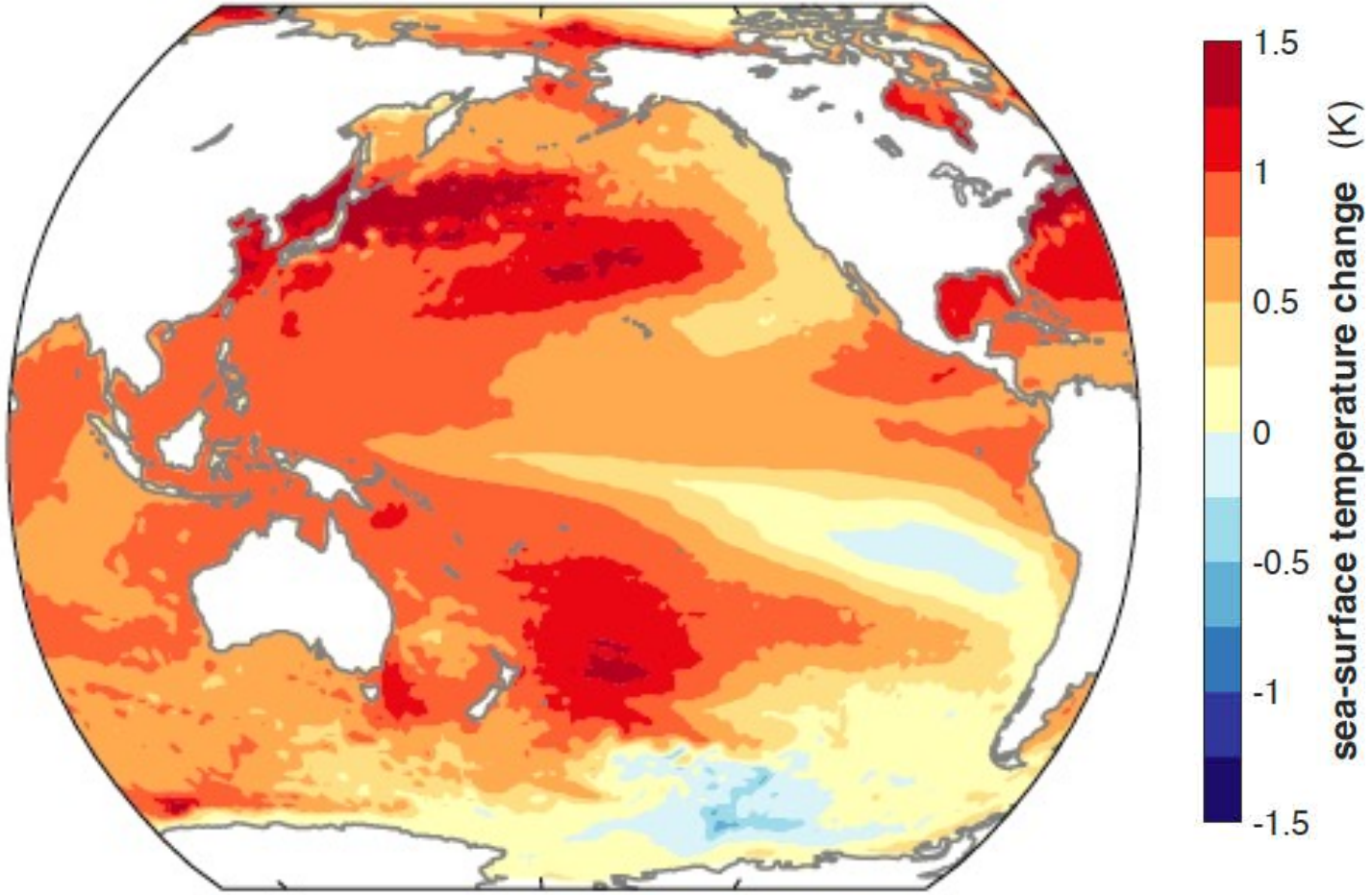
Recent tropical Pacific cooling driven by anthropogenic emissions

Pedro DiNezio, Clara Deser, Ping Chang, Carolina Vera, Julia Mindlin, Marisol Osman, Nicola Maher, Robb Wills, Nan Rosembloom, Jeremy Klavans & the Mesa Club team (formerly iHESP)

Many proposed mechanisms for tropical Pacific cooling, some suggest could be forced;

But mechanisms do not arise spontaneously in coupled models, hindering causation.

