Presentation to NOAA's 40th CDP Workshop in Denver

Influences of Southeast Asian Climate on Global Climate

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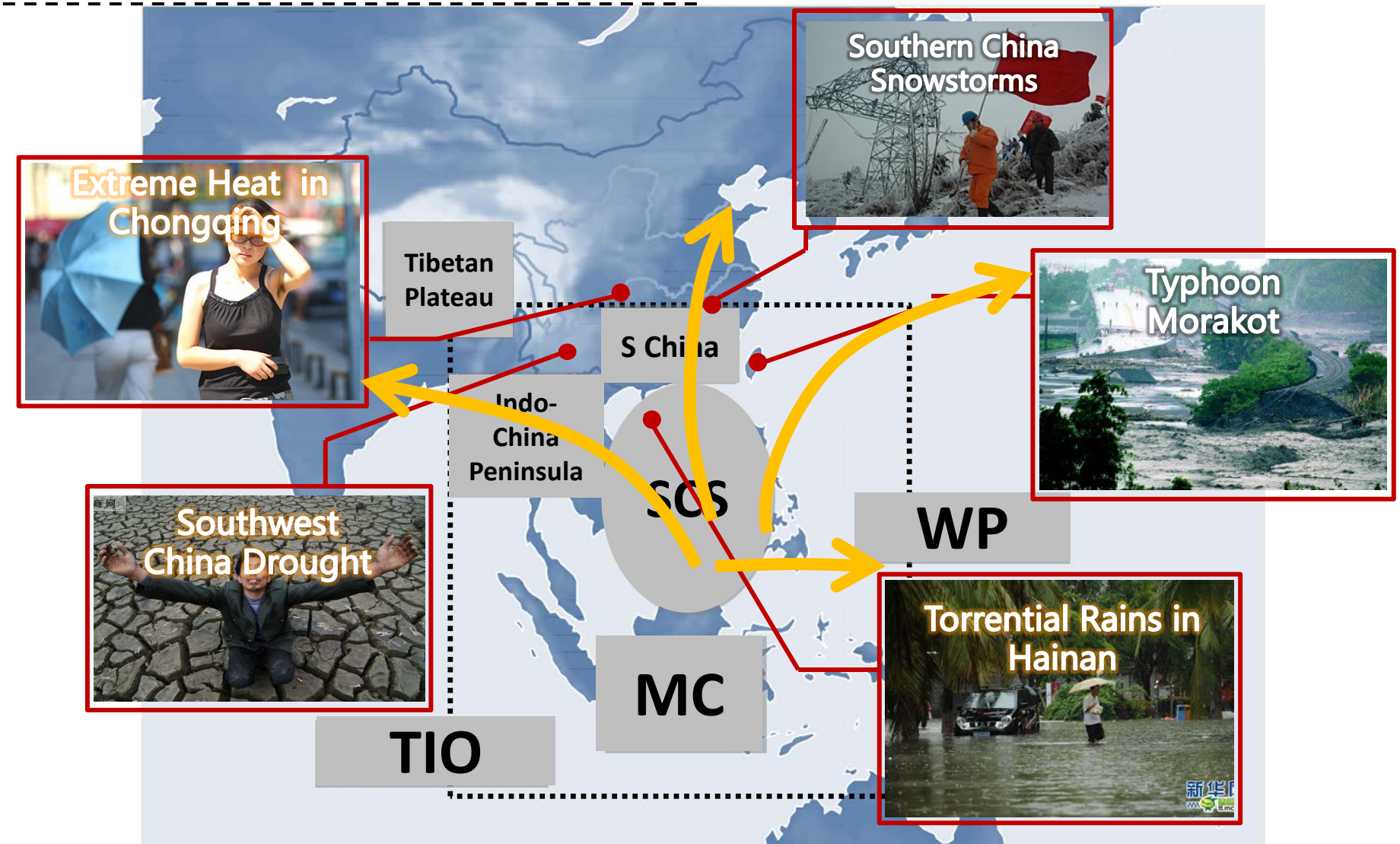
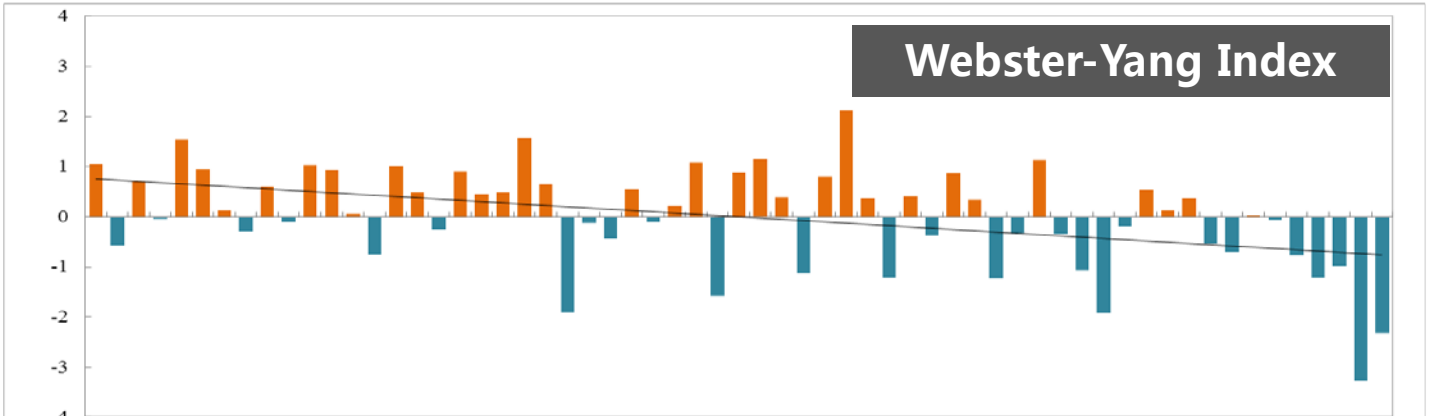
An On-Going Project

