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Mechanisms of ENSO-like Variability in the Absence of Dynamical Coupling

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Motivation

El Niño-Southern Oscillation (ENSO) is widely considered as a dynamically coupled phenomenon between ocean and atmosphere.

However, ENSO-like variability (defined as the Thermally Coupled Walker mode, TCW) emerges as the dominant mode of variability in the tropical Pacific in models that do not have interactive ocean dynamics.

A new mechanism of TCW in the absence of dynamical coupling is proposed in this work.

Data

The data used include simulations of 10 AGCMs coupled with a 50m slab ocean archived by CMIP3 (see legend in Fig. 4).

Methods

To study the mechanism, we performed the composite heat budget analysis. Radiative heat flux is decomposed into cloud- & clear sky- radiation to highlight the role of clouds.

$$\rho h C_p \frac{\partial T}{\partial t} = Q_{clouds} + Q_{clearsky} + Q_{latent} + Q_{sensible} + Q_{constant}$$

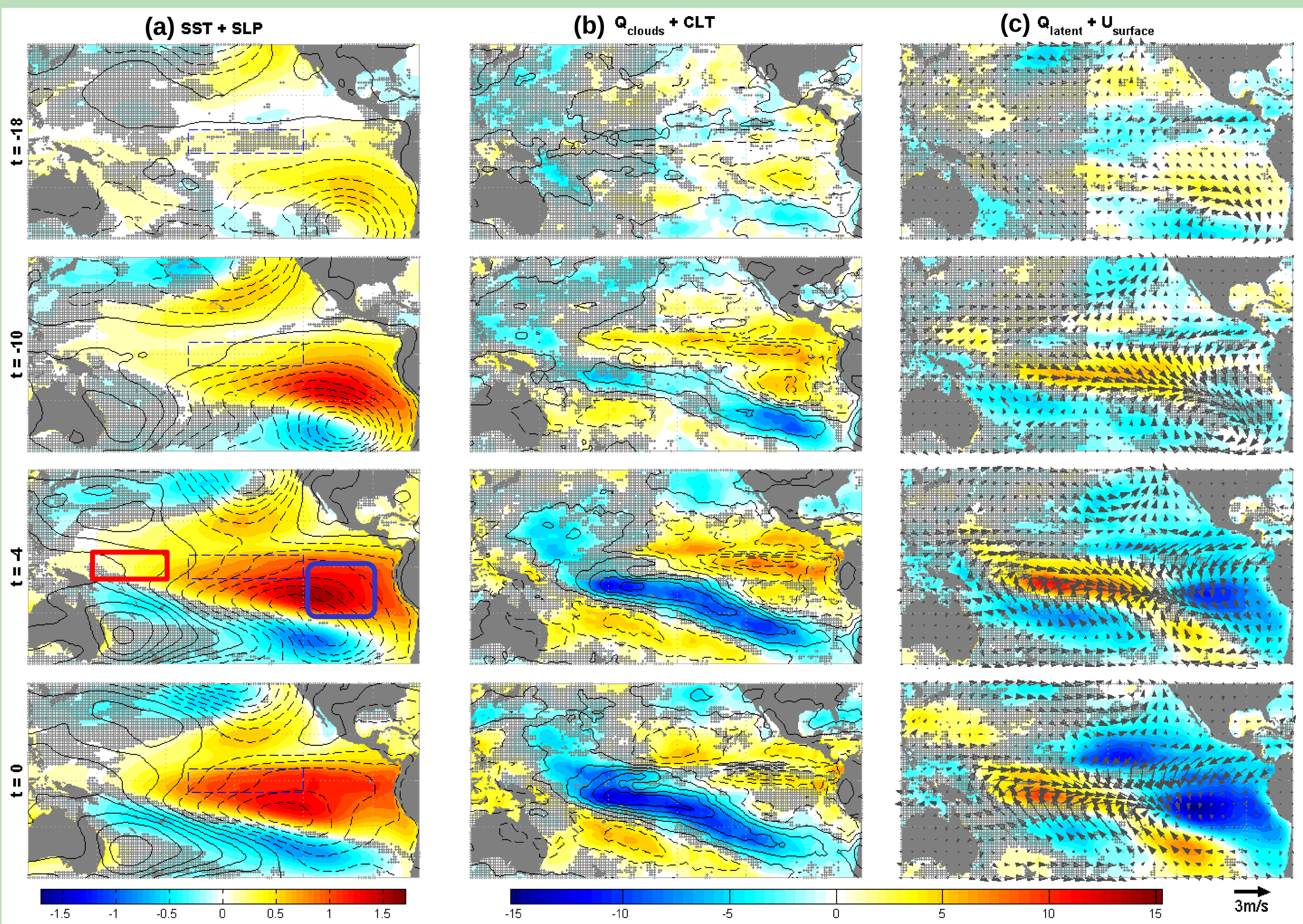

Figure 1. Multimodel-mean snapshots of anomalous SST and SLP (left column), Q_{clouds} and total cloud cover (middle), Q_{latent} and $U_{surface}$ (right) at time of 18, 10, 4 and 0 months before Nino3.4 SST peak.

