Dominant daily modes of the South Asian summer monsoon rainfall in the NCEP CFS

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With thanks to
Prof. V. Krishnamurthy, COLA/GMU

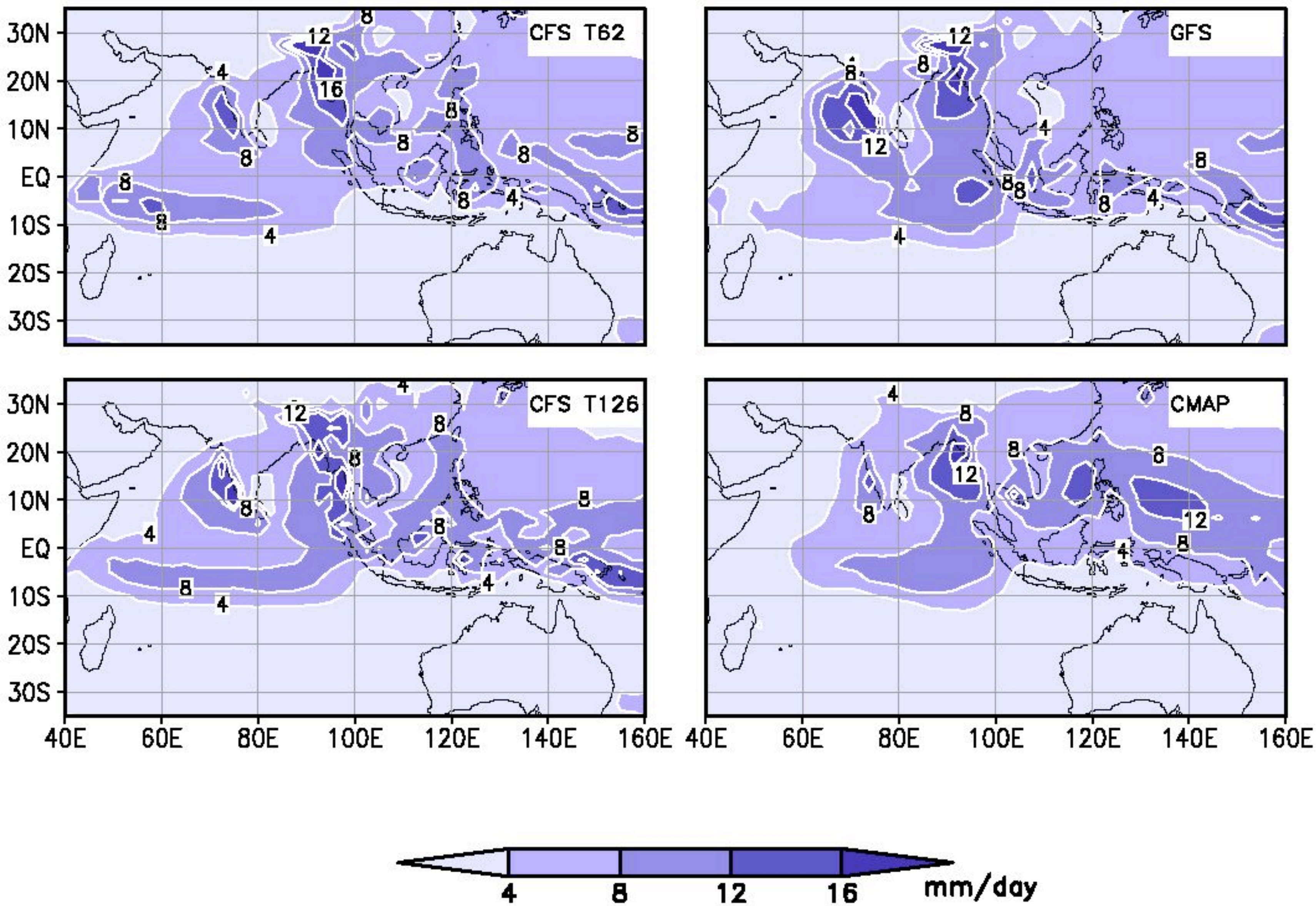
Background and Objectives

- Observational studies show presence of two dominant intraseasonal modes and two non-oscillatory modes in summer monsoon rainfall
- Identify dominant intraseasonal and persistent summer modes in CFS and compare with observations
- Compare the modes simulated by CFS T62, T126 and GFS free runs.

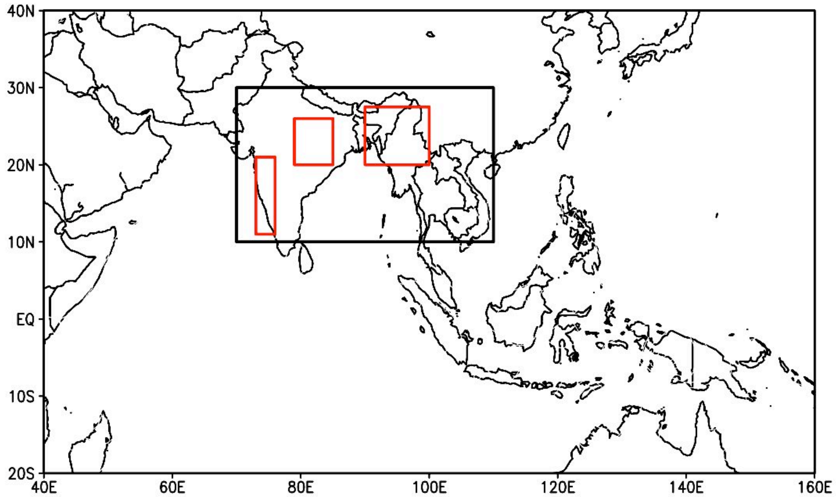
Models and Data

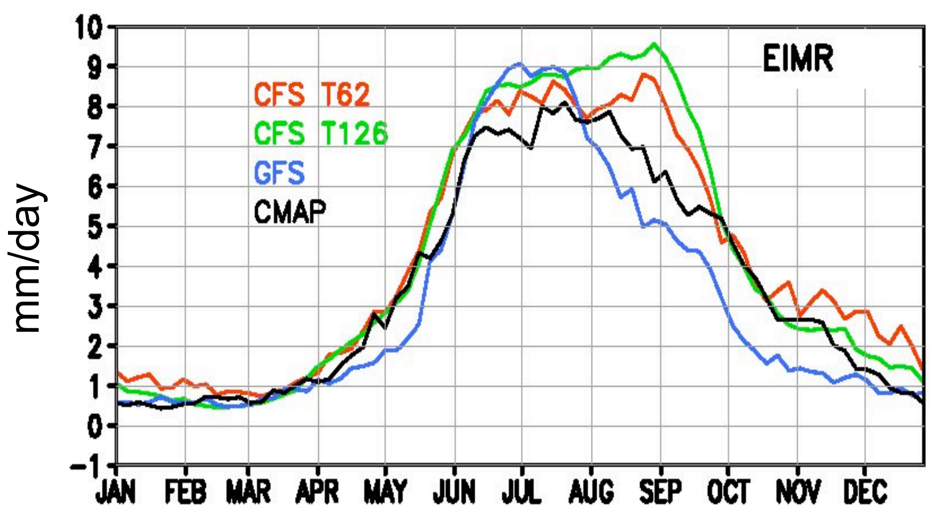
- CMIP run of CFS T62
  - Pegion and Kirtman, 2008
- CMIP run of CFS T126
  - Saha et al. 2006 (obtained from NCEP CFS web link)
- AMIP run of GFS T62
  - B. Jha 2007, Personnel communication
- 30 years of daily precipitation & SST (5-day running means)
- Observational results based on daily OLR data
  - Krishnamurthy and Shukla, 2008
  - Krishnamurthy and Kirtman, 2008

Seasonal (JJAS) climatology of precipitation

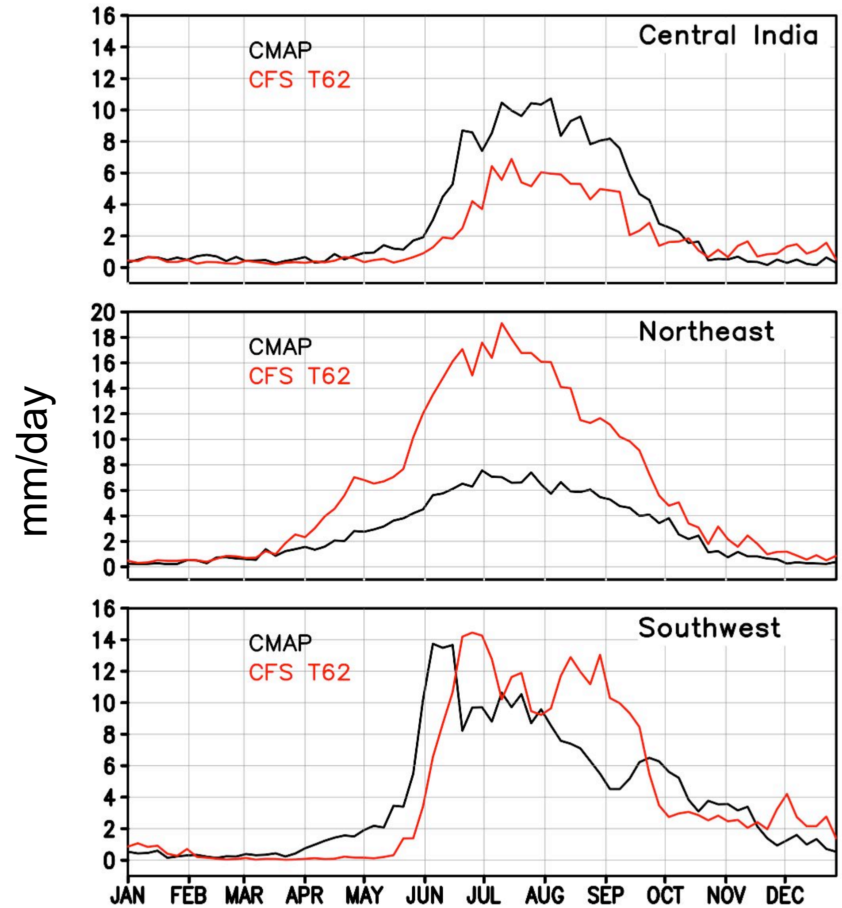


Annual cycle of precipitation (pentad climatology)

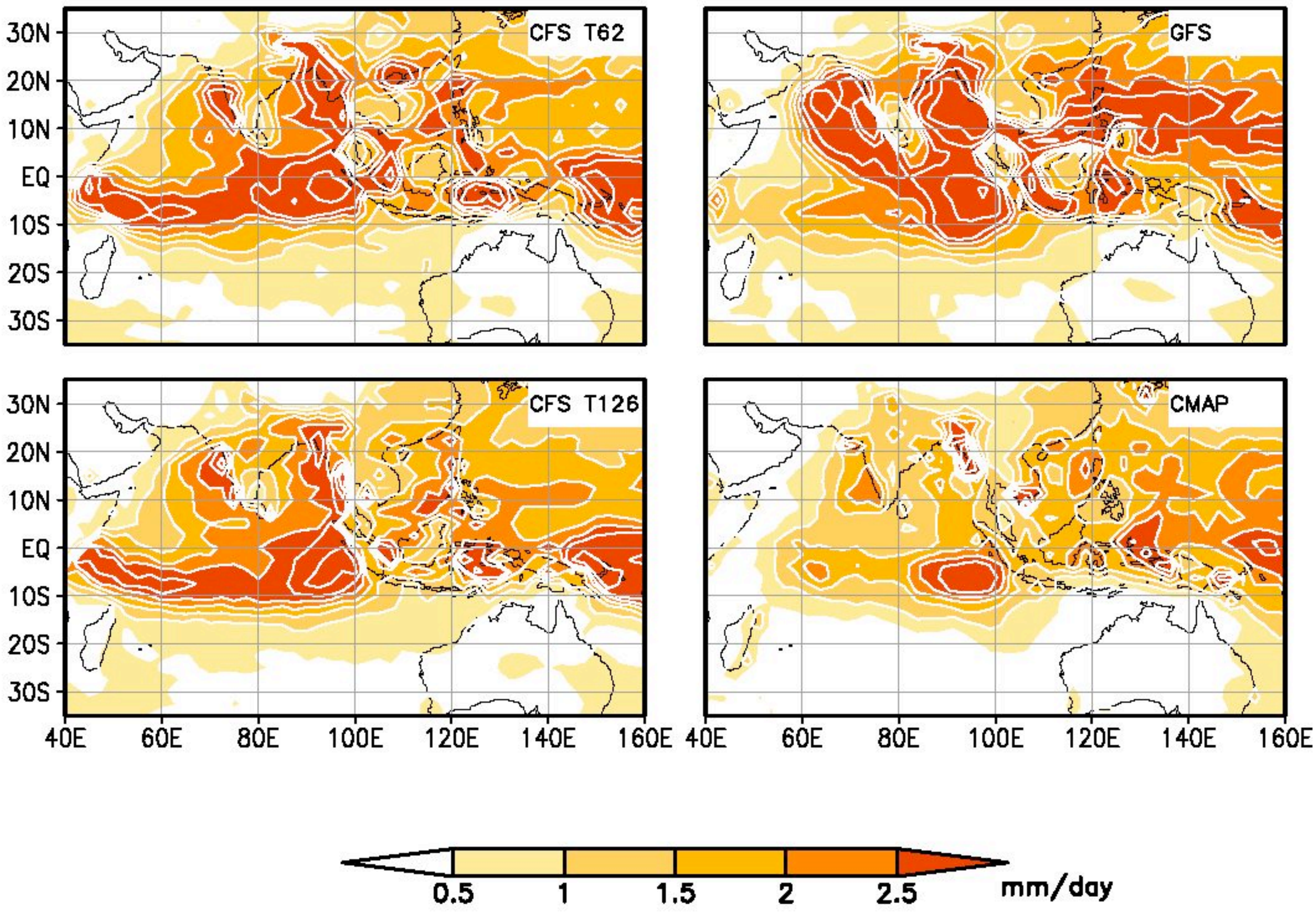




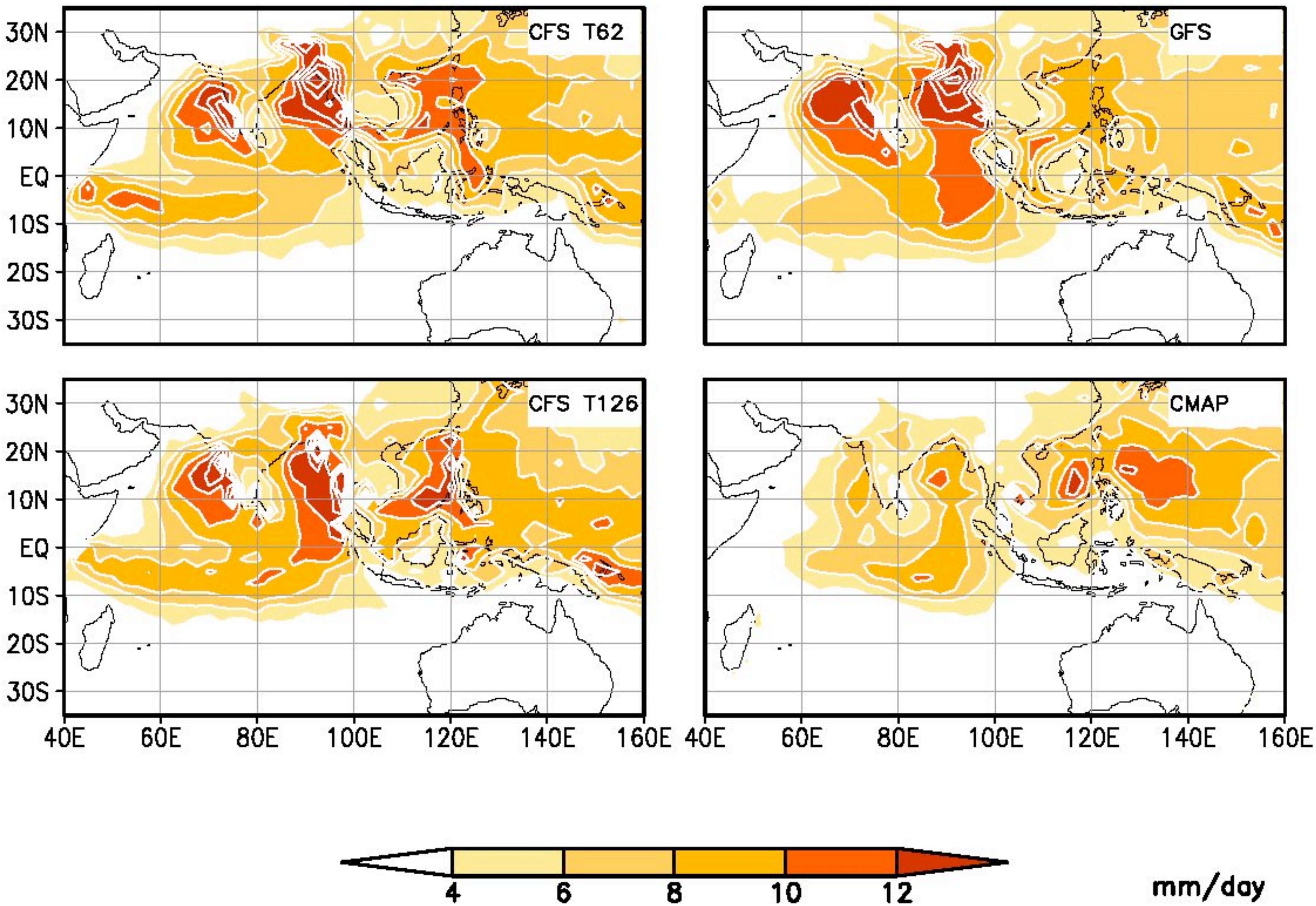
Rainfall over different boxes



Rainfall: Standard deviation of JJAS seasonal anomalies



Rainfall: Standard deviation of pentad anomalies



Multi-channel Singular Spectrum Analysis (MSSA)

