Simulation of the Asian Monsoon using a regionally-coupled global climate model

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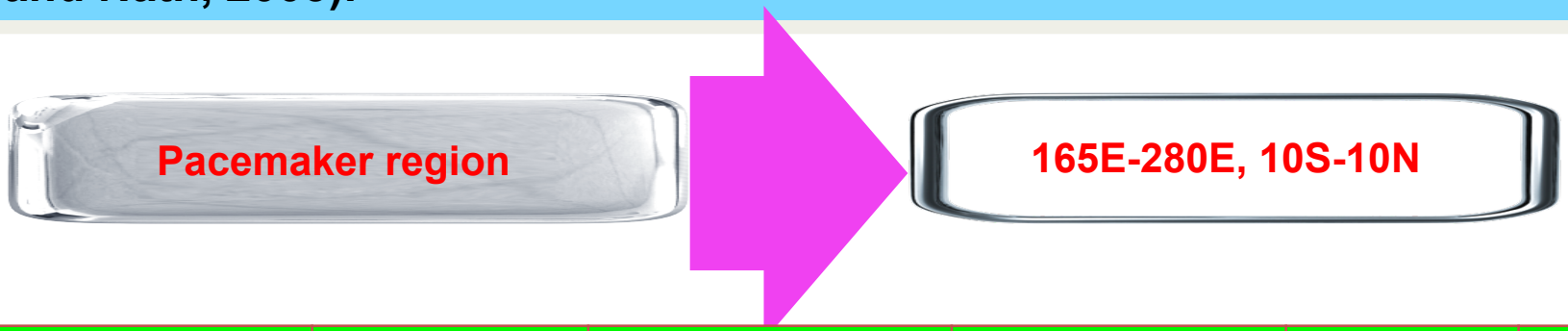
Model and Experimental Design

"Pacemaker": Tropical Pacific SST is prescribed from observations, but coupled air-sea feedbacks are maintained in the other ocean basins (e.g. Lau and Nath, 2003).



Experiment	Extratropics	Tropics	Mixed-layer depth	Period	Member
PACEMAKER	Slab Ocean Mixed-layer	Observed interannual SST (165-280E, 10S-10N)	Smoothed zonal mean monthly Levitus climatology	55 Yr (1950-2004)	4
AGCM/AMIP	Observed Interannual SST		None	53 Yr (1950-2002)	1
CGCM (NCEP CFS)	MOM3			52 Yr	1
PACEMAKER/ AMIP	Interannual $SST_{Pacemaker}$		None	55 Year (1950-2004)	4

Ravi P. Shukla and James L. Kinter (**2014**) "Simulation of the Asian Monsoon using a regionally-coupled global climate model", **Climate Dynamics,** DOI: 10.1007/s00382-014-2188-3

Focus of the present Study:

1. Does the pacemaker method improve the structure of the seasonal mean (JJAS) monsoon and interannual variability (IAV) of the Asian monsoon?
2. Does the pacemaker method improve the spatial and temporal structure of the monsoon intraseasonal oscillation (MISO) in JJAS ?
3. Does the pacemaker method reproduce the relationship between MISO and IAV of the South Asian monsoon in JJAS ?

