Subseasonal Extended Range(2-3 Weeks) Prediction

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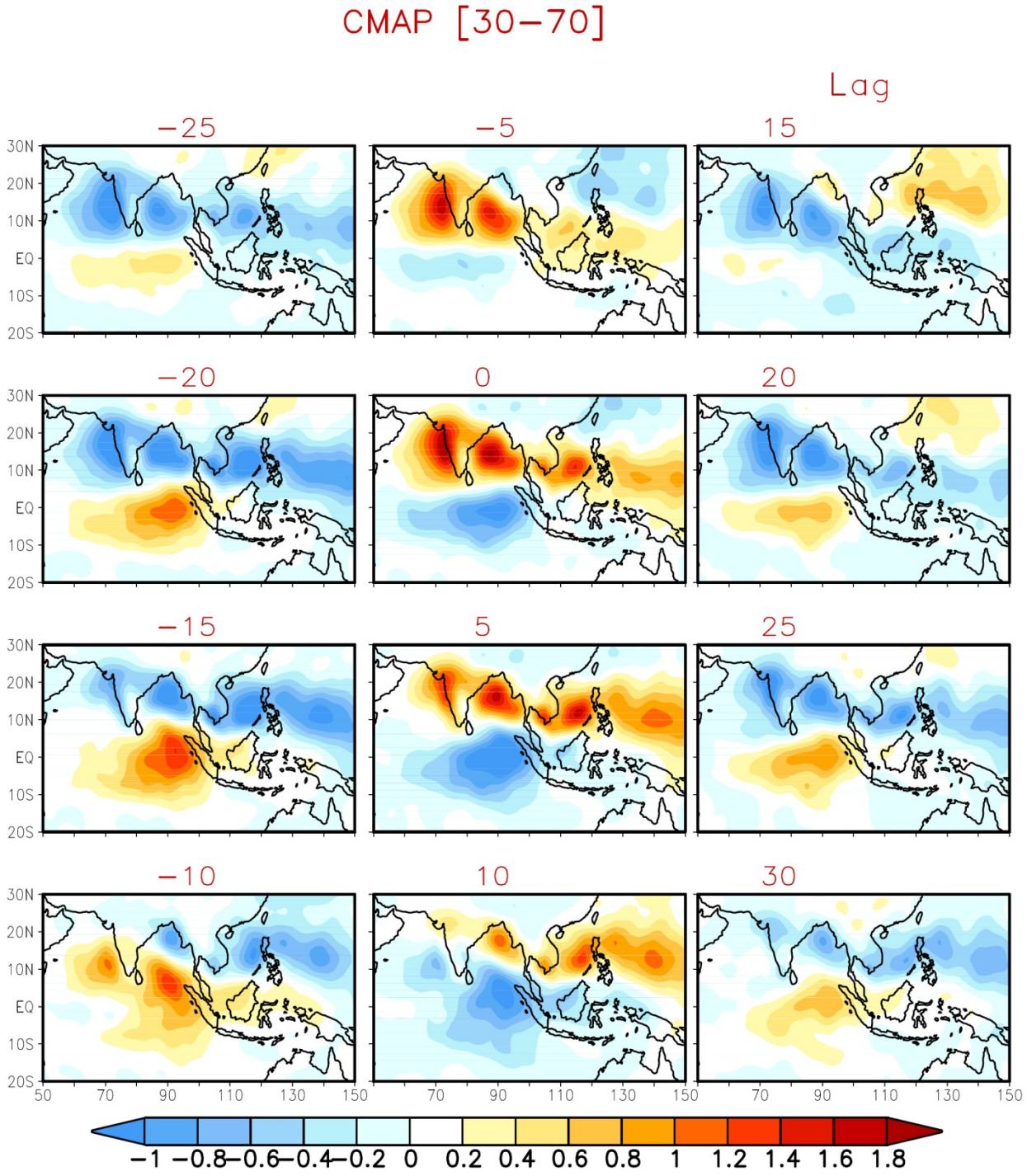
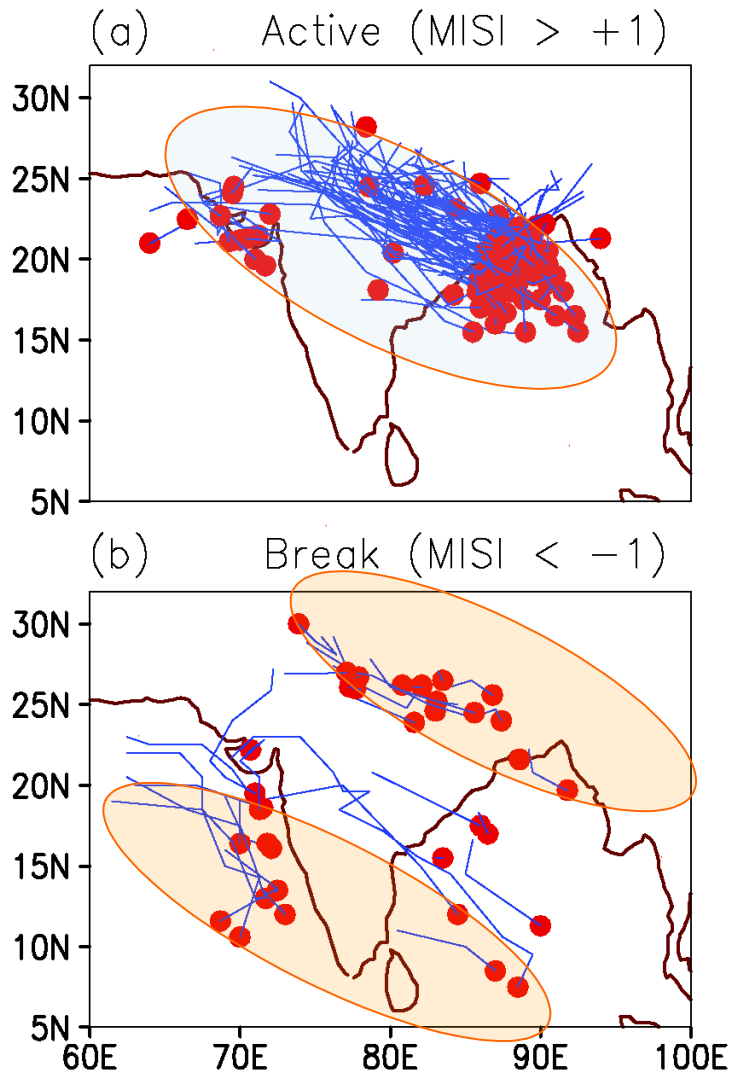


Observed evolution of the precipitation anomaly patterns over a full cycle of the 30-70 day mode.

Lag regressions of the 30-70 day filtered CMAP anomalies with respect to a reference time series over the

ISOs Modulate Monsoon Synoptic Activity



Tracks of LPS for the period 1954-1983 during extreme phases of monsoon ISO. (a) 'Active' ISO phase (MISI > +1) and (b) 'Break' ISO phase (MISI < -1). Red dots represent the genesis point and their lines show the tracks.

Goswami et al. 2003, *GRL*, 30, doi:10.1029/2002GL016734

SST, its Bias and Operational Extended Range Forecast

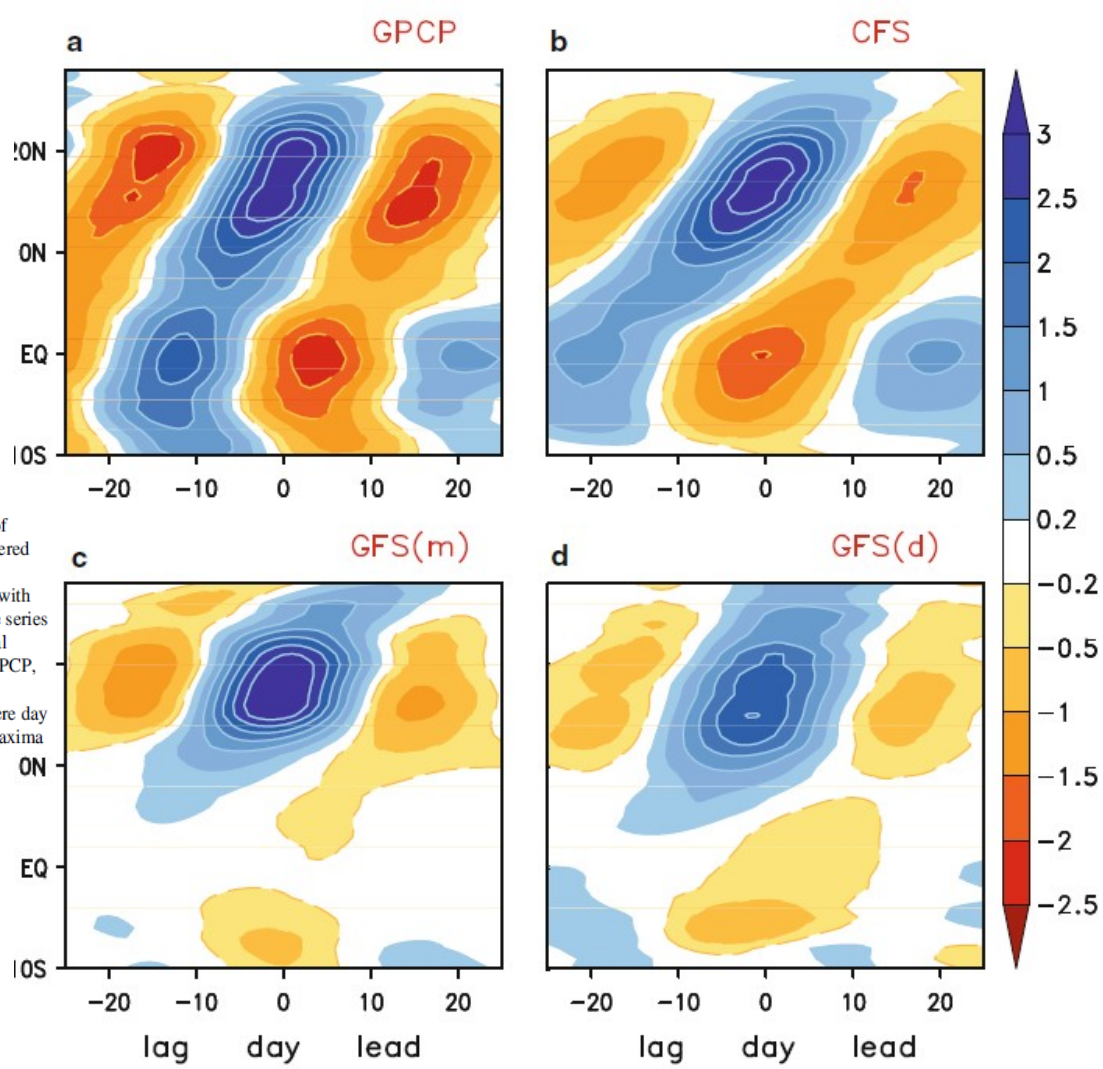
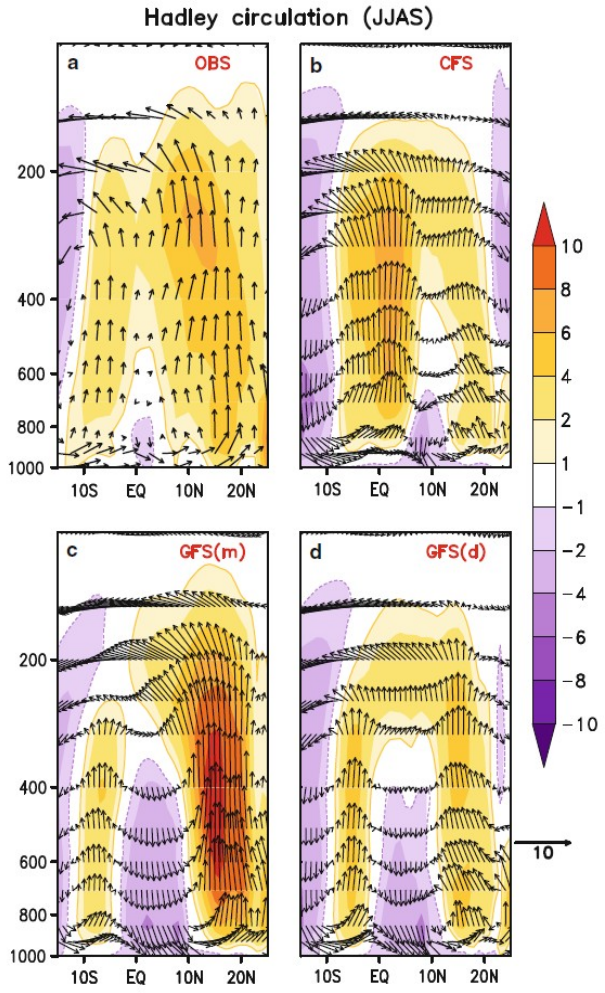


