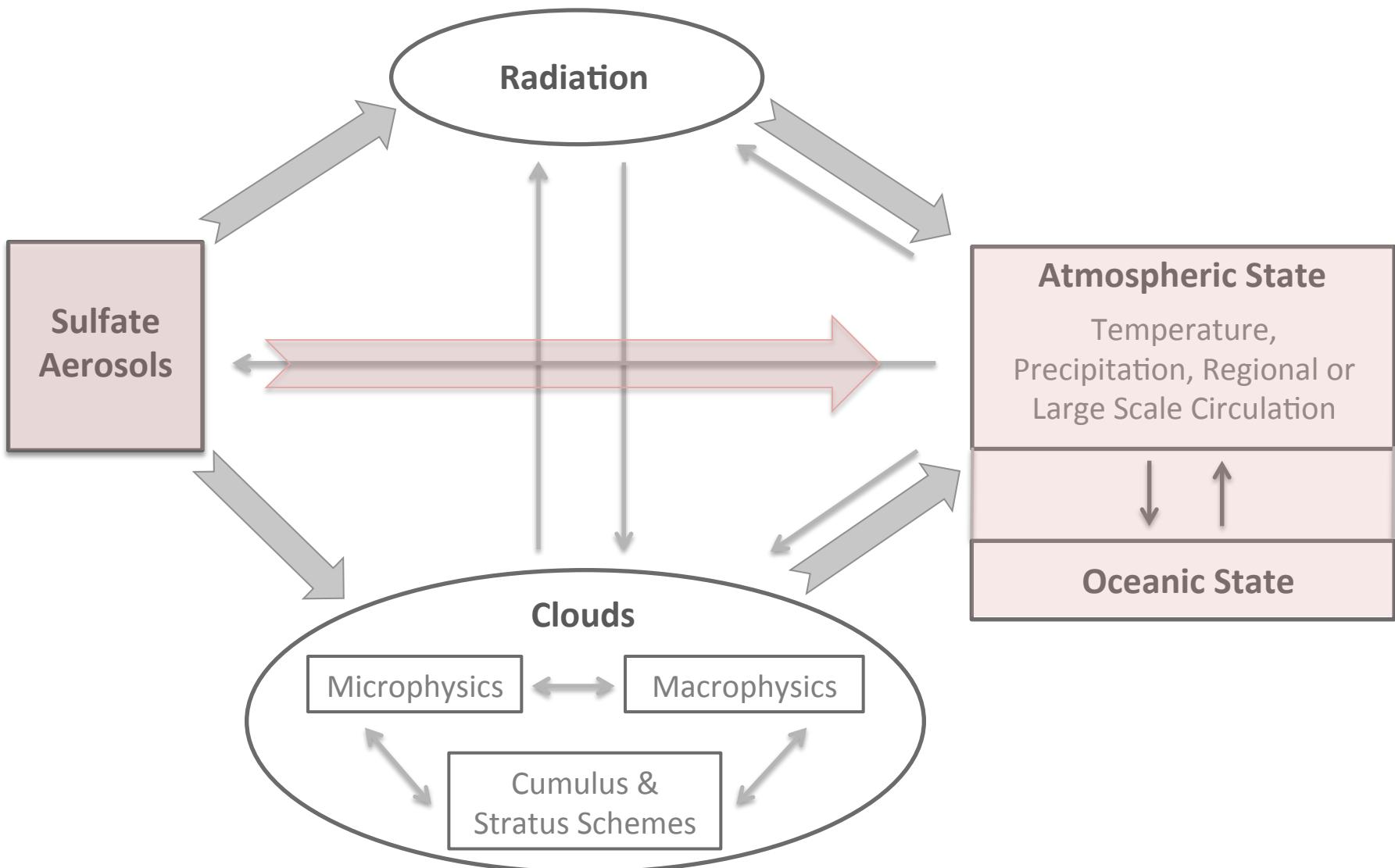


Ocean Feedback in a Regional Climate Response to Sulfate Aerosol Forcing

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Texas A&M University

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How Sulfate Aerosols affect Climate? : A simple schematic



Previous findings...

- Sulfate aerosols (S) cool Northern Hemisphere, shift ITCZ southward; Black carbon aerosols (BC) has opposite effect. (*Ocko et al. 2014*)
- Linear relationship between BC concentration and tropical expansion.
(Kovilakam and Mahajan 2015)
- (BC + S) weakens South Asian monsoon and local Hadley cell, strengthens equatorial zonal circulation. (*Bollasina et al. 2011*)
- BC modulates the ENSO-Indian Monsoon relationship. (*Kim et al. 2015*)
- SST feedback results in slower and larger response than rapid adjustment of radiation, clouds and land surface in South Asian Monsoon. (*Ganguly et al. 2012*)

Does regional climate response to anthropogenic sulfate aerosols over Southeast Asia excite ocean feedback response over Tropical Pacific?

