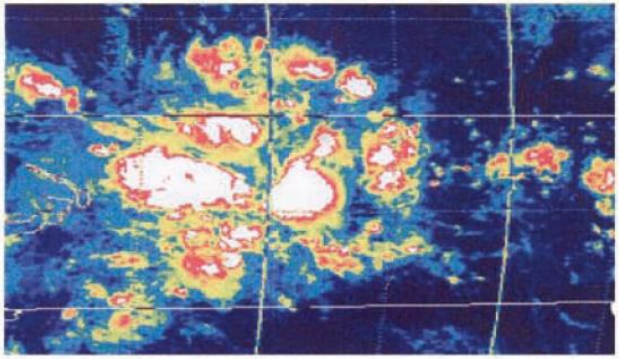
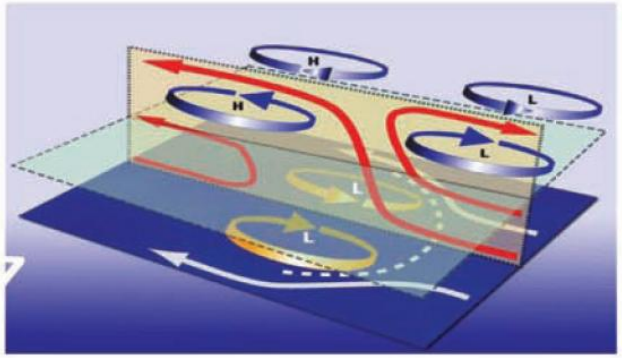
Northward Propagating Summer Monsoon ISOs during YOTC Period

B. N. Goswami

Indian Institute of Tropical Meteorology (IITM)

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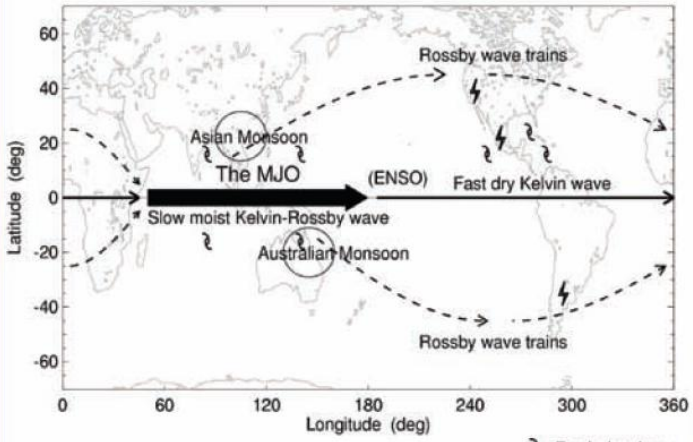
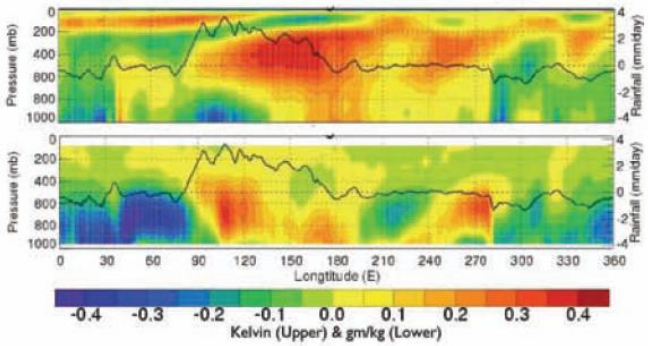
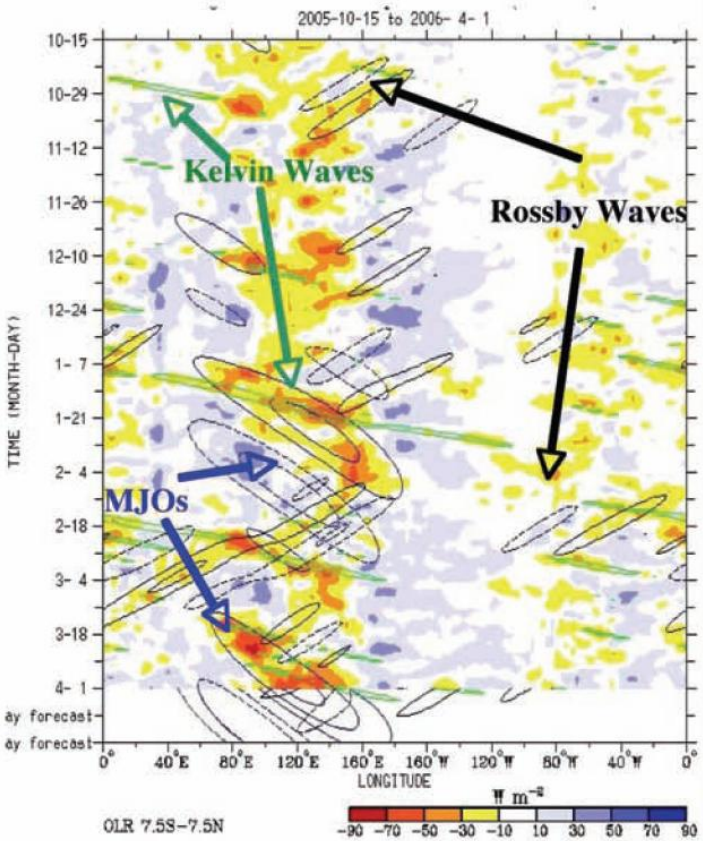
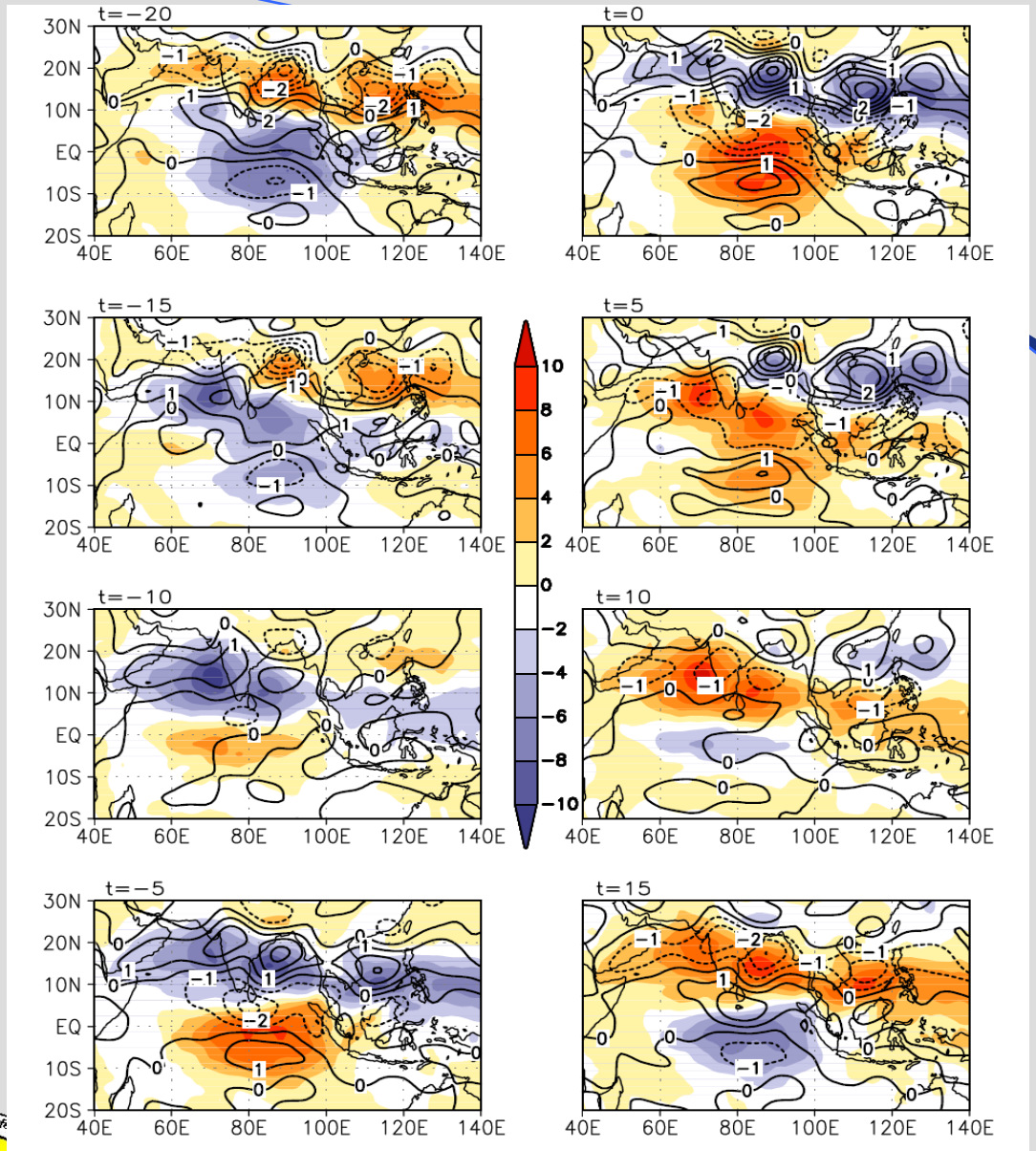

Rossby wave trains
Asian Monsoon
The MJO
(ENSO)
Fast dry Kelvin wave
Slow moist Kelvin-Rossby wave
Australian Monsoon
Rossby wave trains
Latitude (deg)
Longitude (deg)
Tropical cyclone
Storm

