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DIVECHA CENTRE FOR CLIMATE CHANGE

Are winds and moisture necessary to cause Indian summer monsoon extremes?

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1

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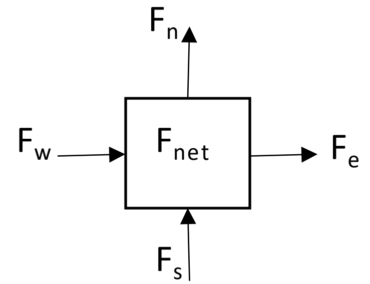
Moisture budget theory

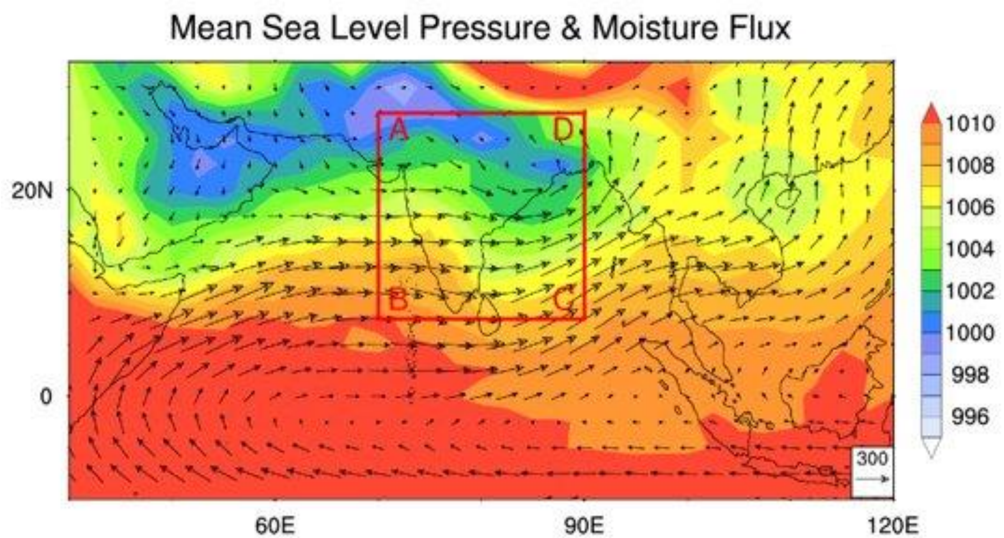
$$\frac{1}{A}(F_w - F_e + F_s - F_n) = \bar{P} - \bar{E} + \frac{\partial P_{wat}}{\partial t},$$

$$\frac{1}{A}(F_{net}) = \bar{P} - \bar{E} + \frac{\partial P_{wat}}{\partial t}$$

Vertically integrated moisture fluxes (F)