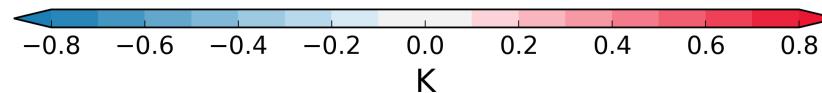
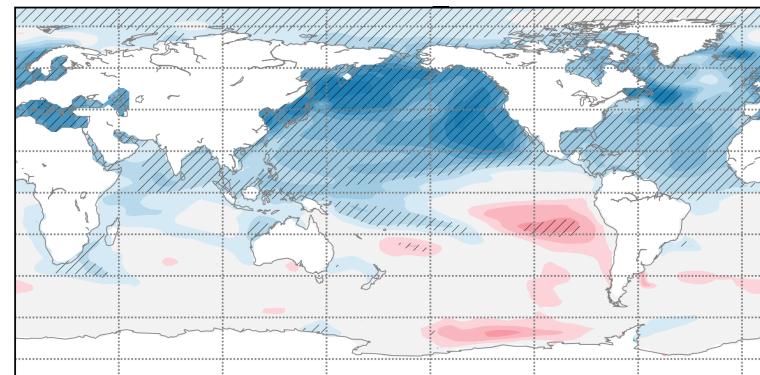
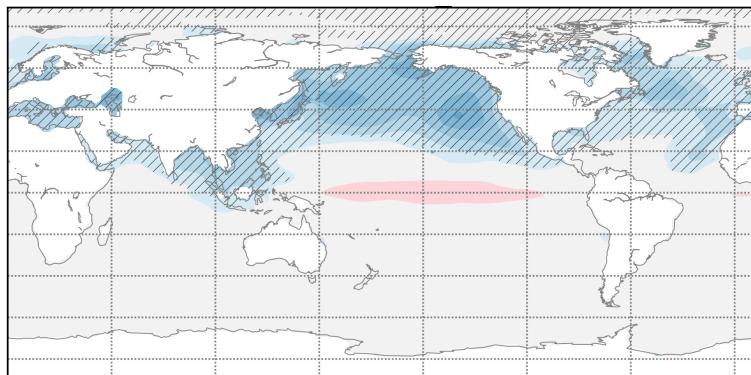
First Year versus Equilibrium Response

Annual Mean, 2000S-1850S

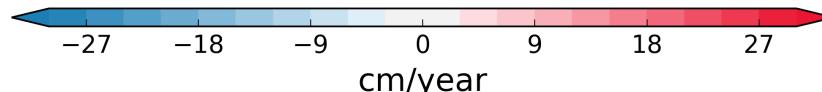
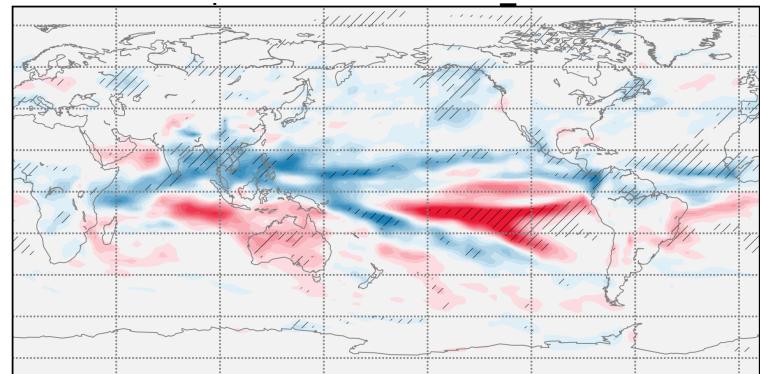
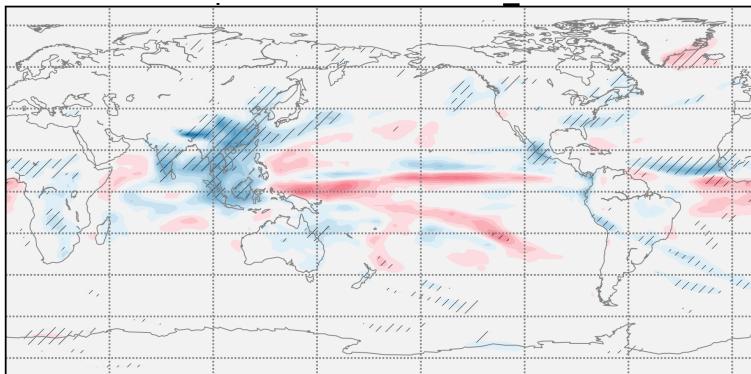
First Year Response