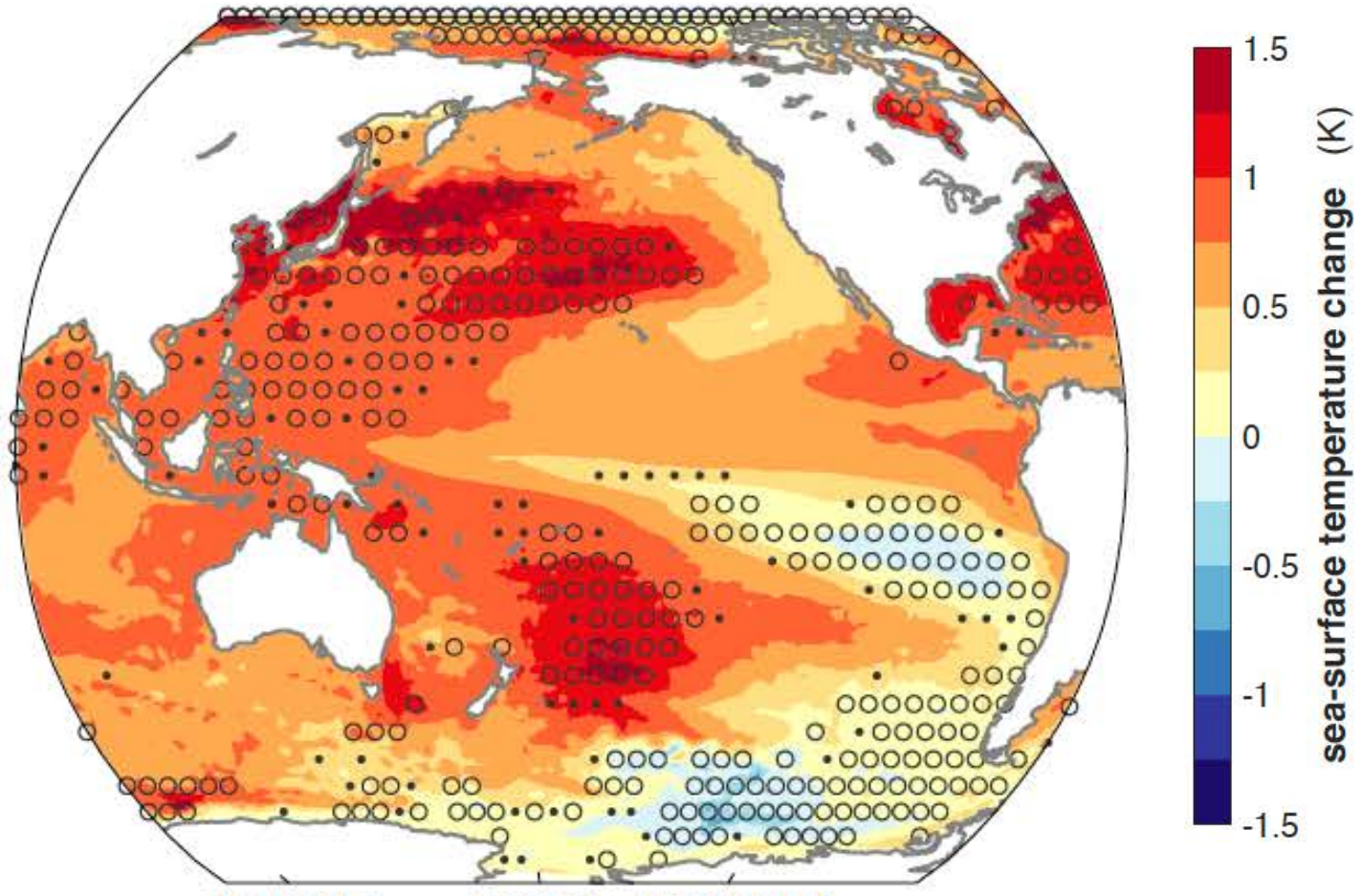
High resolution CESM1 simulates forced cooling in the tropical Pacific



4-member mean SST change 1980-2022

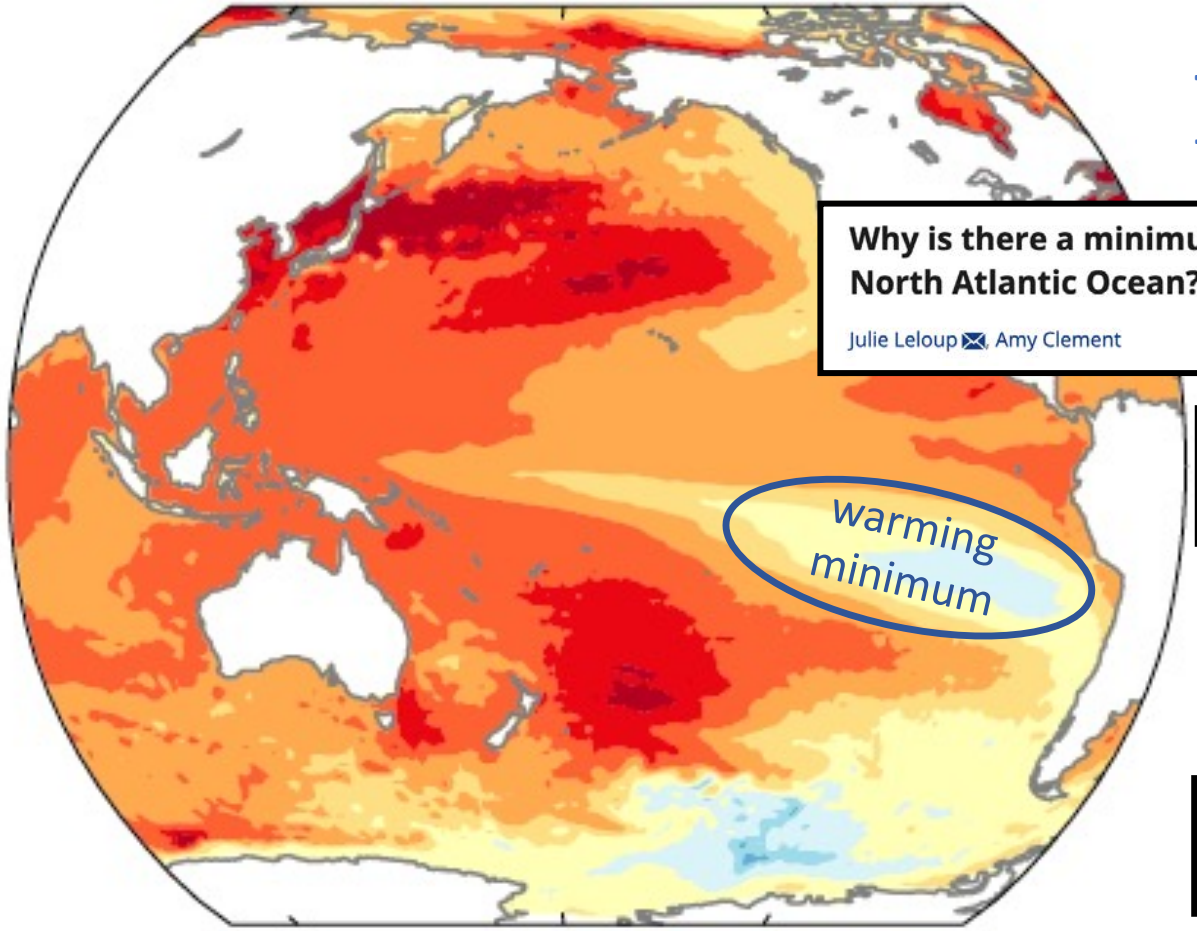
High resolution CESM1 simulates forced cooling in the tropical Pacific

Open circles indicate where the simulated changes are completely outside the distribution of changes simulated by 4-member trends randomly sampled from the 40-member CESM1 LENS.



4-member mean SST change 1980-2022

Proposed mechanism: **Positive feedback due to two-way tropical-extra tropical interactions**



Thermodynamic SST response to GHG forcing

Why is there a minimum in projected warming in the tropical North Atlantic Ocean?