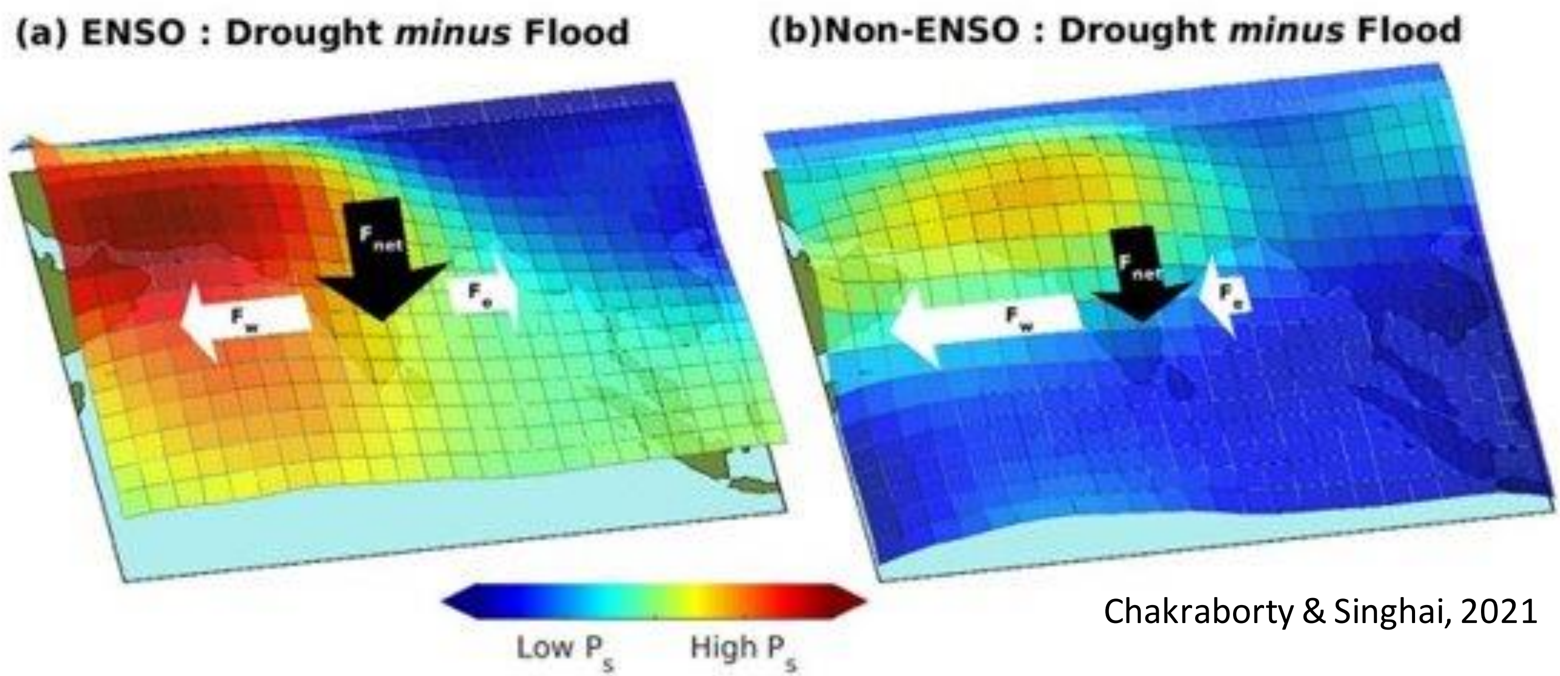
ISMR (P) ∝ Net moisture convergence (F_{net})



June-September climatological mean sea level pressure along with vertically integrated moisture flux

Chakraborty & Singhai, 2021

Extremes:



