24 October 2013, ICTP, Trieste, Italy

The observed and simulated monsoon intraseasonal variability over the Asia-Pacific: The Role of Air–Sea Coupling

Jagadish Shukla

Department of Atmospheric, Oceanic and Earth Sciences (AOES),

George Mason University (GMU)

Center for Ocean-Land-Atmosphere Studies (COLA)

Institute of Global Environment and Society (IGES)

Thanks to: Ravi P. Shukla, Jieshun Zhu, James L. Kinter, Wallace

IGES

Center of Ocean-Land-Atmosphere studies COLA

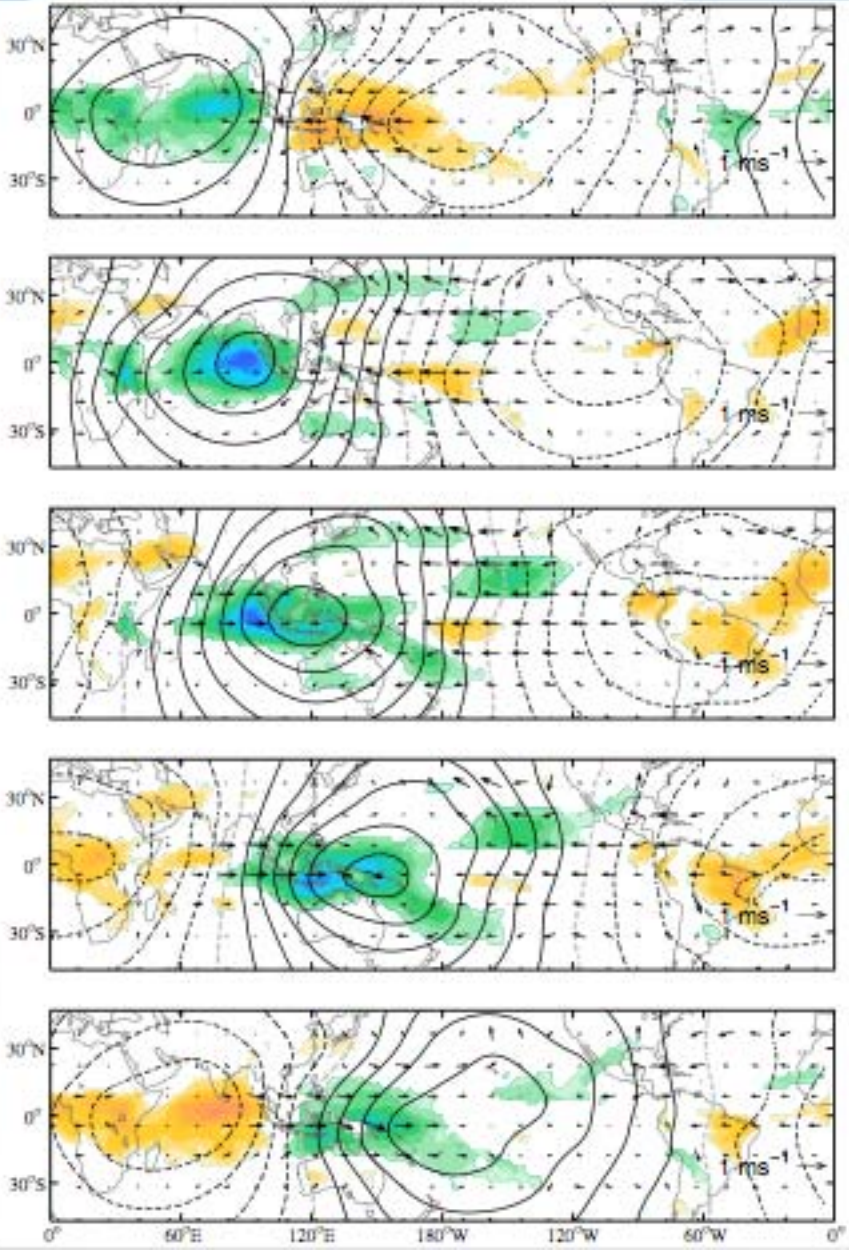
GEORGE MASON UNIVERSITY

Data

- ERA – Interim pressure level fields
  - 1979-2011 four times daily (33 years)
  - 1.5° x 1.5° resolution
- NOAA OLR
  - 1979-2011 daily
  - 2.5° x 2.5° resolution

Angel Adames and Mike Wallace
COLA MJO Workshop, June, 2013

MJO phases with 150-850 hPa χ



Phase 2 -> - PC2

Phase 3 -> PC1 - PC2

Phase 4 -> PC1

Phase 5 -> PC1 + PC2

Phase 6 -> PC2

❖ **Daily/Pentad anomalies** (obtained by subtracting the respective seasonal-varying climatological-mean fields from total field and also removed each year mean)

❖**EOFs analysis was performed on the:-**

(**OLR field, 850hPa wind and 150hPa wind fields**)

defined within a:-

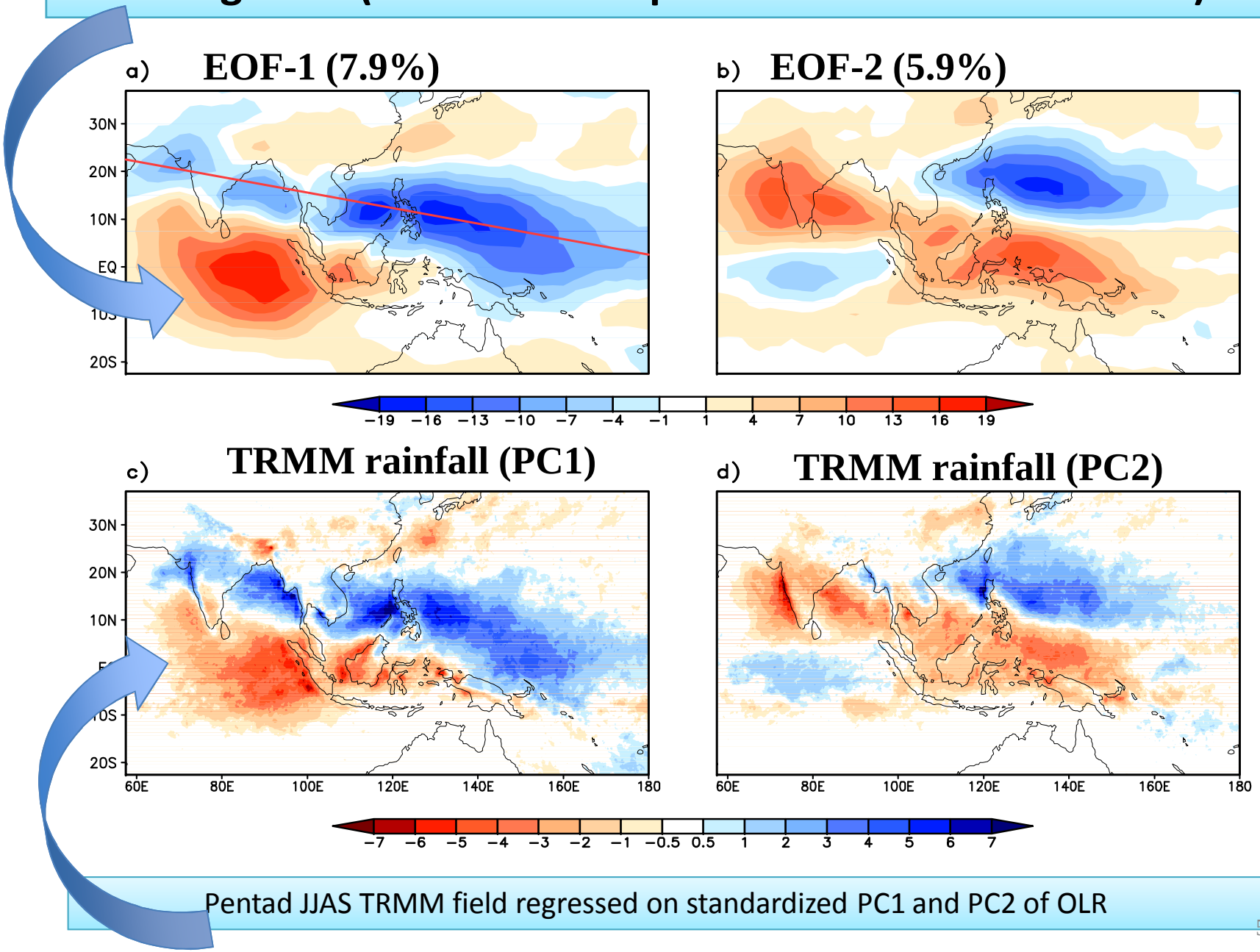
(number of different domains)

comprising South Asia during the monsoon season (JJAS)