A(*x,y,t*) --------> ***A***(*l,t*), *l* = *1,…,L and t = 1,…,N*

Choose a lag window, *M* and let *N' = N-M+1*

Make M lagged copies of ***A*** -> ***B***(*M x N'*)

Compute Lag-covariance matrix ***C***(*LM x LM*) = *1/N'* ($\mathbf{B}^T\mathbf{B}$)

Diagonalize ***C*** to get eigenvectors

Extended EOF (*x,y,t = 1, …, L*)

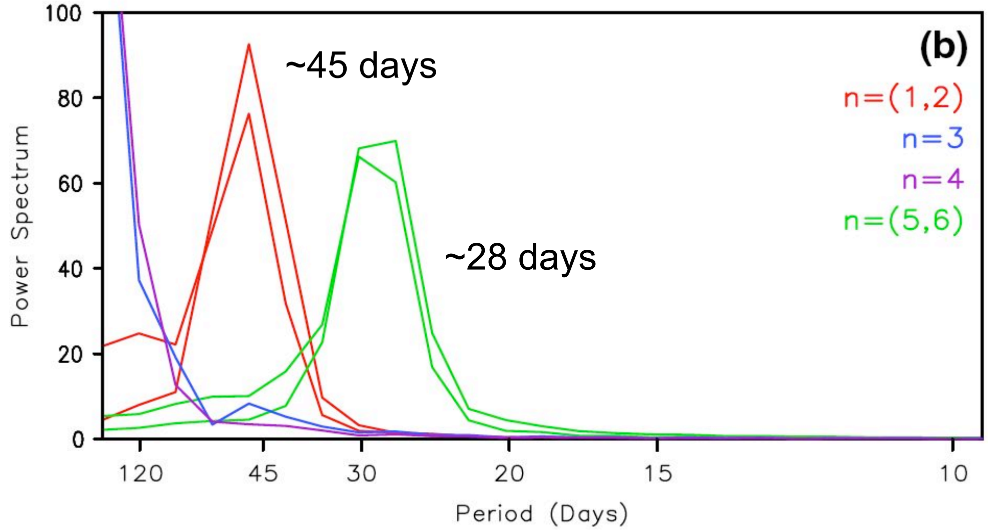
PC (*t = 1, …, N'*)

Reconstructed components (RCs) by projecting PCs on EEOFs

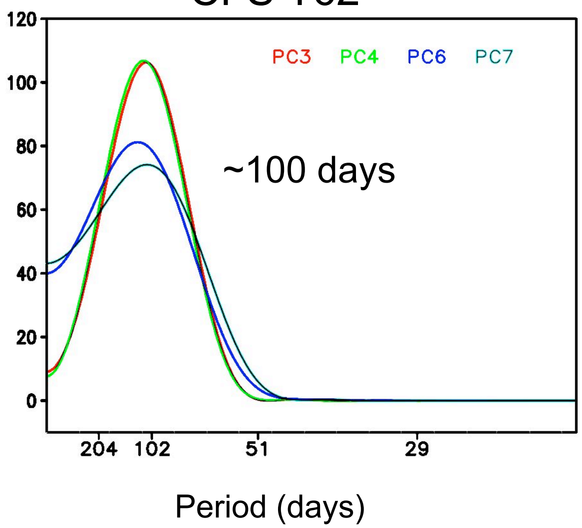
Ref: Ghil et al. 2002; Krishnamurthy and Shukla, 2008

Power Spectra of the dominant modes

OBS



CFS T62



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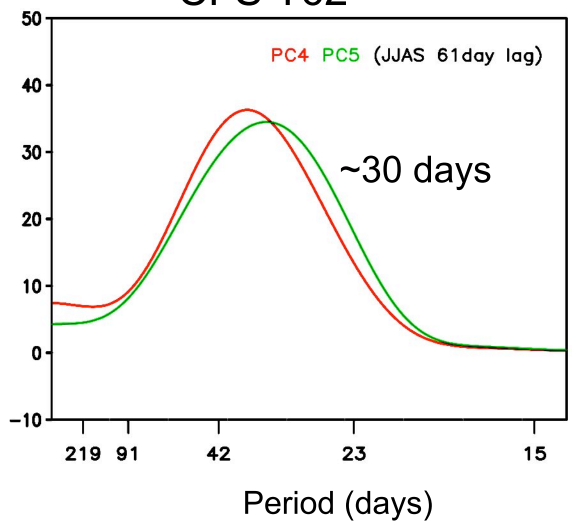

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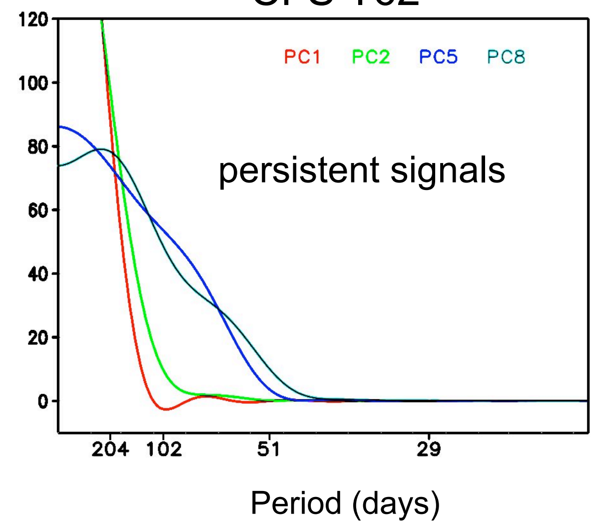
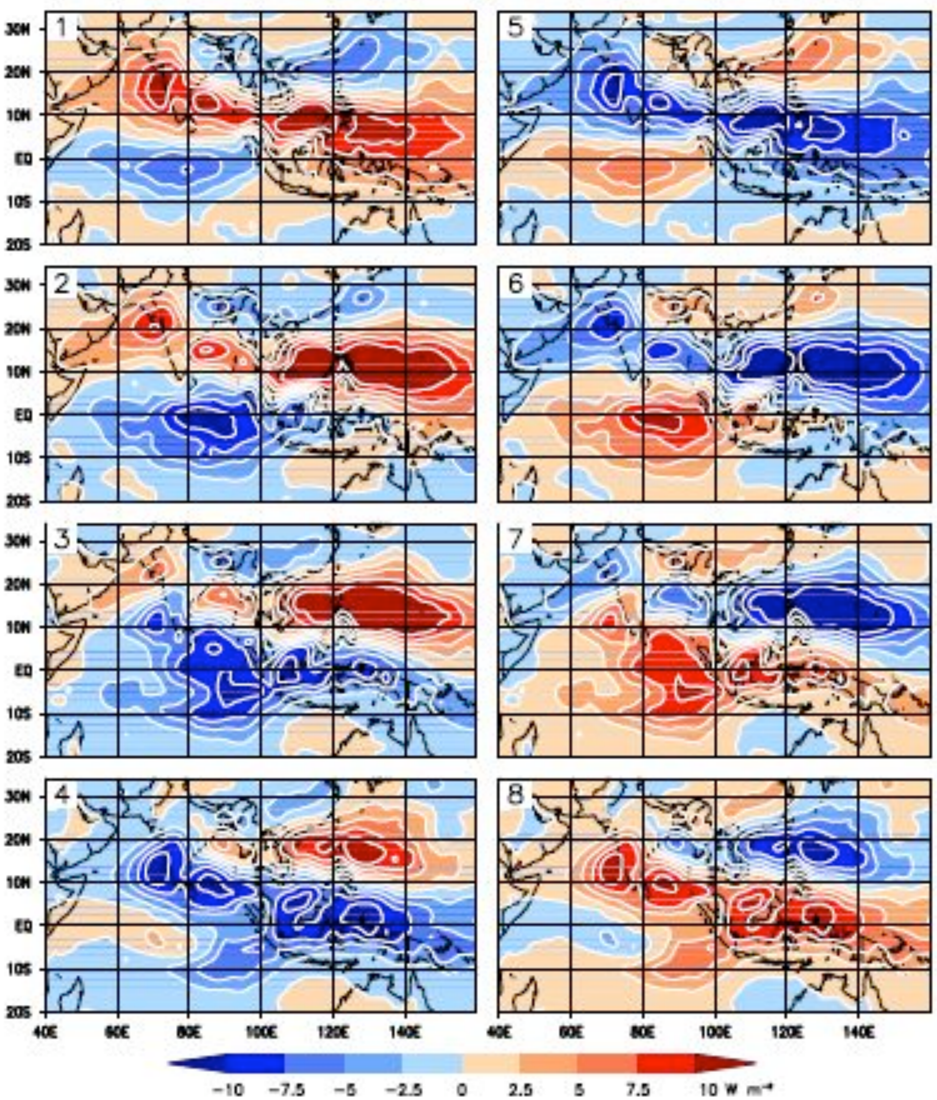


Summary of summer monsoon daily modes

Observations	CFS T62
2 oscillatory modes periods 45 & 28 days	2 oscillatory modes; periods 100 & 30 days
2 persistent signals ENSO and IOD signs	4 main persistent modes

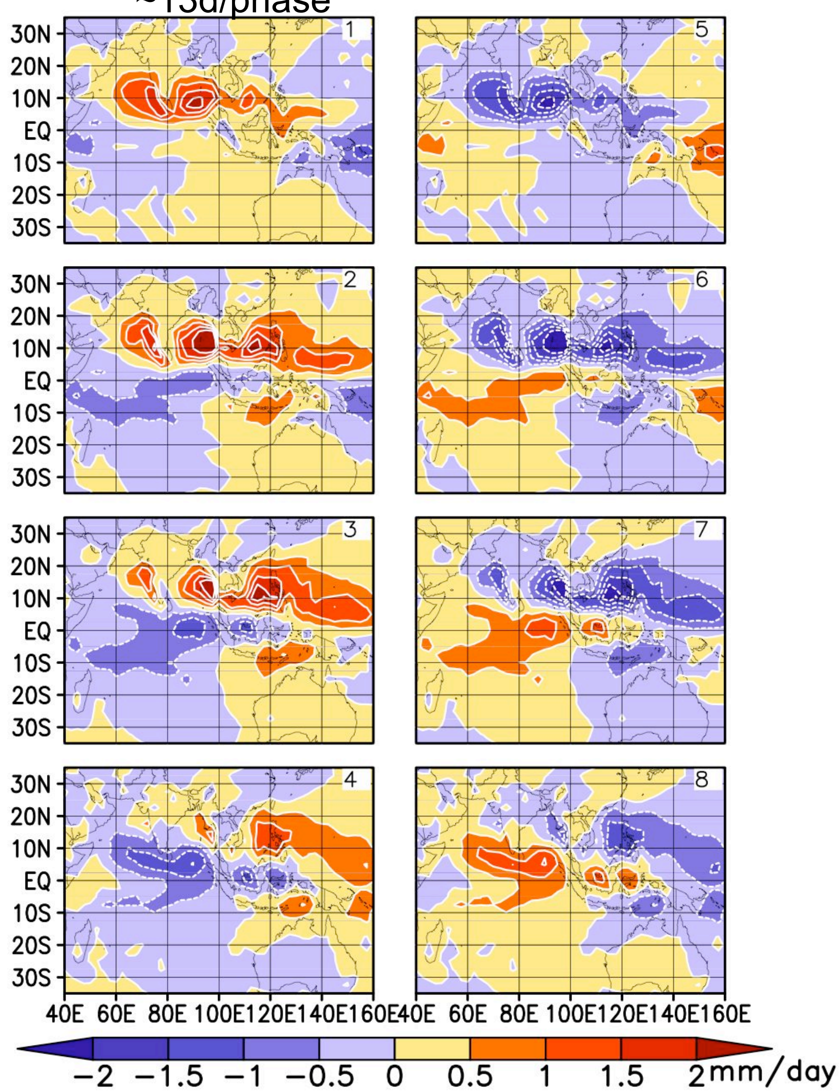
Phase composites of the first oscillatory mode

