Can tropical cyclones impact climate?

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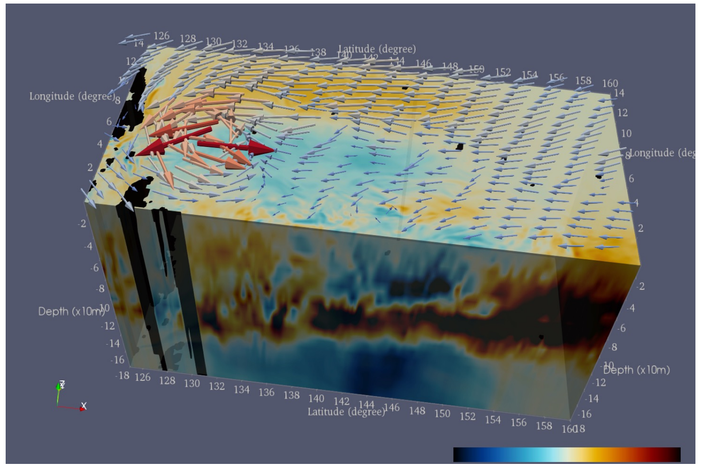

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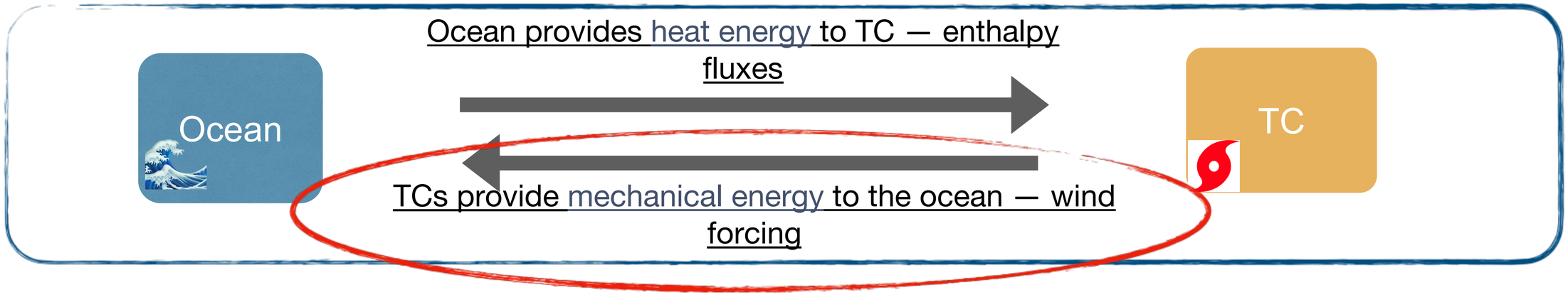
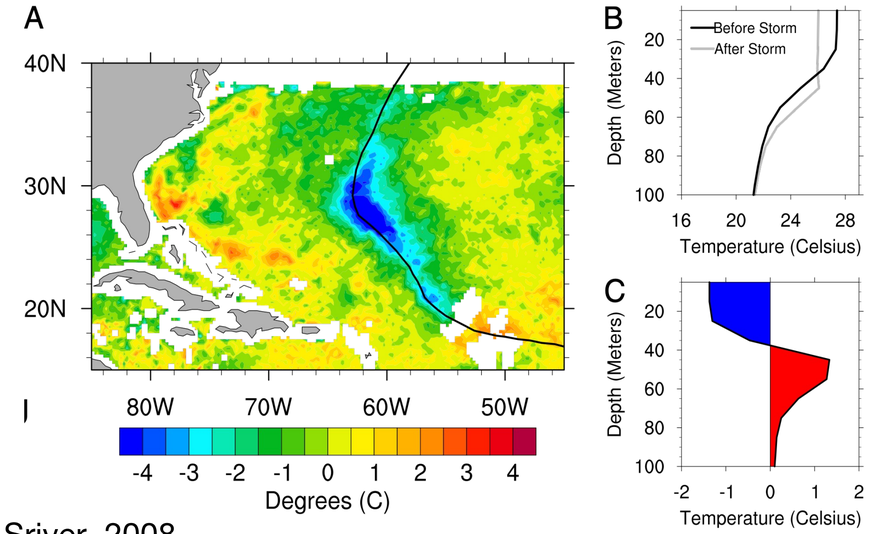
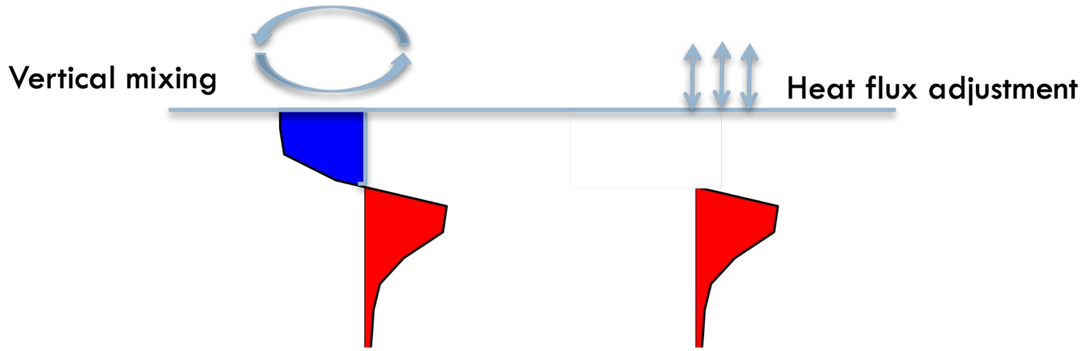
Tropical cyclone (TC) - ocean interaction and the impact on the climate





