Impact of tropical cyclone winds on ENSO



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The ENSO-TC relationship

 \succ ENSO can effectively modulate global tropical cyclone (TC) activity by altering the large-scale atmospheric and oceanic conditions.

TCs' impact on ENSO?

ENSO dynamics:

ENSO is suggested as a neutrally-stable natural mode of oscillation resulting from ocean-atmosphere interactions, sustained by stochastic atmospheric forcing. (i.e., Fedorov and Philander 2000, 20 Kessler 2002; Thompson and Battisti 2000, 2001).

> ENSO characteristics depend on:

- The ocean state ullet
- The westerly wind bursts (WWBs) •
- Kelvin wave propagation and warm pool expansion. lacksquare



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TCs can influence just the right ingredients for ENSO The initial ocean state – TCs can impact the tropical Pacific ocean heat

Heat flux adjustment

content through enhanced ocean vertical mixing.

Vertical mixing

The westerly wind bursts (WWBs) - - The majority of the near-equator TCs are associated with WWBs

Precentage of TCs associated with WWBs



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TCs can excite equatorial Kelvin waves that deepen the equatorial thermocline.





Tropical Cyclone (TC) Event

The goal of the study: explore the <u>impact of TC winds on ENSO characteristics</u> in the context of a <u>fully-coupled Earth system model</u>





Method -- TCs in CESM1.3

* Add transient TC surface winds from the high-res (0.25° atmosphere) model to the low-res coupled model (1° atmosphere & 1° ocean)



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Results – ENSO statistics



LR-TC has higher power in the power spectrum The primary ENSO frequency shifted more approaching the observations





Results – strong to extreme El Nino events

SST zonal distribution



LR-cntl: 18 El Nino events, 2 extreme events LR-TC: 19 El Nino events, 6 extreme events.



Strong El Nino events and TC wind power



P.S. Near-equator TC wind power: TC power dissipation index of nearequator TCs (within 12°S-12°N)



Results – El Nino Composites





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- The added TC winds can enhance El Nino SST, thermocline depth, and zonal current
- Importance of the synergetic annual cycle of El Nino and TCs



Results – El Nino dynamics

Heat budget analysis of the ocean mixed layer:





$$- \bar{v}\frac{\partial T'}{\partial y} - \bar{w}\frac{\partial T'}{\partial z} - u'\frac{\partial T'}{\partial x} - v'\frac{\partial T'}{\partial y} - w'\frac{\partial T'}{\partial z} + R,$$

TCs can impact El Nino through enhanced thermocline feedback and zonal advection feedback

Summary

- We investigate the impact of TC winds on ENSO by prescribing high-res TC winds into a lowres fully coupled model (CESM 1.3)
- The added TC winds increased the ENSO power and shifted the ENSO frequency more approaching the observations
- TCs lead to an increase of strong to extreme El Nino events, and a positive correlation is identified between the strong El Nino and TC wind power
- TCs' impact on El Nino is mainly through enhanced zonal advection feedback and thermocline feedback
- Our results suggest that TCs can actively influence ENSO characteristics in a fully coupled comprehensive Earth System model, pointing to an important two-way interaction between TCs and ENSO





Tropical Pacific zonal T anomalies