Chakraborty & Singhai, 2021

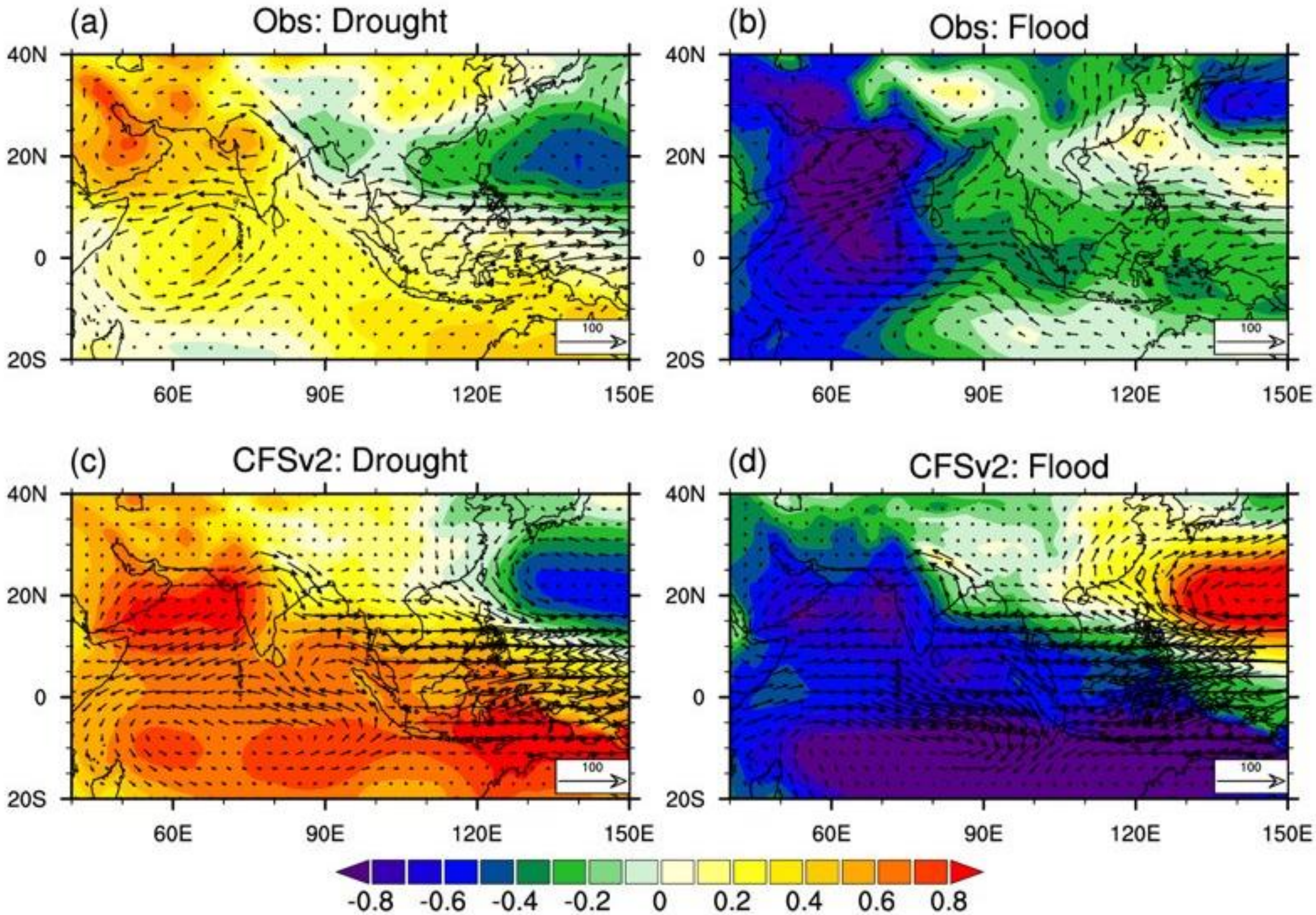
Schematic showing variations in surface pressure surrounding the Indian monsoon region due to (a) ENSO and (b) Non-ENSO forcing leading to Indian summer monsoon rainfall extremes (drought and flood).