Julie Leloup, Amy Clement

Allen Mewhinney
Monday poster

Hadley Cell adjustment to hemispheric forcings

Yen-Ting Hwang
Monday poster

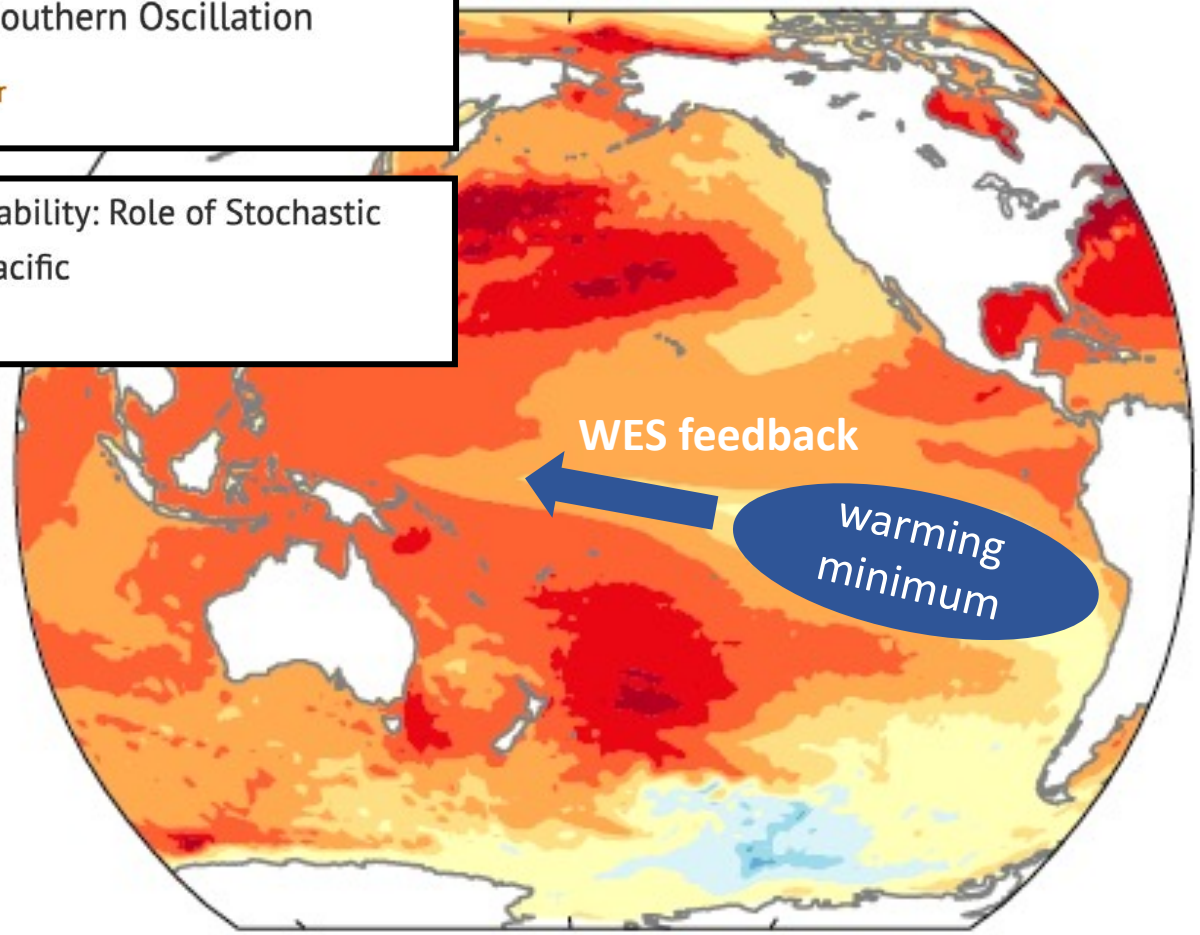
Proposed mechanism: **Positive feedback due to two-way tropical-extra tropical interactions**

Rethinking the Ocean's Role in the Southern Oscillation

Amy Clement, Pedro DiNezio, and Clara Deser

Origins of Tropical Pacific Decadal Variability: Role of Stochastic Atmospheric Forcing from the South Pacific

Yuko M. Okumura



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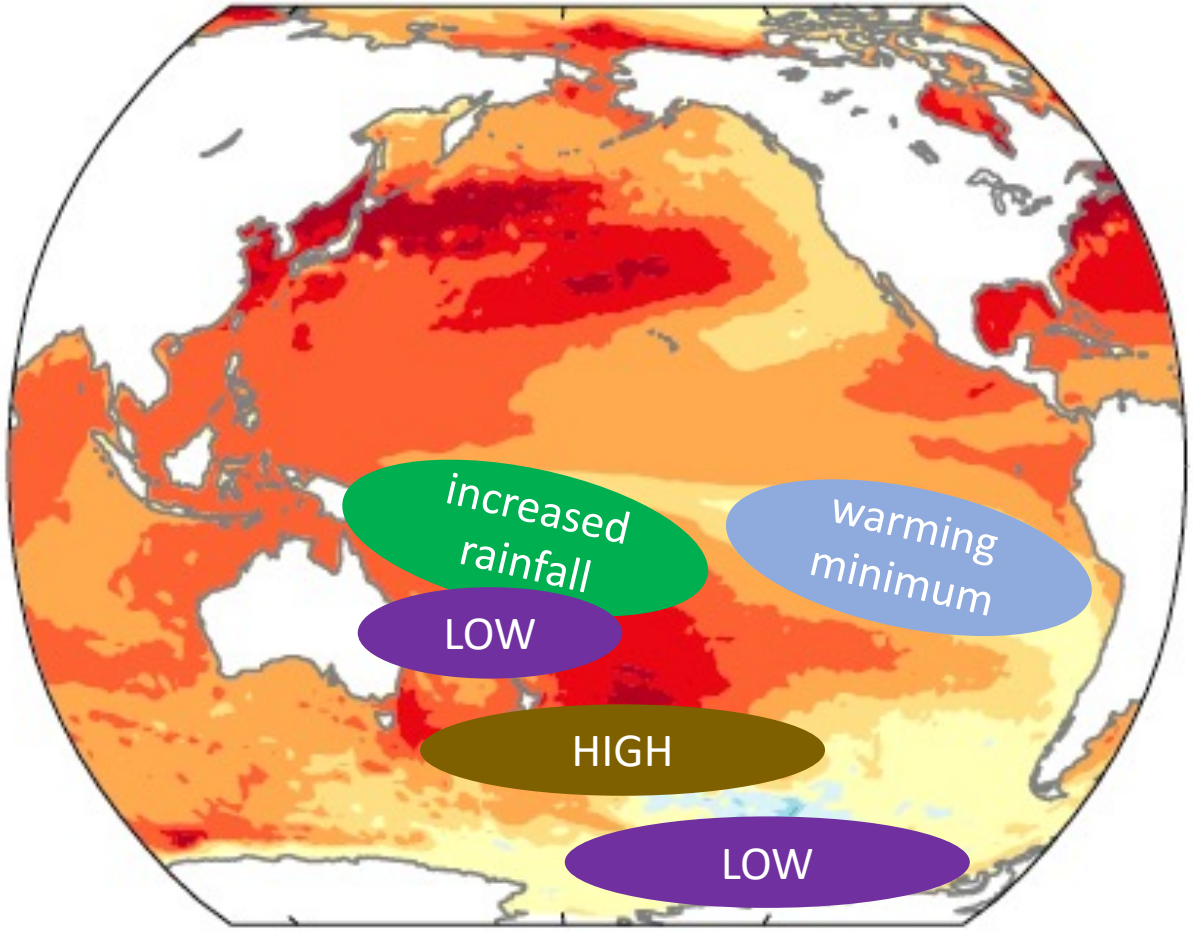