Fig. 7 Hovmöller plots of regressed 20–100 day filtered precipitation anomalies averaged over 70°–90°E with respect to a reference time series area averaged over central Indian region for the **a** GPCP, **b** CFS, **c** GFS(m) and **d** GFS(d) respectively. Here day 0 is the day of rainfall maxima



ECMWF Extended Range FCST

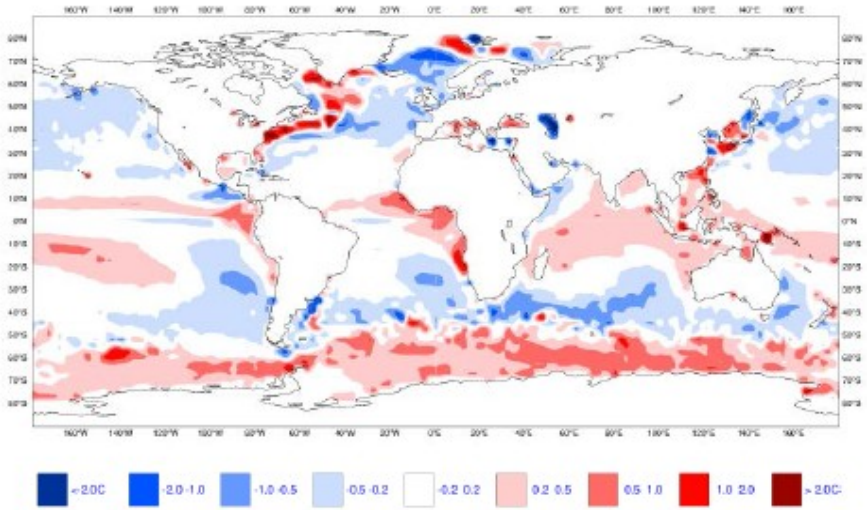
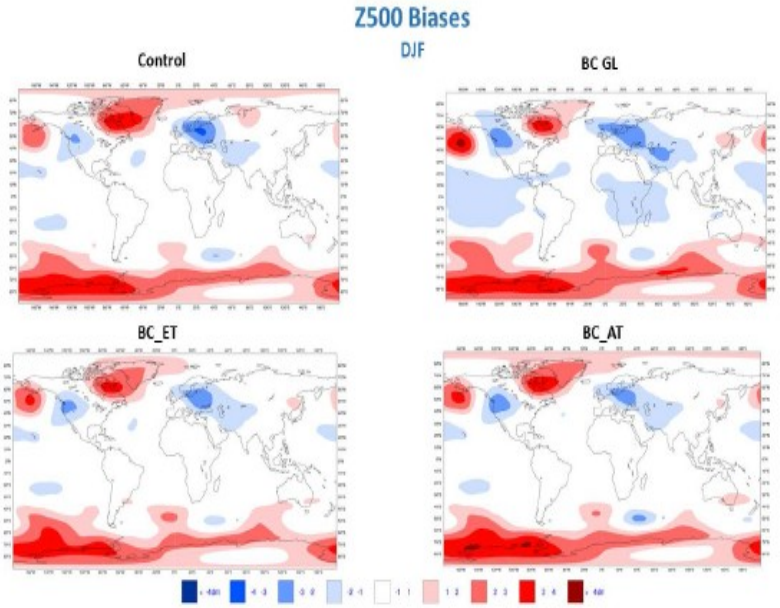


Figure 1: SST biases (relative to ERA-Interim) at the time range day 26-32 for the period NDJFM 1989-2016.



ıre 8: Same as Figure 5 but for 500 hPa geopotential height. Units are decametres

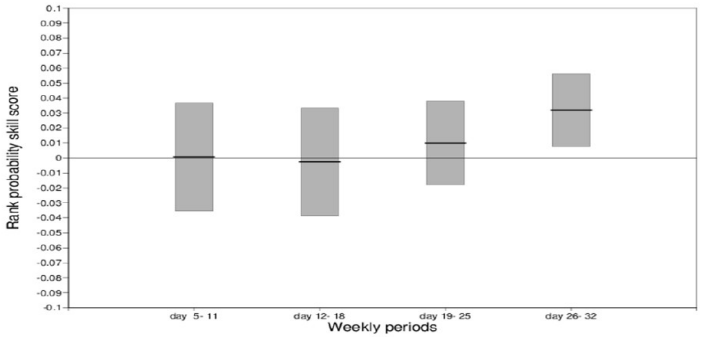


Figure 13: Difference of CRPSS of 200 hPa zonal wind between BC_ET and Control for week 1 to 4 over Europe. Positive (negative) differences indicate that BC_ET outperforms (underperforms) Control.

Vitart and Balmaseda 2019
ECMWF technical Note 830

LaRow MWR 2013

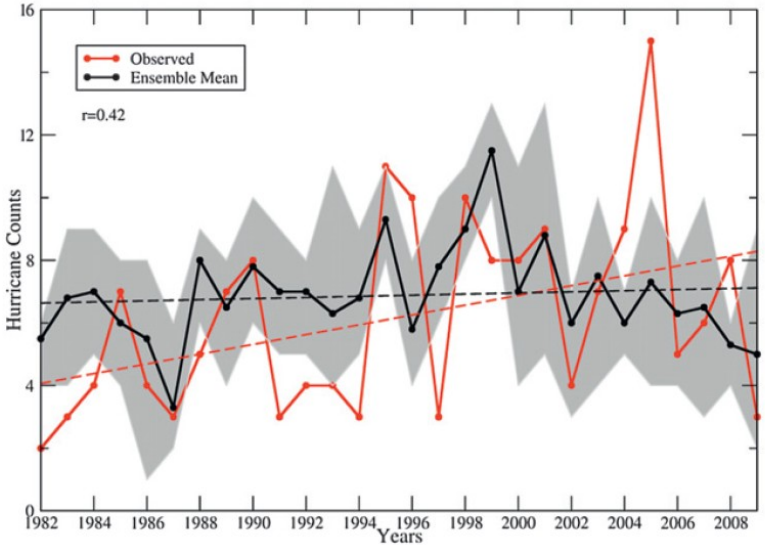


FIG. 5. Interannual hurricane counts from 1982–2009. The solid red line is the IBTrACS observed dataset and the solid black line is the ensemble mean. The shaded region is the ensemble spread using the NBC SSTs. The correlation coefficient is 0.42. The dashed lines are the linear trends.

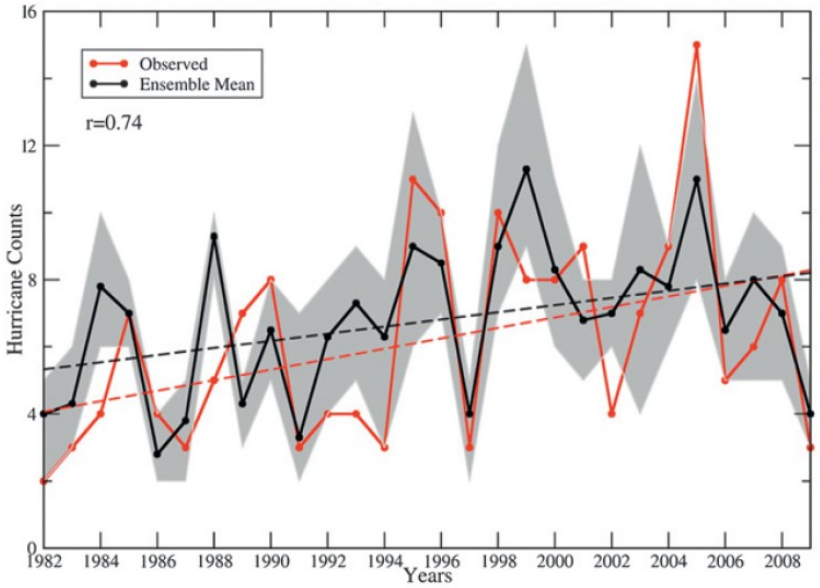


FIG. 6. As in Fig. 5, but using the BC SSTs. The correlation coefficient is 0.74.

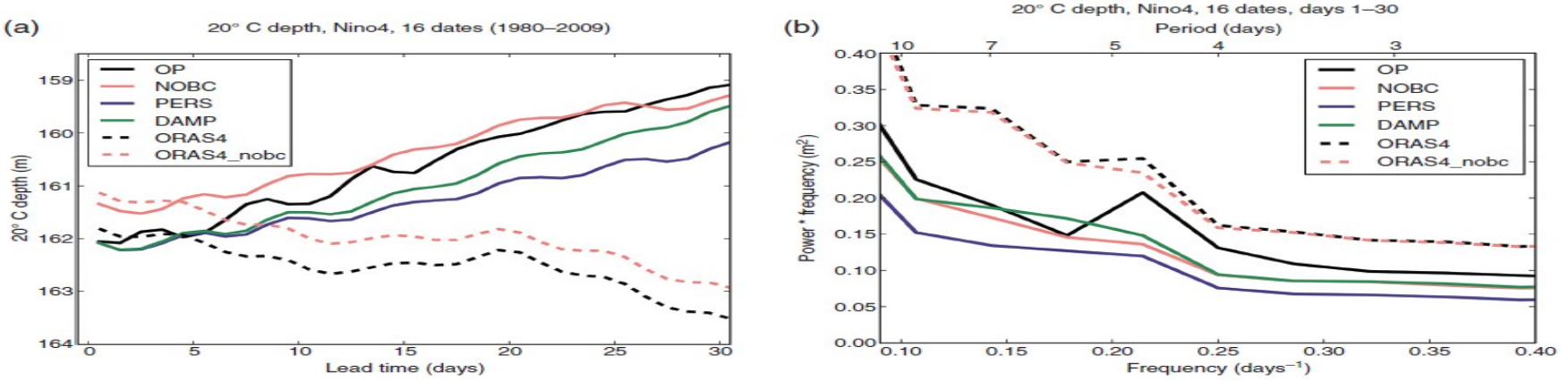
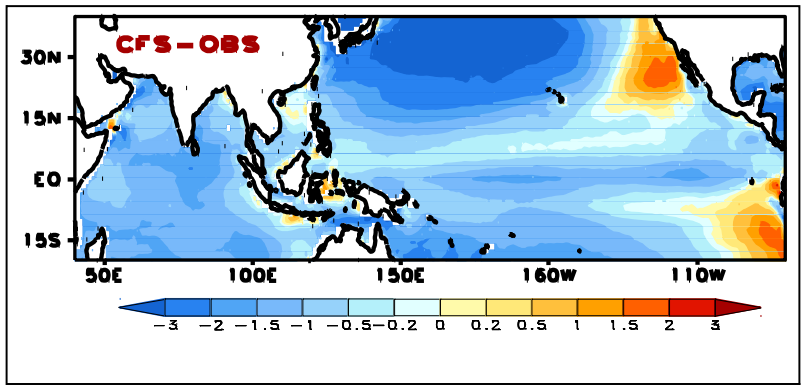


