Dominant Modes of A-AM Variability in Observations and Multi-Model Ensemble Hindcasts (DEMETER and APCC)

Bin Wang[1], June-Yi Lee[1], In-Sik Kang[2], J. Shukla[3], C.-K. Park[4]

1. University of Hawaii
2. Seoul National University
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APCC/CliPAS model Specifications

APCC 1-Tier Models

Institute	AGCM	Resolution	OGCM	Resolution	Ensemble Member	Reference
***FRCGC**	ECHAM4	T106 L19	OPA 8.2	2^o cos(lat)x2^o lon L31	9	Luo *et al*. (2005)
NASA	NSIPP1	2^o lat x 2.5^o lon L34	Poseidon V4	$1/3^o$ lat x $5/8^o$ lon L27	3	Vintzileos *et al*. (2005)
***NCEP**	**GFS**	**T62 L64**	**MOM3**	**$1/3^o$ lat x 1^o lon L40**	**15**	**Saha *et al*. (2005)**
***SNU**	SNU	T42 L21	MOM2.2	$1/3^o$ lat x 1^o lon L32	6	Kug *et al*. (2005)
UH	ECHAM4	T31 L19	UH Ocean	1^o lat x 2^o lon L2	10	Fu and Wang (2001)

APCC 2-Tier Models

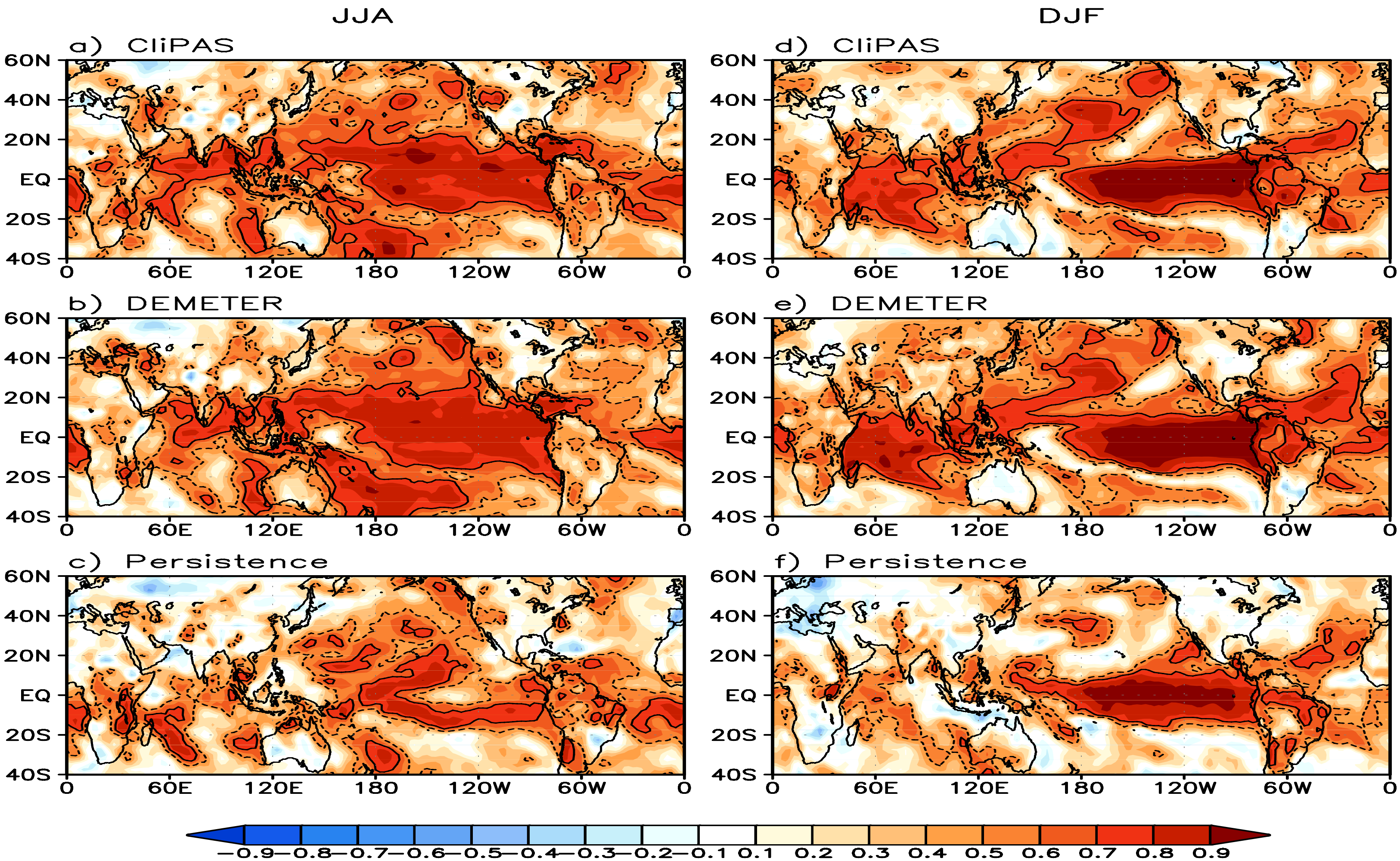
Institute	AGCM	Resolution	Ensemble Member	Reference
FSU	FSUGCM	T63 L27	10	Cocke, S. and T.E. LaRow (2000)
GFDL	AM2	2^o lat x 2.5^o lon L24	10	Anderson *et al*. (2004)
SNU/KMA	GCPS	T63 L21	6	Kang *et al*. (2004)
UH	CAM2	T42 L26	10	Liu *et al*. (2005)
UH	ECHAM4	T31 L19	10	Roeckner *et al*. (1996)

DEMETER model Specification

- **Development of European Multimodel Ensemble system for seasonal-to-interannual prediction**
- **One-tier prediction system using CGCM**
- **9 ensemble members of 7 models**
- **1980-1999 forecast**