Sriver, 2008

❖Turbulent ocean vertical mixing → net heat gain in the ocean



TCs' impact on climate

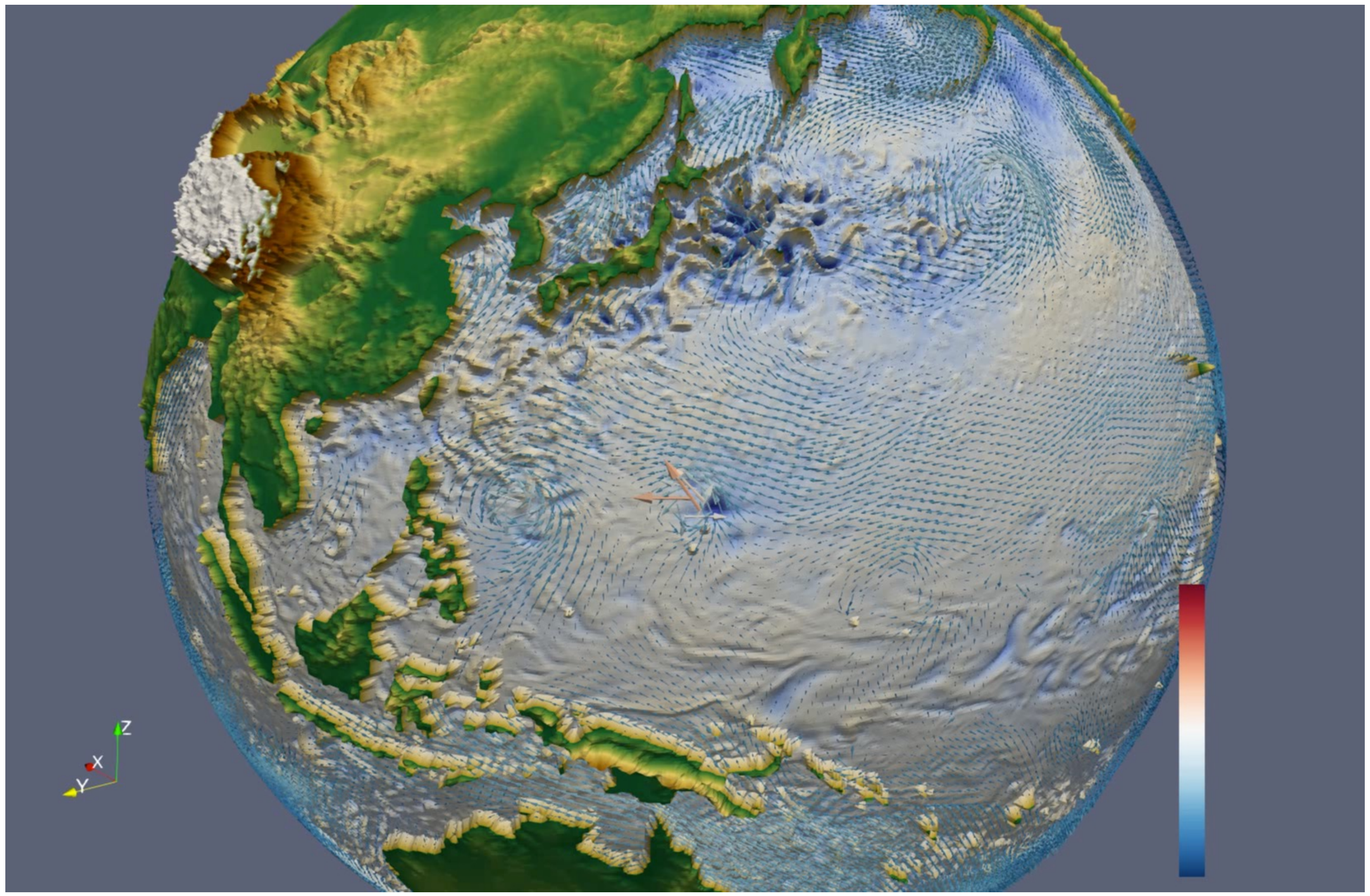
- TCs have the potential to alter ocean heat content and heat transports [*Emanuel, 2001; Srive and Huber, 2007; Hu and Meehl, 2009; Fedorov et al., 2010; Mei et al., 2013*], ocean temperature patterns, seasonal cycles of SST and mixed layer depth. [*Vincent et al., 2014; Hart 2011; Li and Sriver, 2018*]

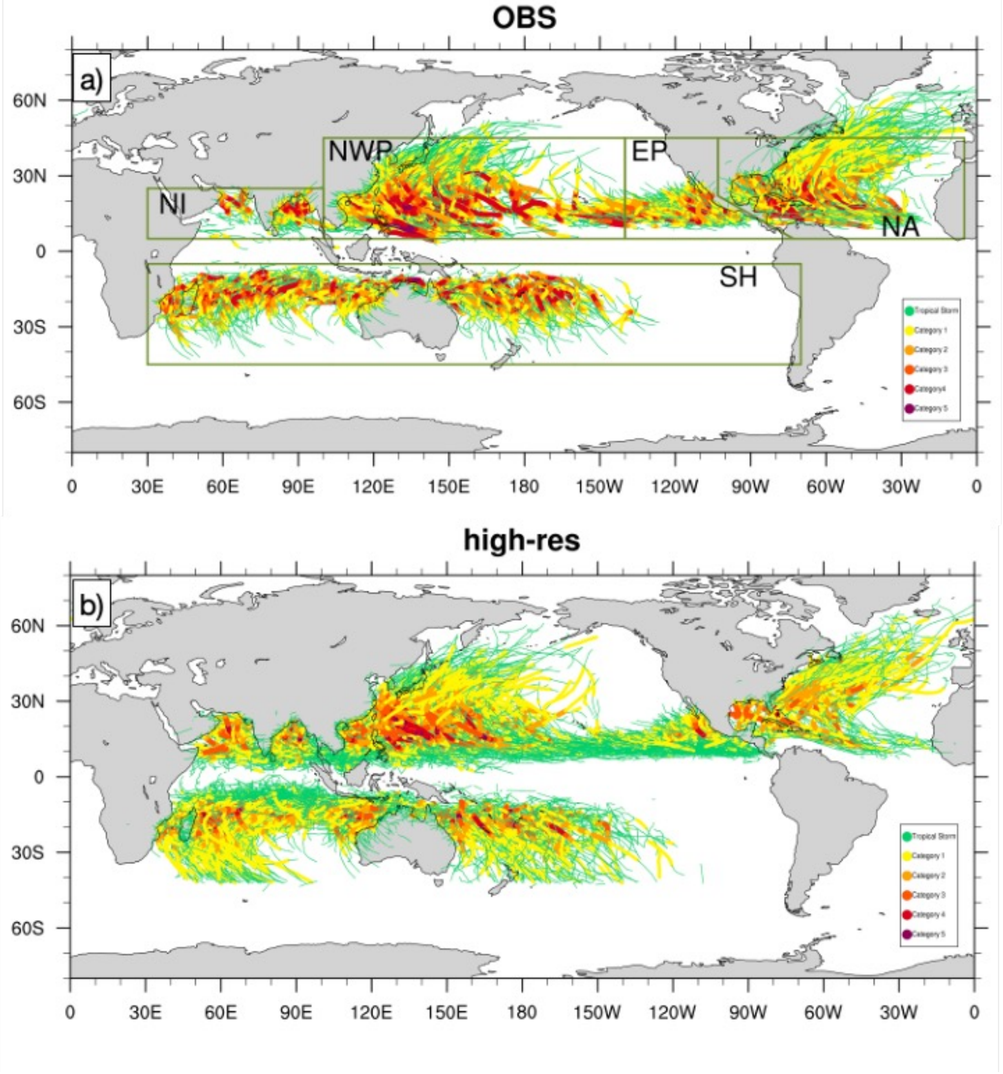
- Understanding TCs' contribution to the climate system may help constrain uncertainties in climate simulations and projections.

