WGSIP activity proposal: Evaluation of Asian summer monsoon prediction

- Long-Range Forecasts of Asian Monsoon Intercomparison Project (LRFAMIP) -

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Outline

- Backgrounds and motivation
  - Updates of understanding of Asian summer monsoon predictability
  - Science questions
  - Linkage to other projects
  - Previous multi-model evaluation studies

- Research plan
  - Evaluation of the seasonal prediction of Asian monsoon (up to 7 months.) using CHFP.
  - Identification of key predictable variability and multi-model evaluation/comparison of representation of these variability

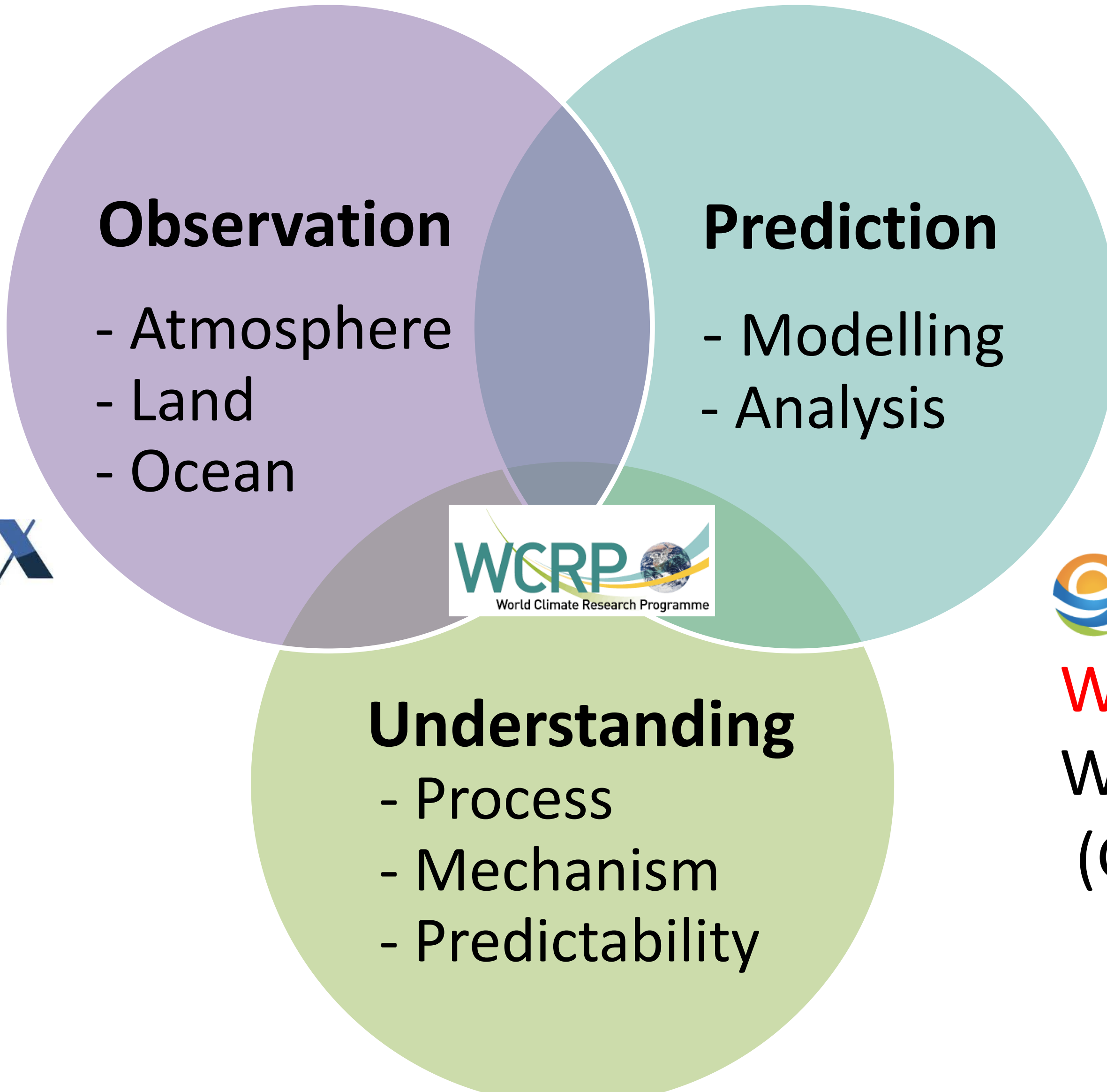
Backgrounds and motivation (1)

- Better understanding of Asian monsoon dynamics
  - ENSO influence
  - Indian Ocean influence (IPOC mode, Xie et al. 2009)
  - Indian Ocean Dipole (Saji et al. 1999, Webster et al. 1999)
  - Predictable modes
- Improved technology (model, initialization)
  - Numerous models present extended predictive skill for the WNP summer monsoon.
  - While, the ensemble technique still need to be improved to draw full benefits of ensemble predictions.

Linkage to other projects

- **AsiaPEX,** GEWEX Regional Hydrological Project in Asia, will start in 2020 (not officially endorsed by GEWEX SC yet). The project will focus on subseasonal-to-decadal predictions (as one of research foci) in line with the WCRP/GEWEX strategy.
- S2S
  provides hindcast and quasi-realtime forecast data. (11 operational models)