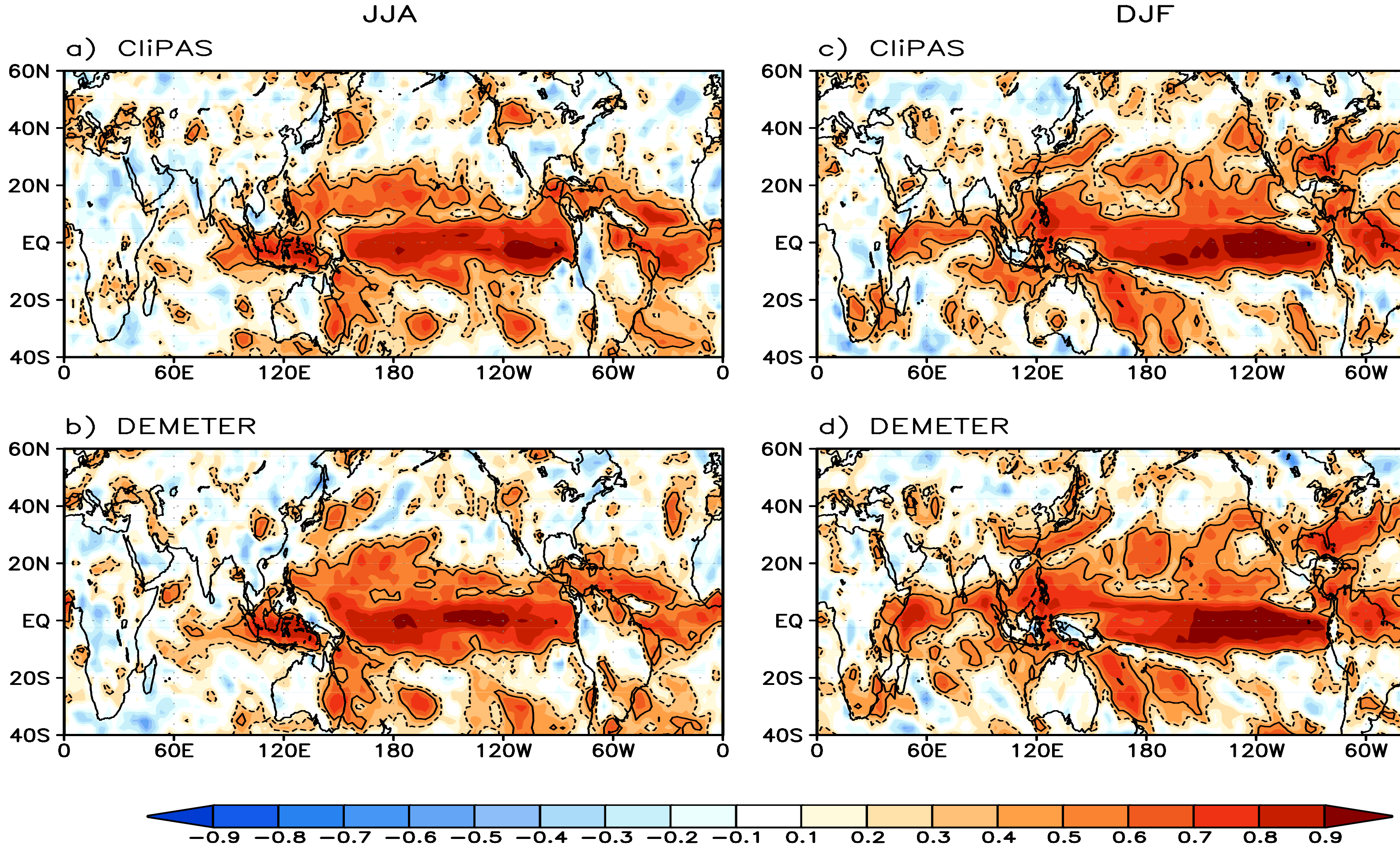
Institute	AGCM	Resolution	OGCM	Resolution	Atmosphere initial conditions	Ensemble generation
CERFACE	ARPEGE	T63 31 Levels	OPA 8.2	2.0x2.0 31 Levels	ERA-40	Windstress and SST perturbations
ECMWF	IFS	T95 40 Levels	HOPE-E	1.4x0.3-1.4 29 Levels	ERA-40	Windstress and SST perturbations
INGV	ECHAM-4	T42 19 Levels	OPA 8.1	2.0x0.5-1.5 31 Levels	Coupled AMIP-type experiment	Windstress and SST perturbations
LODYC	IFS	T95 40 Levels	OPA 8.2	2.0x2.0 31 Levels	ERA-40	Windstress and SST perturbations
Meteo-France	ARPEGE	T63 31 Levels	OPA 8.0	182GPx152 GP 31 Levels	ERA-40	Windstress and SST perturbations
MPI	ECHAM-5	T42 19 Levels	MPI-OM1	2.5x0.5-2.5 23 Levels	Coupled run relaxed to observed SSTs	Atmospheric conditions from the coupled initialization run (lagged method)
UK Met Office	HadAM3	2.5x3.75 19 Levels	GloSea OGCM based on HadCM3	1.25x0.3-125 40 Levels	ERA-40	Windstress and SST perturbations

Temporal Correlation / 2m Air Temperature



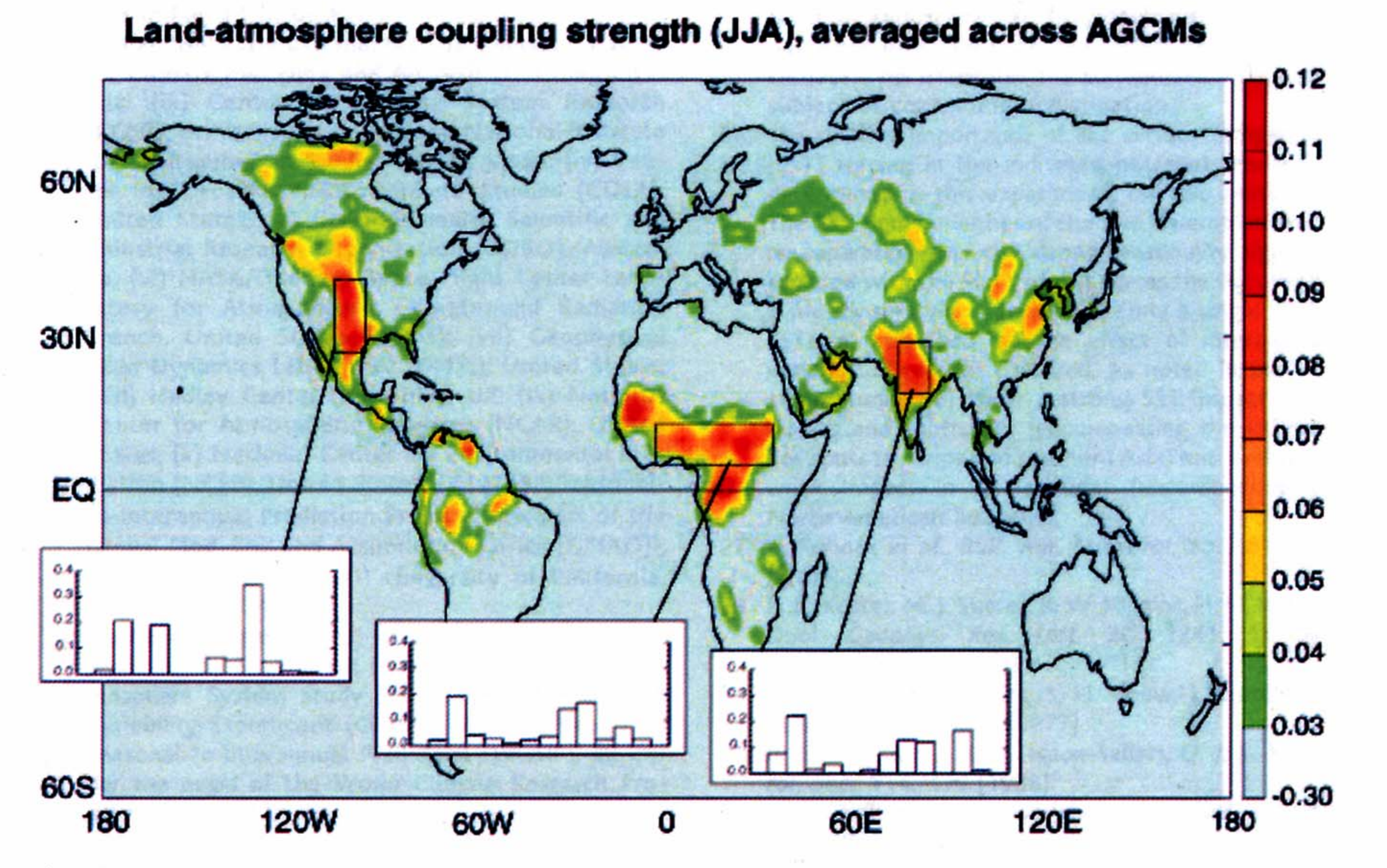
- Superior to the persistence except JJA SE Africa and SWIO.
- Two MMEs similar. DEMETER better over the Asia, but CliPAS is better over the North America-North Atlantic.
- Tropical Pacific: JJA better in the region between 10N and 20N (north of the ITCZ) Tropical IO: the local summer surface temperature is better predicted than local winter season. Tropical Atlantic better during the local winter. Role fo ENSO.
- Poleward of 20N and 20S, higher in local winter than local summer: North Pacific and Atlantic, SPCZ. Role of westerly Jet.
- JJA and along 35N-50N