* Influences on Surrounding Regions

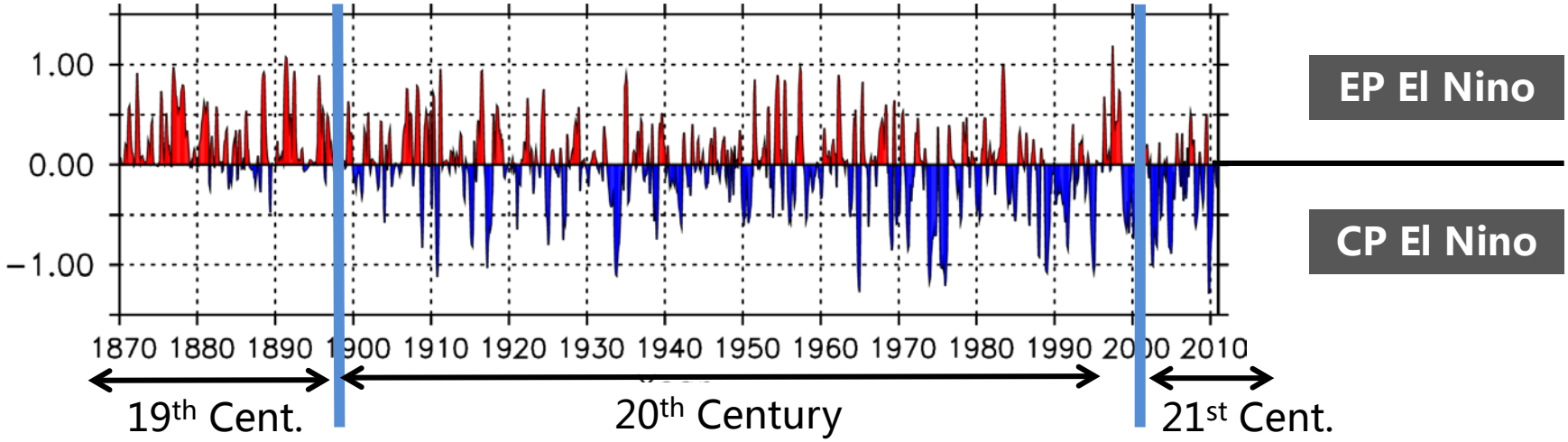


Changes in Monsoon and ENSO

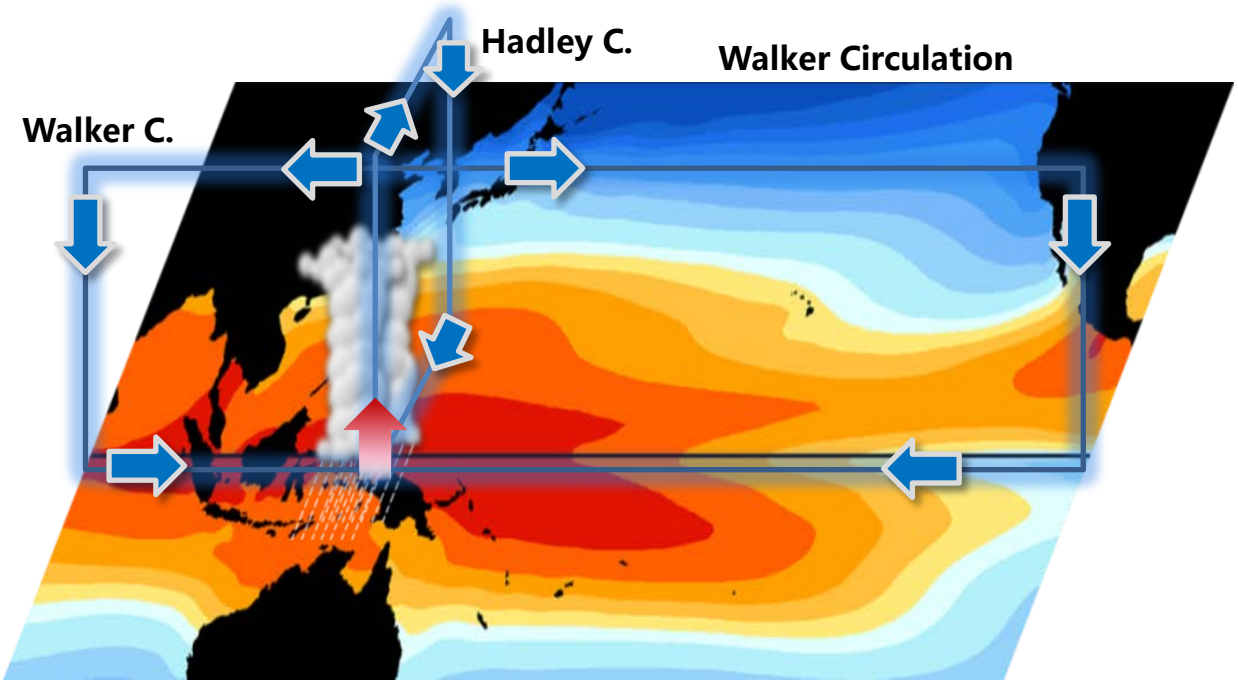
* Weakening Monsoon



* From EP El Nino to CP El Nino



ENSO-Monsoon Interaction



Spring is a very unique season in the domain of interest

Problems to Address

1. Response of Regional Climate to Global Warming
2. Role of Atmosphere-Ocean Interaction
3. Role of Atmosphere-Land Interaction
4. Attribution of Regional Climate Change Signals
5. Influence of Regional Climate on Global Climate

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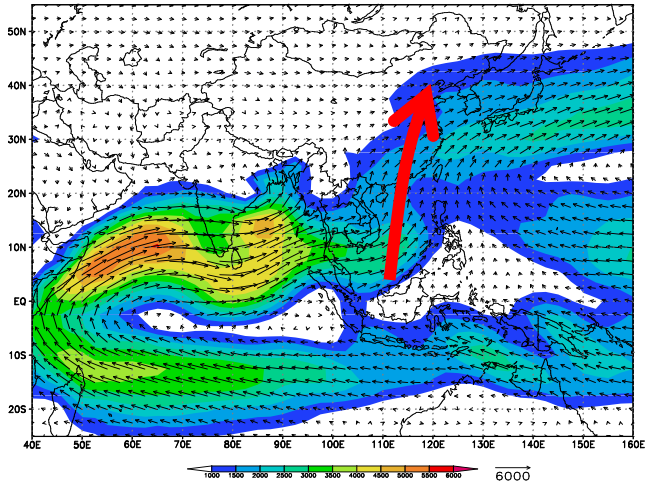
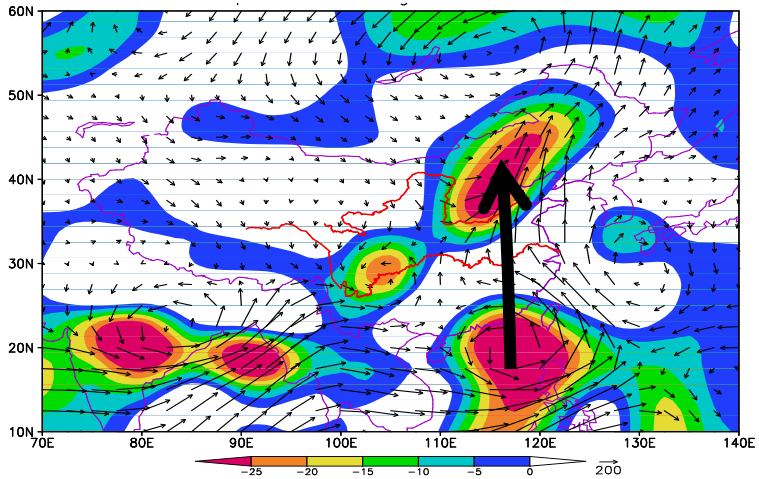
Source of Water Vapor

Water Vapor Transport, Climatology



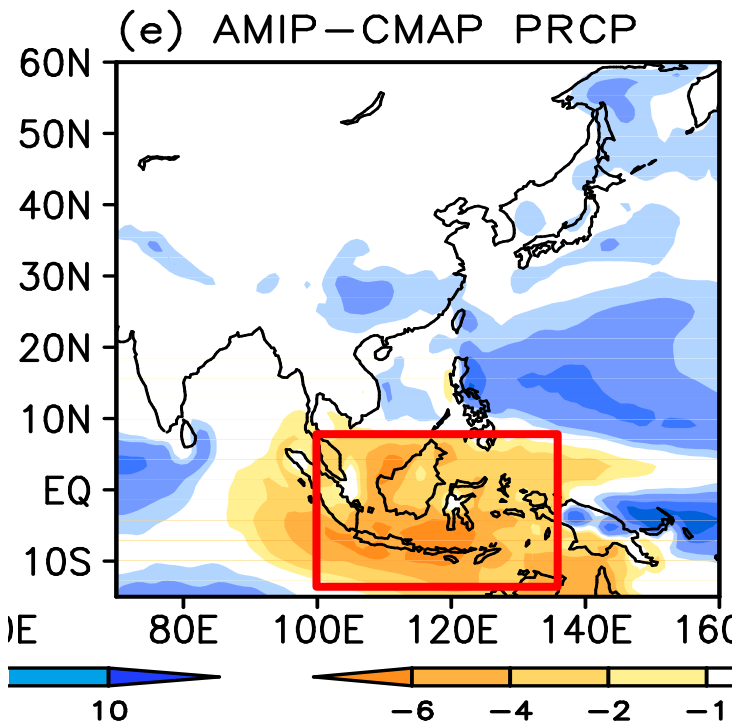
7.21 Severe Storm, Beijing, 2012

Liu et al. (2013)