Data & Model used

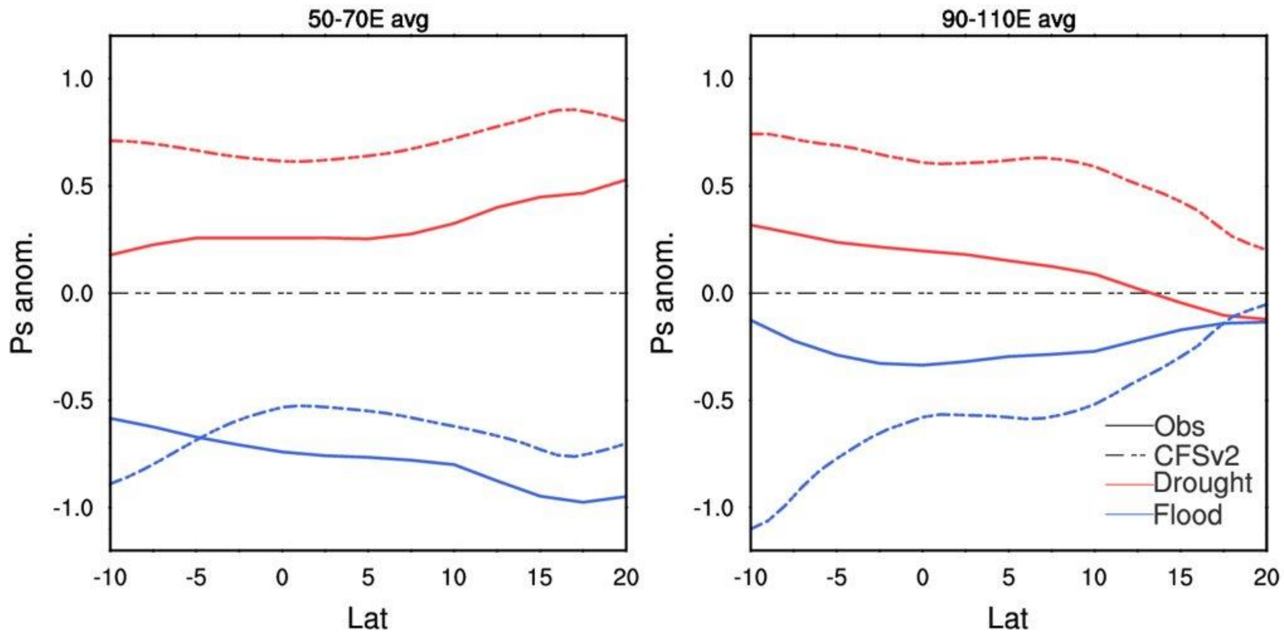
- **Datasets used:**
  - Precipitation: IMD $1^{o}X1^{o}$
  - SST: ER-SST
  - Atmospheric parameters: NCEP/NCAR reanalysis product
- **Period:** 1979-2016 (June-September)
- **Model:** NCEP Climate Forecast System version 2 (CFSv2)
  - Resolution: $0.91^{o}X91^{o}$ horizontal resolution & 64 vertical levels.
  - Integrated for 9 months
  - 5 Initial conditions: (00UTC of 21 April, 26 April, 1 May, 6 May and 11 May)

Drought vs Flood

Ps anomalies composites:



Drought & Flood



Arabian Sea (50-70E): $(dPs/dy)_{clm} < 0$

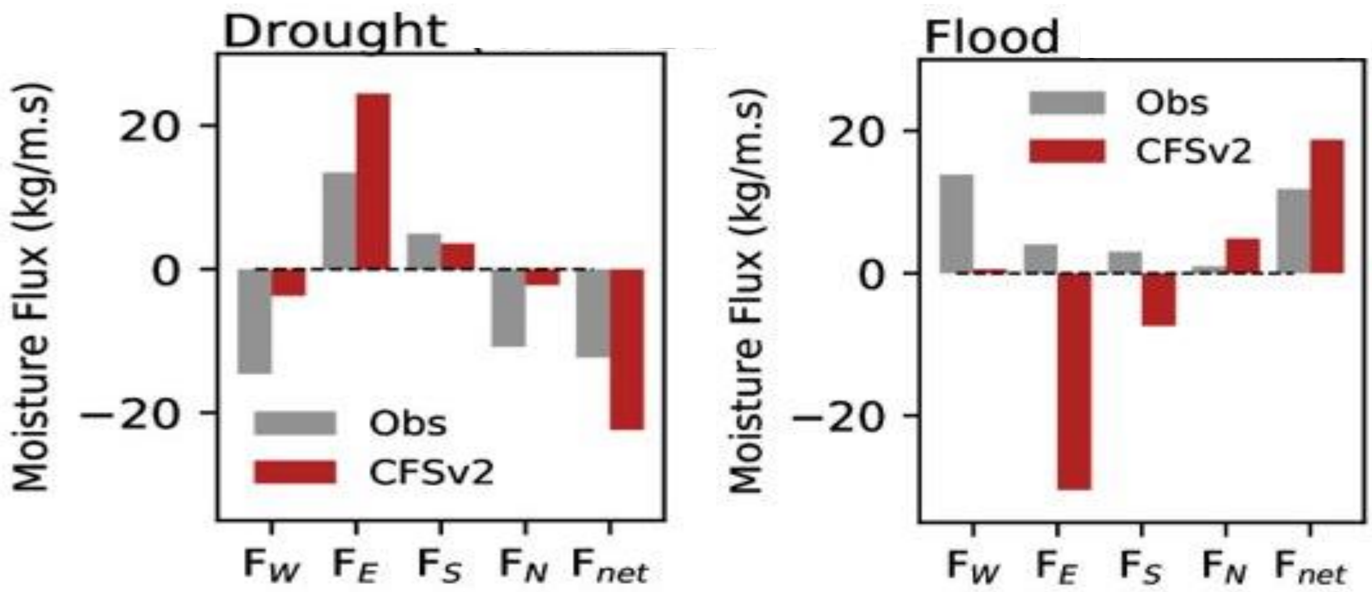
Drought: (dPs'/dy) > 0 (weaken)
Obs: Weakening of Ps gradient
CFSv2: Ps remain unchanged