Temporal Correlation / Precipitation



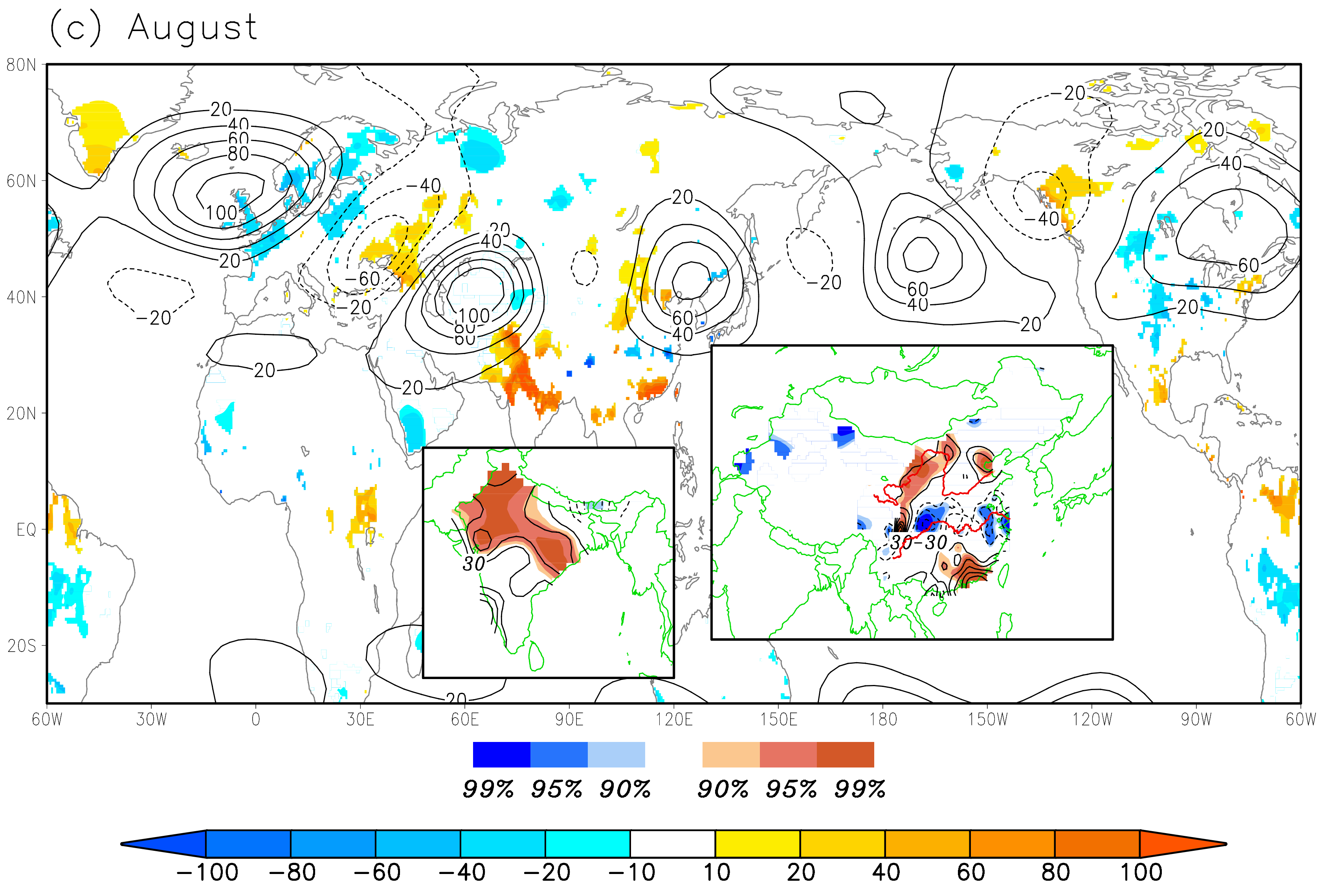
- Two MMEs similar. DEMETER MME better in DJF over the East Asia and eastern tropical Africa.
- The high skills : the tropical Pacific between 10S and 20N, MC, and the northeast Brazil and the equatorial Atlantic Ocean
- Western Hemisphere tropics is better. Hoarse show low-skill region in the EH.
- Land regions are lacking skills. During DJF ENSO impacts extends to Land.
- DJF is better than JJA. Particularly in (a) the subtropical NP and NA (20-40N); (b) EIO; (c) SPCZ; (d) the northern South America, (e) Southern Africa; (f) Mexico and southern United States, and (g) Southeast Asia.
- However, over Southeast South America-southwest AO (20S-35S, 10W-50W) and east Australia, JJA (local winter) better.
- JJA: midlatitude wavelike patterns of moderate skill is notable.

Hot places of land surface feedback



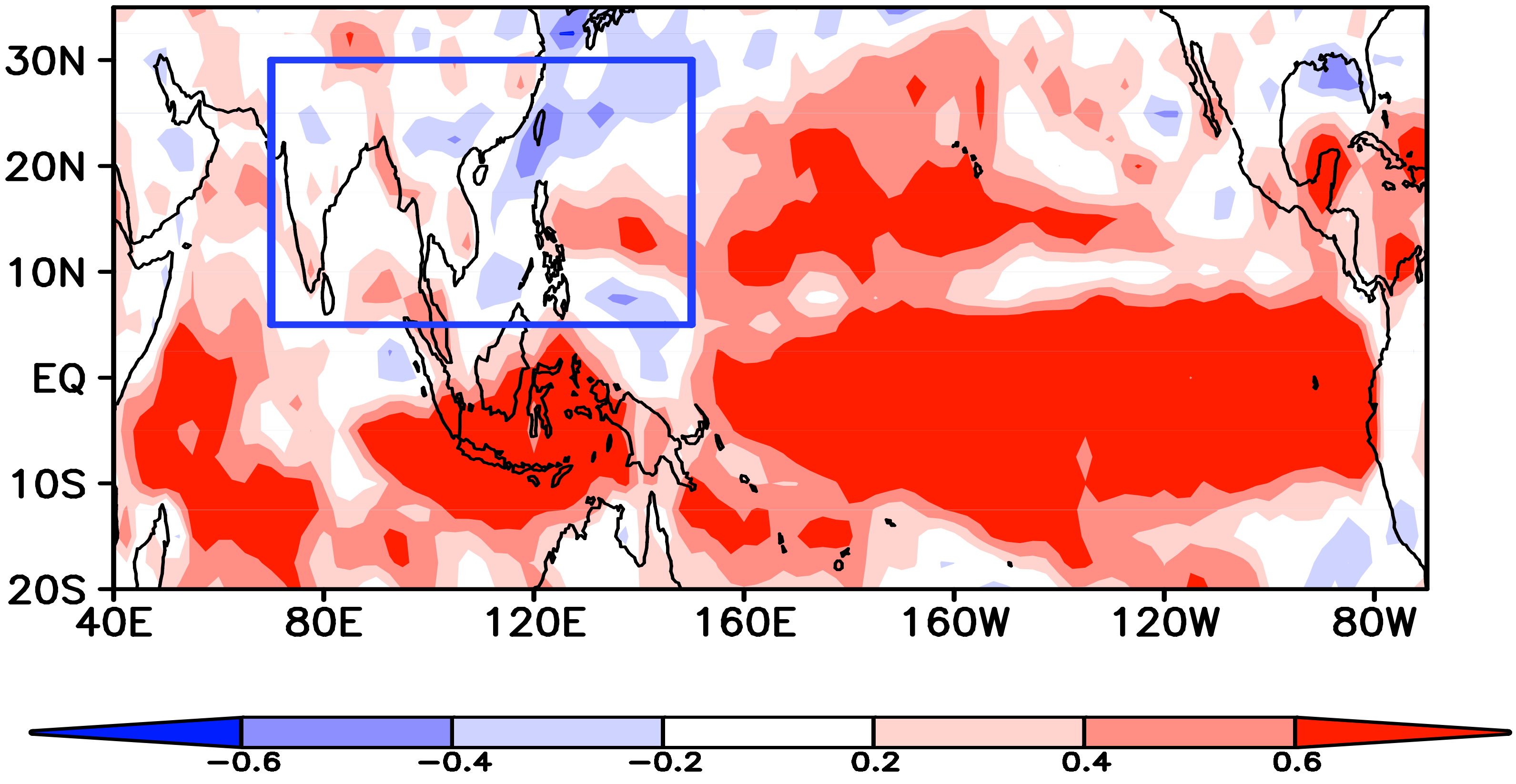
Koster et al. 2004

NH Summer Circumglobal Teleconnection (CGT



Ding and Wang'05

Correlation Coefficients between the observed and 5 AGCM MME hindcast June-August precipitations (1979-1999)



Wang et al. (2005)

Fig. 1

Can Multi-Model Ensemble Capture the Dominant Modes of A-AM Variability?

Questions

1. What are the essential features of the leading modes of IAV of A-AM?
2. How well do the DEMETER and CliPASS 10 coupled climate models capture these leading modes?

Methodology: Seasona-Reliant EOF

(Wang and An 2005, GRL)

Physical consideration

Anomalous climate (ENSO is only an example) is often regulated by the seasonal march of the solar radiation forcing and the resultant climatological annual cycles.

We propose Season-reliant Empirical Orthogonal Function (S-EOF) analysis to detect seasonal evolving major modes of climate variability.