❖**Most of the results shown in this lecture will base on:-**

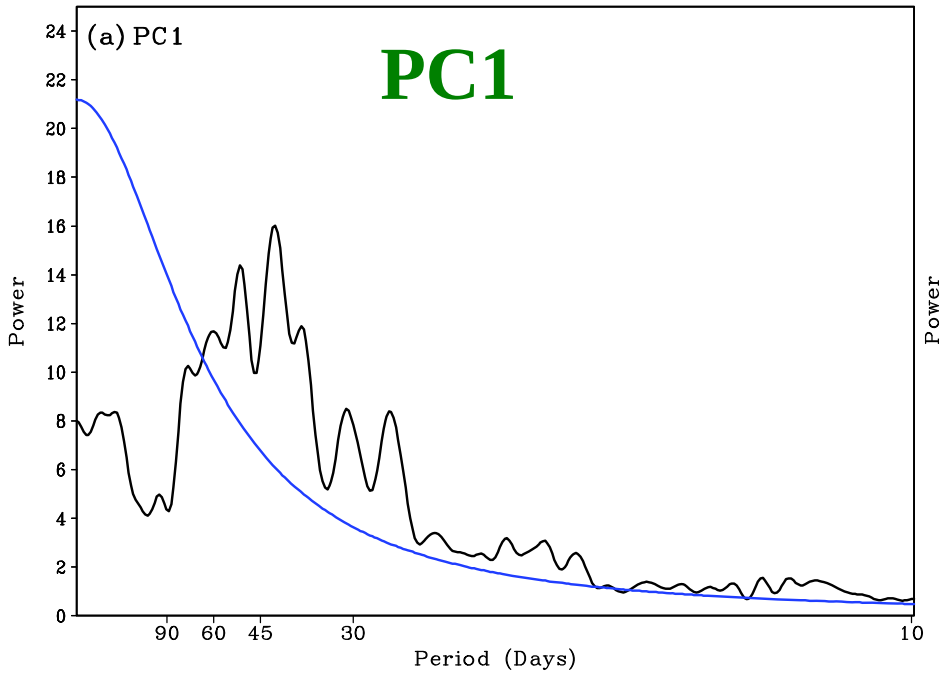
(The leading EOFs of OLR defined within the domain **57.5° E – 180° E, 22.5° S – 40° N**)

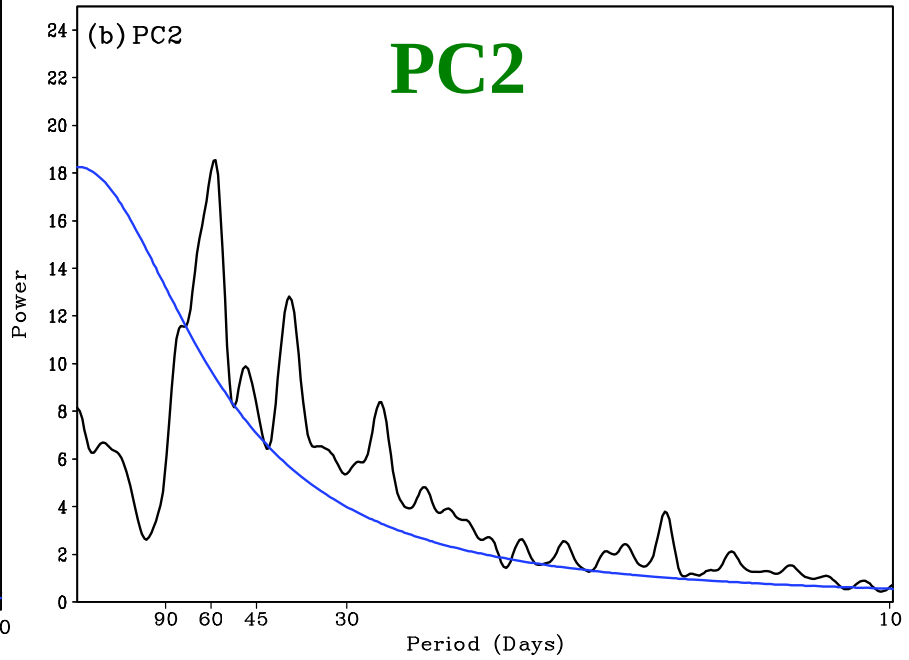
Leading EOFs (OLR based on pentad data for JJAS Season)



Pentad JJAS TRMM field regressed on standardized PC1 and PC2 of OLR

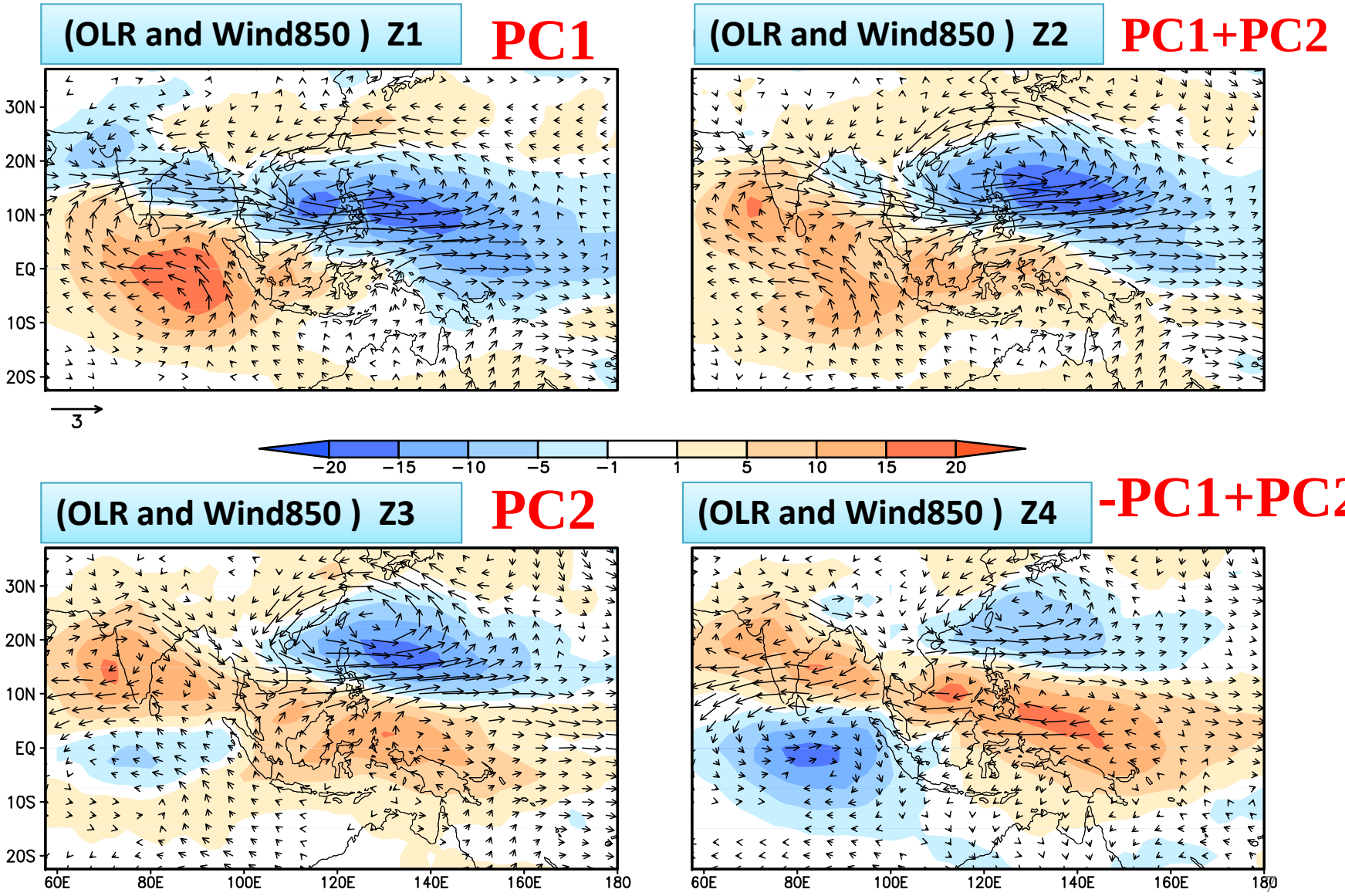
Power spectra of the PCs of the leading two EOFs of the JJAS OLR