SST, Q_{clouds} and Q_{latent} are in shading and SLP, CLT in contour with solid denoting positive. Unhatched area means no less than 7/10 models agree in sign.

Results

- TCW (Fig. 1a) is characterized by a peak occurring around (15°S, 125°W), southeast of Nino3.4 and ~4 months prior, and propagating to northwest.
- In the eastern Pacific, Mechanisms mainly involve:
  - Growing: local positive feedback between SST and low level clouds (dominant, Fig. 1a&b & 2), and less latent heat loss due to weakening surface winds during initial stage (Fig. 1c & 2)
  - Damping: more latent heat loss due to strong SST anomalies (Fig. 1c & 2)
  - Westward propagation: wind-evaporation-SST (WES) feedback (Fig. 1c)
- In the western Pacific, variability originates from the east via the WES feedback, and is damped by high-level clouds (Fig. 3).

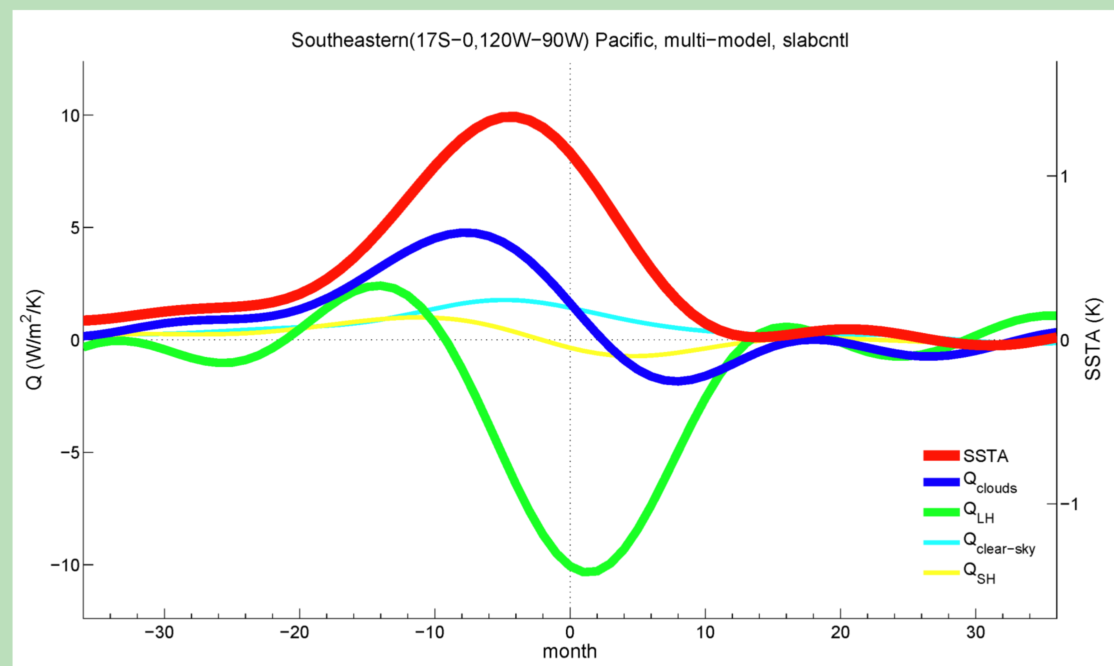

Figure 2. Composite heat budget of southeast Pacific (blue box in Fig. 1a, the 3rd panel)