Collaborative framework in Asian monsoon research



AsiaPEX

WGSIP

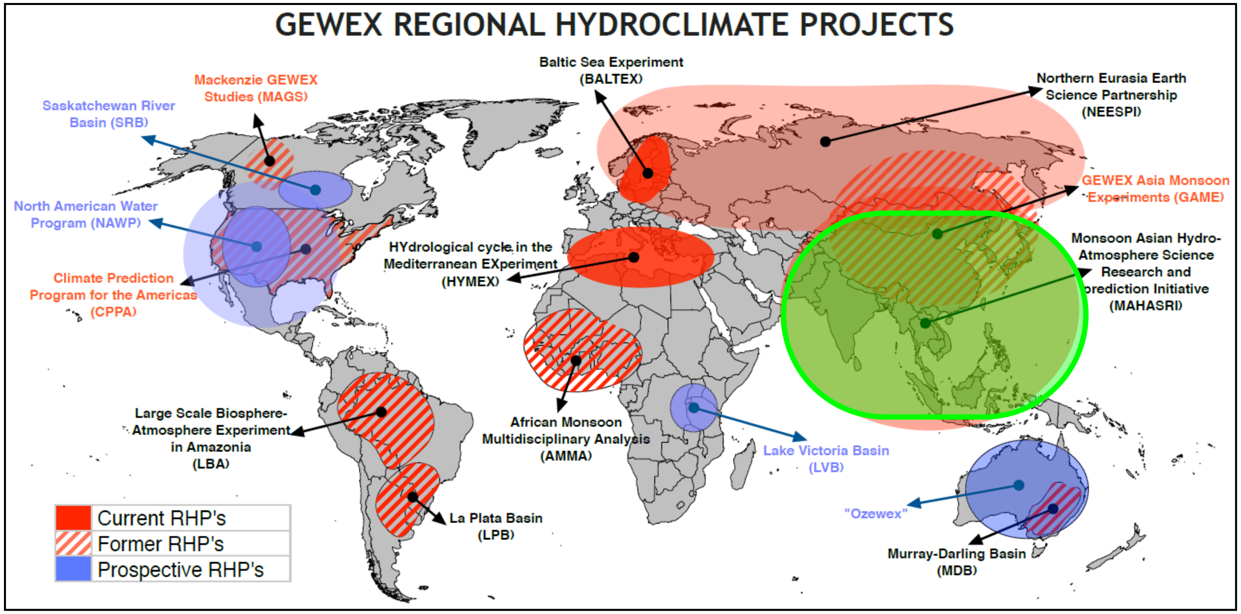
WGCM/CMIP

(GMMIP)

GEWEX Regional activity in Asia

Monsoon Asia Hydroclimatological Research has continued since 1995 under GAME and MAHASRI

- GAME (GEWEX Asian Monsoon Experiment 1996-2005)
- MAHASRI (2007-2016)
- AsiaPEX (2020-)



GEWEX Imperatives

Previous studies of multi-model intercomparison (1)

Dynamical Seasonal Predictability of the Asian Summer Monsoon

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(Manuscript received 5 July 2000, in final form 19 February 2001)

ABSTRACT

Ensembles of hindcasts from seven models are analyzed to evaluate dynamical seasonal predictability of 850-hPa wind and rainfall for the Asian summer monsoon (ASM) during 1987, 1988, and 1993. These integrations were performed using observed sea surface temperatures and from observed initial conditions. The experiments were designed by the Climate Variability and Predictability, Working Group on Seasonal to Interannual Prediction as part of the Seasonal Prediction Model Intercomparison Project. Integrations from the European Union Prediction of Climate Variations on Seasonal to Interannual Timescales experiment are also evaluated.

The National Centers for Environmental Prediction–National Center for Atmospheric Research and European Centre for Medium-Range Weather Forecasts reanalyses and observed pentad rainfall form the baseline against which the hindcasts are judged. Pattern correlations and root-mean-square differences indicate errors in the simulation of the time mean low-level flow and the rainfall exceed observational uncertainty. Most models simulate the subseasonal EOFs that are associated with the dominant variations of the 850-hPa flow during the ASM, but not with the fidelity exhibited by the reanalyses as determined using pattern correlations. Pattern correlations indicate that the first EOF, associated with the tropical convergence zone being located over the continental landmass, is best simulated. The higher-order EOFs are less well simulated, and errors in the magnitude and location of their associated precipitation anomalies compromise dynamical seasonal predictability and are related to errors of the mean state. In most instances the models fail to properly project the subseasonal EOFs/principal components onto the interannual variability with the result that hindcasts of the 850-hPa flow and rainfall are poor. In cases where the observed EOFs are known to be related to the boundary forcing, the failure of the models to properly project the EOFs onto the interannual variability indicates that the models are not setting up observed teleconnection patterns.

Monsoon study as a part of SMIP (CLIVAR/WGSIP)

Previous studies of multi-model intercomparison (2)

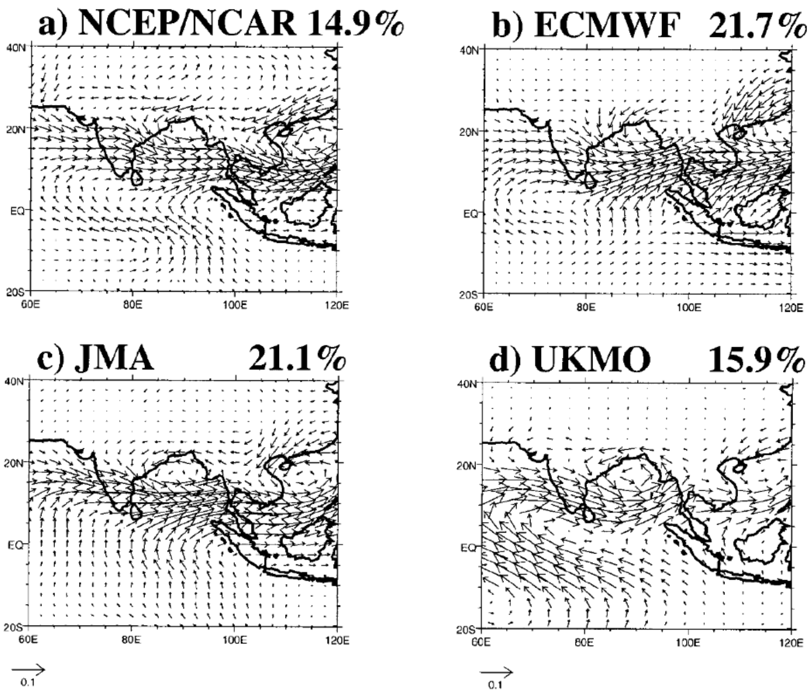


FIG. 3. EOF-1 of daily 850-hPa wind anomalies (calculated with respect to the climatological daily means) for Jun–Sep 1987, 1988, and 1993. The percentage variance explained is also given.