OBS 45-day oscillations

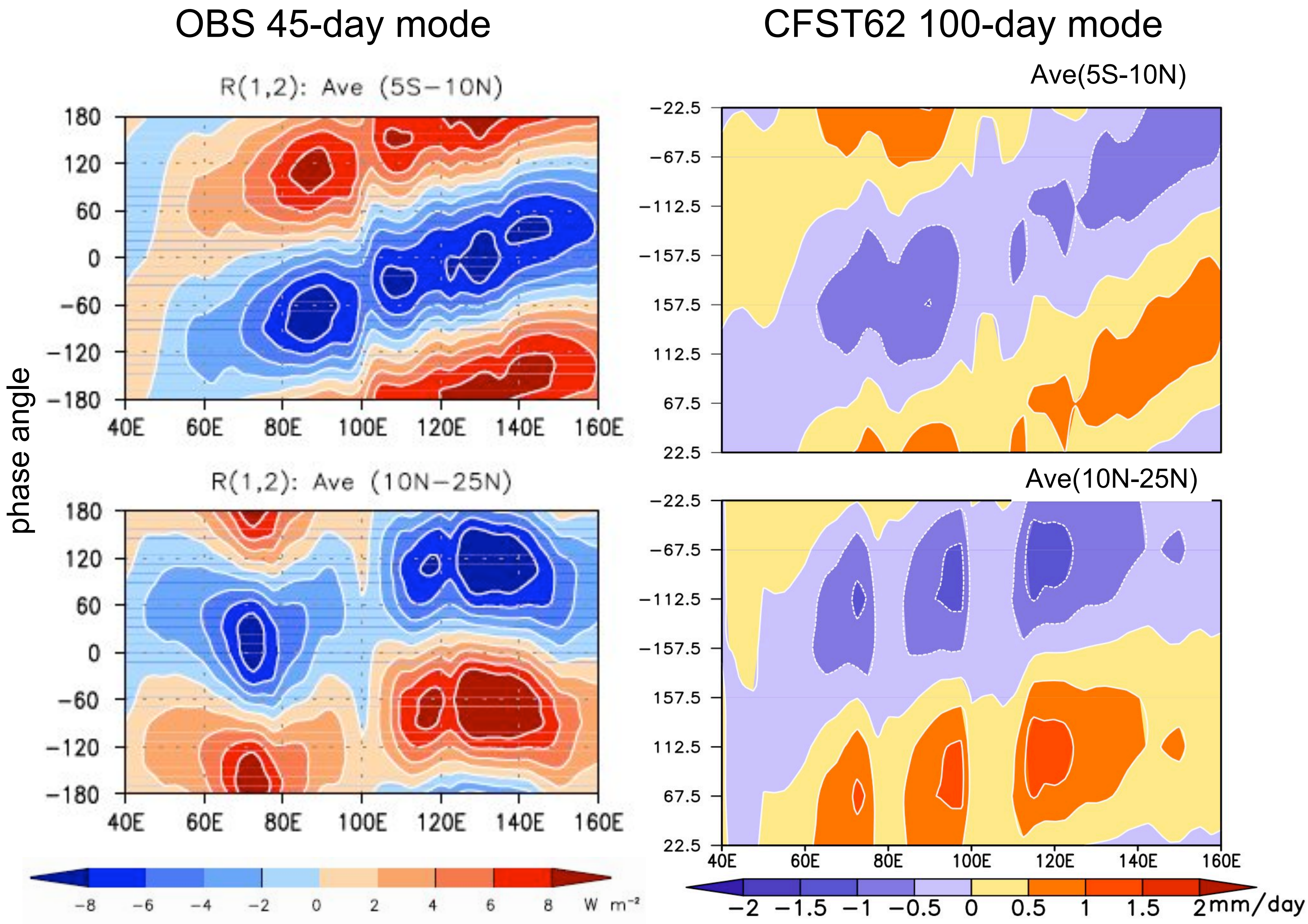


CFST62 100-day oscillations

~13d/phase



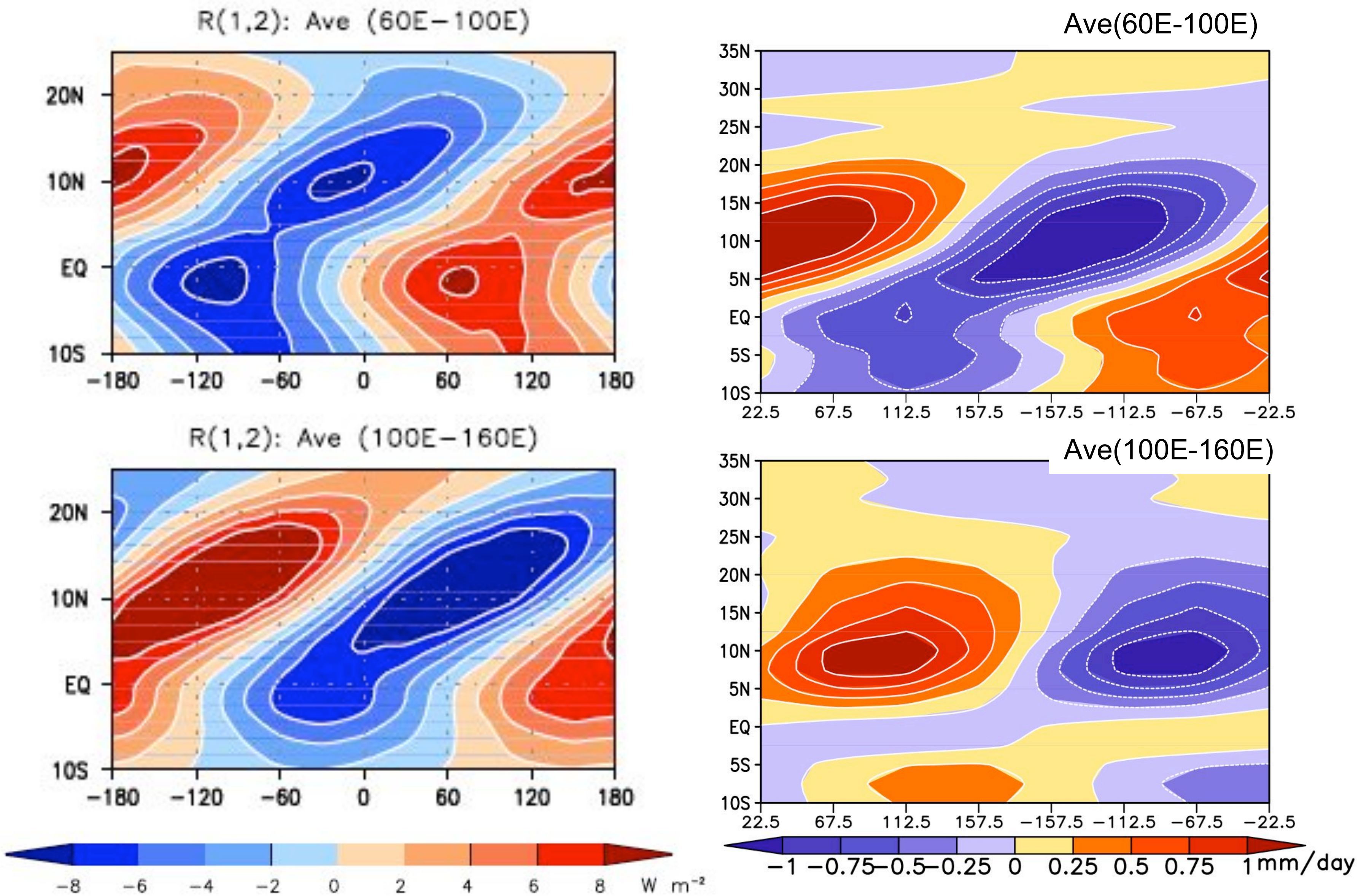
Eastward propagation of the first oscillatory mode