Method of S-EOF Analysis

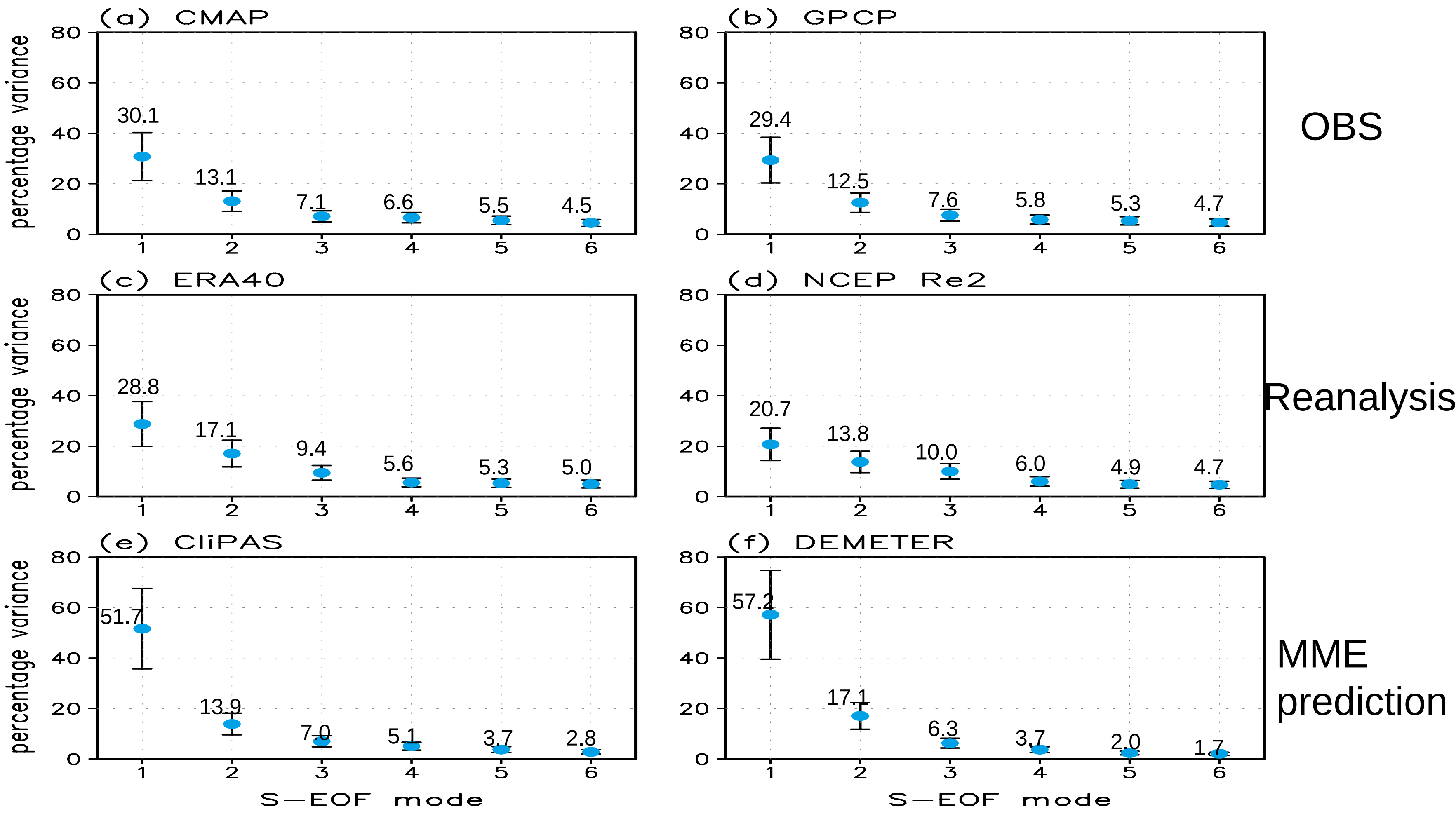
Basic Idea: Search for seasonally evolving patterns from year to year.

Keys: Examine a set of sequential seasonal anomalies for one year.

Coding: Constructing a covariance/correlation matrix by treating the given set of seasonal sequence as one time step (year).

Interpretation: The obtained spatial patterns for each S-EOF mode describes evolving seasonal anomalies in a given year. These patterns share the same yearly value in the corresponding PC.

Fractional Variance of the first 6 S-EOF modes

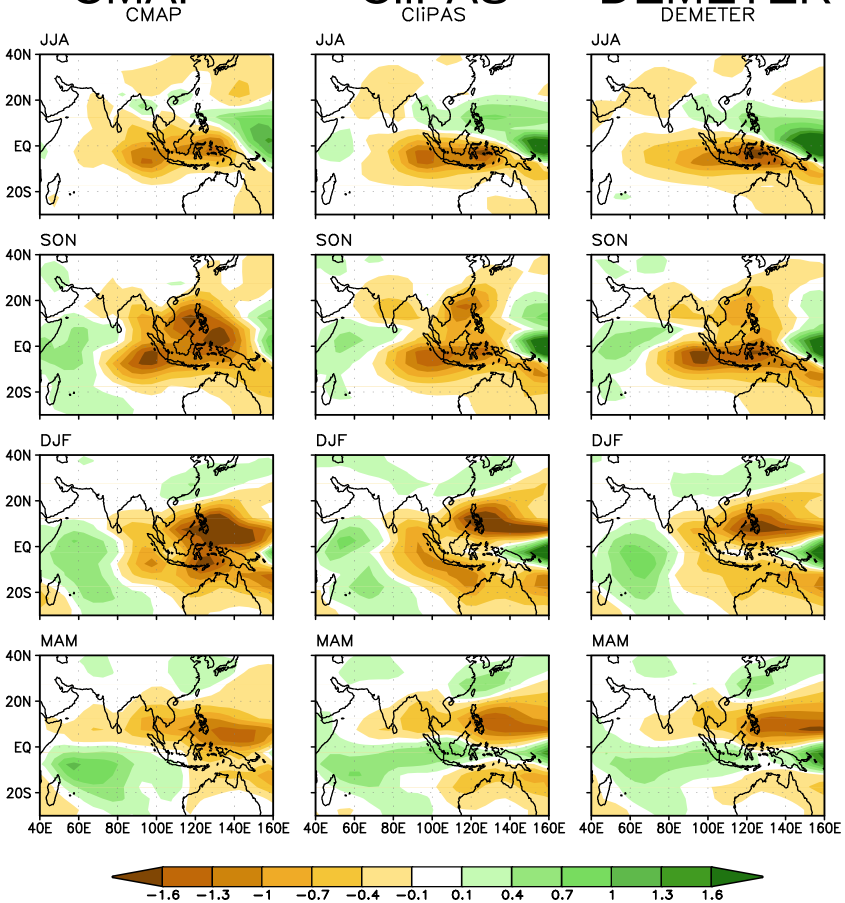


Percentage variance (%) explained by the first six S-EOF modes of seasonal precipitation obtained from (a) CMAP, (b) GPCP, (c) ECMWF reanalysis, (d) NCEP reanalysis 2, (e) CliPAS MME prediction and (f) DEMETER MME prediction. The error bars represent one standard deviation of the sampling errors.

DEMETER and CliPAS one-tier MME hindcast capture leading IAV modes of precipitation