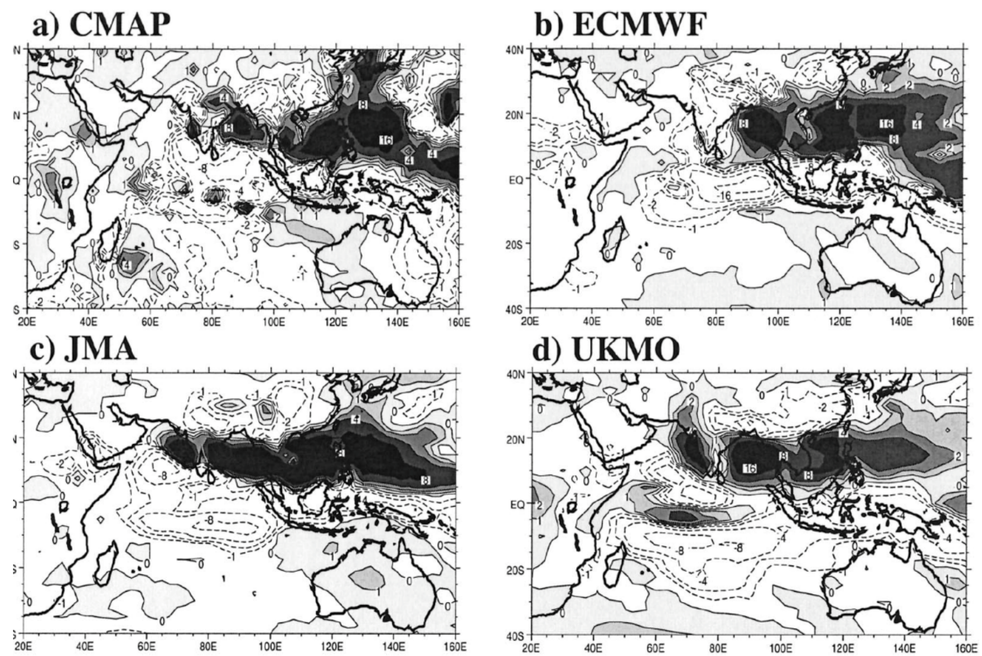


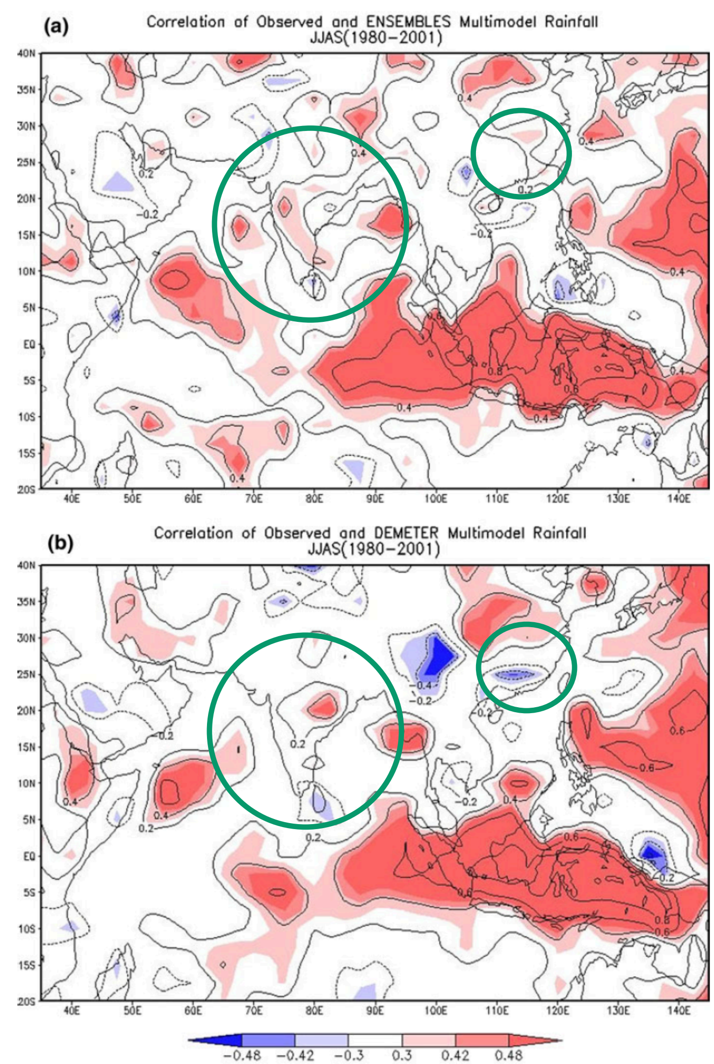
FIG. 6. Difference of daily composites of rainfall based on strong–weak days of the PC time series of EOF-1 using 0 and −1.0 standard deviation thresholds to define extreme days. The CMAP validation data is pentad based in hich case the standardized daily PC time series was pentad averaged with extreme pentads defined using 1.0 and −1.0 standard deviation thresholds. Positive anomalies are shaded, and the contour interval is +/− 0, 1, 2, 4, 8, . . . mm day^{-1}.

Previous studies of multi-model intercomparison (3)

Predictions of regional precipitation seem to be Improved from DEMETER to ENSEMBLES.

How about latest systems?

Fig. 9 Spatial pattern of correlation coefficient between observed rainfall and **a** ENSEMBLES MME (*above*) and **b** DEMETER MME (*below*) for the period 1980–2001



Rajeevan et al. 2012, Clim. Dyn.