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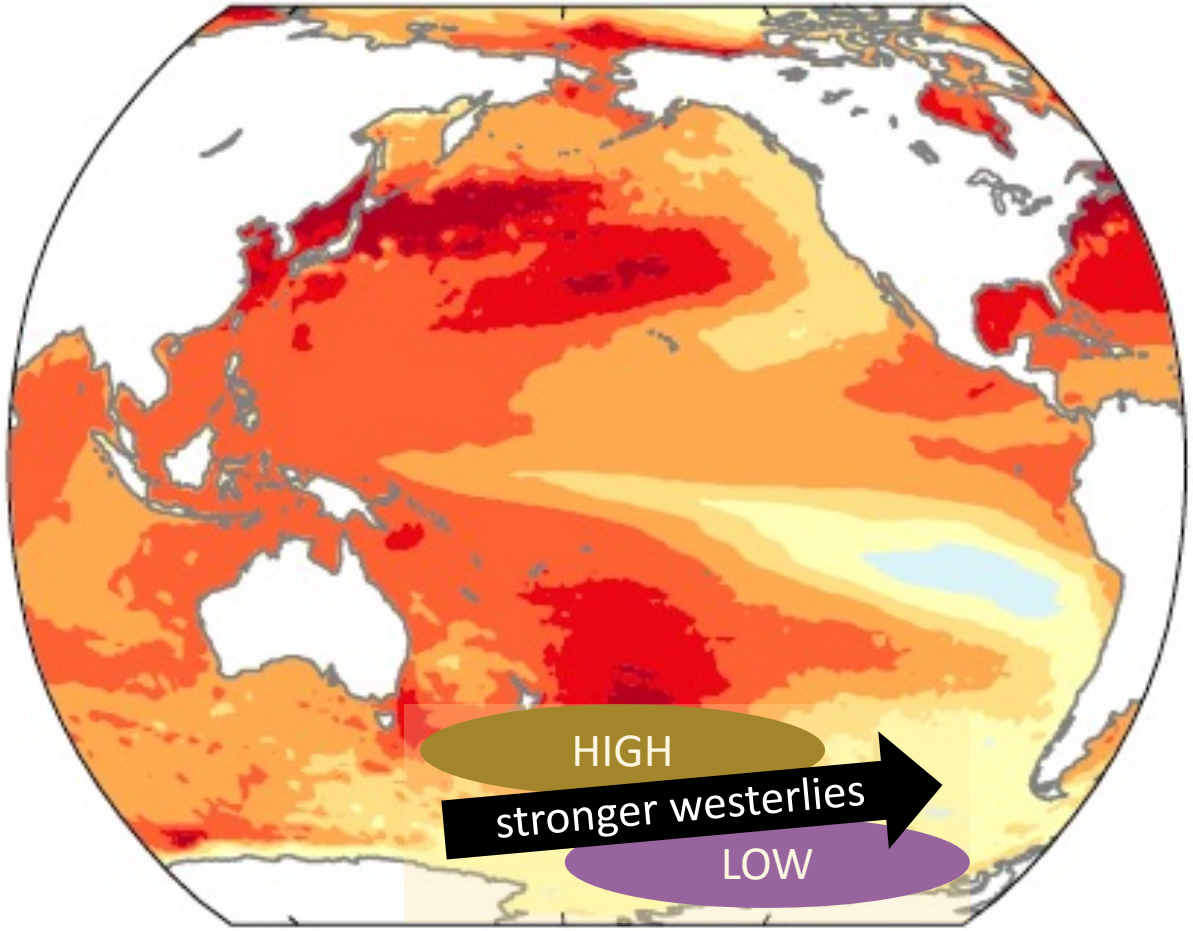