SST

Long Term Response



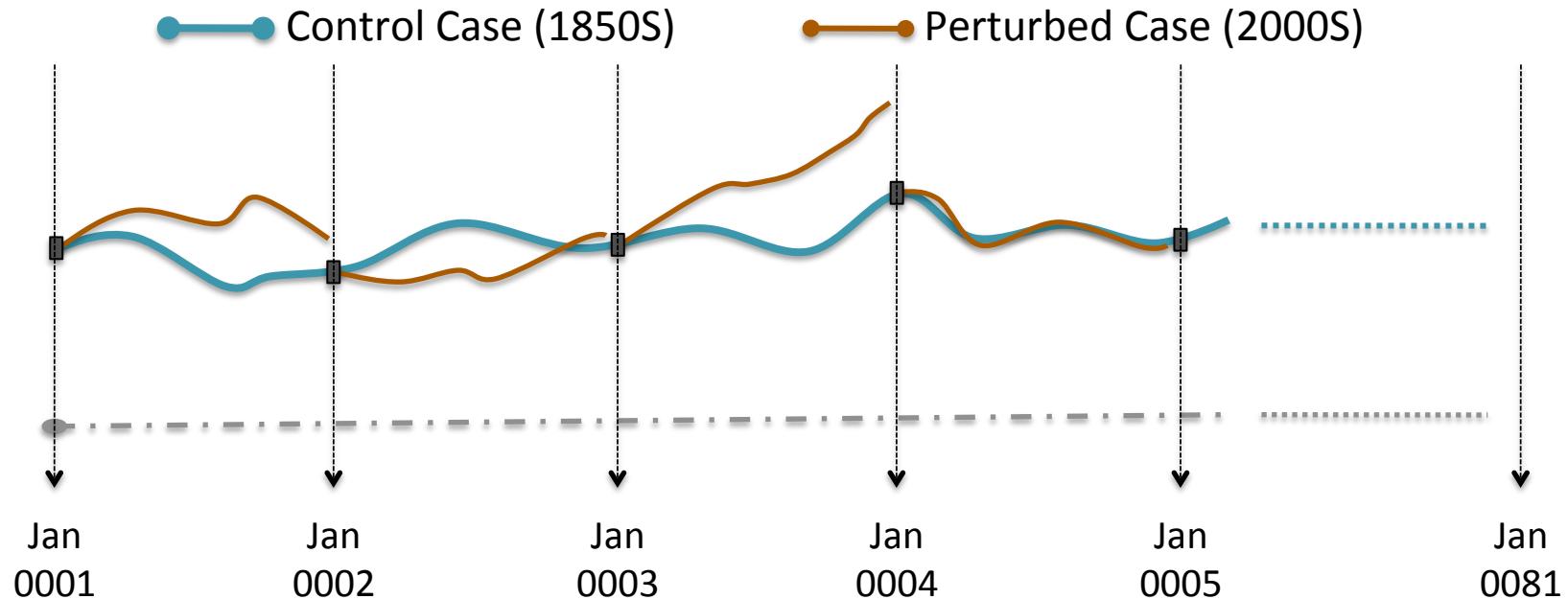
Precipitation



Model and Experiment Details

- CESM 1.1.2 - all active components
- FV 1.9x2.5 grid for atm/Ind
- 1 deg. displaced pole grid for the ocn/ice
- Pre-industrial forcings
- MAM3, Indirect effects (both 1 and 2) are included

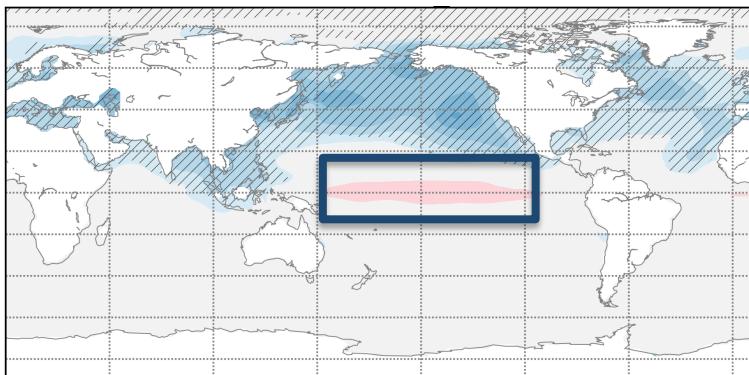
Ensemble of year-long simulations approach ->