Northward propagation of the first oscillatory mode

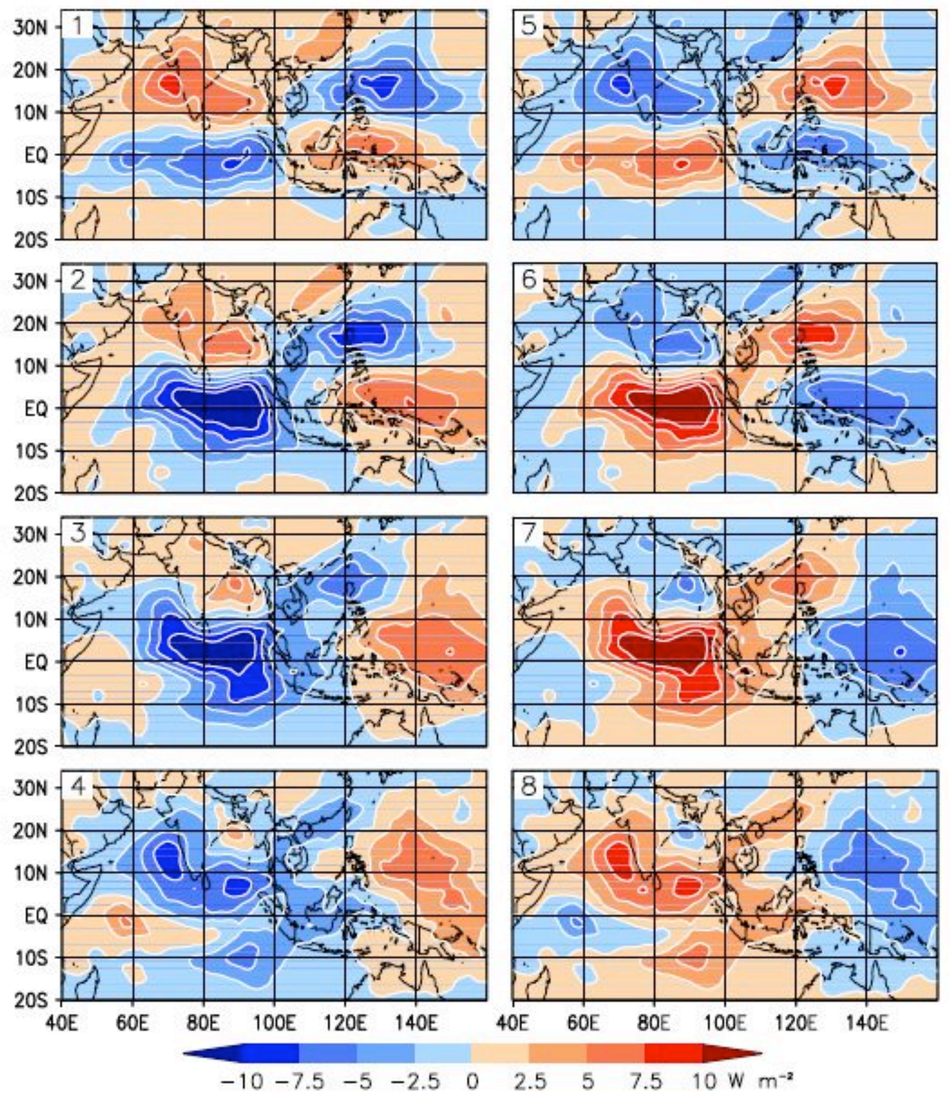
OBS 45-day mode

CFST62 100-day mode

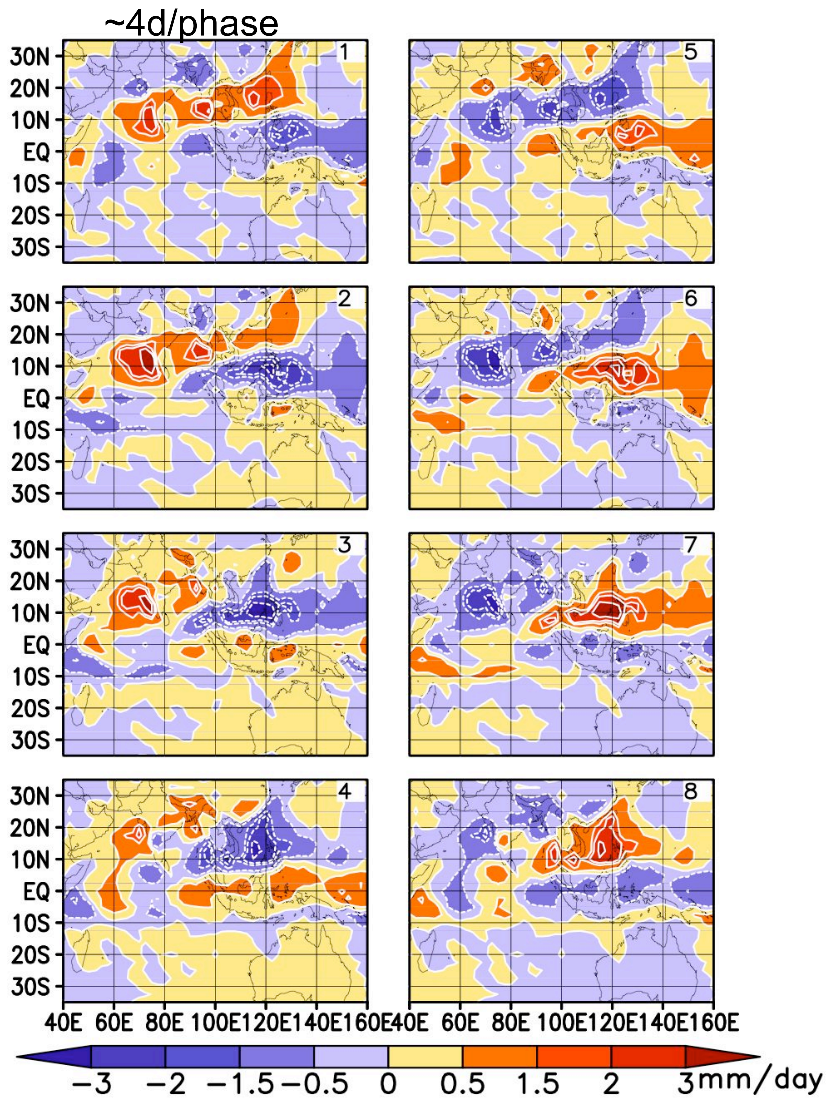


Phase composites of the second oscillatory mode

OBS 28-day mode

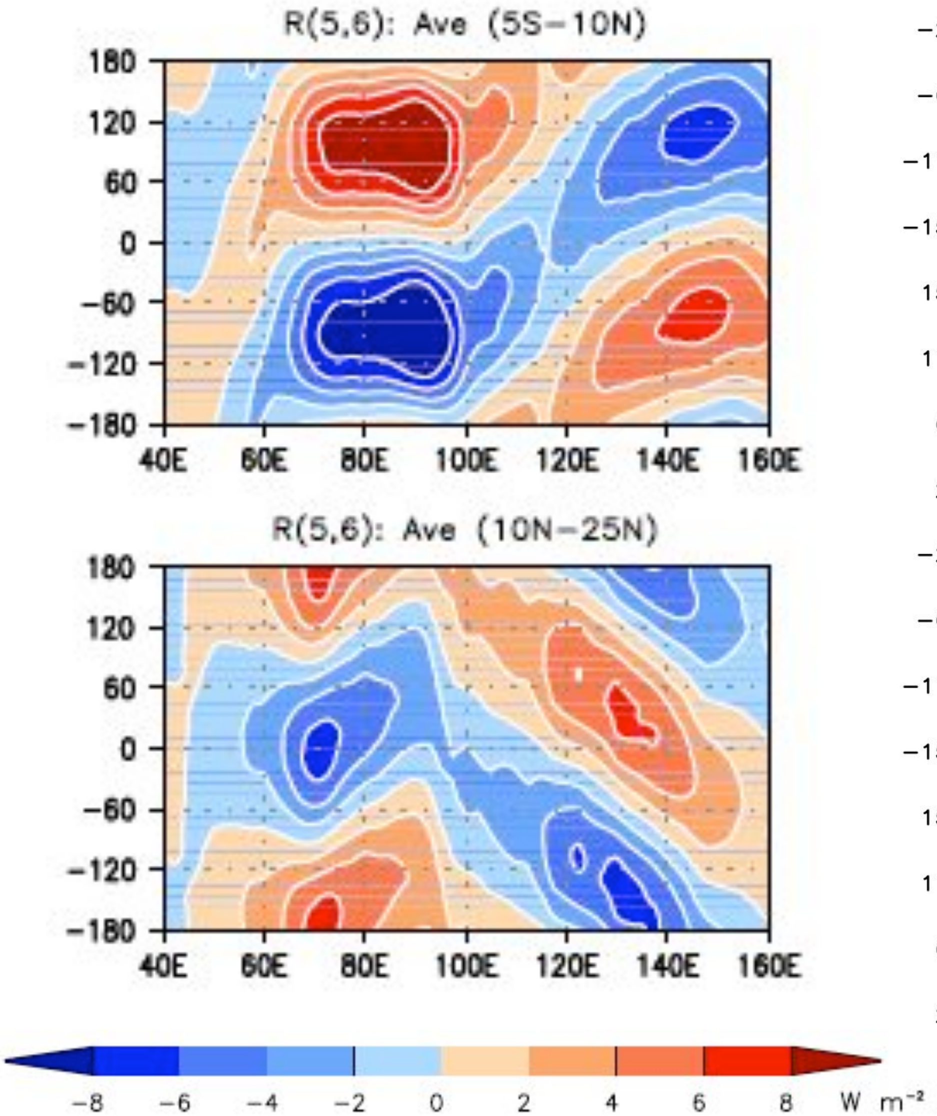


CFST62 30-day mode

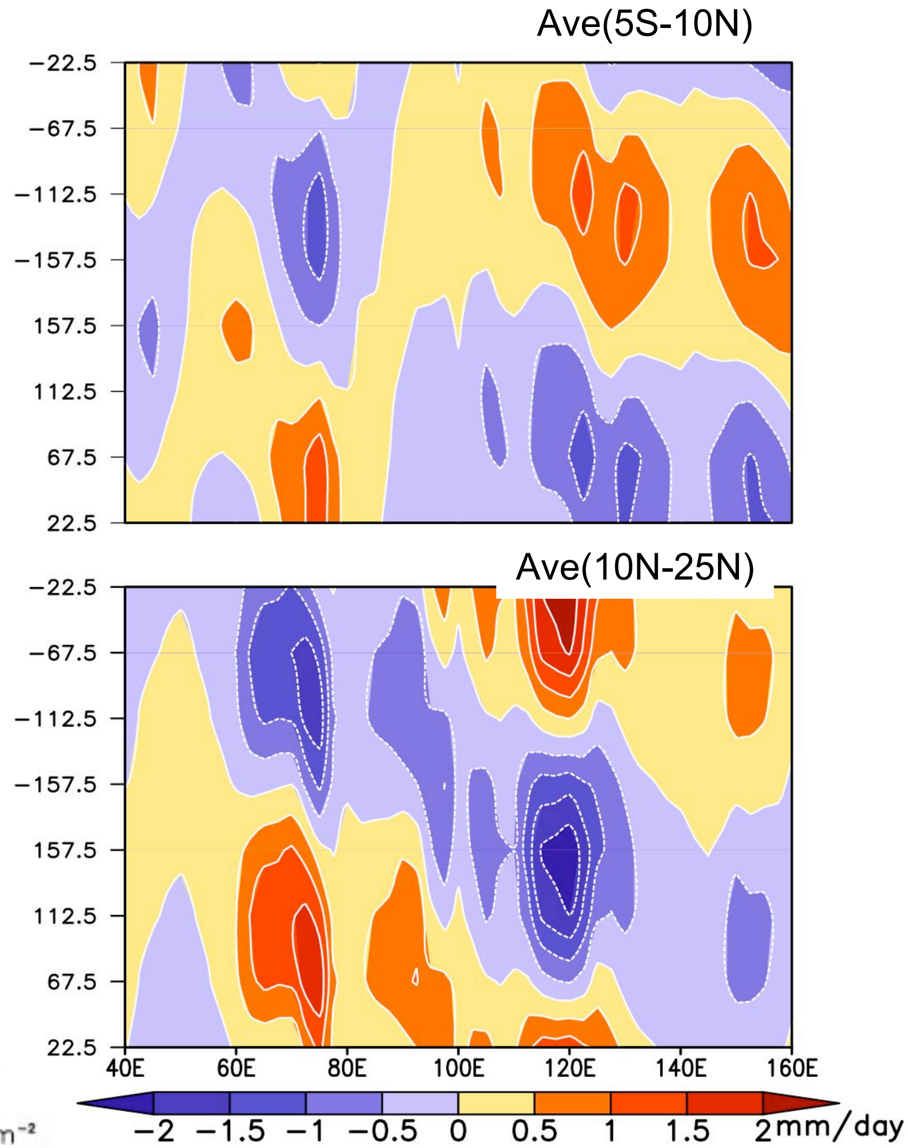


Westward propagation of the second oscillatory mode

OBS 28-day mode



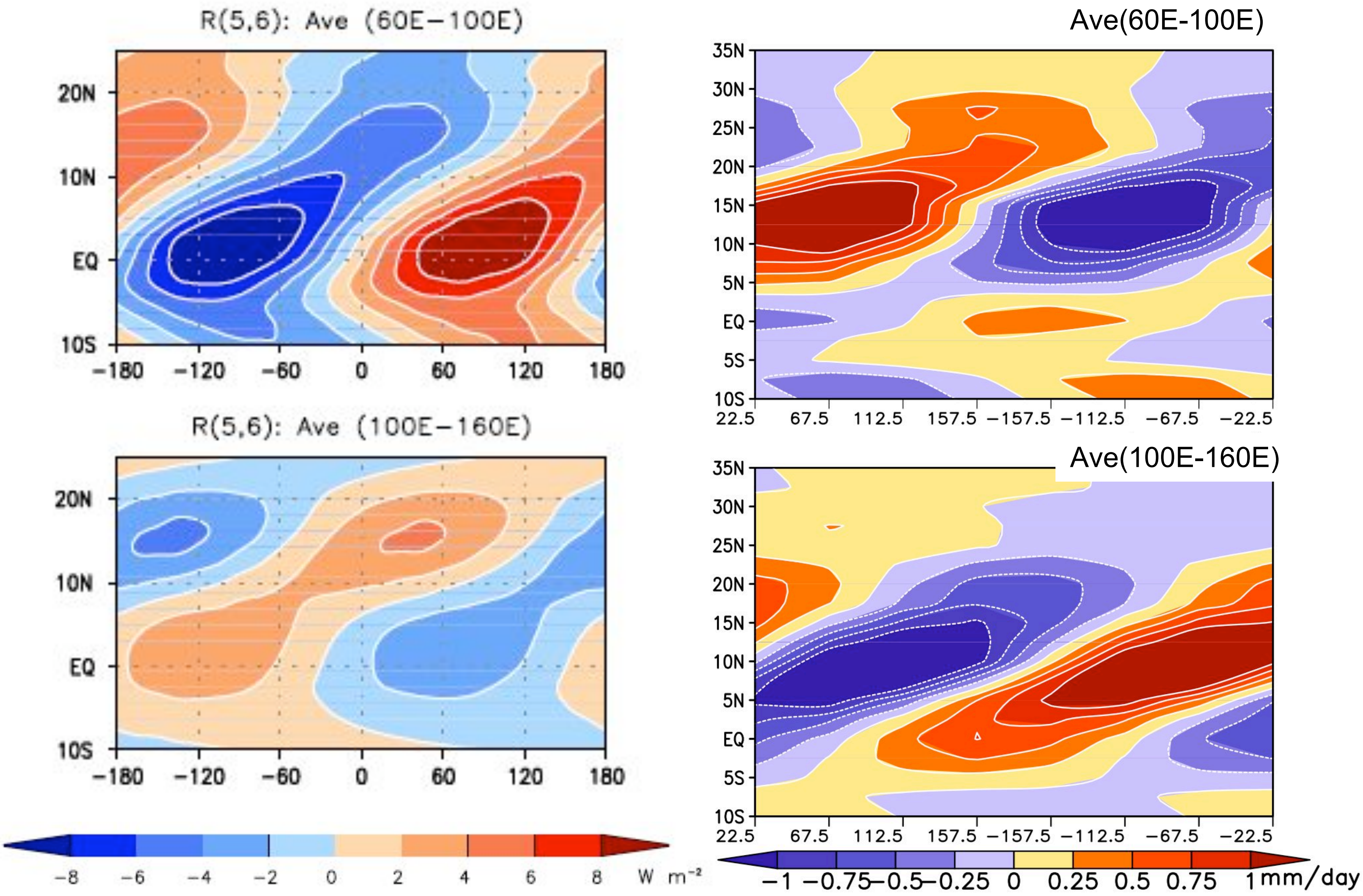
CFST62 30-day mode



Northward propagation of the second oscillatory mode

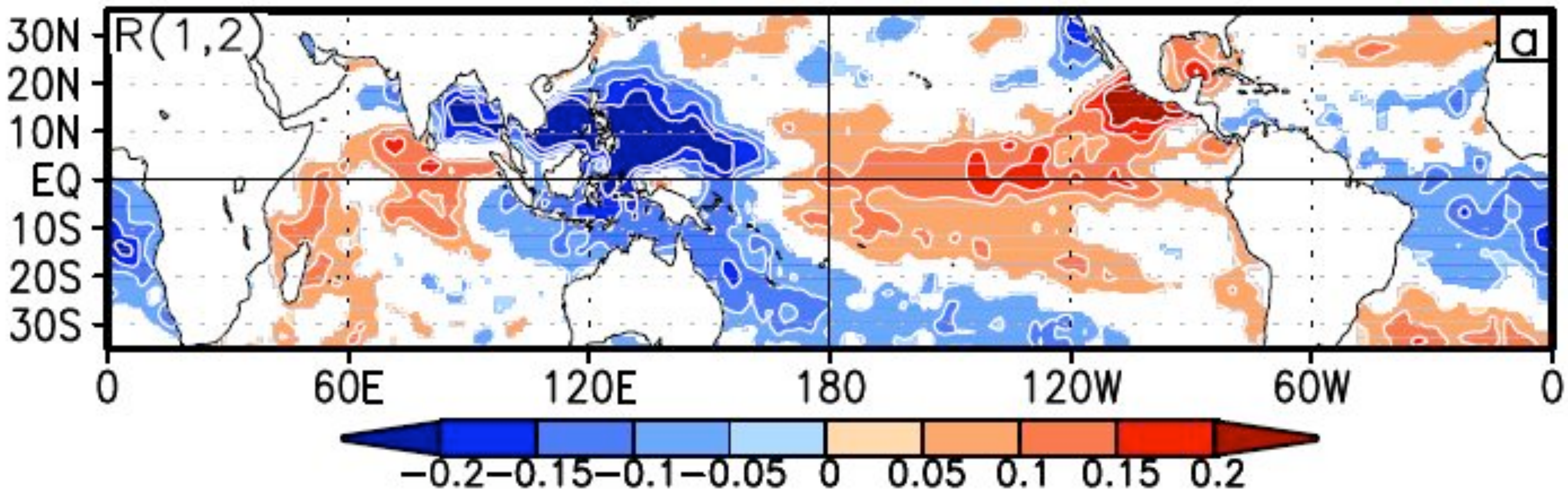
OBS 28-day mode

CFST62 30-day mode

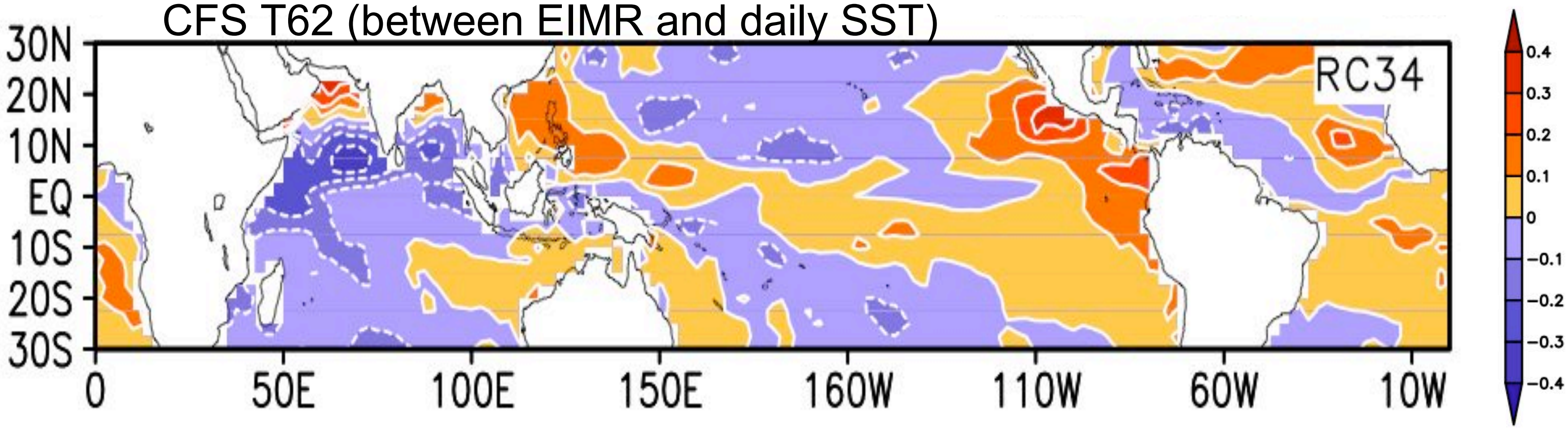


Correlation between first intraseasonal mode and SST

Observations (between IMR and daily SST)

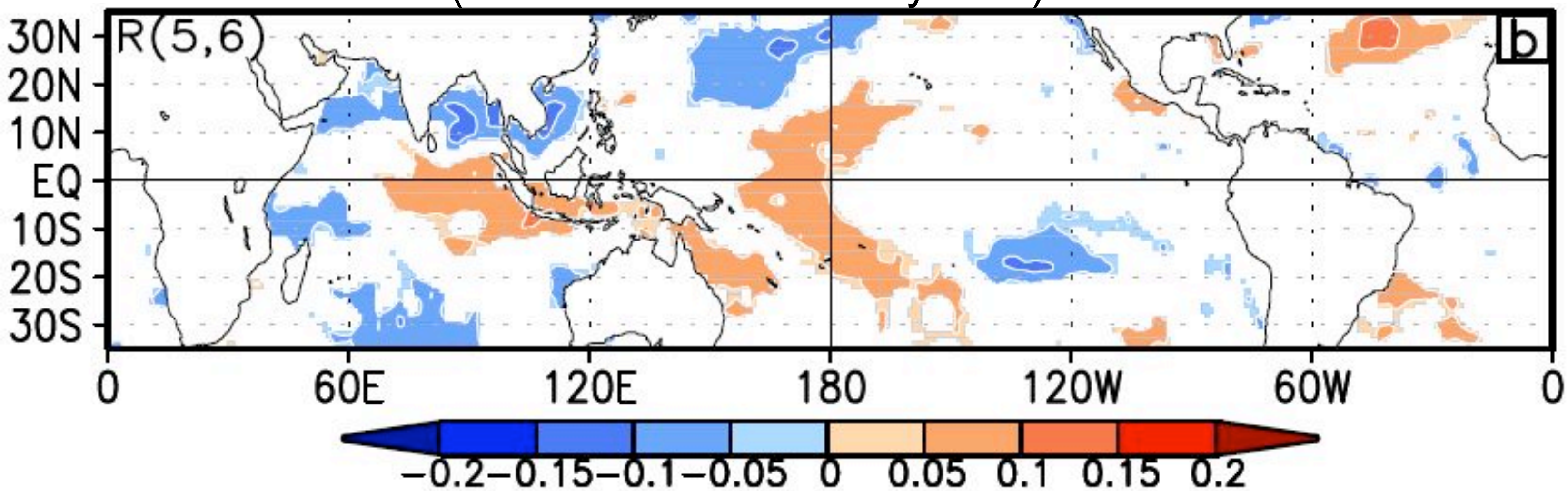


CFS T62 (between EIMR and daily SST)

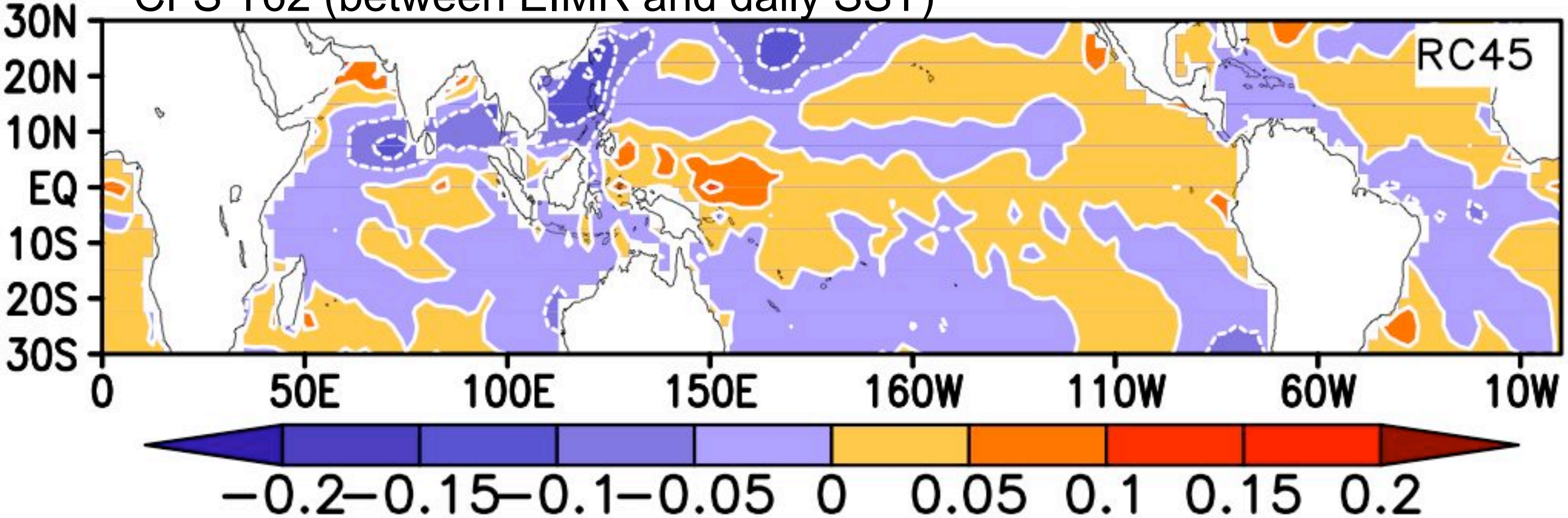


Correlation between second intraseasonal mode and SST

Observations (between IMR and daily SST)

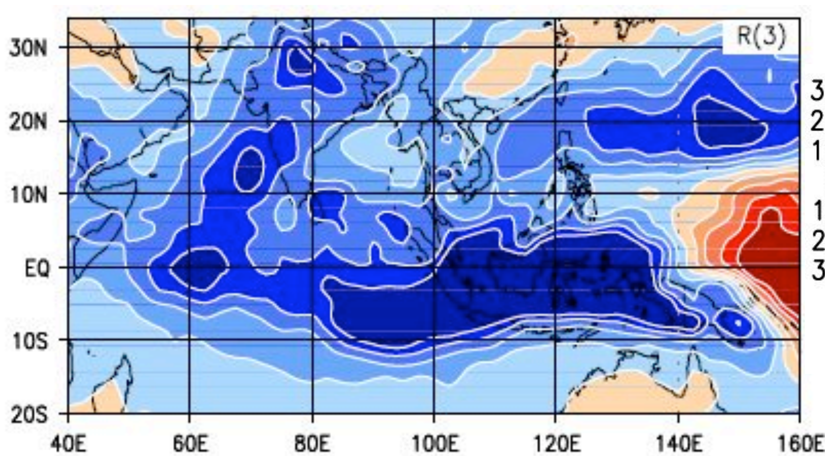


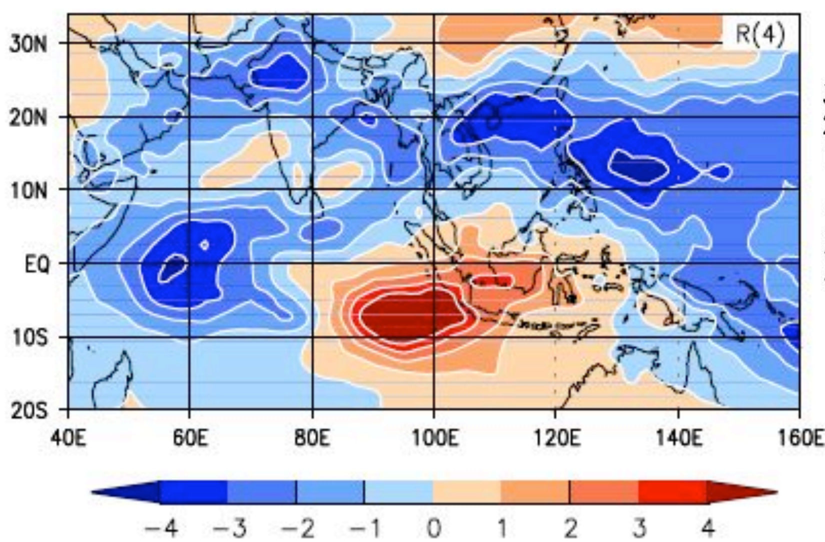
CFS T62 (between EIMR and daily SST)