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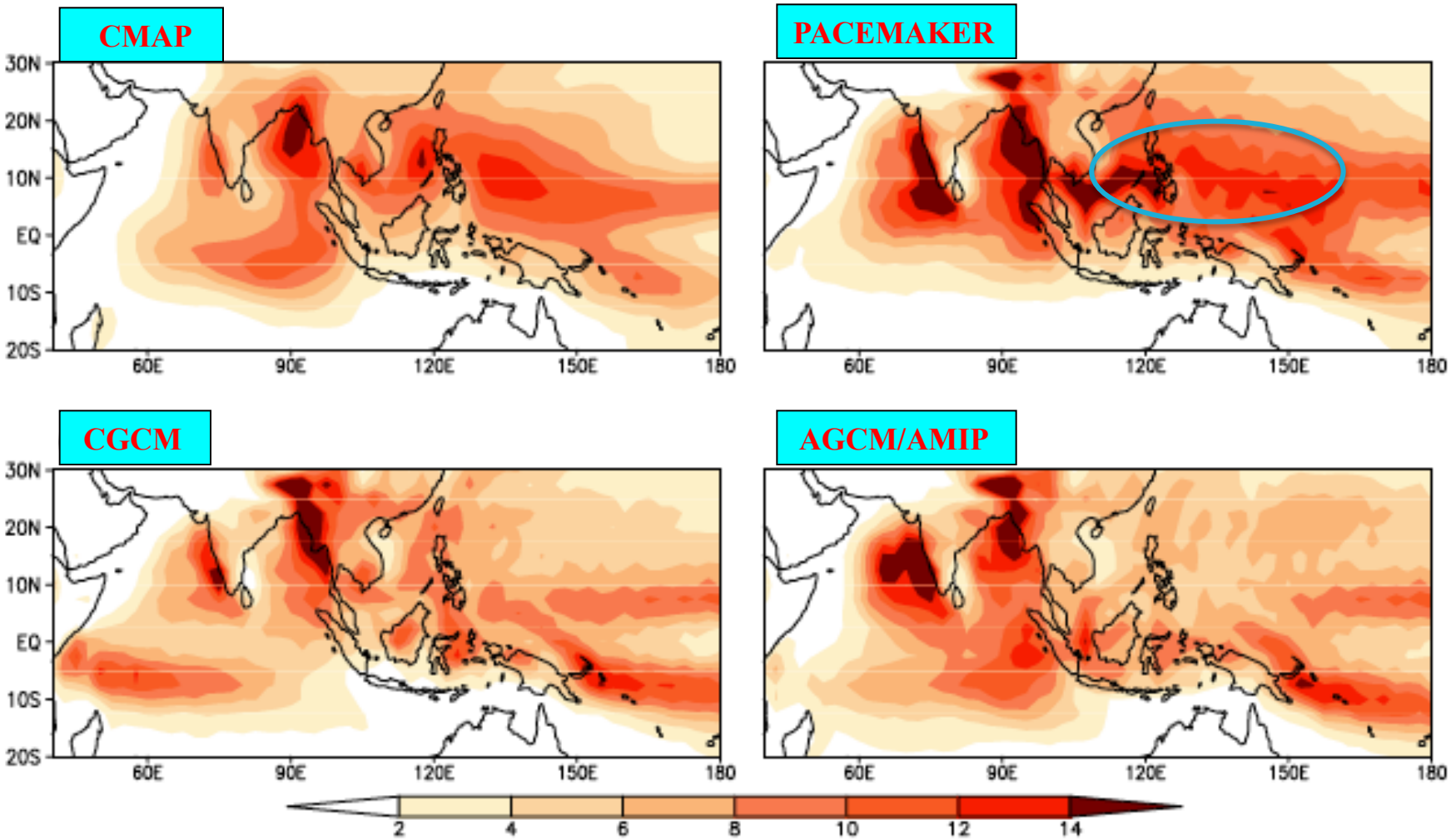
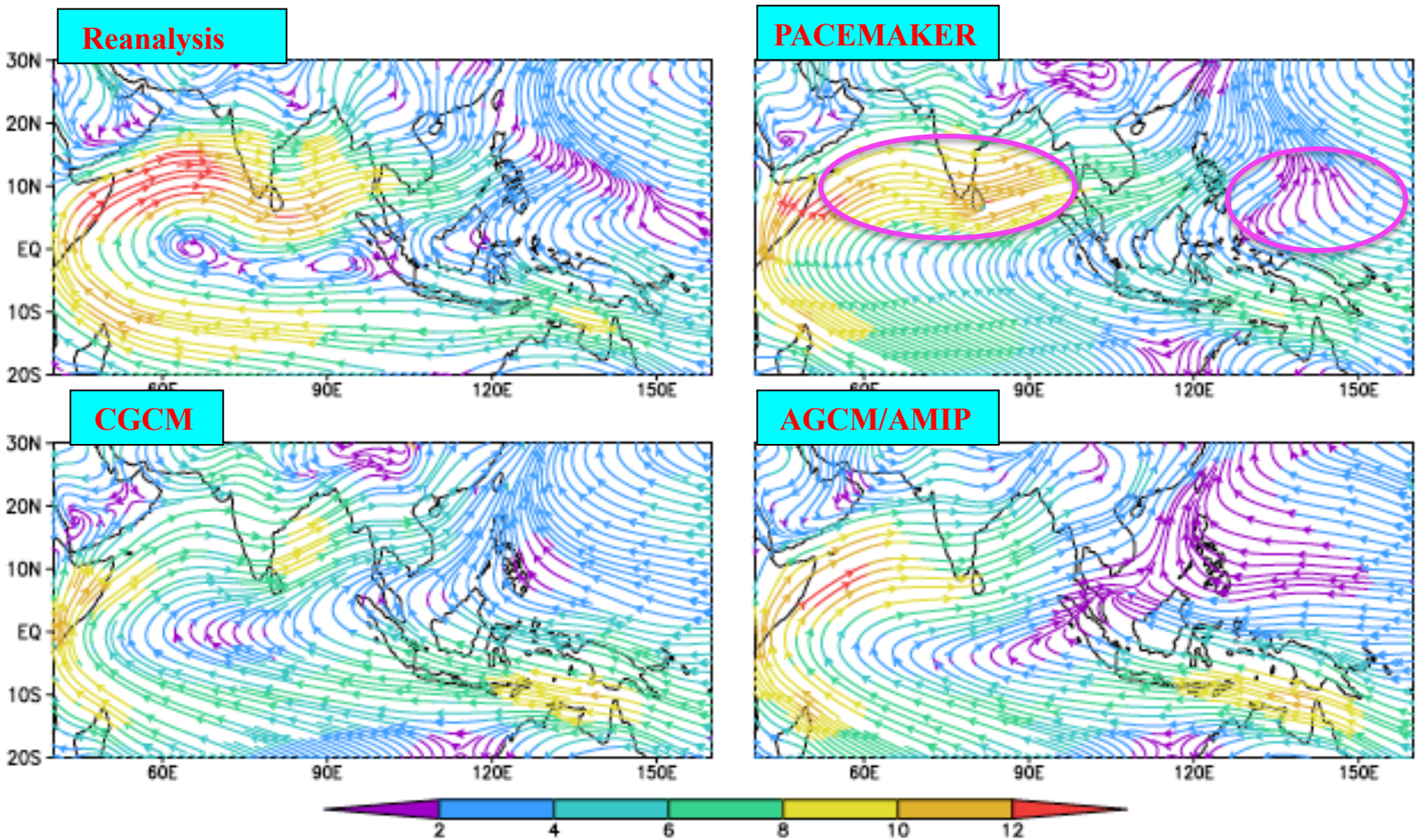
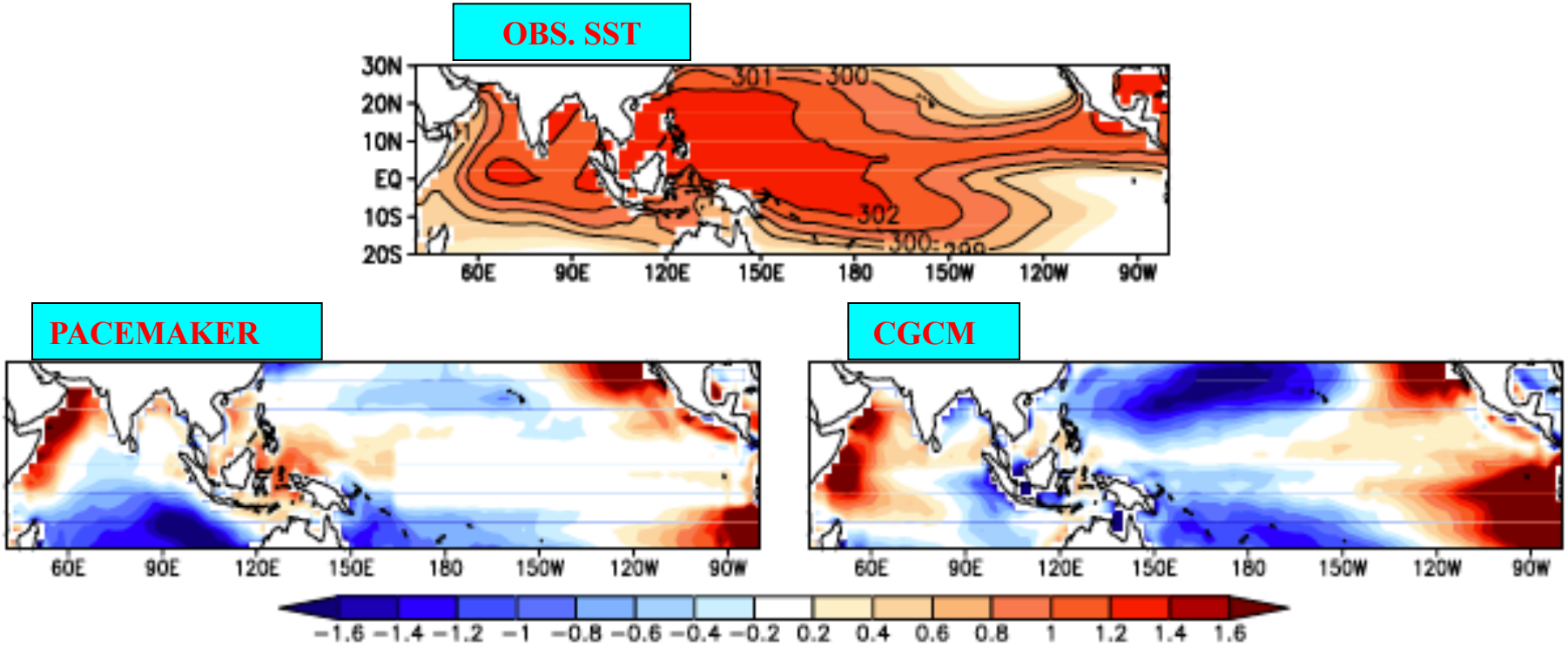
JJAS Rainfall Climatology