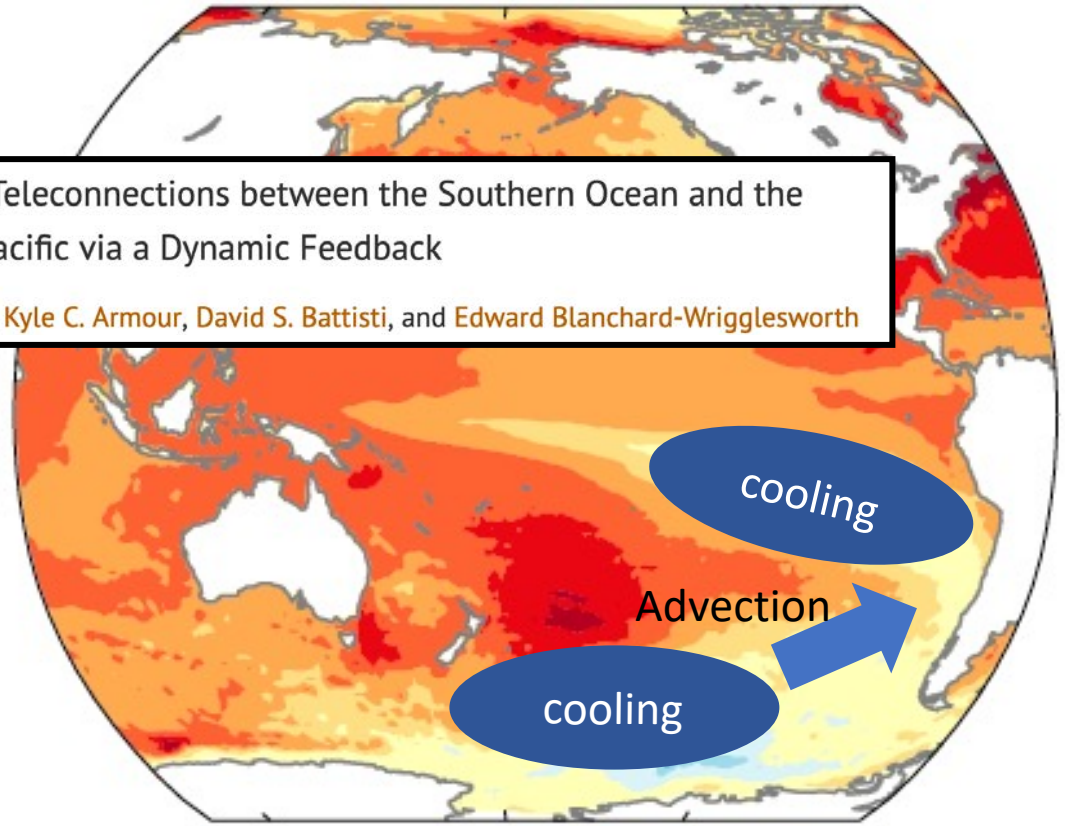
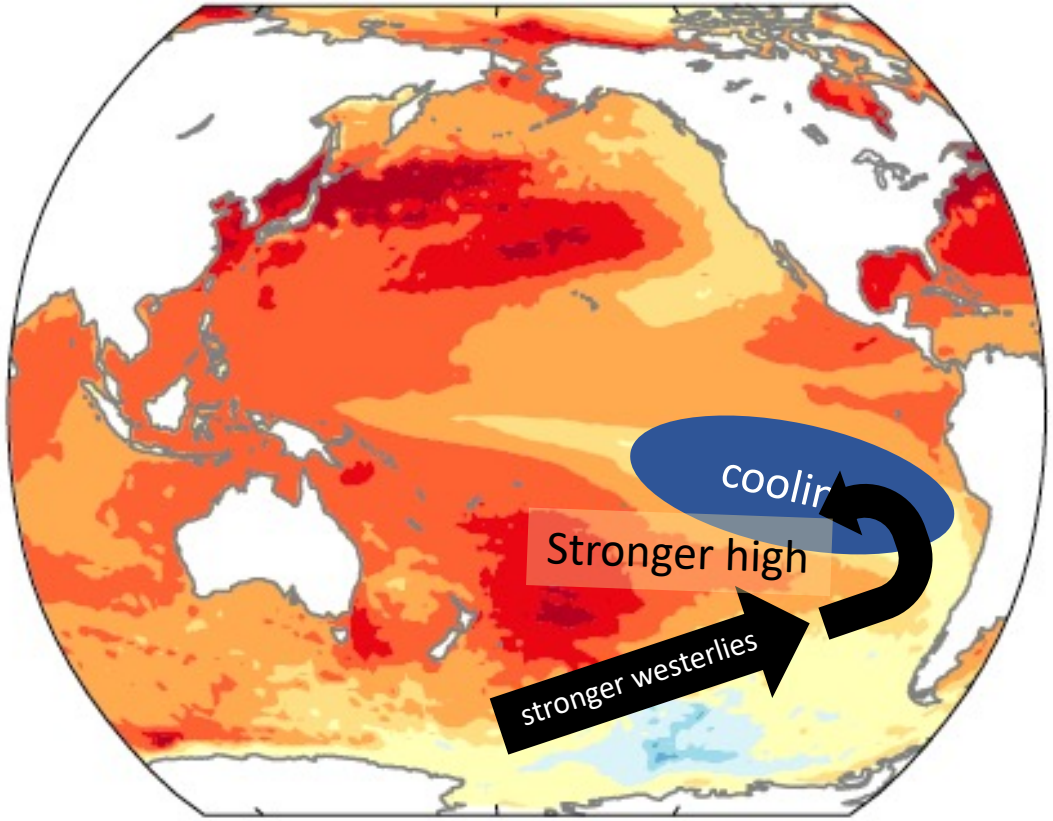


