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A dominant mode in the first phase of the Asian summer monsoon rainfall: role of antecedent remote land surface temperature

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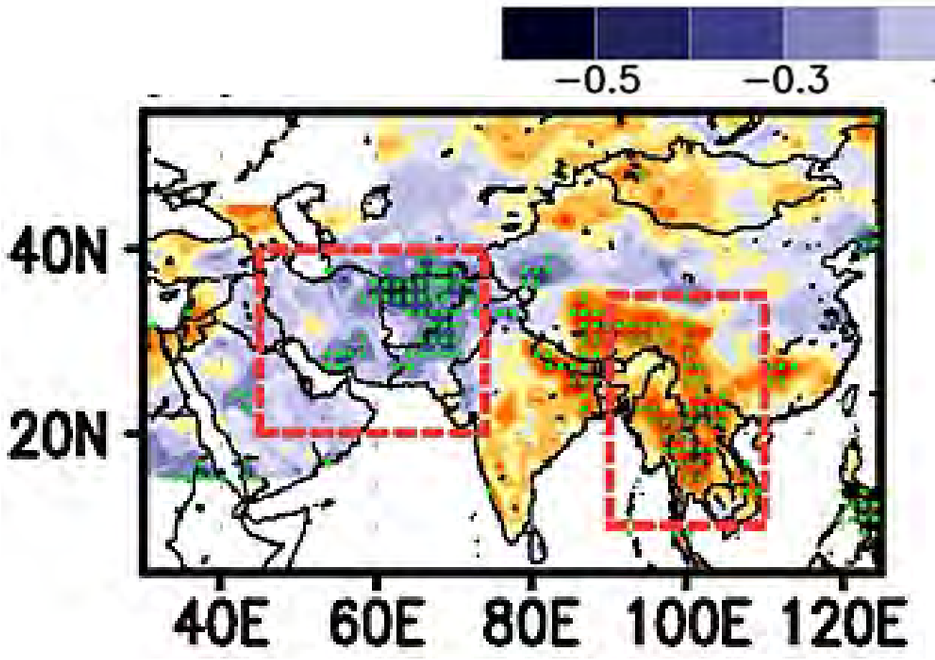
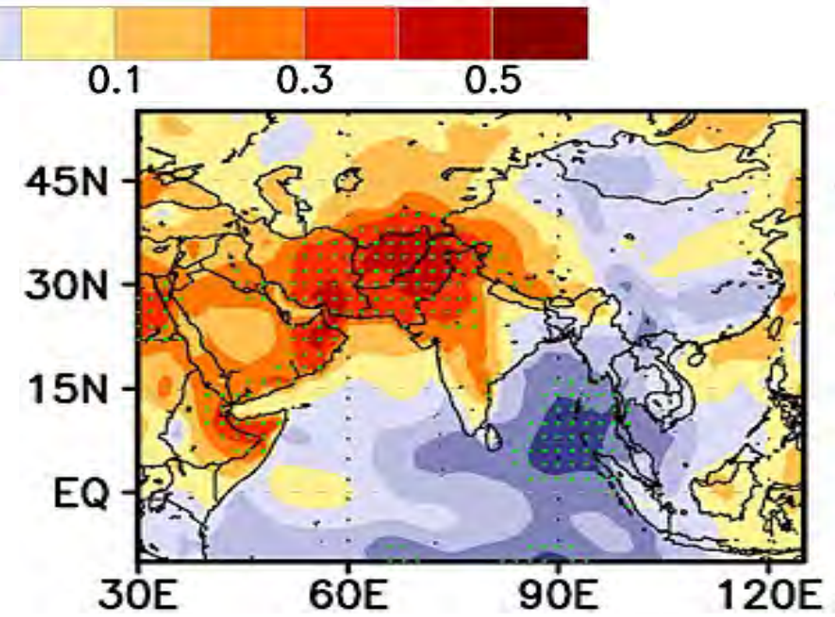
Saha, Xue et al., 2023; Clim. Dyn.

Independent Studies on Effects of LST on Monsoon

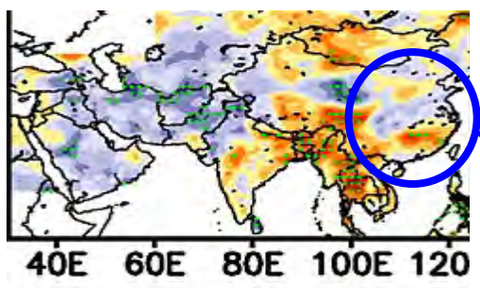


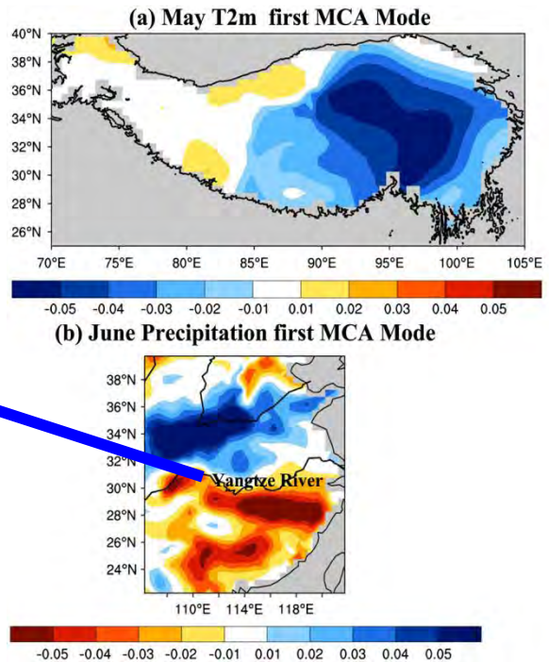
Central India averaged June rainfall is correlated with April-May rainfall

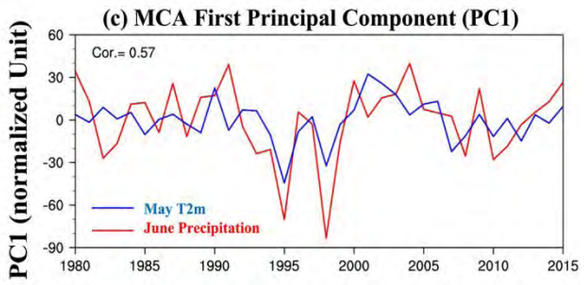


Central India average June rainfall is correlated with April-May 2m temp

Rai et al., 2015, JGR







MCA over East Asia. (a and b) Spatial patterns of MCA1 for May T2 m over TP and June precipitation over East Asia, respectively. (c) PC1 of MCA during 1980–2015 for May T2 m (blue line) and June precipitation (red line).