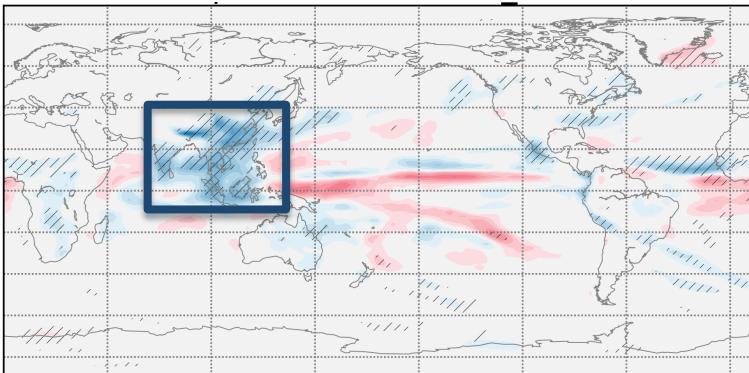
Aerosol Forcing/Regions of interest

First Year Response

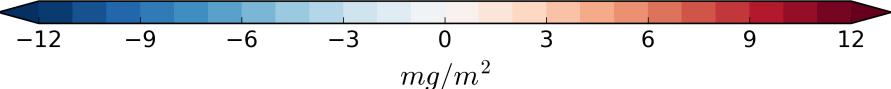
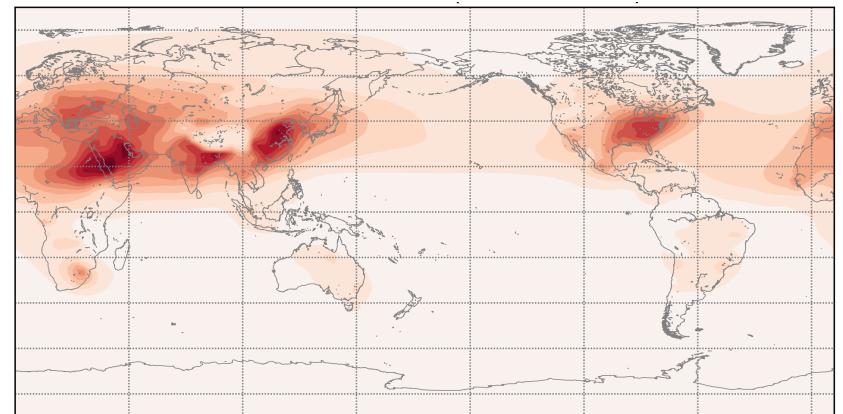
SST