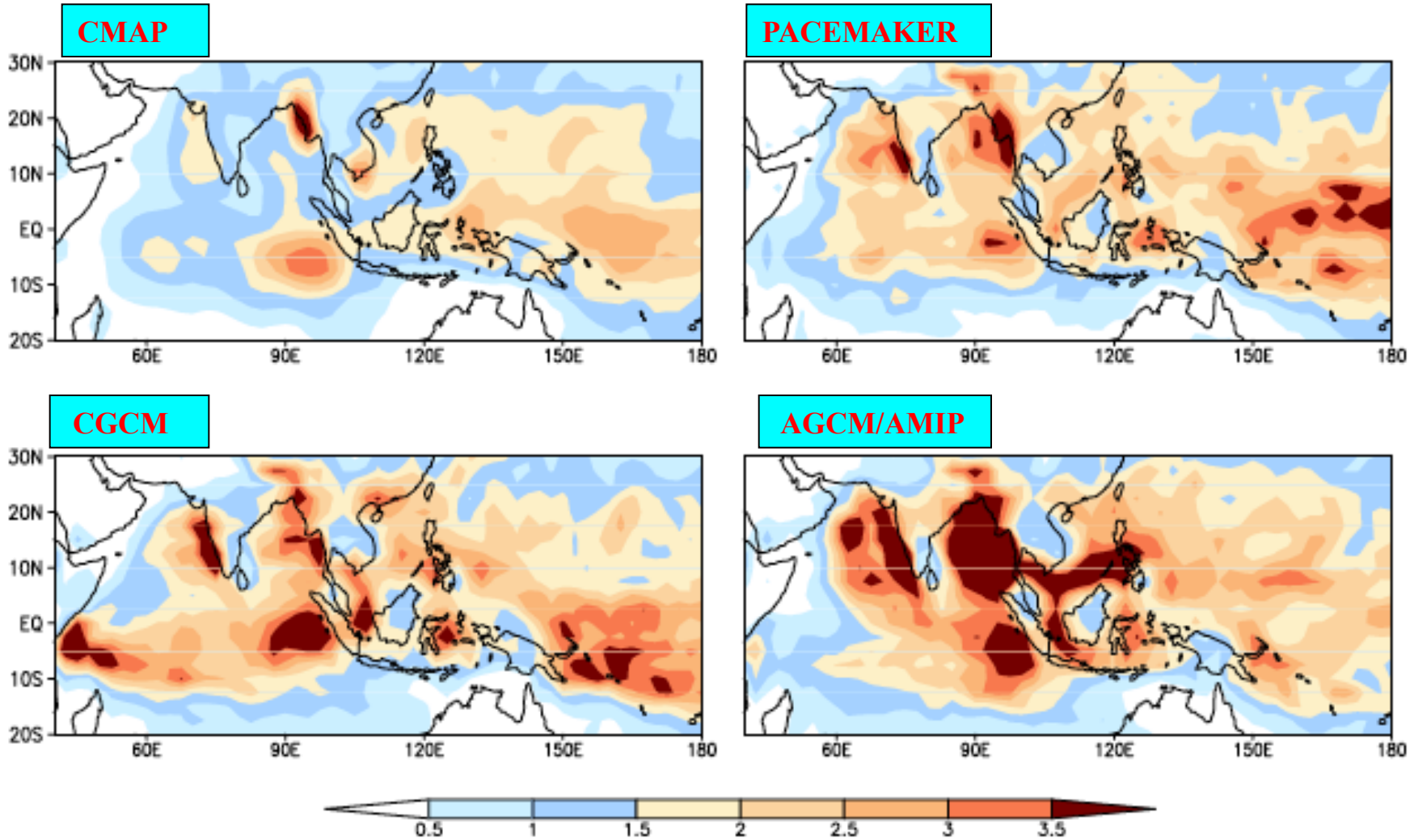
JJAS Wind850hPa Climatology



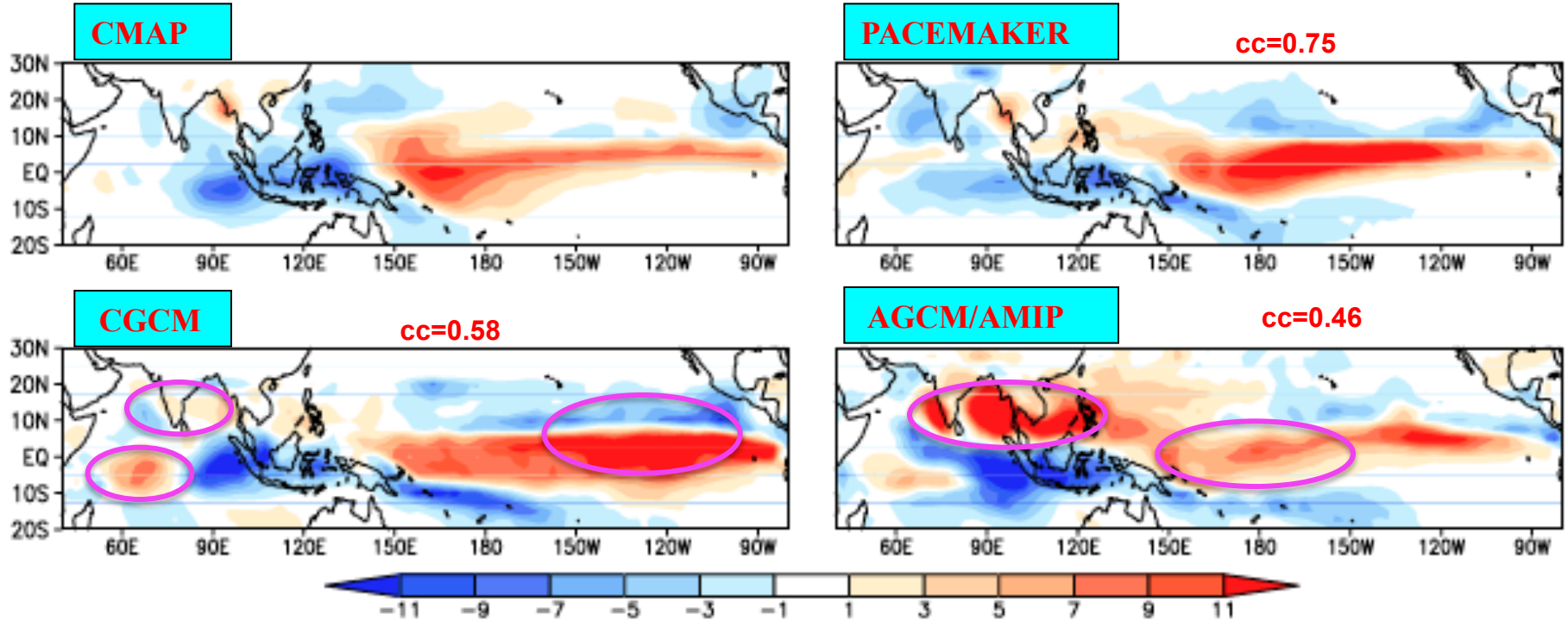
JJAS SST Climatology (Bias)