Flood: (dPs'/dy) < 0 (strengthen)
Obs: Strengthening of Ps gradient
CFSv2: Ps remain unchanged

Bay of Bengal (90-110E): $(dPs/dy)_{clm} < 0$

Drought: (dPs'/dy) < 0 (Strength)
Obs: Strengthening of Ps gradient
CFSv2: Strengthening of Ps gradient

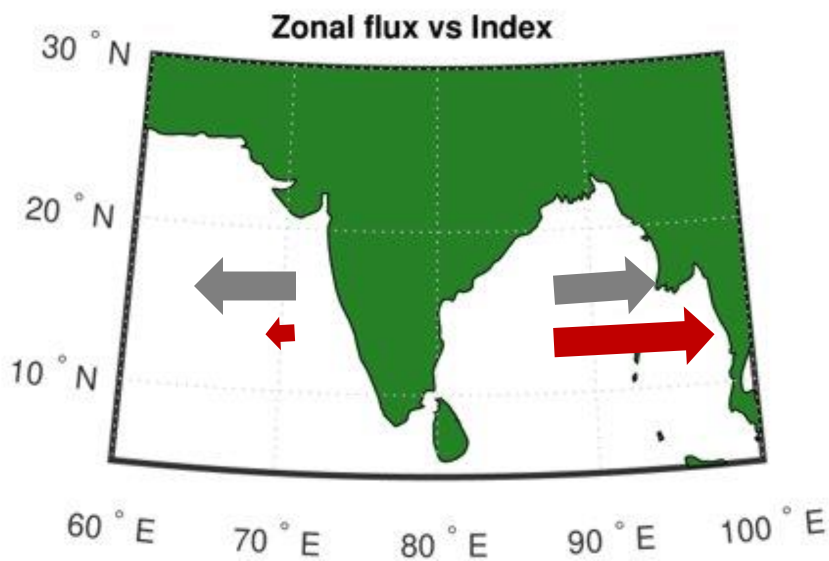
Flood: (dPs'/dy) > 0 (Weaken)
Obs: Weakening of Ps gradient
CFSv2: Strong weakening of Ps gradient



The corresponding change in moisture flux and its components and precipitation during drought and flood years over the Indian region in observation and model.