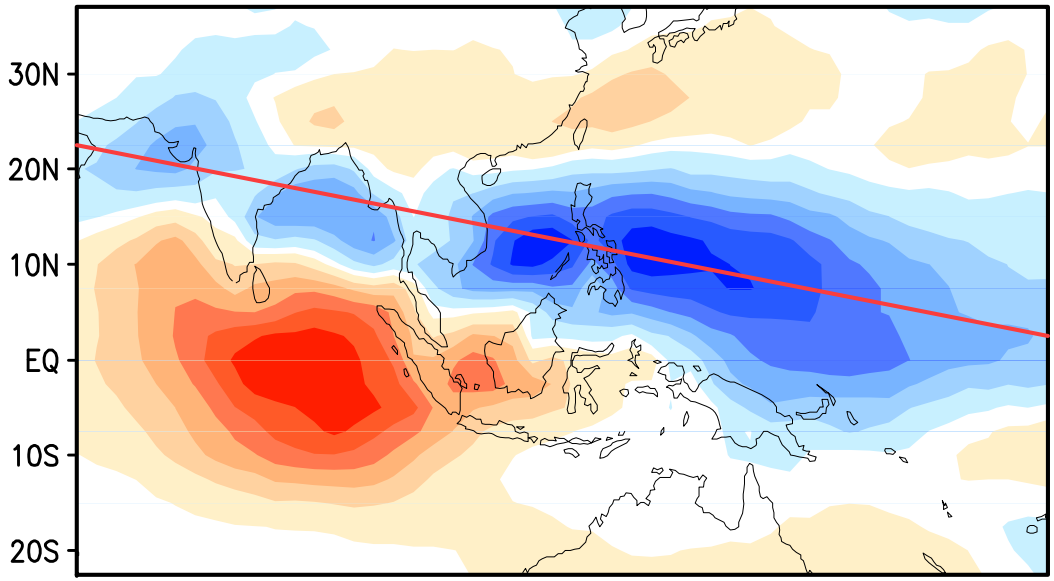


30-60 day oscillation

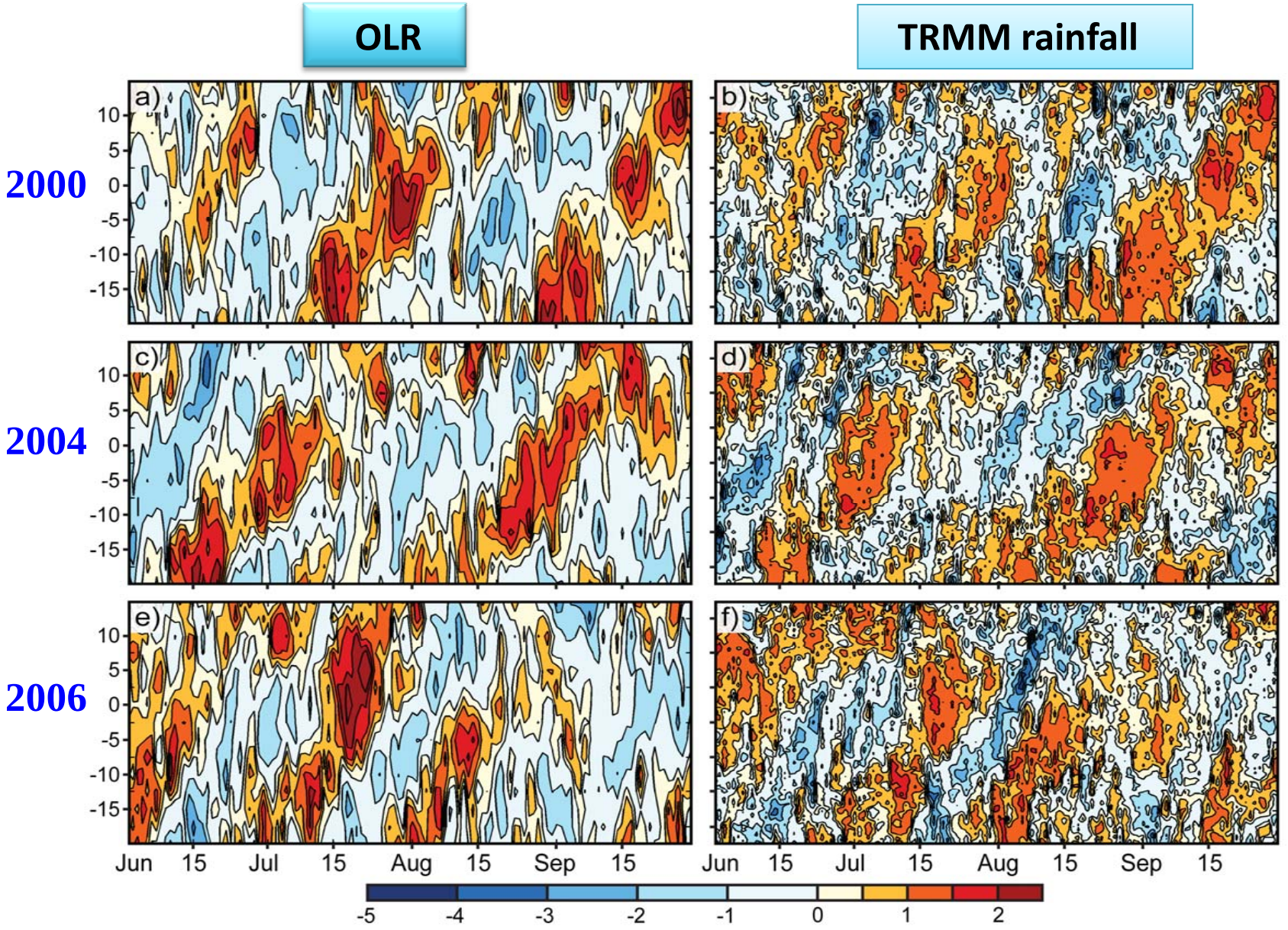
Projection of OLR (colored shading) and 850 hPa wind vectors upon standardized linear combinations of PC1 and PC2 of pentad-mean JJAS OLR: (*a*) PC1; (*b*) PC1 + PC2; (c) PC2; (*d*) –PC1 + PC2.



For evidence of the northward propagation: (Time-latitude plots of zonally averaged OLR and TRMM rainfall: based on daily data)