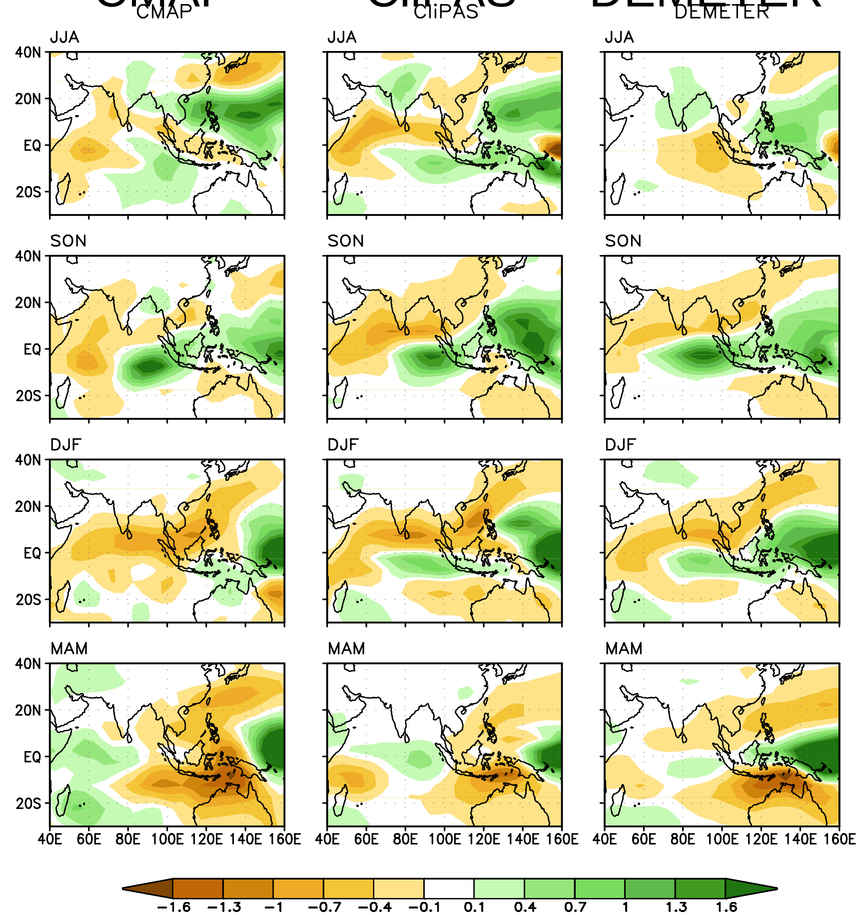
S-EOF 1 of CMAP: 30%

CMAP CliPAS DEMETER



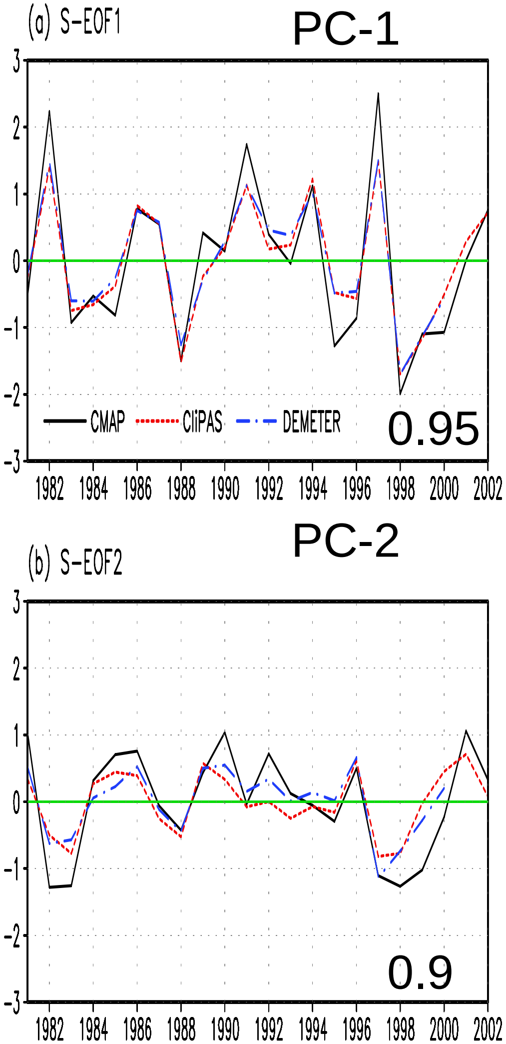
S-EOF 2 of CMAP: 13%

CMAP CliPAS DEMETER

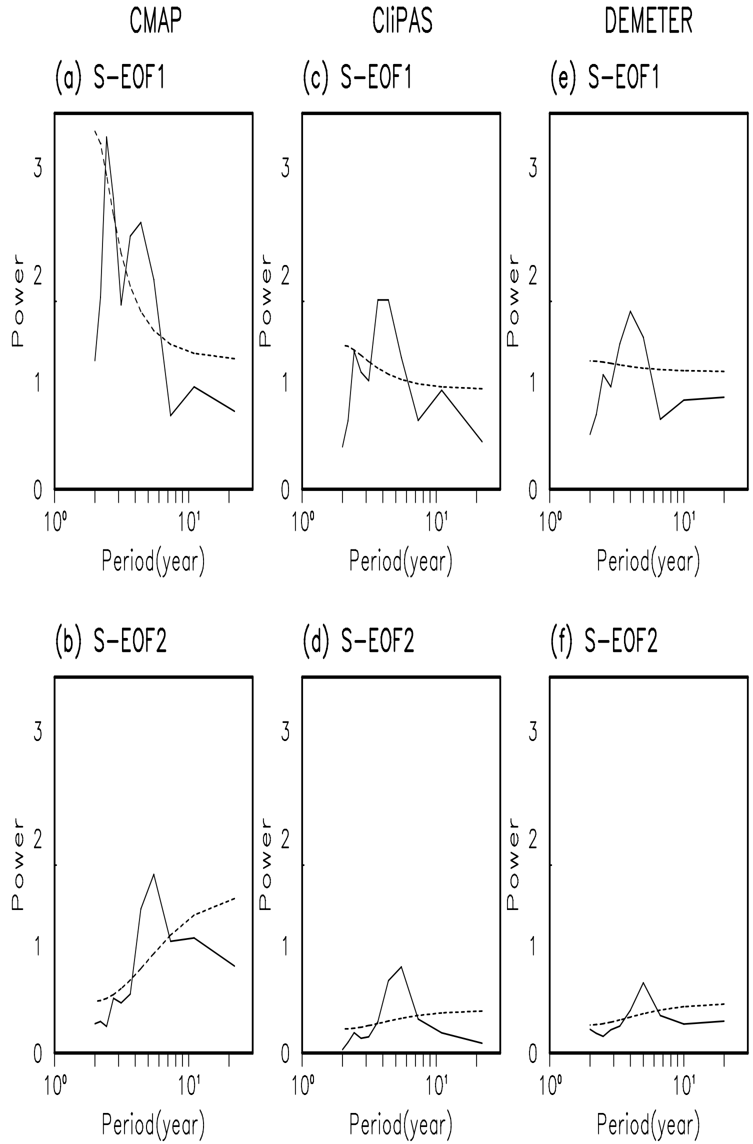


- DEMETER and CliPAS MMEs capture spatial patterns of QB &QQ with PCC of ~0.8 for SEOF1 and 0.65-0.7 for SEOF2