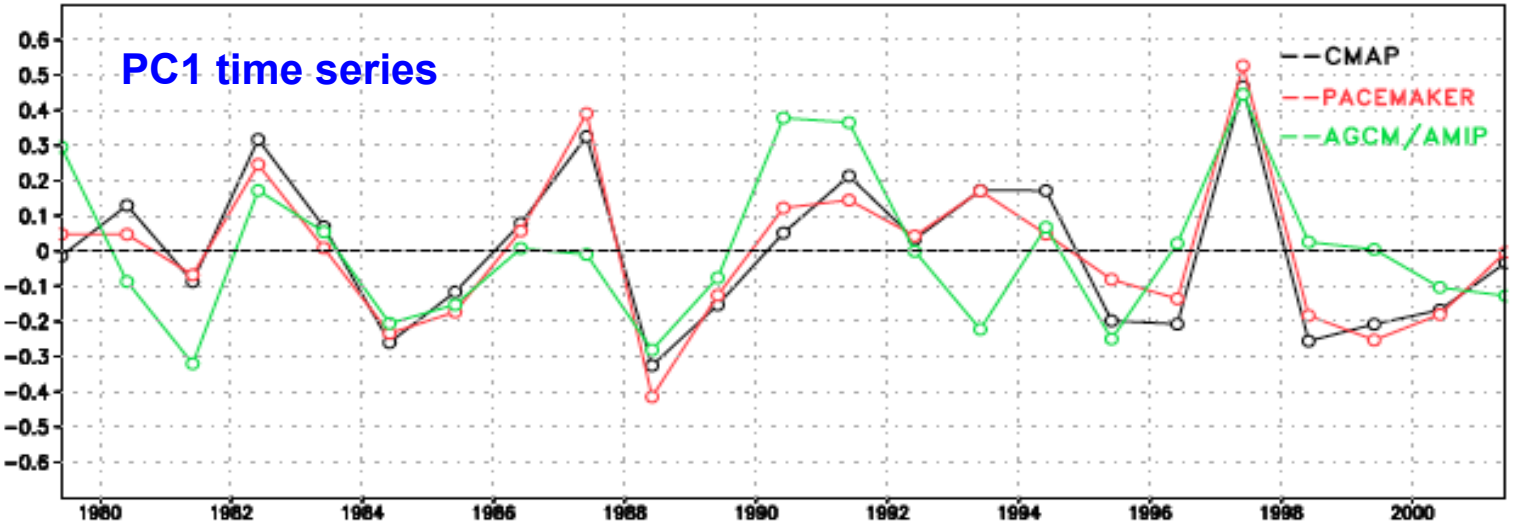


Standard deviation of JJAS Rainfall



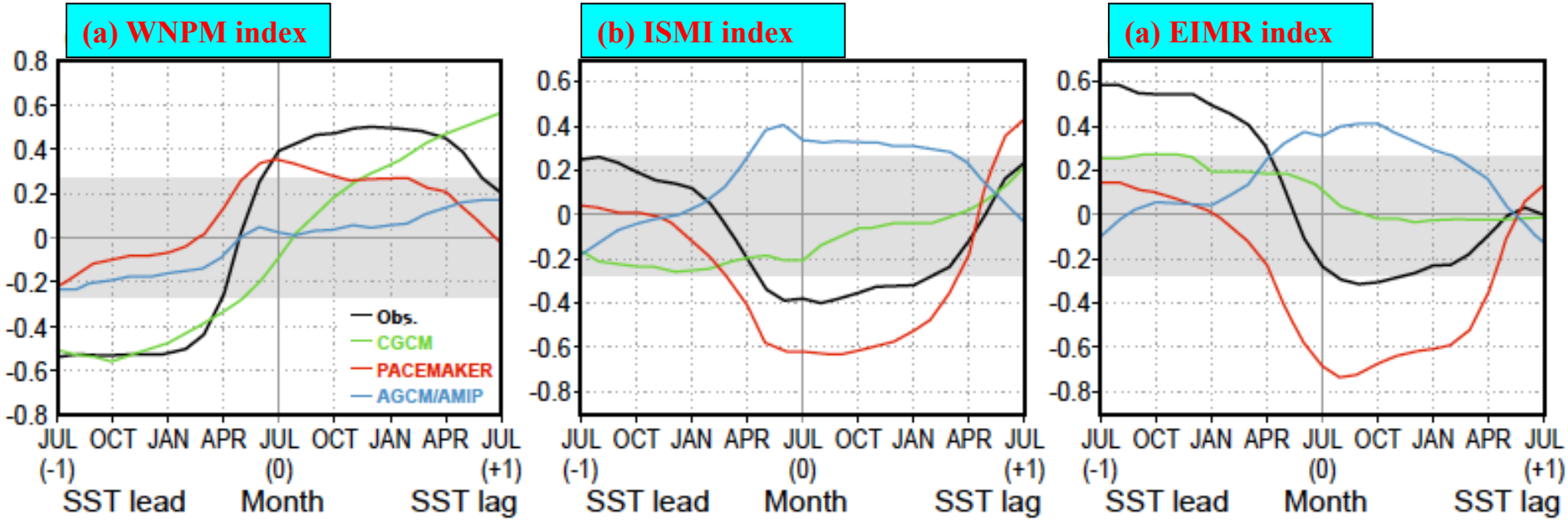
EOF1 Analysis of JJAS Rainfall Anomalies





PACEMAKER (cc=0.95)
AGCM/AMIP (cc=0.58)

Correlation coefficients with observed PC time series



The lead-lag correlation coefficients between NINO3.4 (170 W–120 W, 5 S–5 N) SST index with respect to JJAS monsoon indices including (a) the western North Pacific summer monsoon index, (b) the Indian summer monsoon index and (c) the extended Indian monsoon rainfall index.