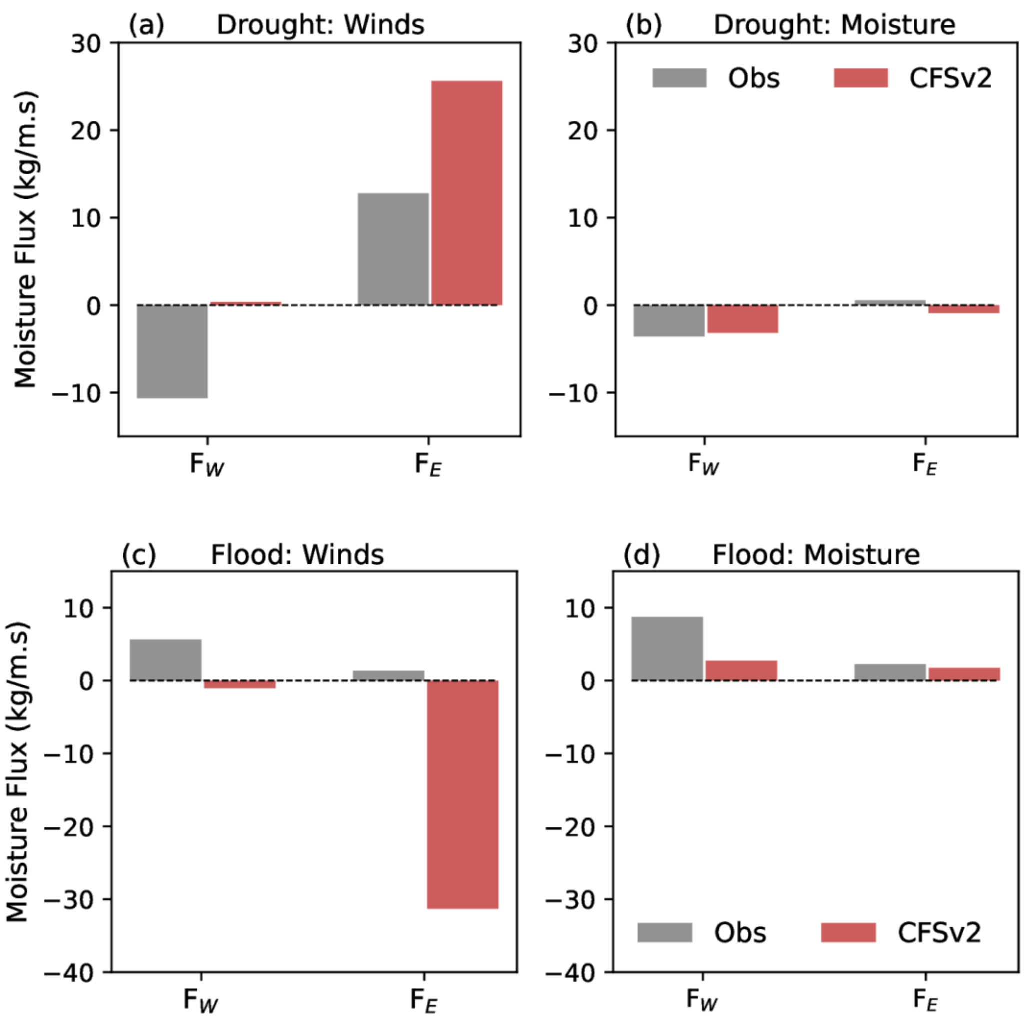
Drought:
Zonal divergence

Flood:
Zonal convergence



$$\vec{F}' = \langle \vec{V} q \rangle' = \langle \vec{V}' \bar{q} \rangle + \langle \bar{\vec{V}} q' \rangle + \langle \vec{V}' q' \rangle$$