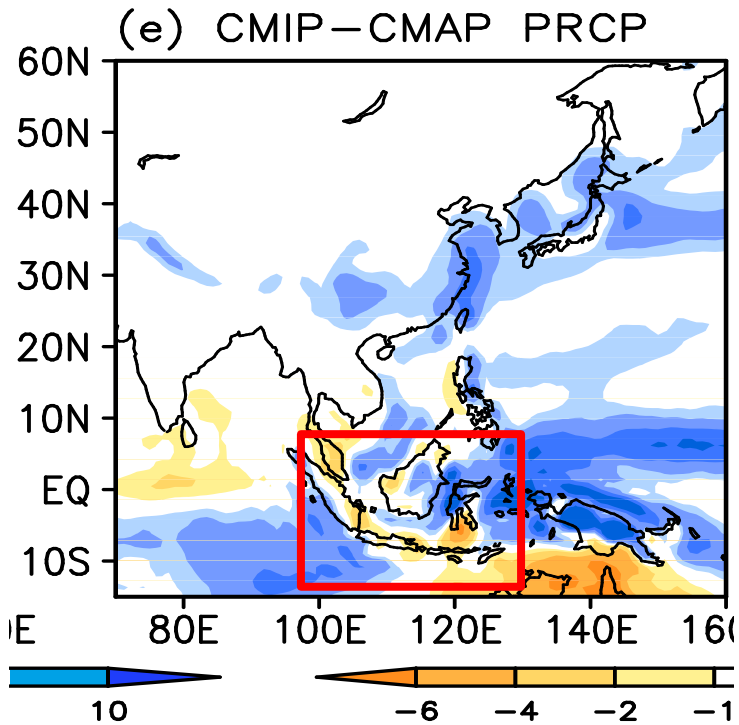


Influence on Monsoons

Skill of Prediction of the East Asian Winter Monsoon Is Related to the Ability of MC Convection Simulations



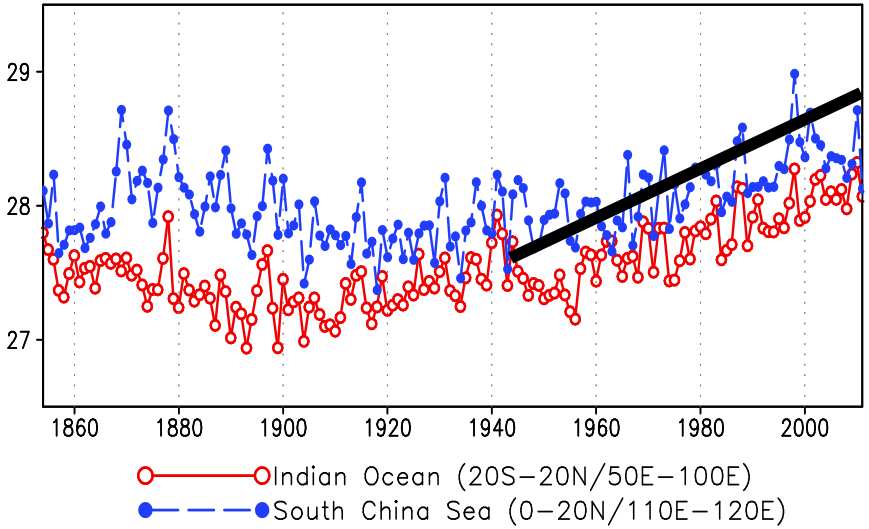
High Skill



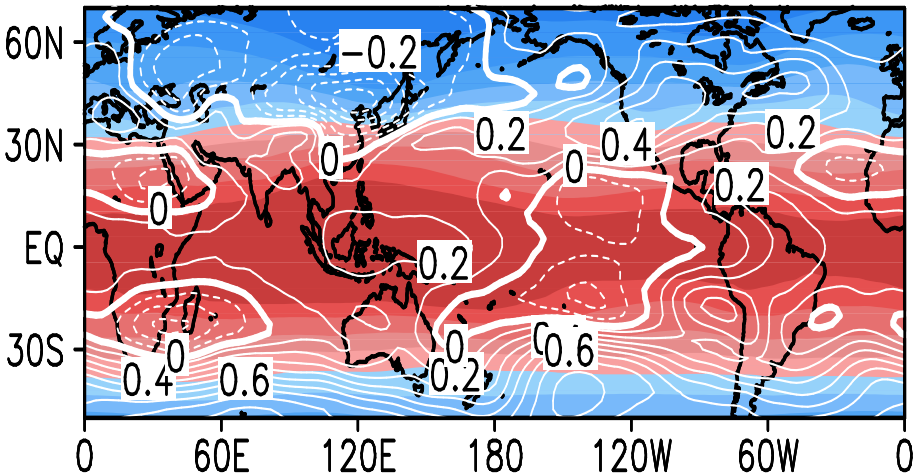
Low Skill

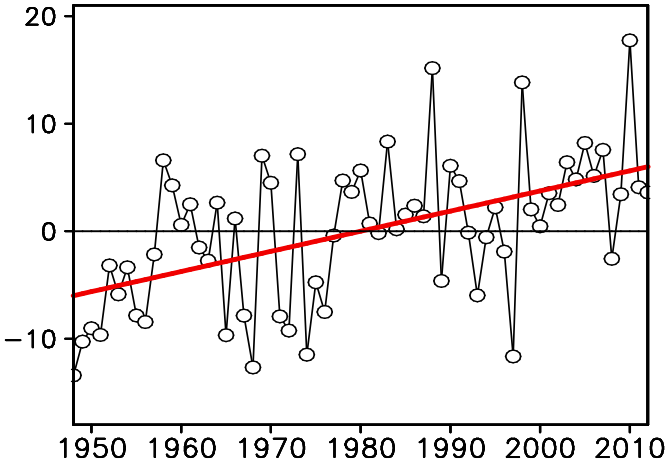
Changes in SST & Atmospheric Heating

Change in SST (Left)



Change in Atmospheric Heating (Below)