- TCs' impact have not been explored in a fully-coupled global Earth System Model

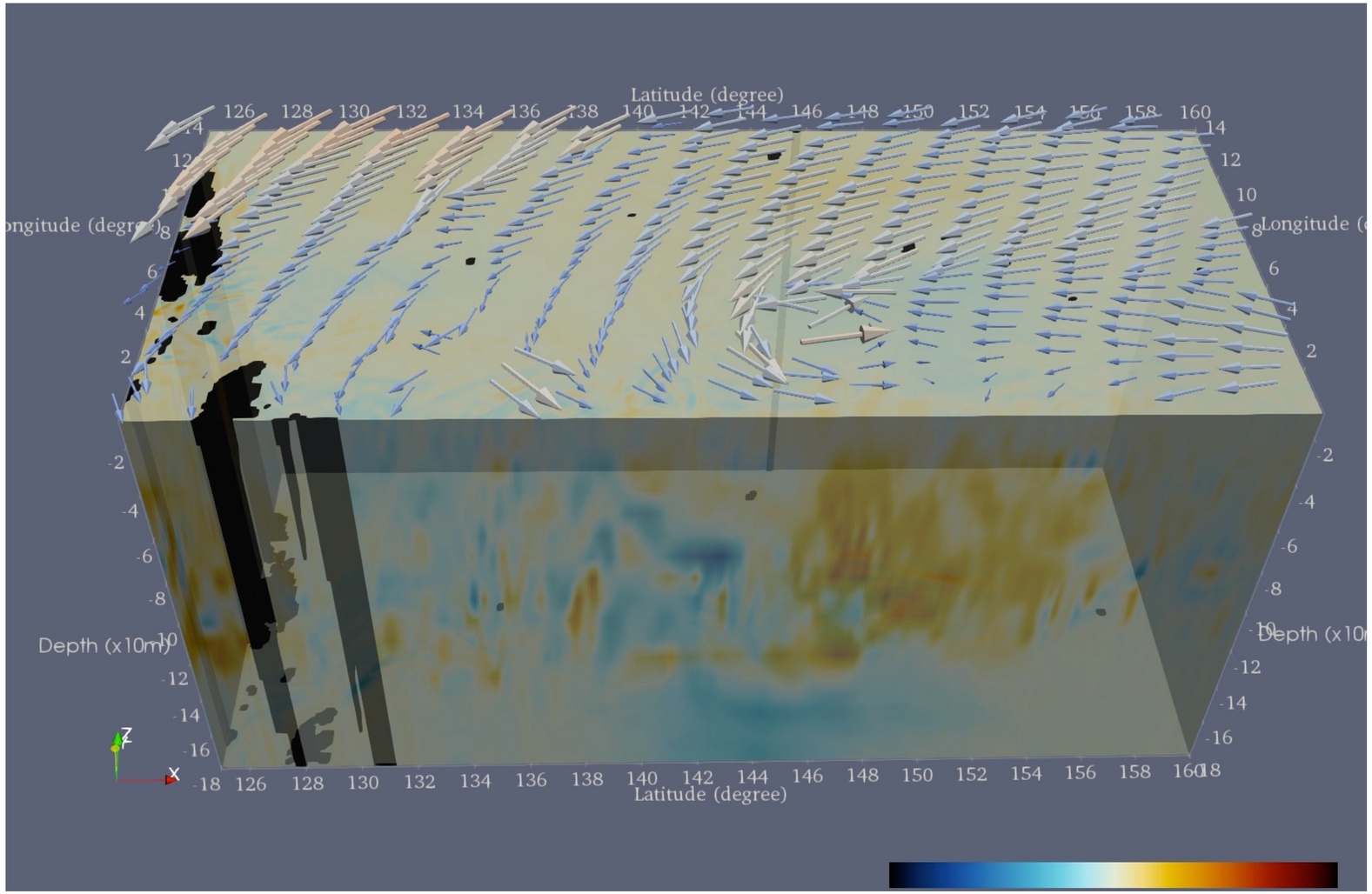
Here we investigate the ocean's response to TC forcing and its feedback to the atmosphere in a fully-coupled global climate model.

TCs in high-res CESM (0.25° atmos resolution)