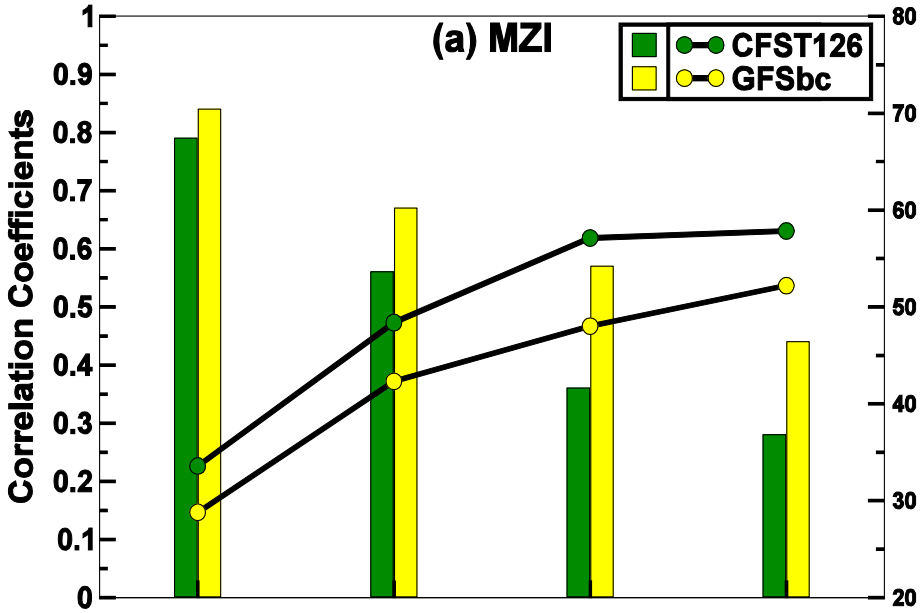
Figure 2. Niño-4 20 °C isotherm depth: (a) ensemble mean time series (m) and (b) ensemble mean frequency spectra (m^2), for the four experiments (solid) and two reanalyses (dashed). Values plotted in (a) and used to calculate (b) are daily means, starting at day 1.

Mulholland, D. P., Haines, K. and Balmaseda, M. A. (2016), Improving seasonal forecasting through tropical ocean bias corrections. Q.J.R. Meteorol. Soc., 142: 2797-2807. doi:10.1002/qj.2869

Development of Bias-correction Technique

SST Bias from Long Simulation





Prediction of MISO/MJO
IITM Extended Range Prediction

Time Line of development of IITM ERPS using CFSv2

2011: Ensemble Prediction System developed, [Abhilash etal., 2014, IJOC]

2012: Bias Correction of CFS forecasted SST implemented
[Abhilash etal., 2014, ASL; Sahai etal., 2013, Cur. Sci.]

2013: High Resolution CFST382 implemented
[Sahai etal., 2014, CD;Borah etal, 2014, IJOC]

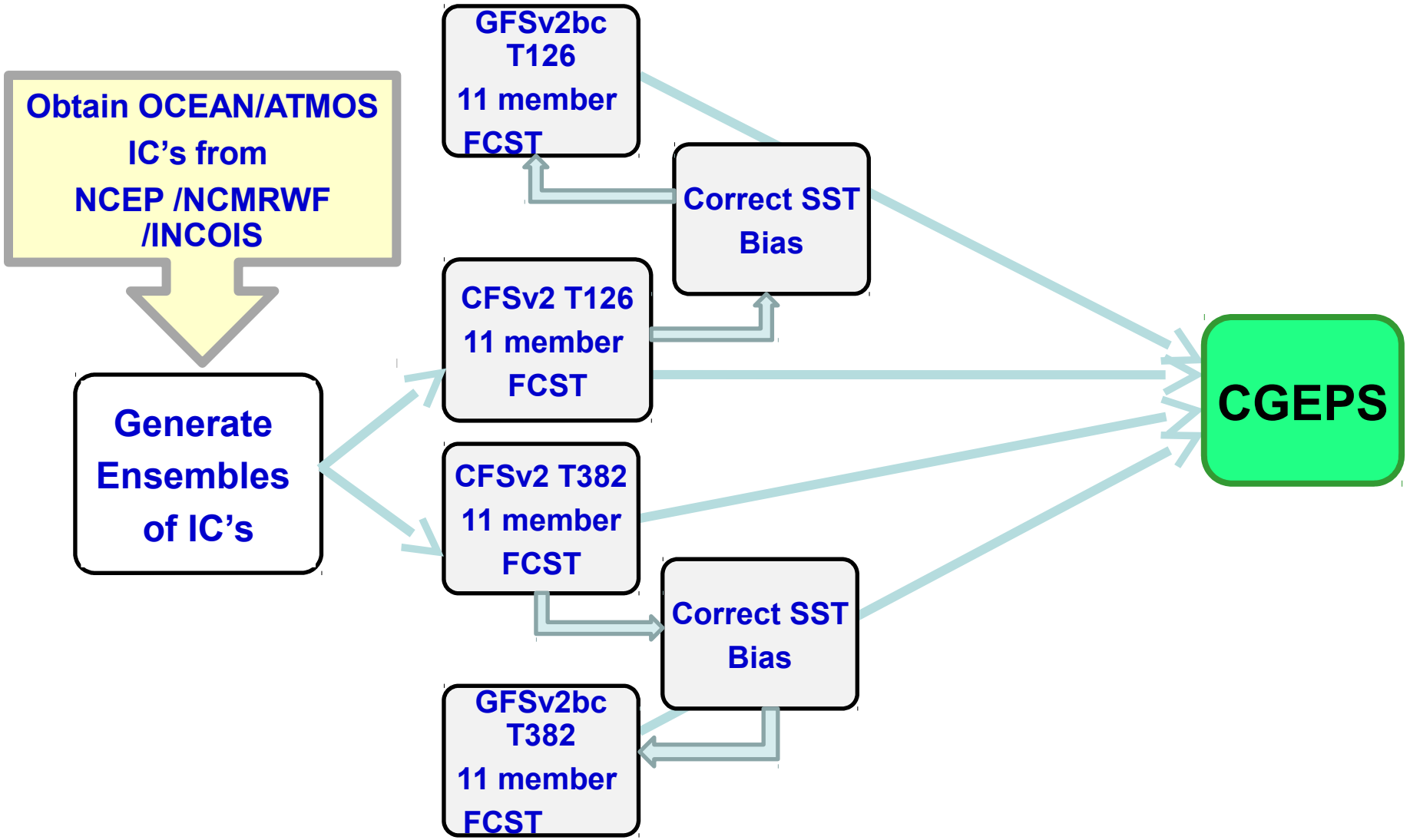
2014: CFS based Grand EPS Implemented
[Abhilash etal., 2015, JAMC; Sahai etal., 2015, Cur. Sci]

2015: Forecast for winter and other seasons started

2016: Forecast for Heat Waves started

[Applications: **Onset Prediction:** Joseph etal, 2014, JC; **Uttrakhand Heavy Rainfall:** Joseph etal, 2014, CD; **Skill of CFST126:** Abhilash etal., 2014, CD; **Comparison 2013 and 2014 June extremes:** Joseph etal., QJRMS, 2015; **Prediction skill of MJO:** Sahai et al., 2016, IITM-RR]

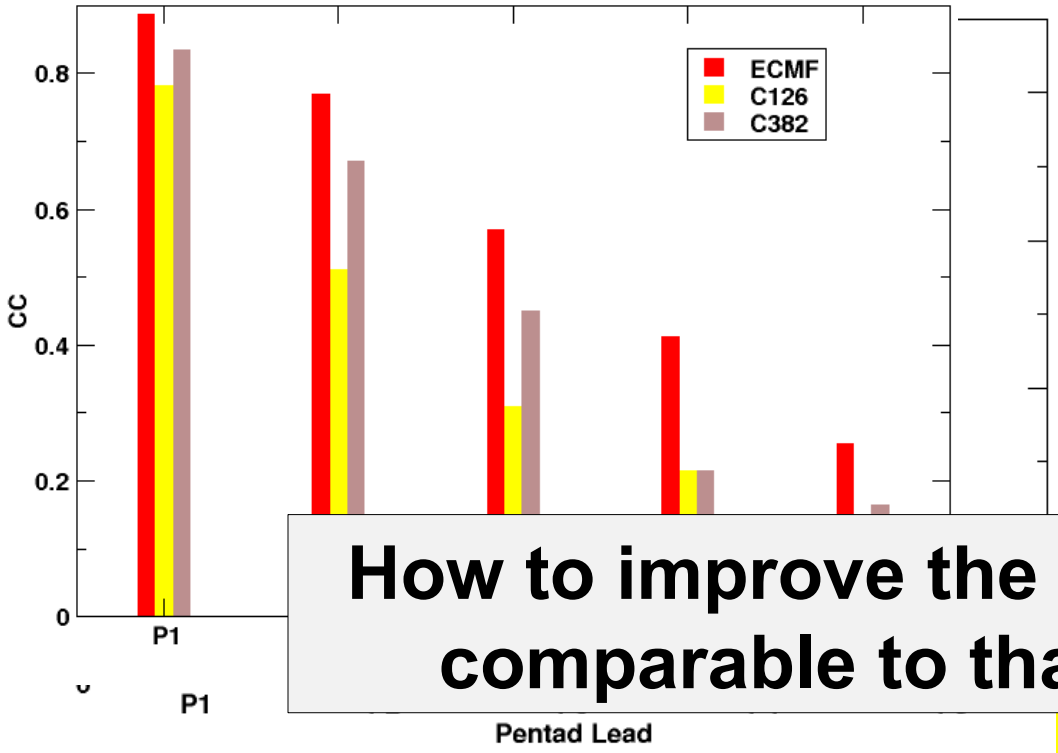
IITM Ensemble Prediction System



Why MME?