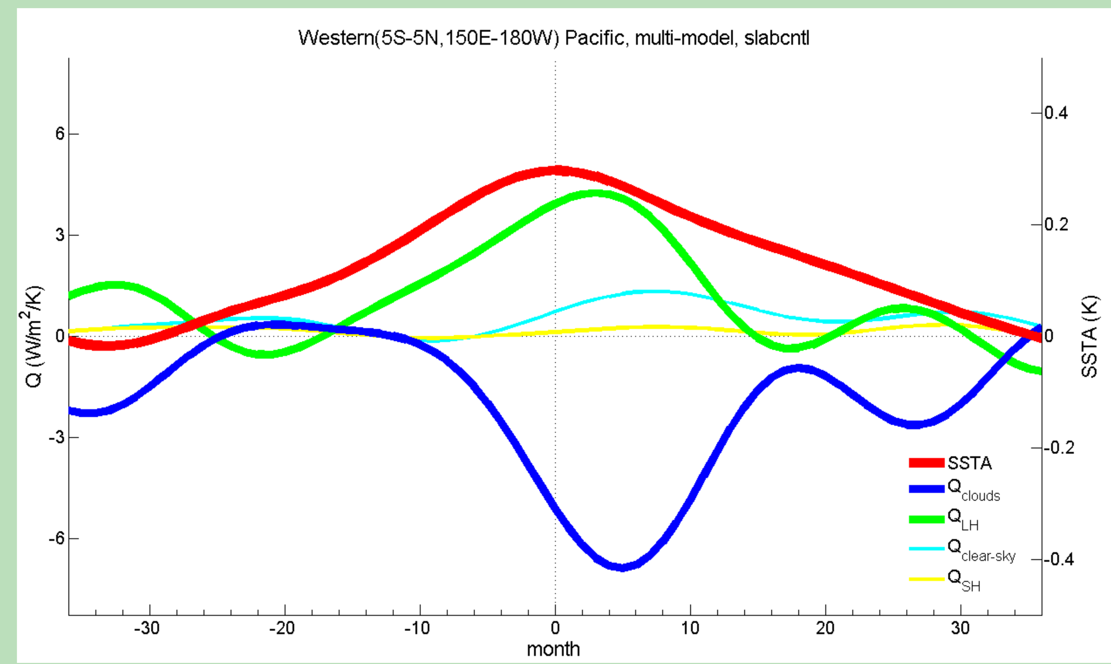

Figure 3. Same as Fig. 2 but for western Pacific (red box in Fig. 1a, the 3rd panel)

- The varying amplitudes of positive cloud feedback among models largely account for their TCW variance difference (Fig. 4):
  - the stronger the positive cloud feedback, the larger the TCW variance

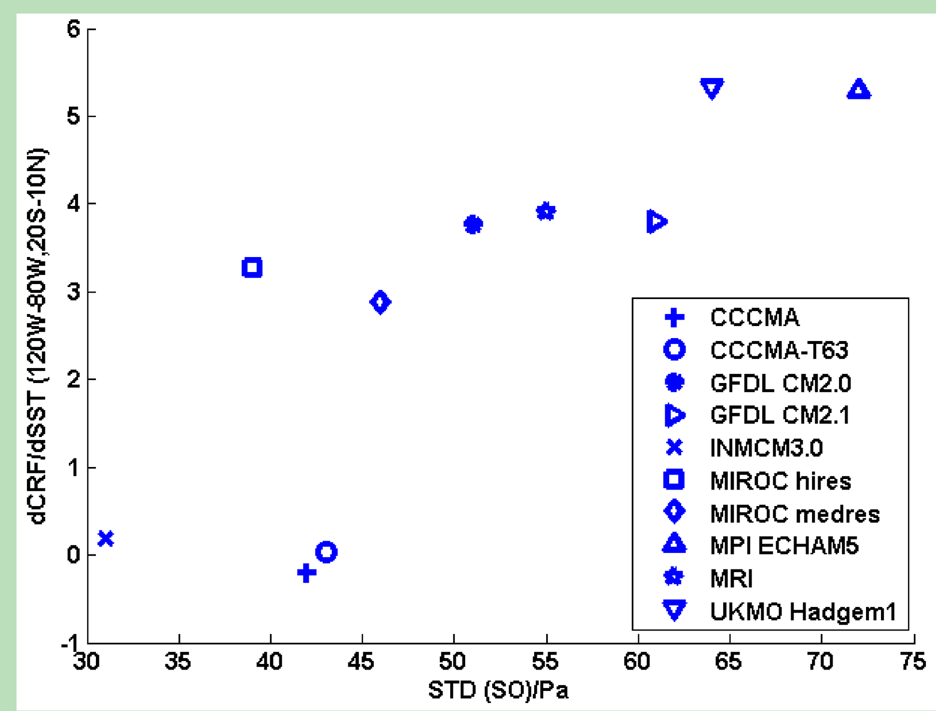

Figure 4. cloud feedback VS standard deviation of TCW

Conclusions

In the absence of dynamical coupling, the positive cloud feedback acts as the growing mechanism of TCW. It explains the intermodel difference of the TCW variance.

The latent heat loss due to evaporation depends on both SST and surface winds. While contributing to the initial growth of TCW, it mainly acts as the damping mechanism.

References

Clement, Amy, Pedro DiNezio, Clara Deser, 2011: Rethinking the Ocean's Role in the Southern Oscillation. *J. Climate*, **24**, 4056–4072.

Acknowledgments

This work is supported by the Office of Science, U. S. DOE, and by NSF Climate and Large-scale Dynamics Program