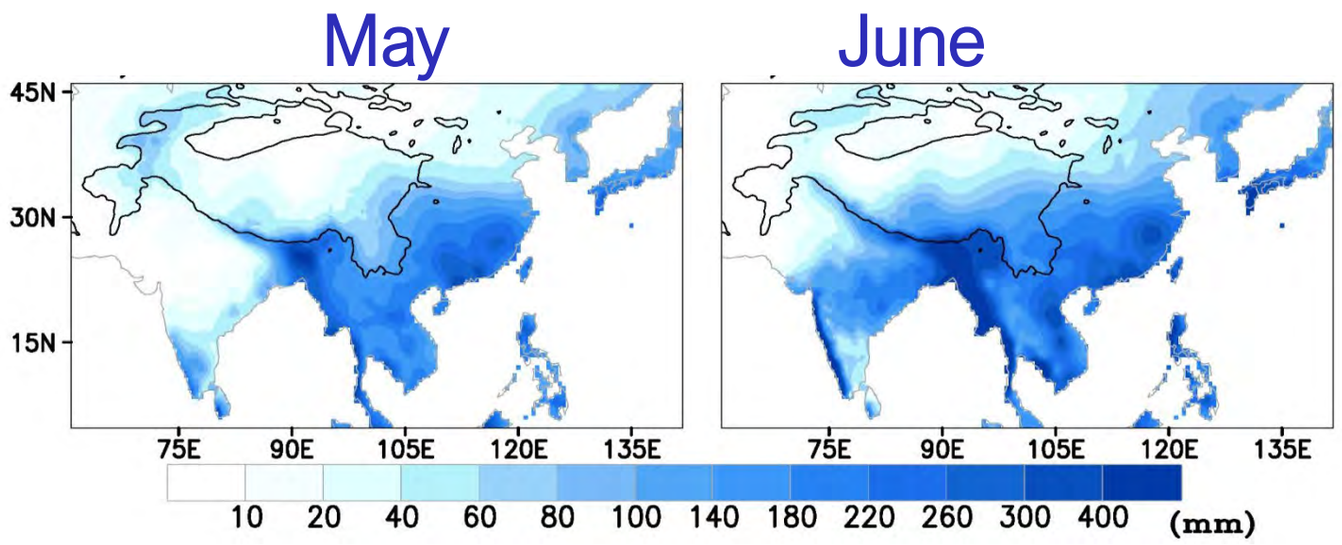
Xue et al., 2018; JGR

Is there a common mode of variability in the first phase of the Asian summer monsoon ?

If so, how it looks like ? Is it related with the elevated heating of Tibetan plateau ?

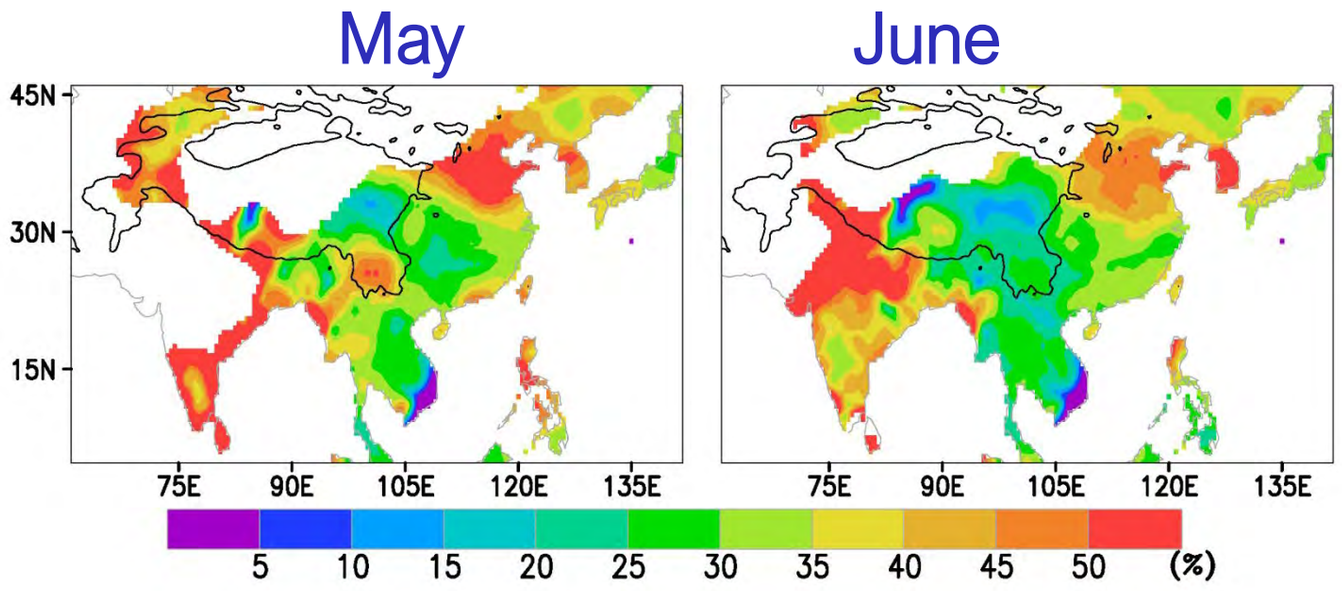
The First Phase of Asian Summer Monsoon

Mean



- The Asian summer monsoon (ASM) is an inter-hemispheric circulation system, initially driven by land-ocean temperature gradient.
- South Asian & East Asian monsoon are not independent completely.