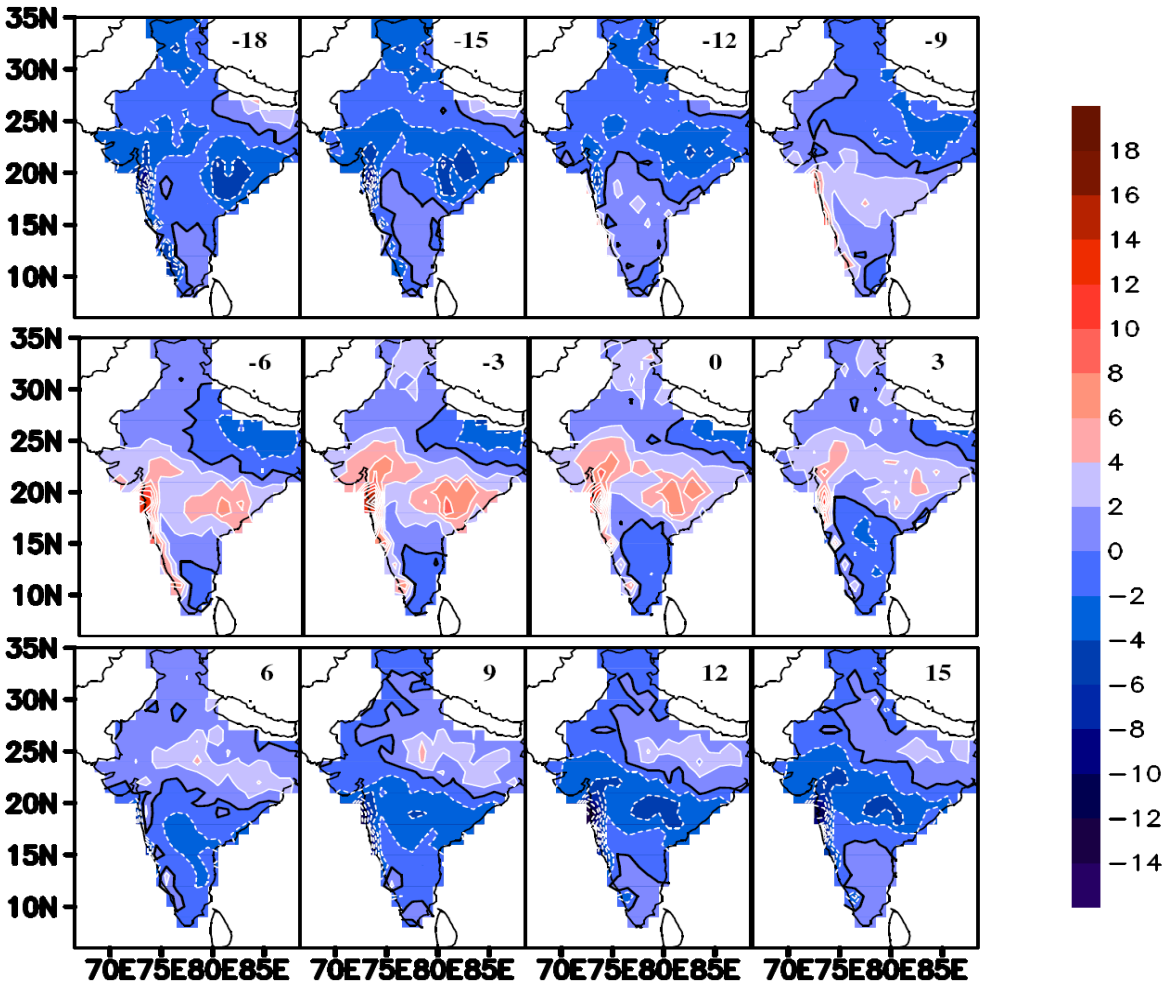

Pressure (mb)
Rainfall (mm/day)
Longitude (E)
Kelvin (Upper) & gm/kg (Lower)


2005-10-15 to 2006- 4- 1
Kelvin Waves
Rossby Waves
MJOs
TIME (MONTH-DAY)
LONGITUDE
W m-2
OLR 7.5S-7.5N



What is responsible for the northward propagation?

Regressed OLR (shaded) and 850 hPa relative vorticity (contour) w.r.t a reference time series of 10-90 day filtered OLR



S3. (a) Lagged phase composites of 20-70 day filtered rainfall anomalies (mm/day) between May - October with respect to active phase of monsoon ISO identified from a reference series averaged over central India (72°E- 85°E, 15°N - 25°N). Composites from 18 day lag to 15 day lead are shown for the pre75 period. Lag or lead day is indicated at the top right corner of each panel.

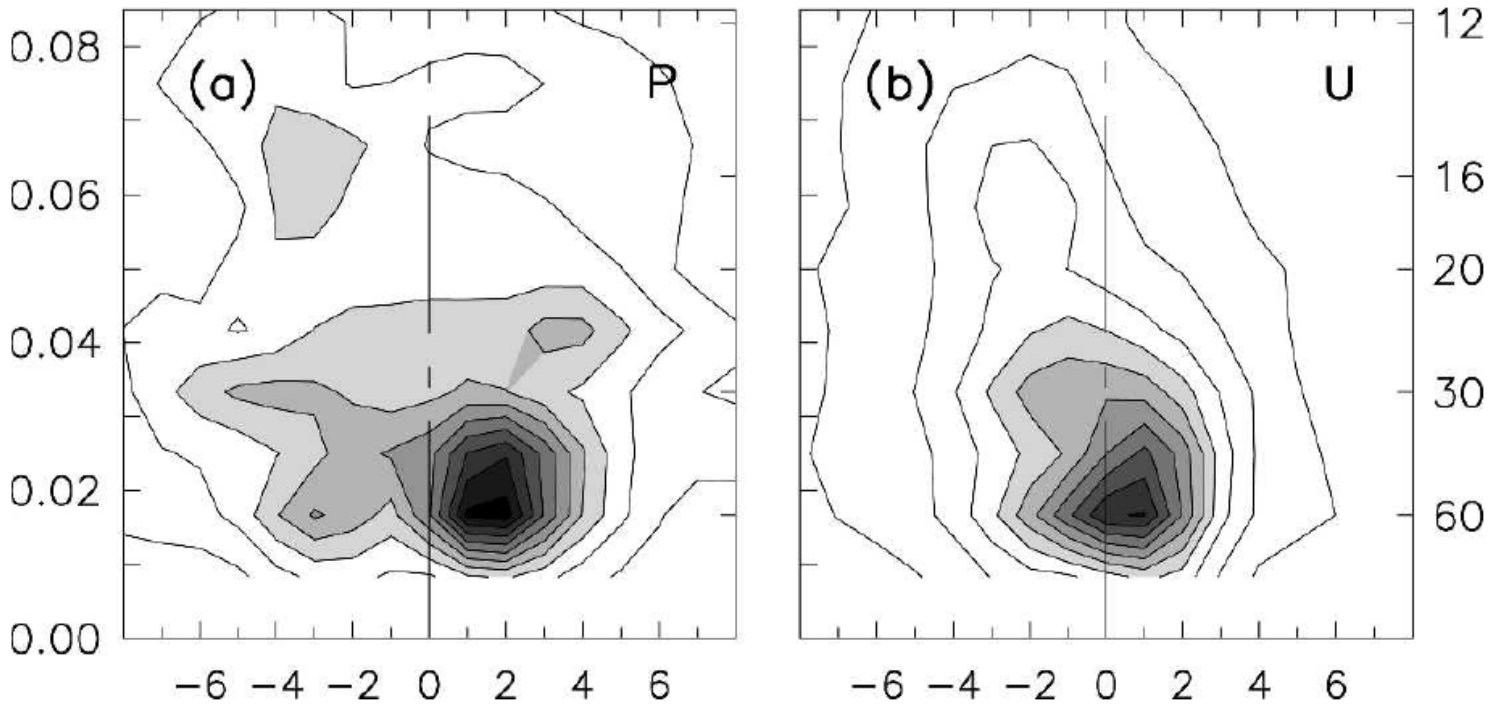


FIG. 2. Wavenumber–frequency spectral power of observed precipitation and 850-hPa zonal winds anomalies averaged over the latitude band 5°–25°N. The *y* axis left ordinate is frequency (in cycles per day, cpd) and right ordinate is period (days), while the *x* axis represents zonal wavenumber. The minimum contour and contour interval is 0.5; contours greater than 2.0 are shaded.

