Mean cross-equatorial winds and ENSO cycle

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Introduction

- El Niño has undergone a shift from Eastern Pacific (EP) events to Central Pacific (CP) events around year 2000.
- Correspondingly, ITCZ has stopped crossing the equator during El Niño after year 2000.
- Concurrently, observations reveal a robust decadal strengthening of cross-equatorial winds that paralleled the observed shifts in El Niño.

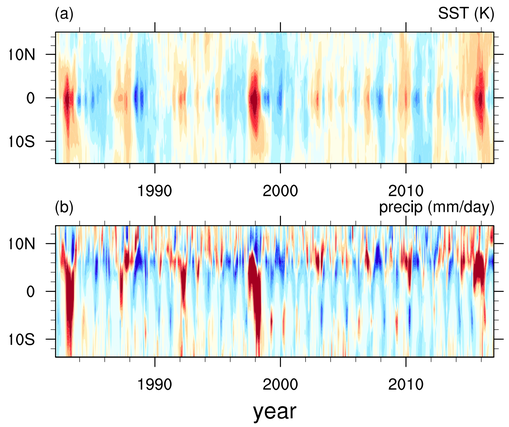


Fig.1 (a) SST and (b) precipitation anomalies averaged over 150°W-90°W. ITCZ stopped crossing the equator after year 2000.

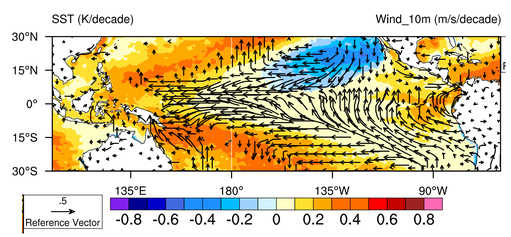


Fig.2 SST (color) and surface wind (vecotr) trend during 1982-2014.

Hypothesis

We hypothesize that the cross-equatorial wind strengthening contributes to El Niño events shift.

Materials and Methods

- Model: CESM 1.2.2 with 2-degatmosphere, 1-deg ocean.
- Simulation period: 90 years (more later).
- Experiment design: Opposing surface heat fluxes aredadded over two regions on both sides of the equator in the eastern Pacific to enhance the north-south SST contrast and thereby strengthen the cross-equatorial winds while keep zonal winds virtually unchanged.

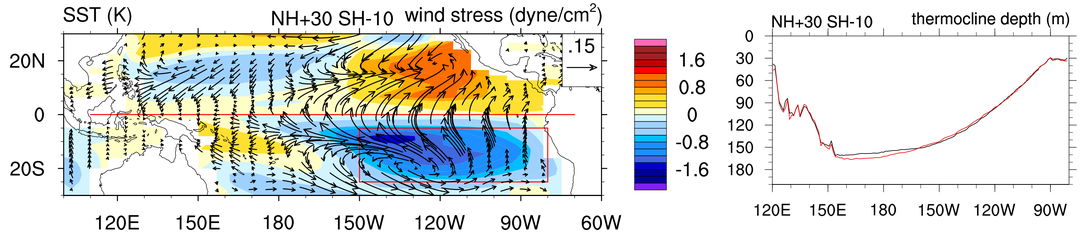
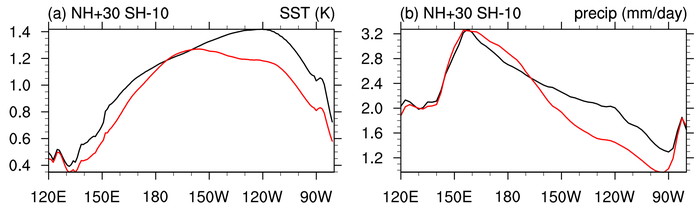