Precipitation



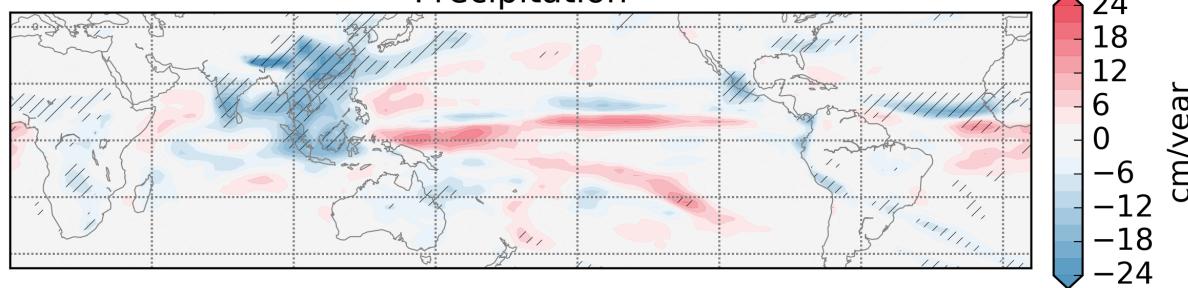
Sulfate Burden



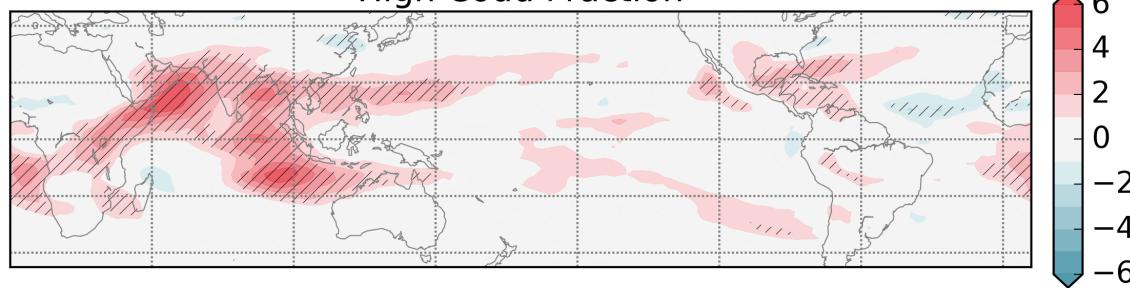
Aerosol-Cloud-Precipitation Effect

Annual Mean, 2000S-1850S

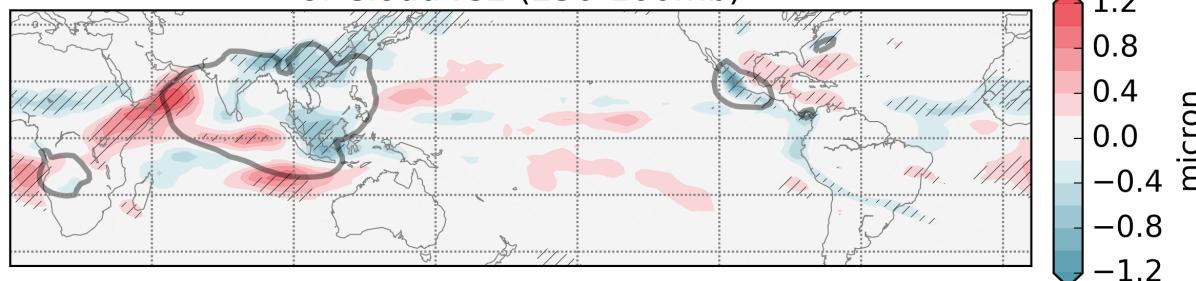
Precipitation



High Cloud Fraction

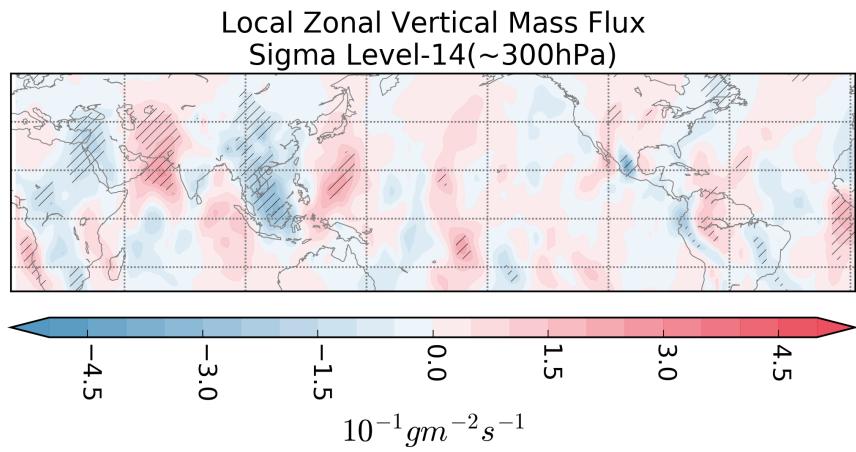
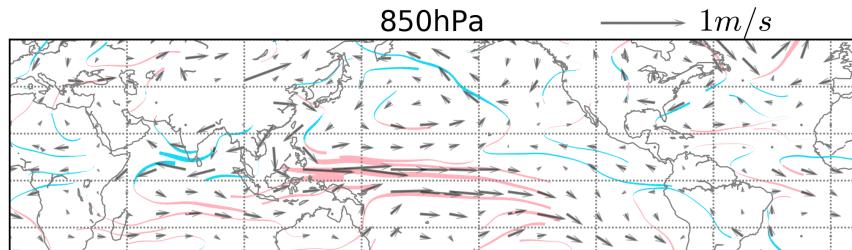
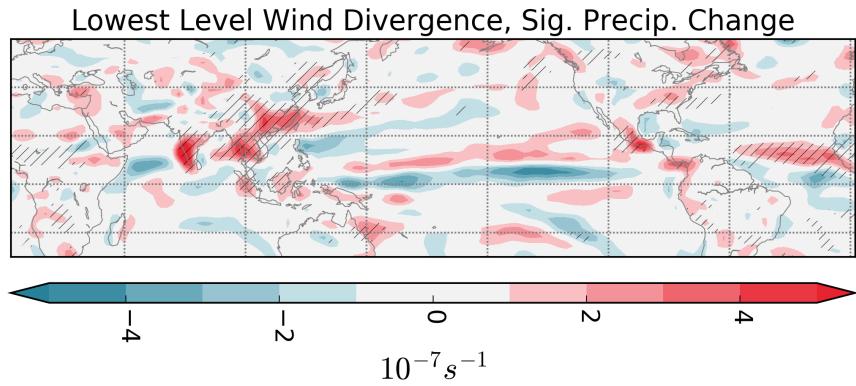
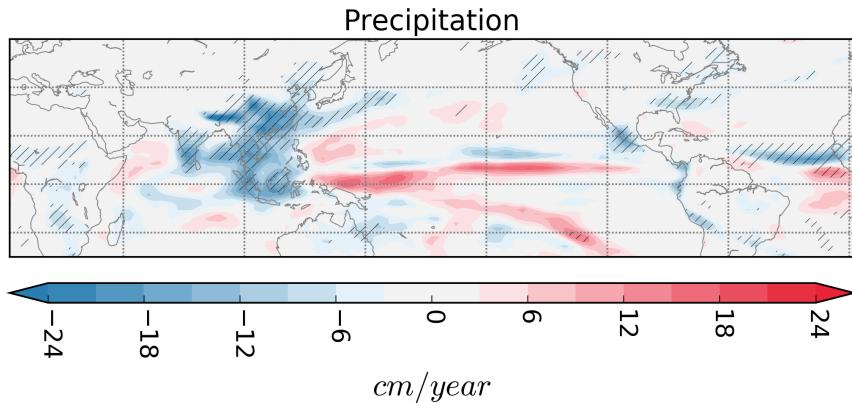