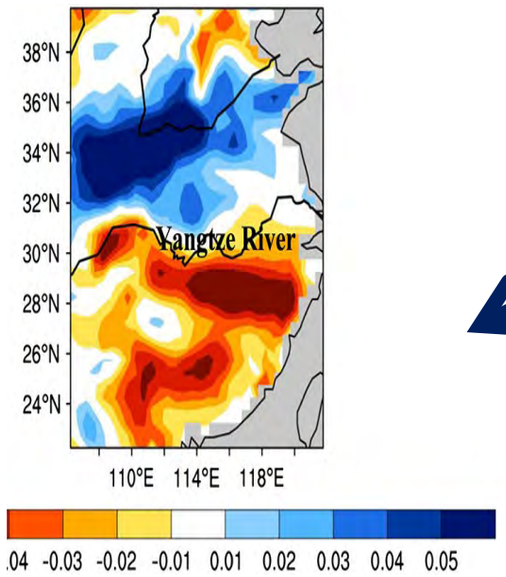
SD



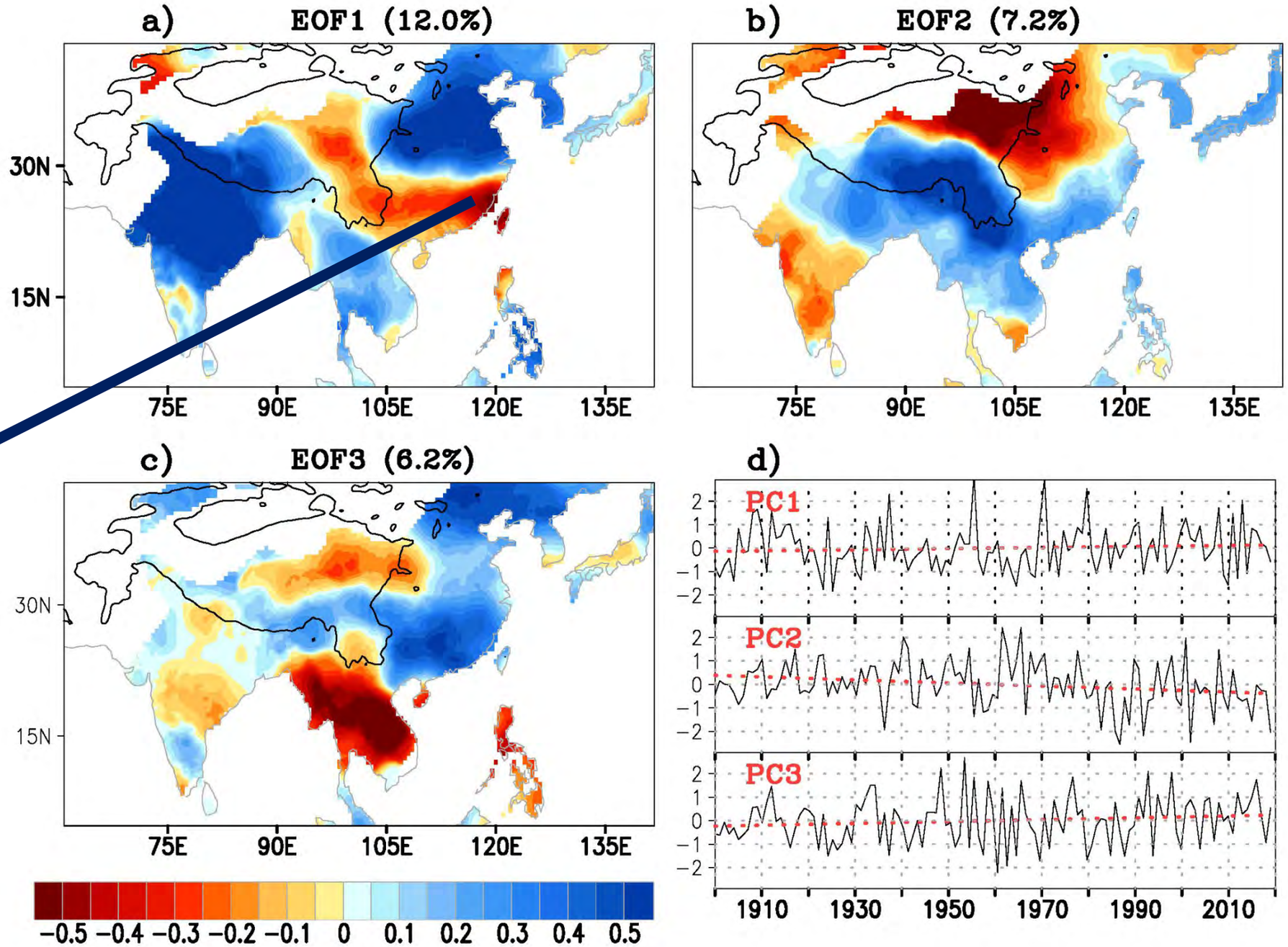
- A large. inter-annual variability in the first phase of ASM

As land-ocean temperature gradient primarily initiates the monsoon circulation, variability in the land-surface conditions may affect initial phase of Asian summer monsoon.

EOFs of June Rainfall (1901-2019)

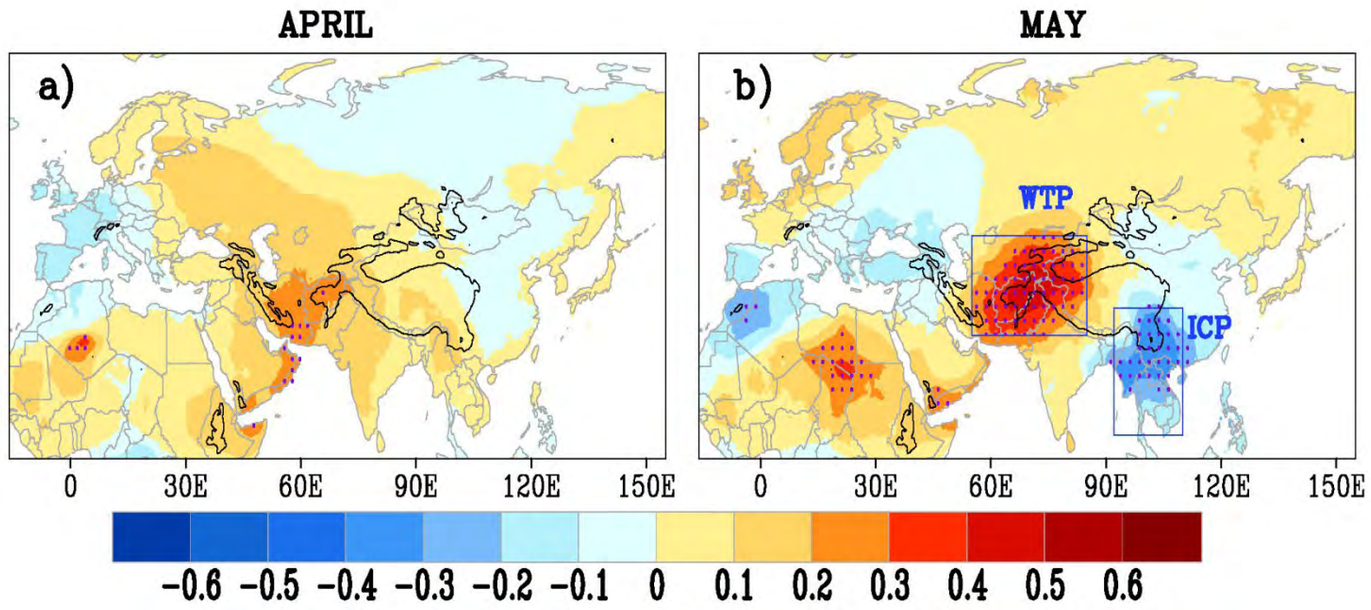


Pattern of EOF-1 around Yangtze river is similar to *Xue et al., 2018*



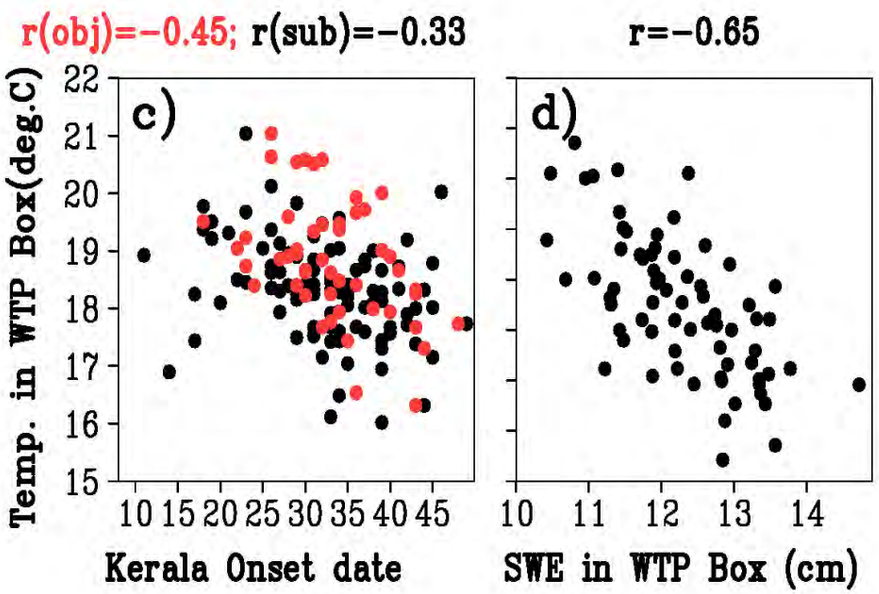
First three EOFs and PCs of June rainfall from CRU (1901–2019). The percentage of total variance explained by individual EOFs are given in the sub-figure captions.