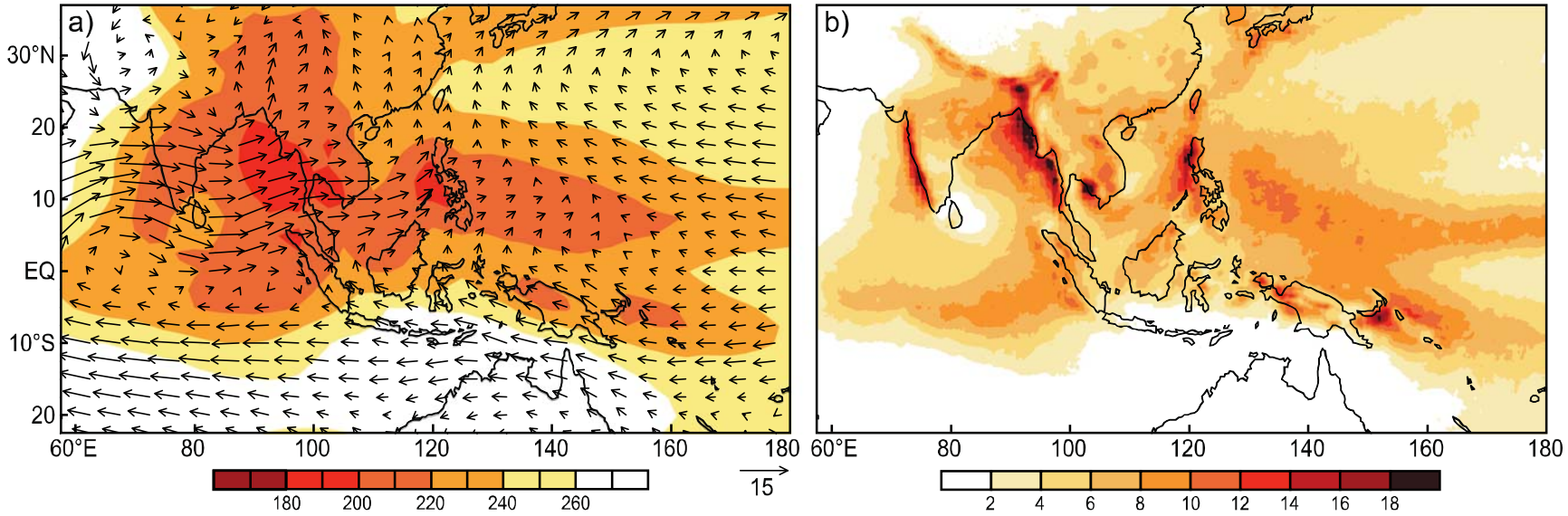


Time-Latitude section of daily JJAS OLR and TRMM Rainfall



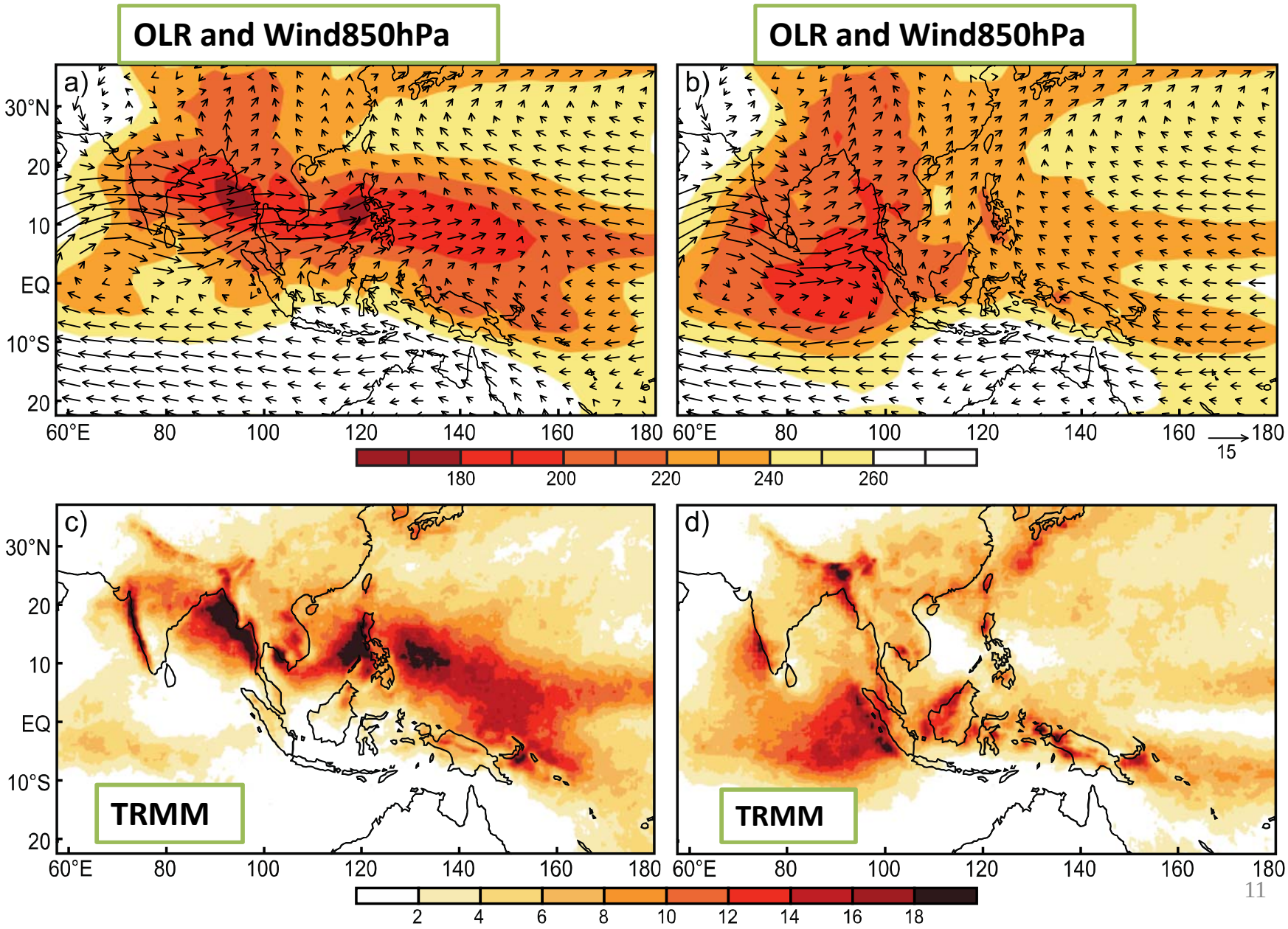
OLR and Wind850hPA

TRMM rainfall

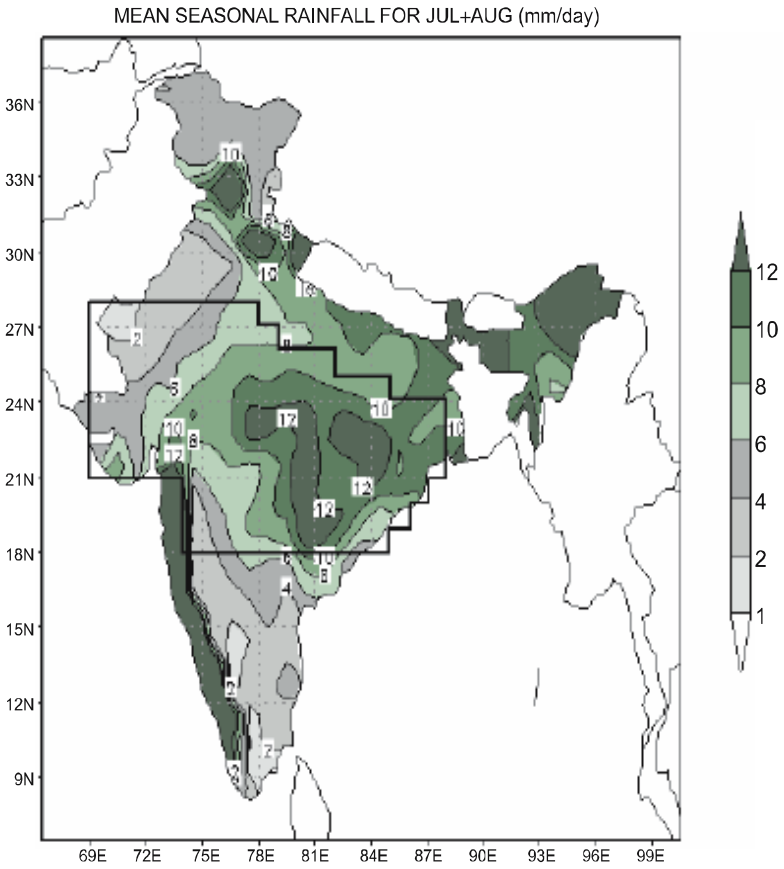


The JJAS OLR and 850 hPa wind climatologies and the corresponding TRMM rainfall climatology

Impact of the MISO on the Asian summer monsoon



Active and break spells of the Indian summer monsoon rainfall



Active spell: **Standardized rainfall anomaly is less than 1.0, consecutively for three days and more**

Break spell: **Standardized rainfall anomaly is less than -1.0, consecutively for three days and more.**

	active	unclassified	break
PC1+	65	219	10
unclassified	139	903	150
PC1–	5	221	86

Contingency table comparing "active", unclassified, and "break" dates in Rajeevan et al. (2010) with dates for which the polarity of PC1 of daily JJAS OLR is above +1, between –1 and +1, and below –1 standard deviation.

Rajeevan, M., S. Gadgil, and J. Bhate, 2010: Active and break spells of the Indian summer monsoon. *Earth Syst. Sci.*, **119**, 229–247.

The Role of Air–Sea Coupling:

1. Prediction of mean monsoon rainfall

2. Monsoon intraseasonal variability over Asia-Pacific

Model and Experiments

***Tier-1** vs. **Tier -2**: 6-month hindcasts starting from April (1982-2009)*

- **Forecast Model: NCEP CFS version 2**

1) Atmosphere T126, L64
2) Ocean (MOM4) 0.5° x0.5° (0.25° lat, 10° S-10° N), L40

- **Initialization Conditions (1982-2009)**

1) Ocean initial state: **Instantaneous states from ECMWF ORA-S4**
2) Atmosphere/Land initial state: CFSR
3) Perturbed Atmosphere-land IC (4-member with each OIC, Apr 1-4, CFSR)