Effective Radius/Regional Increase in Number Concentration
of Cloud ICE (250-100mb)



Precipitation and Circulation Response

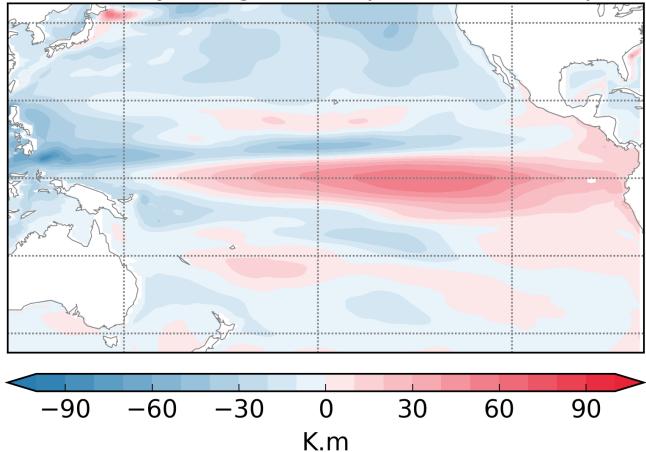
Annual Mean, 2000S-1850S



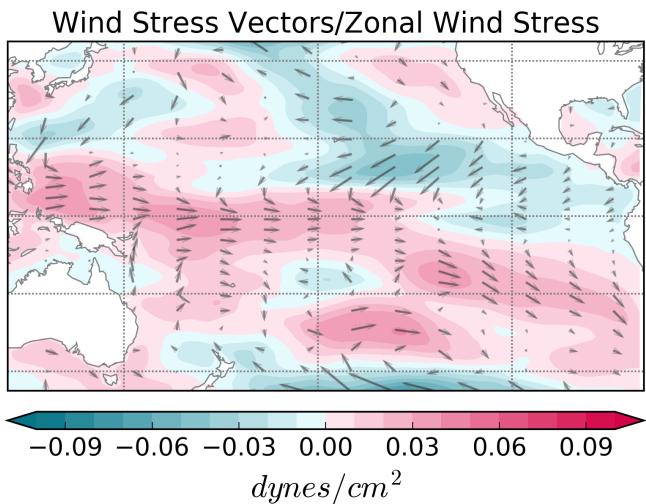
Tropical Pacific Upper Ocean Response

Annual Mean, 2000S-1850S

Vertically Integrated (upto 400m) Temp.