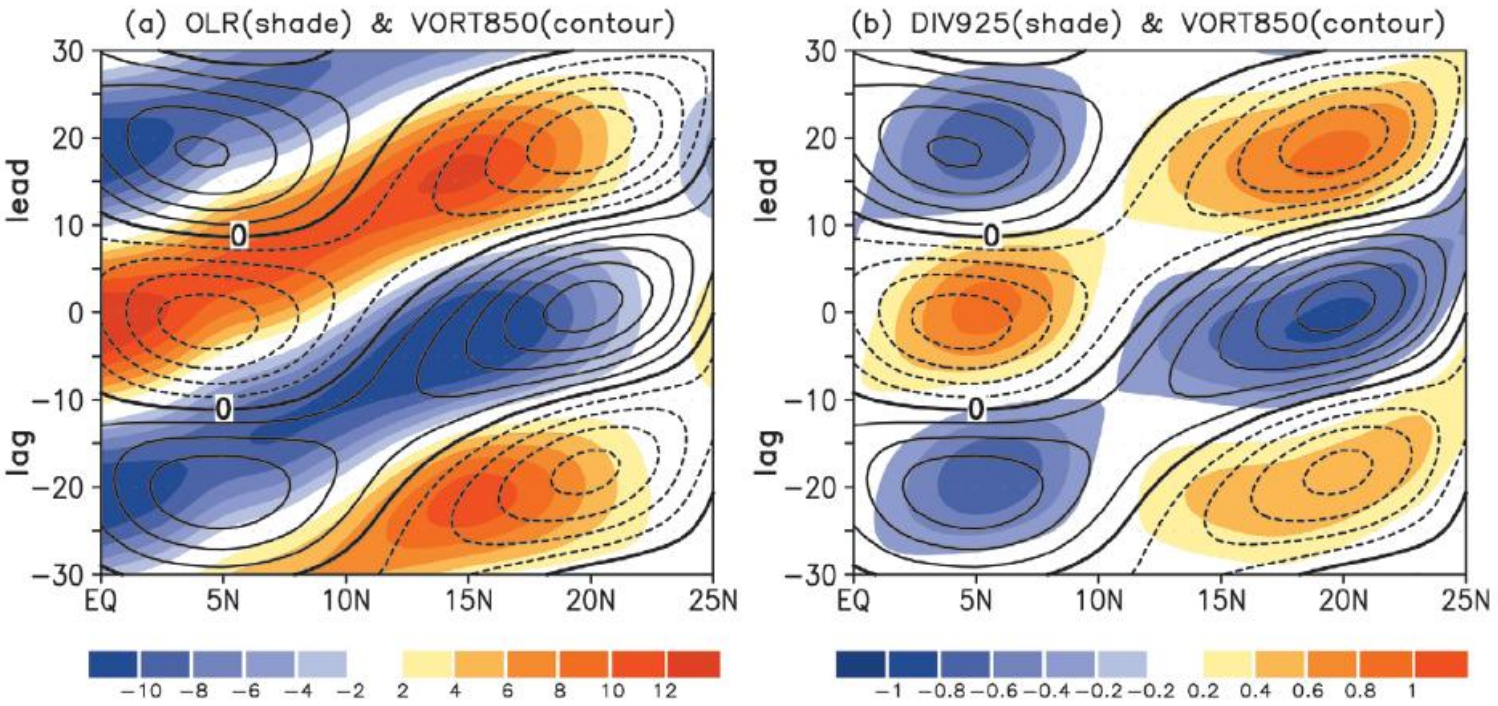
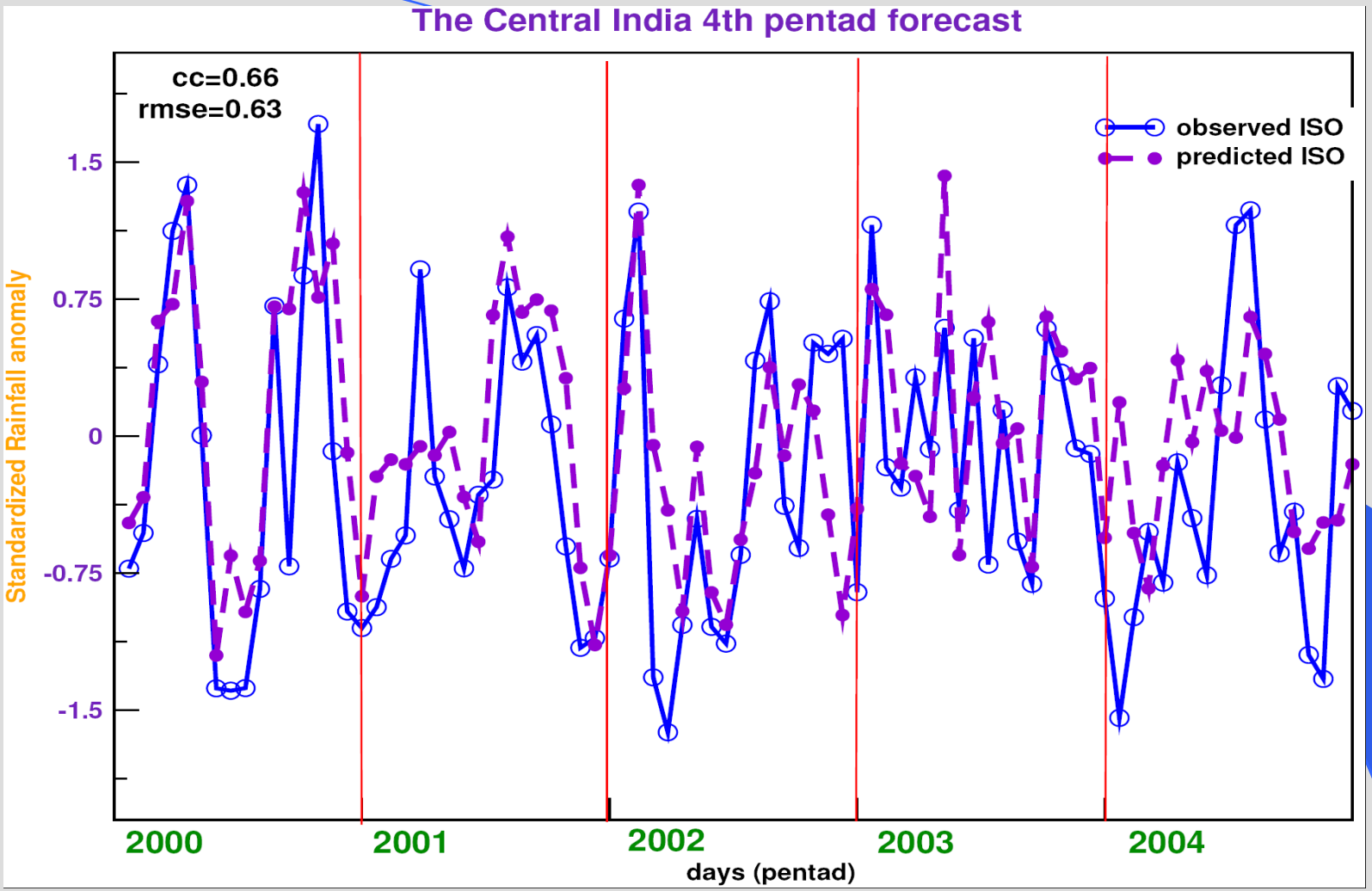
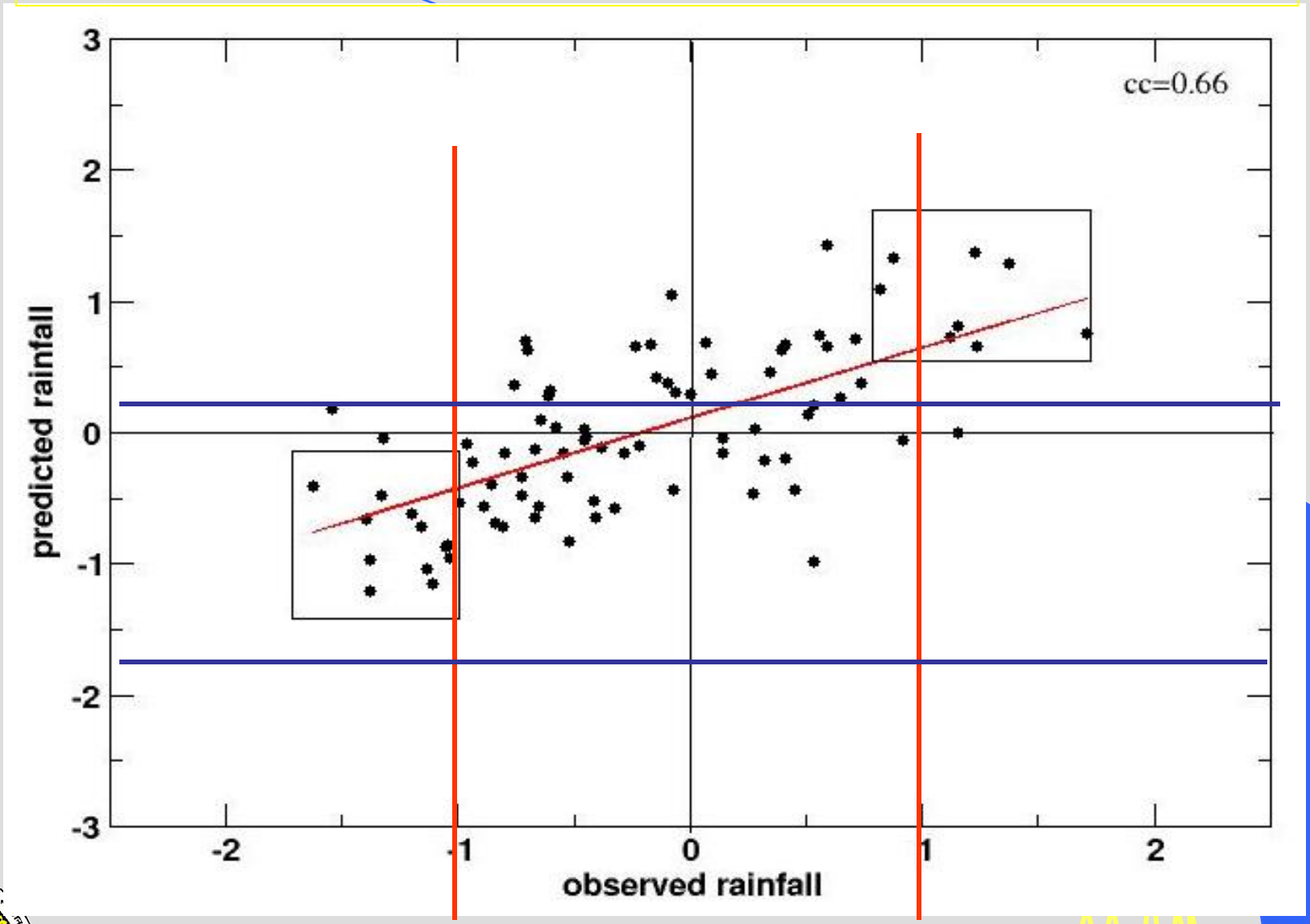
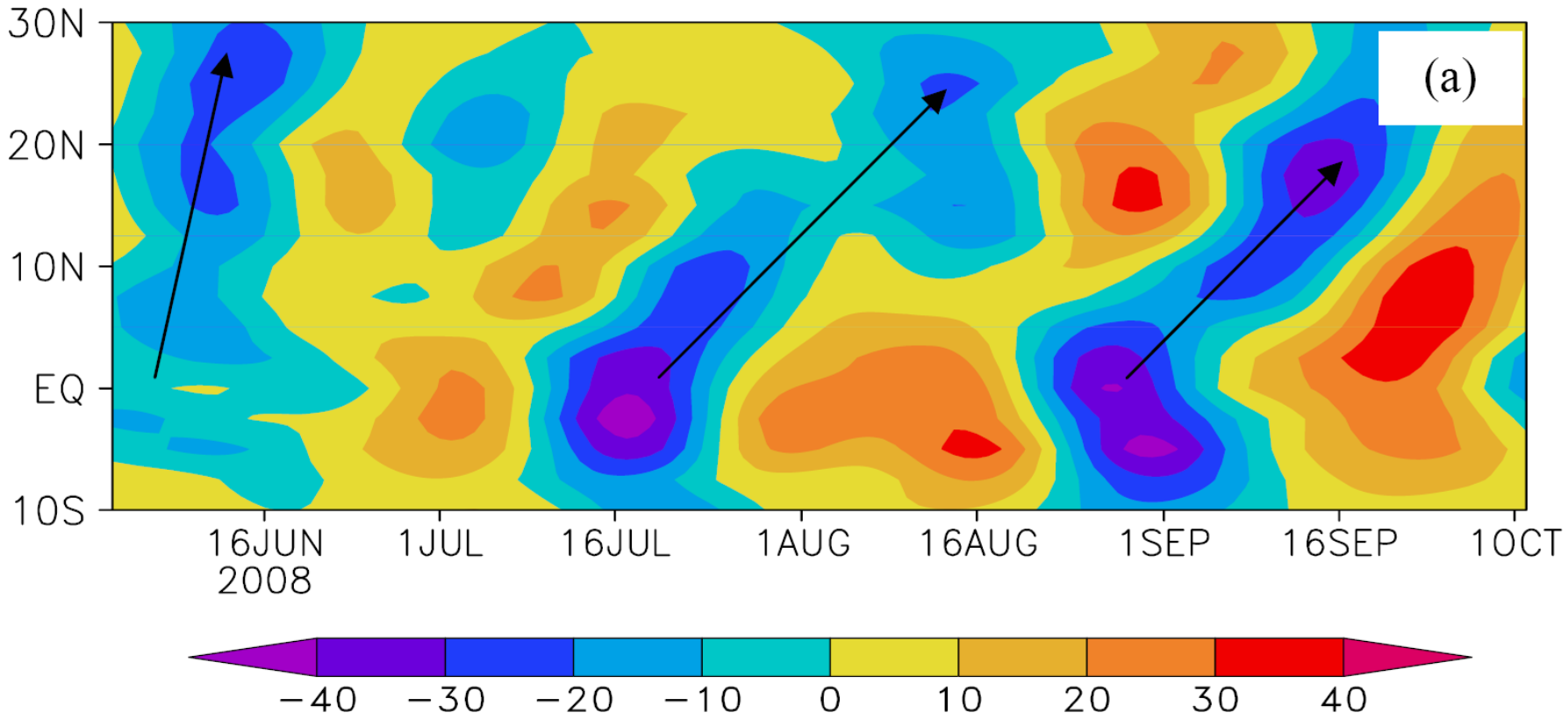


Figure 2.15. (a) Regressed 30–60-day filtered anomalies of OLR (shaded; $W\,m^{-2}$) and 850-hPa relative vorticity (contour, positive solid and negative dashed, contour interval $1 \times 10^{-6}\,s^{-1}$) with respect to the reference time series described in Figure 2.10 averaged over 80°E–90°E. (b) Regressed 30–60-day filtered anomalies of 850-hPa relative vorticity (contour, positive solid and negative dashed, contour interval $1 \times 10^{-6}\,s^{-1}$) and divergence at 925 hPa (shaded; $10^{-6}\,s^{-1}$) with respect to the same reference time series.