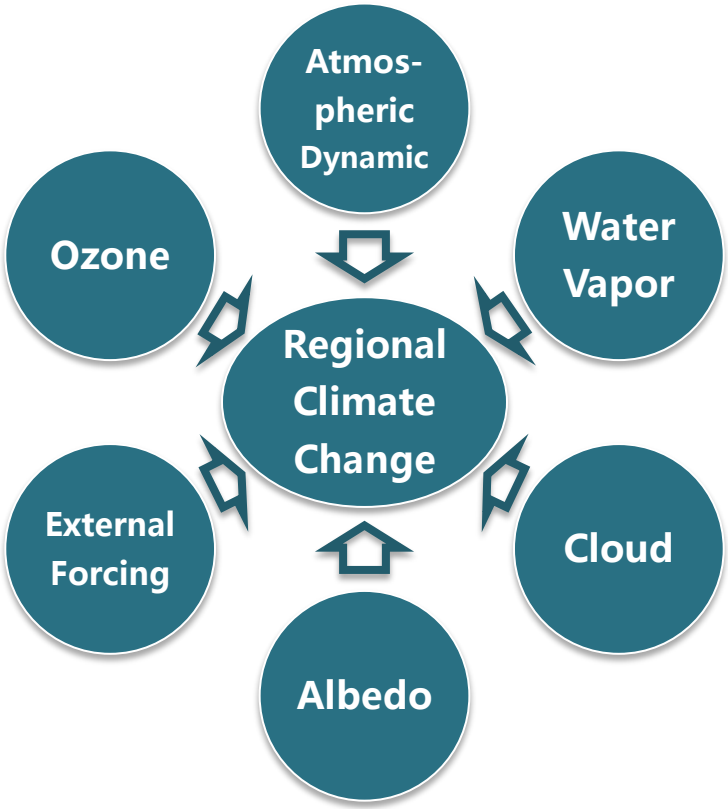


Attribution Analysis

CFRAM

Coupled Atmosphere-Surface Climate Feedback-Response Analysis Method (Lu and Cai 2009)

- √ Feedback attributions of the SCS and surrounding area climate changes characterized by temperature
- √ Feedbacks and their effects are additive
- √ Area and season choices are flexible



Attribution Analysis

Energy balance of each layer within an atmospheric-surface column:

$$\vec{\mathbf{R}} = \vec{\mathbf{S}} + \vec{\mathbf{Q}}^{turb} + \vec{\mathbf{Q}}^{conv} + \vec{\mathbf{D}}^{v} + \vec{\mathbf{D}}^{h} + \vec{\mathbf{W}}^{fric} - \frac{\partial \vec{\mathbf{E}}}{\partial t}$$

Considering the differences between two states: EP (CP) versus ENSO-Neutral

Feedback decomposition of the global El Niño temperature response:

ozone, cloud, surface latent heat flux, surface energy transport/storage

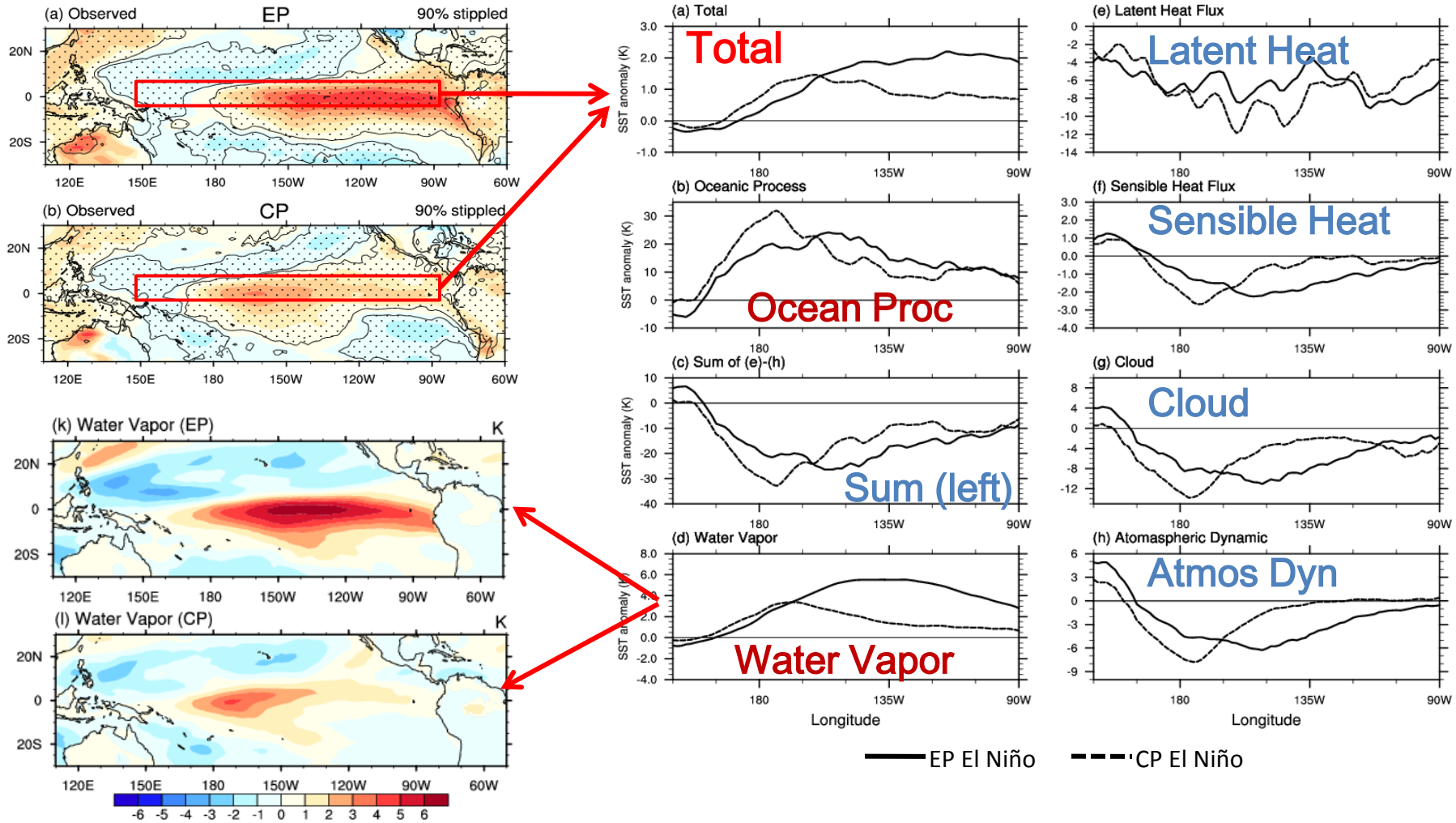
$$\Delta\vec{\mathbf{T}} = \left(\frac{\partial\vec{\mathbf{R}}}{\partial\vec{\mathbf{T}}}\right)^{-1}\left\{\Delta^{(o)}(\vec{\mathbf{S}}-\vec{\mathbf{R}}) + \Delta^{(\alpha)}\vec{\mathbf{S}} + \Delta^{(c)}(\vec{\mathbf{S}}-\vec{\mathbf{R}}) + \Delta^{(w)}(\vec{\mathbf{S}}-\vec{\mathbf{R}}) + \Delta\vec{\mathbf{Q}}^{LH} + \Delta\vec{\mathbf{Q}}^{SH} + \Delta\vec{\mathbf{Q}}^{sfc_dyn} + \Delta\vec{\mathbf{Q}}^{atmos_dyn}\right\}$$

surface albedo, water vapor, surface sensible heat flux, atmospheric energy transport

Feedbacks and their effects are additive!

$$\Delta\vec{\mathbf{T}}^{(n)} = \left(\frac{\partial\vec{\mathbf{R}}}{\partial\vec{\mathbf{T}}}\right)^{-1}\Delta\vec{\mathbf{F}}^{(n)} \qquad \Delta\vec{\mathbf{T}}^{tot} = \sum_{n}\Delta\vec{\mathbf{T}}^{(n)}$$