The black lines denote the observation,

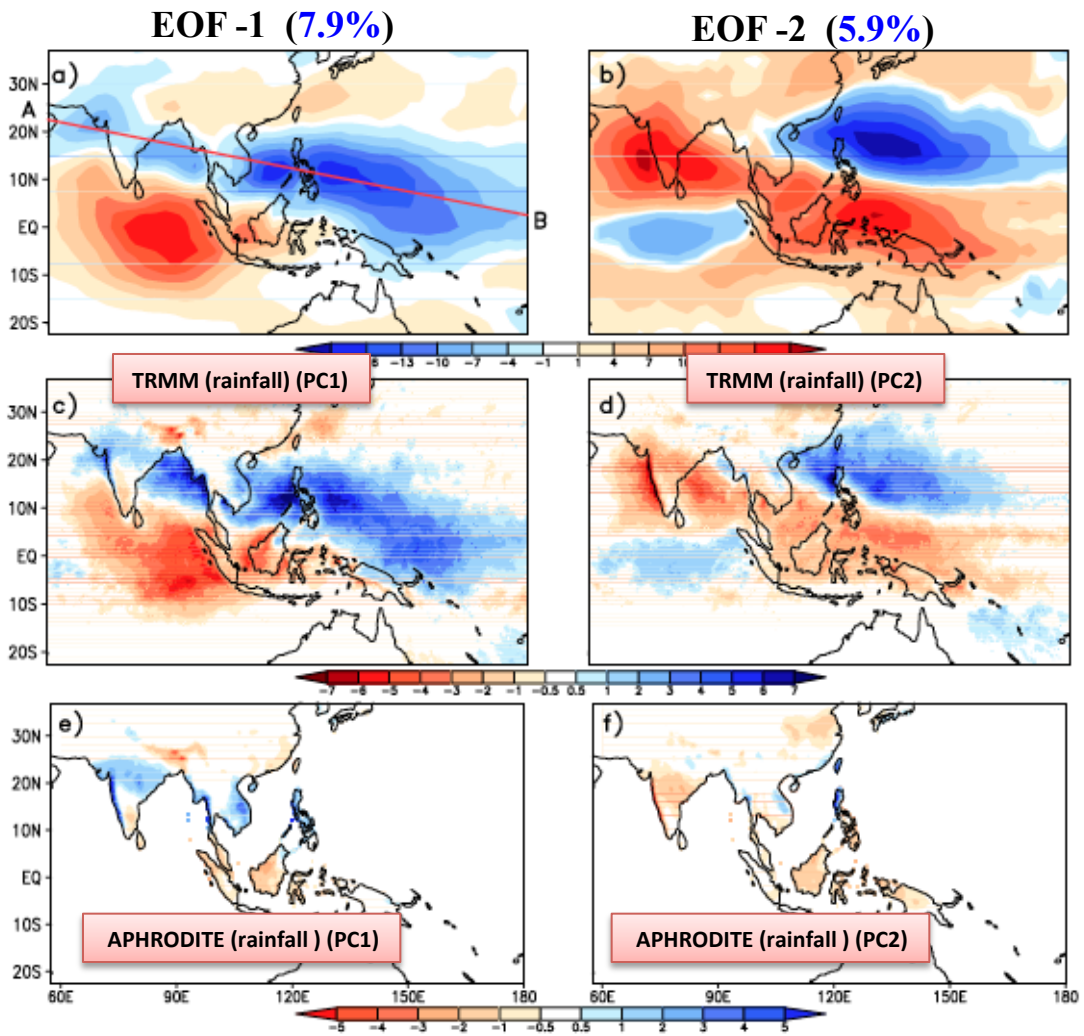
The green lines denote the CGCM,

The red lines denote the pacemaker run,

The blue line denotes AGCM AMIP run

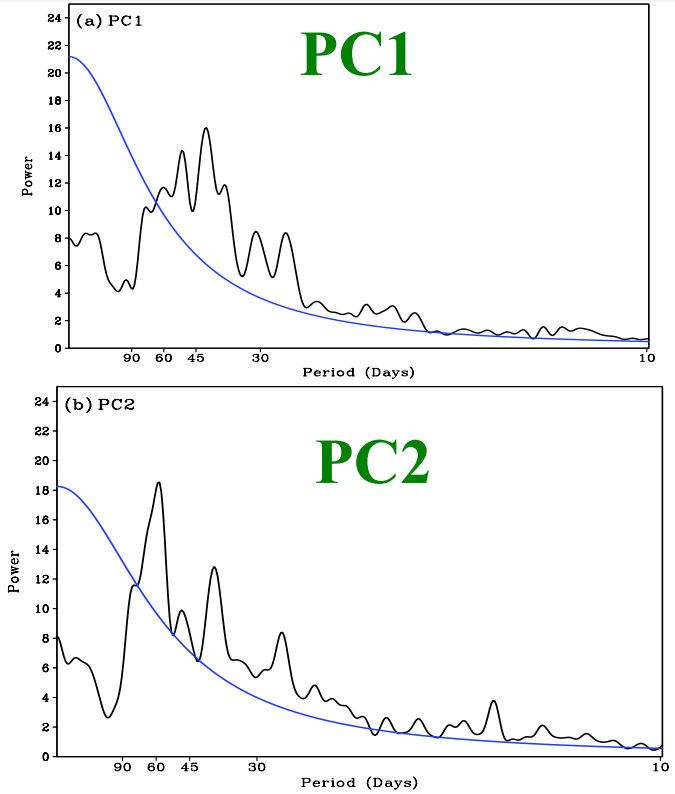
The dominant intraseasonal mode of intraseasonal South Asian summer monsoon

(a, b) Leading EOF 1, 2 of OLR anomalies based on pentad data in June-September (1979-2007) (57.5°E – 180°E, 22.5°S – 40°N)



The red line AB (Fig a) denotes the location of center of action associated with the minimum OLR

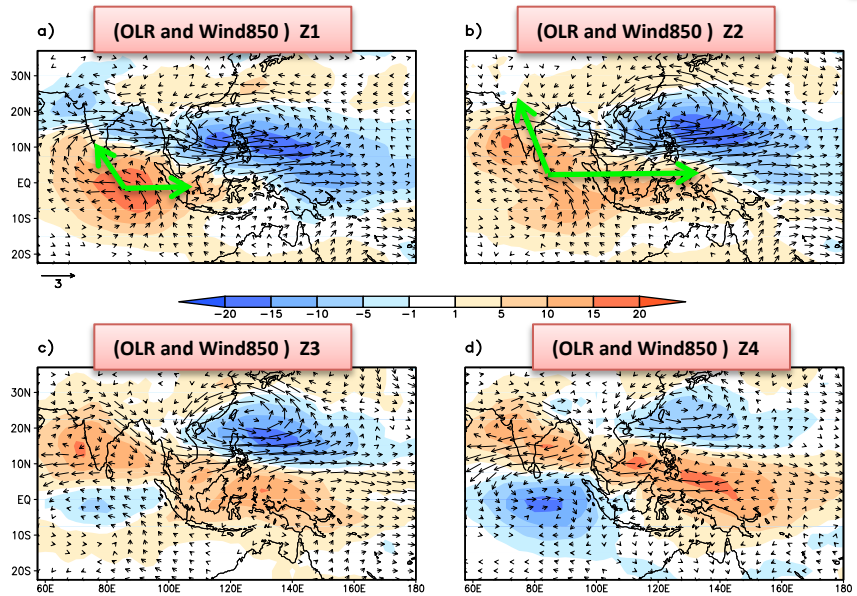
Power spectra of the rainfall PCs of OLR anomalies

