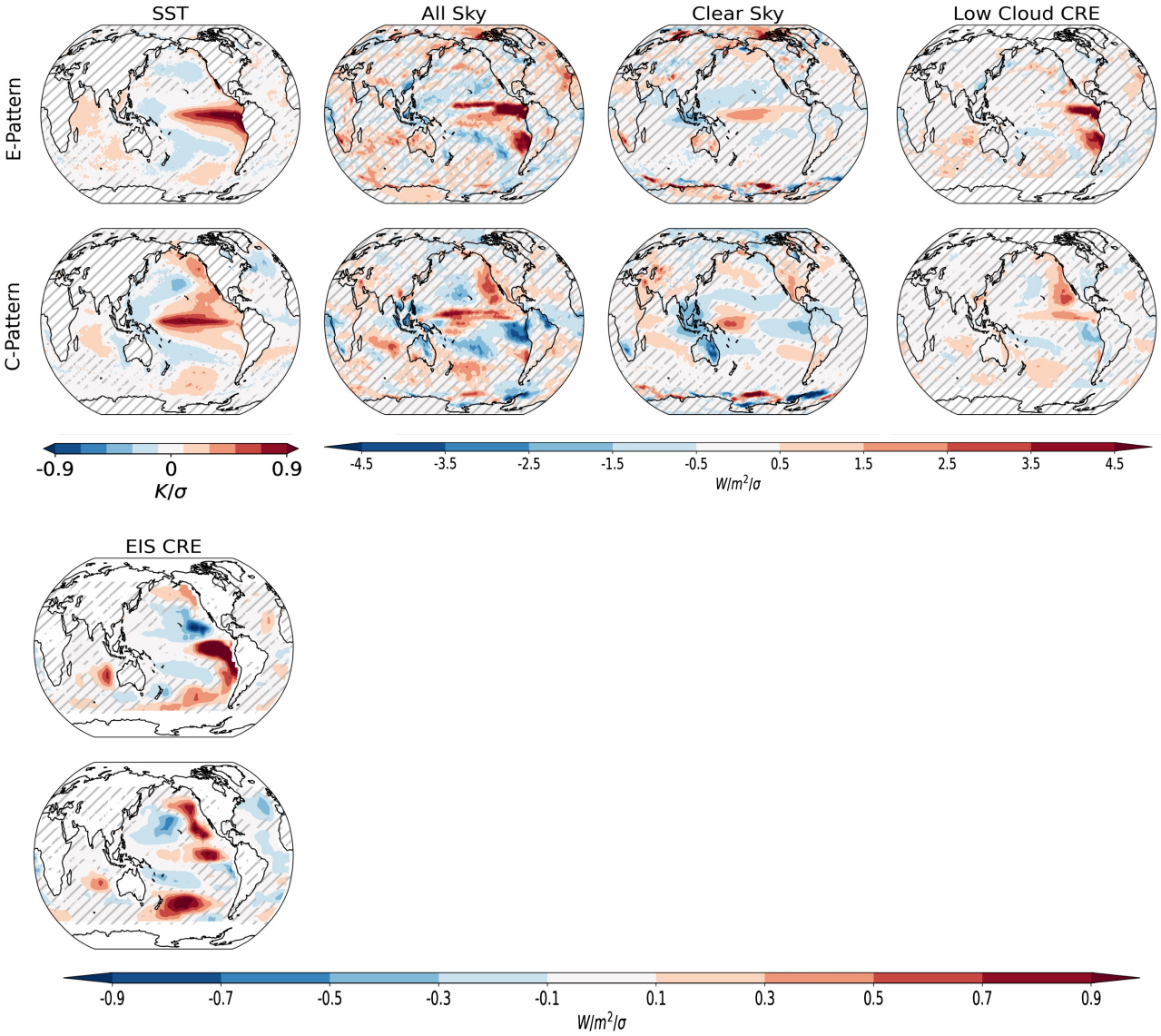
EP and CP ENSO SSTs



Observational Radiation Patterns

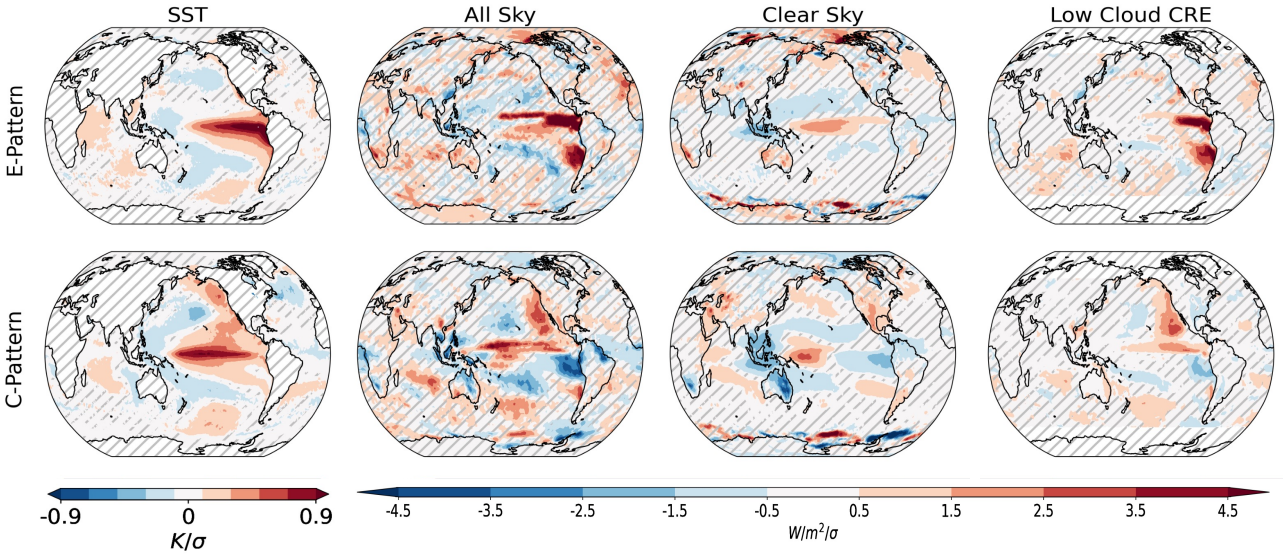
EP and CP ENSO SSTs