Attribution Analysis

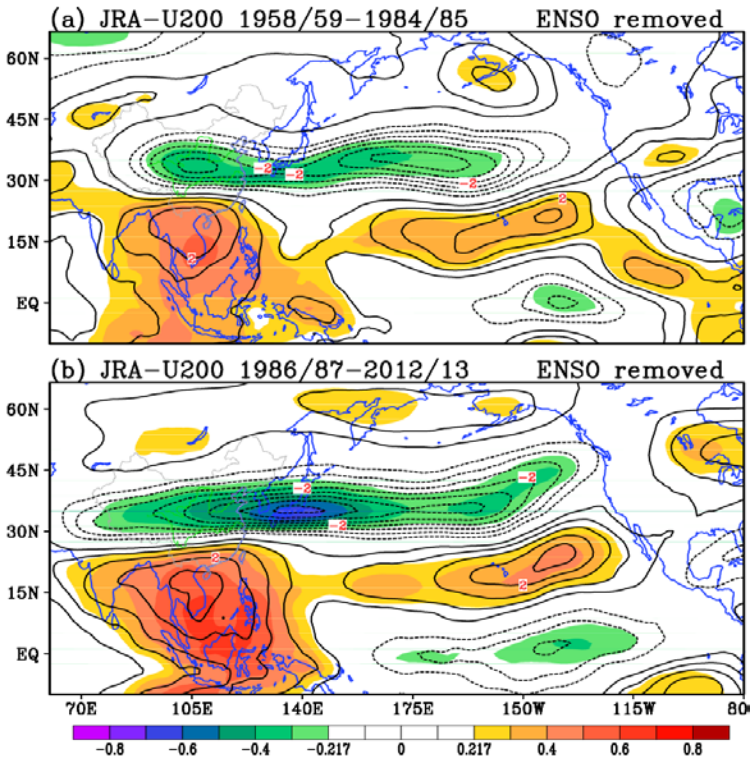


For surface temperature, emphasize the importance of water vapor feedback (manuscript under review in Climate Dynamics)

Observational Evidence of Climate Links

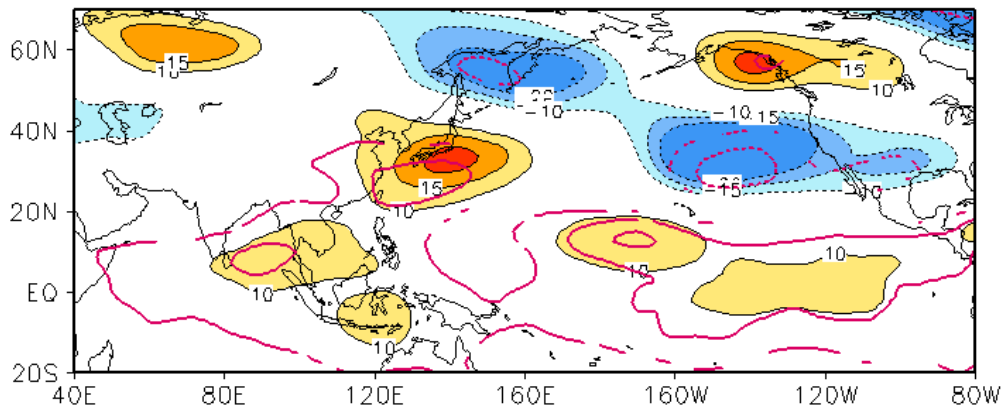
Atmospheric Heating & Westerly Jet Stream

1958-1985



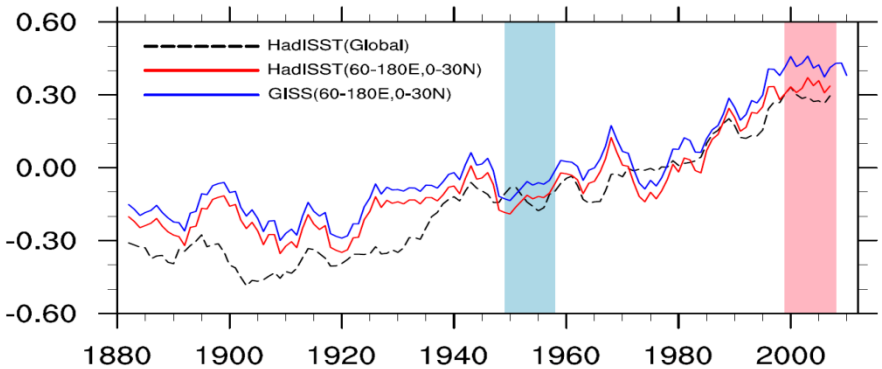
1986-2013

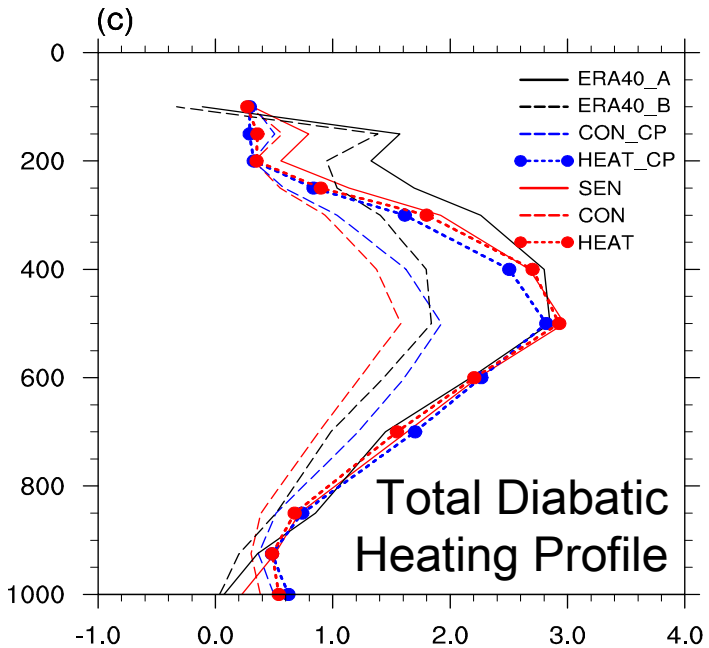
SST and Wave Train



Model Experiment Designs

Exp	Description
CON	AGCM run, the climatology SST from 1949 to 1958 is used as low boundary, and other external forcings are prescribed as their 1949 values. The model intergrates for 30 years.
CON_CP	CGCM run, the external forcings are same as in CON but the SST is simulated. The model intergrates for 50 years.
SEN	AGCM run, the climatology SST from 1999 to 2008 is used as low boundary, and other external forcings are prescribed as their 1999 values. The model intergrates for 30 years.
HEAT	AGCM run, the same SST and other external forcings as in CON, but we add a specific heating profile in the region 110° –150° E/0° –30° N during June–July–August (JJA). This specific heating is derived from the monthly mean output from SEN minus CON in the same region. The model intergrates for 30 years.
HEAT_CP	CGCM run, the same as HEAT but the SST is simulated. The model intergrates for 50 years.