PC time series
MMEs are highly correlated with CMAP

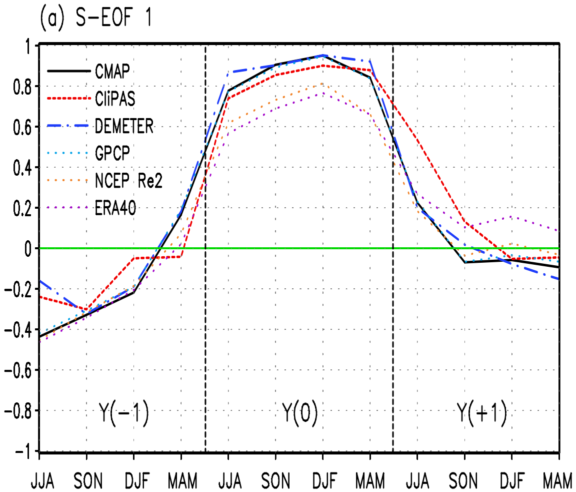


PC Spectra:
MMEs underestimate QB Peak and total variances

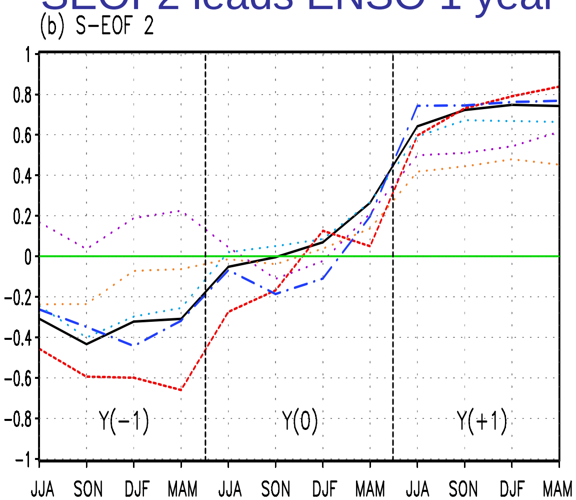


Lead/lag correlation with Nino3.4 SSTA: MME capture ENSO-MNS relation

S-EOF1 concurs with ENSO

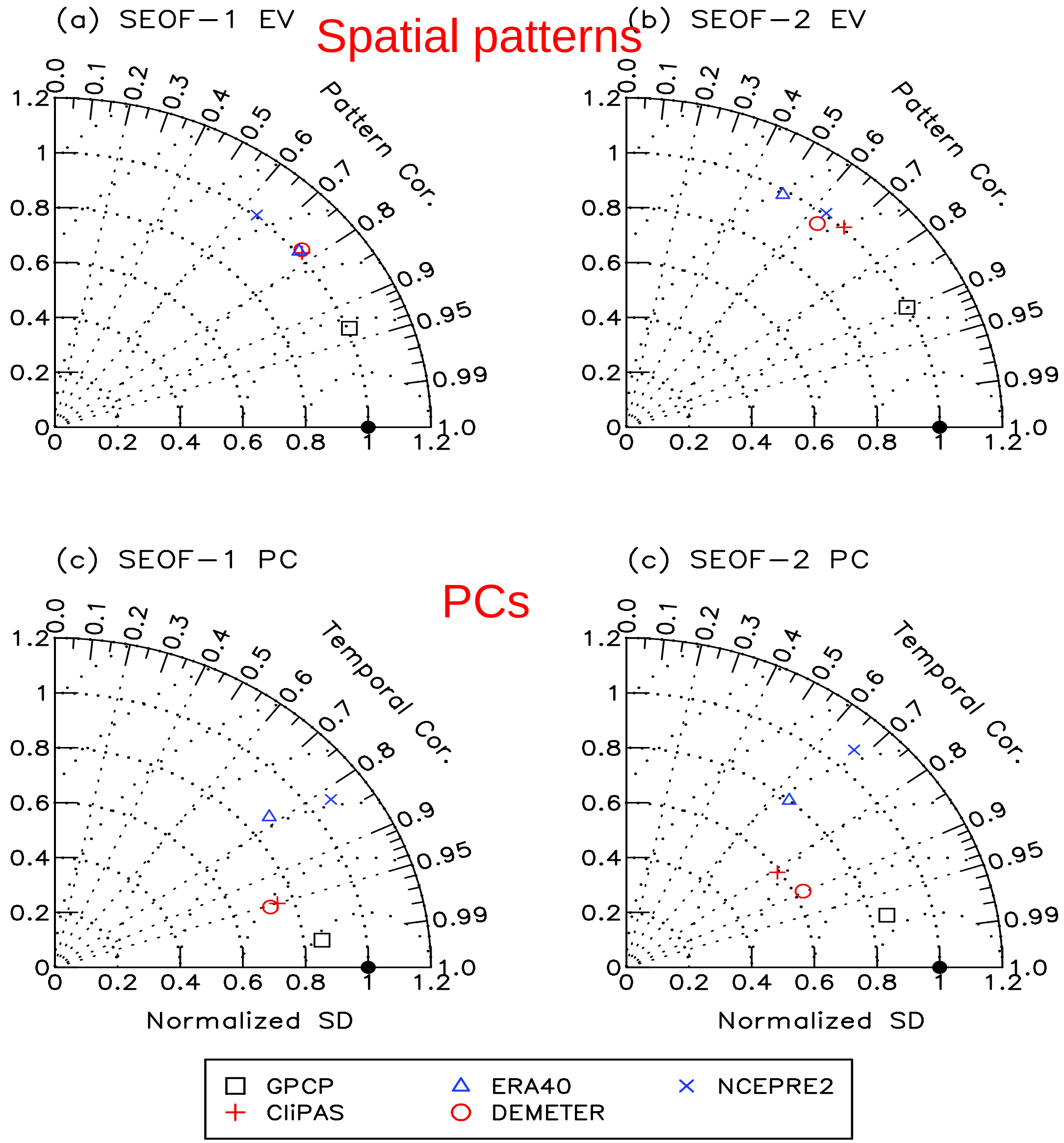


SEOF2 leads ENSO 1 year



MME hindcast VS. ER40 and NCEP-2 (IAV leading modes

S-EOF1 S-EOF2



Taylor diagram: PCC vs. Normalized SD with Reference to CMAP and GPCP.

DEMETER and **CliPAS** MME have higher PCC than ER 40 and NCEP-2 reanalysis, particularly for PCs.

But MME PCs carry lower variances

Correlation Skill of EV and PC Predicted by CFS

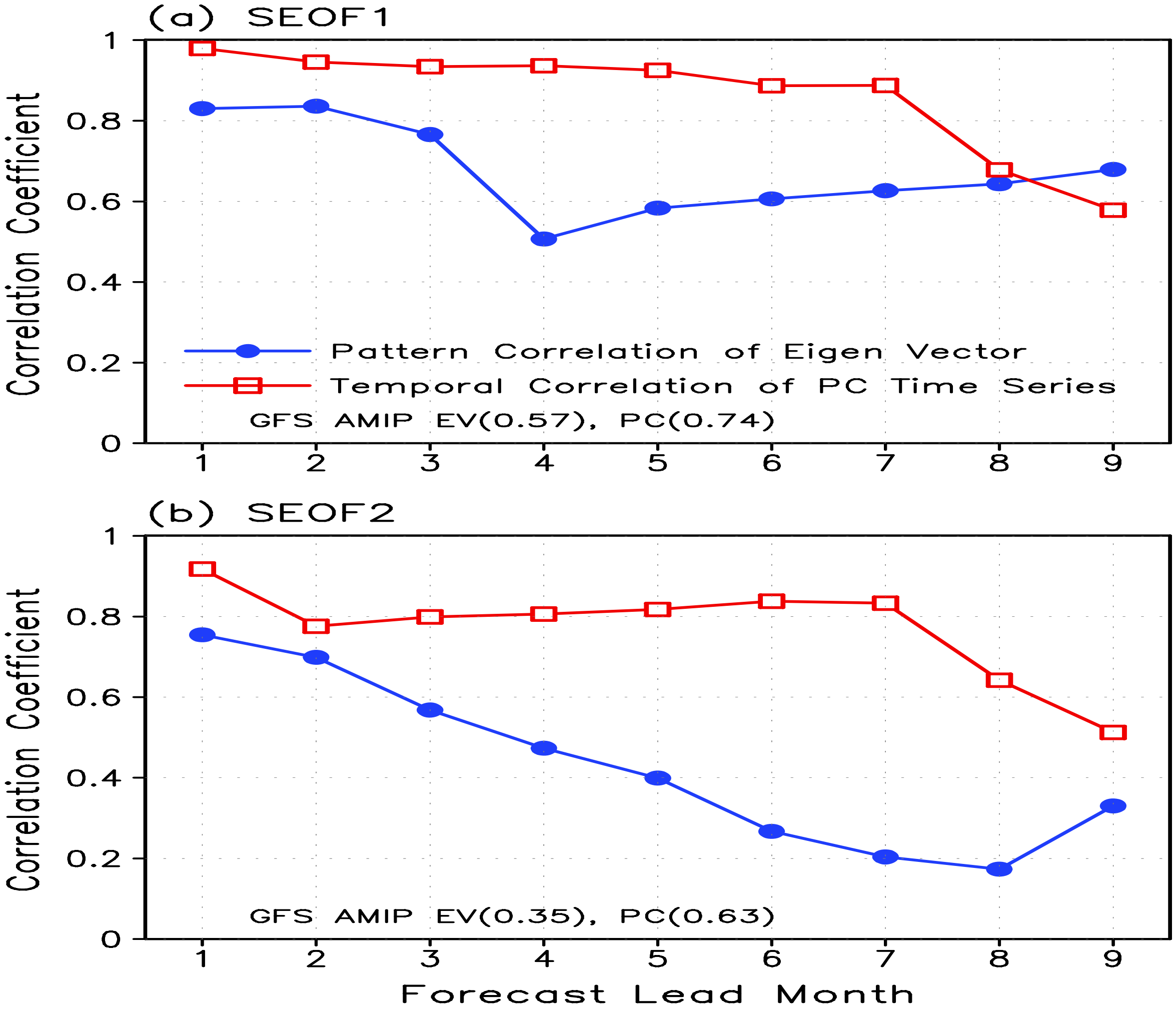


Fig. 10. Pattern correlation of eigenvector and temporal correlation of principle component predicted by CFS with forecast lead time up to 9 month for (a) the 1st mode of SEOF and (b) the 2nd mode of SEOF.