Comparison of IITM-ERPS with ECMWF

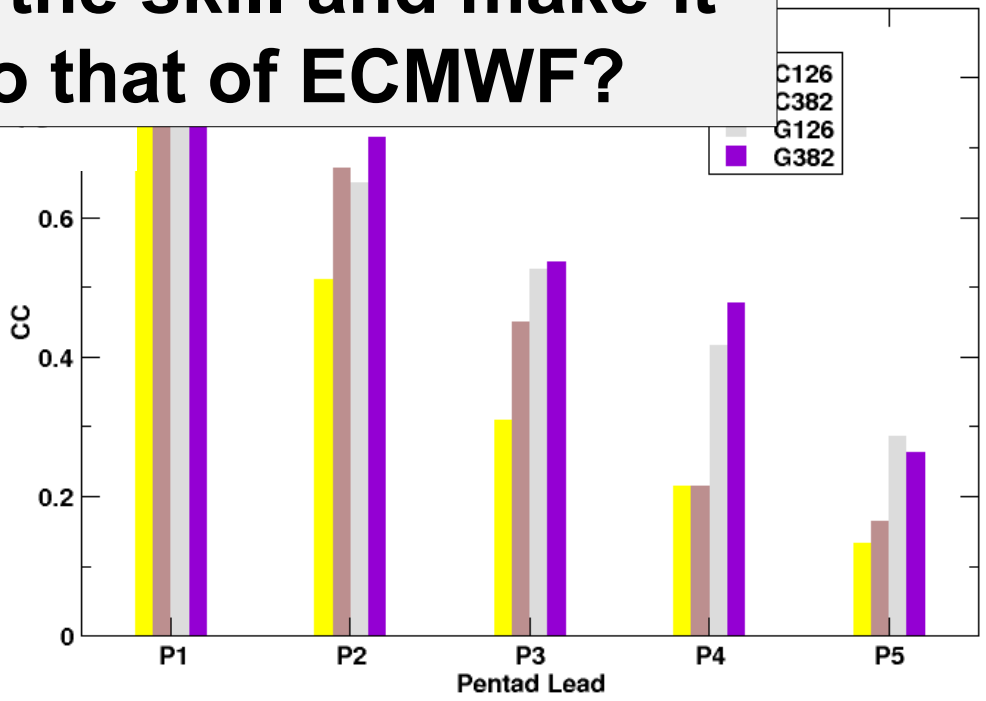
Comparison of IITM-ERPS with ECMWF



Skill of CFST126/T382 is much less than ECMWF in longer leads

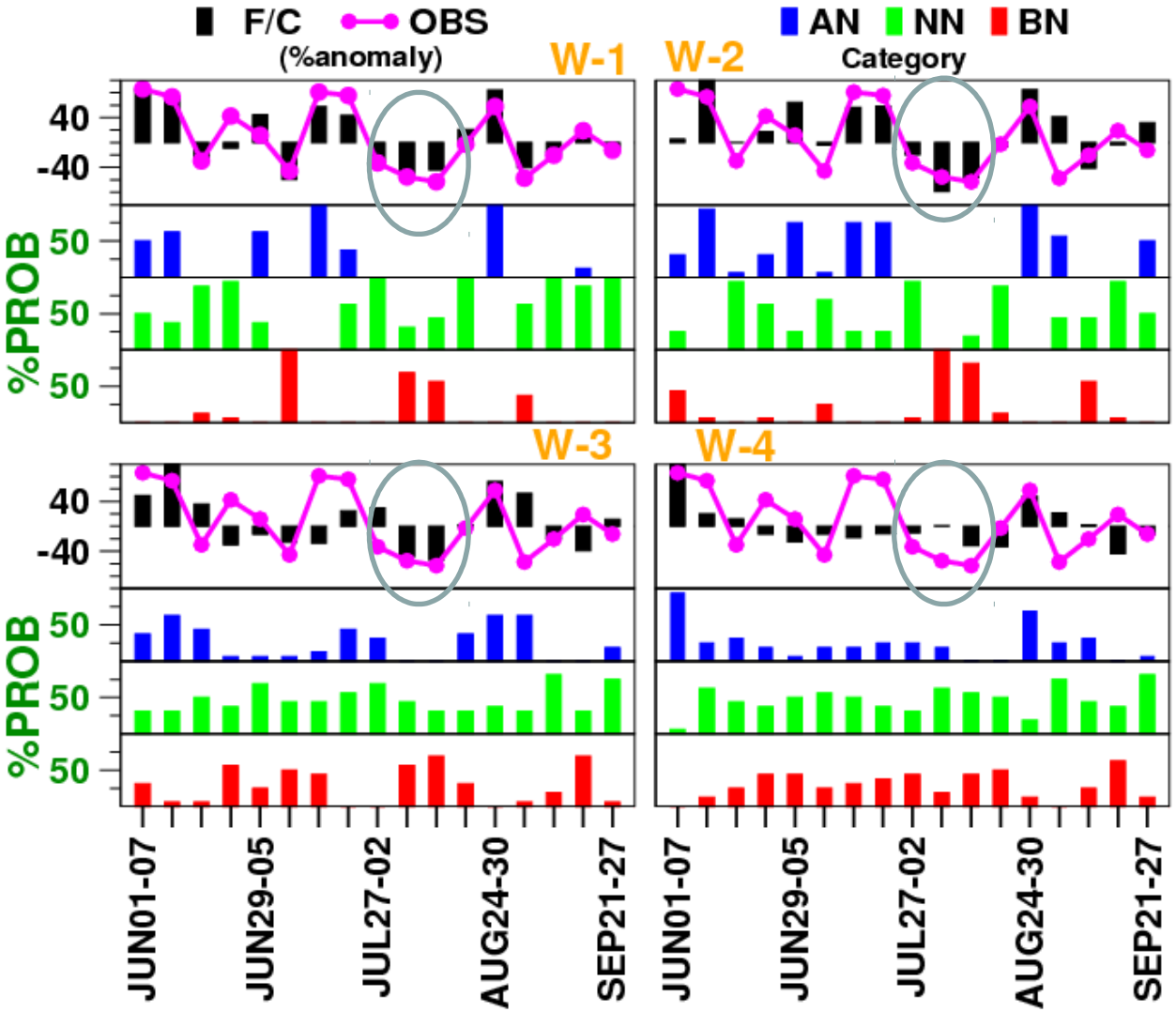
How to improve the skill and make it comparable to that of ECMWF?

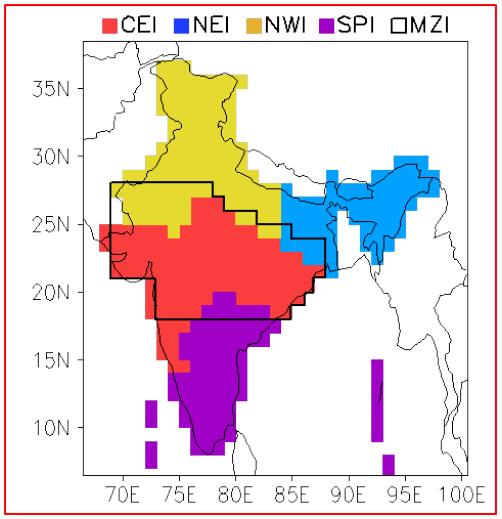
Skill improved due to bias correction

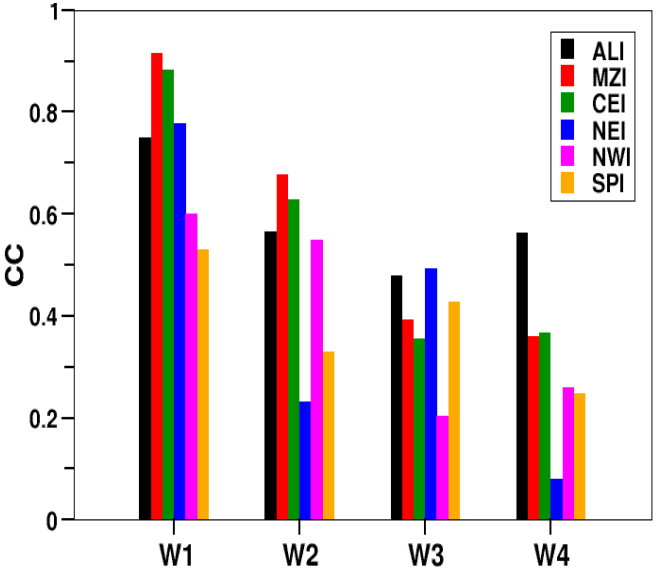


Applications of IITM ERPS: Some Examples

Week-wise verification of rainfall over MZI Region



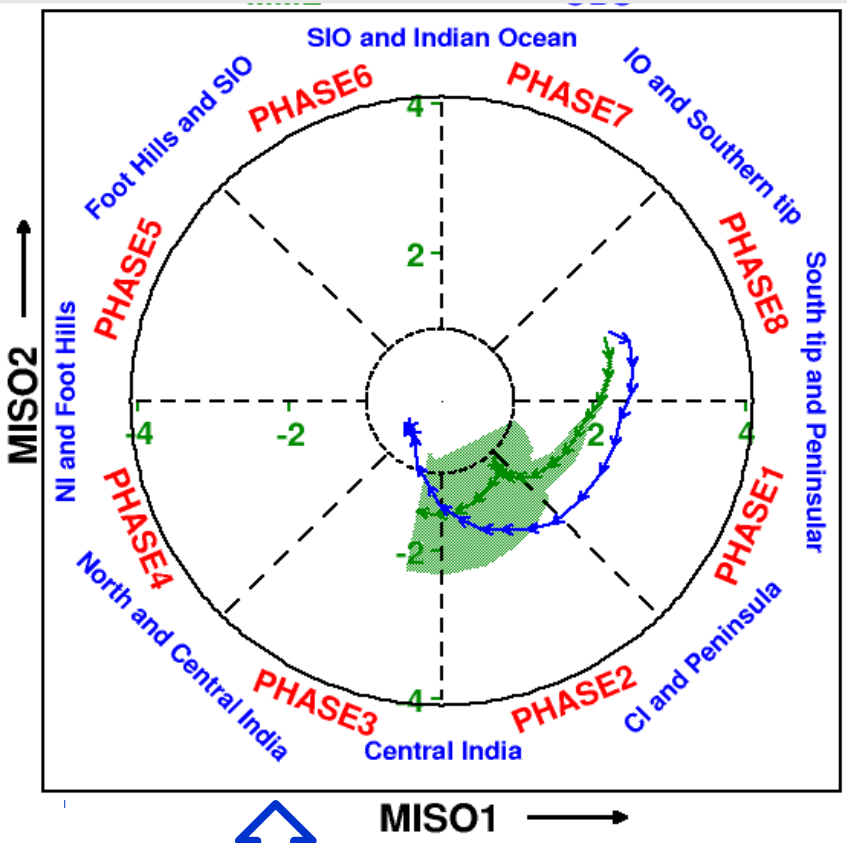




2017 Monsoon Season

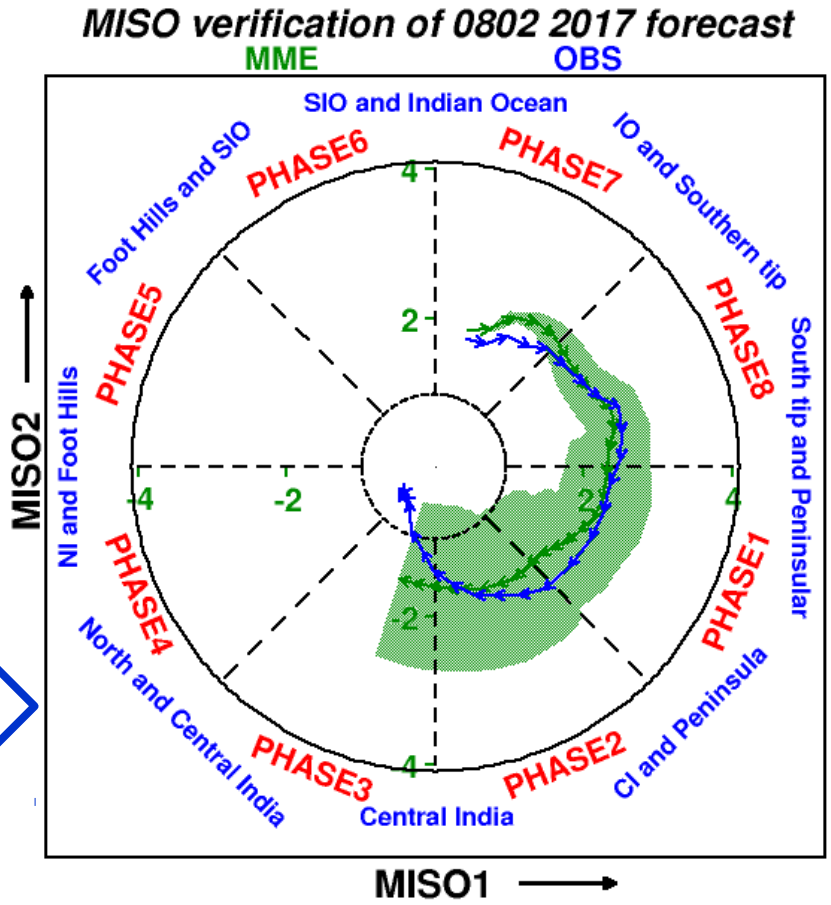
Observed as well as predicted MISO during 2017