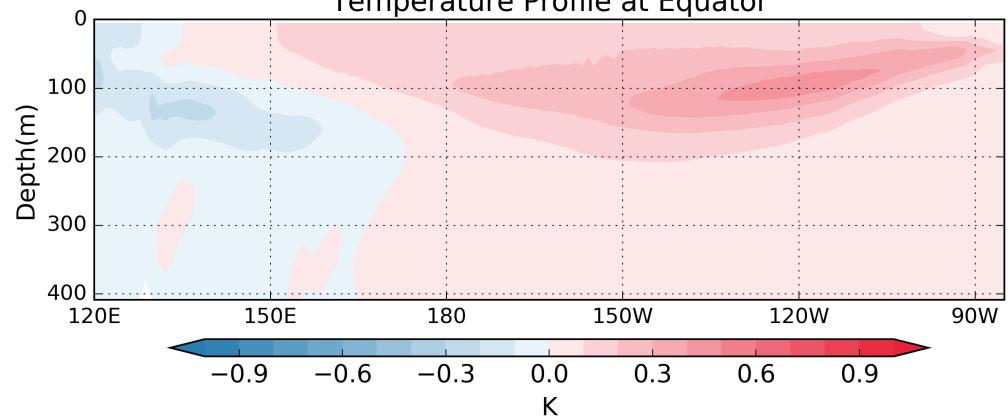


→ .1dynes/cm²

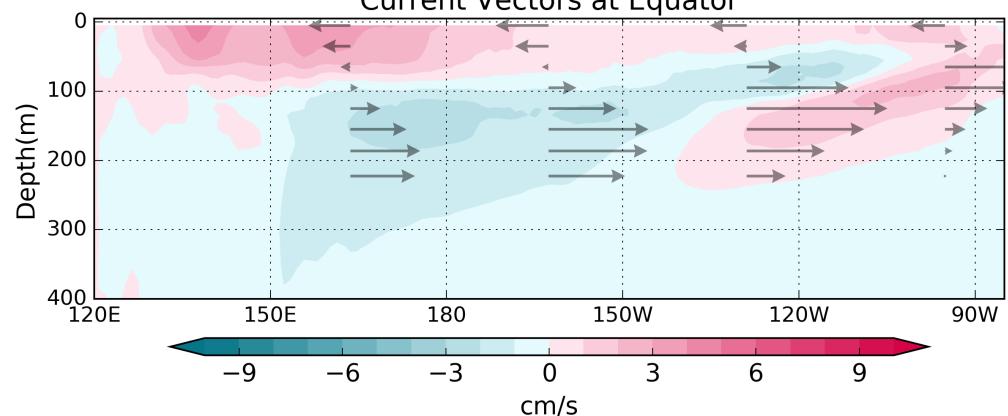


dynes/cm²

Temperature Profile at Equator



→ 50cm/s
Subsurface Zonal Current Response/Climatological Zonal Current Vectors at Equator