Science questions

- What are key variability modes for the seasonal ASM prediction?
- To what extent can state-of-the art seasonal prediction models reproduce and predict these modes?
- How can we improve further current systems in terms of the seasonal ASM prediction? (Common deficiency?)
- How did the seasonal prediction systems advance in the past? (Periodic evaluation of operational systems)

Prediction data

- CHFP (Tompkins et al. 2017)

C3S, ENSEMBLE, DEMETER etc. can be used if needed.

Institution (country)	Model	Retrospective period	Forecast months	No. of ensemble members	Daily *T/P*	Reference(s)
Meteorological Research Institute (MRI)-JMA (Japan)	JMA/MRI-CGCM1	1979–2010	7	10	✓	Takaya et al. (2017a)
	JMA/MRI-CGCM2	1981–2011	7	10		Takaya et al. (2017b)
Met Office (United Kingdom)	L38GloSea4	1989–2003	5	9		Arribas et al. (2011)
	L85GloSea4	1989–2010	5	9		Fereday et al. (2012)
	GloSea5[a]	1996–2009	3	24		MacLachlan et al. (2015)
CCCma (Canada)	CMAM	1979–2009	4	10	✓	Scinocca et al. (2008)
	CMAMlo	1979–2009	4	10	✓	Sigmond et al. (2008)
	CCCma-CanCM3	1979–2010	12	10	✓	Merryfield et al. (2013)
	CCCma-CanCM4	1979–2010	12	10	✓	von Salzen et al. (2013)
NOAA (United States)	CFS	1981–2007	9	7	✓	Saha et al. (2006)
MétéoFrance (France)	ARPEGE	1979–2008	4	11		Voldoire et al. (2013)
CAWCR (Australia)	POAMA	1980–2009	9	10		Cottrill et al. (2013)
CCSR-University of Tokyo (Japan)	MIROC5	1979–2011	12	8	✓	Watanabe et al. (2010); Imada et al. (2015)
ECMWF (international)	ECMWF-S4	1981–2010	7	15		Molteni et al. (2011)
MPI (Germany)	MPI-ESM-LR	1982–2012	12	9		Baehr et al. (2015)
	MPI-ESM-MR	1981–2012	7	10		Stevens et al. (2013); Jungclaus et al. (2013)

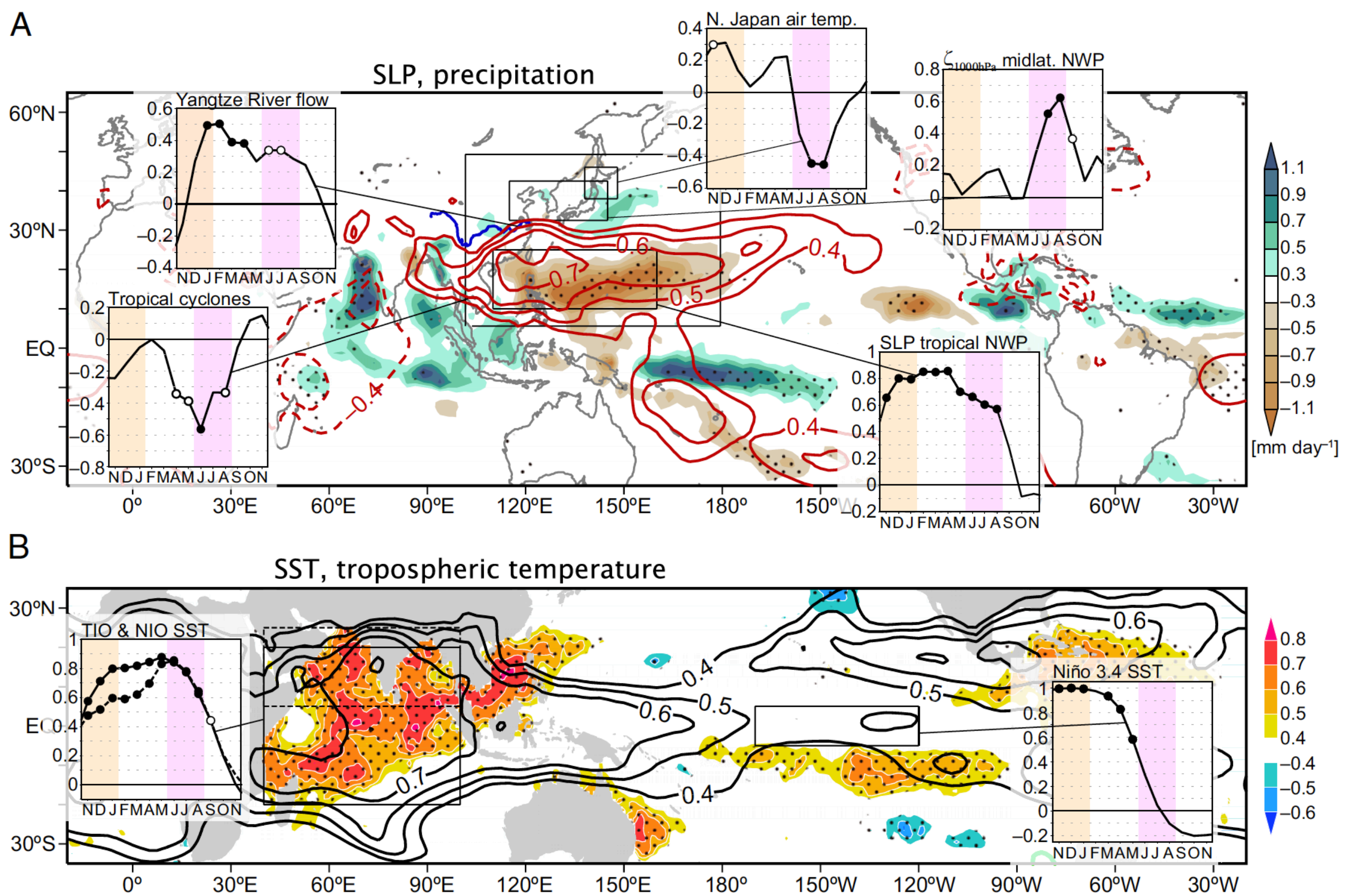
ENSEMBLES
(Weisheimer et al. 2009)