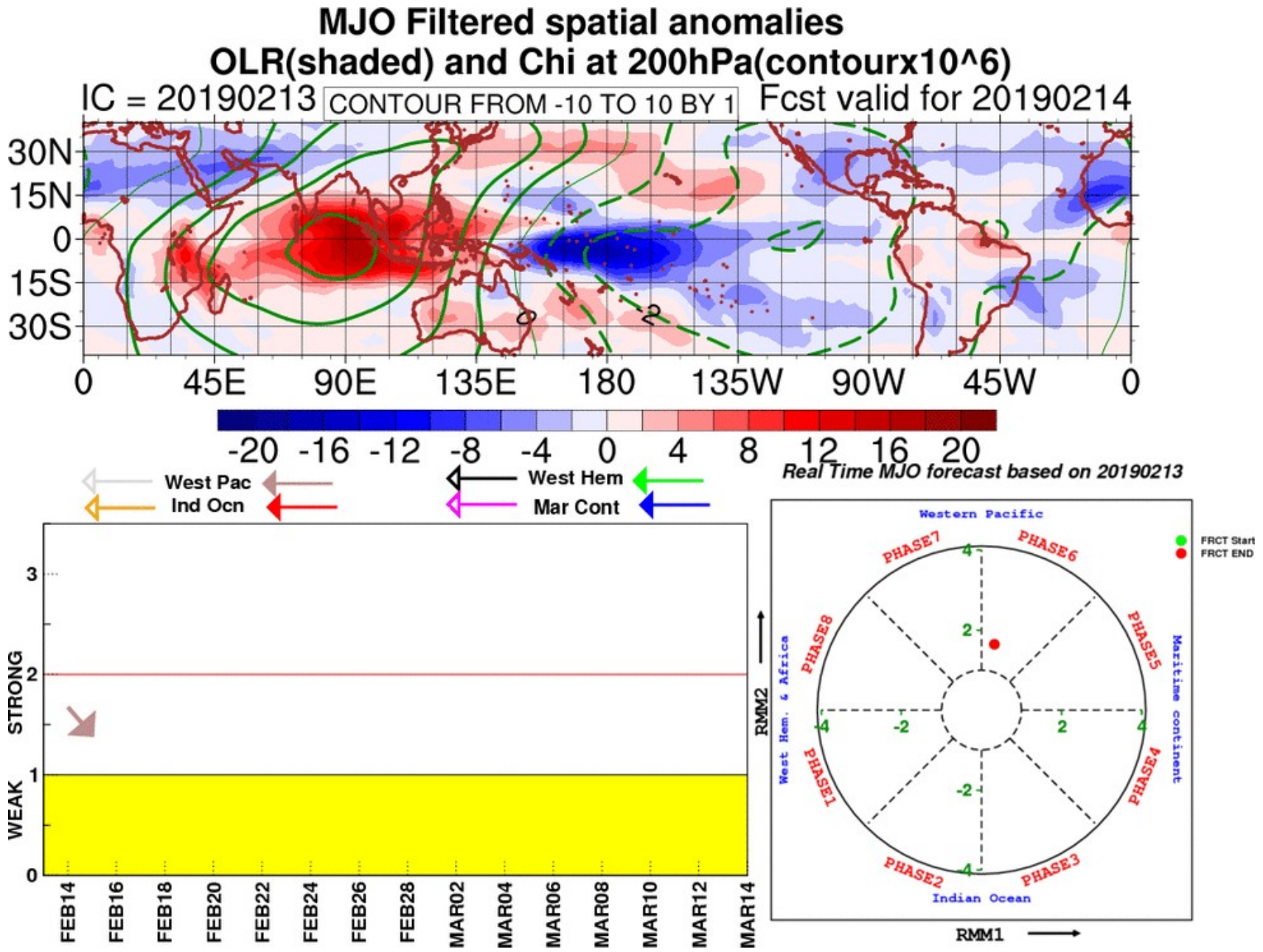
Revival from Break



IC: 09 Aug

IC: 02 Aug




MJO Filtered spatial anomalies
OLR(shaded) and Chi at 200hPa(contourx10^6)
IC = 20190213
CONTOUR FROM -10 TO 10 BY 1
Fcst valid for 20190214
30N
15N
0
15S
30S
0
45E
90E
135E
180
135W
90W
45W
0
-20 -16 -12 -8 -4 0 4 8 12 16 20
West Pac
Ind Ocn
West Hem
Mar Cont
Real Time MJO forecast based on 20190213
STRONG
WEAK
FEB14
FEB16
FEB18
FEB20
FEB22
FEB24
FEB26
FEB28
MAR02
MAR04
MAR06
MAR08
MAR10
MAR12
MAR14
RMM2
RMM1
Western Pacific
Indian Ocean
West Hem. & Africa
Maritime continent
PHASE1
PHASE2
PHASE3
PHASE4
PHASE5
PHASE6
PHASE7
PHASE8
FRCT Start
FRCT END

Conclusions

- ✓ **The CGEPS MME from operational runs could realistically provide an outlook on the intraseasonal fluctuations within the 2017 monsoon season.**
- ✓ **The EPS proved to be useful but imperfect prediction technology, in the face of the mostly-unpredictable.**
- ✓ **It can supplement the weather information.**

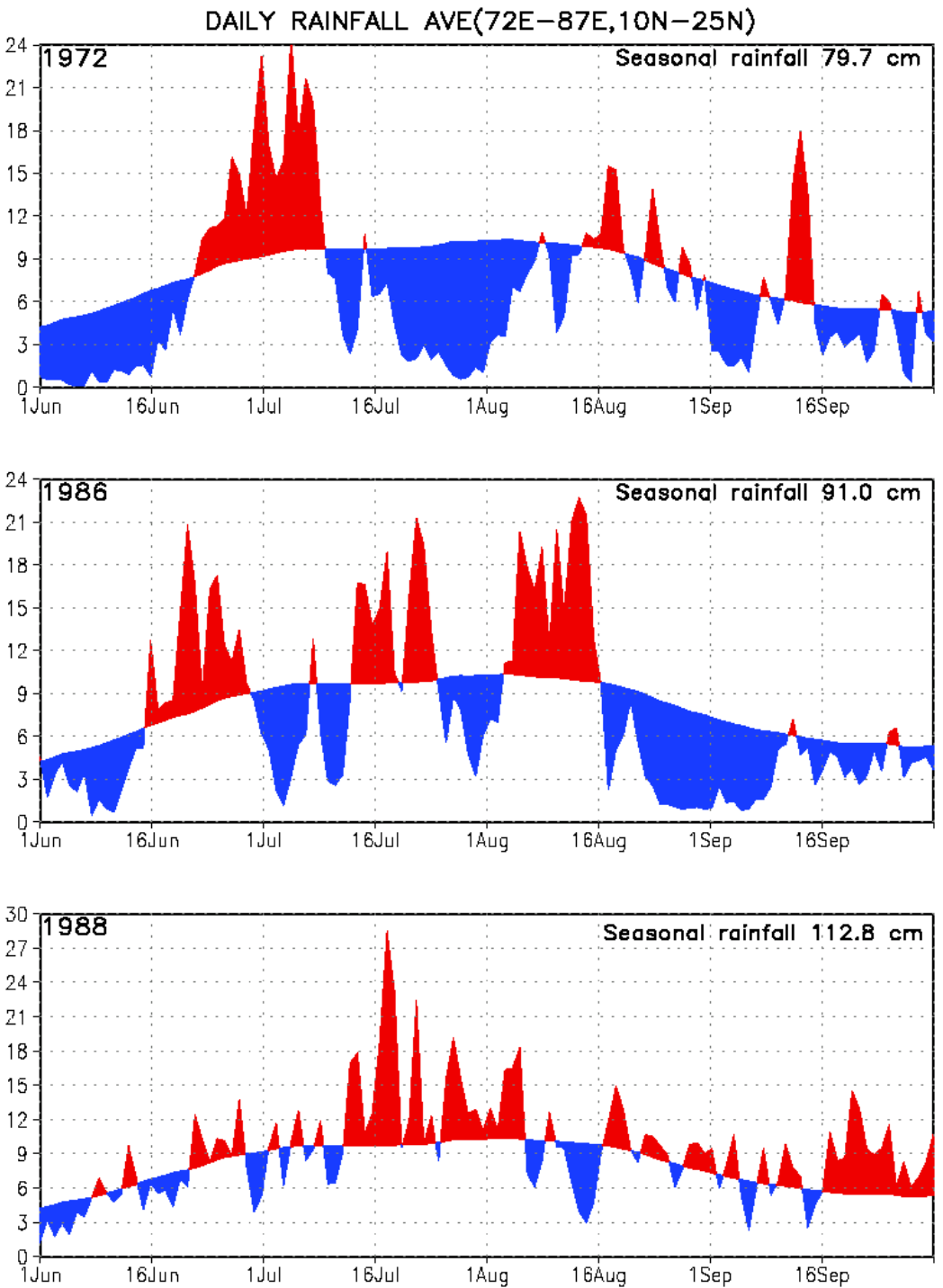
THANK YOU

Active-break spells (cycles)

Daily rainfall (mm/day) over central India for three years, 1972, 1986 and 1988

The smooth curve shows long term mean.

Red shows above normal or wet spells while blue shows below normal or dry spells



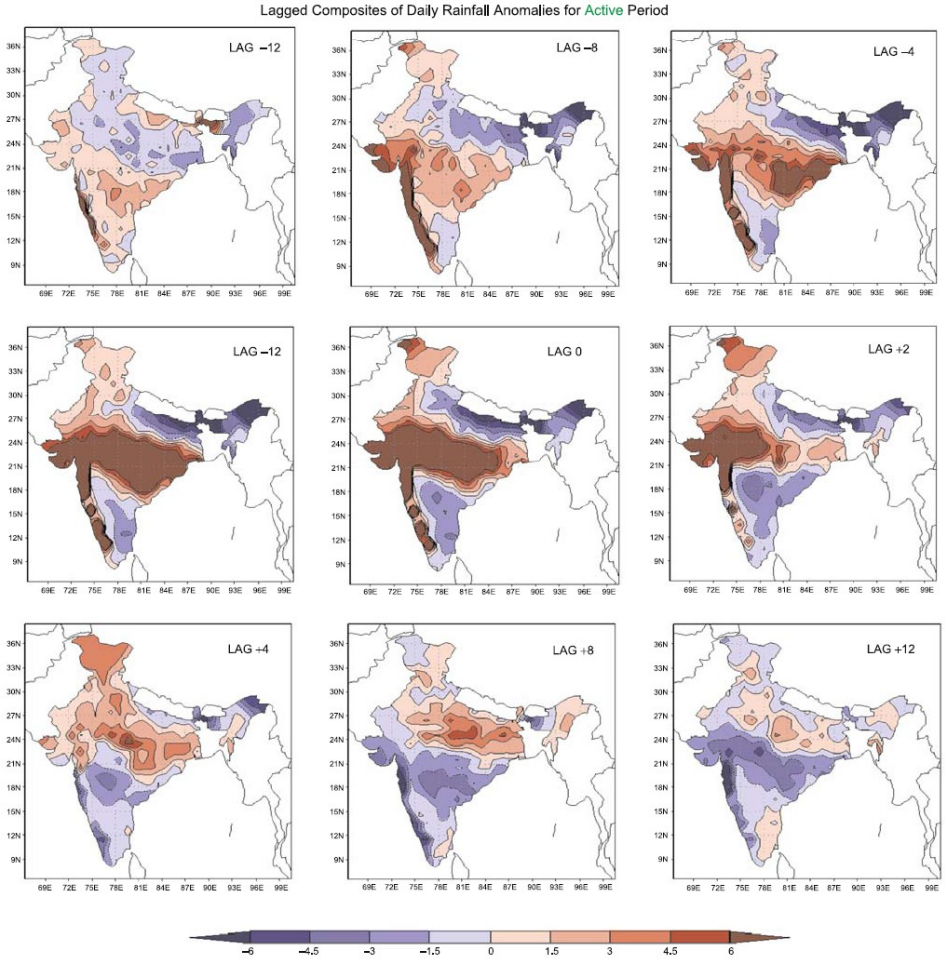


Figure 7(b). Lagged rainfall (mm) composites for the active spells (1951–2004).