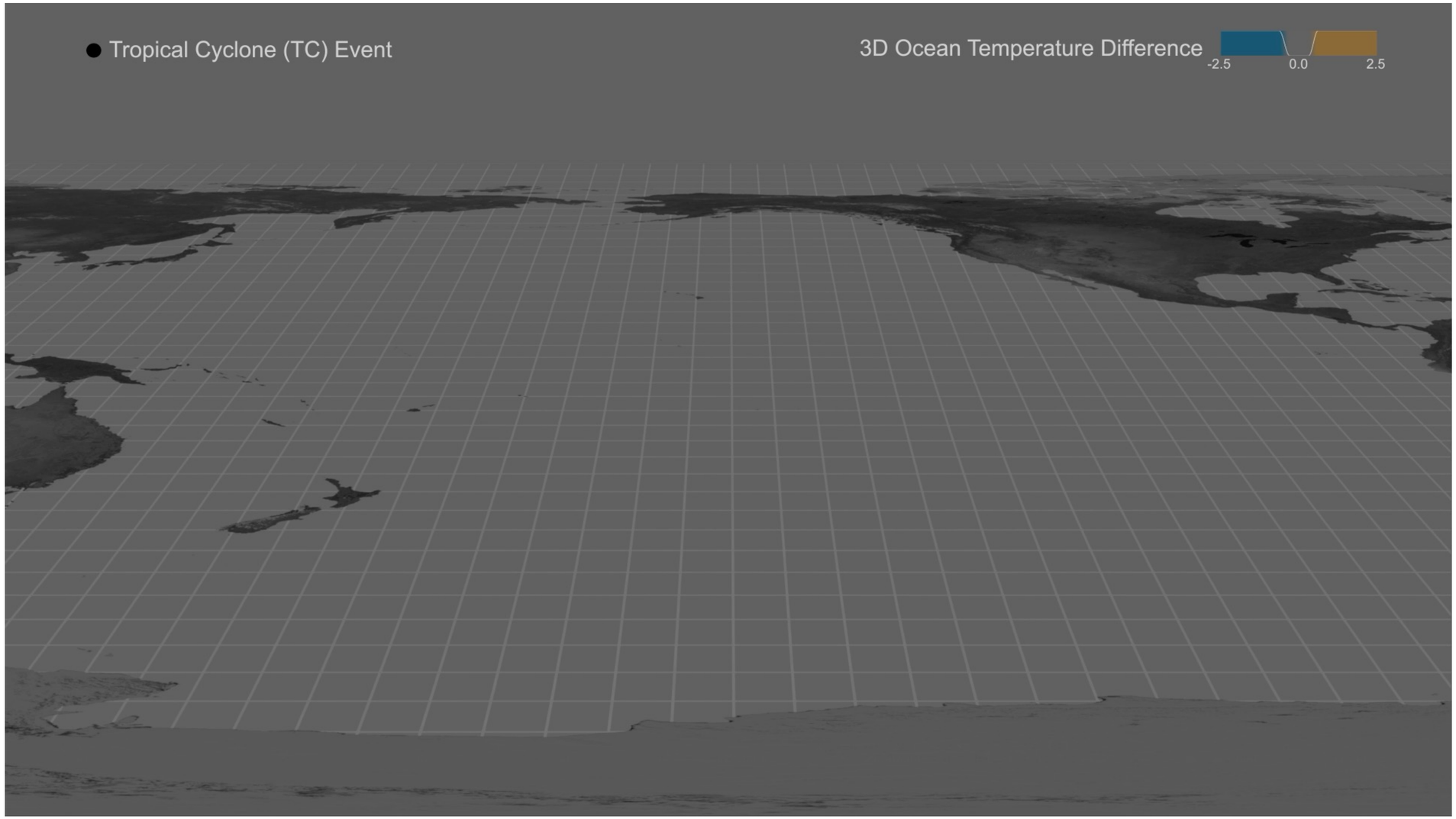




TC-ocean interactions in high-res CESM (0.25° atmos & 0.1° ocn)



TC-ocean interactions in high-res CESM (0.25° atmos & 0.1° ocn)