Teleconnection of Dominant Precipitation Mode



PC1 is correlated (1901–2019) with surface air temperature (2 m) during **a)** April and **b)** May.

PC-1 of June rainfall is strongly correlated with May 2m air temperature over Western Tibetan Plateau (WTP) region

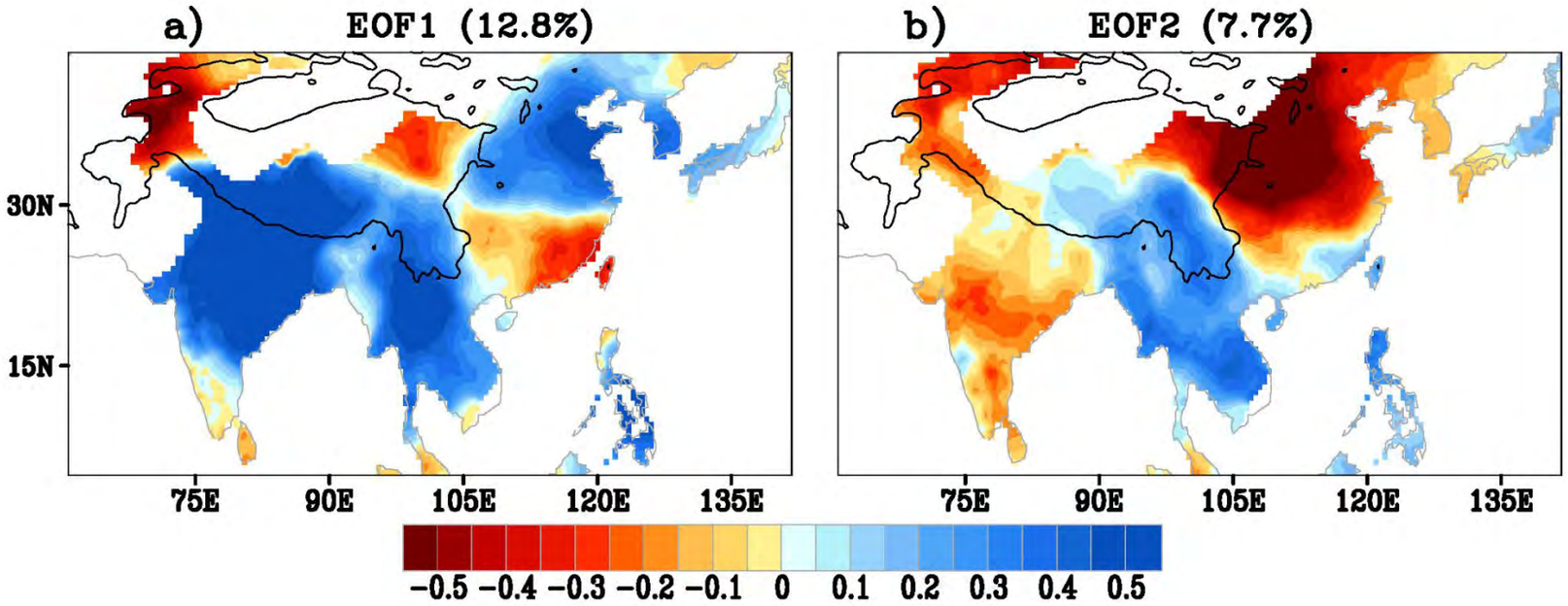


WTP box averaged temperature Vs **c)** monsoon onset date over Kerala based on IMD's subjective (black), objective (red) criteria, **d)** snow water equivalent averaged over WTP box during May

During May, 2m air temperature is inversely correlated with SWE over WTP region (r=-0.65), suggesting role of land-surface processes on atmospheric temperature anomaly

Monsoon onset date over Kerala (southern tip of India) is inversely related with WTP averaged 2m air temperature of May.

Dominant Modes & Teleconnection in May-June Rainfall



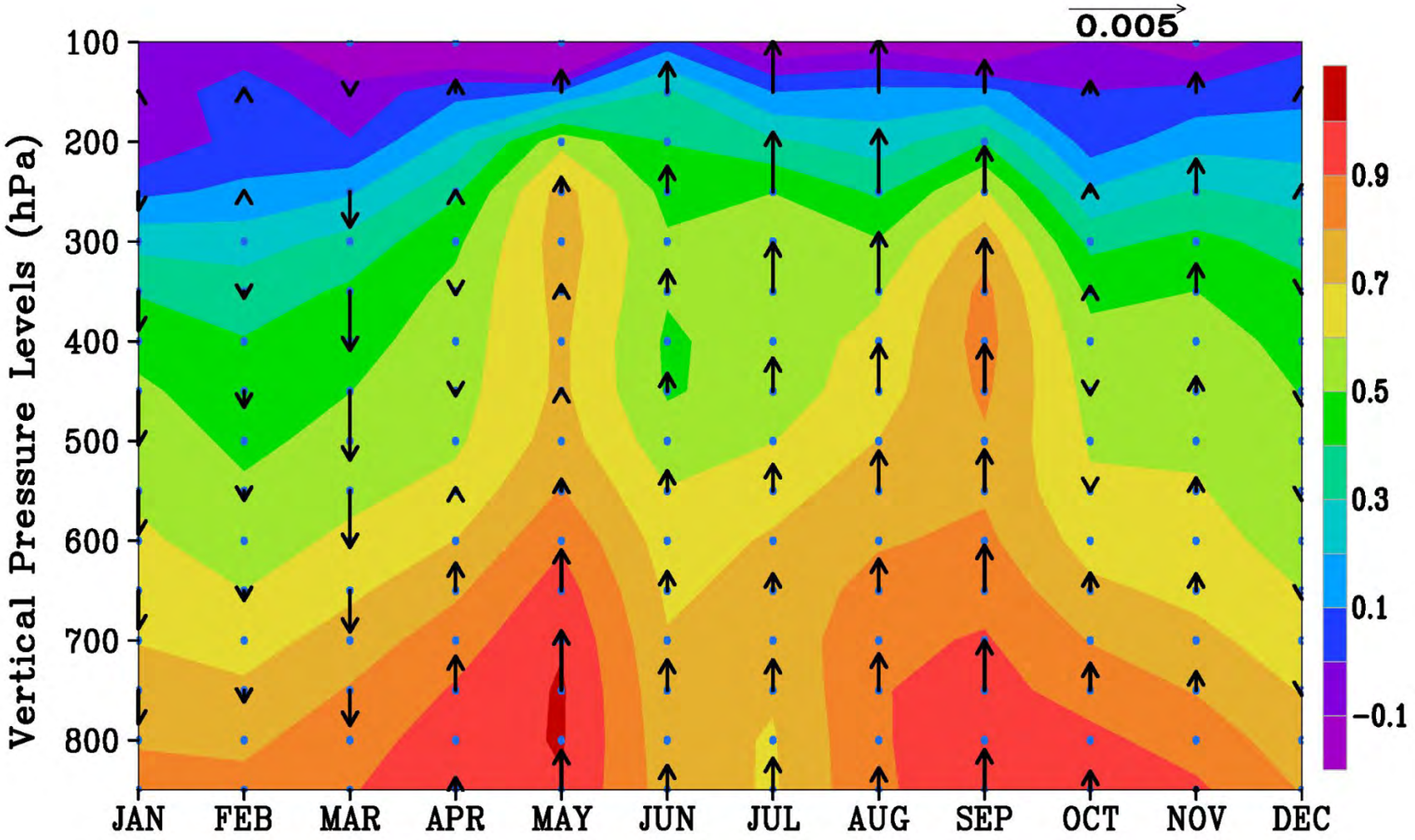
EOFs in May-June rainfall (1901-2019)