The Central India 4th pentad forecast
cc=0.66
rmse=0.63
observed ISO
predicted ISO
Standardized Rainfall anomaly
1.5
0.75
0
-0.75
-1.5
2000
2001
2002
2003
2004
days (pentad)

SOM and the prospect of Extreme Event Prediction

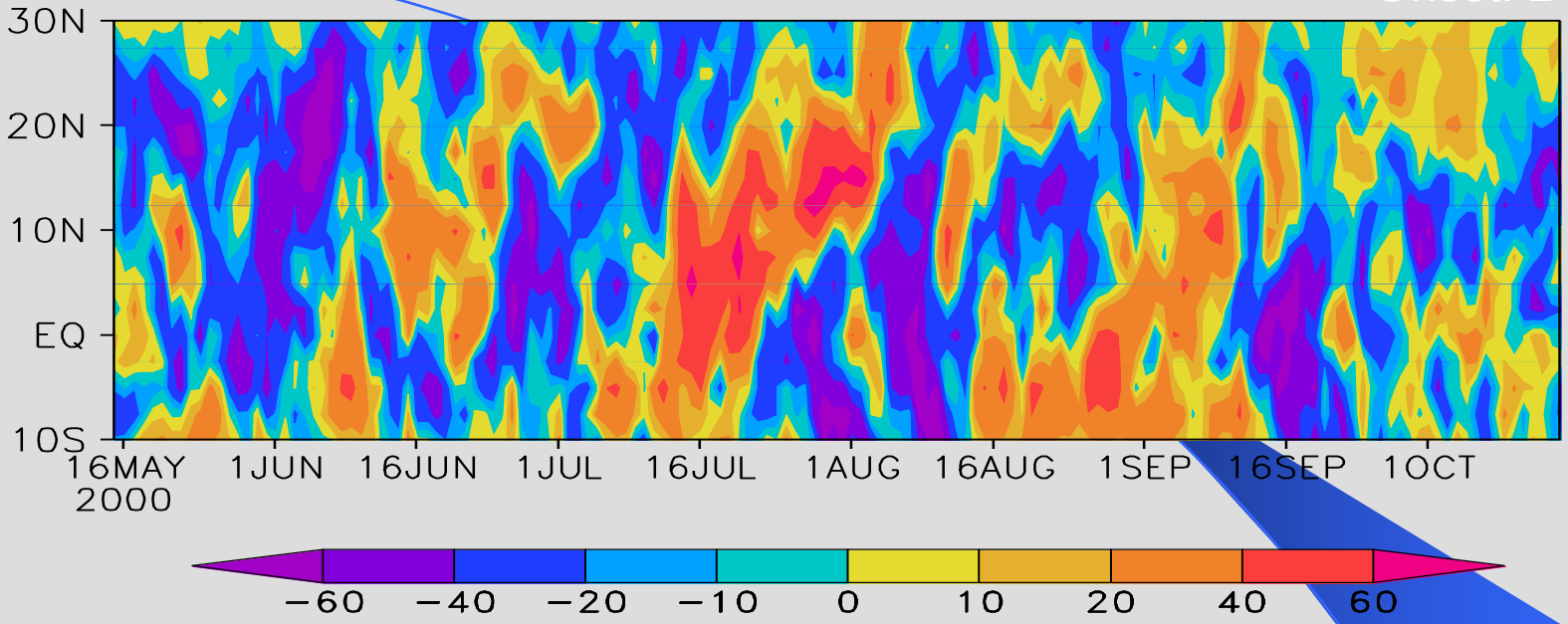


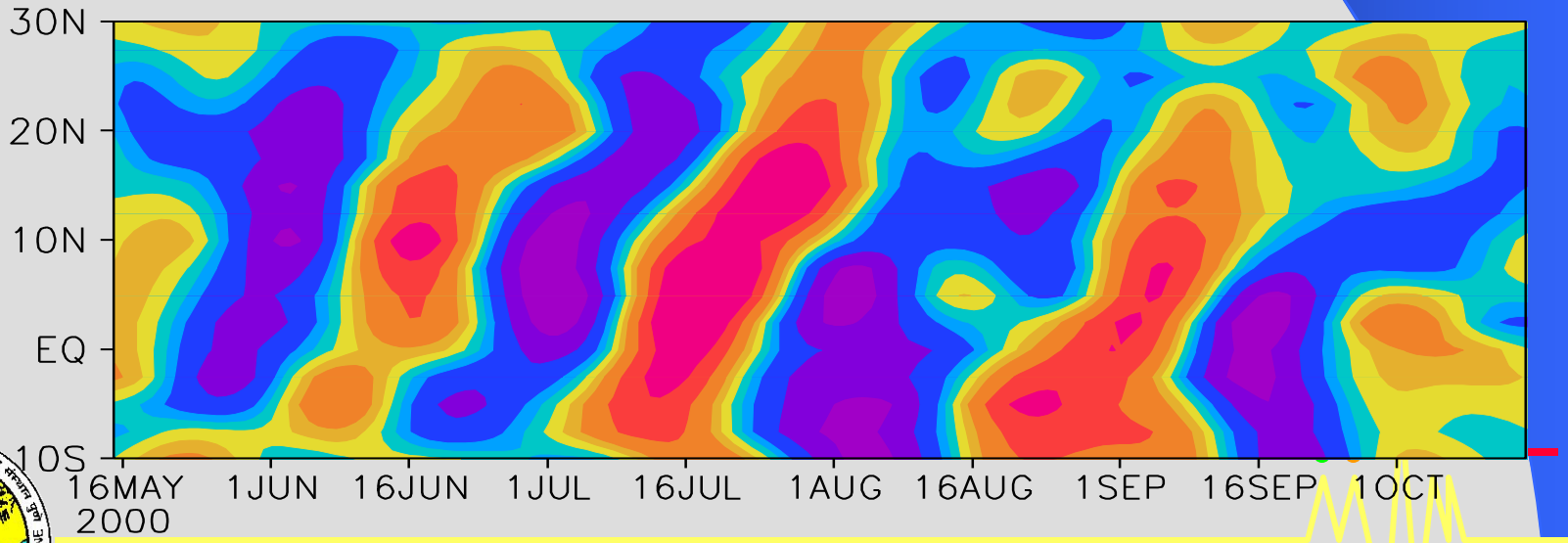


Lat-time plot of 20-90 day filtered OLR averaged over 70-90E during summer monsoon 2008