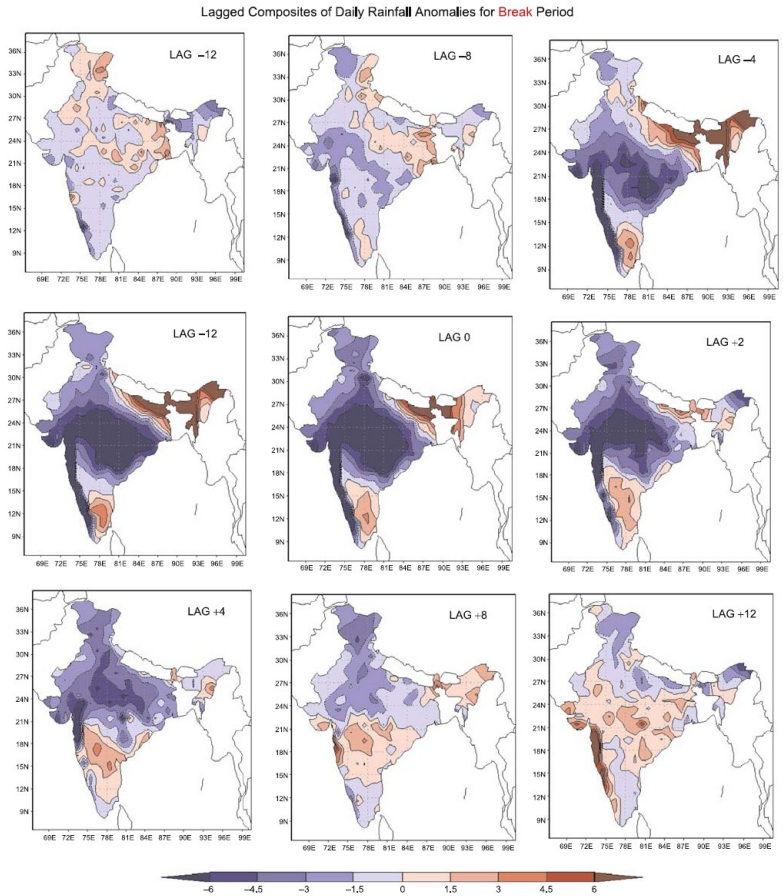


Figure 7(a). Lagged rainfall (mm) composites during the break spells (1951–2004).

Active Composite

Break Composite

Active and break Spells are Manifestations of Monsoon ISO

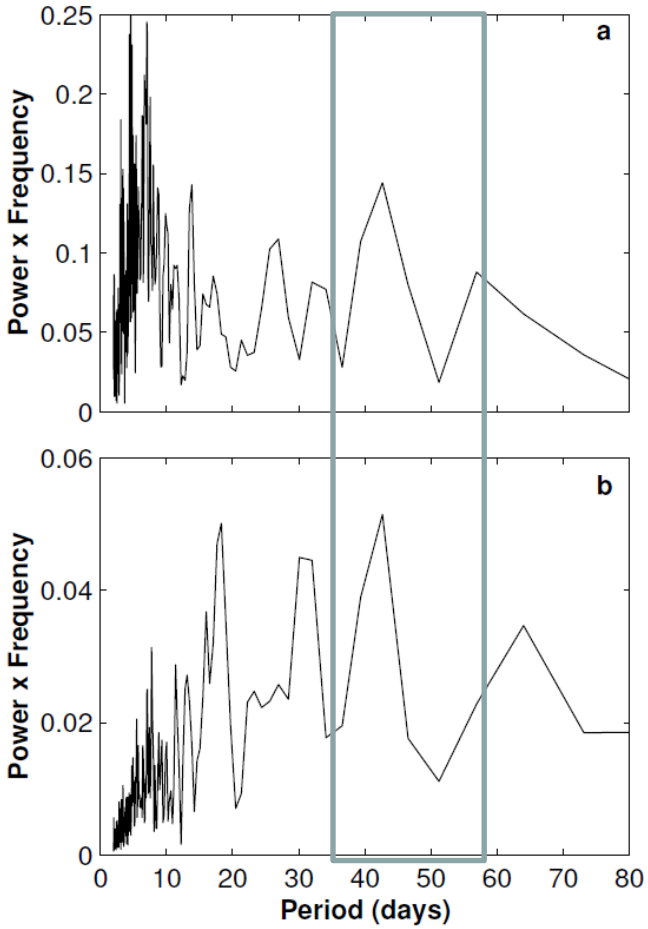
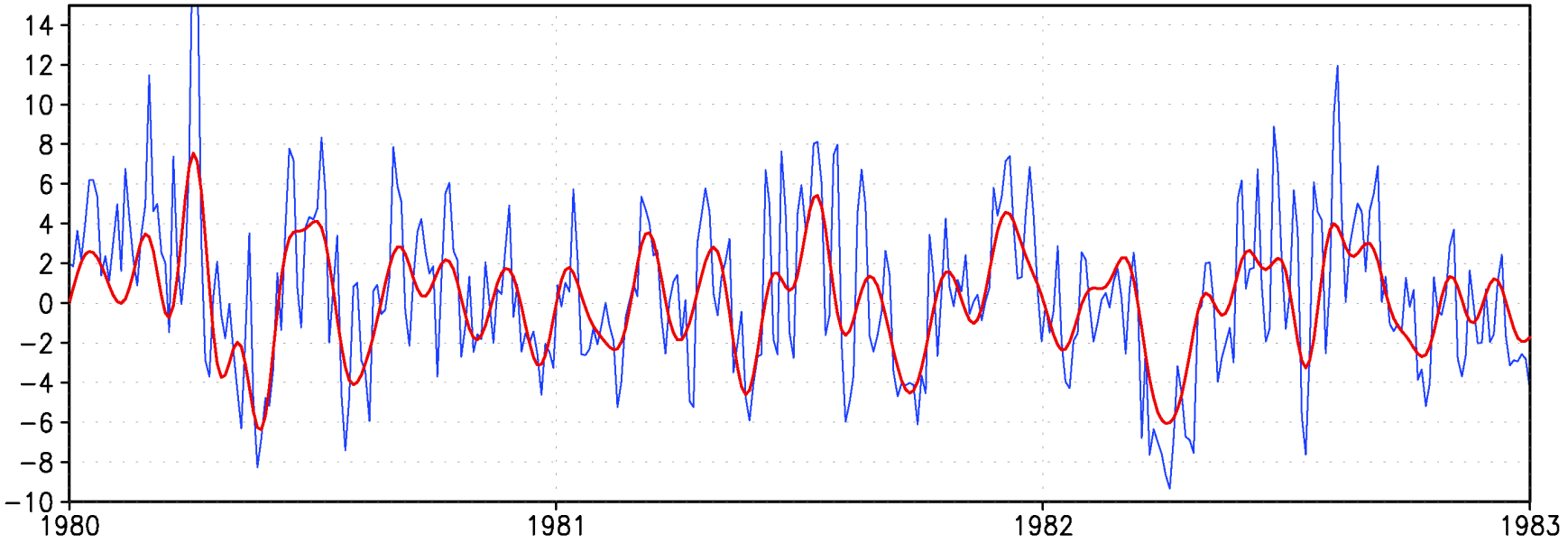


Figure 1: Spectrum of (a) rainfall anomalies for 20 (1971-1989) summer seasons (1 June -30 September) from station data averaged over 75E-85E and 15N-25N and (b) zonal wind anomalies at 850 hPa for 20 (1979-1998) summer seasons from NCEP reanalysis averaged over 55E-65E and 5N-15N.

Monsoon Intraseasonal Oscillation

Active Break Spells With Northward Propagation of ITCZ



Time series of daily rainfall anomaly (mm/day) over central India (blue) during 1 June – 30 Sept. for three years and 10-90 day filtered (red) rainfall.

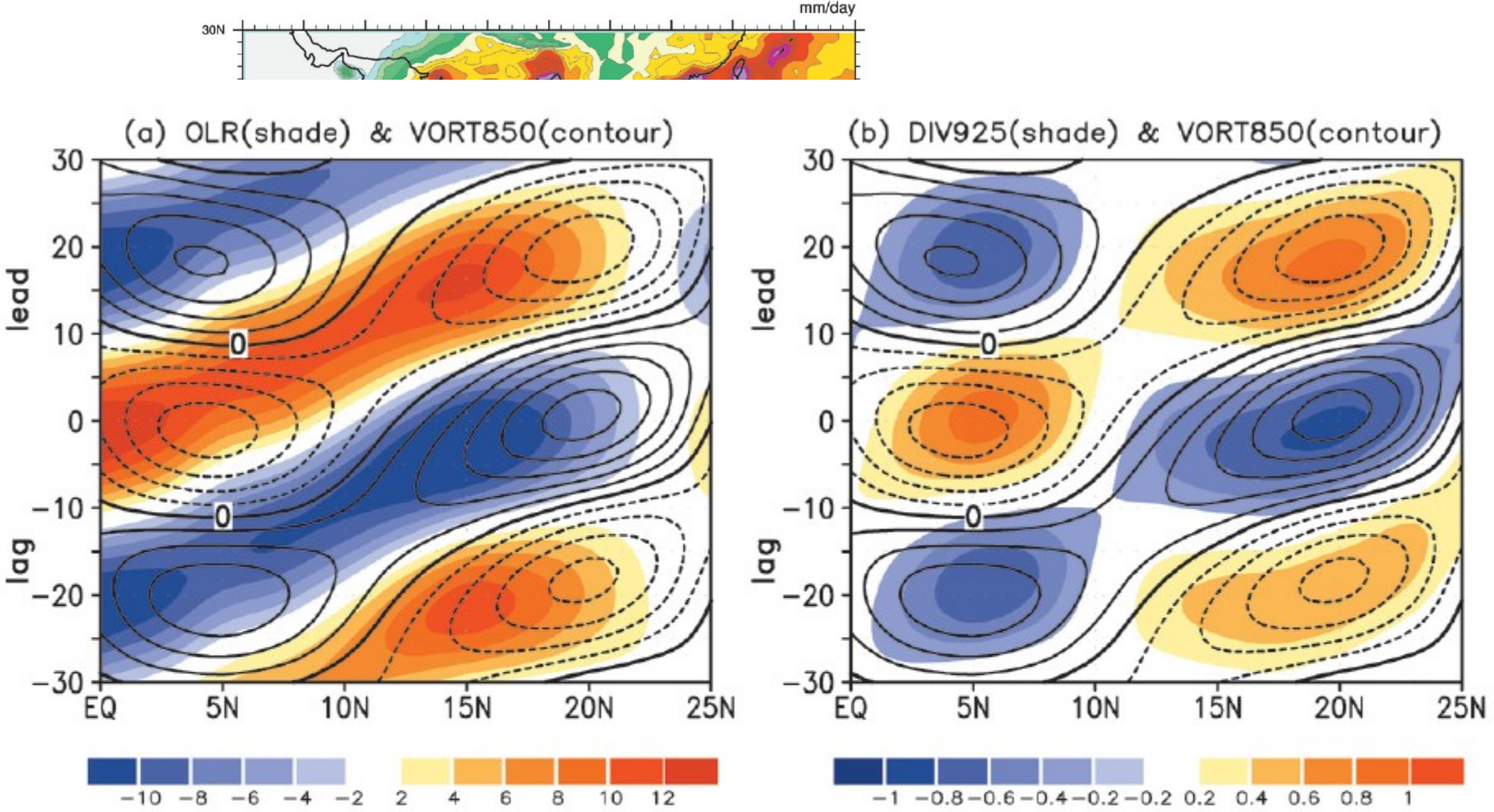
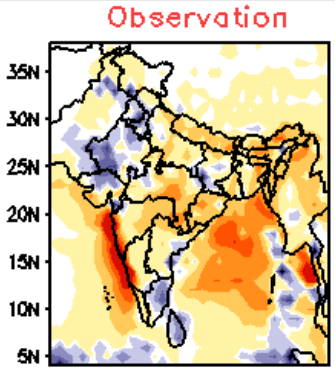


Figure 2.16. (a) Regressed 30 to 60-day filtered anomalies of OLR (shaded; $\mathrm{W\,m^{-2}}$) and 850 hPa relative vorticity (contour, positive solid and negative dashed, contour interval $1 \times 10^{-6}\,\mathrm{s^{-1}}$) with respect to the reference time series described in Figure 2.10 averaged over 80°E–90°E. (b) Regressed 30 to 60-day filtered anomalies of 850 hPa relative vorticity (contour, positive solid and negative dashed, contour interval $1 \times 10^{-6}\,\mathrm{s^{-1}}$) and divergence at 925 hPa (shaded; $10^{-6}\,\mathrm{s^{-1}}$) with respect to the same reference time series.