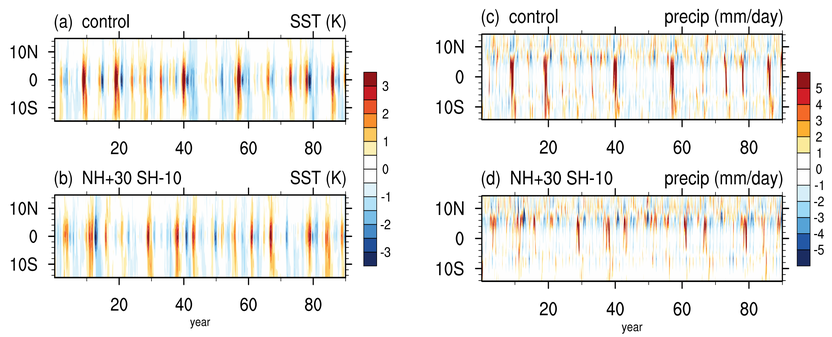
Fig. 3 (left) Mode climatology differences in SST (color) and wind stress (vector) between the perturbed run and the control run. Surface heat flux of -10 Wm^2 are added in the southern box while +30 Wm^2 are added in the northern box. (right) Mode climatology thermocline depth in the perturbed run (red) and the control run (black). The thermocline slope changes little.

Results



El Niño shifts from EP events in the control run to CP events in the perturbed run.

Fig. 4 Standard deviation of (a) SST and (b) precipitation anomalies in the perturbed (red) and control run (black).



In the perturbed run ITCZ barely crosses the equator (d) as El Niño shifts/weakens.

Fig. 5 (a, b) SST and (c, d) precipitation anomalies averaged over 150°W-90°W.

Diagnosis

Stability index I_{BJ} to reveal mechanisms for the weakening of El Niño anomalies in the eastern Pacific.

$$2I_{BJ} = \left\{ \alpha_Q - \frac{\langle \overline{u} \rangle}{H_m} + \frac{\langle 2y\overline{v} \rangle}{L_y^2} - \frac{\langle \mathcal{H}(\overline{w}) \cdot \overline{w} \rangle}{H_m} - \mu_a^* \beta_u \langle \frac{\partial \overline{T}}{\partial x} \rangle - \mu_a^* \beta_w \langle \frac{\partial \overline{T}}{\partial z} \rangle - \mu_a^* \beta_h a_h \frac{\langle \mathcal{H}(\overline{w}) \cdot \overline{w} \rangle}{H_m} \right\}$$

$$2I_{BJ} = \left\{ HF + U_{damp} + V_{damp} + W_{damp} \quad + \quad Zonal \quad + \quad Ekman \quad + Thermocline \right\}$$

μ_a^* – wind sensitivity to SST anomalies;
$\beta_{\{u,w,h\}}$ – oceanic sensitivity to wind anomalies;
a_h – T_{sub} sensitivity to thermocline movement.

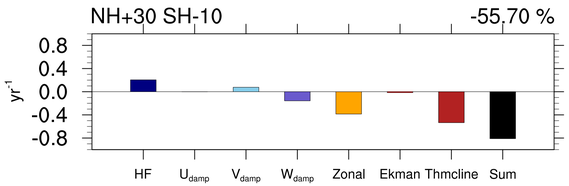


Fig. 6 Decrease in each term of I_{BJ} in the perturbed run from the control run. Weakening zonal advection feedback and thermocline feedback contributes most to the weaker El Niño anomalies in the eastern Pacific.

How do cross-equatorial winds cause weaker feedbacks?

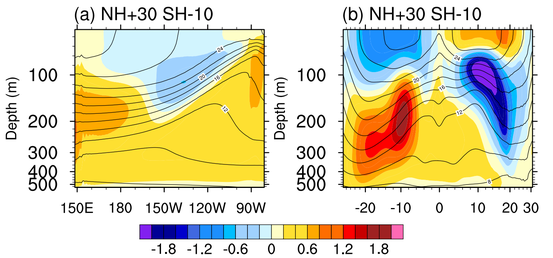


Fig. 7 Model climatology difference in (a) equatorial subsurface temperature averaged over 5°S-5°N and (b) eastern Pacific subsurface temperature averaged over 15O°W-120°W.

Conclusion

- Strengthening Cross-equatorial winds can shift El Niño from EP to CP events.
- Weakening in zonal advection feedback and thermocline feedback contributes most to the shift.
- Stratification decrease resulting from large-scale wind stress forcing is one diagnosed mechanism.

Acknowledgement

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