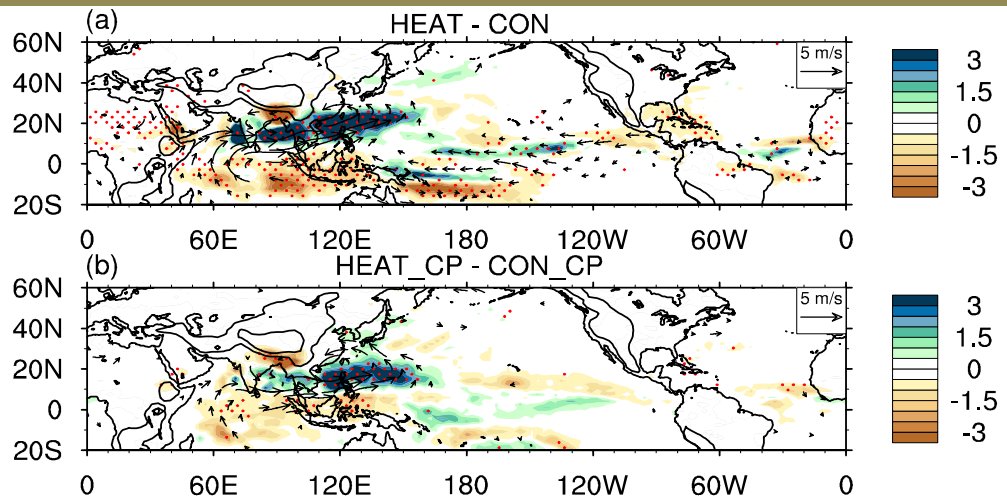




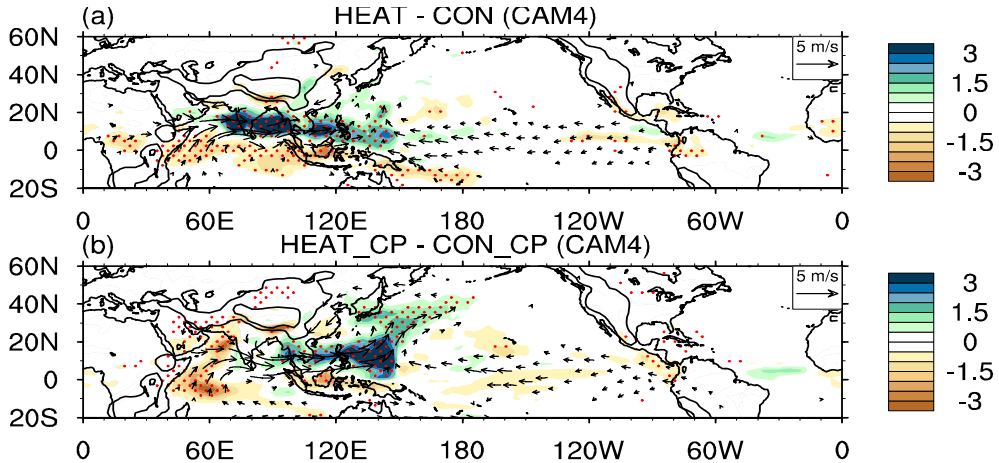
Total diabatic heating profile for 0-30N/110-150E in each experiment

Effect on the Indian Monsoon

CAS/IAP FGOALS-s2

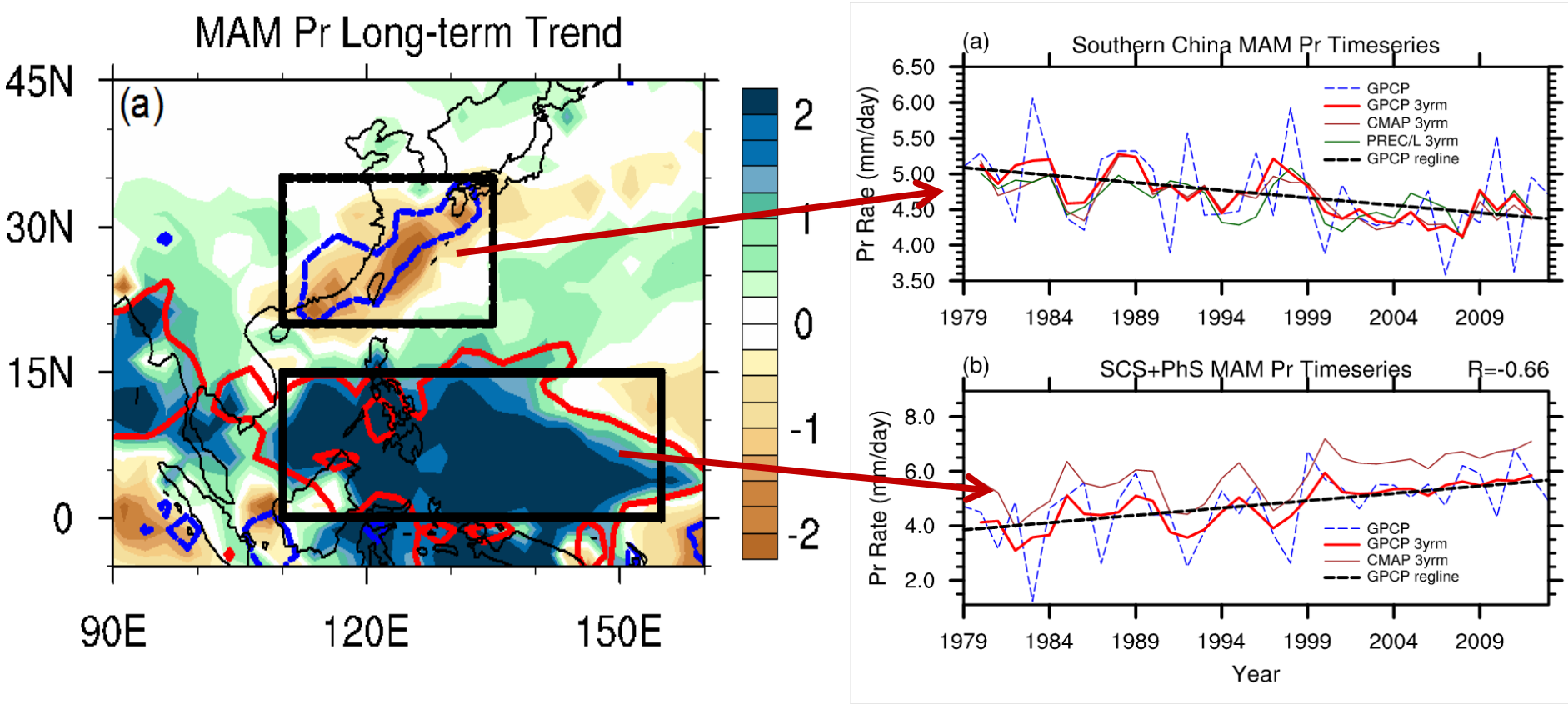


NCAR CESM



Increase in Atmospheric Heating over Southeast Asia Causes Drying Effects over India and the Arabian Sea (He et al. 2015; Climate Dynamics)