2000

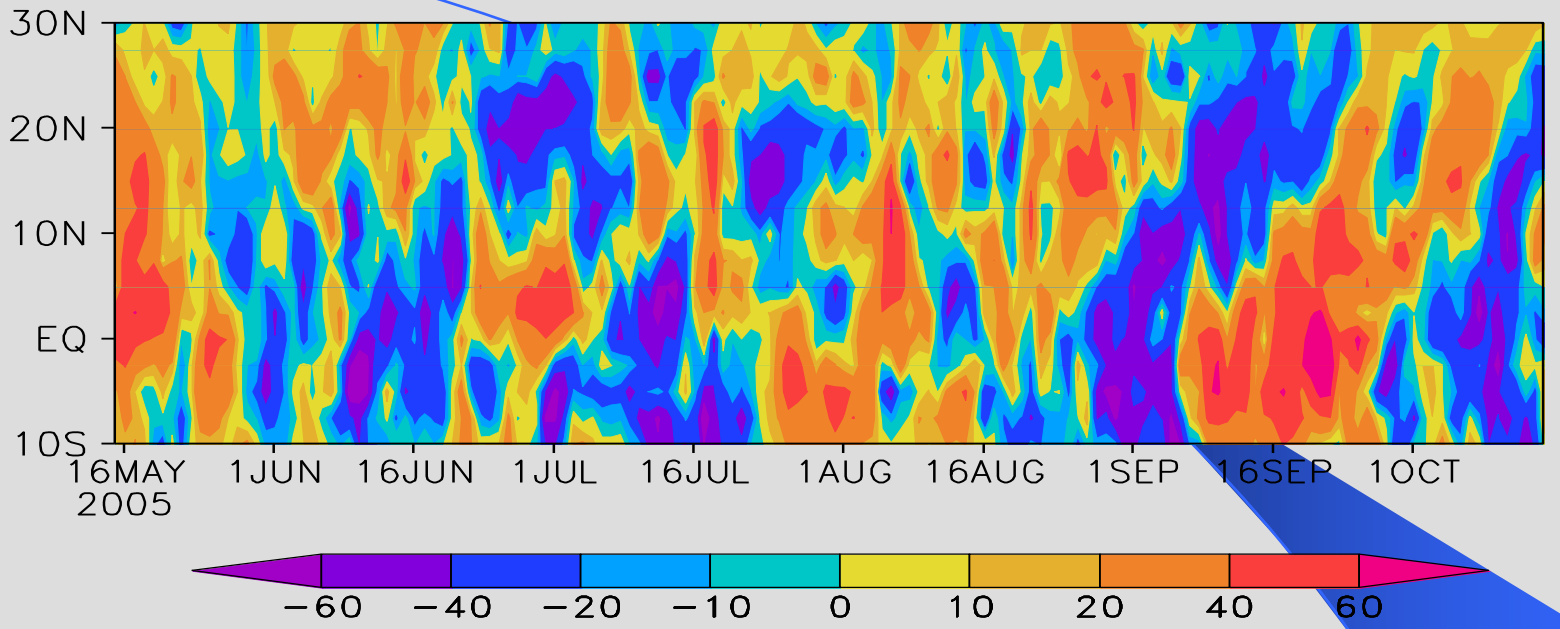
Onset: 1 June

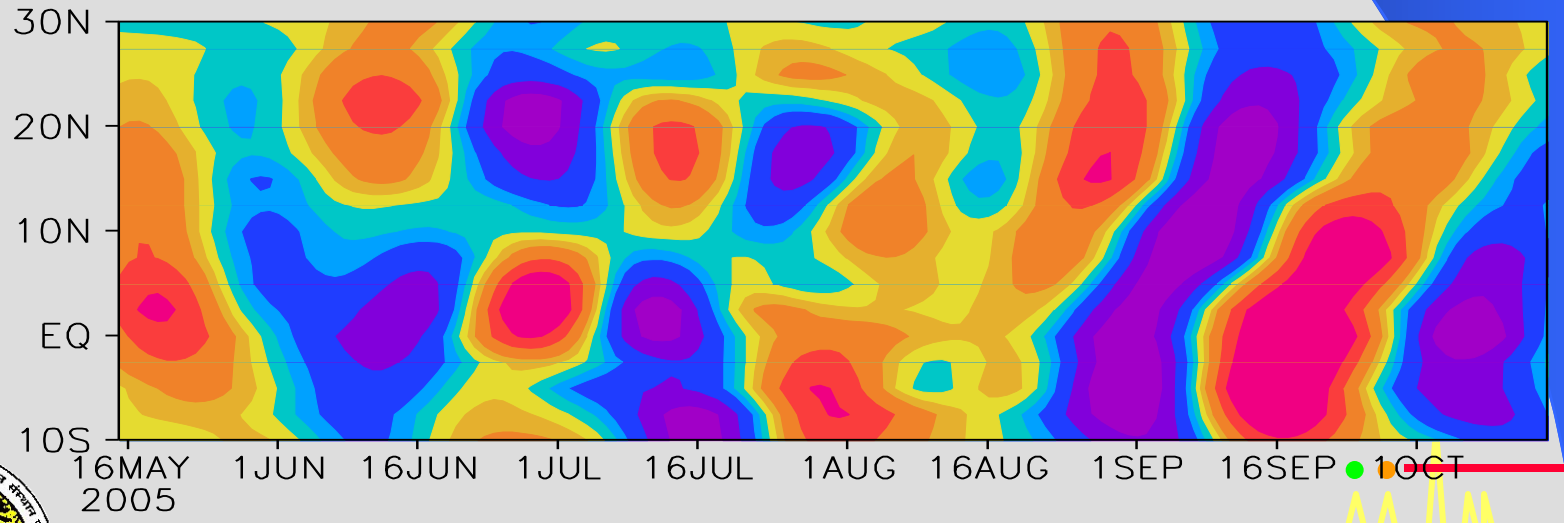




2005

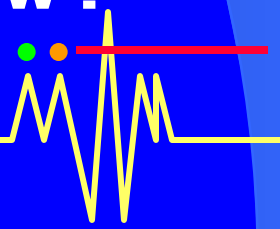
Onset: 5 June

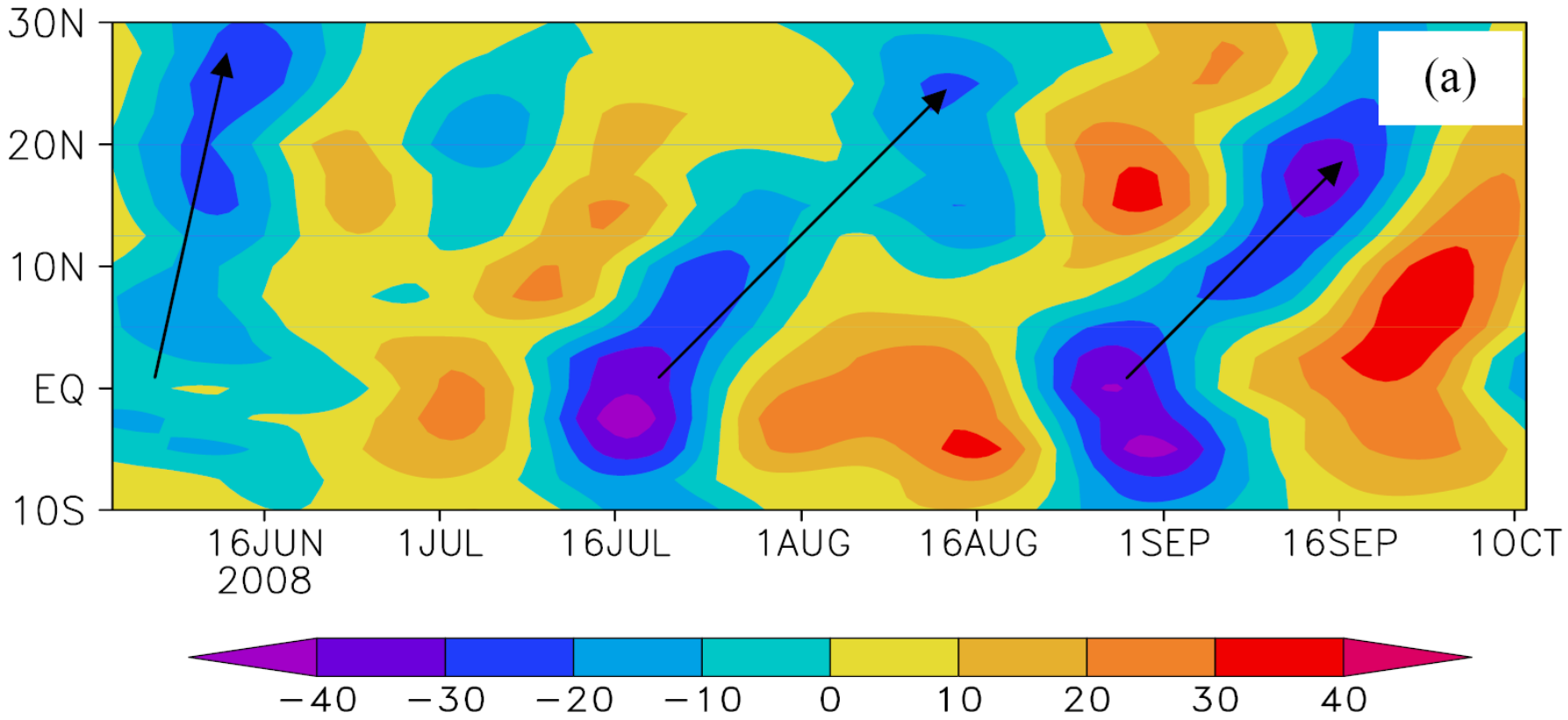




The Problem:

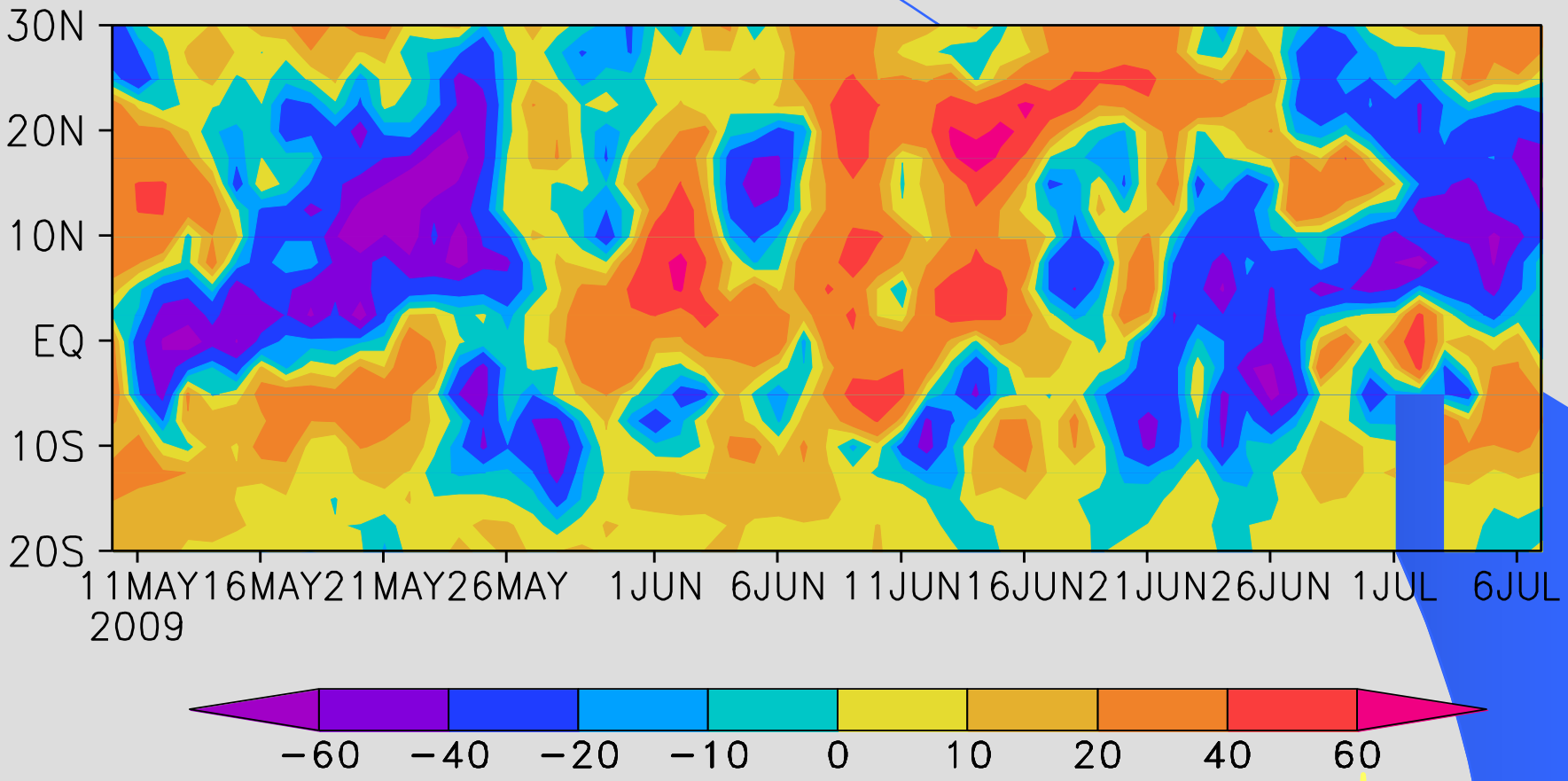
- The event-to-event variations of northward propagation speed of summer ISO's limits the potential predictability
- YOTC period provides an unique opportunity to study and understand the factors responsible for variation of northward propagation of the ISO during onset phase of the Indian monsoon
- Two very contrasting cases are witnessed. During 2008 onset phase, the propagation of the ISO was very fast while in 2009 onset took place but the northward propagation of ISO was very slow !





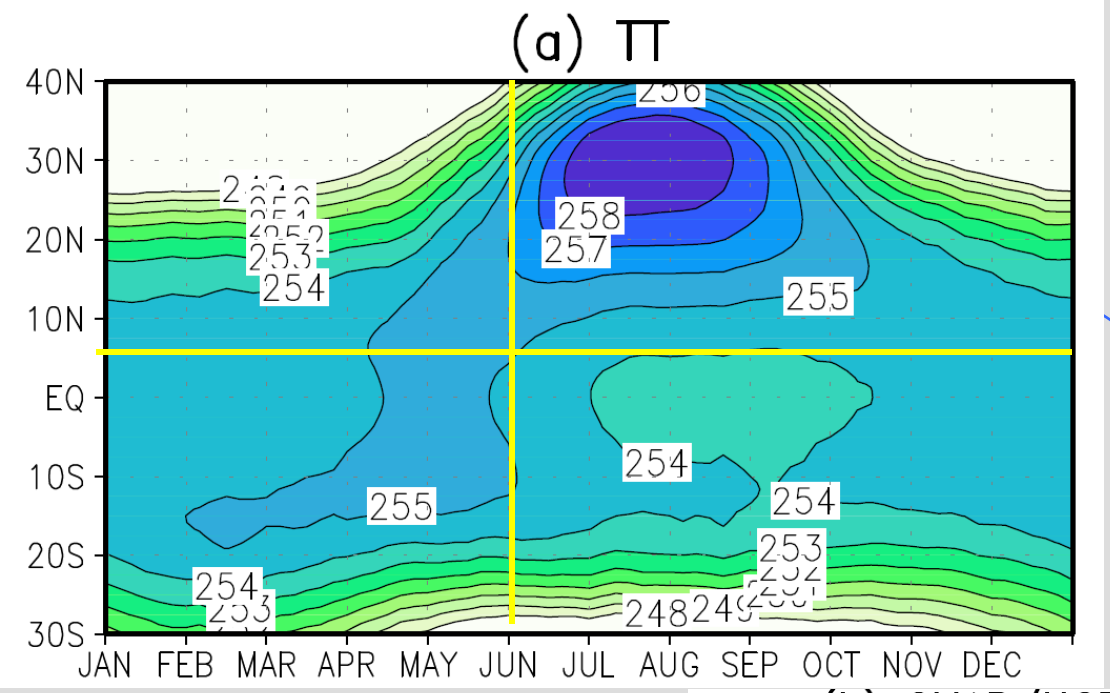
Lat-time plot of 20-90 day filtered OLR averaged over 70-90E during summer monsoon 2008

Northward propagation of OLR anomalies (70 – 90 E)