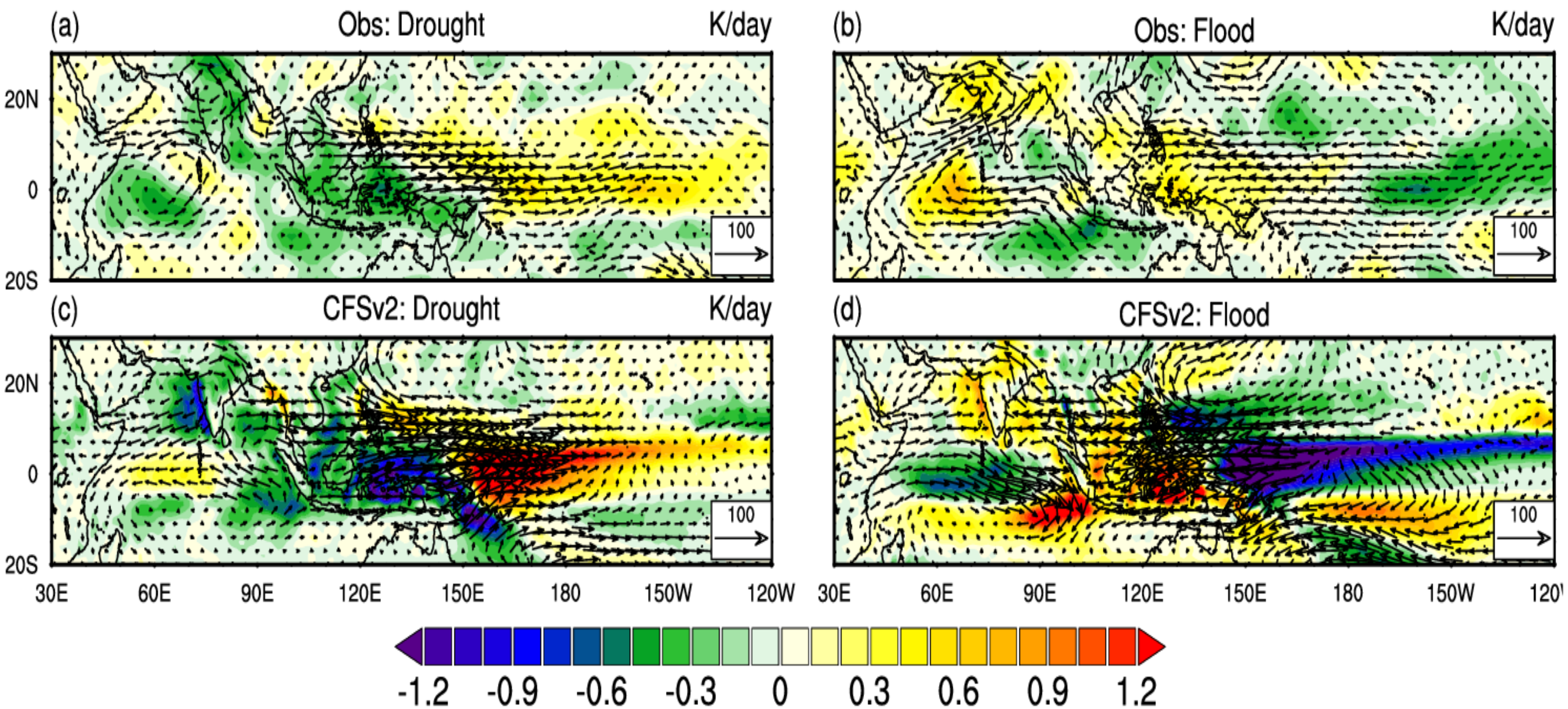
Wind component | Moisture component | Eddy flux component



Obs: Winds and moisture components of Fw both plays an important role

CFSv2: Winds component over the Bay of Bengal dominates.

Q1: Extreme



Composite change in the anomalous heating rate during drought and flood for observation and model.

Conclusions & Significance

- Outgoing eastward moisture flux over the Bay of Bengal is the only important factor determining ISMR extremes in the CFSv2, in contrast to observation where both outgoing and incoming eastward fluxes play a major role.

- Characterized the nature of moisture fluxes during extreme events.

Significance:

- Open new avenue for the improvement of general circulation model deployed for seasonal prediction.

- Teleconnection patterns in changing climate scenarios.

$$VMS = MSE_{\{500\text{-}100\ hPa\}} - MSE_{\{Psfc\text{-}500\ hPa\}}$$

$$VMS \propto 1/Prec$$