Obs Features of E & SE Asian Climate

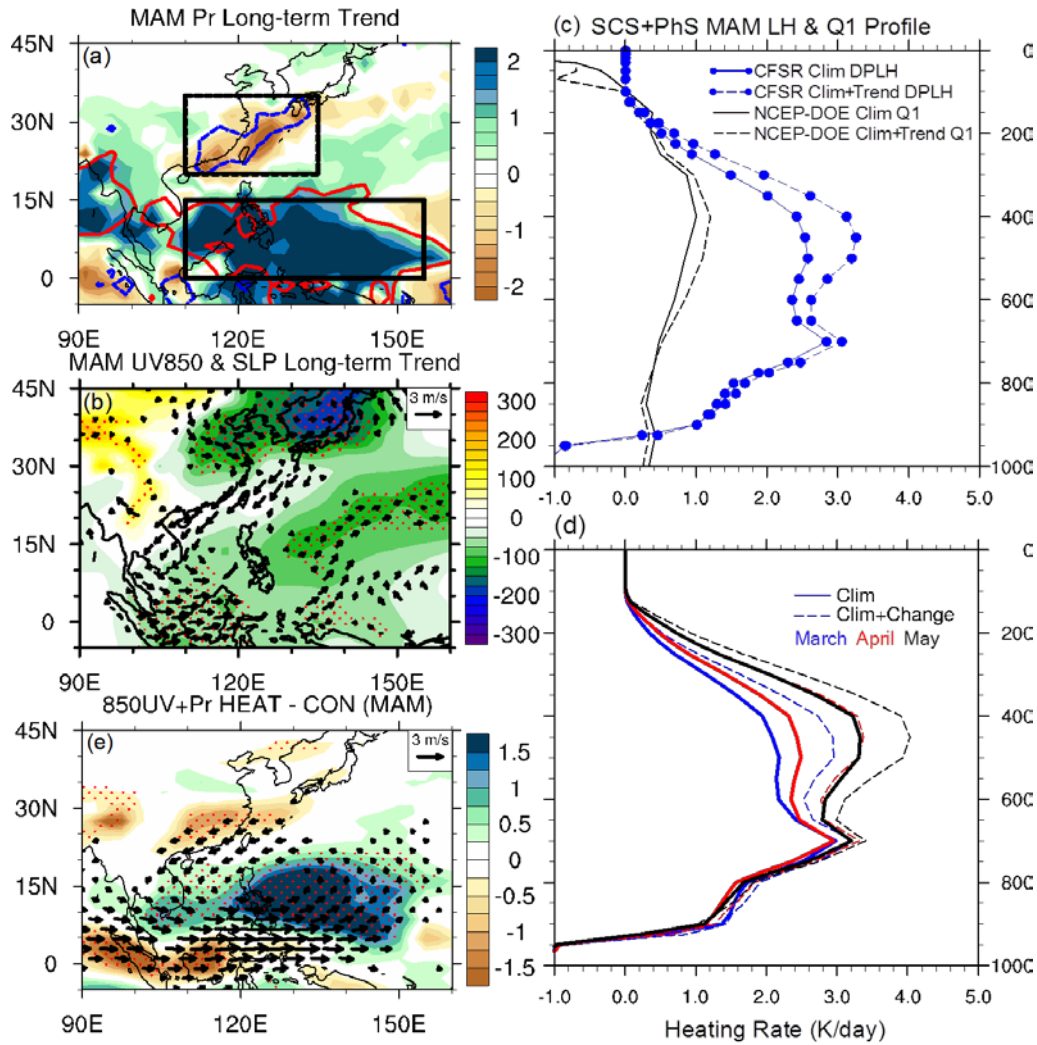


Wetting Southeast Asia and Drying Southern East Asia

Impact of SE Asia on E Asian Climate

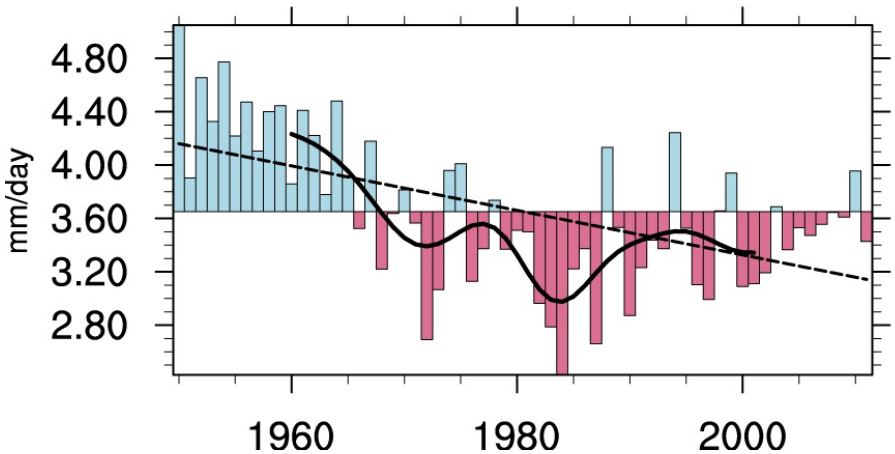
Obs

CESM

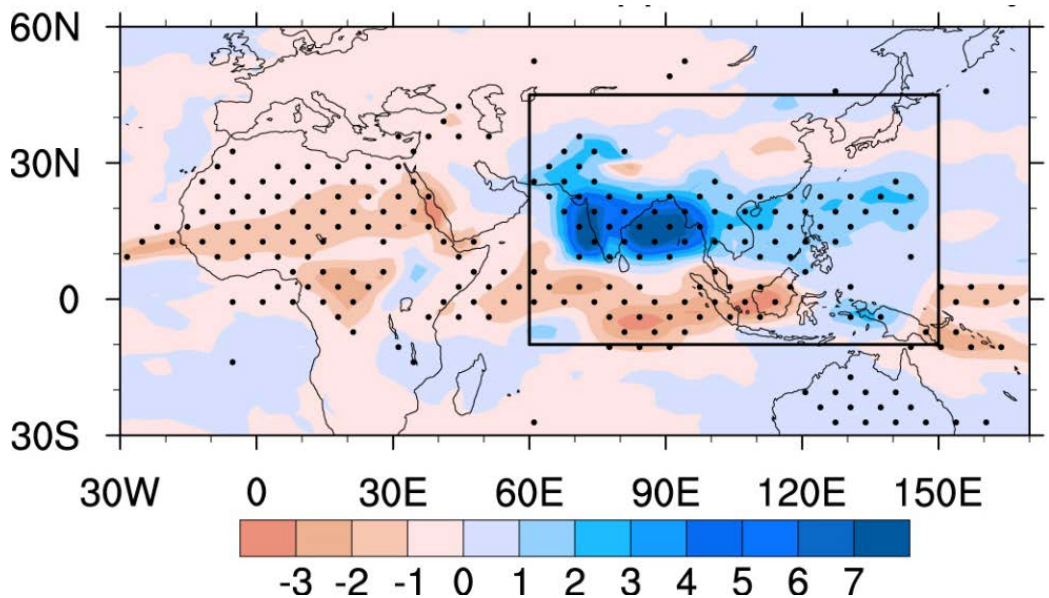


Drying Southern East Asia: Effect of Southeast Asian Climate
(manuscript under preparation)