Proposed mechanism: **Positive feedback due to two-way tropical-extra tropical interactions**

Two-Way Teleconnections between the Southern Ocean and the Tropical Pacific via a Dynamic Feedback

Yue Dong, Kyle C. Armour, David S. Battisti, and Edward Blanchard-Wrigglesworth





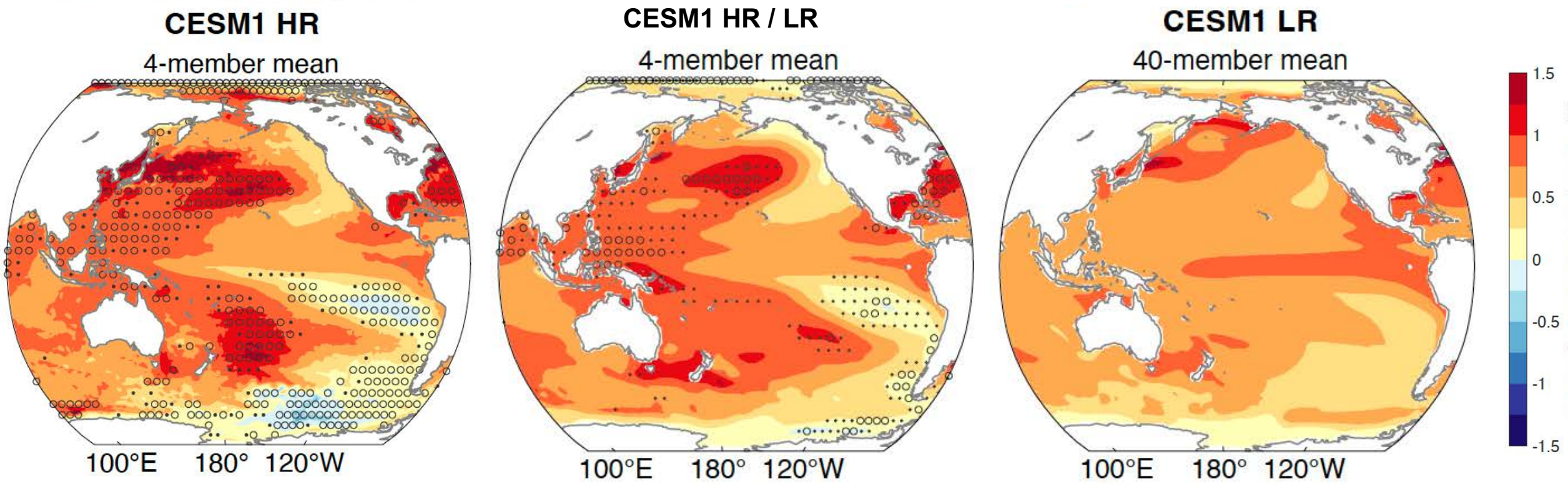
What are CMIP models misrepresenting?

- **Strength of WES feedback in the SE tropical Pacific,**
  - Most likely due to double ITCZ,
  - Strength of cloud feedbacks?
- **Response of Southern Ocean to stronger westerlies**
  - Coupling between SST fronts and westerlies,
  - Eddy heat transports across the polar front.
- **Interactions of South Pacific atmosphere with the Andes.**

Data and Methods

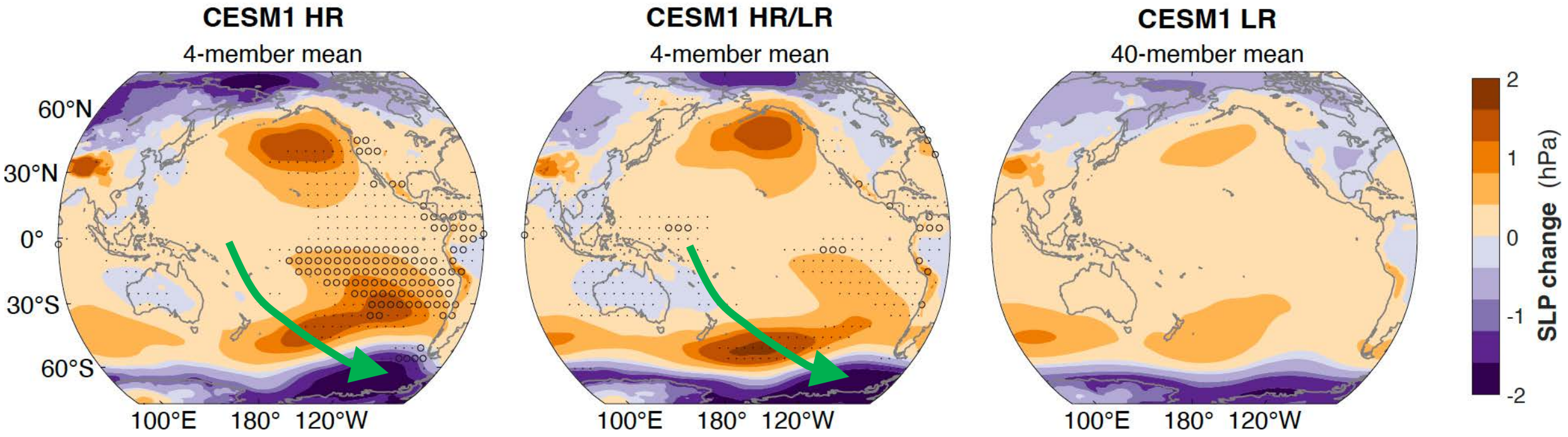
- Comparison of high resolution vs. standard resolution CESM1
  - **Standard resolution (LR):** 1° atmosphere + 1° ocean,
  - **High Resolution (HR):** ¼° atmosphere + 1/10° ocean (eddy resolving/permitting),
  - **HR/LR:** ¼° atmosphere + 1° ocean.
- Historical simulations under identical CMIP5 external forcings
- Ensembles:
  - **LR:** 40 members (Kay et al. 2015),
  - **HR:** 4 members (Chang et al. 2022).
  - **HR/LR:** 3 members (Meehl et al. 2019).
- Analysis interval: 1980-2022.

Both atmospheric and ocean resolution matter

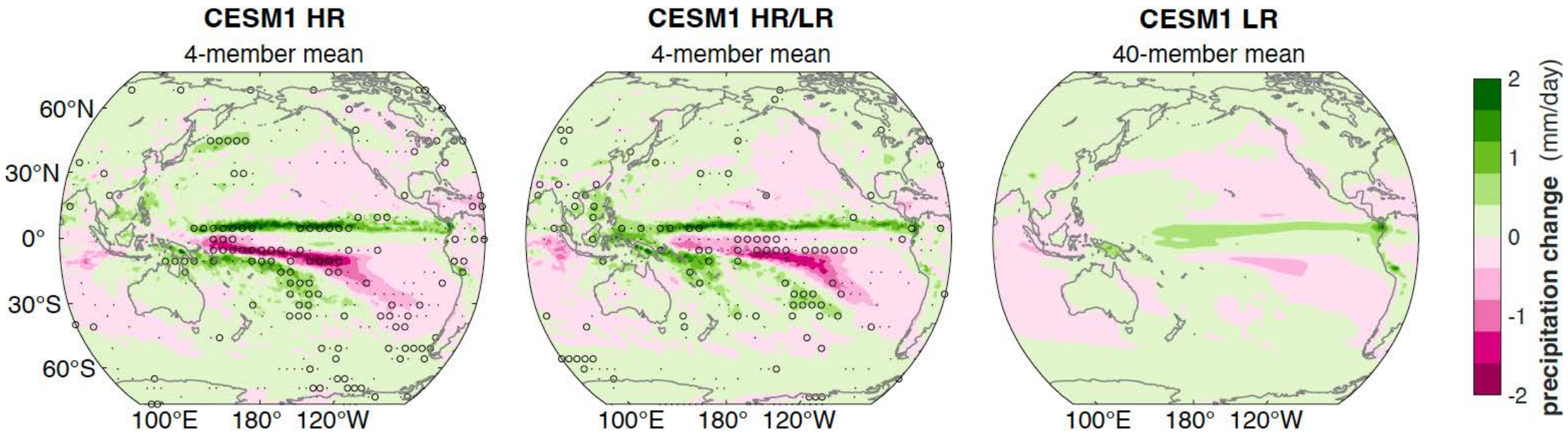


This is the ensemble in which CESM was configured with a HR atmosphere and a LR ocean