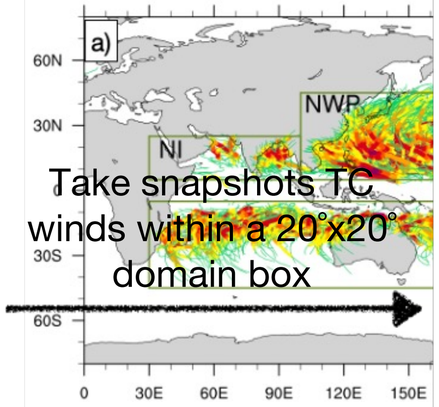
Method -- TCs in CESM

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

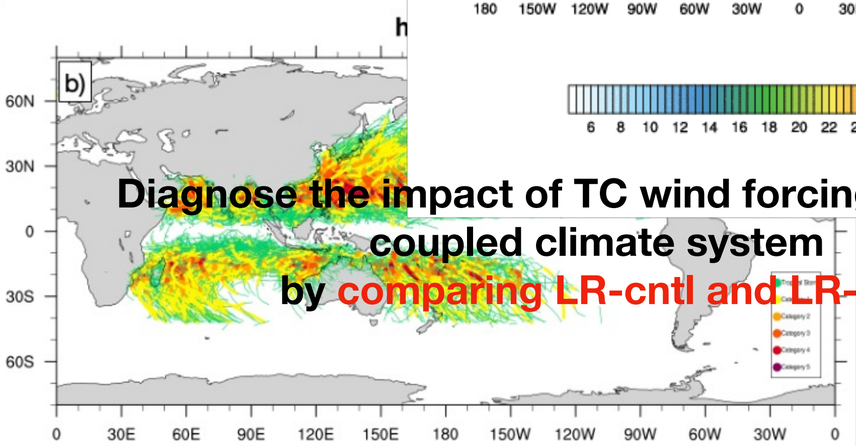
HR-cntl

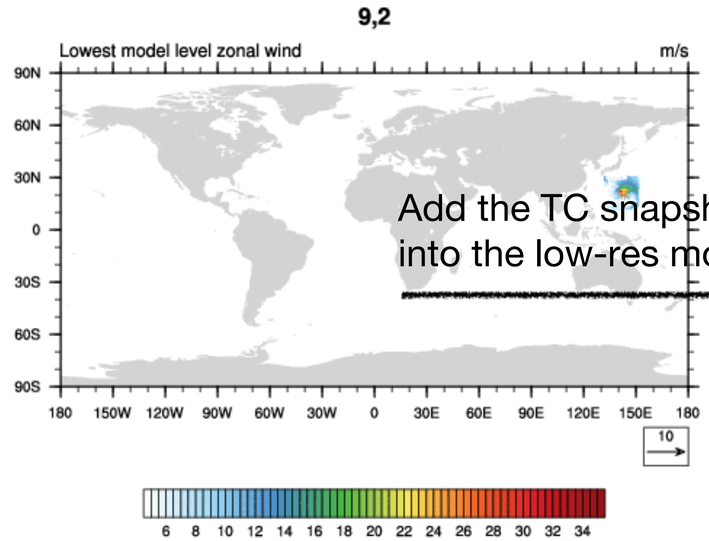
Atmosphere CAM5 SE 0.25° grid

Ocean POP2 1° grid



Take snapshots TC winds within a 20°x20° domain box





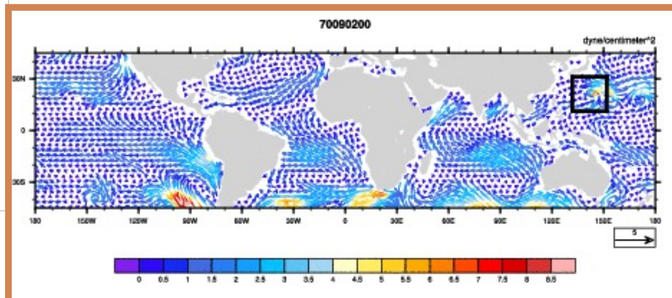
Add the TC snapshots into the low-res model

Diagnose the impact of TC wind forcing within the coupled climate system by comparing LR-cntl and LR-TC