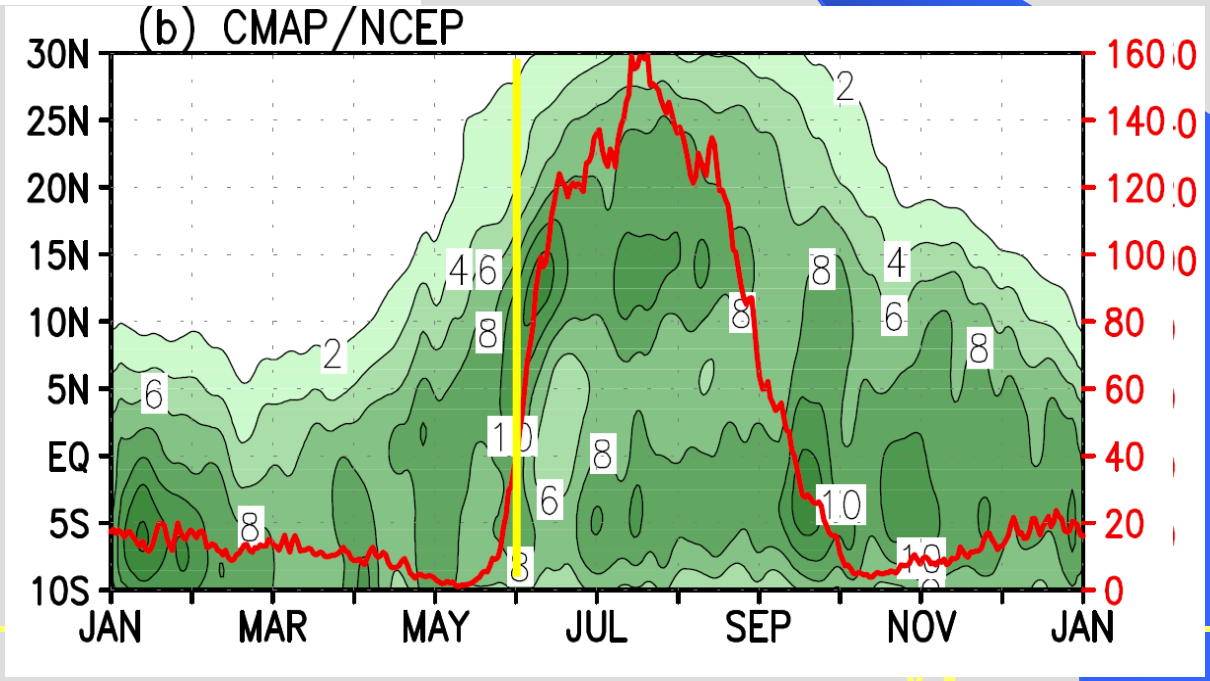


Questions:

- What is responsible for these differences?
- What is the role of eastward propagating MJO on this speed of northward propagation of summer ISO's?
- What is the role of mid-latitude influence versus tropical forcing?
- What is the role of stratiform vs convective rain on this propagation?
- Is there any role of local air-sea interactions on this?



Tropospheric temperature averaged between 200 and 600 hPa (TT) averaged between 40E and 100E



CMAP precipitation averaged between 70E and 90E (green) & K.E. at 850 hPa averaged over low level jet region (red line)

Goswami and Xavier 2005, GRL, doi:10.1029/2005GL023216

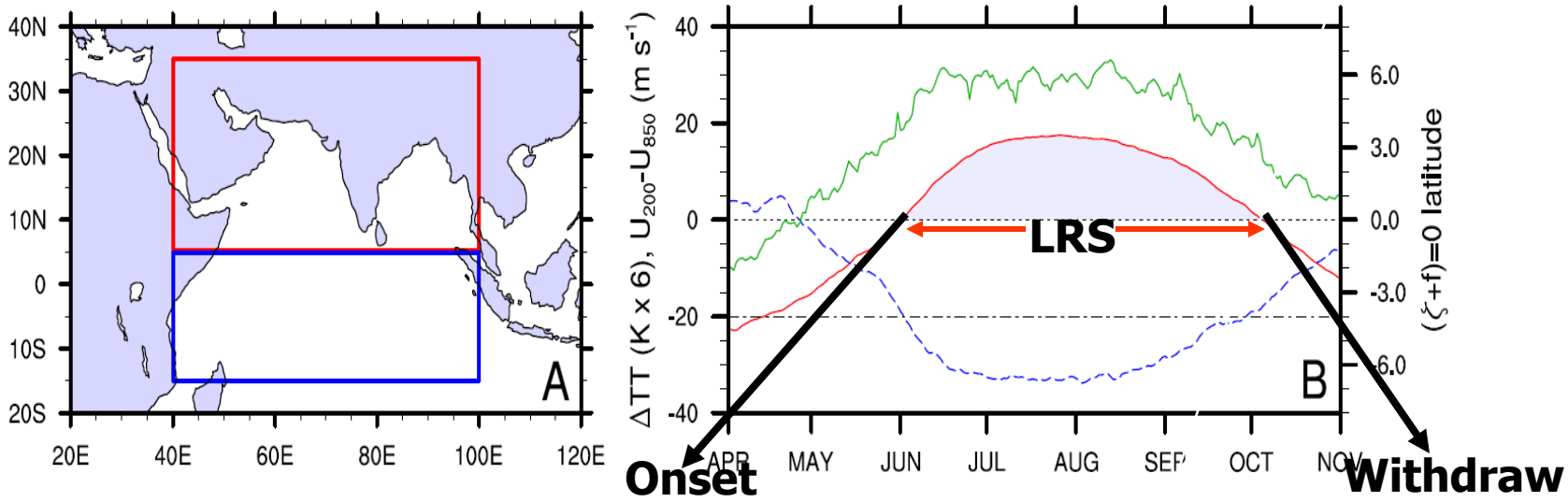
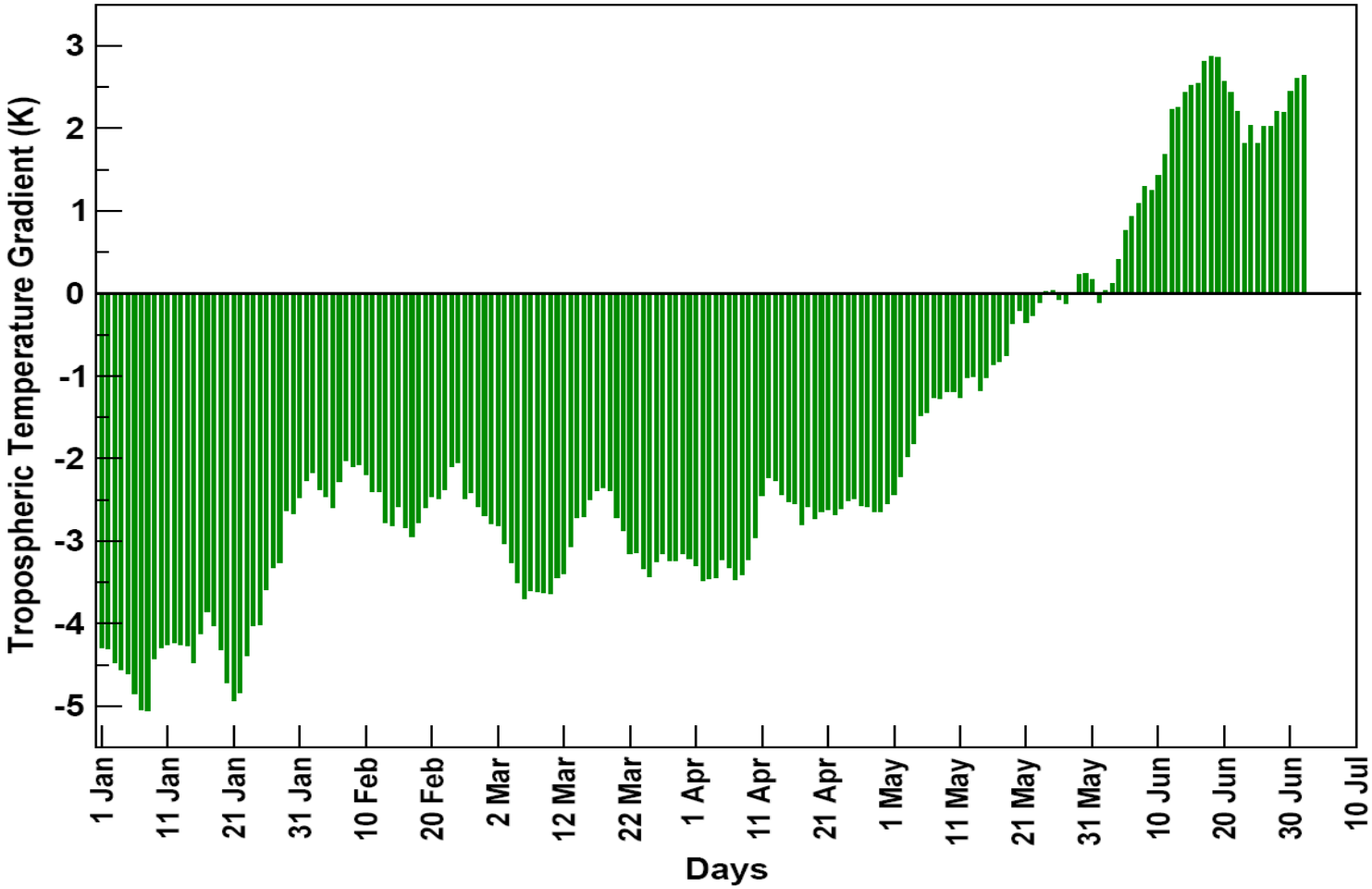


FIGURE 3.3: (A) The area used to define ΔTT. (B) Shows the evolution of climatological values of ΔTT (K×6, solid red line, scale to the left) and the climatological mean vertical shear of zonal winds (U_{200} - U_{850}) averaged over 50°-95°E, 0°-15°N (m s^{-1}, dashed blue line, scale to the left). The latitude of zero absolute vorticity averaged between 50°E and 100°E (solid green line, scale to the right). Shaded area under the ΔTT curve represents the climatological value of TISM (Section 3.1.1).