DEMETER
(Palmer et al. 2004)

Possible addition
NMME
(Kirtman et al. 2014)

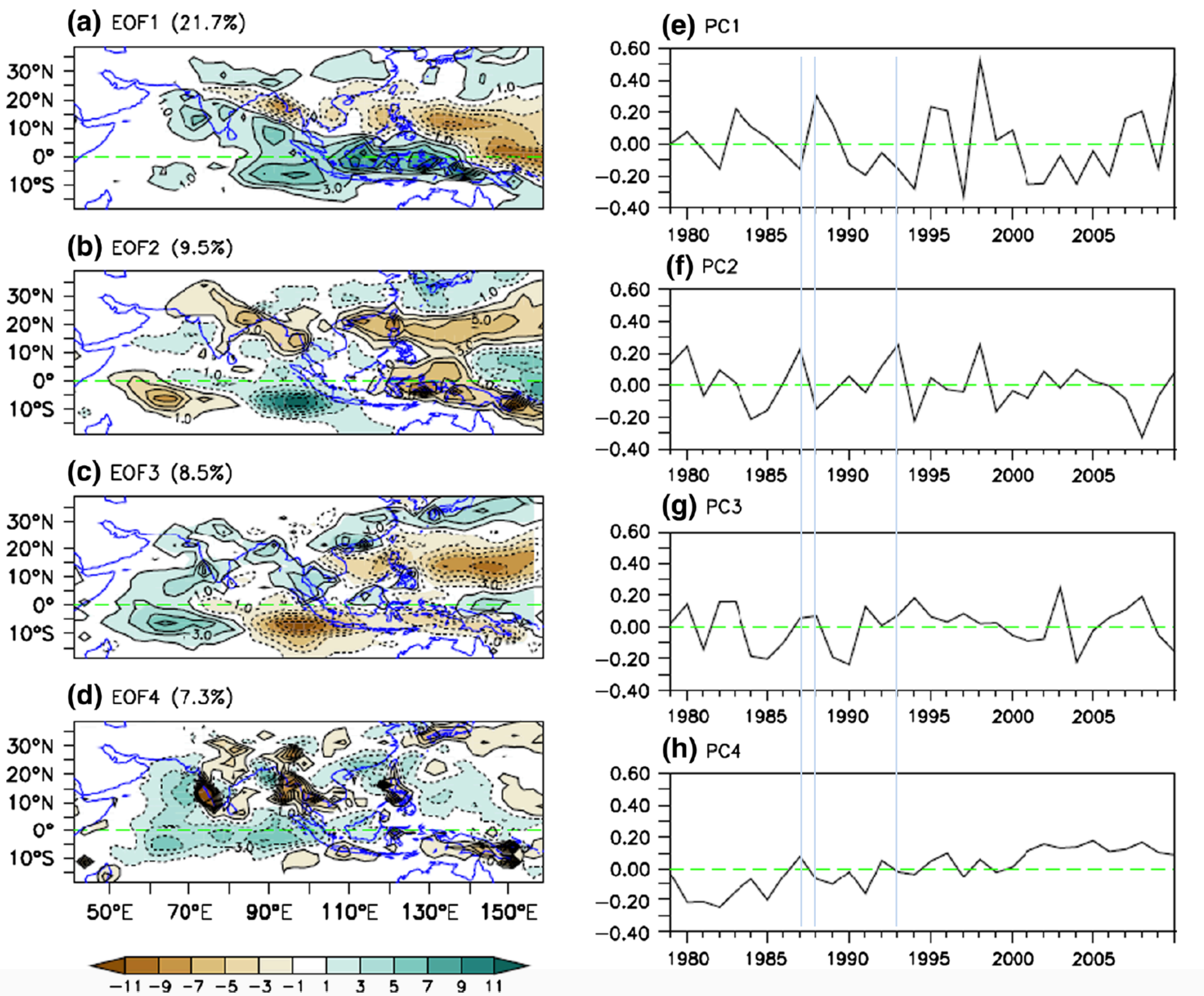
APCC?

ENSO delayed influence (Indo-western Pacific Ocean mode; IPOC mode)



Kosaka et al. 2013 PNAS

Predictable precipitation modes of ASM (1)



Wang et al. 2015 Clim. Dyn.

Predictable precipitation modes of ASM (2)