LR-cntl

Atmosphere CAM5 SE 1° grid

Ocean POP2 1° grid

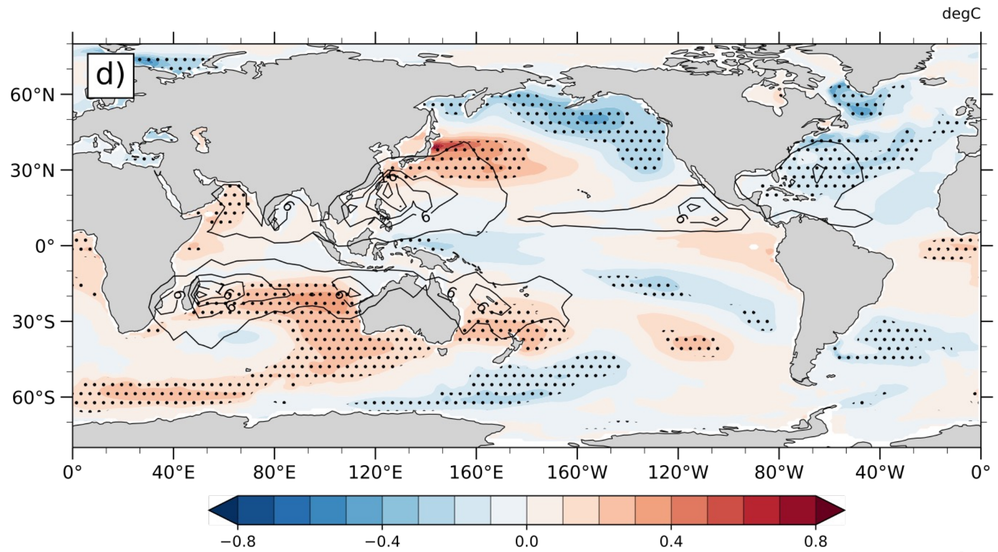


LR-TC

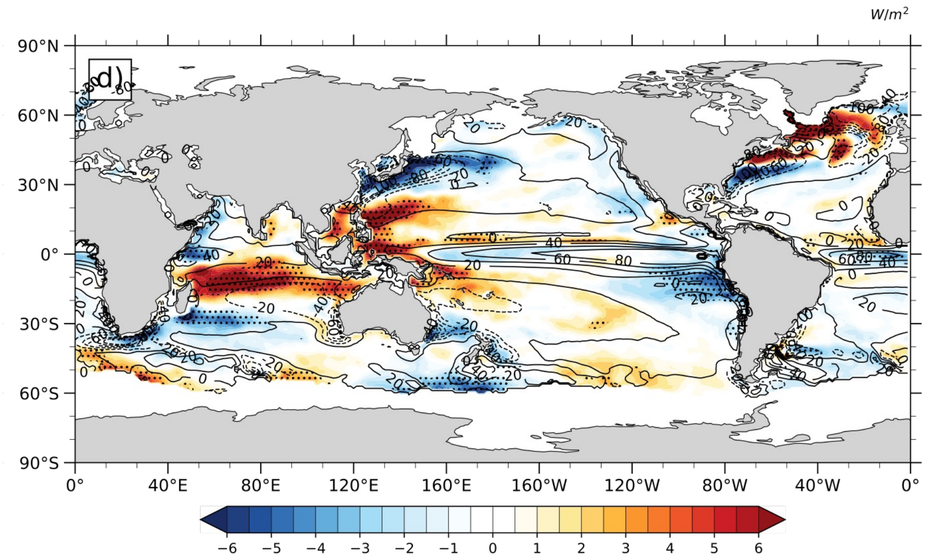
100 years

TCs' impact on SST, heat fluxes and precipitation

SST anomalies

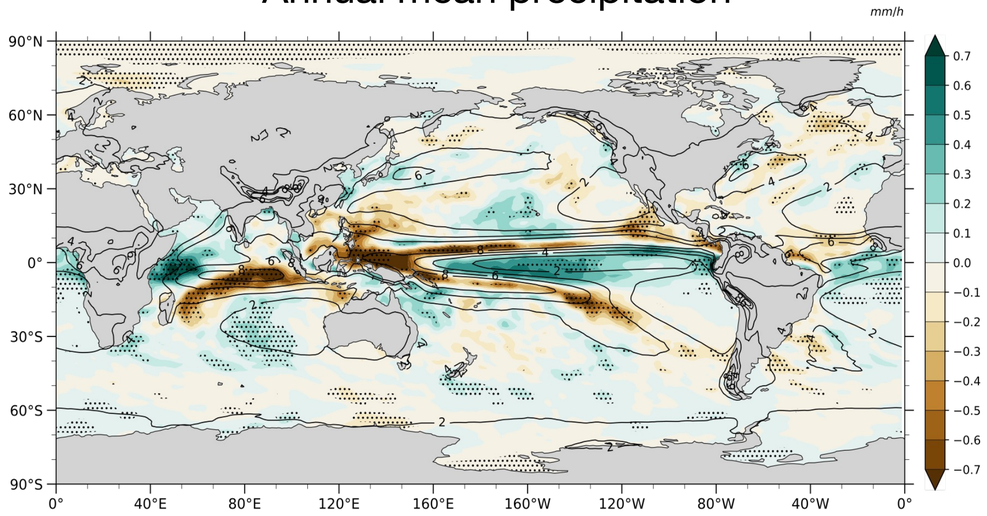


Total heat flux anomalies

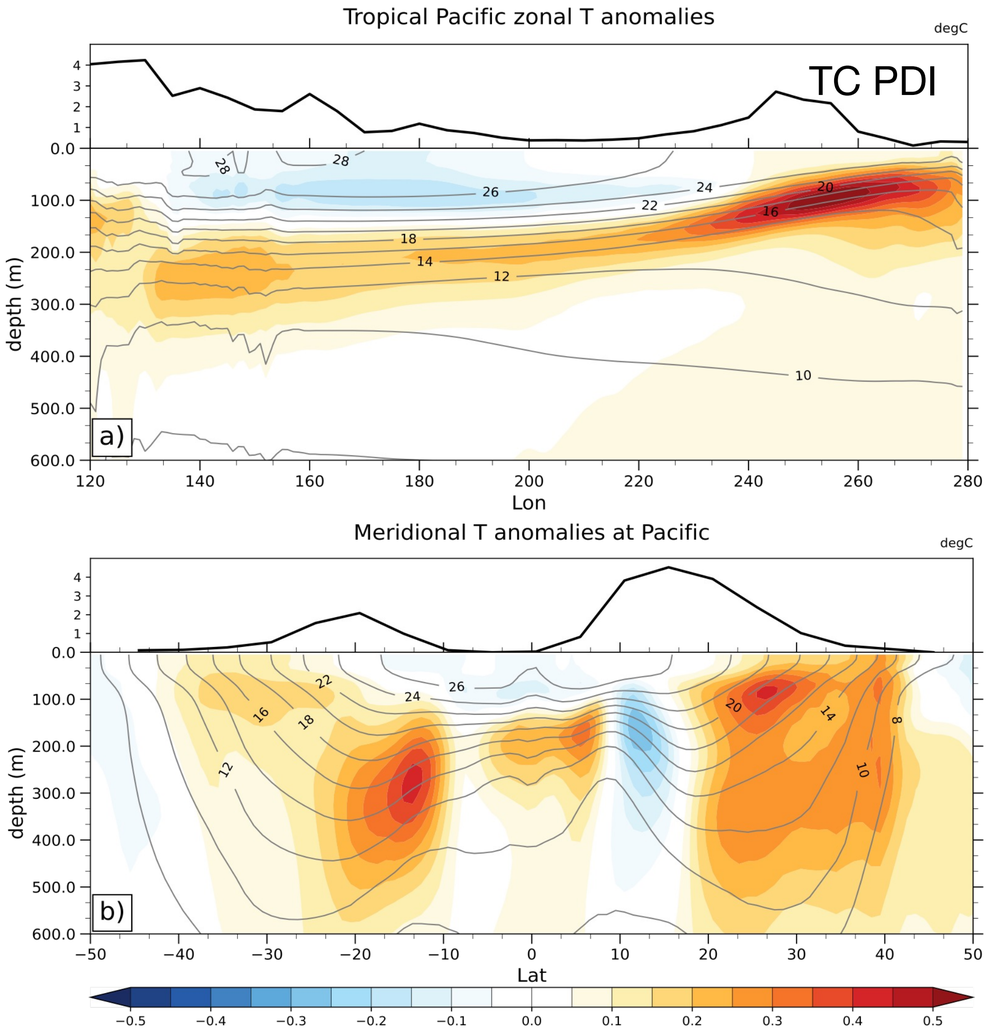


*Positive into the ocean

Annual mean precipitation



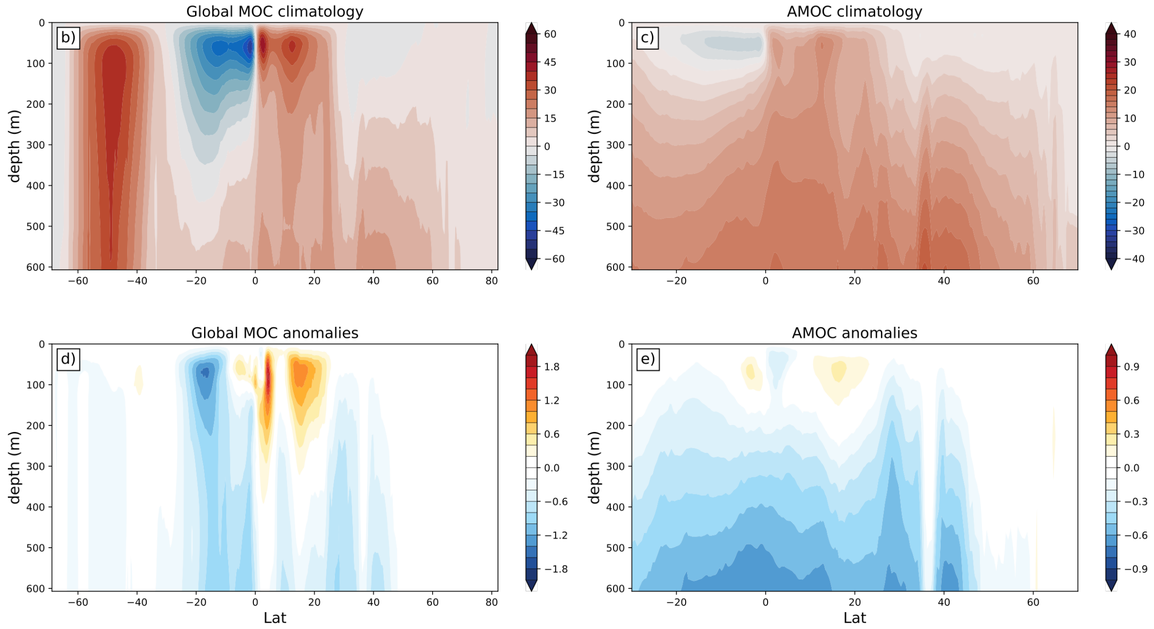
TCs' impact on ocean temperature

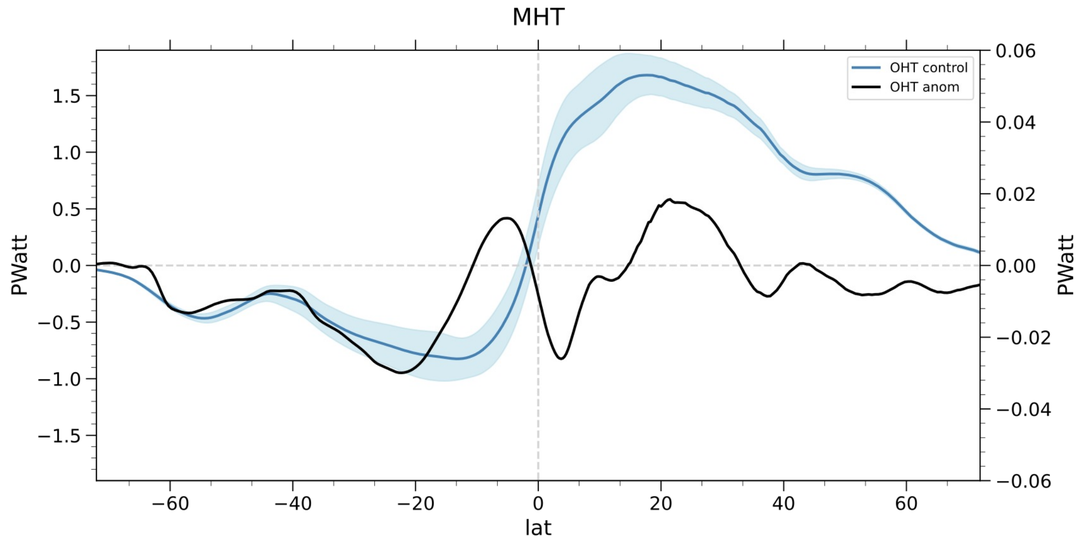