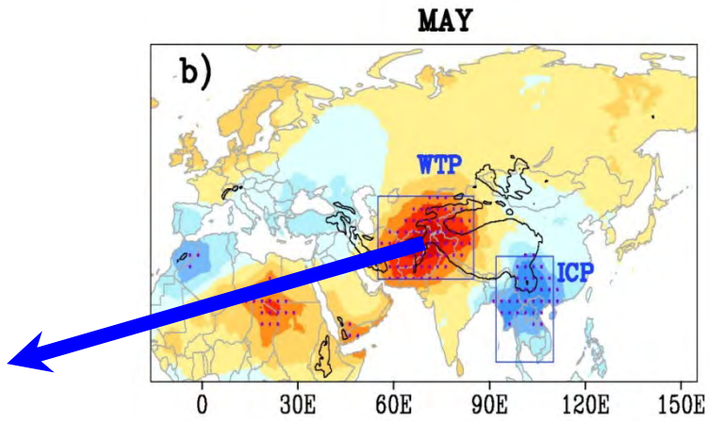
PC1 correlated with T2m air temperature

May to June averaged rainfall shows similar EOF patterns to that of June rainfall.

PC-1 of May-June rainfall has teleconnection pattern with 2m air temperature, which is similar to that using PC-1 of June rainfall

Local LST forcing on the atmosphere

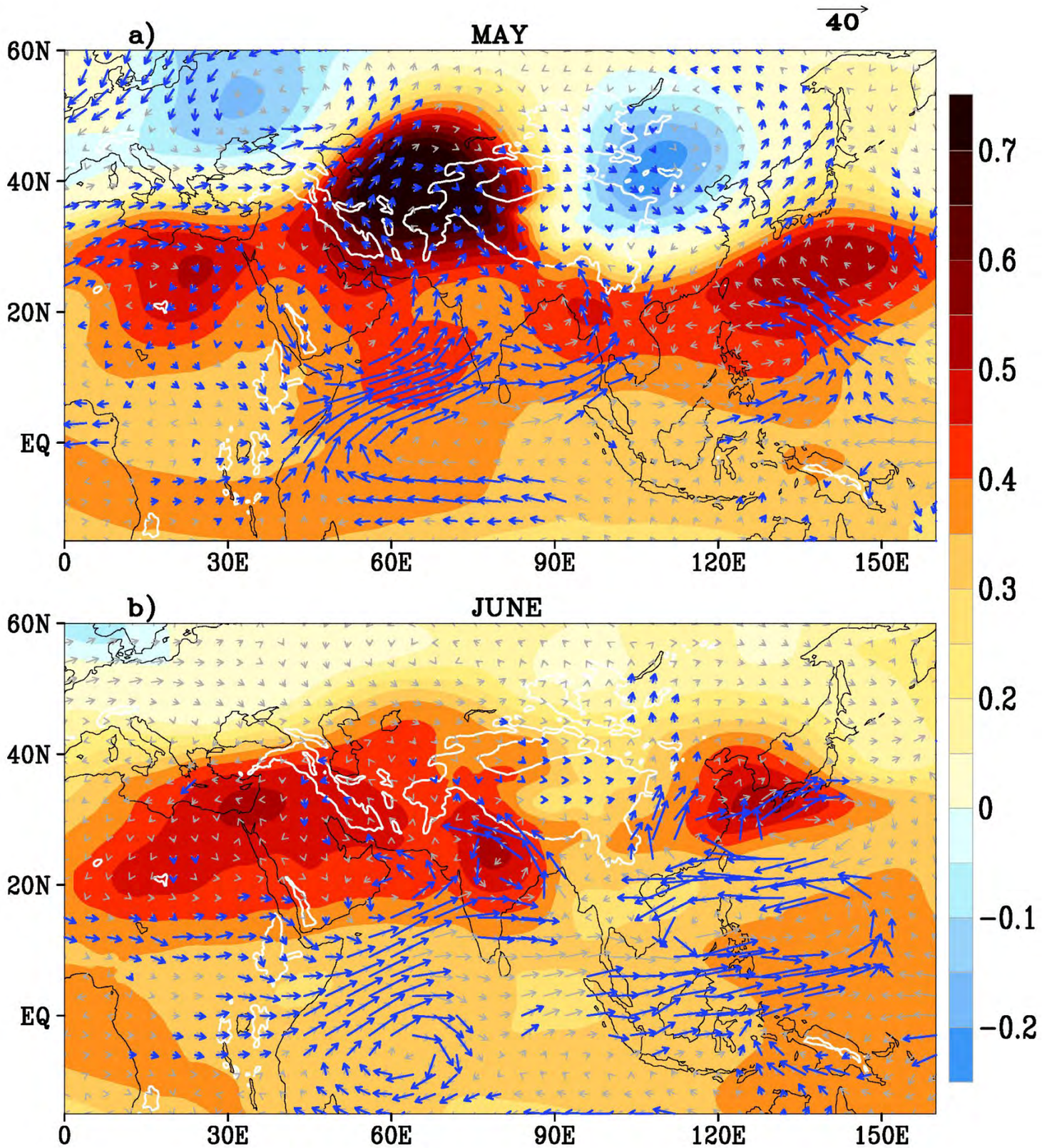




Monthly WTP surface temperature is correlated (color shade) and regressed (arrow) with the air temperature and Omega in the vertical levels (1901–2015) respectively.

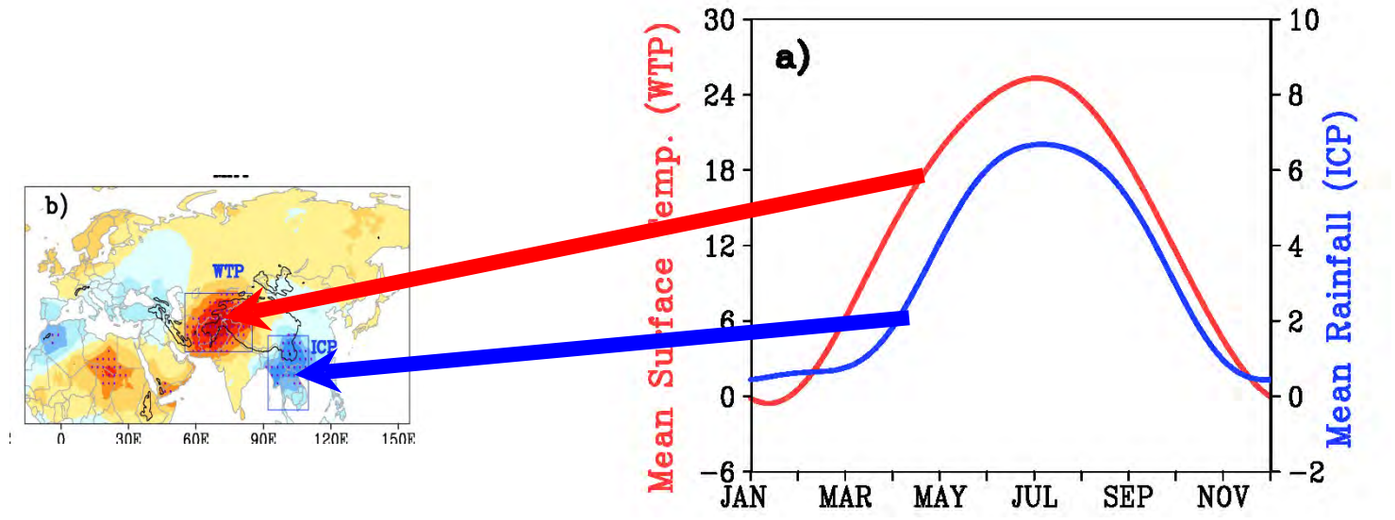
Strong ascending motion in association with WTP surface temperature, particularly during spring and autumn suggest sensible heating of the troposphere by elevated land surface.