Weakened African Monsoon

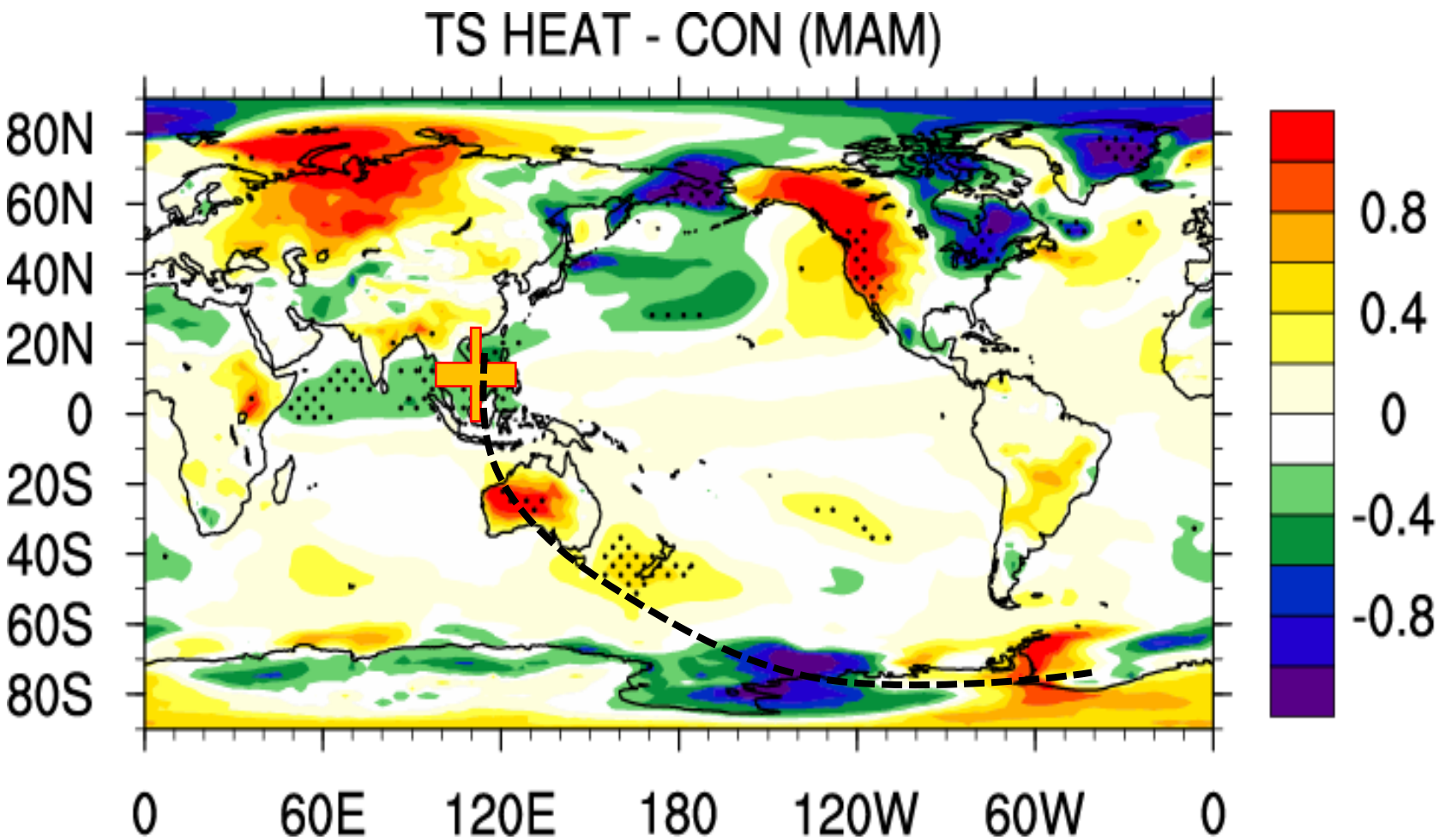


Observed weakening of the African monsoon



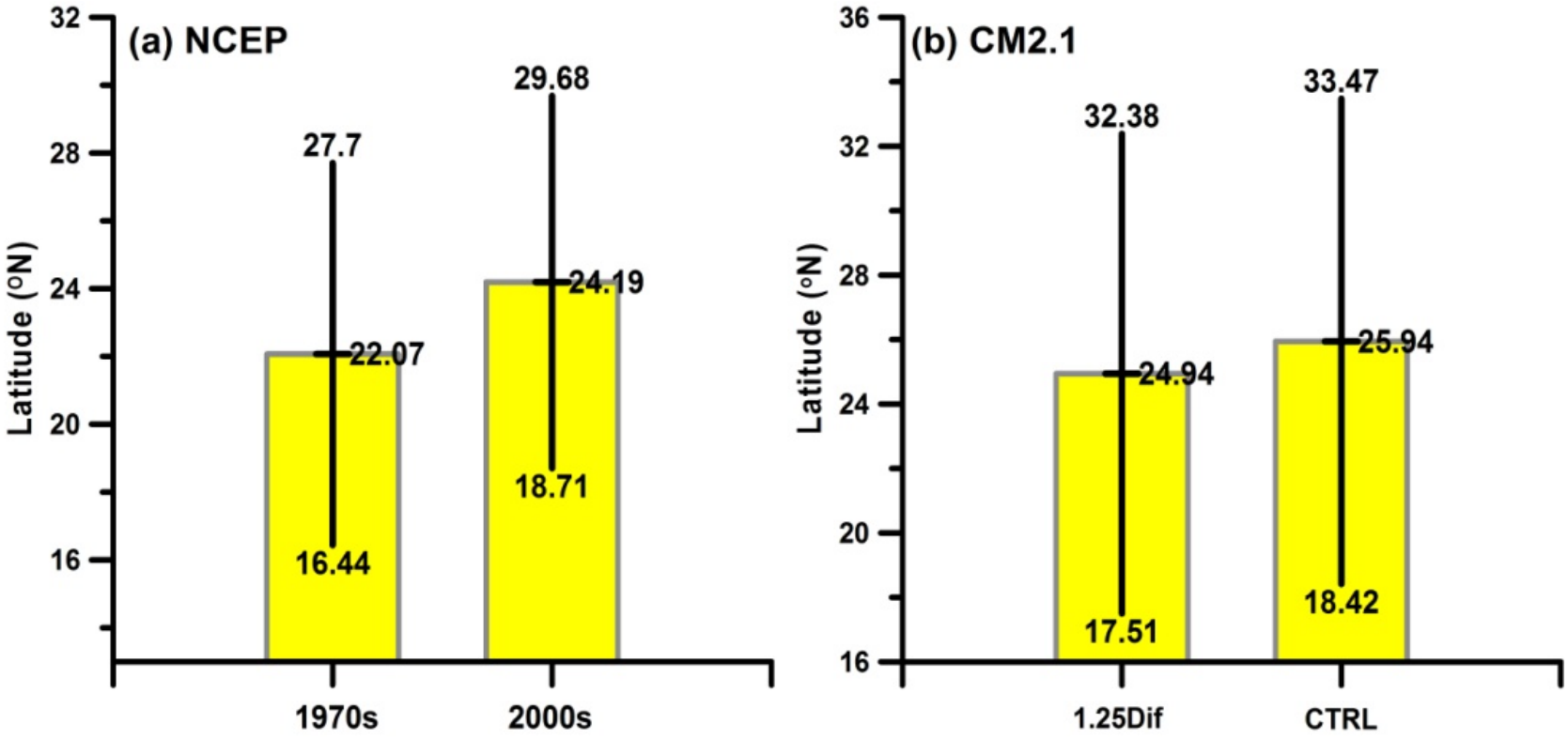
Increase in atmospheric heating over southern Asia explains the weakening of African monsoon (manuscript under preparation)

Wave Train Patterns



Increase in atmospheric heating over Southeast Asia generates wave train patterns in both N & S Hemispheres (manuscript under preparation)

Impact of SST on Northward Shift of Typhoons



Increase in SST around SE Asia Shifts Typhoon Position Northward by 1-2° of Latitudes

(Curtsey of S. Q. Peng)

Summary

- Both SST and atmospheric heating over Southeast Asian increase under the global warming background. Water vapor feedback explains the difference in SST patterns between EP El Nino and CP El Nino.

- The increases in SST and atmospheric heating over Southeast Asia lead to:

  - ✓ Wetting effect over Southeast Asia and western Pacific but drying effects over India and the Arabian Sea
  - ✓ Weakening of the African monsoon
  - ✓ Decease in rainfall over southern East Asia
  - ✓ Northward shift of northwestern Pacific typhoons
  - ✓ Anomalous wave patterns over both northern and southern hemispheres