- TC-induced warm anomalies enters the equatorial main thermocline, gets carried eastward by equatorial Kelvin waves and the Equatorial Undercurrent, and accumulates and rises to the surface in the eastern Pacific.

- The warm anomalies in the permanent thermocline are transported equatorward along the isotherms through the subtropical cells (STCs)

TCs' impact on ocean circulations and meridional heat transport

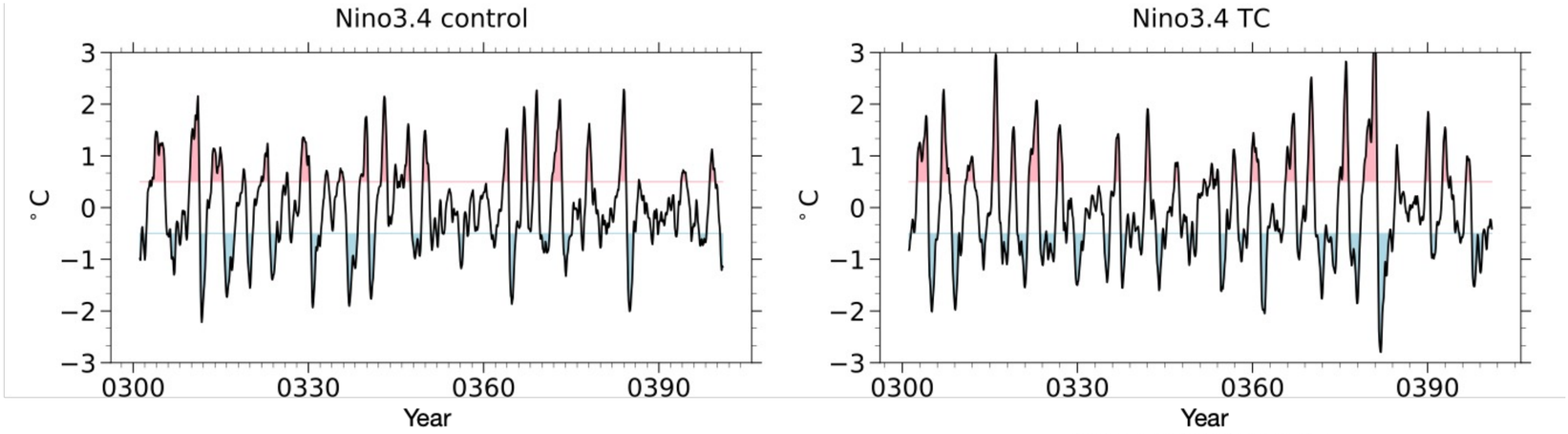


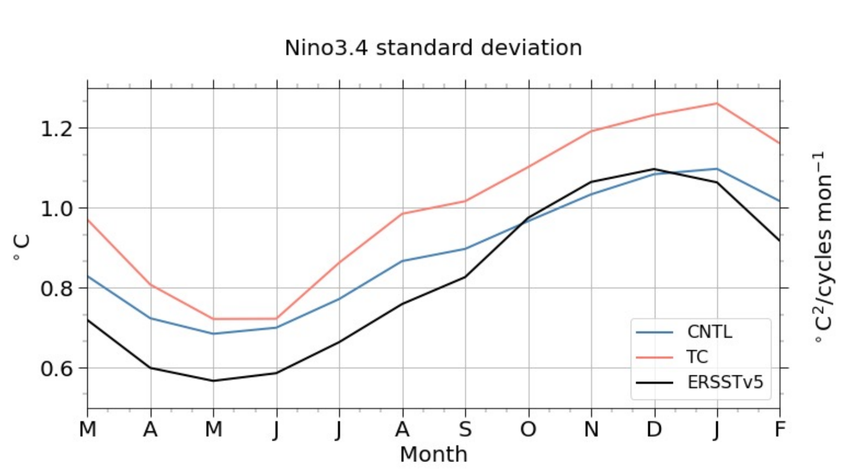


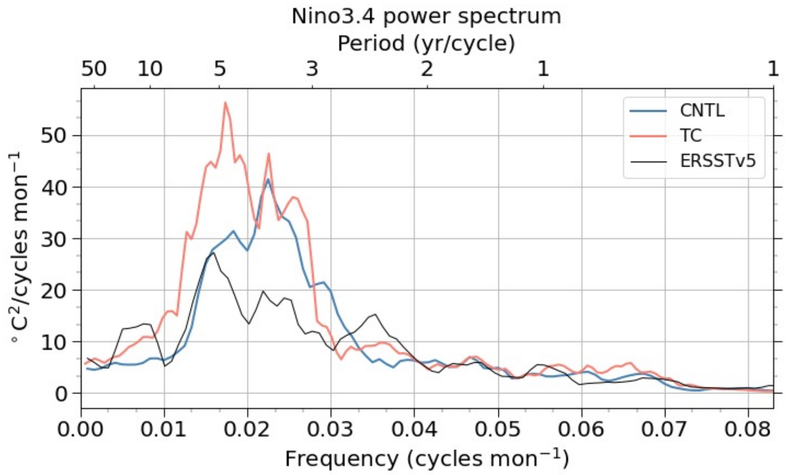
- Strengthened STC at TC wind bands
- Weakened AMOC
  - due to increased heat and freshwater flux