Seasonally persistent signals in daily rainfall data
Summary from observations

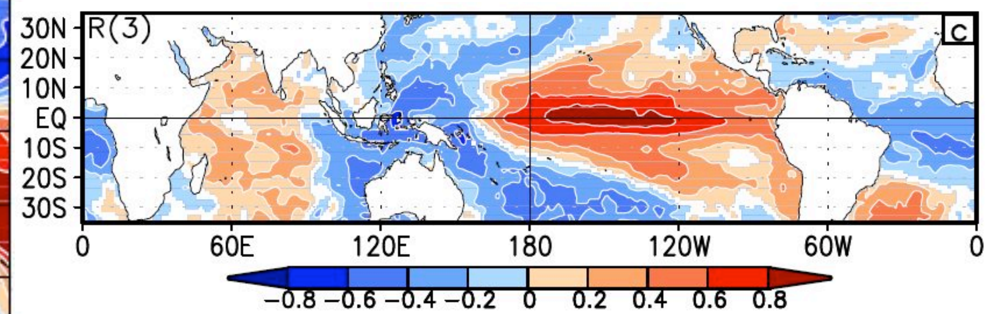
spatial EOF of persistent modes



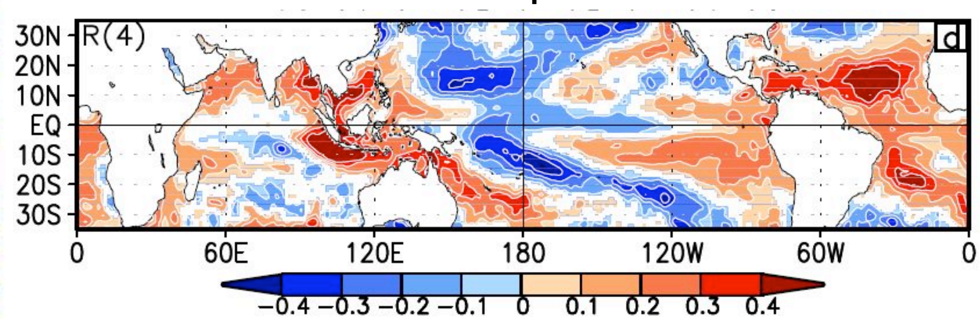


Point correlation with SST

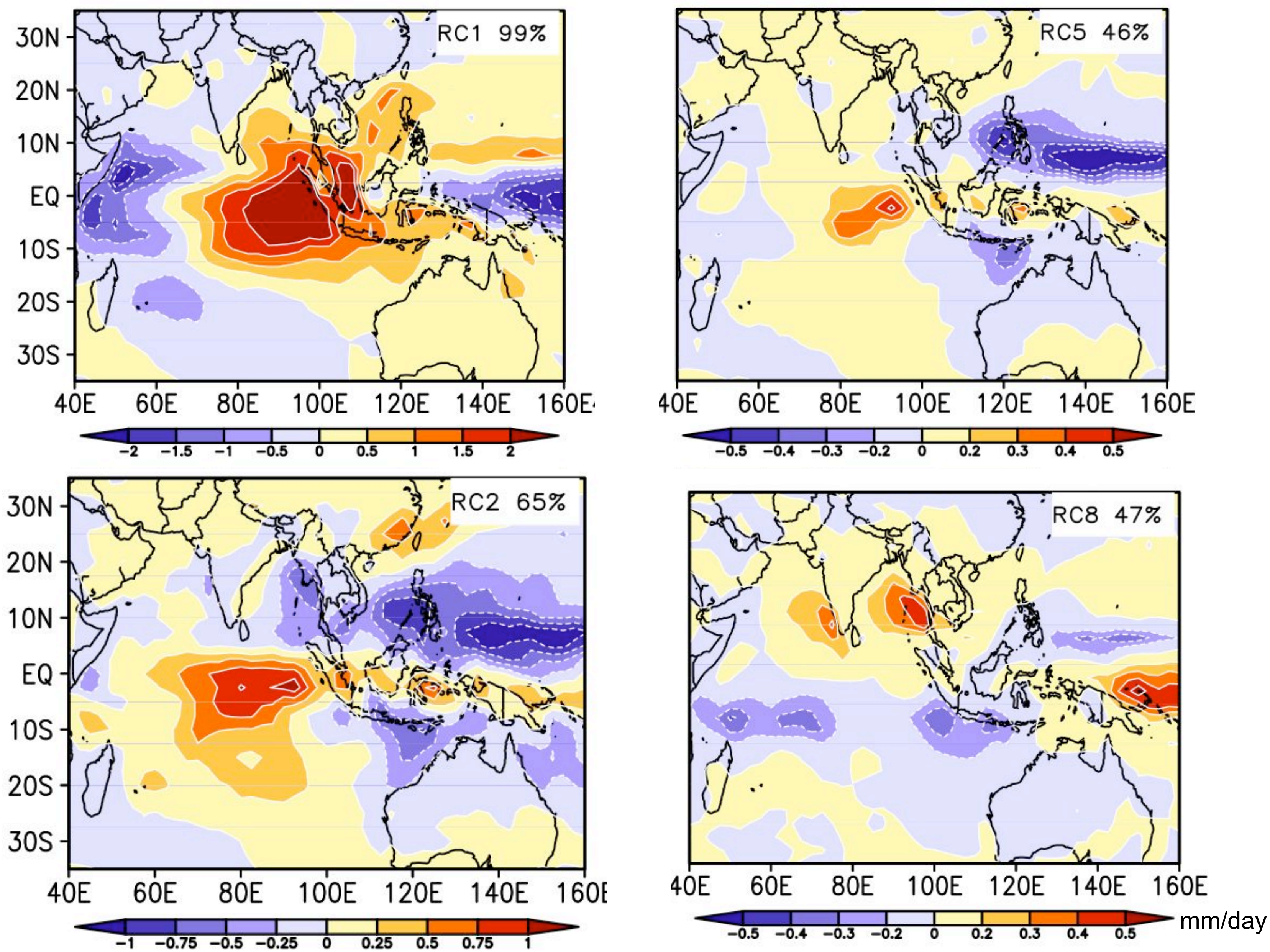
ENSO mode



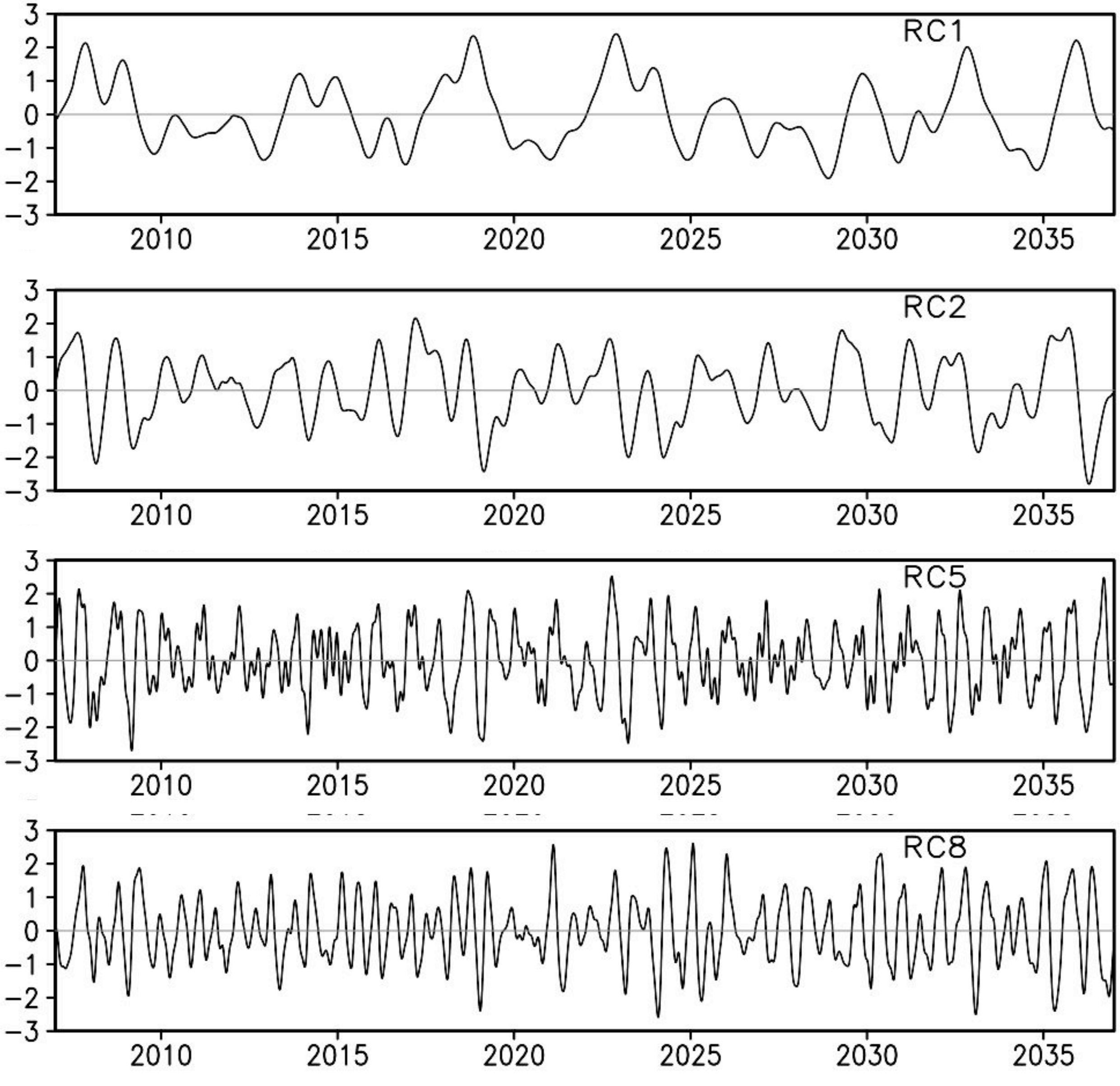
Indian Ocean dipole mode



Persistent signals in CFS T62 (EOF of modes)



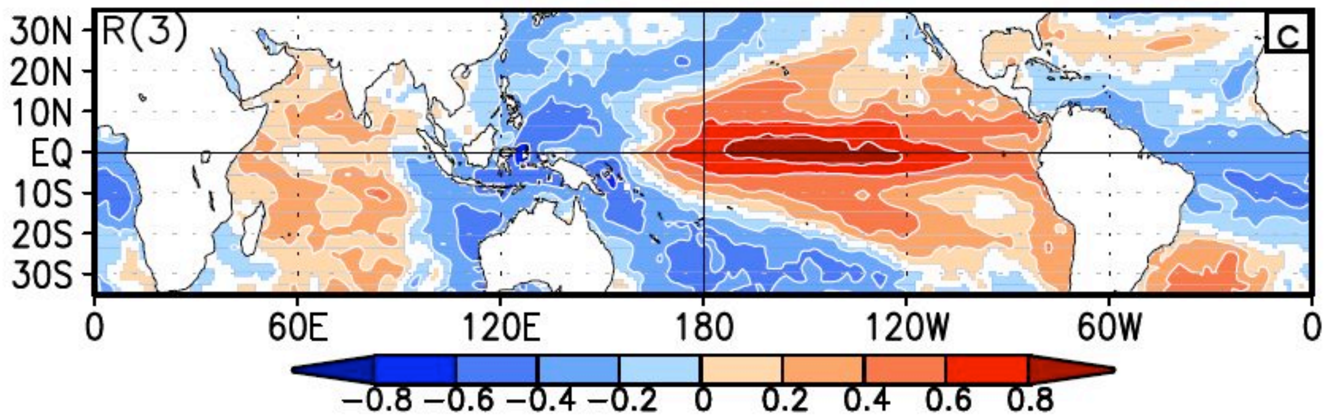
Persistent signals in CFS T62: Amplitude of EOFs of modes



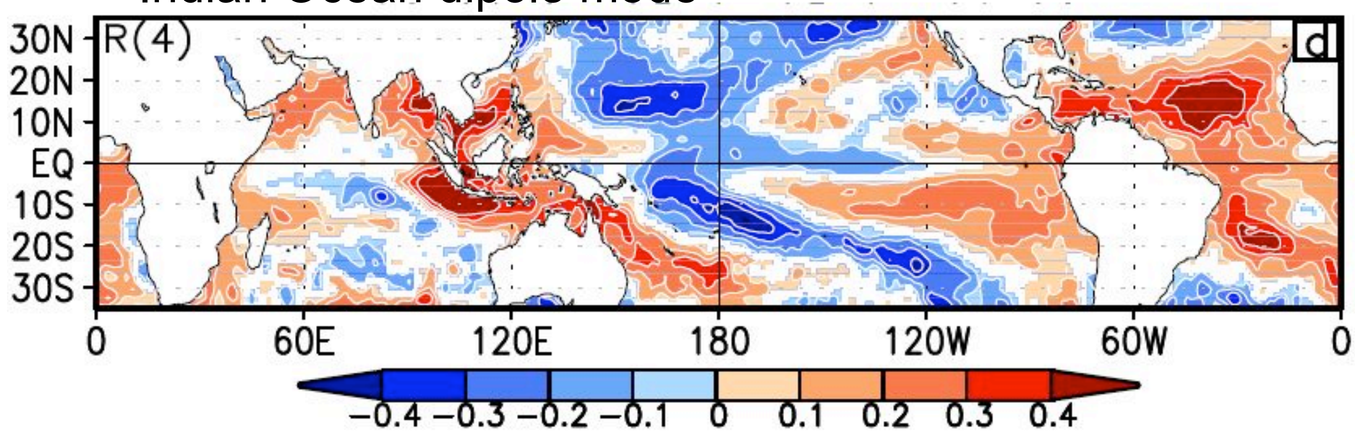
Seasonally persistent signals in daily rainfall data
Summary from observations