Cloud Controlling Factors (CCFs)



Observational Radiation Patterns

EP and CP ENSO SSTs



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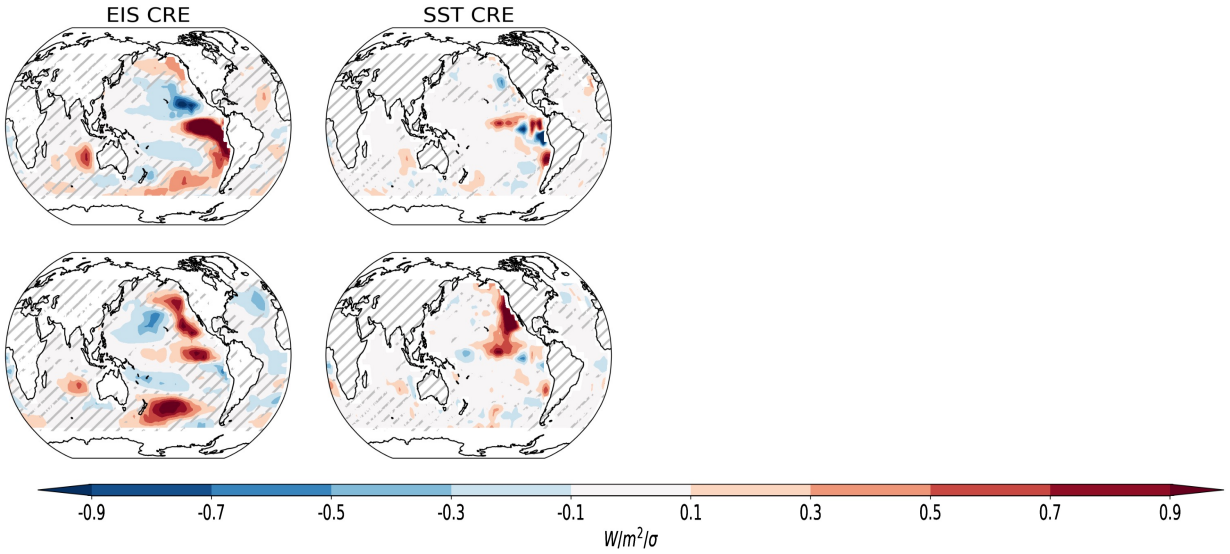