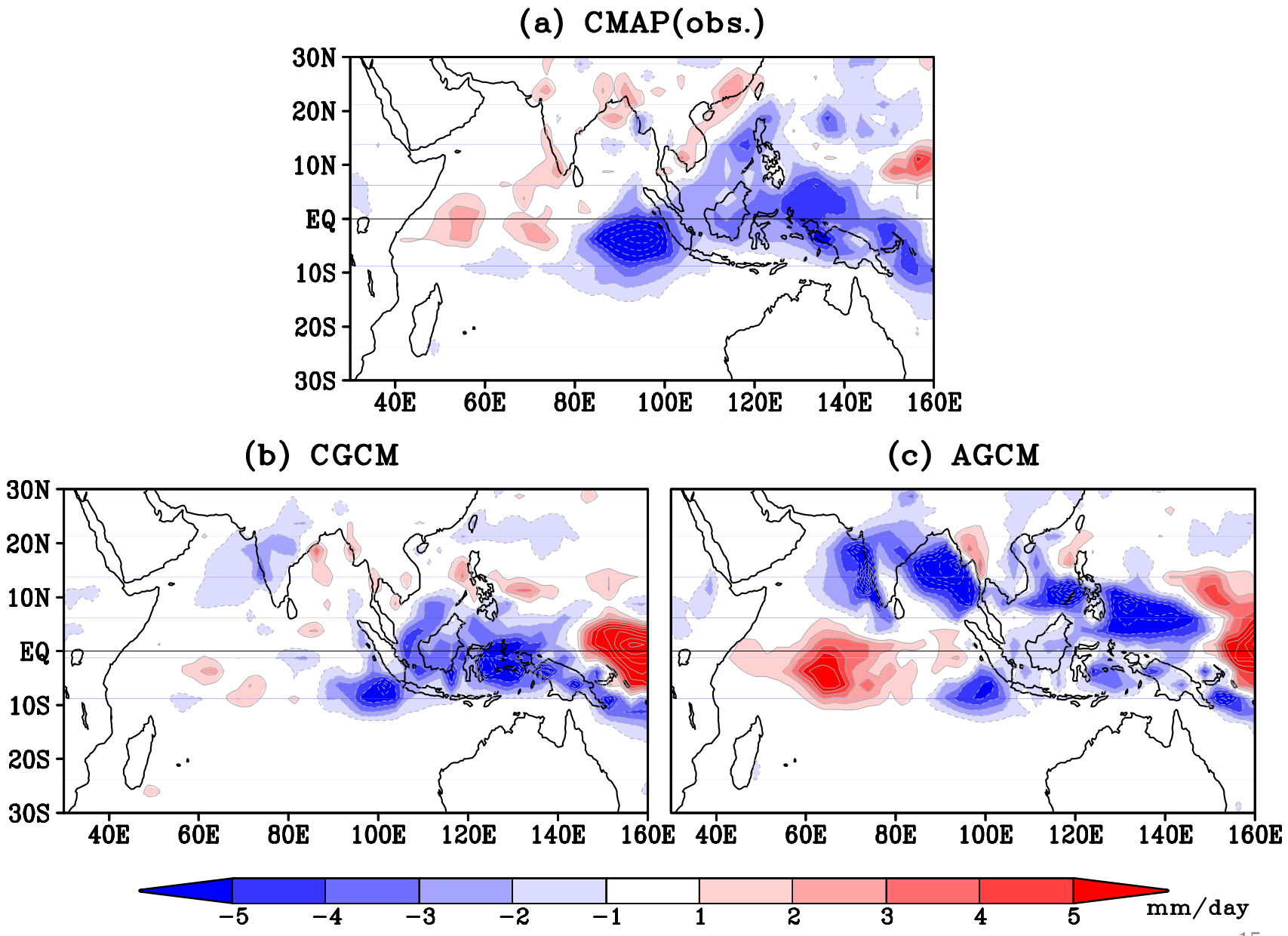
Experiment design (Coupled vs. Uncoupled)

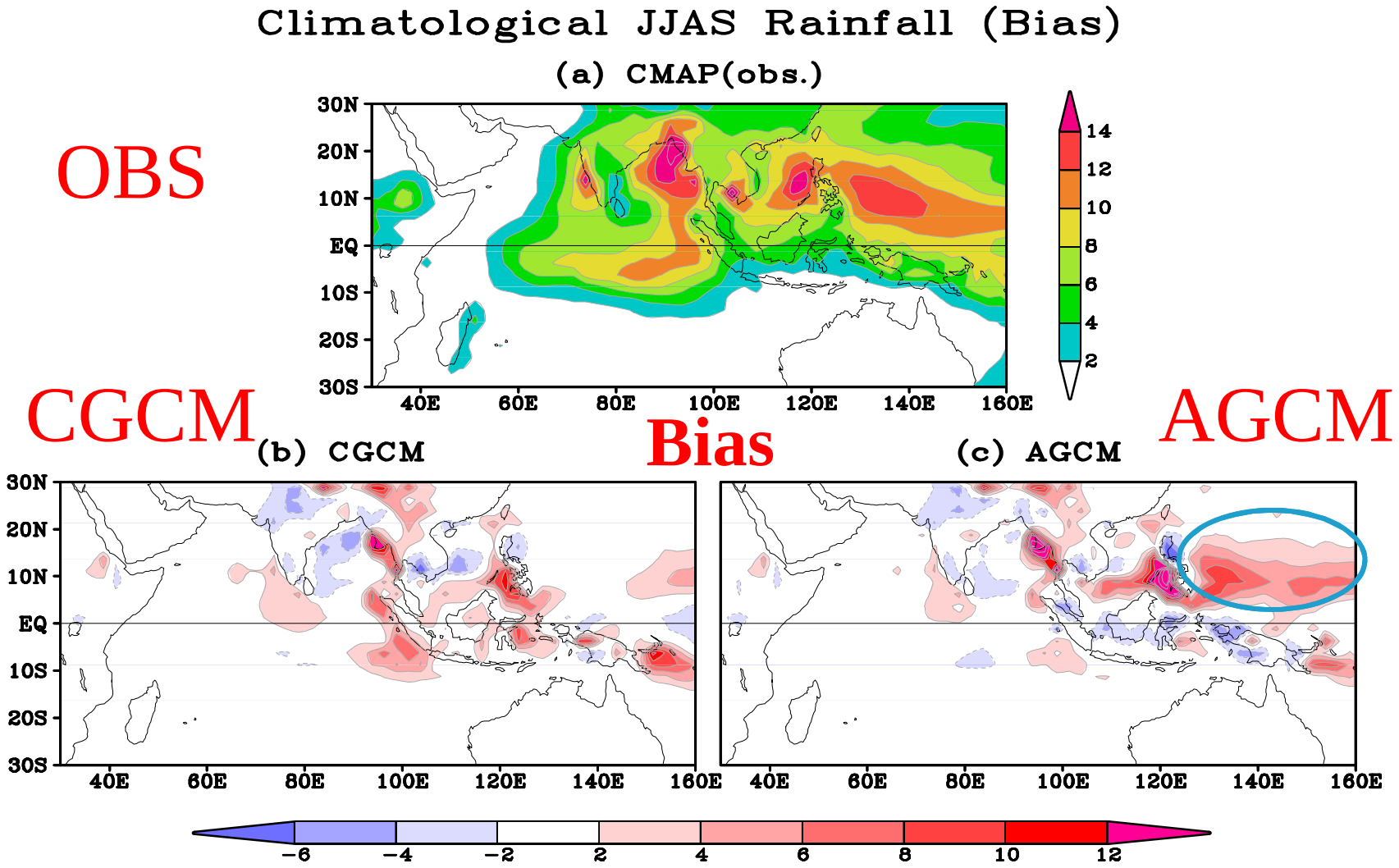
An identical AGCM and IC is used in Tier-1 and Tier-2 predictions

Tier-1: coupled run based on CFSv2

Tier-2: Daily mean SSTs from Tier-1 are prescribed as boundary conditions

JJAS Rainfall Anomalies in 1997



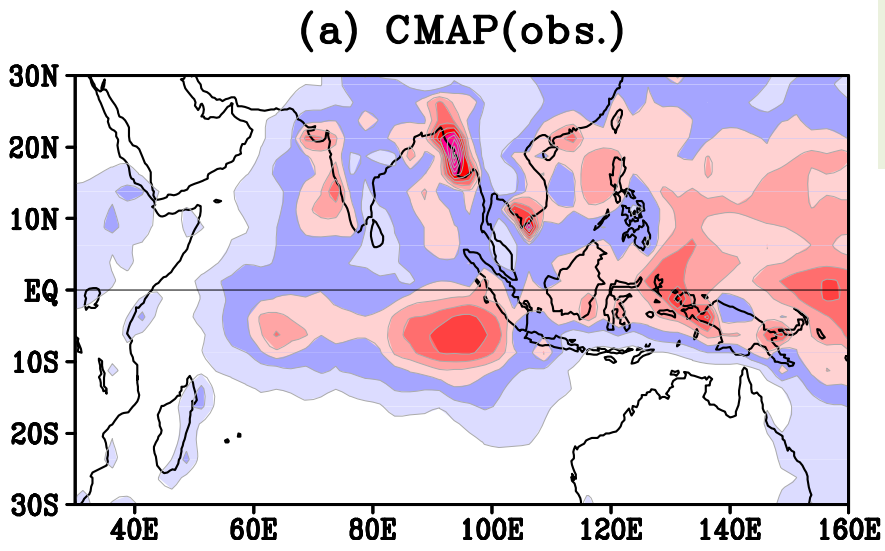


Zhu, J. and J. Shukla, 2013: The Role of Air–Sea Coupling in Seasonal Prediction of Asia–Pacific Summer Monsoon Rainfall. *J. Climate*, **25**, 5689-5697, doi:10.1175/JCLI- D-13-00190.1.