Point correlation with SST

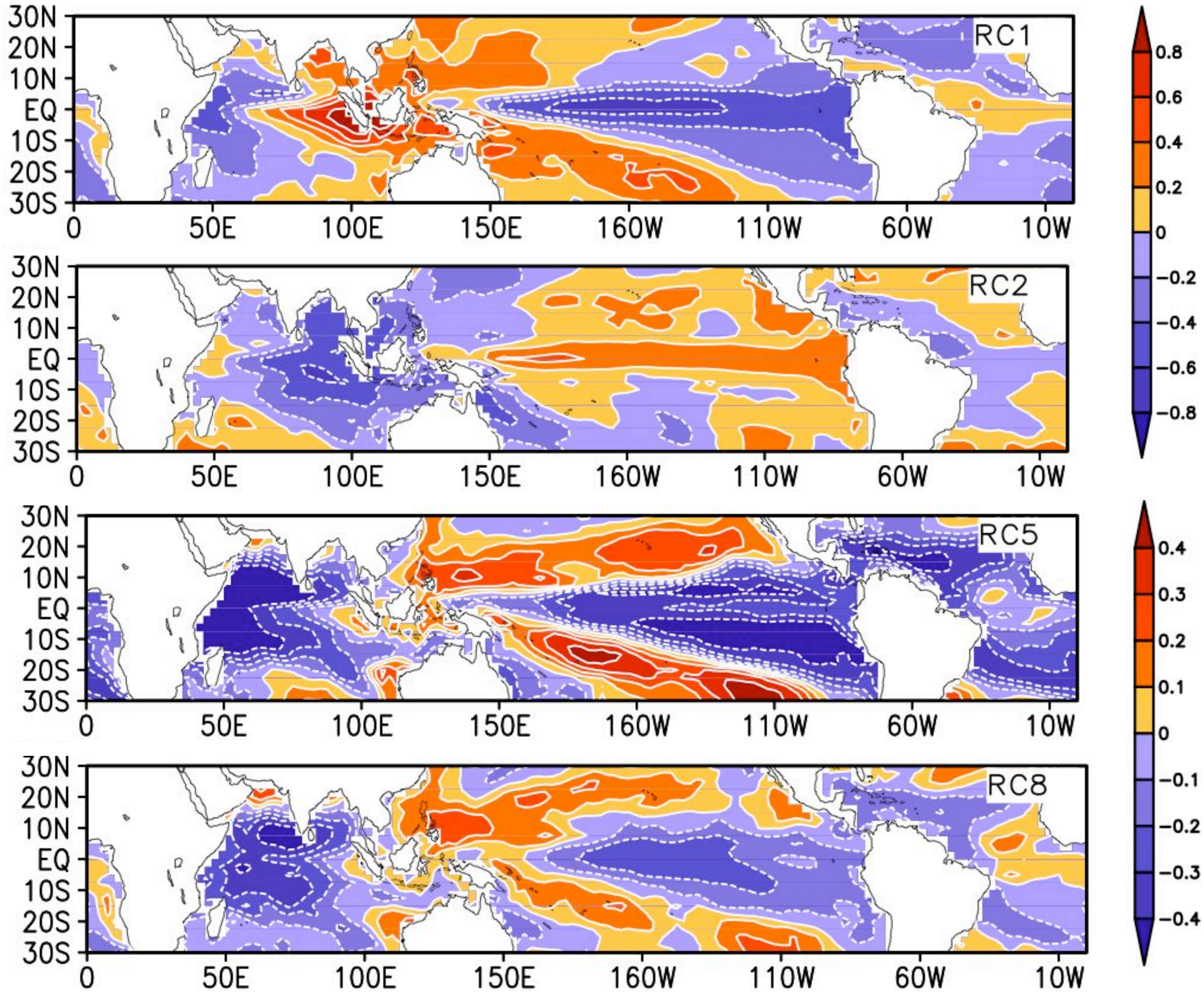
ENSO mode



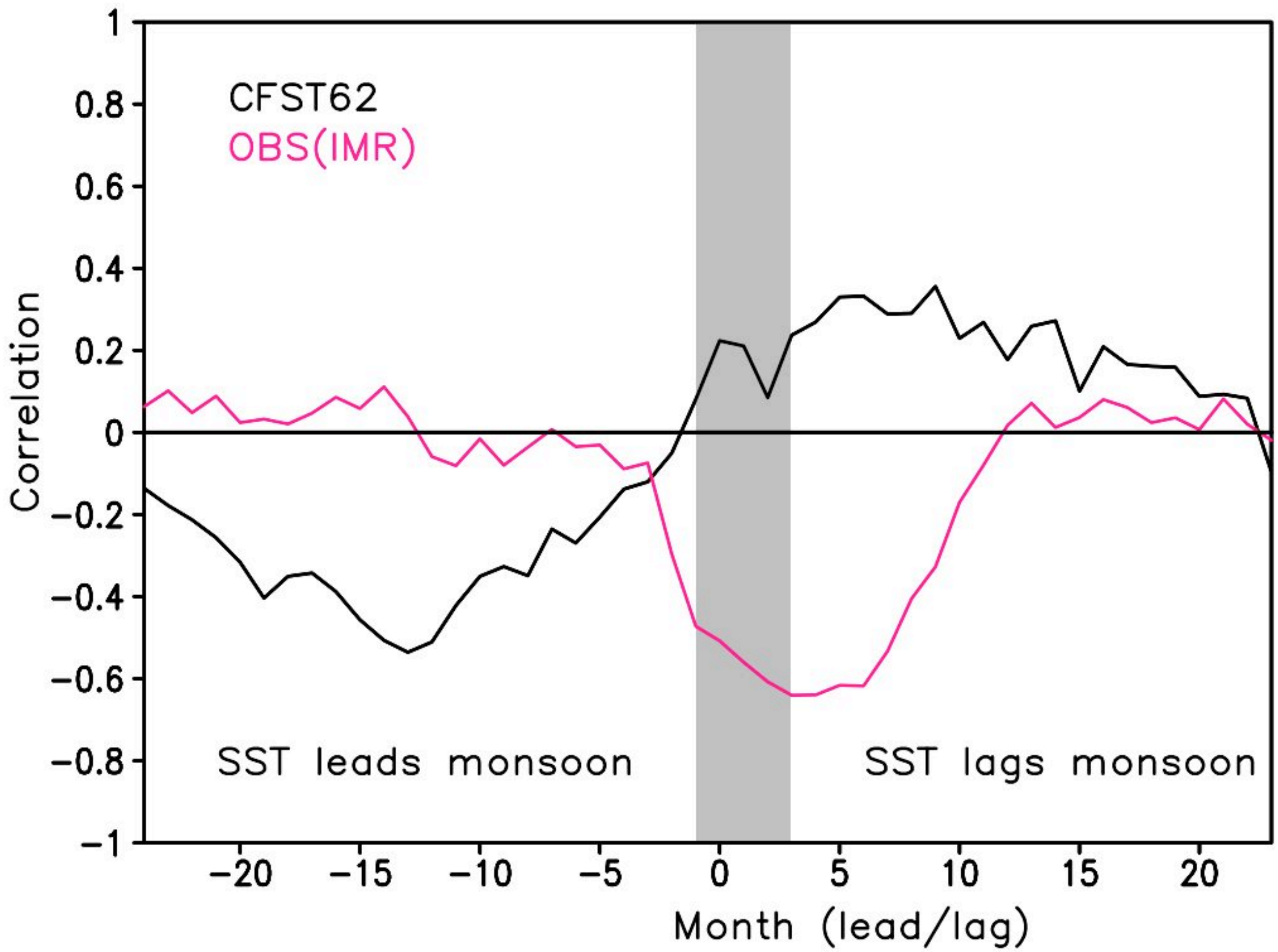
Indian Ocean dipole mode



Persistent signals in CFS T62: correlation with SST



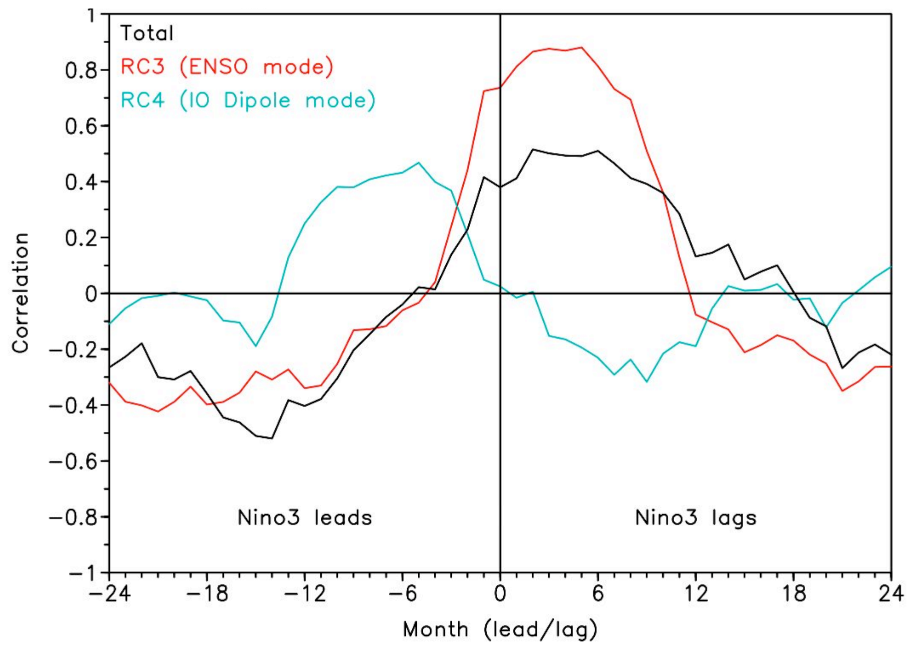
ENSO-Monsoon relation: Correlation between EIMR & NINO3



Correlation between seasonal (JJAS) (E)IMR and monthly Nino3

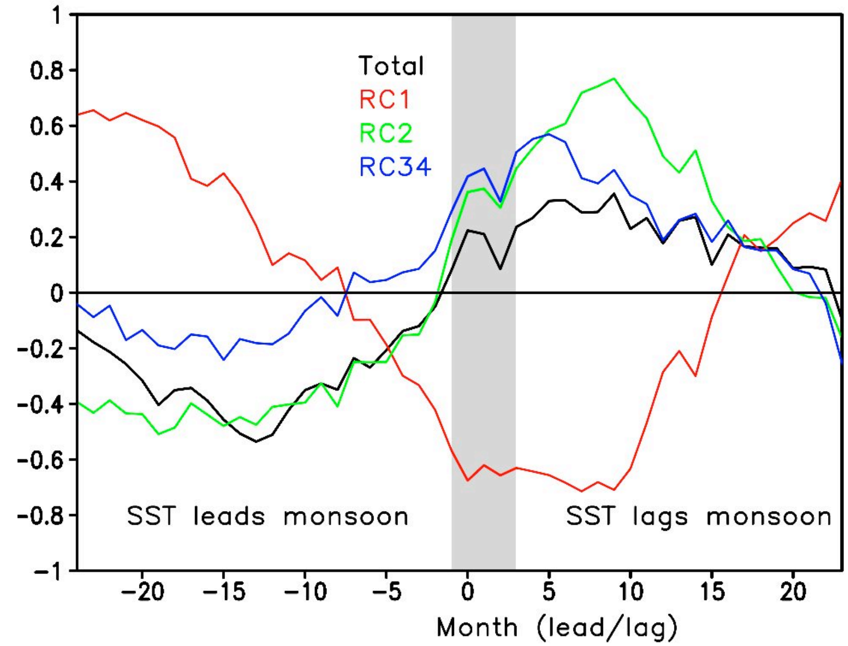
ENSO-Monsoon relation using daily rainfall modes

Observations



V.Krishnamurthy, Personnel communication

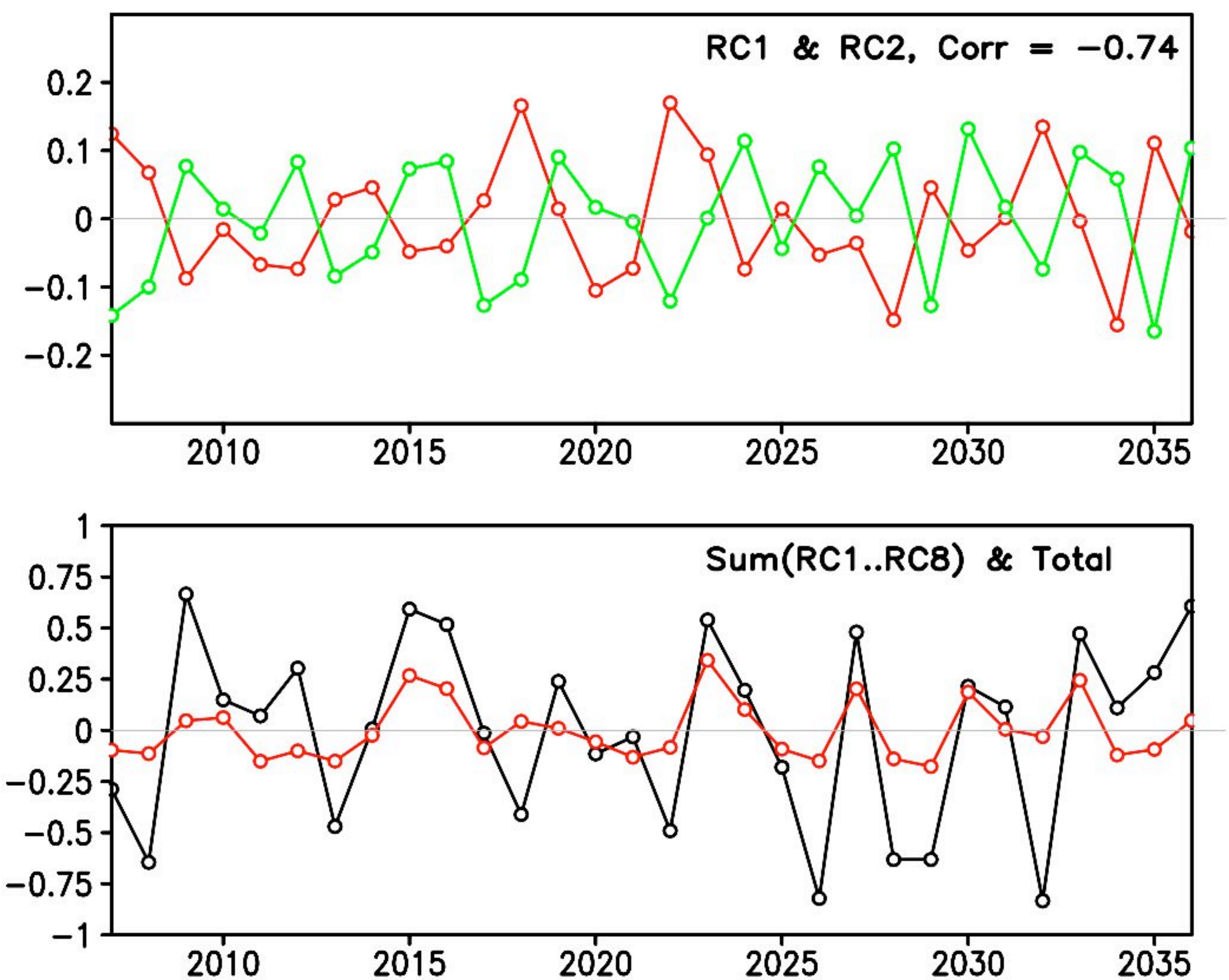
CFS T62



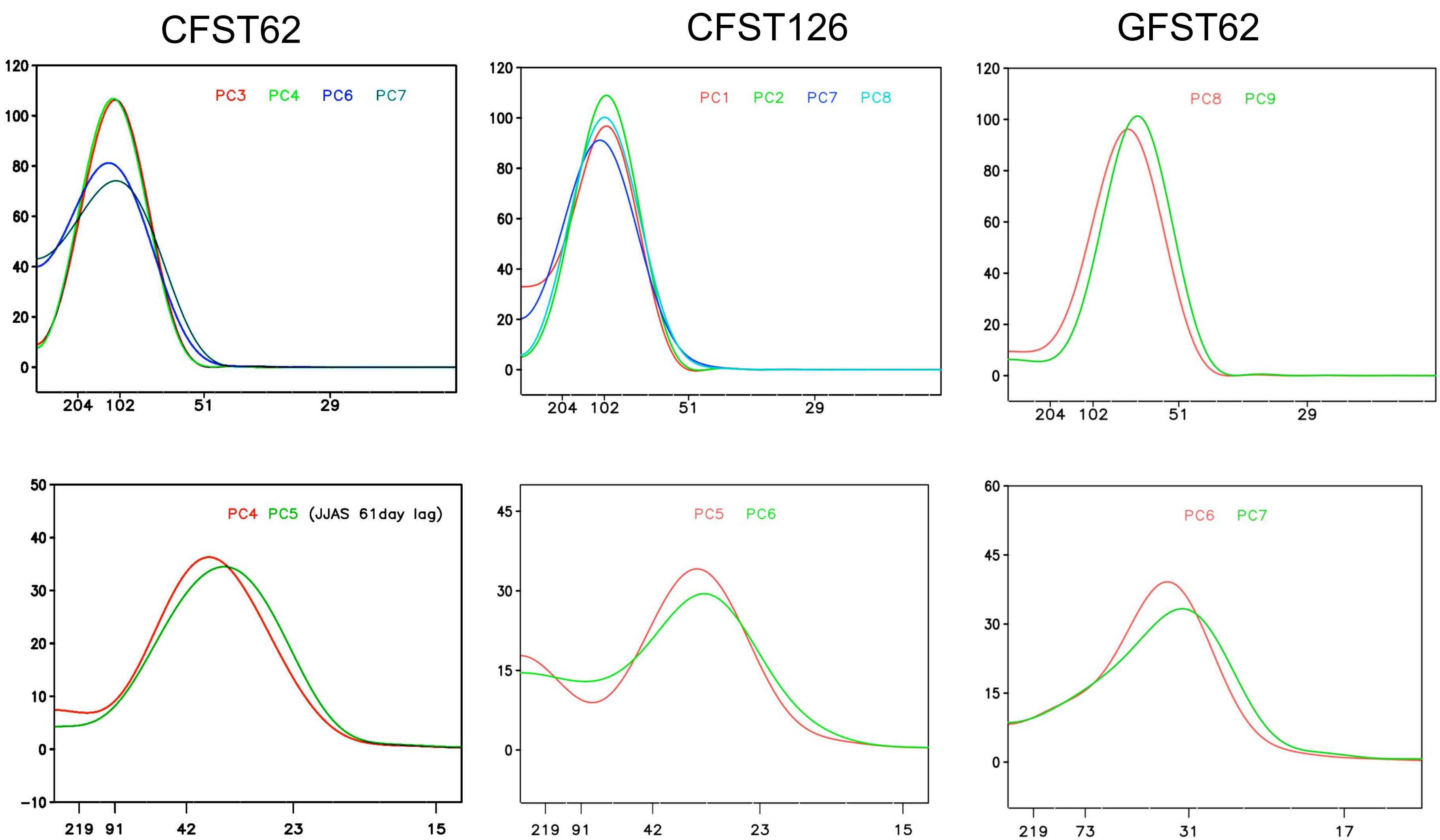
Correlation between seasonal (JJAS) EIMR and monthly Nino3; EIMR computed for different daily modes