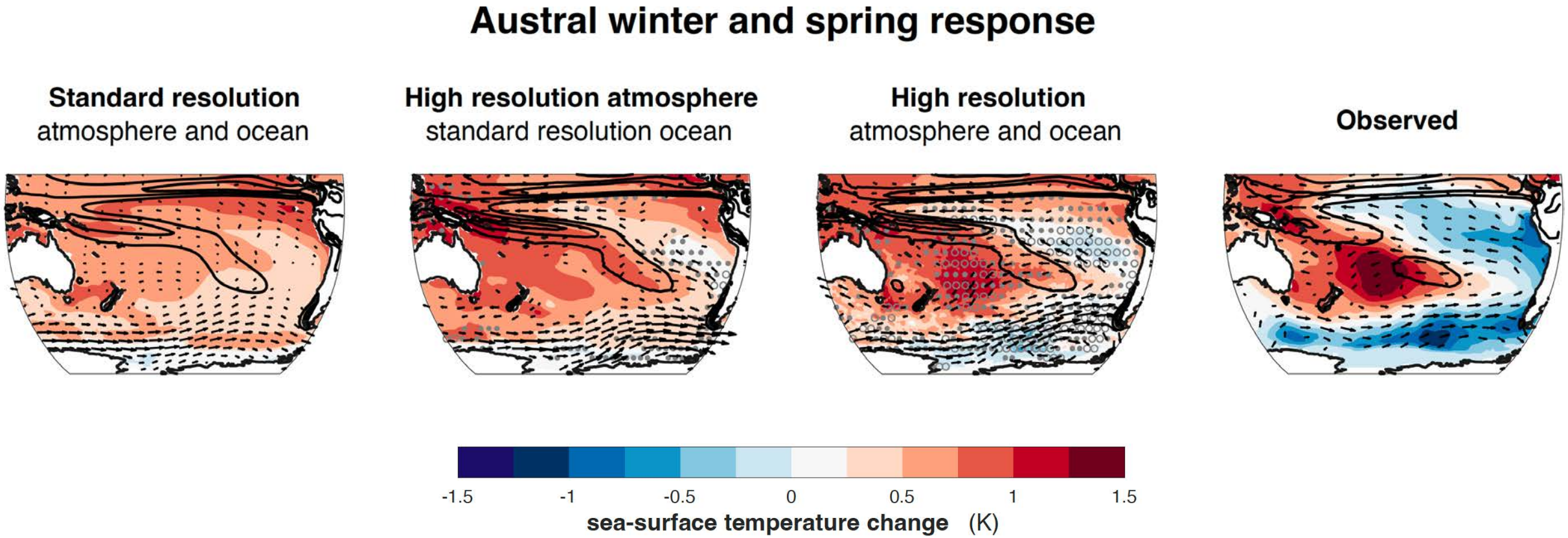
HR atmosphere produces stronger teleconnection to SH