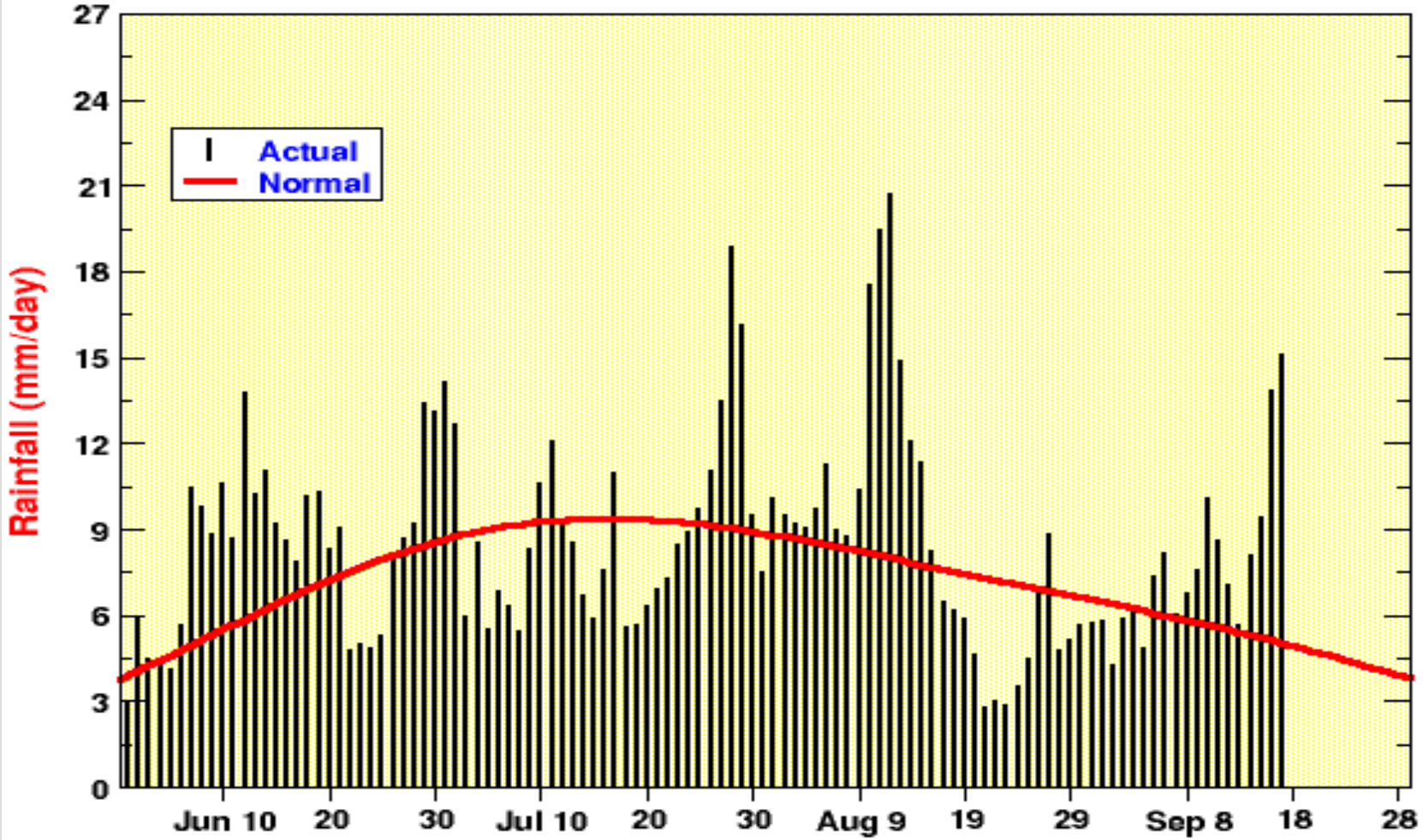
Green → absolute vorticity (ζ + f) averaged between 50E -100E

Red → Meridional gradient of TT (ΔTT = TT_n –TT_s)

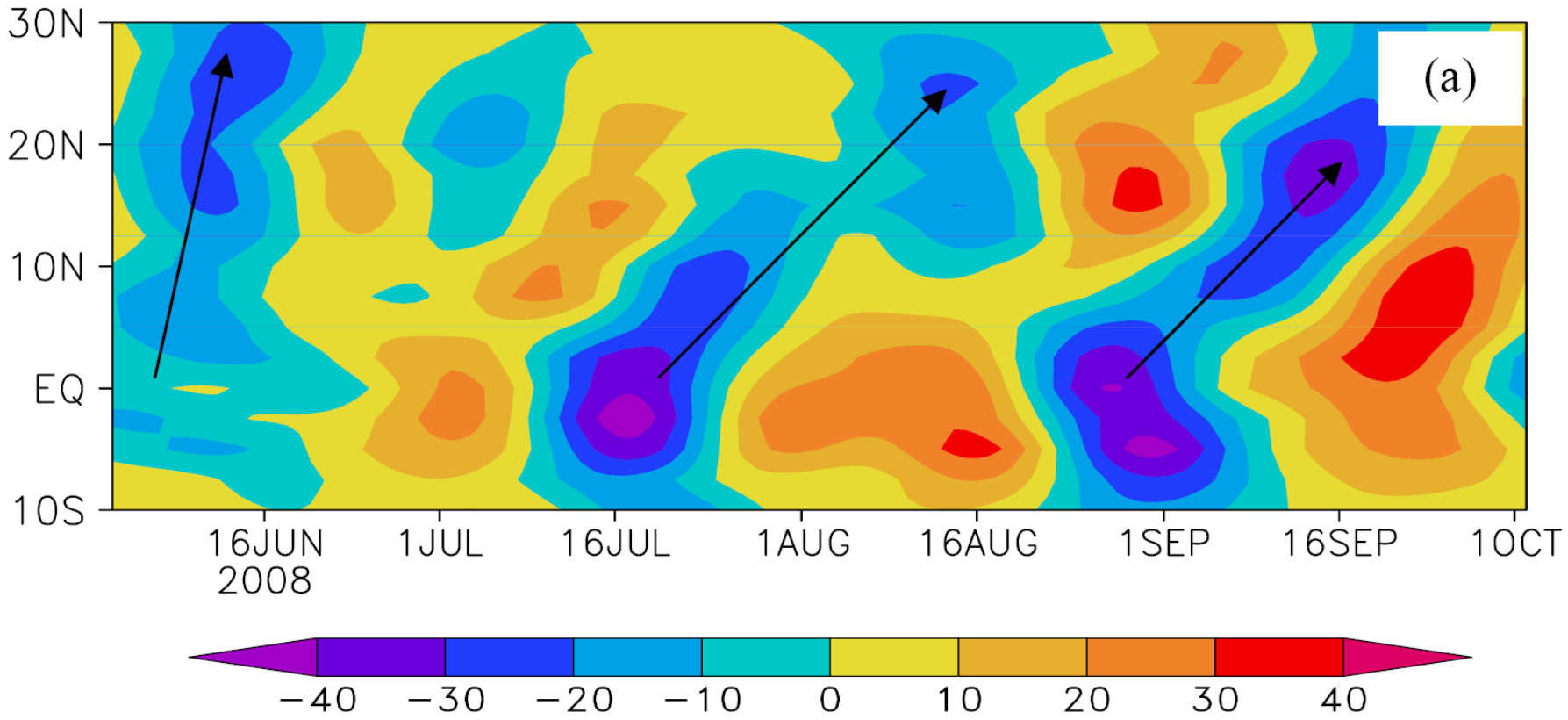
Blue → Vertical shear of zonal wind (U_{200} –U_{850}) ave (50E-95E, 0-15N)



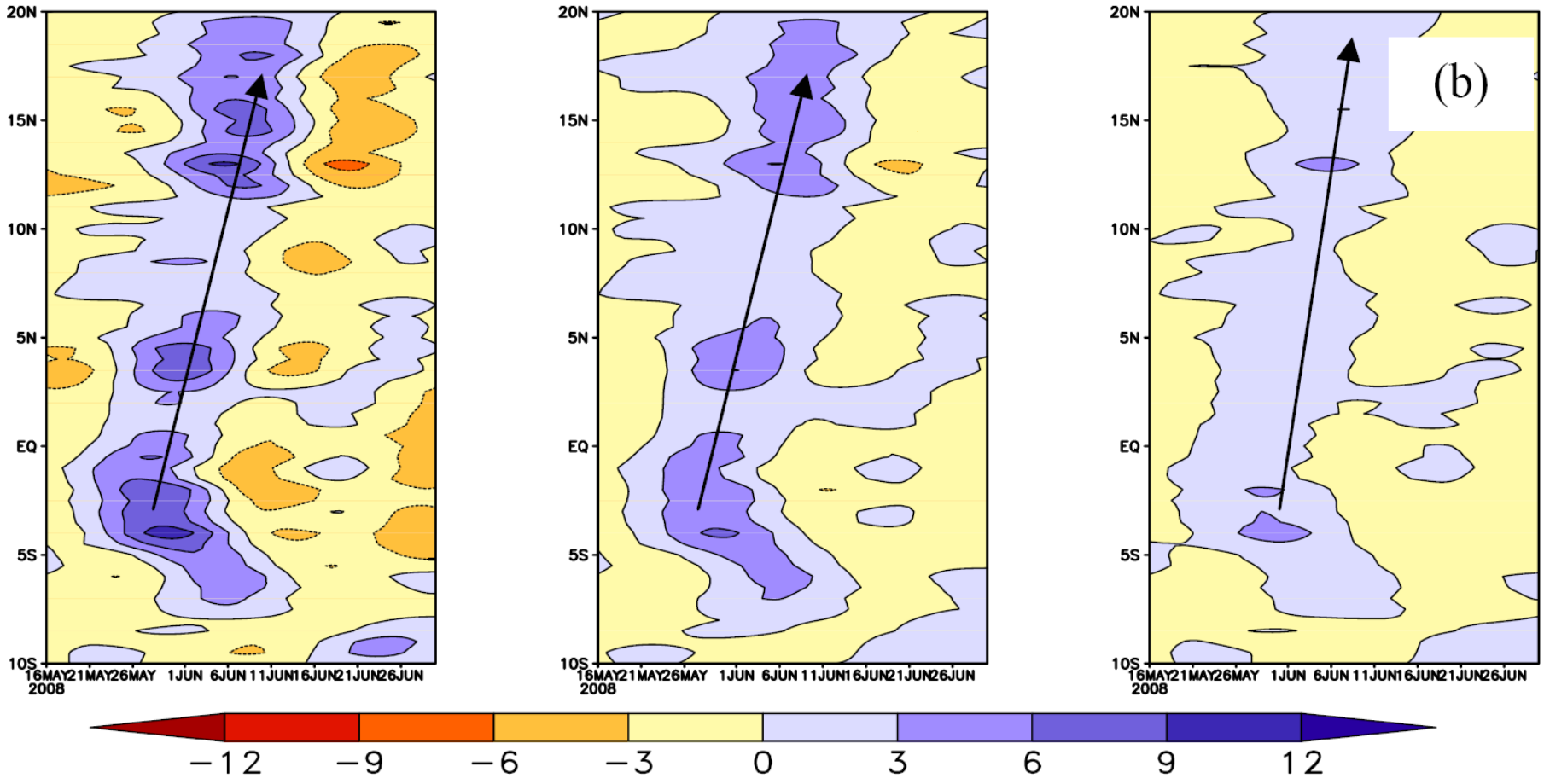
TT gradient has slightly changed sign from negative to positive on 23rd May. But after two days, it has again gone to negative side. The data is up to 1st July. On 28th May, again TT gradient has become positive, became negative on 31st May. 1st June onwards, it is in the positive side.