- Increased poleward heat transport at the subtropics
- Heat convergence in the deep tropics

TCs’ impact on ENSO statistics



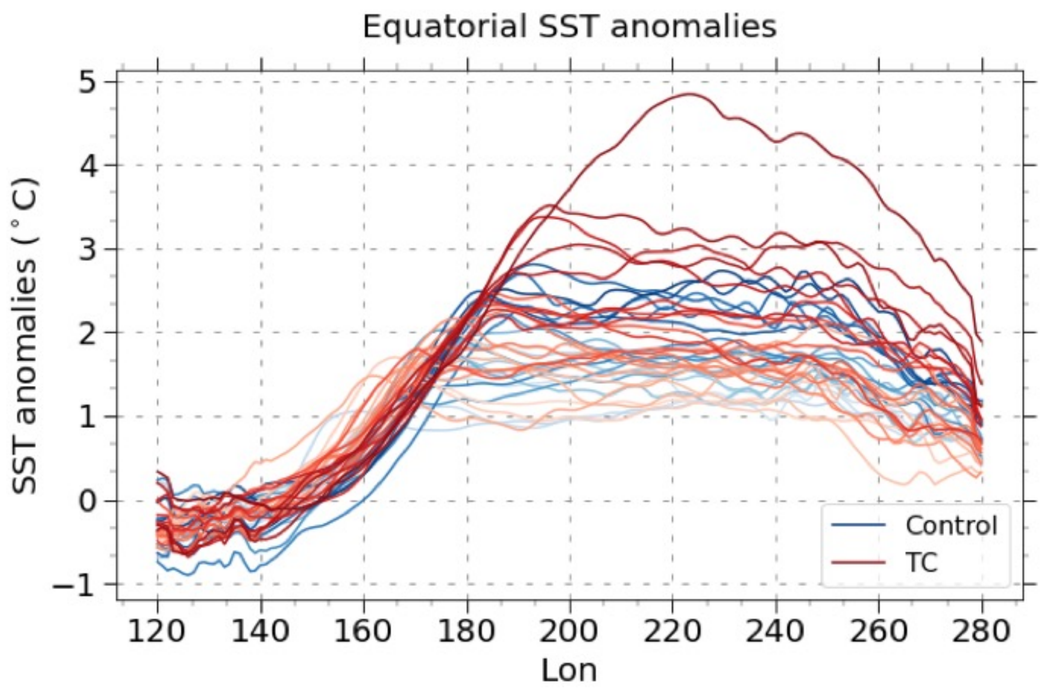




LR-TC has higher power in the power spectrum
The primary ENSO frequency shifted more approaching the observations

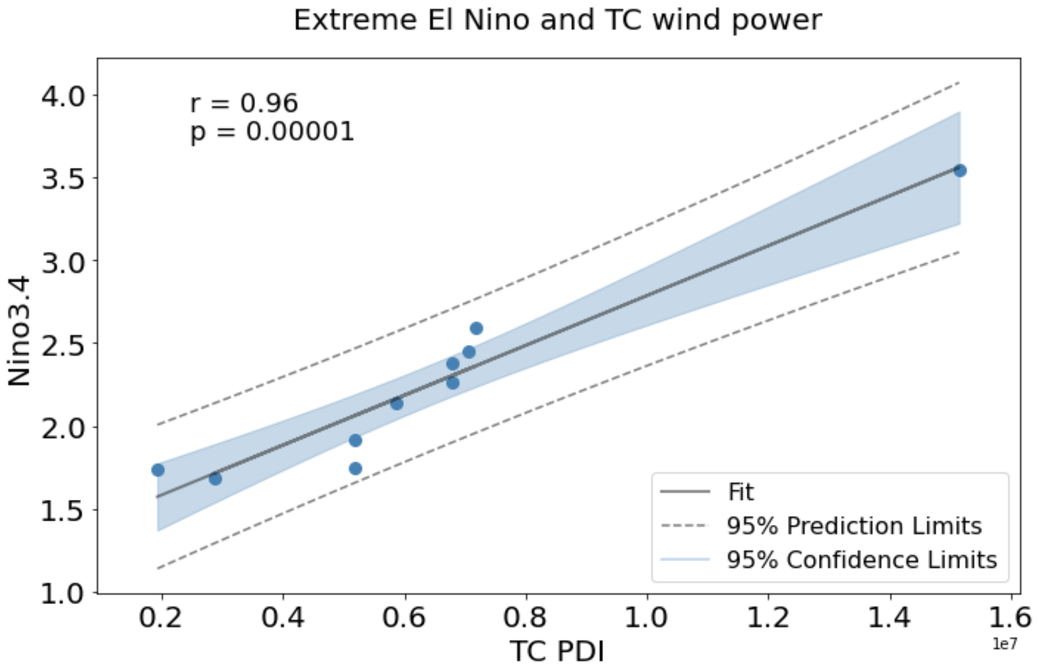
TCs' impact on strong to extreme El Nino events

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 near-equator TCs (within 12°S-12°N)

Summary

- We examine the impact of TC wind forcing in a fully coupled climate model by prescribing high-res TC winds into a low-res model
- TC winds can impact global SST patterns, leading to changes in surface heat fluxes and precipitations.
- TC winds strengthen the STCs and the meridional ocean heat transport in the Pacific Ocean. The AMOC weakens due to anomalous buoyancy gain in the NA subpolar gyre.
- 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