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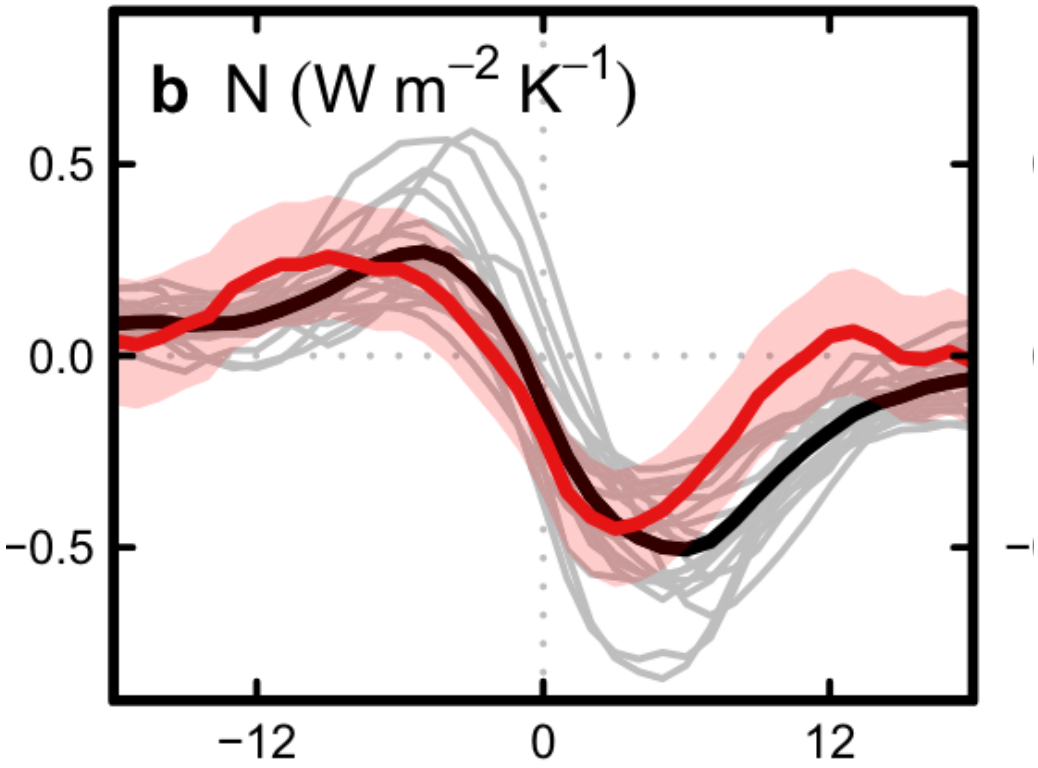