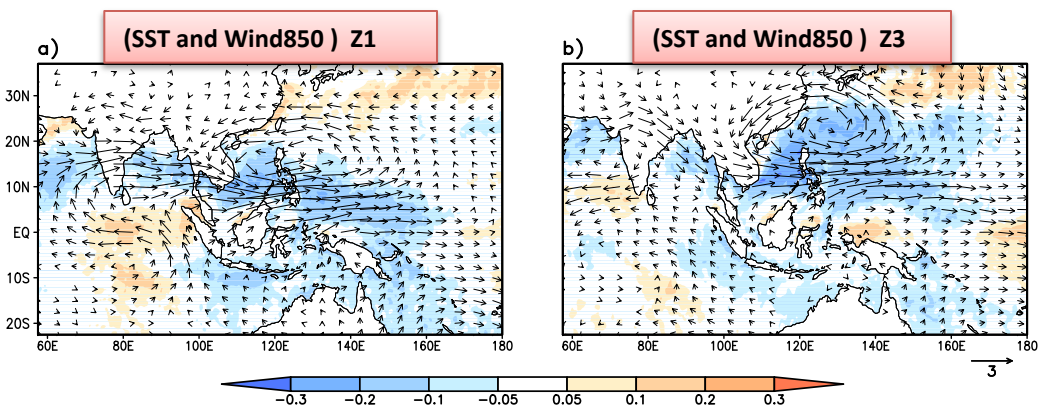


Ravi P Shukla, (**2014**) The dominant intraseasonal mode of intraseasonal South Asian summer monsoon, **Journal of Geophysical Research: Atmospheres,** 119, 635–651, doi: 10.1002/2013JD020335

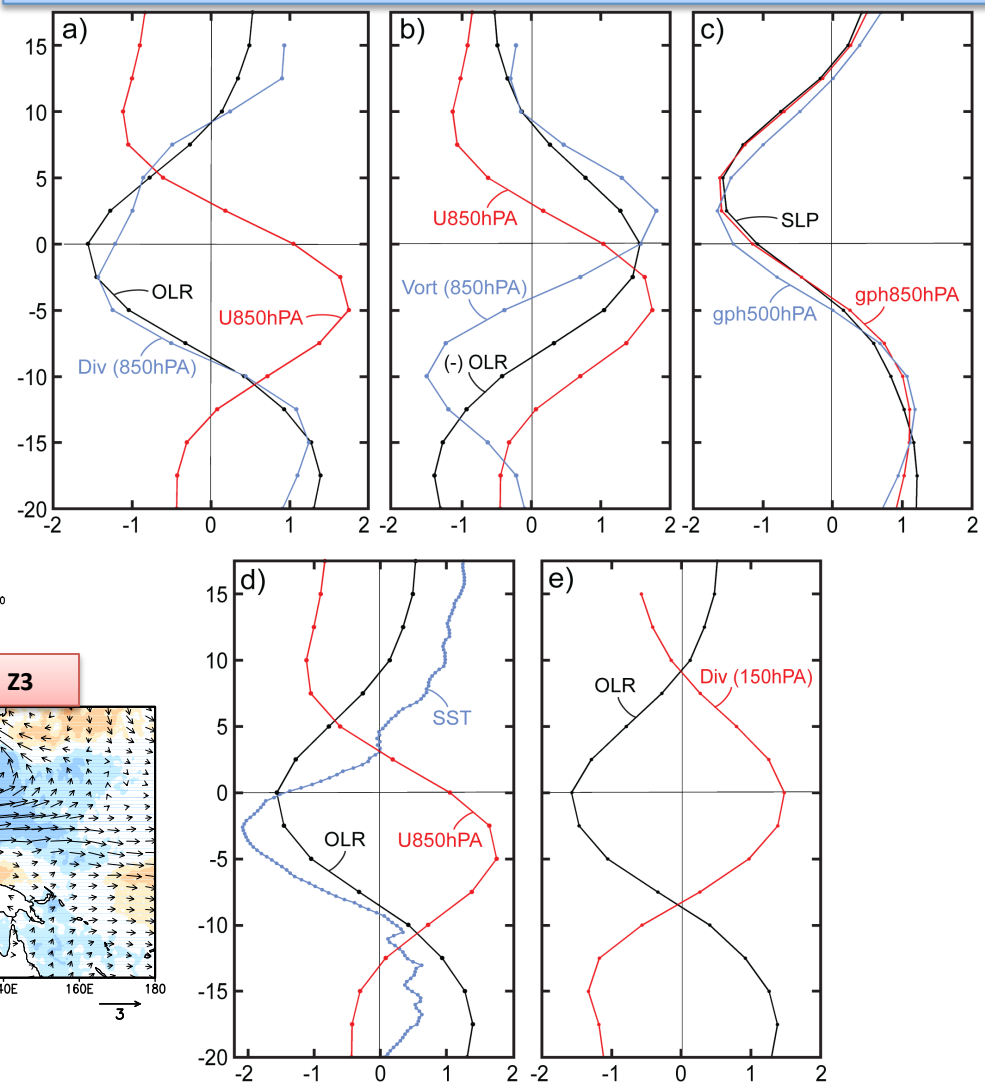
Evolution of the leading patterns of intraseasonal variability

(Four panel figures) $Z1 = PC1, \quad Z2 = \frac{1}{\sqrt{2}}(PC1 + PC2), \quad Z3 = PC2, \quad Z4 = \frac{1}{\sqrt{2}}(-PC1 + PC2)$





Standardized meridional profiles of a selection of variables relative to the sloping reference line