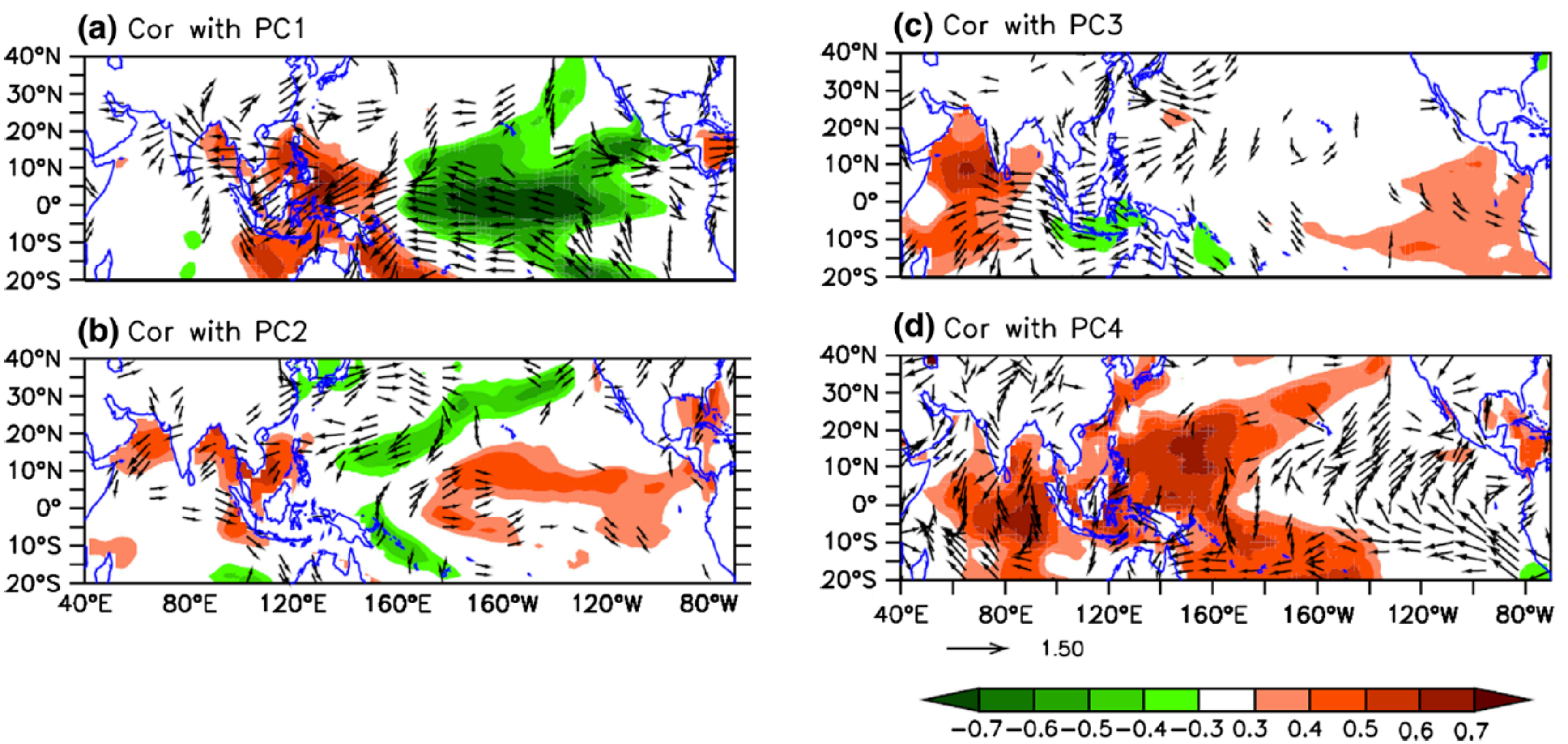
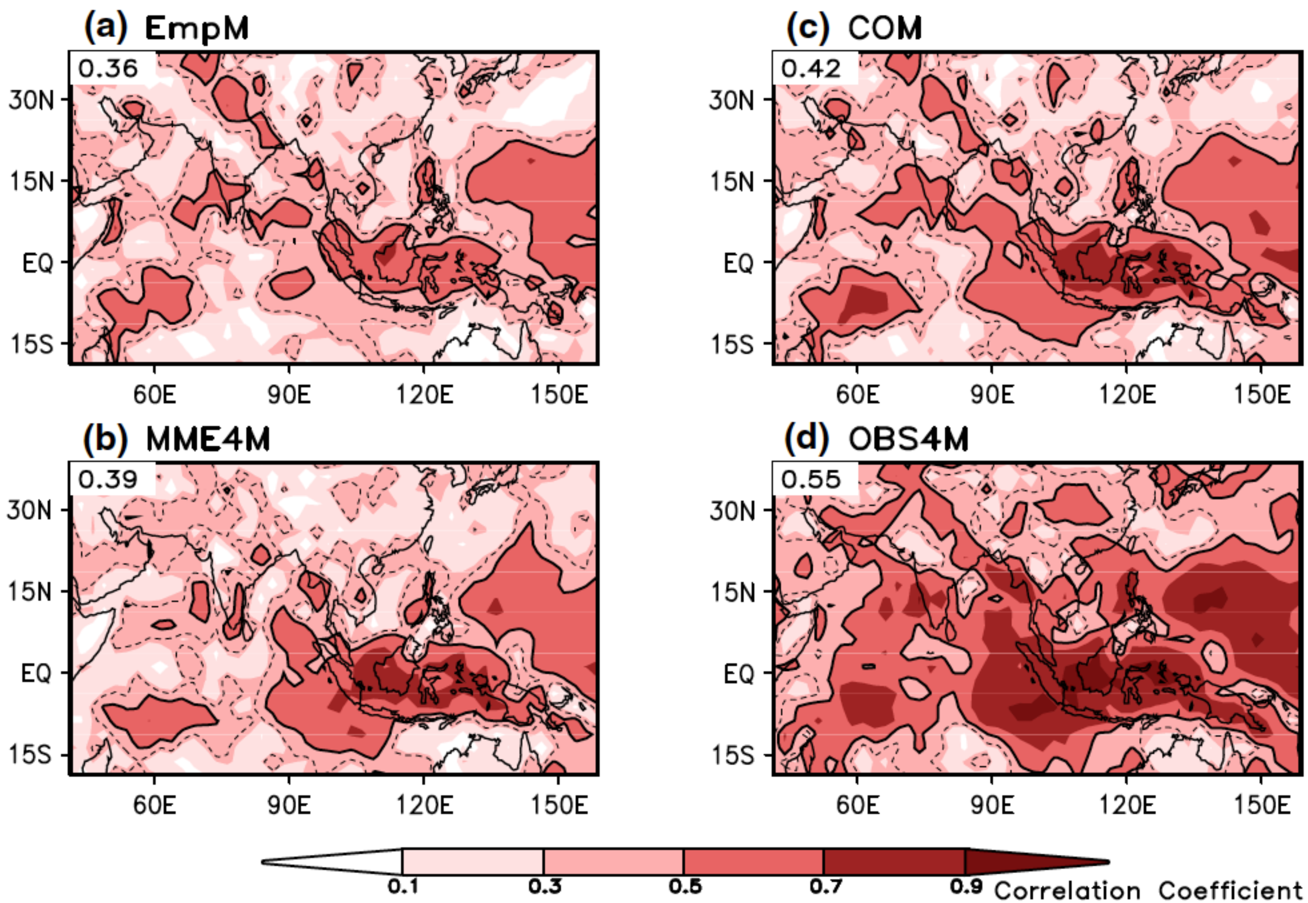