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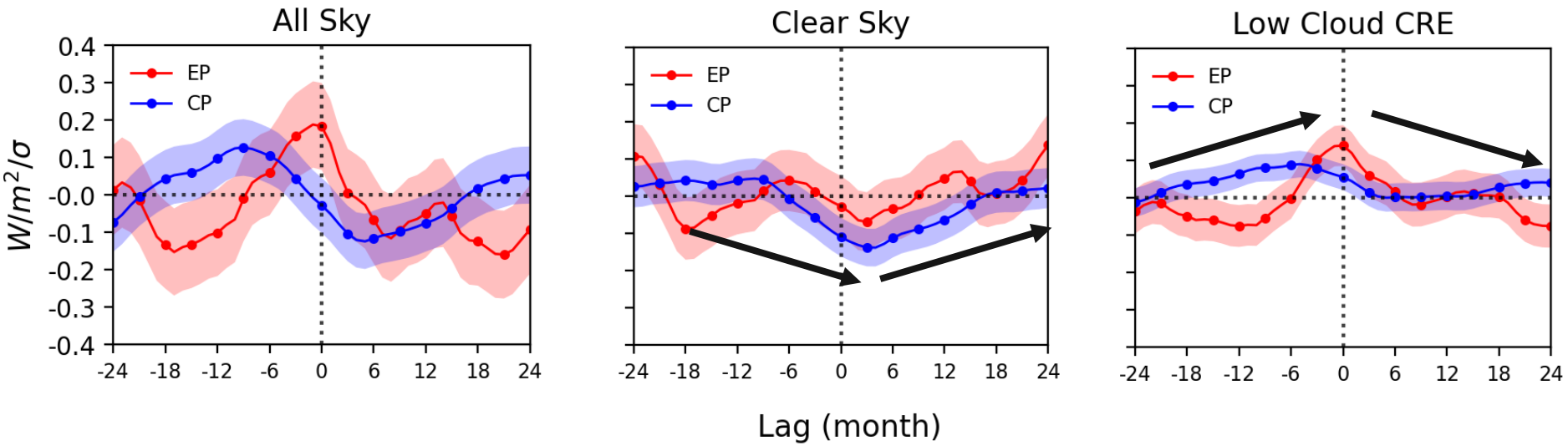
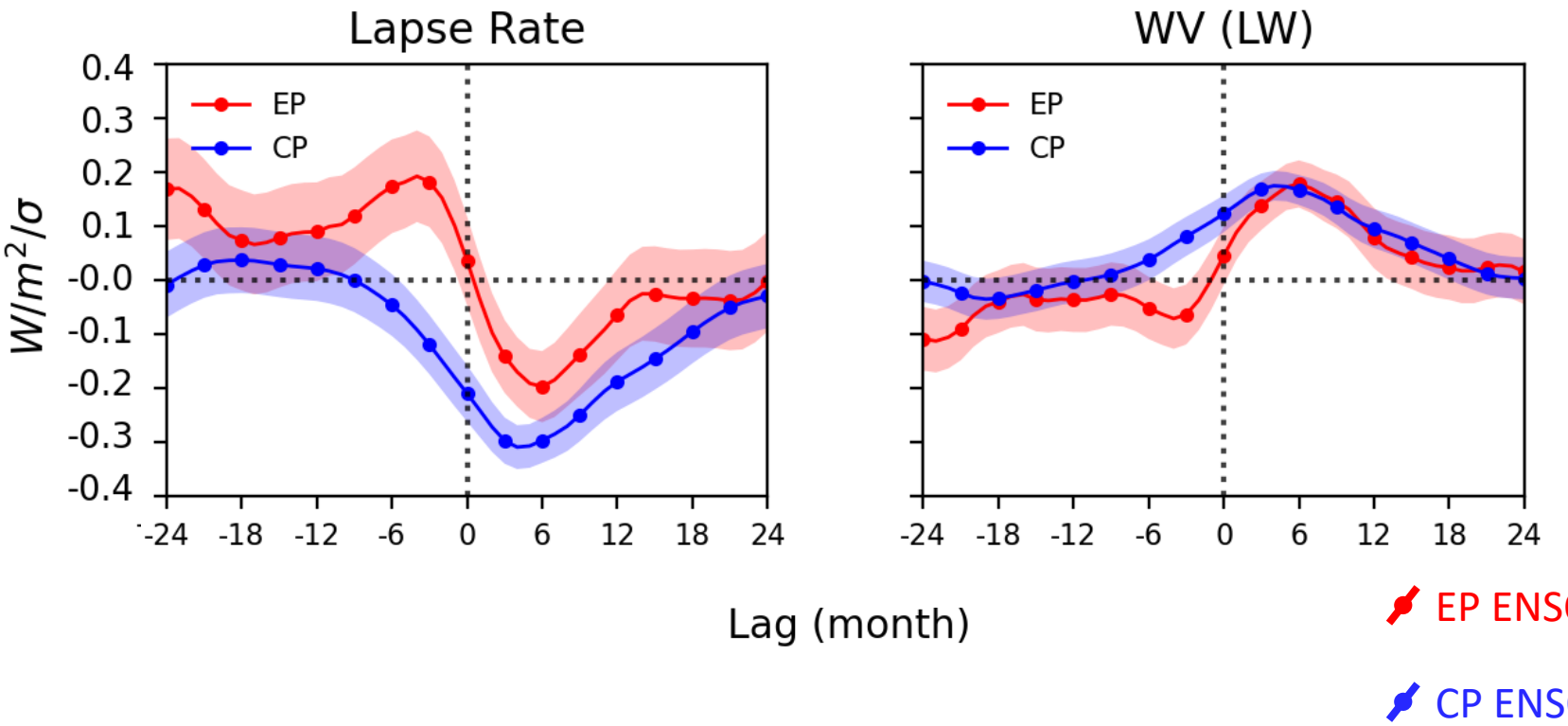