Large-scale moisture flux and tropospheric temperature

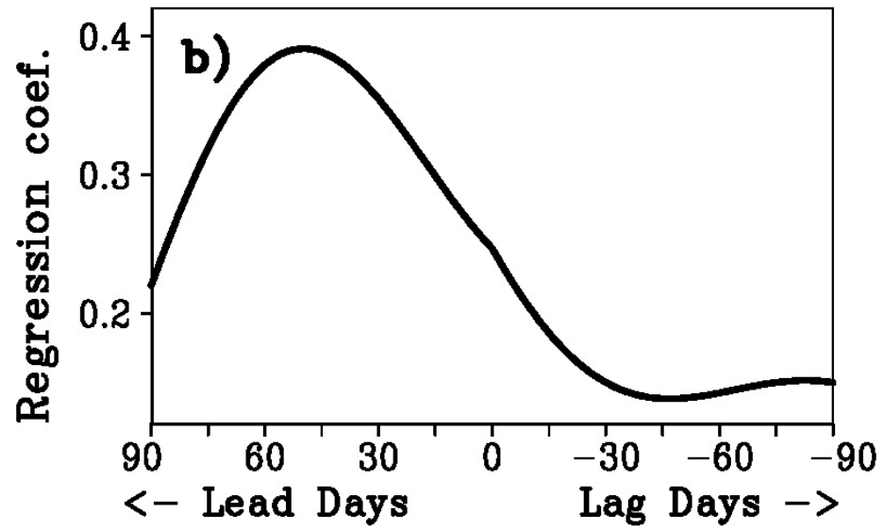


Relationship of WTP surface temperature with large scale tropospheric temperature (average of 600–200 hPa) and vertically integrated moisture fluxes (surface to 200 hPa). WTP averaged surface temperature during May is correlated (regressed) with tropospheric temperature (moisture flux) of the month **a)** May and **b)** June. Correlations (shaded plot) above 0.18 are significant at above 95% level. Regressed moisture fluxes (vectors) significant at above 95% are marked by blue colors

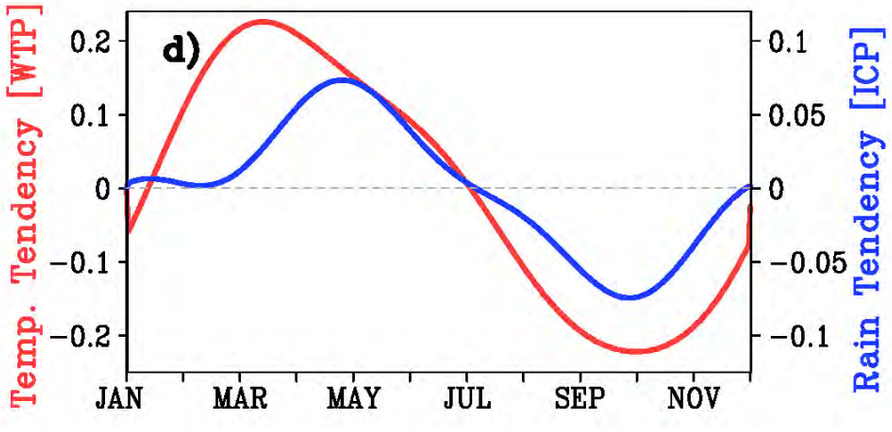
Observed Link between BoB Convection & WTP LST



Climatological mean smooth annual cycle of WTP averaged 2m air temp. (red) and ICP averaged rainfall (blue)



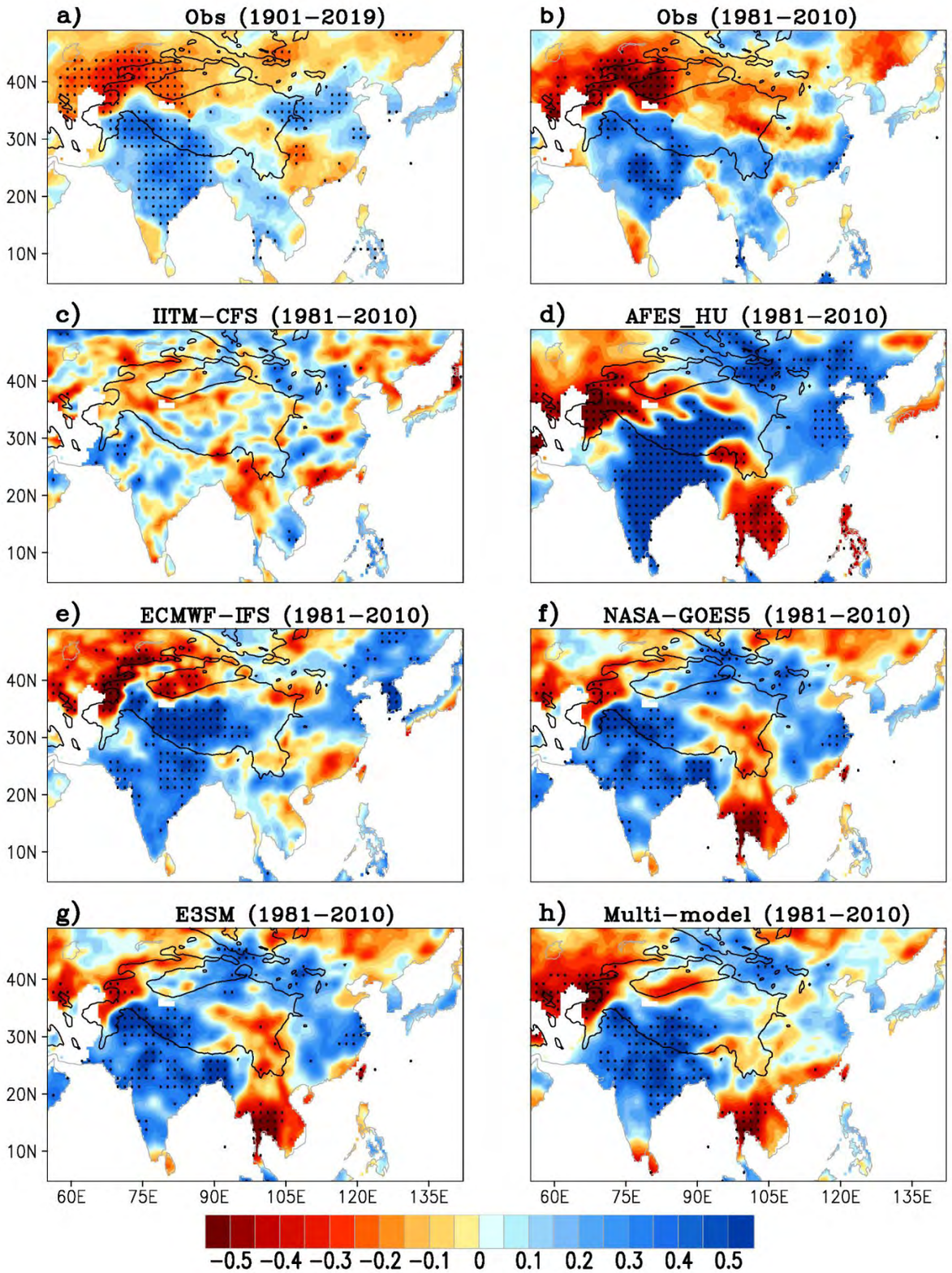
Lead-lag regression suggests that WTP surface temp. leads ICP rainfall by ~50 days