Fig. 3 The corresponding correlation maps of the four modes (**a**–**d**) with the simultaneous SST and 850 hPa wind anomalies

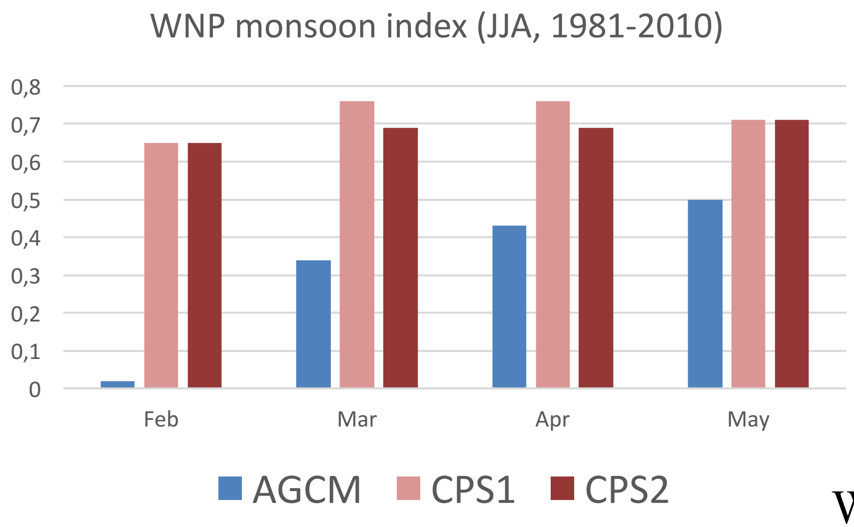
Predictable precipitation modes of ASM (3)

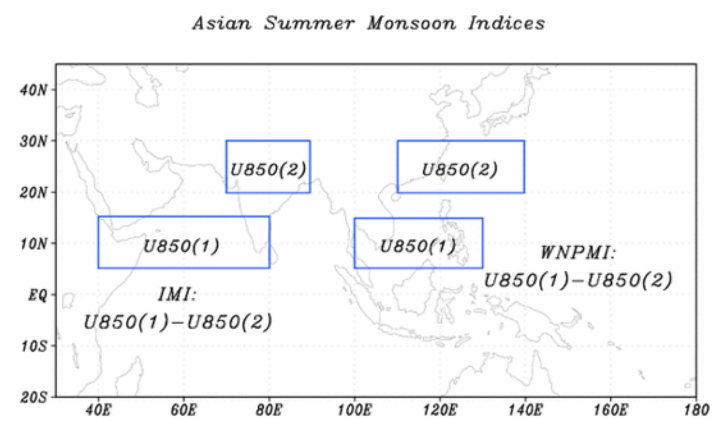
Fig. 6 The TCC skill for JJA precipitation prediction using the **a** P–E model (EmpM), **b** MME's first four modes (MME4M), **c** hybrid empirical-E-dynamical model (COM), and **d** the observed first four modes (OBS4M). For the observed reference field, total anomaly (i.e., all modes of variability) is used whereas the predicted field is reconstructed just by the first four EOF modes. The *dashed contour* is the TCC skill of 0.35 with statistically significance at 0.05 confidence level and the *solid contour* is the skill of 0.5. The number in the *upper-left corner* of each *panel* indicates the averaged TCC skill over the entire region



Wang et al. 2015 Clim. Dyn.

Progress on the WNP monsoon prediction





WNPM index (Wang and Fan 1999)

High skills of the western North Pacific high and associated wind circulation were observed in other coupled systems (e.g., Kim et 2012, MacLachlan et al. 2015)