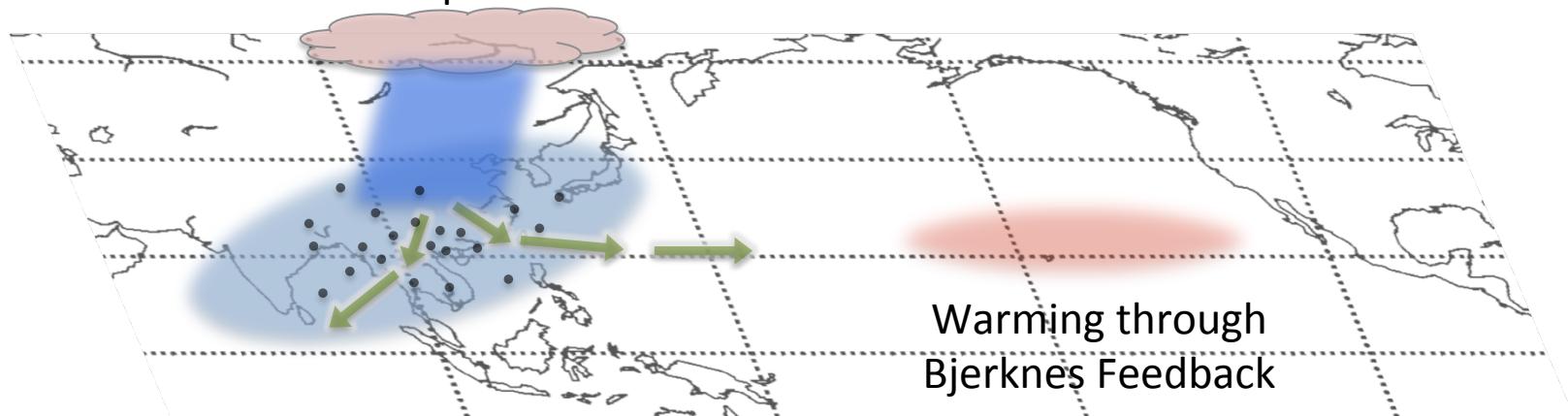
A Possible Connection

- Tropical Pacific warming is linked to Bjerknes Feedback mechanism - westerly wind stress, anomalous upper ocean equatorial currents, thermocline tilt and surface/subsurface warming in the eastern pacific.
- Possible link to East Asia Cooling and Hydrological Response-
 - Abundance of CCNs over Asia drive increase in cloud amount which along with cooling of surface, suppresses precipitation
 - forcing large scale subsidence over the region and lower level divergence
 - easterlies over Indian Ocean and anomalous westerly winds over West Pacific basin
 - making Bjerknes Feedback active

Summary Schematic

Aerosol Indirect/Direct effects

Increase in Clouds, Decrease in
Precipitation



Atmospheric and Surface Cooling

Subsidence, Low Level Divergence

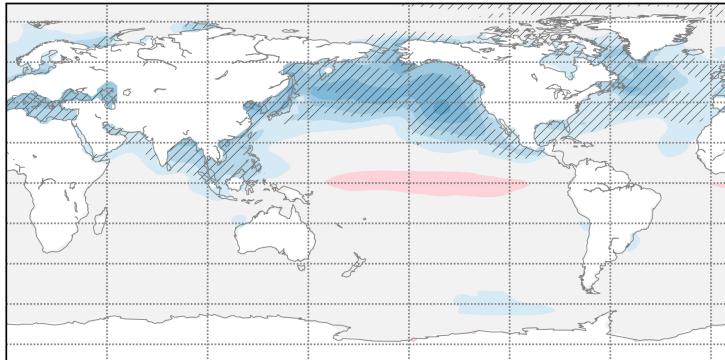
Anomalous Westerlies over West
Pacific

Extras

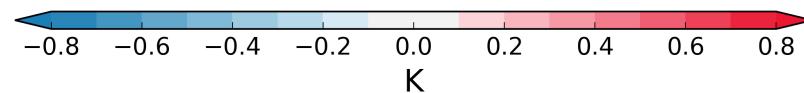
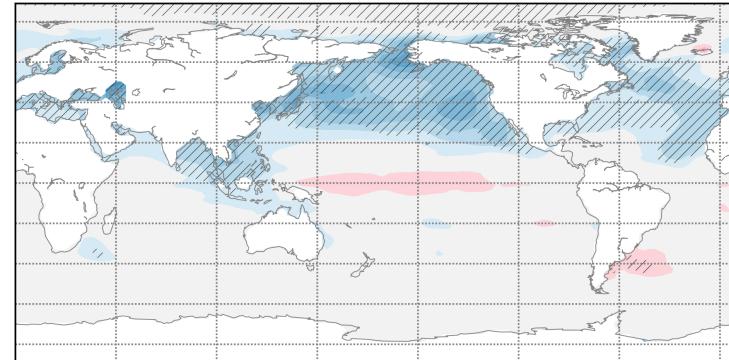
Robustness/Asymmetry of Tropical Pacific Response

Annual Mean SST, 2000S-1850S

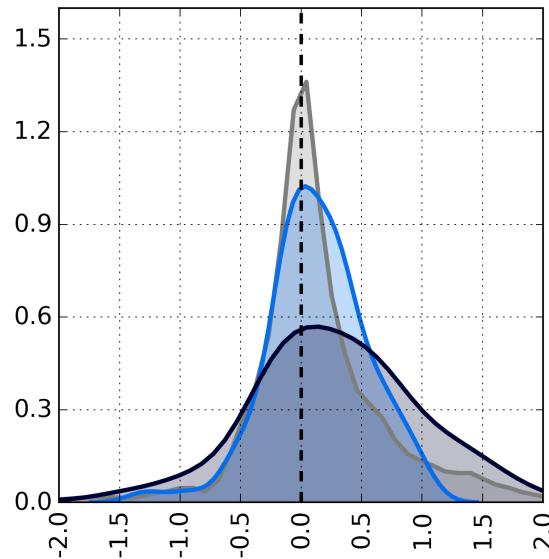
1-40 Yrs



41-80 Yrs



Nino 3.4 SST



Nino 3 Temp@105m