Power spectrum of Time series of S-EOFs/ Precipitation

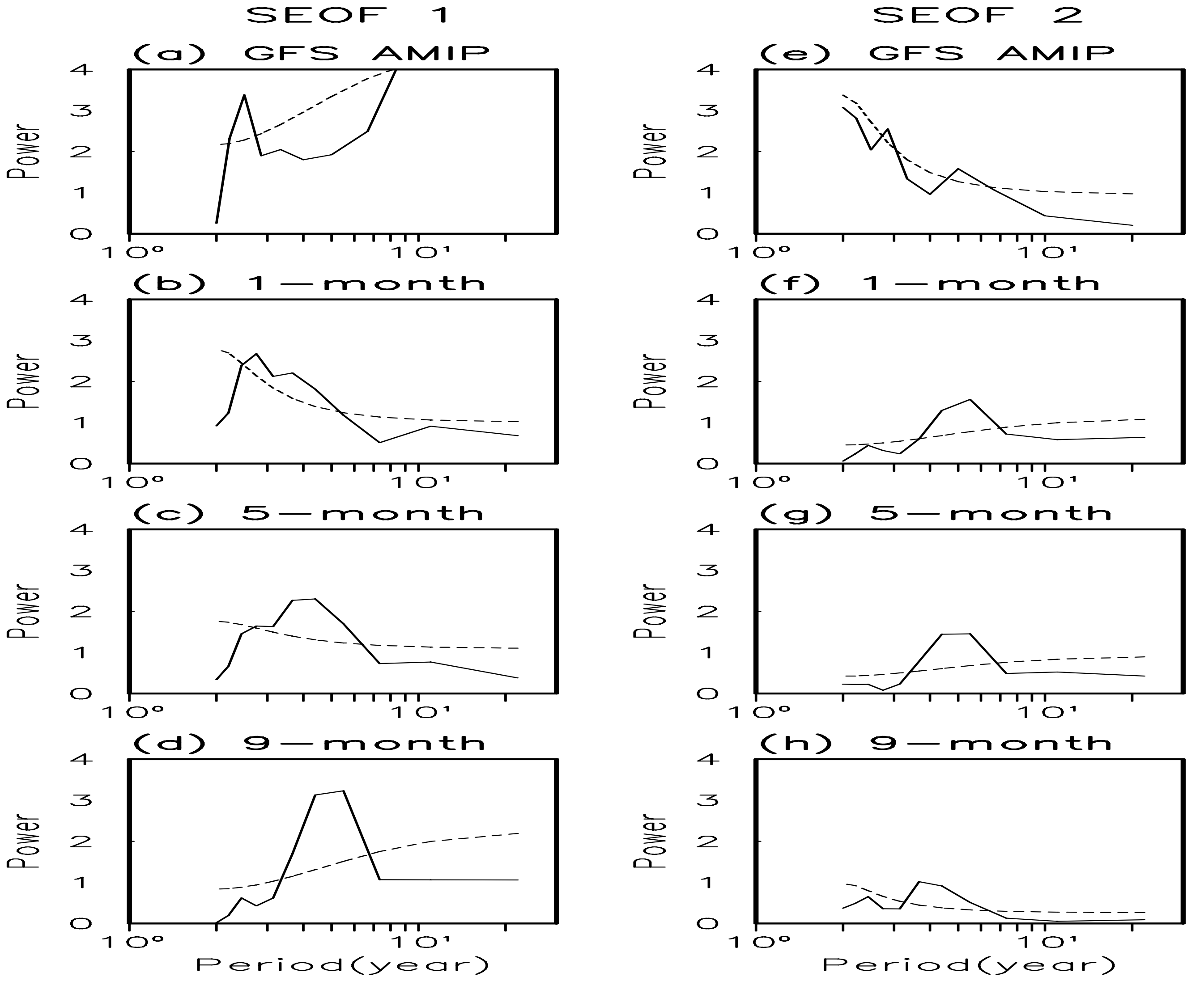


Fig. 9. The power spectrum density (solid line) and red noise (dashed line) of the first (left-hand panels) and the second (right-hand panels) S-EOF principal component of seasonal precipitation anomaly obtained from GFS AMIP simulation (a, e), CFS 1-month (b, f), 5-month (c, g), and 9-month (d, h) lead time forecast, respectively.

How well do the coupled models capture the leading modes of precipitation anomalies?

---The CMAP anomalies show a Quasi-Biennial (QB) and Low-frequency (LF) mode, which accounts for ~ 30% and 13% of the total variance. The QB mode concurs with but LF mode leads ENSO by ~one year.

--The MMEs capture both the spatial patterns and temporal evolutions of the two modes with correlation coefficients higher than their counterparts in re-analyses (ER 40 and NCEP2).

--However, the MMEs significantly underestimate the biennial tendency of first mode and the temporal variability of the two modes, as well as the “background” noise. These deficiencies limit the MME predictive skill.

Prediction Needs

- Design metrics for objective, quantitative assessing predictability and prediction skill.
- Improve MME prediction system and study combined EM and probabilistic forecast.
- Improve initialization scheme and initial conditions and representation of slow coupled physics.
- Develop new strategy and methodology for sub-seasonal monsoon prediction.
- Better understand physical basis for seasonal prediction and ways to predict uncertainties of the prediction.


Diamond Head
Thanks

Issues

- How predictable is the AAM IAV? What factors limit climate models' predictability?
- Other potential sources of predictability besides ENSO? Land processes
- Can we improve seasonal prediction besides getting better models?
- Is monsoon ISO a contributor or a trouble maker to seasonal prediction?
- How to improve the coupled models?

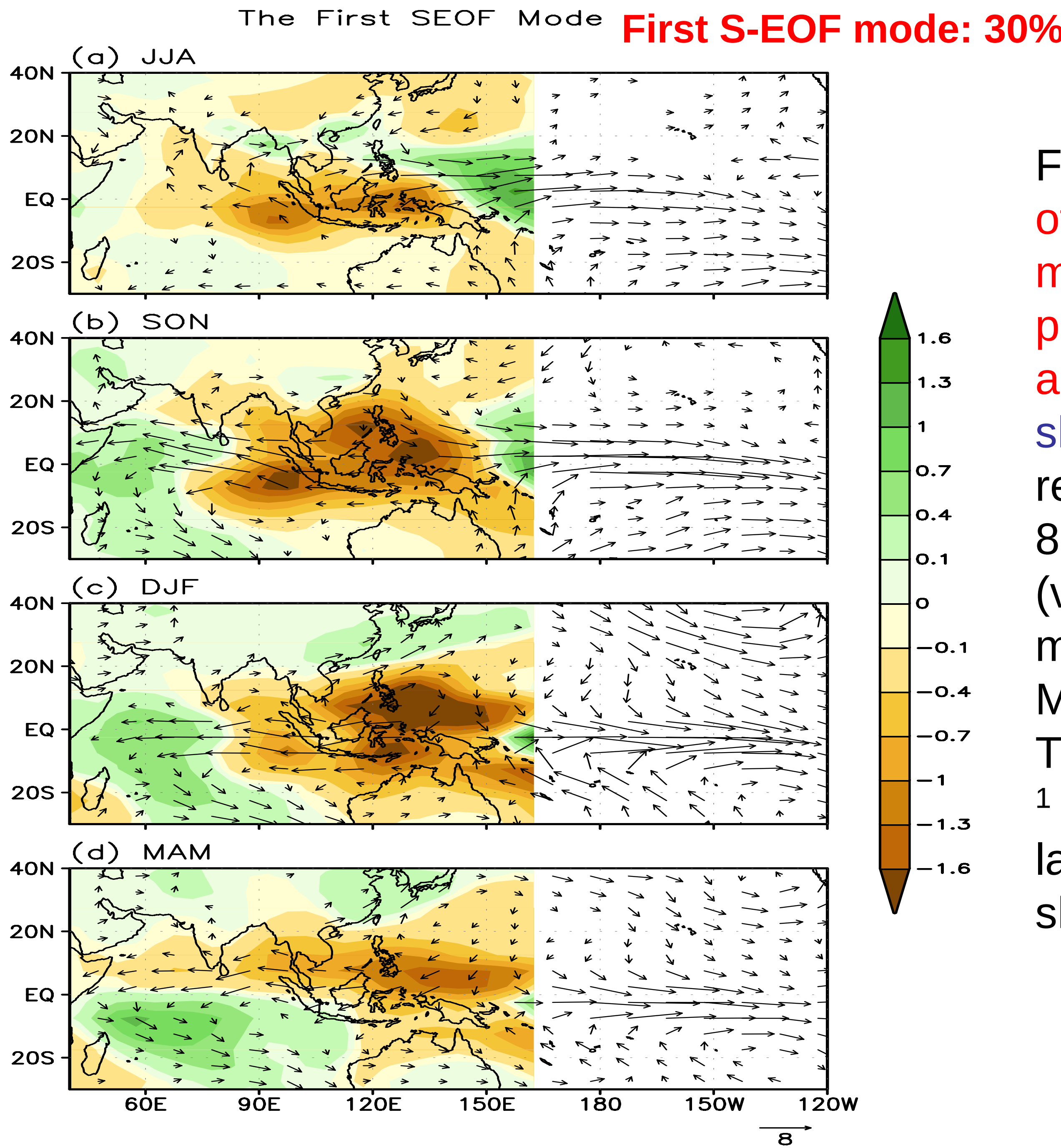


Fig. 1 Spatial patterns of the first S-EOF mode of CMAP precipitation anomalies (color shading) and linear regression of NCEP-2 850 hPa wind (vectors) against the mode from JJA (0) to MAM (1). The vector unit is 8ms^{-1} and wind anomalies larger than 0.5ms^{-1} are shown.