Indian rainfall

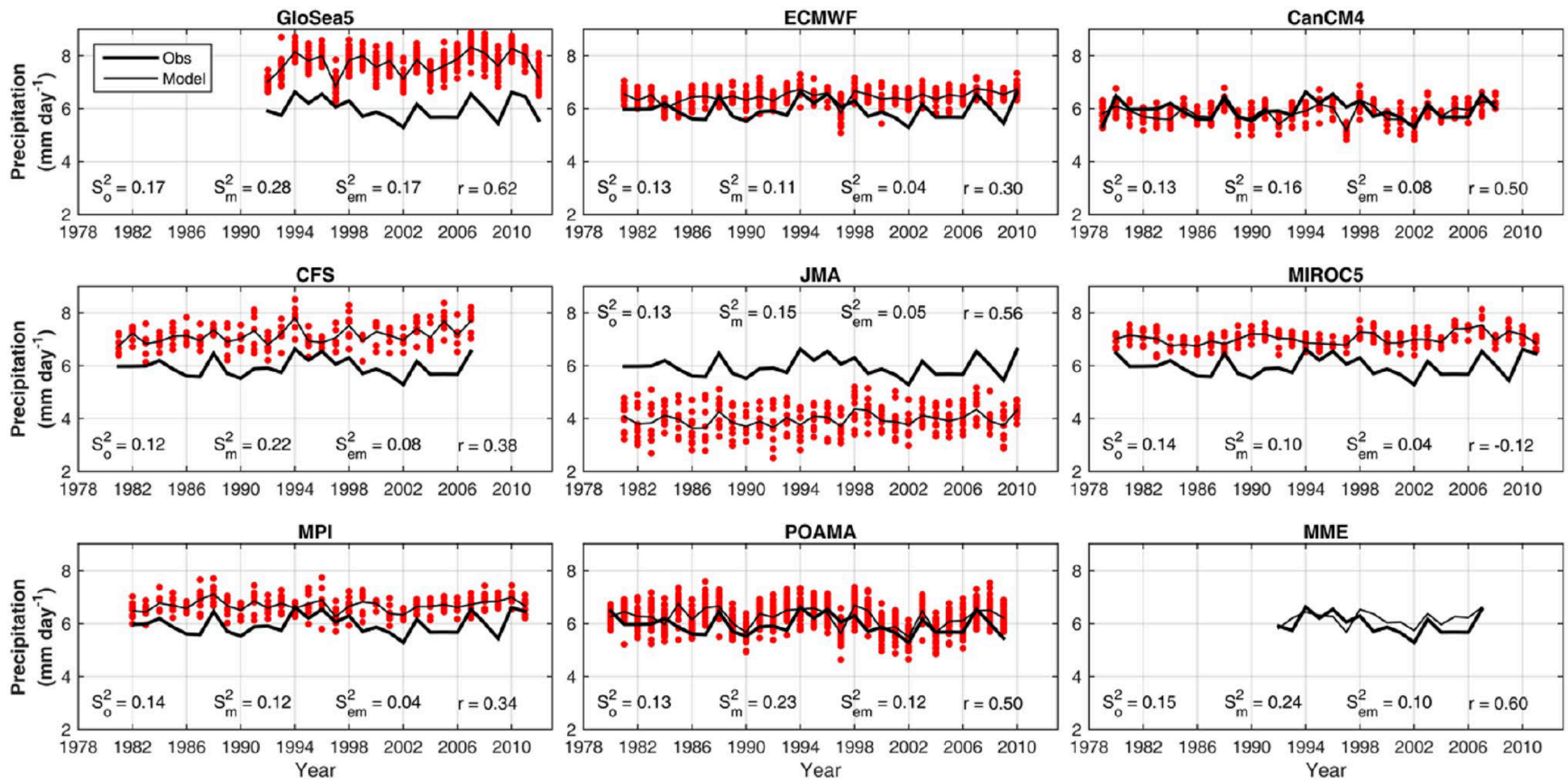


Fig. 3 Time series of precipitation (mm day^{-1}) from observations (black line), model ensemble members (red dots) and model ensemble mean (thin black line). Observed (S_o^2) and predicted variance using ensemble members (S_m^2) and ensemble means (S_{em}^2) are also shown. Correlation values are between the model ensemble mean and observed data. The models, viz. CanCM4, CFS, GloSea5, JMA and POAMA show statistically significant skill at 95% confidence level and therefore the output from these five models has been used to calculate the MME mean

Jain et al. 2018 Clim. Dyn.

Goal and next step ?

Deliver statements on prediction capability of state-of-the-art models and historical progress on the ASM seasonal prediction like the CMIP model assessment by Sperber et al. (2013).

Clim Dyn (2013) 41:2711–2744
DOI 10.1007/s00382-012-1607-6

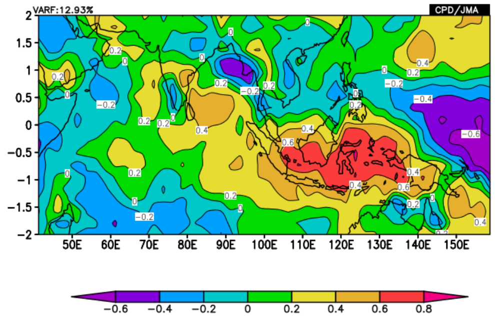
The Asian summer monsoon: an intercomparison of CMIP5 vs. CMIP3 simulations of the late 20th century

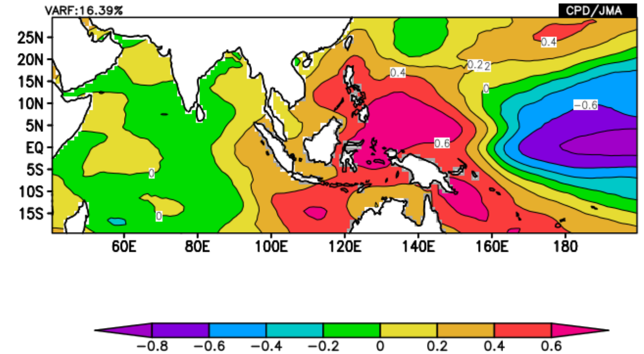
K. R. Sperber · H. Annamalai · I.-S. Kang · A. Kitoh · A. Moise · A. Turner · B. Wang · T. Zhou

ASM modes SVD (SST-precip, JJA 1979-2014)

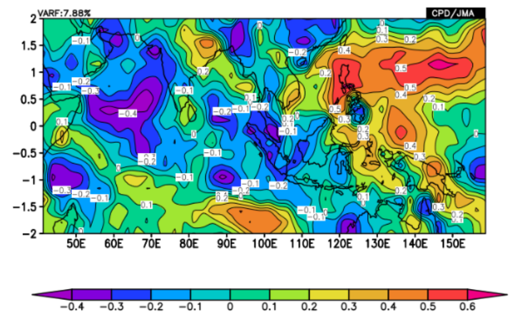
Precipitation | SST

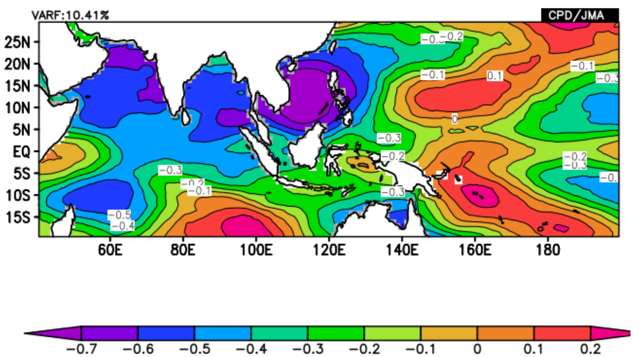
1st mode
(SFC: 45%)





2nd mode
(SFC: 23%)





3rd mode
(SFC: 12%)