Contribution of daily modes to seasonal anomalies

JJAS seasonal mean of daily modes

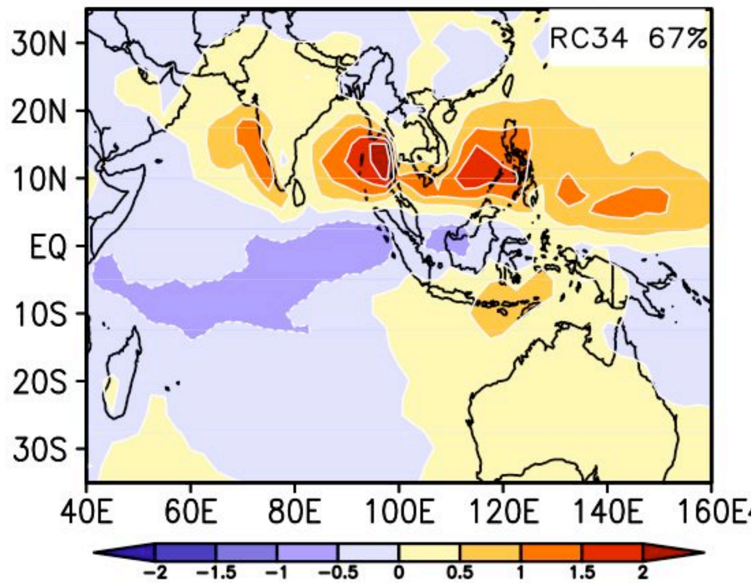


Comparison with T126 and GFS
Period of oscillatory modes: Power spectra

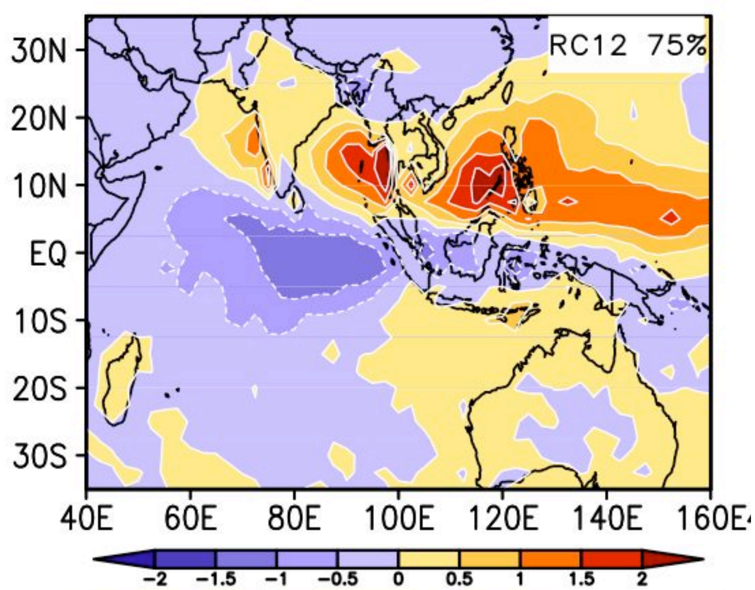


Spatial structure of the first oscillatory mode

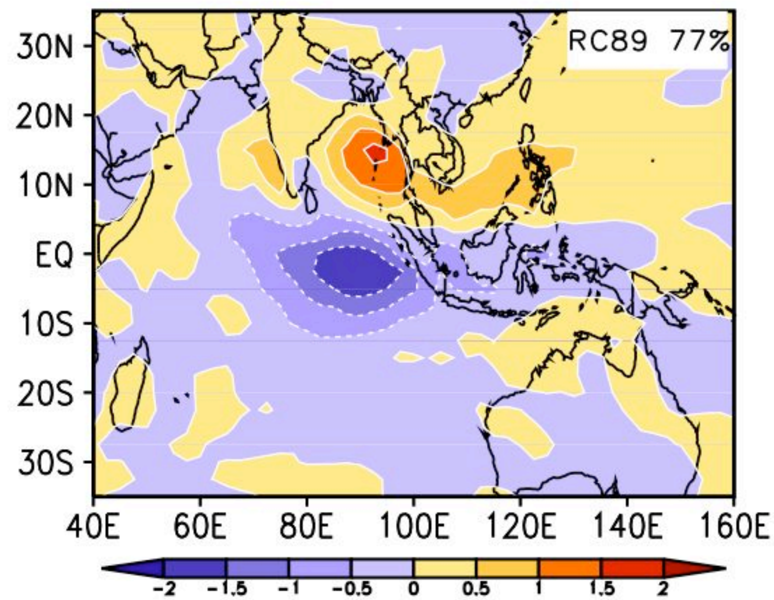
CFST62



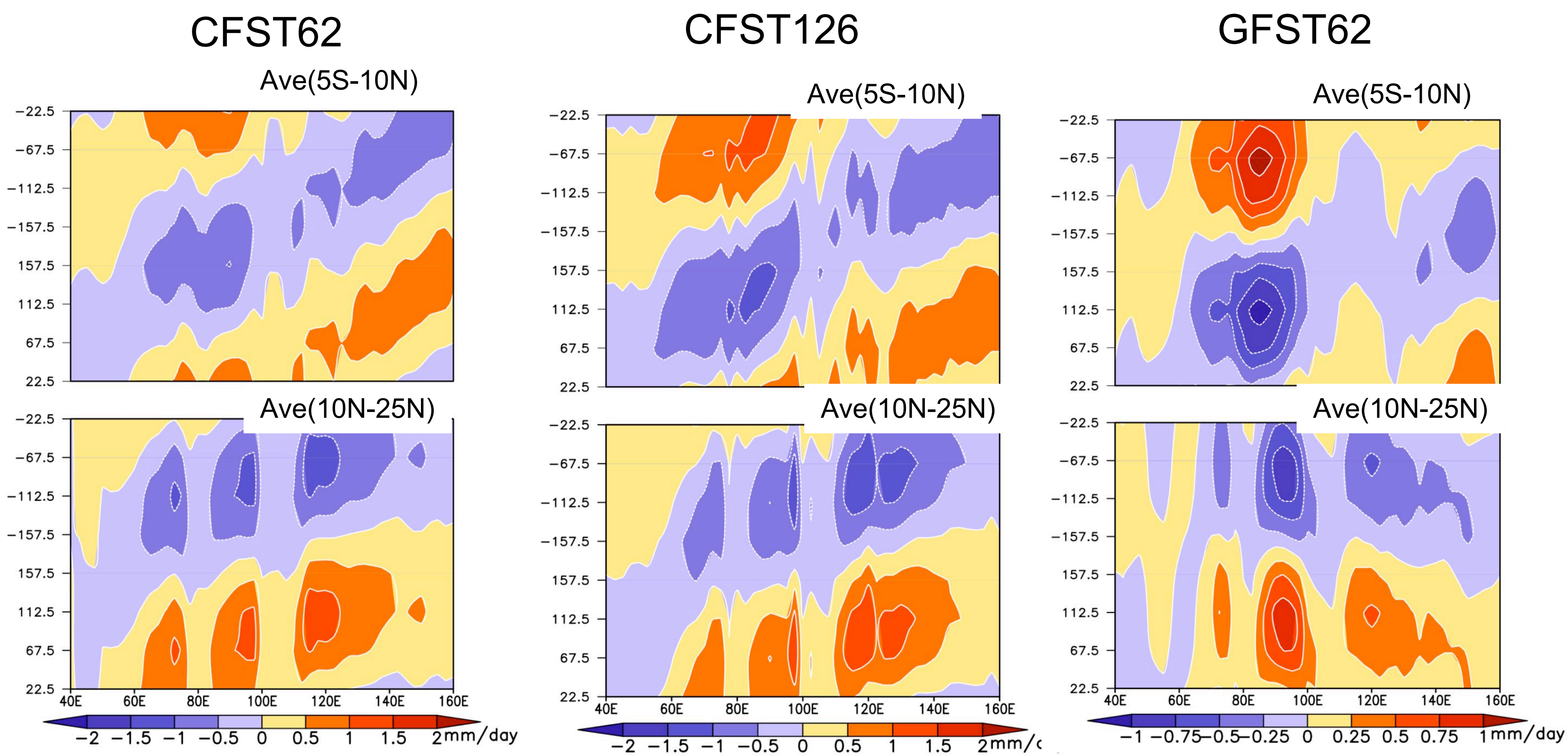
CFST126



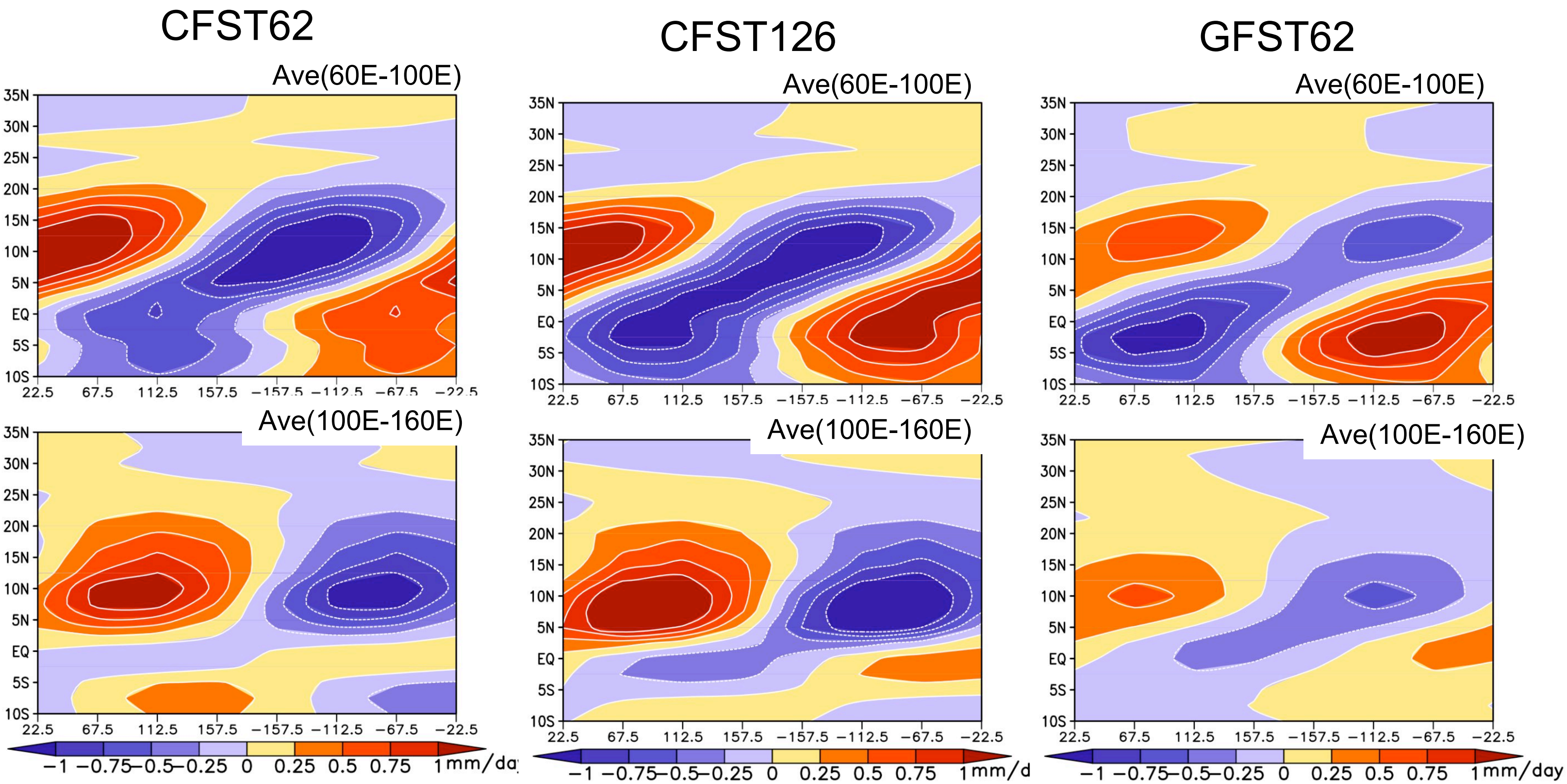
GFST62



Eastward propagation of first oscillatory mode

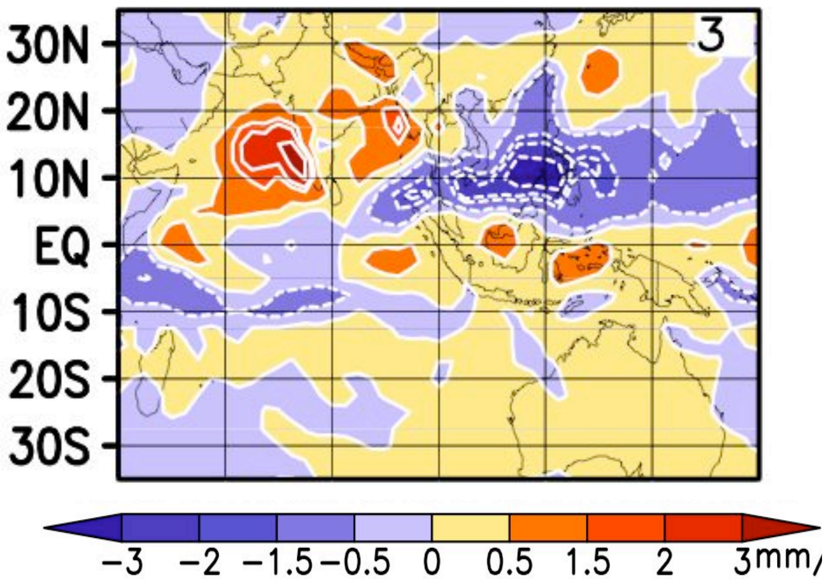


Northward propagation of first oscillatory mode

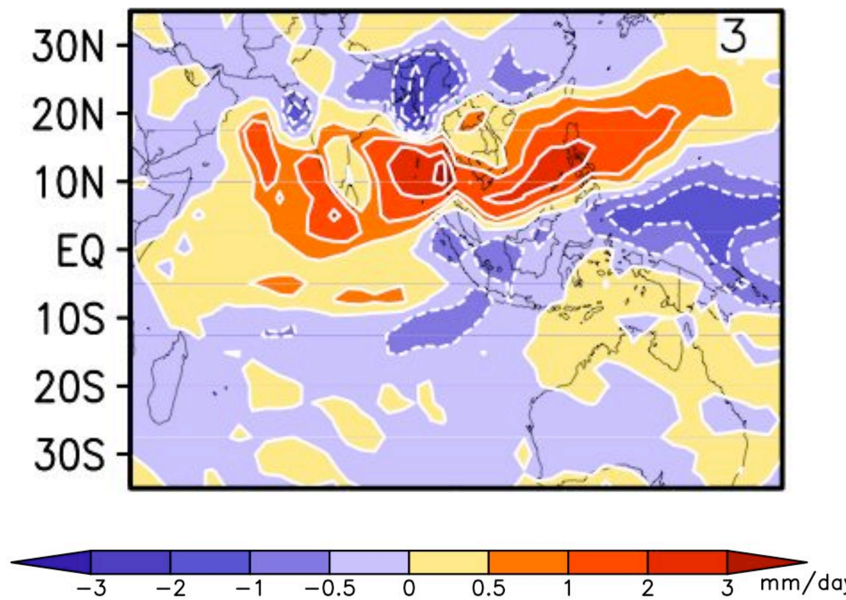


Spatial structure of the second oscillatory mode

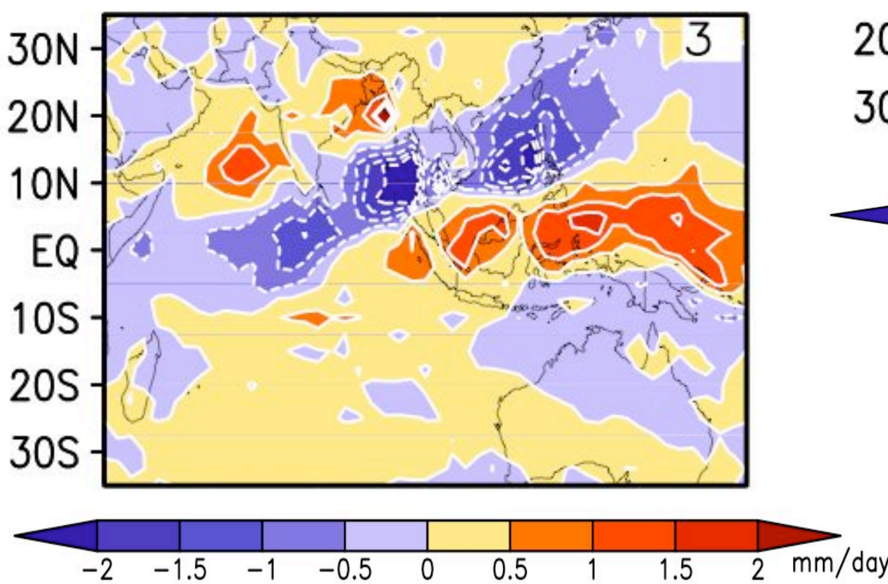
CFST62



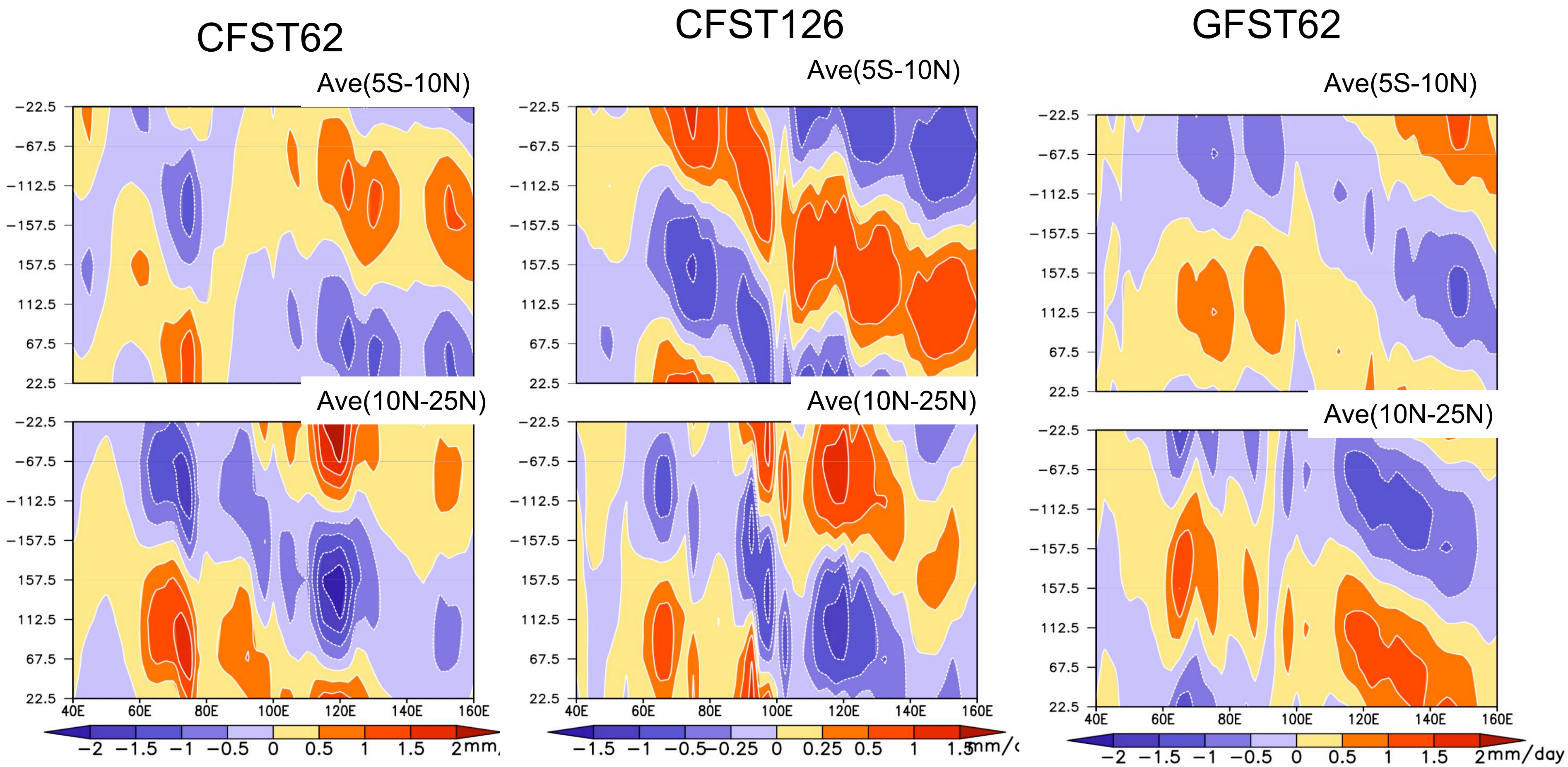
GFST62



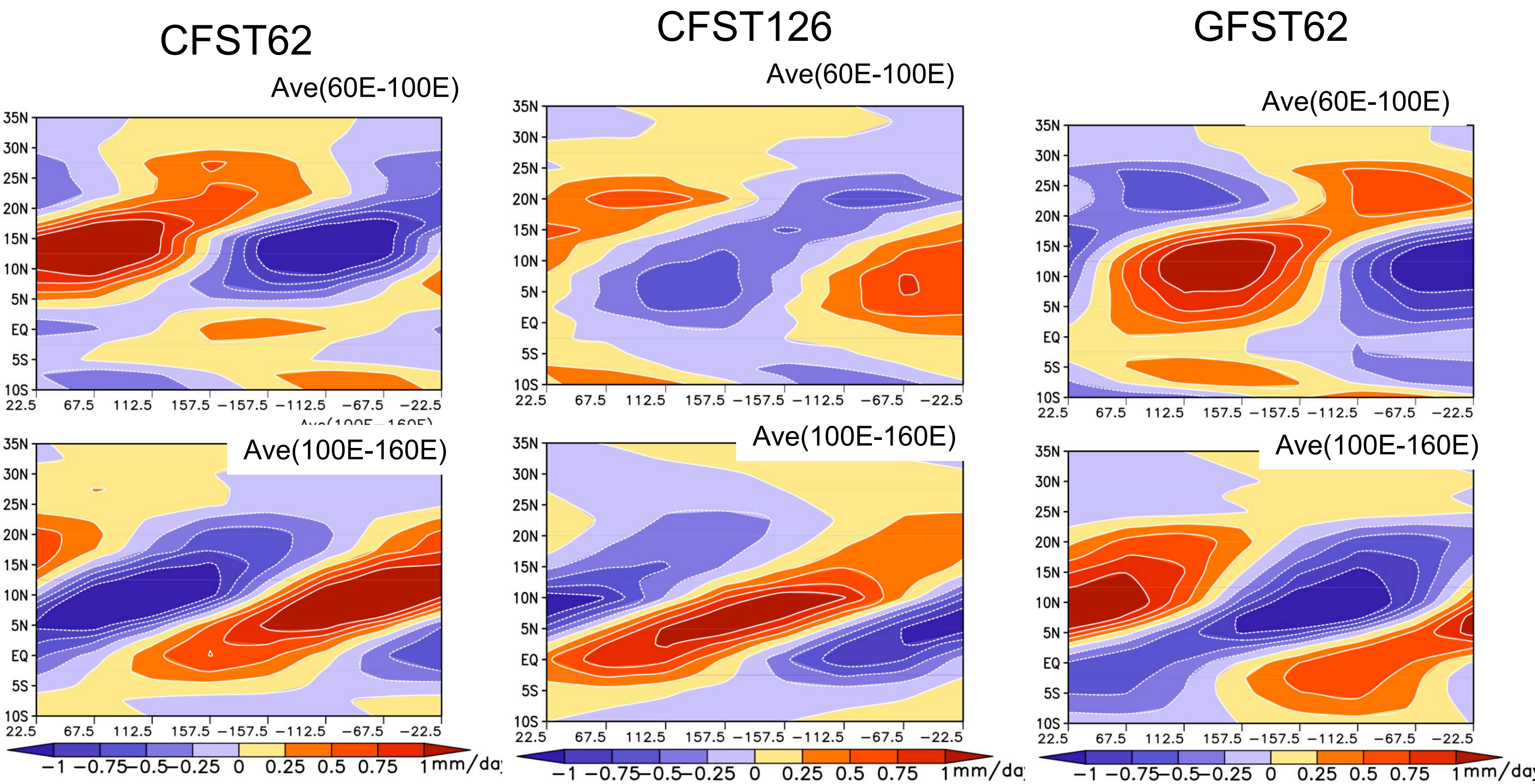
CFST126



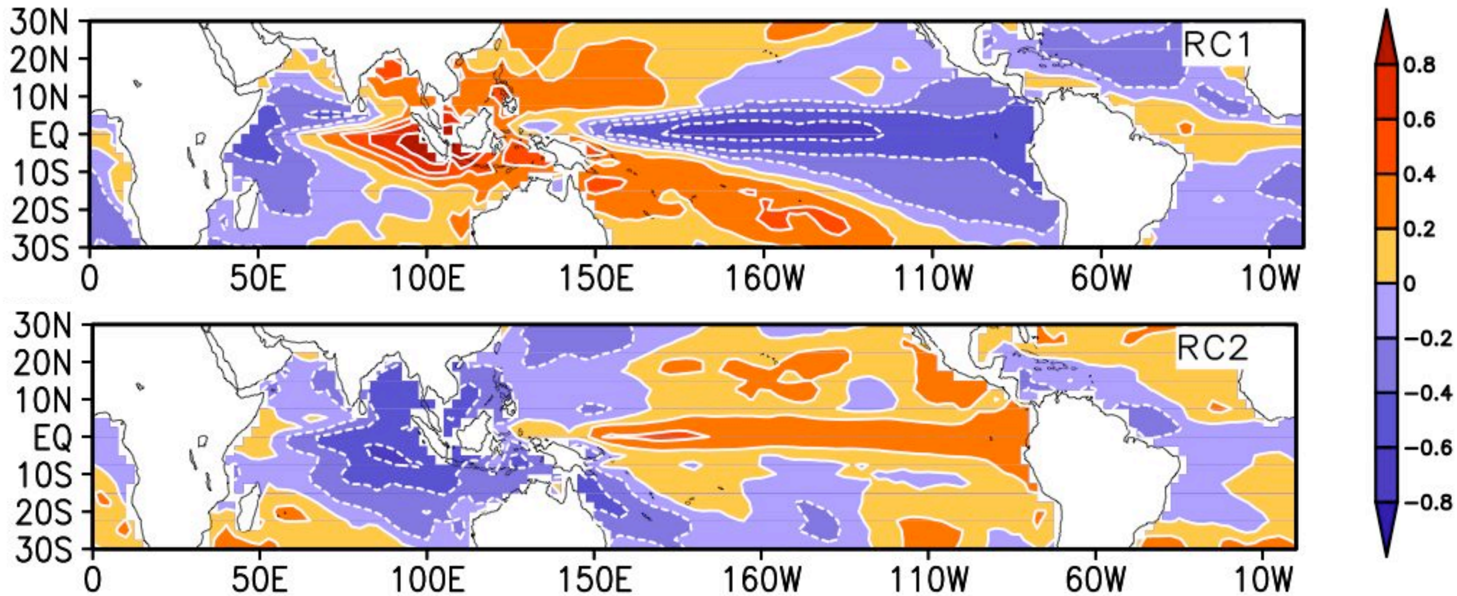
Westward propagation of the second oscillatory mode



Northward propagation of the second oscillatory mode



Comparison with T126 and GFS: Persistent modes



1. Both coupled models have correct ENSO-like mode
2. None of the first 7 persistent modes examined in GFS shows correct correlation with SST