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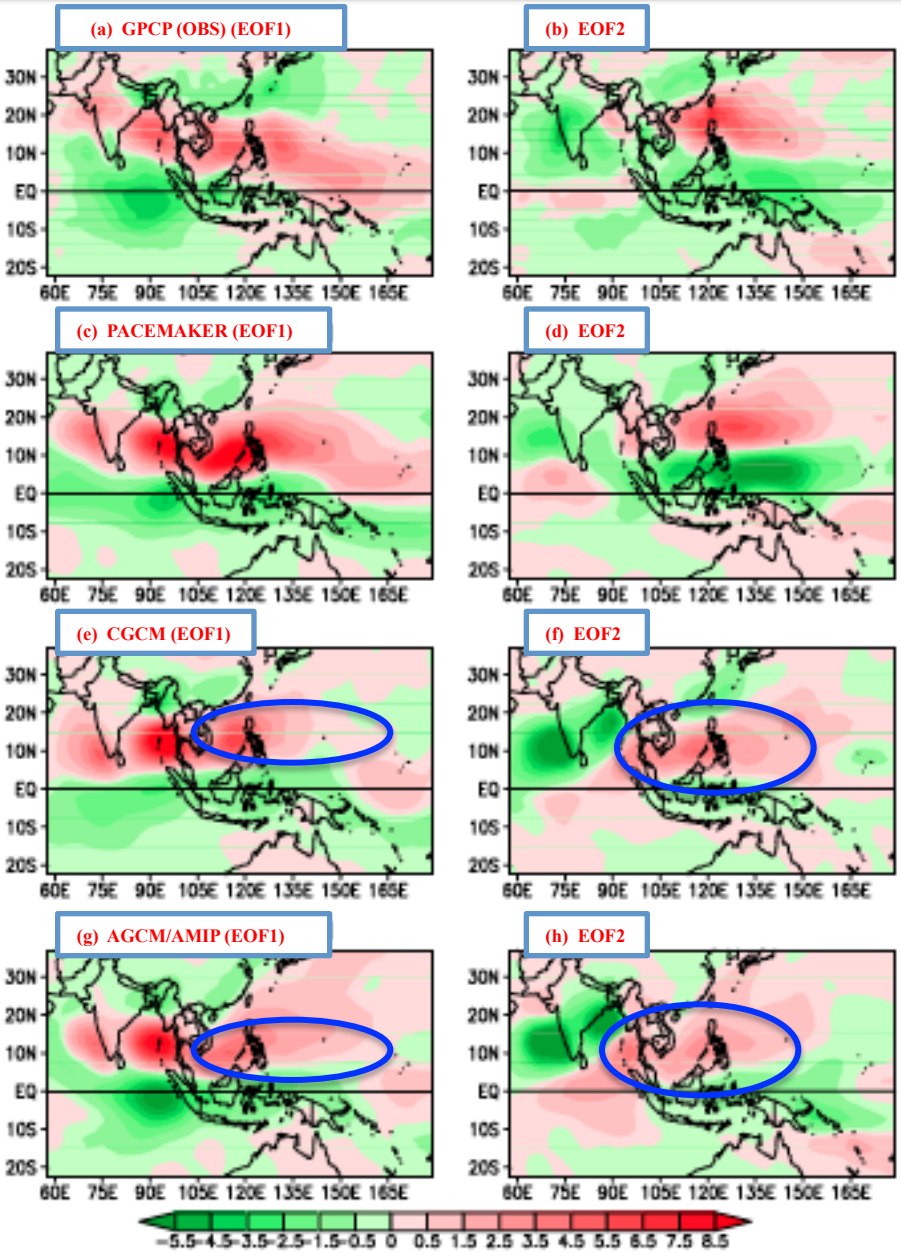
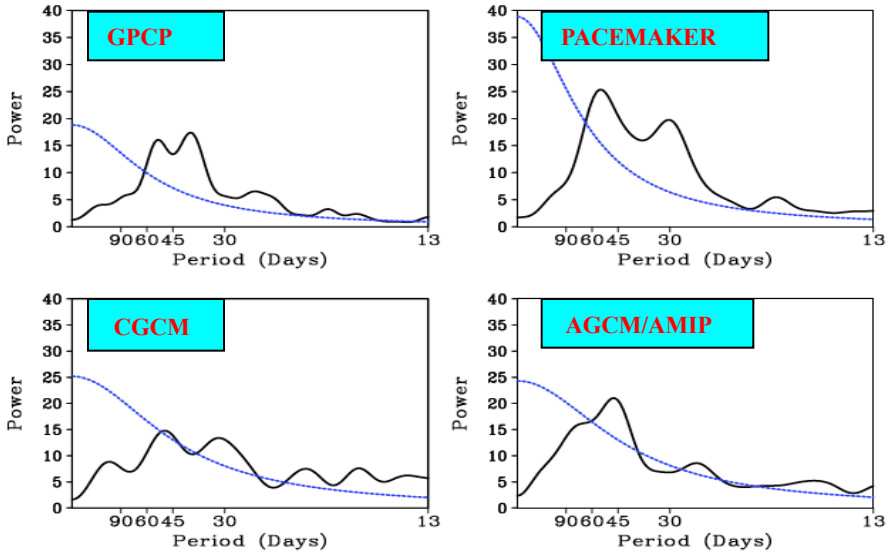
Leading EOF 1, 2 of rainfall anomalies based on daily data during June-September (57.5°E – 180°E, 22.5°S – 40°N)

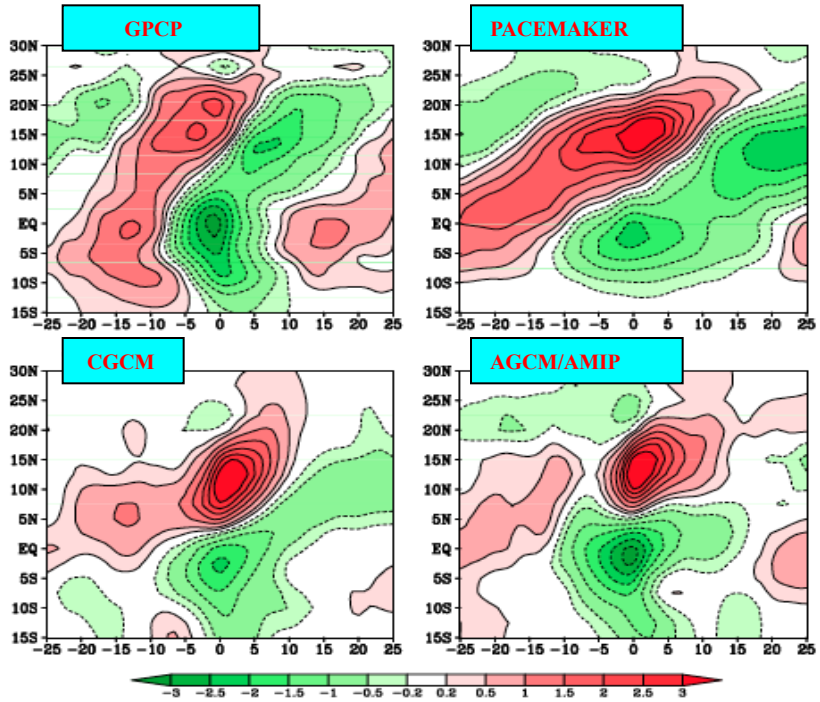


Power spectra of the rainfall PC1 of daily rainfall anomalies



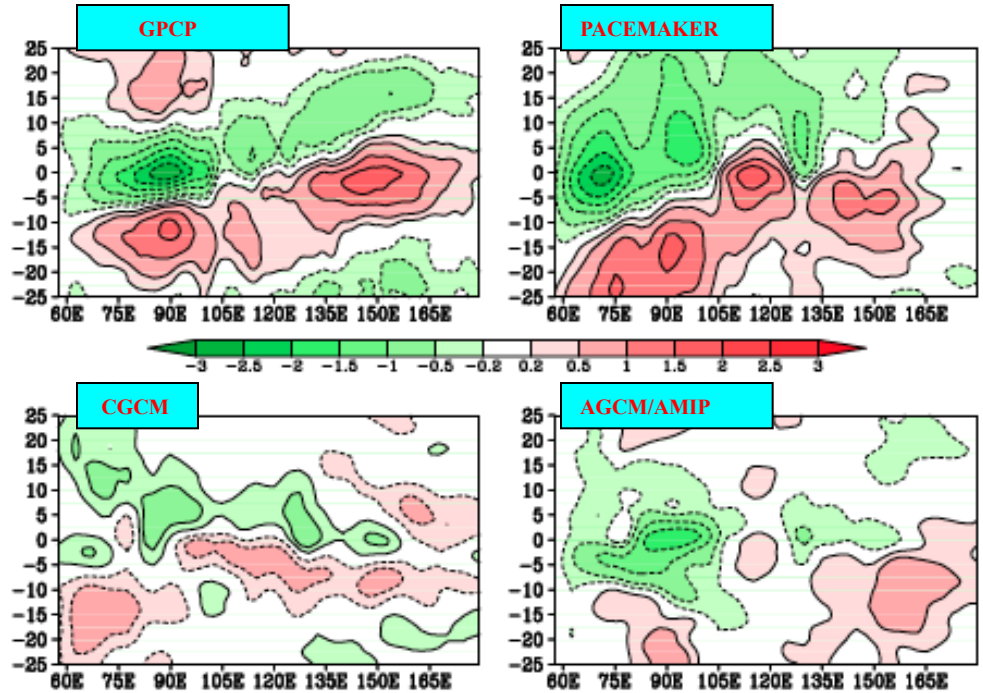
Northward propagation

Indian Longitudes (70°E-90°E)