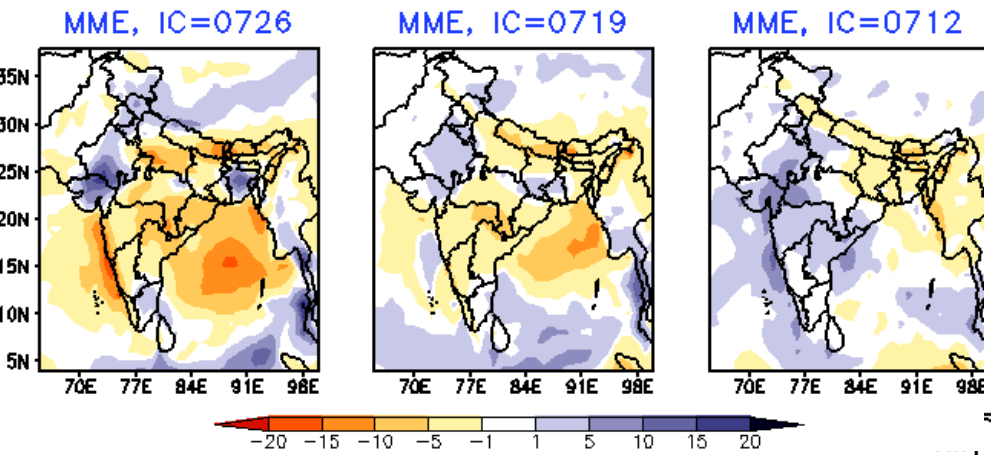
seasonal mean for the period 1997–2007. (c) Amplitude of the annual cycle. Climatological mean absolute value of the difference between JJAS mean and DJF mean for the 1997–2007 period from GPCP.

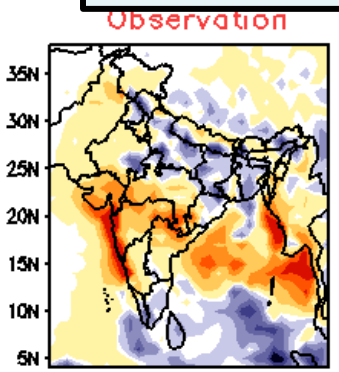
Observed as well as predicted weekly averaged fall