Tendency of WTP averaged 2m air temp. (red) and ICP averaged rainfall (blue)

Warmer (colder) troposphere owing to land-surface heating (cooling) over WTP region enhances (decreases) rainfall over ICP and part of East Asia in May, which eventually cool (warm) surface temperature.

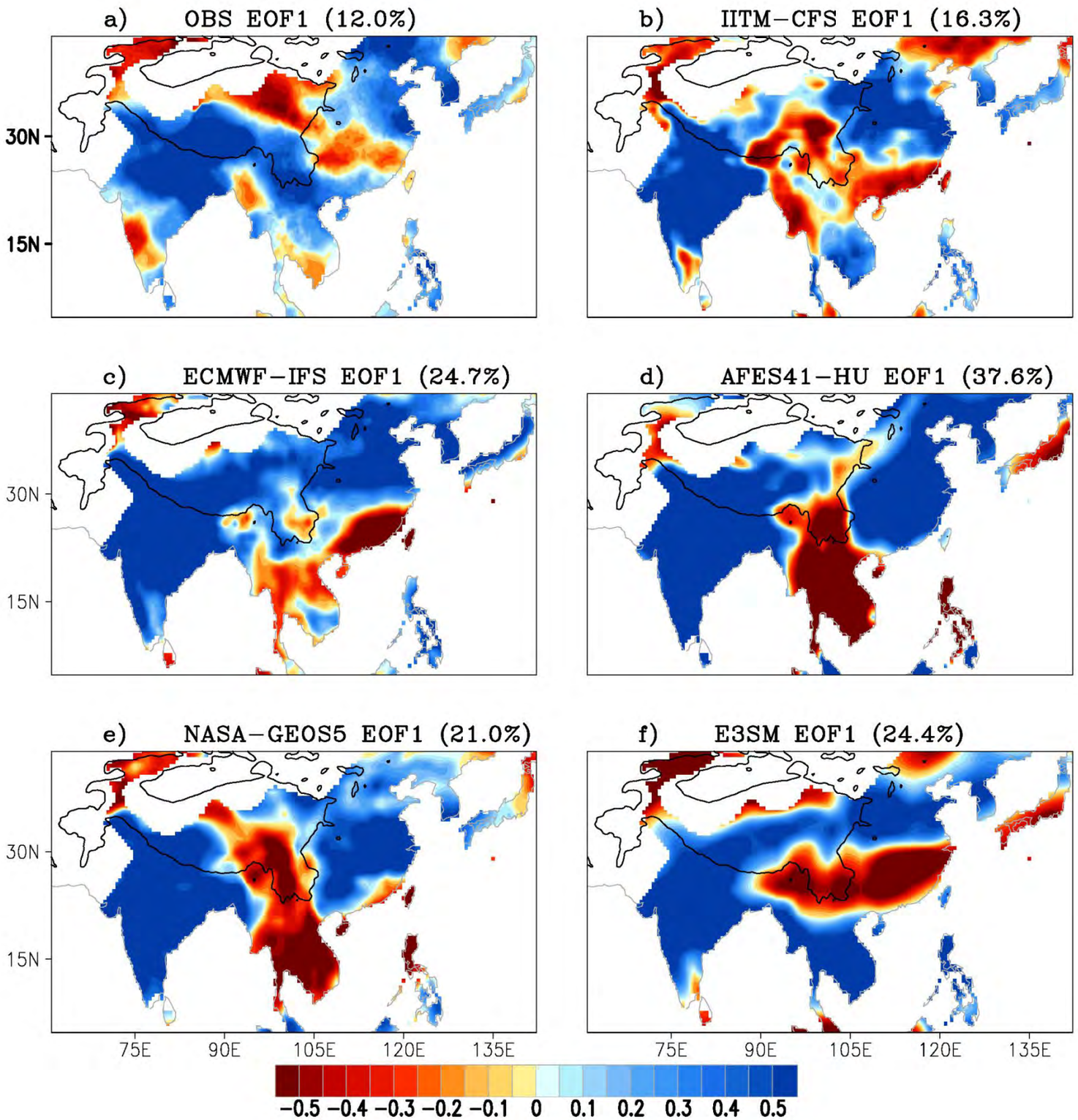
Teleconnection of rainfall (June) with WTP LST (MAY)



Reforecast of 30-yaers from five models were available

Most of the models reproduce observed relationship for South Asia (except IITM-CFS), but fails over East Asia.