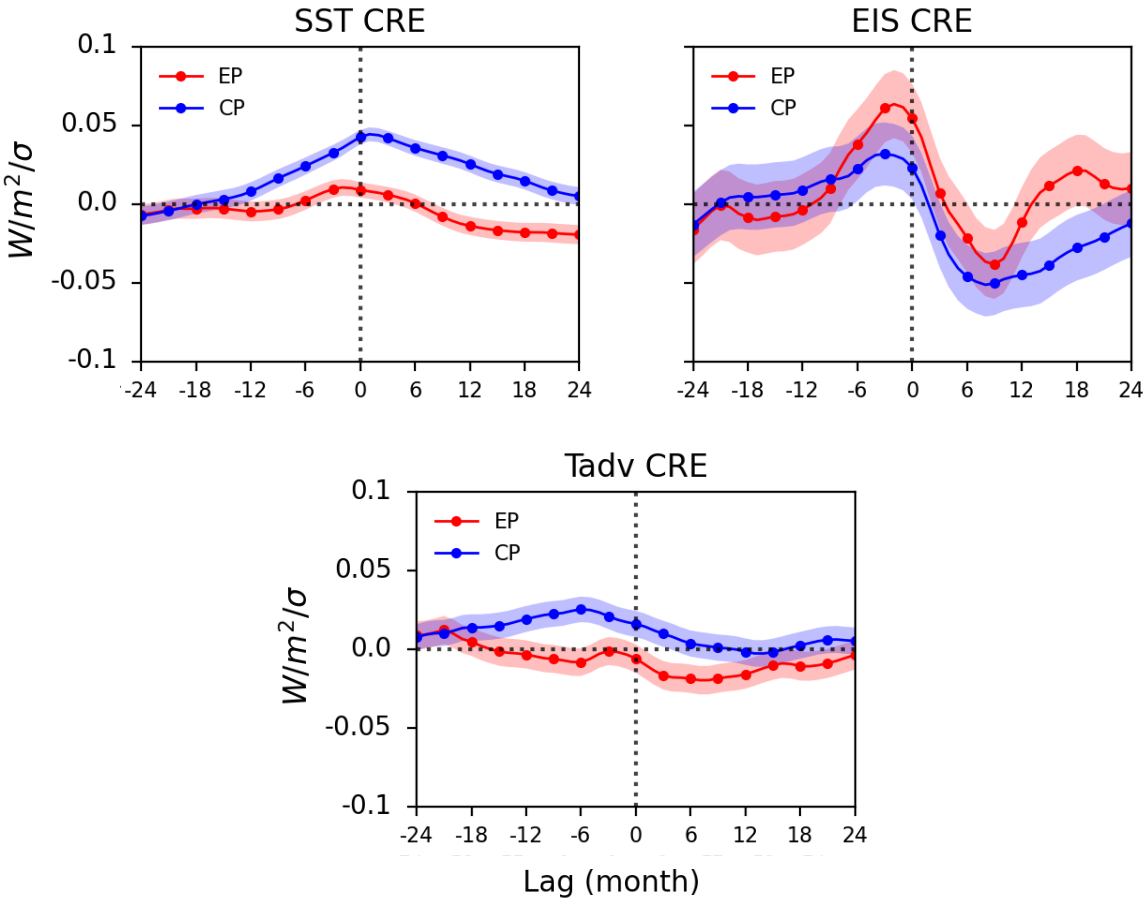
EP ENSO

CP ENSO

Observational Radiation Patterns



Observational Radiation Patterns



EP ENSO

CP ENSO

Summary

- **ENSO is a potential emergent constraint on the pattern effect**
  - ENSO feedbacks have strong linear relationships with pattern effects in 8 CMIP6 models
  - Model pattern effects appear to have similar spatial diversity as their ENSO feedbacks (CP vs EP)
- **Low cloud radiative feedbacks drive the spatial pattern and evolution of ENSO TOA variability**
  - Low cloud feedbacks evolve in-phase with EP ENSO SST patterns but out-of-phase with CP ENSO SST patterns
  - Driven by atmospheric destabilization for EP patterns, but changes in atmospheric stability, SSTs, and warm air advection contribute to CP patterns
- **Clear-sky radiation helps modulate low cloud feedbacks following peak CP ENSO SST anomalies**
  - The clear-sky feedback evolution in both modes is driven by a balance between water vapor and lapse-rate feedbacks, with lapse-rate "winning out" for CP patterns

Future Work

- **Fully understand the physics and dynamics linking ENSO feedbacks to the pattern effect**
  - Will need more models running amip-piForcing simulations
  - CERES-MIP to partition model cloud radiative fluxes into low/high clouds, include larger period of record
  - Maybe use ERBE to extend CERES backward to include more ENSO events in observational study?

- **Evaluate the impacts for ECS**

Thank You!
Questions?