Second S-EOF mode: 13%

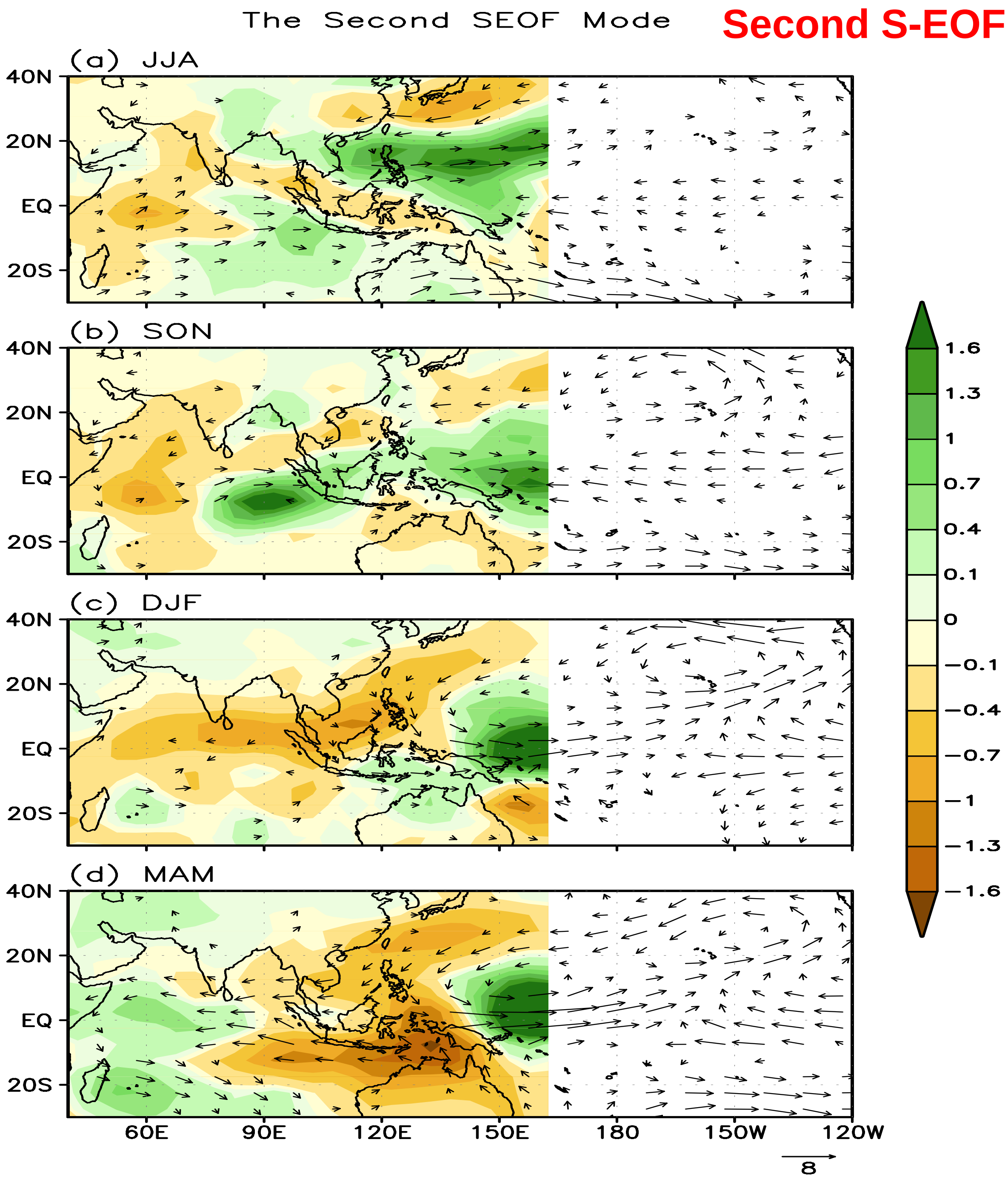


Fig. 2 Same as Fig. 1 except for the 2nd S-EOF mode.

Eigenvectors of SEOF 1/ CFS/ Precipitation

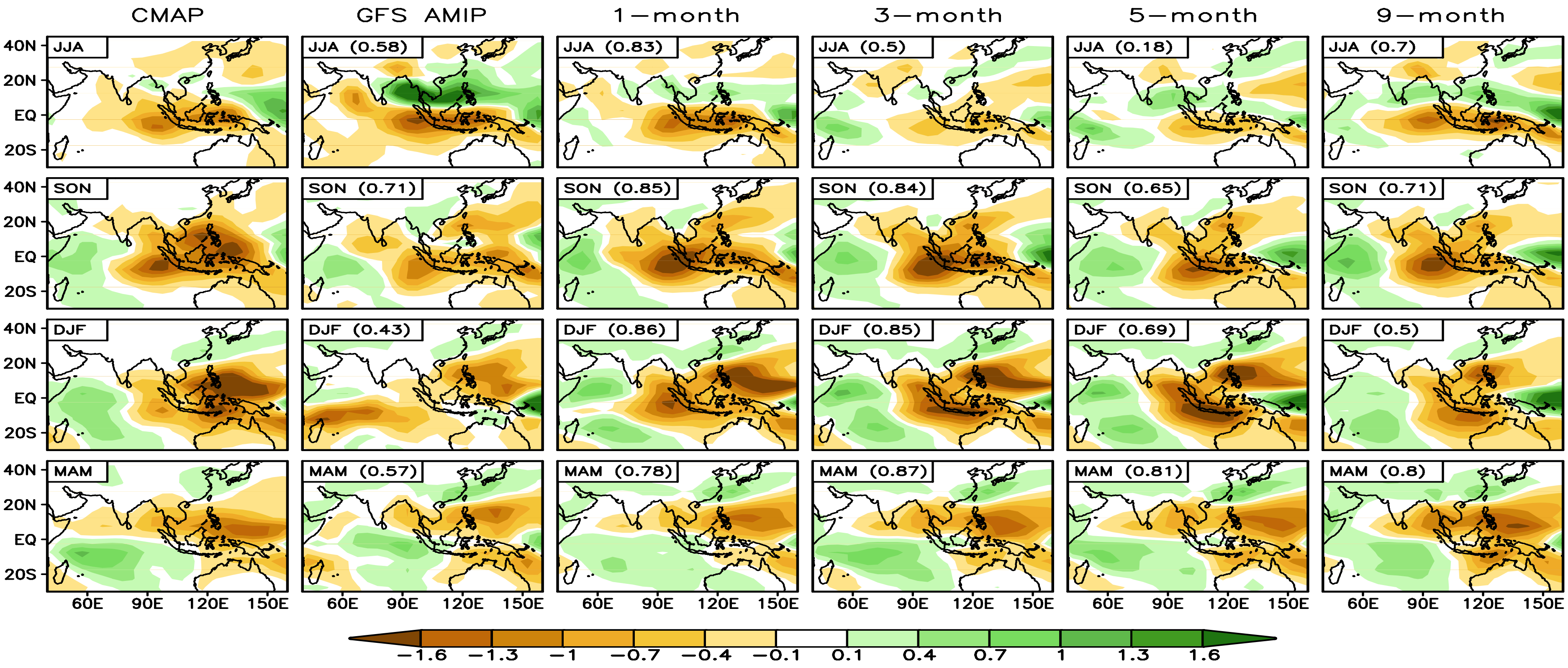


Fig. 11. Spatial patterns of the first S-EOF eigenvector of seasonal (JJA to MAM) precipitation obtained from CMAP, GFS AMIP simulation, and CFS seasonal forecast as a function of lead time of 1, 3, 5, and 9 month.