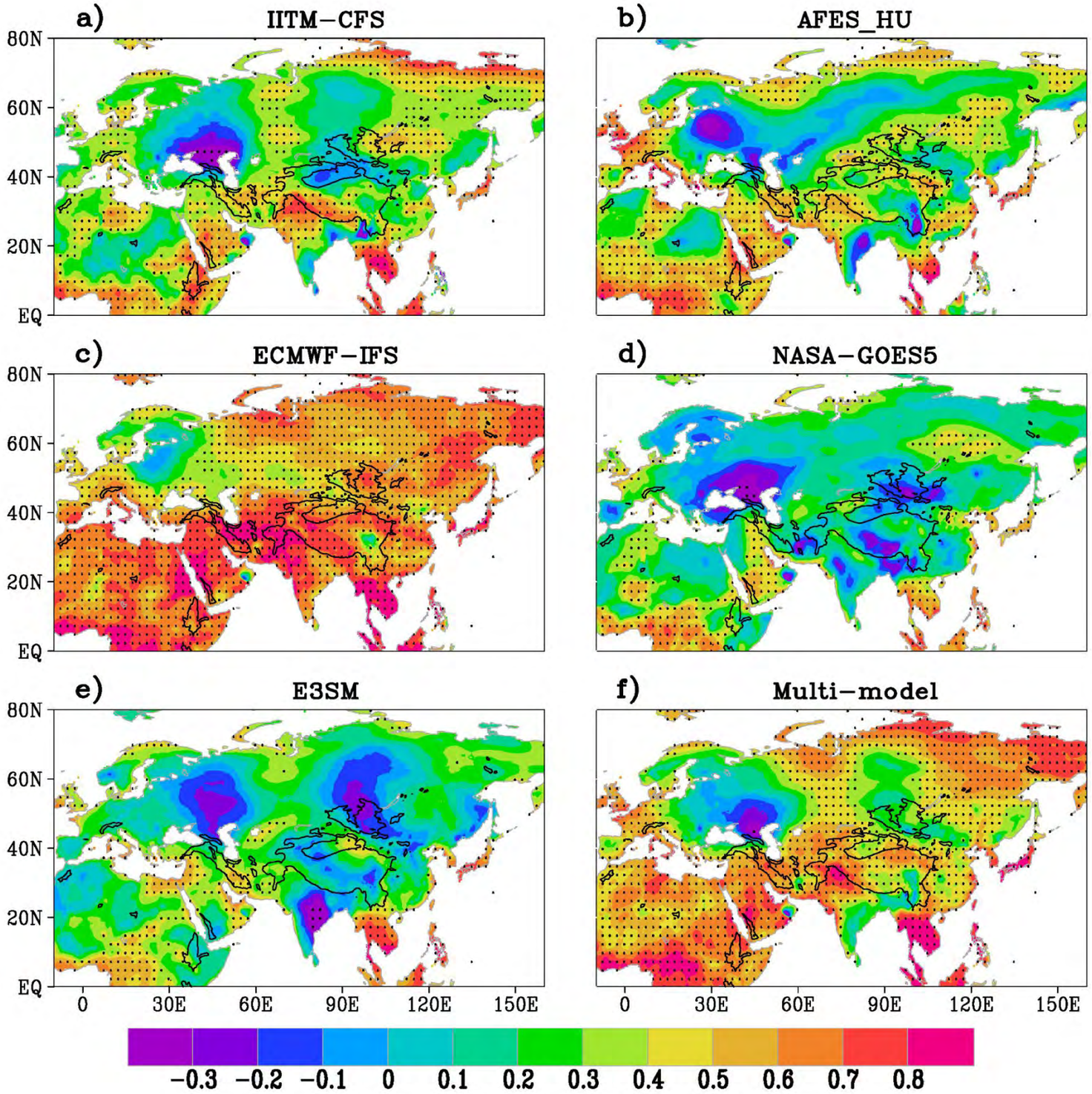
EOF-1 in June Precipitation: Models vs Observations



Models are correctly reproduce observed phases over South Asia, but fails over ICP and around Yangtze river.

Explained variance in EOF-1 is higher in all models except IITM-CFS

Skill in 2m Air Temperature (May)



Poor to moderate skill in surface 2m air temperature of May, including WTP region by all models (except IFS).

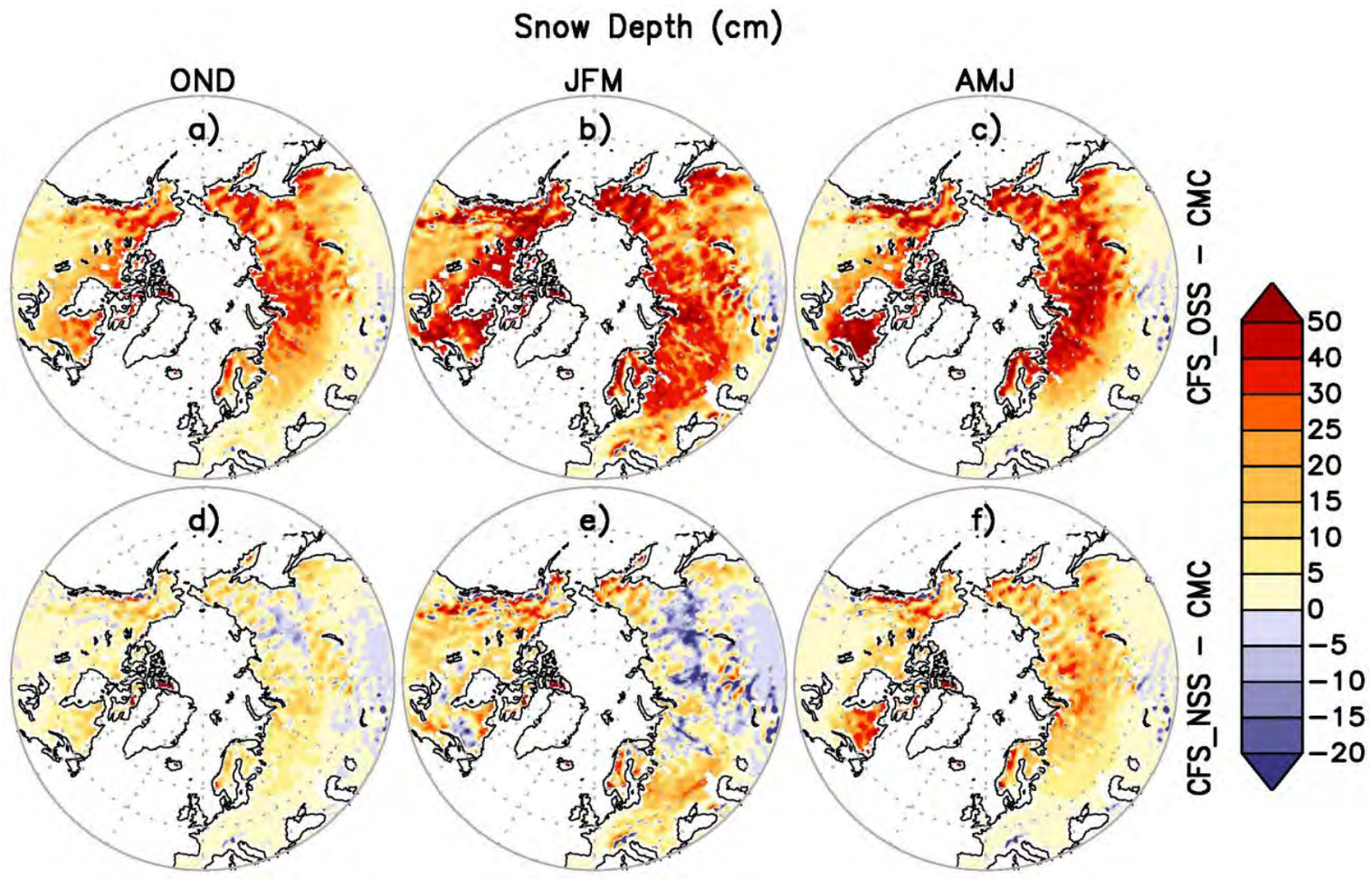
LS4P-II Experiment IITM-CFS

IITM-CFS with improved microphysics scheme was used in LS4P-I experiment

Improved version of IITM-CFS (multi-layer snow scheme) in LS4P-II experiment

Bias in Original Snow Scheme (OSS)

Bias in New Snow Scheme (OSS), i.e. multi-layer snow scheme



Saha, et al., 2017; JAMES

Conclusions

- **A dominant mode of variability in June/May-June rainfall over the Asian summer monsoon (ASM) region is identified.**

- **This mode is found to be linked with the spring (April, May) land surface temperature (LST) centred around the Western Third Pole (WTP).**

- **A strong link of LST with snow water equivalent, vertical winds and tropospheric temperature over WTP suggests a seminal role of land surface processes in the first phase of ASM variability.**

- **Re-forecast (1981-2010) by five global coupled climate models participating in the LS4P-I used to investigate the observed dominant mode and their teleconnection.**

- **Improved IITM-CFS with multi-layer snow scheme will be used in LS4P-II experiment**

Thank You!