3. Coupled processes seem to be crucial for the simulation of the ENSO mode

Summary

CFS has two main summer intraseasonal modes;

- 100-day mode with northeastward propagation
- 30-day mode with northwestward propagation
- moderate correlations with SST - consistent with Obs

Non-oscillatory modes are heavily correlated with ENSO

- Two counteracting ENSO modes
- Failure to produce ENSO-monsoon relation may be dependent on the“alternate” ENSO mode

T62 Vs. T126:

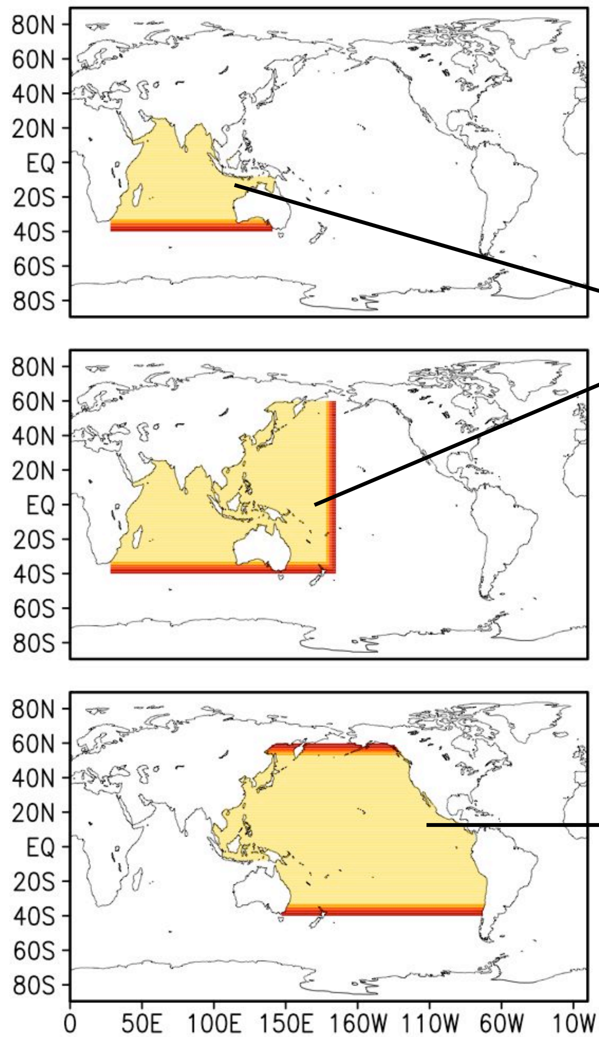
- No noticeable improvement in the oscillatory and persistent modes

T62 Vs. GFS:

- None of the persistent modes in GFS show correct ENSO mode; Coupling is crucial for ENSO-monsoon teleconnection

Further investigations

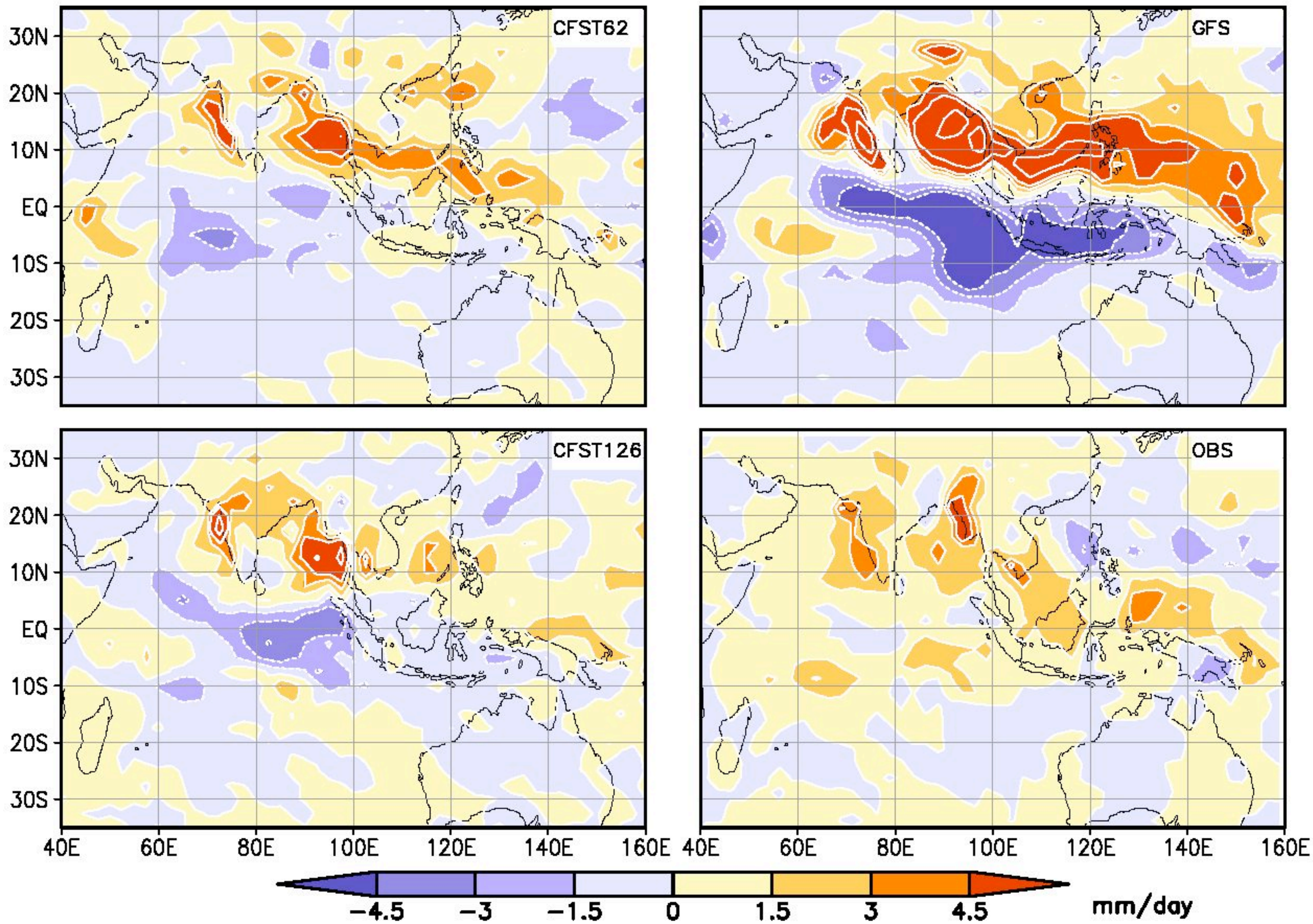
Impact of Indian Ocean on monsoon modes
using regional (un)coupling strategy



Air-sea interaction turned off by prescribing daily SST from control run

Pacific variability suppressed by prescribing climatological SST from control run

Rainfall: Composites of seasonal anomalies (strong-weak)



Rainfall: Composites of pentad anomalies (active-break)