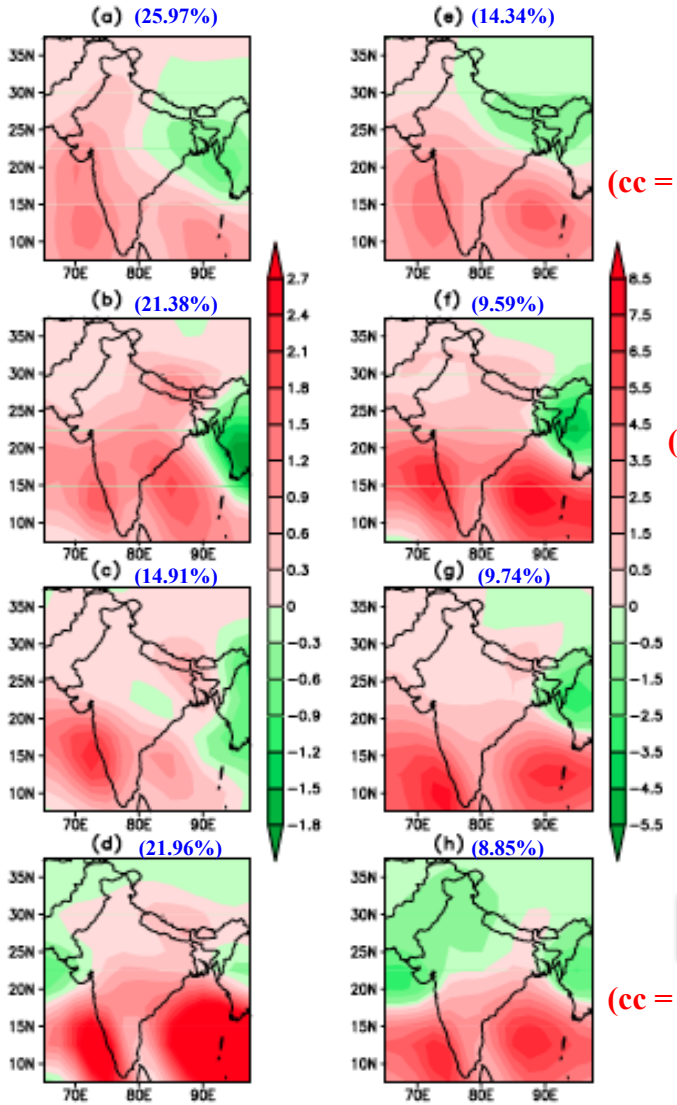
Eastward Propagation

10°S-10°N



(a,b,c,d) EOF-1 of JJAS seasonal anomalies of rainfall
(e,f,g,h) EOF-1 of JJAS pentad anomalies of rainfall

(a,b,c,d) Difference between strong and weak monsoon year composites rainfall
(e,f,g,h) Difference between active and break composites of rainfall



(a, e) CMAP

(cc = 0.78)

(b, f) Pacemaker

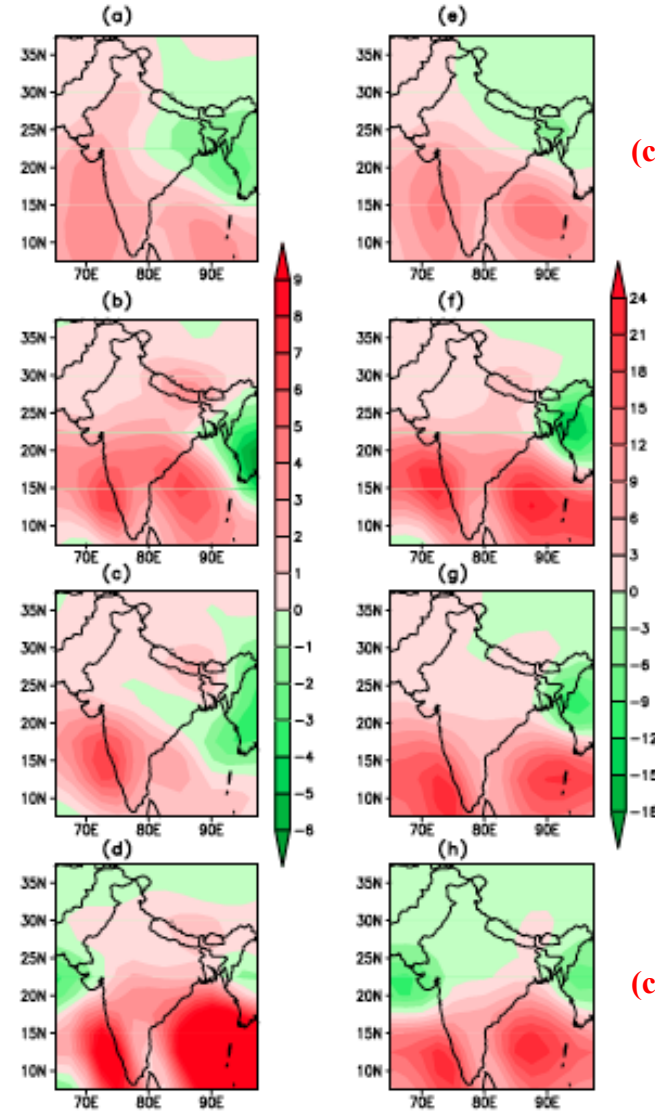
(cc = 0.73)

(c, g) CGCM

(cc = 0.44)

(d, h) AGCM/AMIP

(cc = 0.83)



(cc = 0.76)

(cc = 0.75)

(cc = 0.47)

(cc = 0.80)

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Conclusion:

- *The improvement in the pacemaker method compared to the CGCM shows that* simple systems with only local air-sea feedback are capable of greater realism than a sophisticated coupled model.

- *The northward/eastward propagation features* over India and the subtropical western Pacific region and the spectral peaks of rainfall are significantly more realistically captured by the Pacemaker in comparison to the CGCM and AGCM/AMIP

- *Based on the correlation coefficient between the seasonal and pentad EOF1 patterns and the composite analysis* the Pacemaker is able to reproduce the relationship between the intraseasonal and interannual variability of the South Asian monsoon.