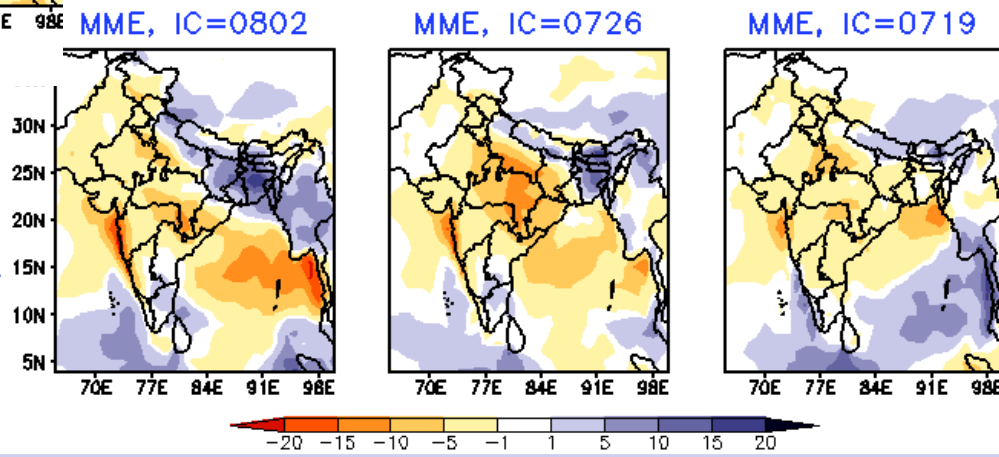
27Jul-02Aug

Long Break Spell – 31 Jul-17 Aug





03-09Aug

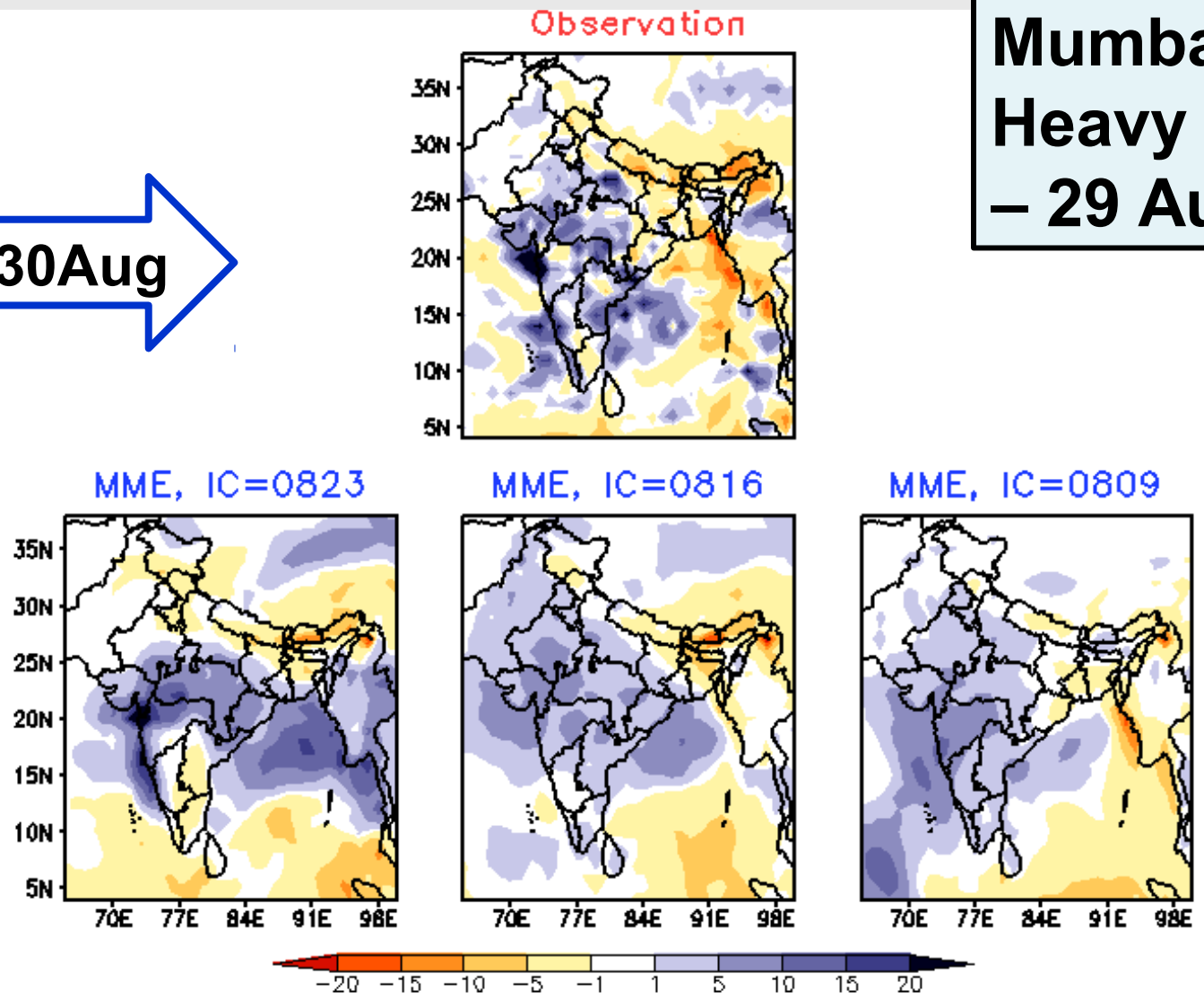


Verification of Selected Active/Break Spells

Observed as well as predicted weekly averaged rainfall

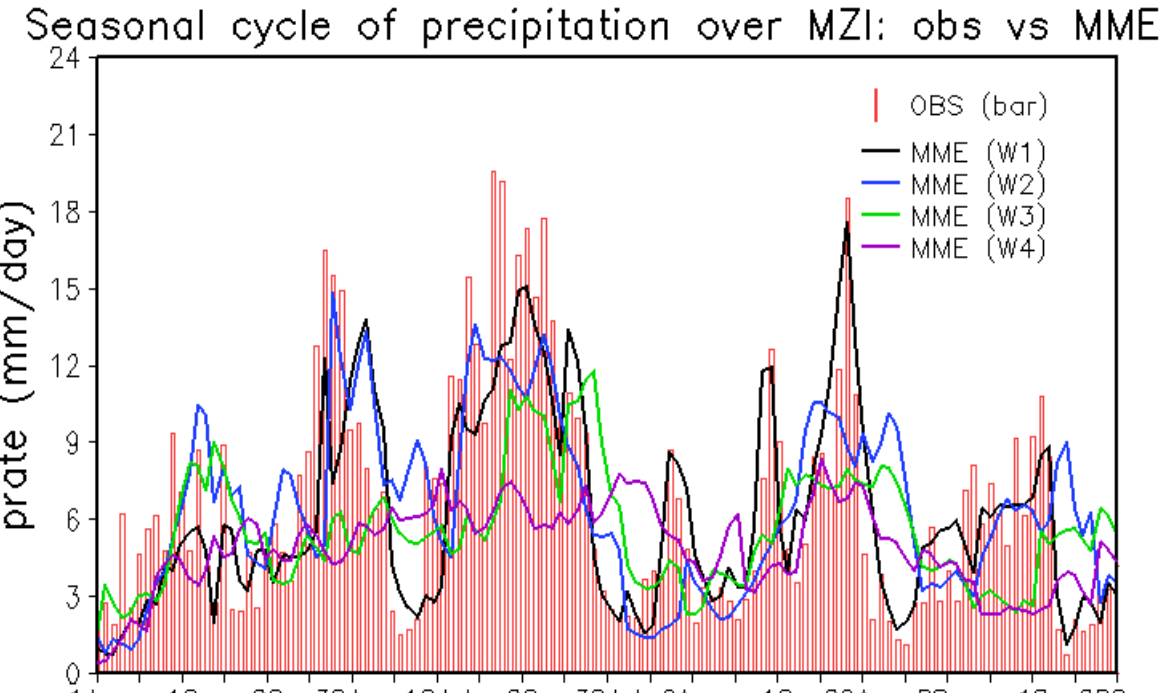
Mumbai Heavy rainfall – 29 Aug

24-30Aug

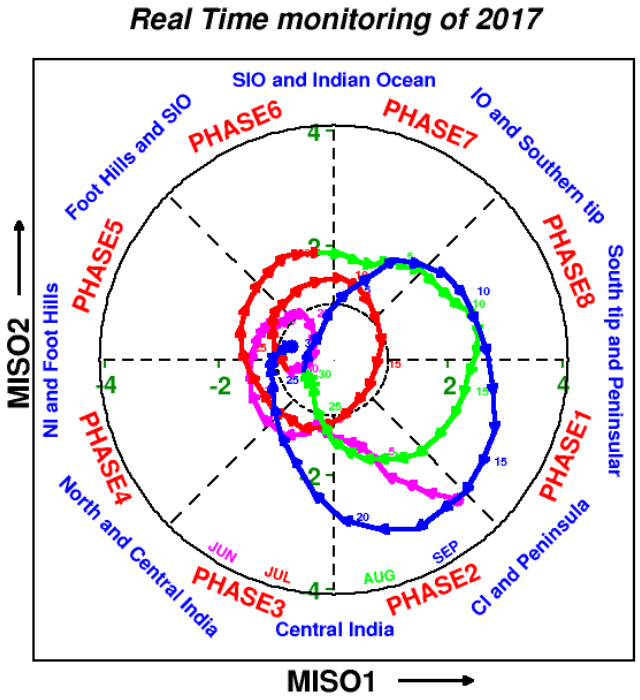


Verification of Selected Active/Break Spells

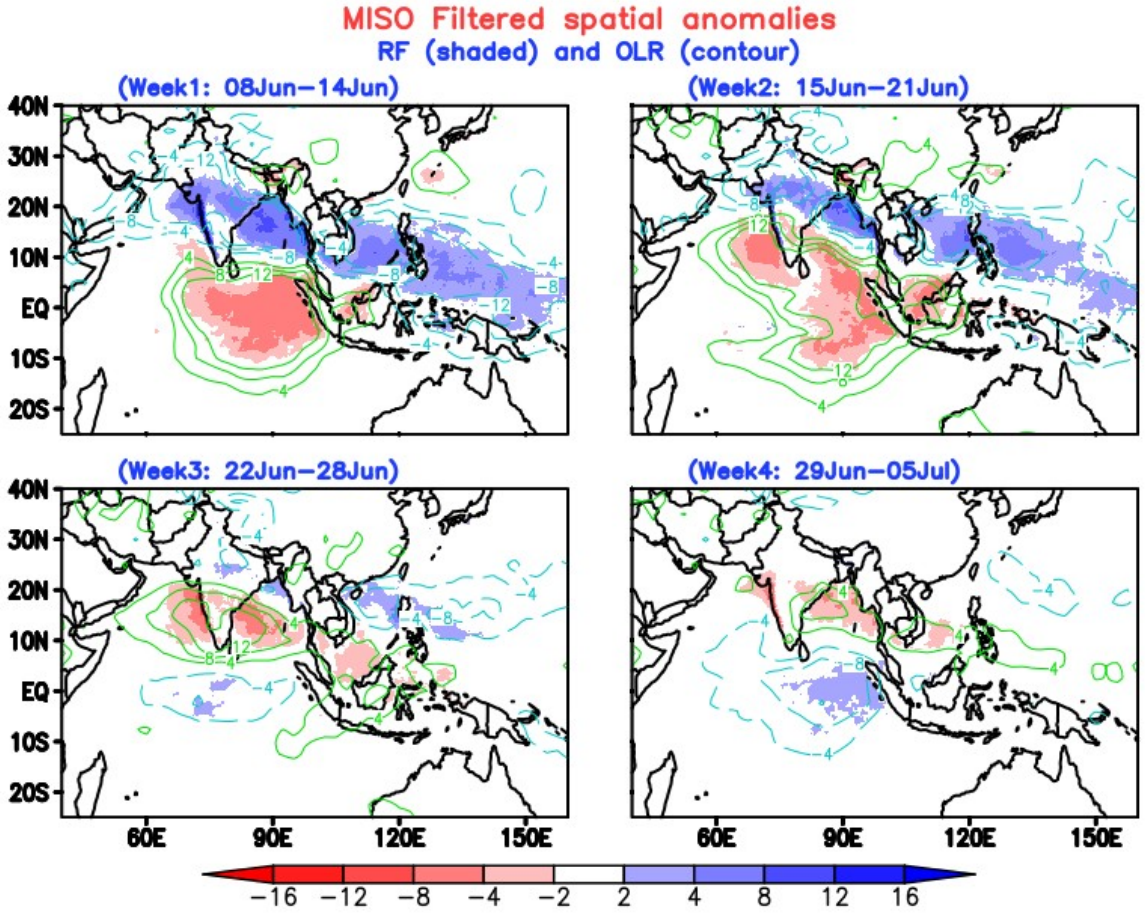
Observed and Predicted seasonal cycle of rainfall over MZI Region

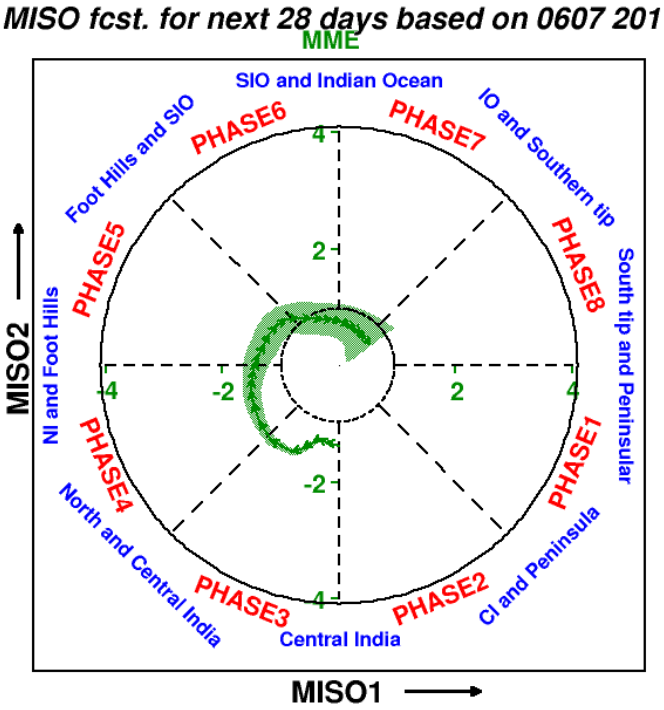


MISO

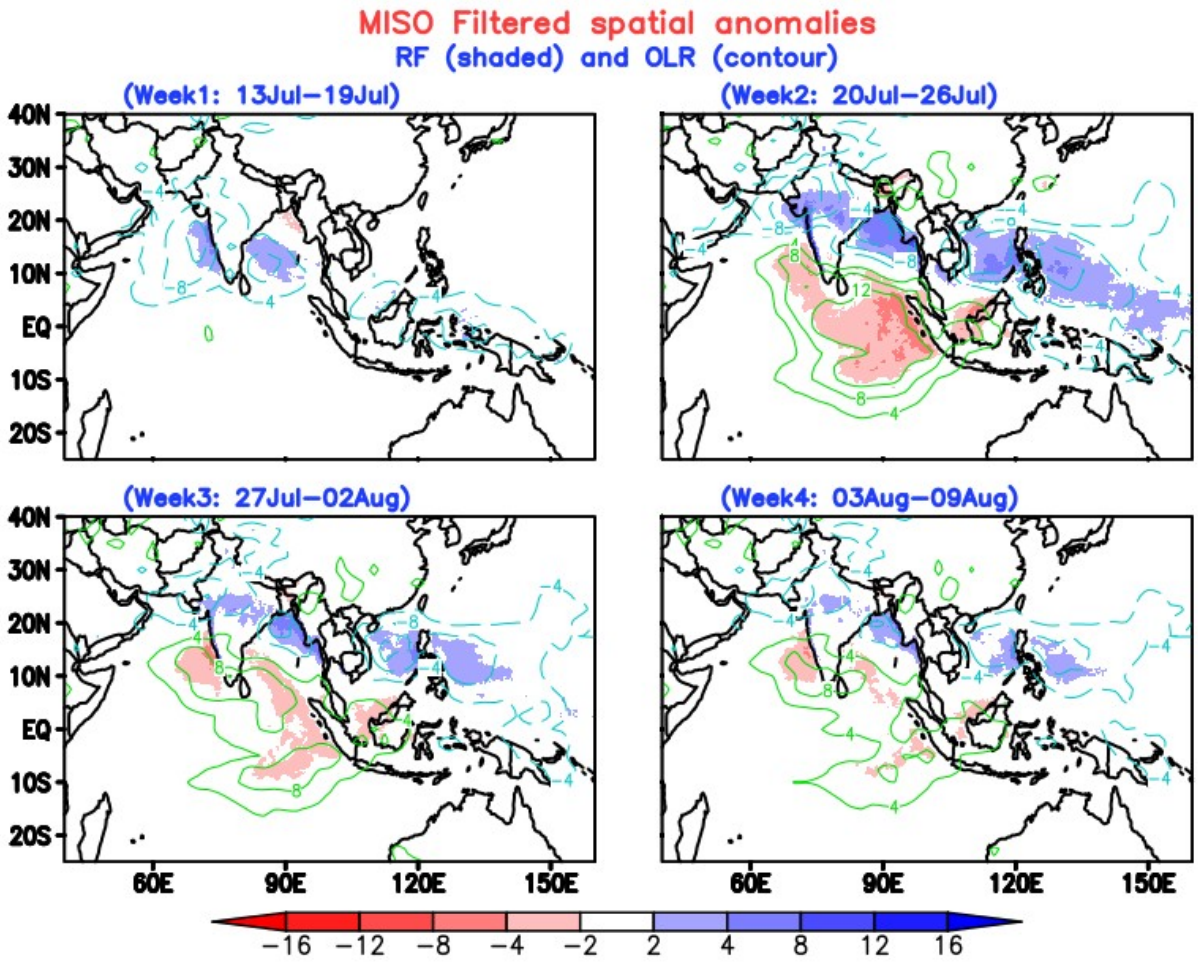


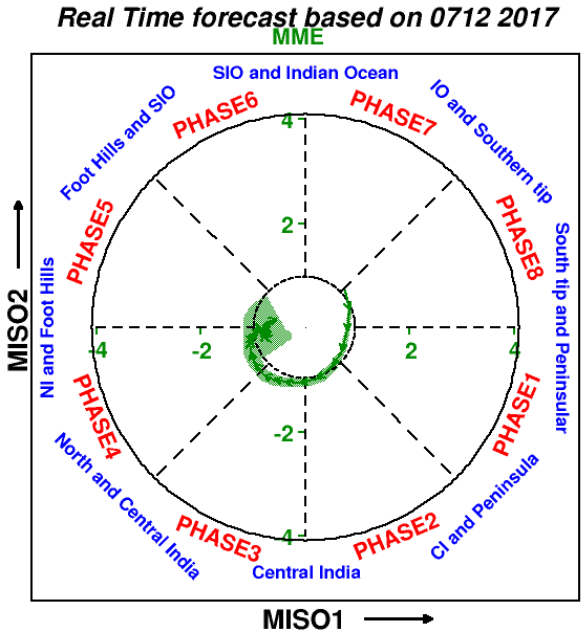
MISO forecast for 28 days during June 2017





MISO forecast for next 28 days





MISO forecast for next 28 days