Standard Deviation

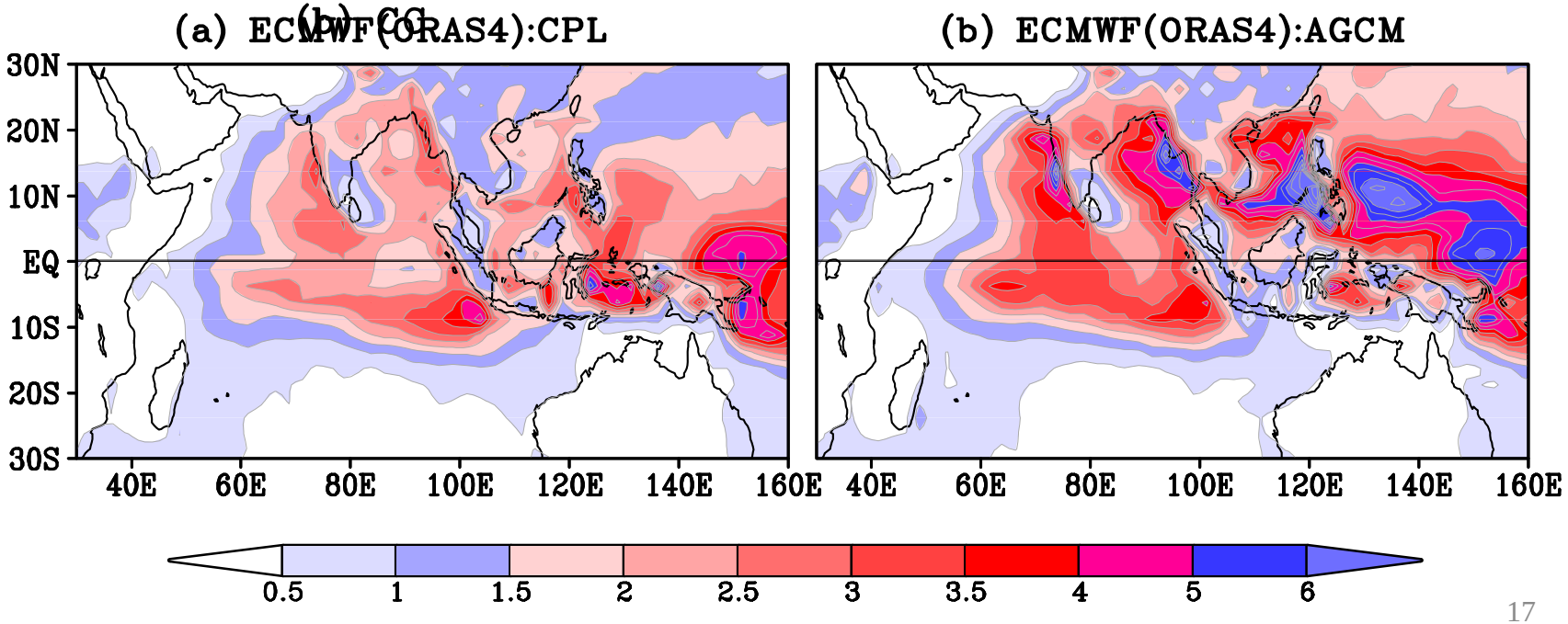
Calculating STD for each member, and then average.

OBS



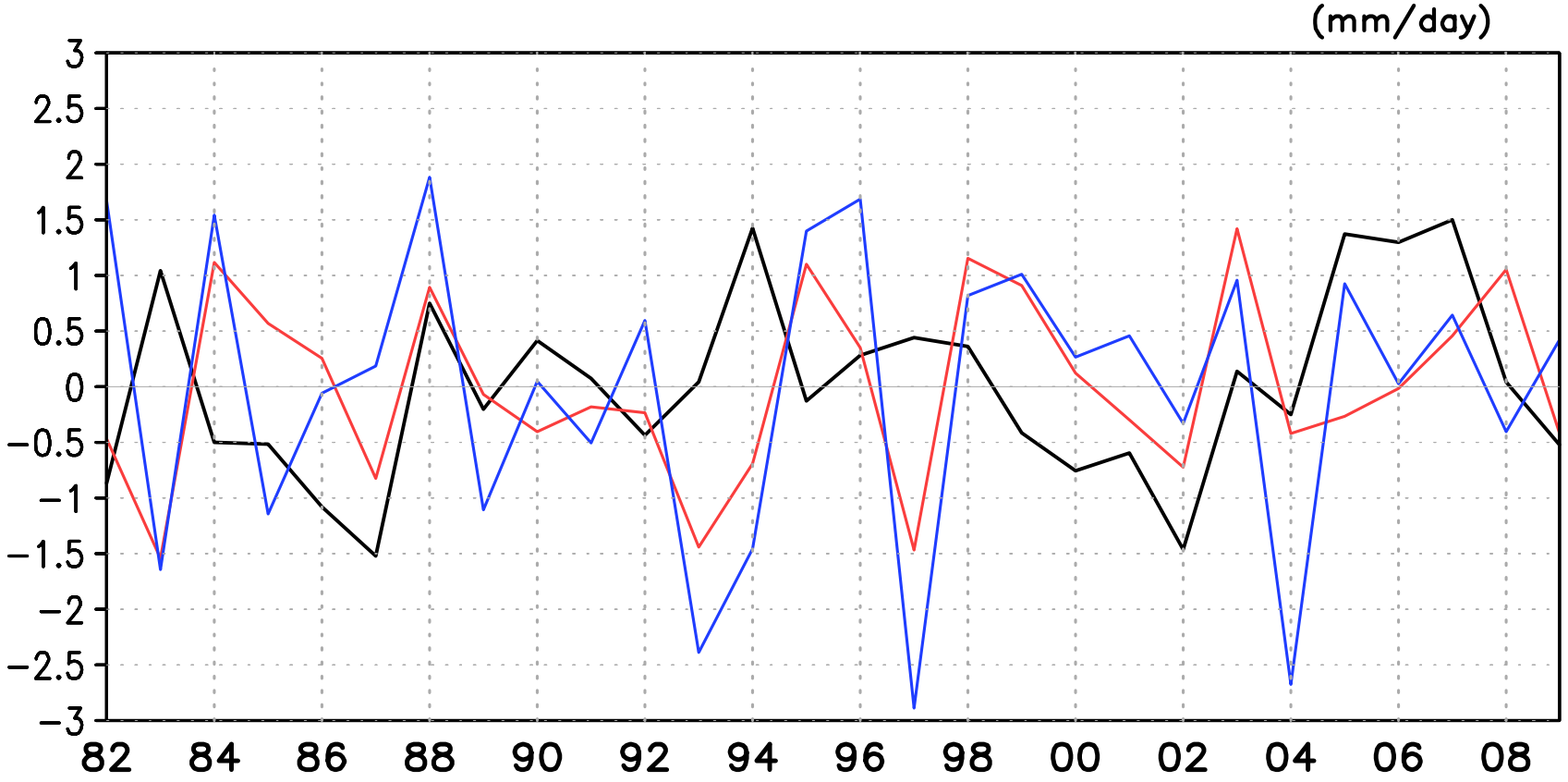
CGCM

AGCM



Seasonal Forecasts (1Apr IC) with CGCM(CFS) & AGCM(GFS)

ISMR (70E–90E,10N–25N: Land)



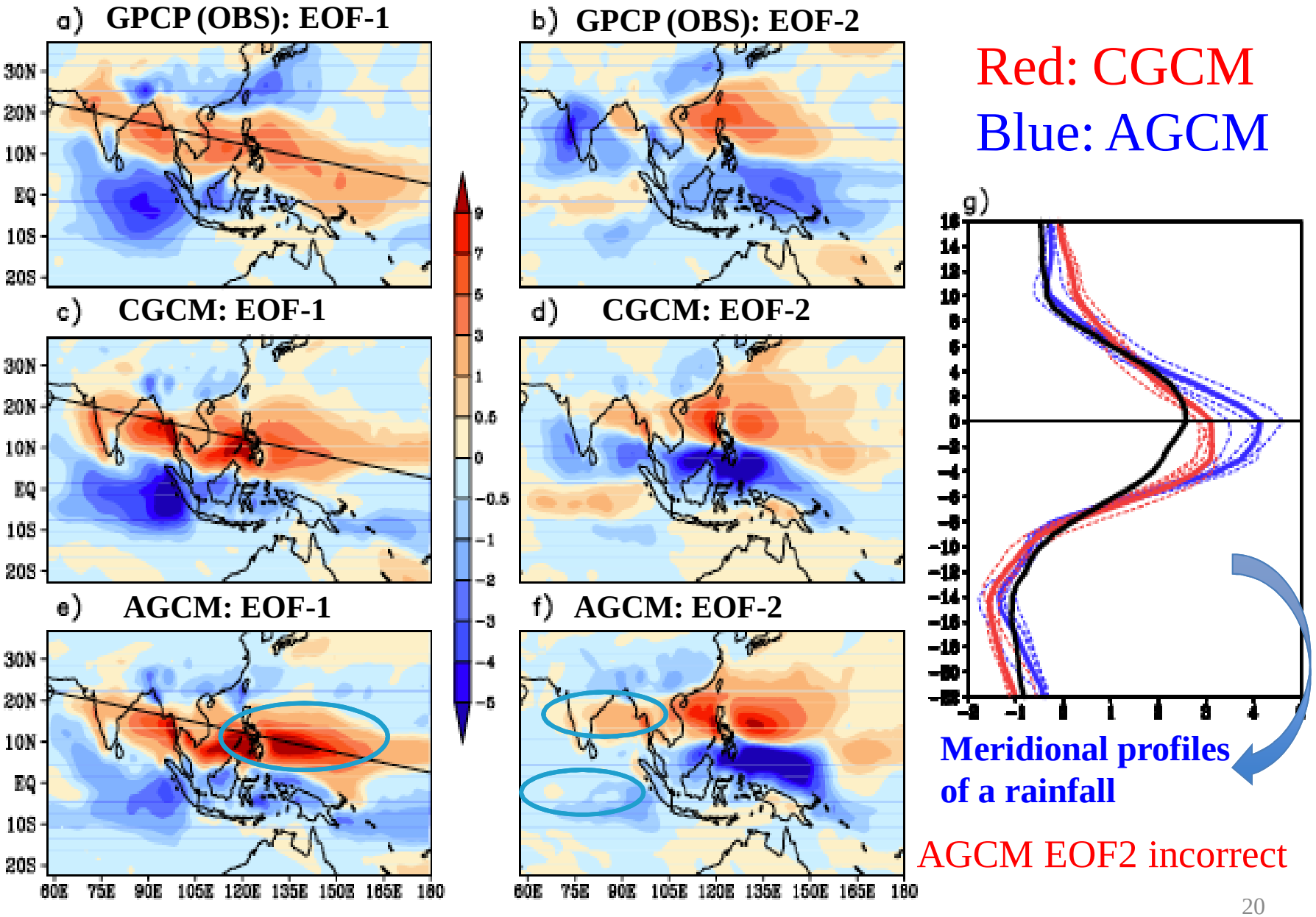
	Observation	CFS(ORA–S4)–Coupled	GFS(ORA–S4)–AGCM
MEAN	7.2	6.3	6.5
StdDev	0.82	0.81	1.30
ACC		−0.01	−0.09
RMSE		1.16	1.60