Teleconnection to SH produced by stronger SPCZ response

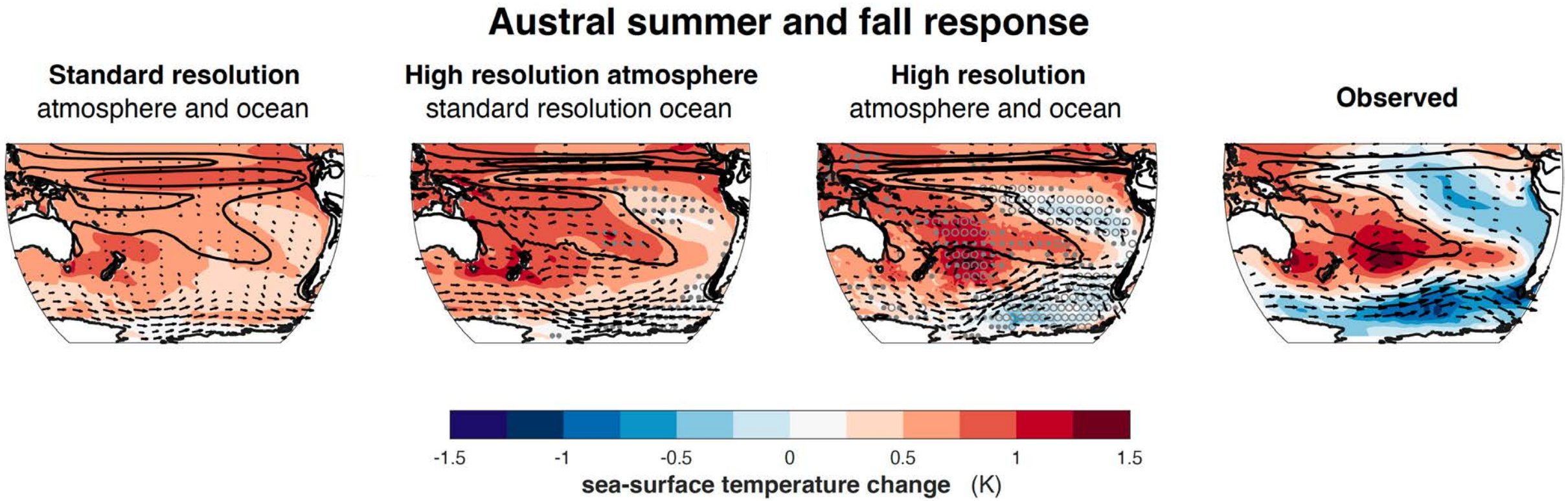


Off equatorial origin of cooling pattern



Better resolution of Andes in HR model also important

Double ITCZ prevents equatorial propagation of subtropical cooling in LR model

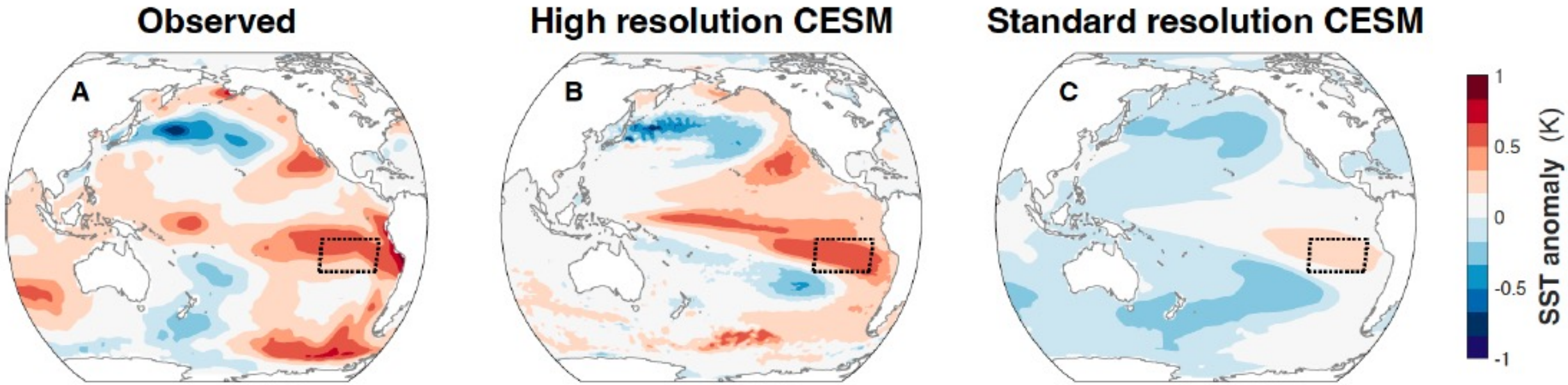


Southern Ocean cooling (reinforcing mechanism)

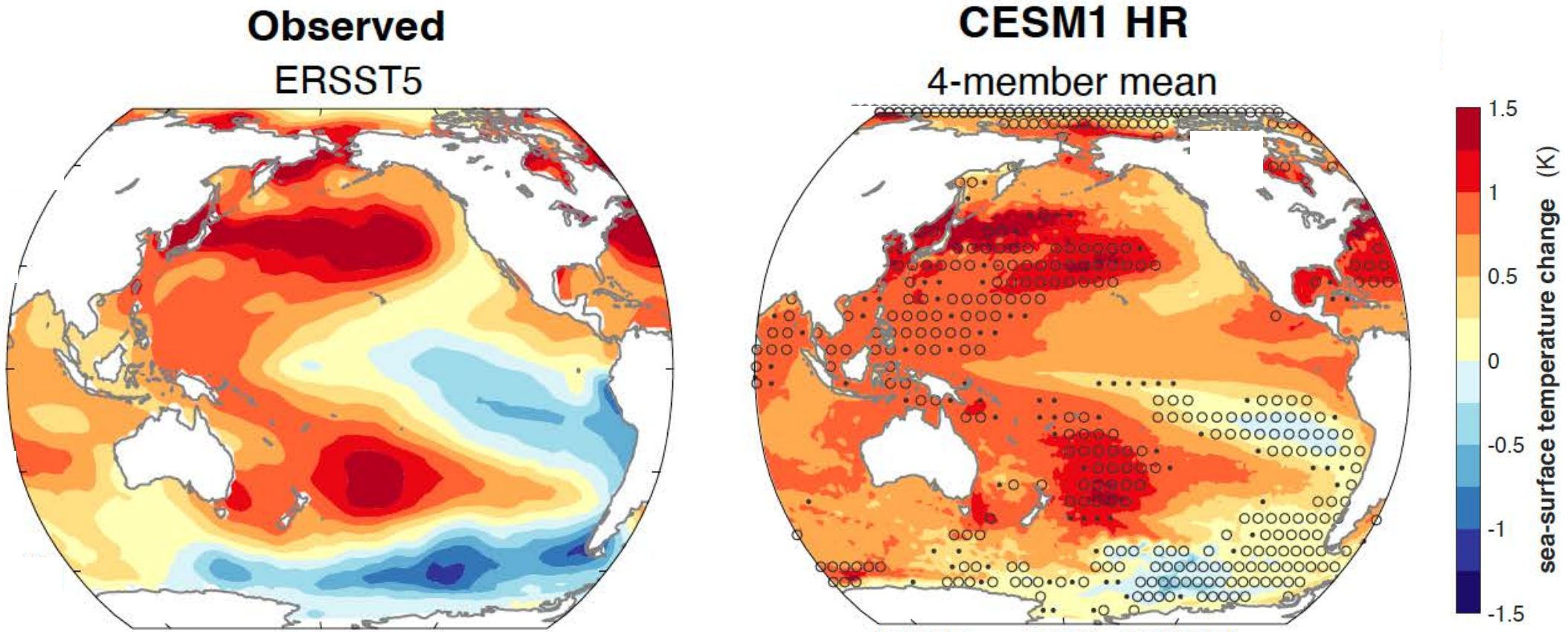
Conclusions

- Increased atmosphere and ocean resolution activate/strengthen two-way feedback between the tropical and high latitude South Pacific,
- Stronger feedback produces a much larger externally forced response than inferred from standard resolution models,
- Forcing still unclear, need single forcing runs,
- Improving ocean-atmosphere-topography interactions might be key to simulate forced modes,
- Same mode can be excited by noise.

Unforced multi-decadal variability (40 year timescales)



HR CESM1 simulates forced cooling pattern similar to observed



Stippling using open circles (dots) indicates where the simulated changes are completely outside the distribution (95% range) of changes simulated by 4-member trends randomly sampled from the 40-member LR ensemble.

DiNezio et al., in prep.