The Role of Air–Sea Coupling:

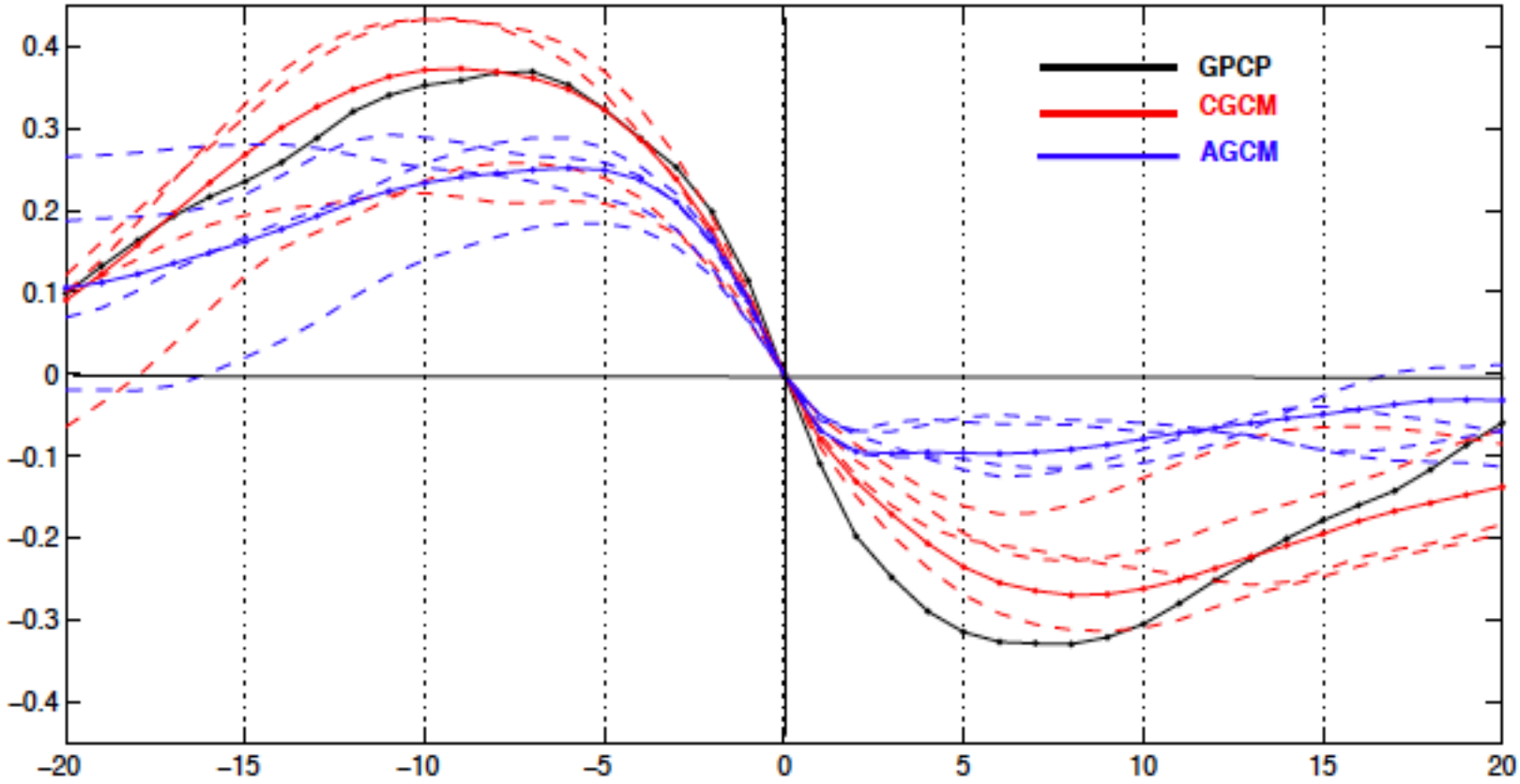
1. Prediction of mean monsoon rainfall

2. Monsoon intraseasonal variability over Asia-Pacific

Leading EOF 1, 2 of rainfall anomalies based on daily data for June-September (JJAS)

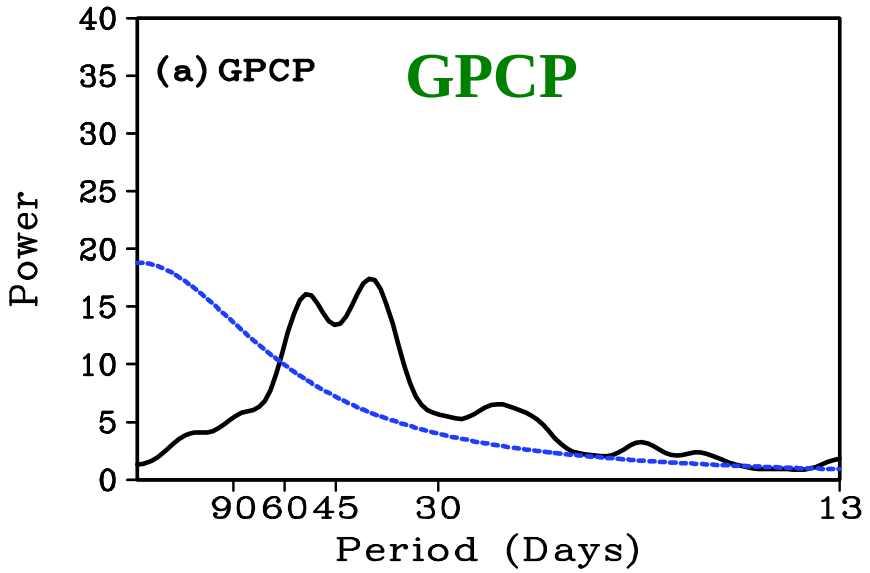


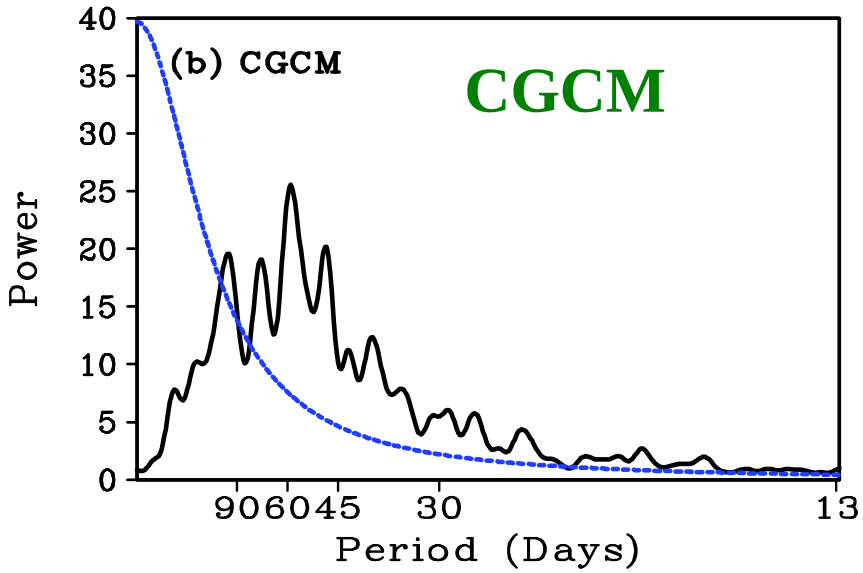
Lead-lag correlation between the two leading principal components (PCs). A lag of +1 indicates PC1 leading PC2 by 1 day.

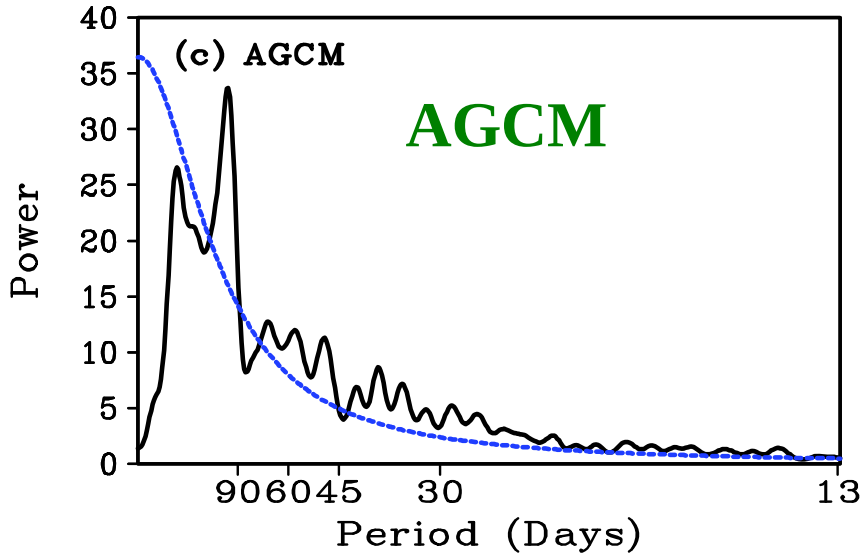


AGCM has incorrect lead-lag relationship between PC1 and PC2.

Power spectra of the PCs of the leading two EOFs of the JJAS rainfall

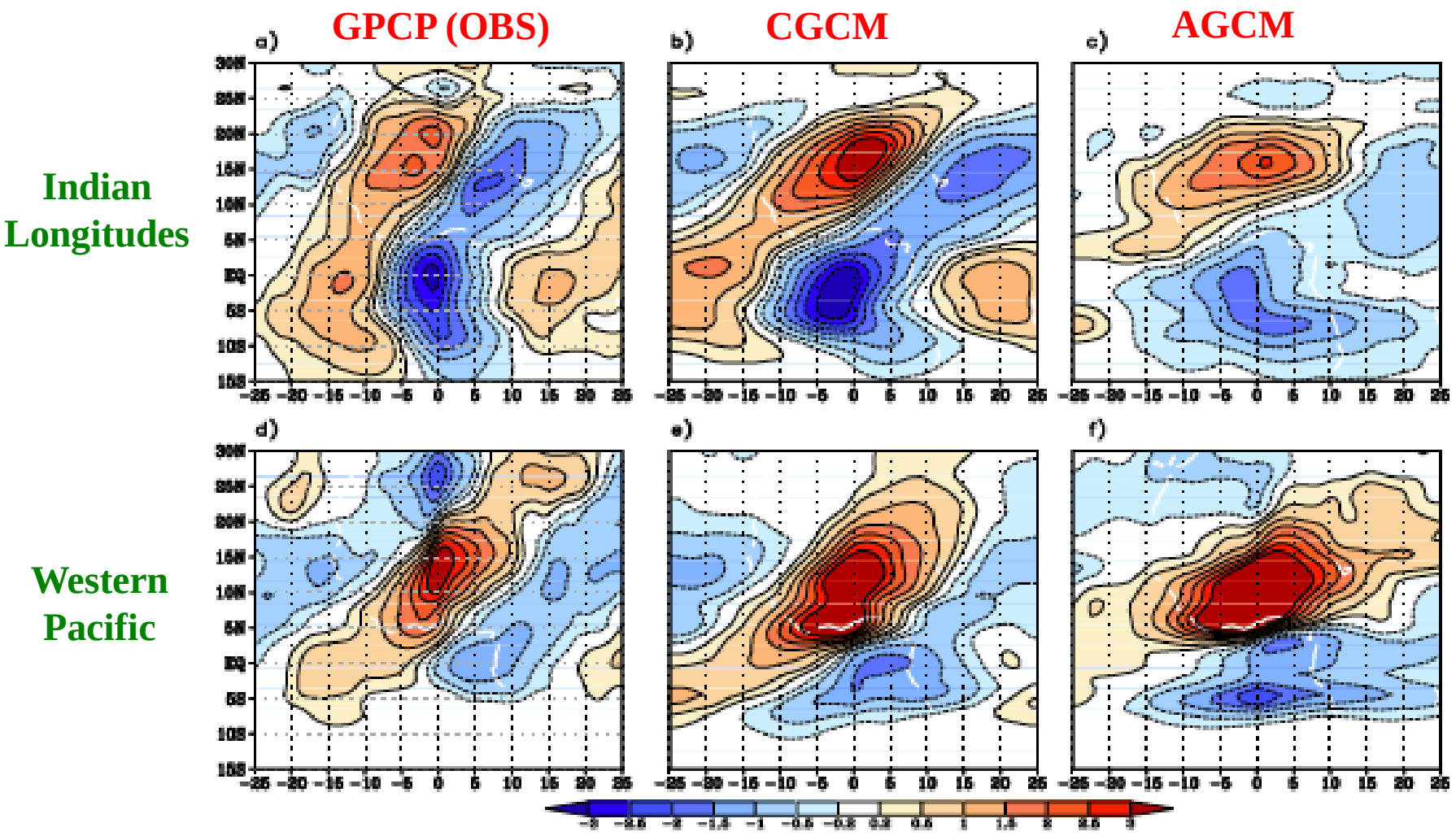






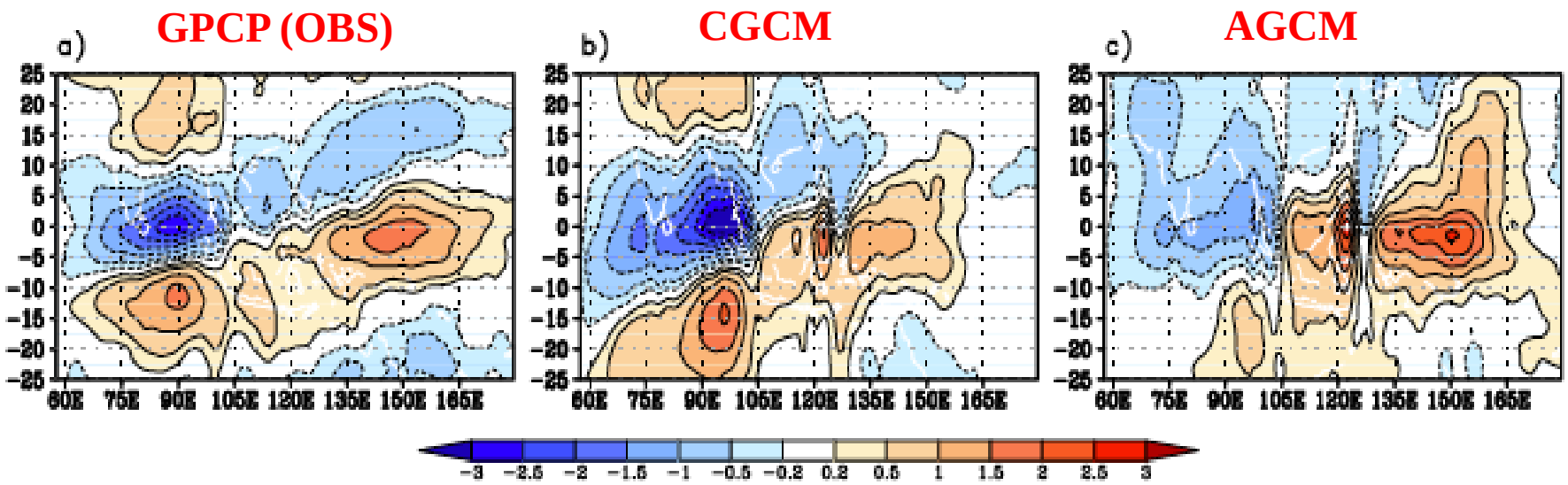
CGCM simulates the observed spectra realistically.

Northward Propagation



CGCM simulates northward propagation realistically.

Eastward propagation



Uncoupled (AGCM) has no eastward propagation

Summary

In the absence of air–sea coupling, AGCM simulation produces **higher rainfall biases** and unrealistically **high rainfall intraseasonal variations** over western pacific region. CGCM has better seasonal forecast skill.

Monsoon Intra-Seasonal variability simulated by **CGCM has realistic northward propagation** over Indian and western pacific region. AGCM has virtually no eastward propagation.

THANK YOU!

ANY QUESTIONS?