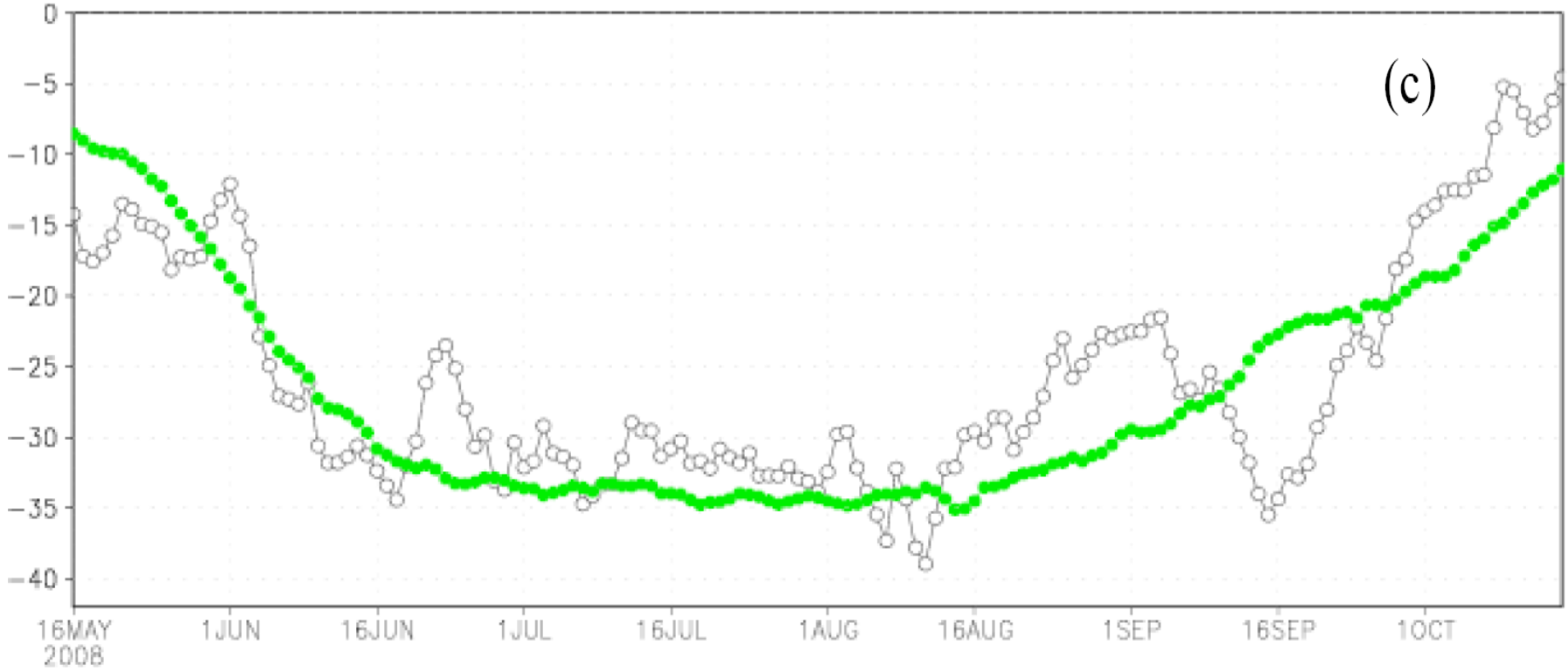
Evolution of daily All India rainfall during 2008 monsoon season



Lat-time plot of 20-90 day filtered OLR averaged over 70-90E during summer monsoon 2008

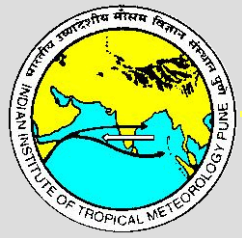


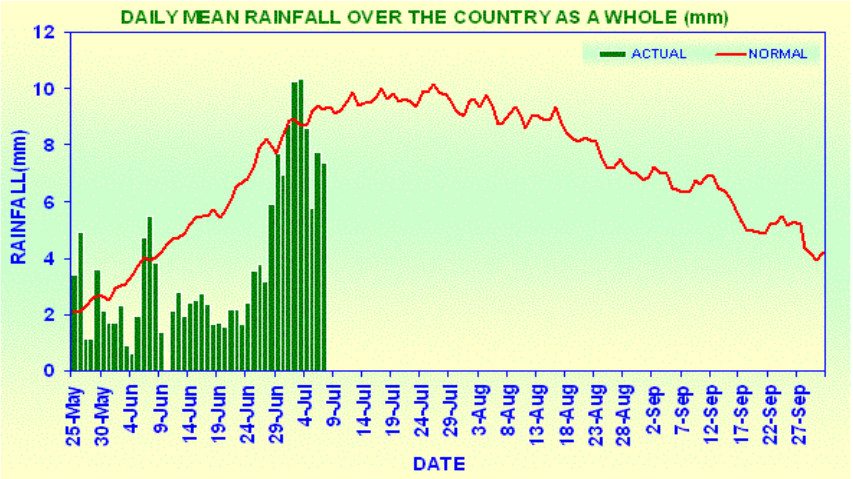
Lat-time plot of 20-90 day filtered TRMM precip averaged over 70-90E during onset phase of summer monsoon 2008, (l) total, (m) stratiform, ® convective

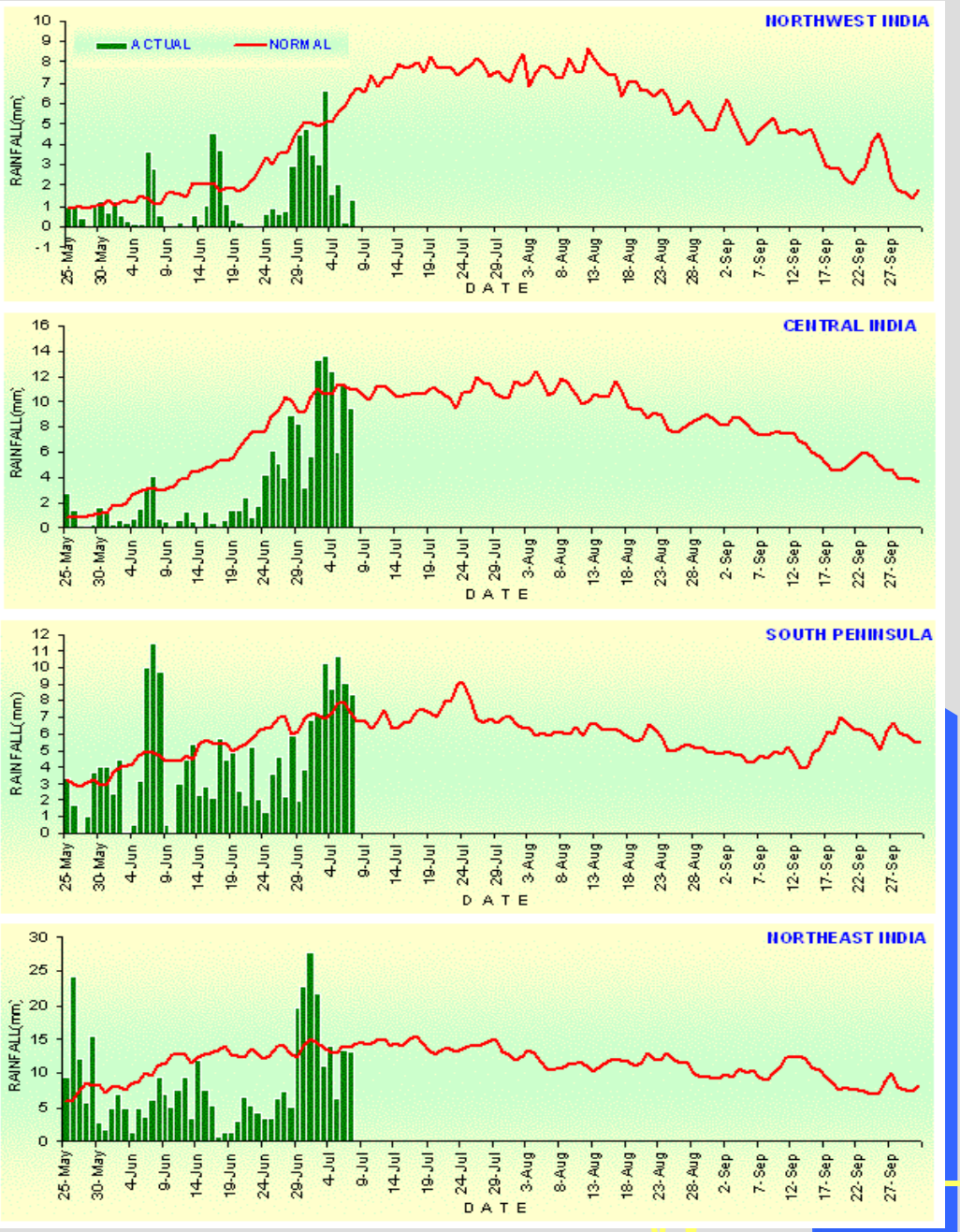


Vertical shear of zonal winds averaged over 50-100E, 5-15N

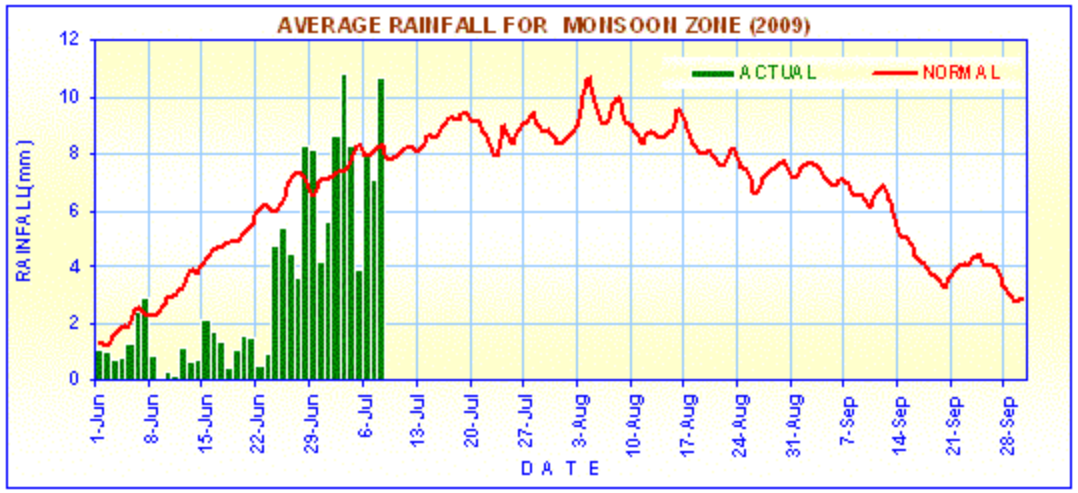
Monsoon of 2009

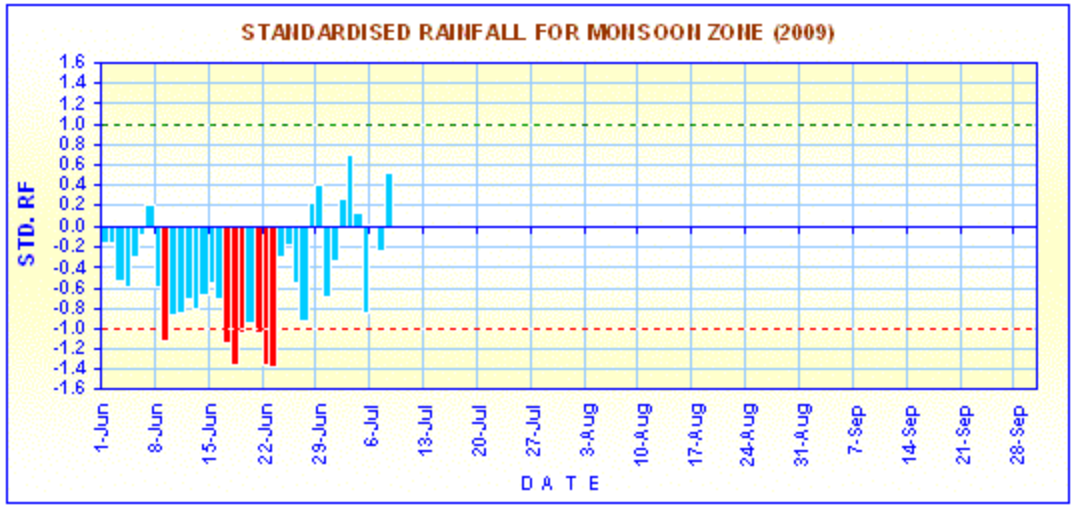


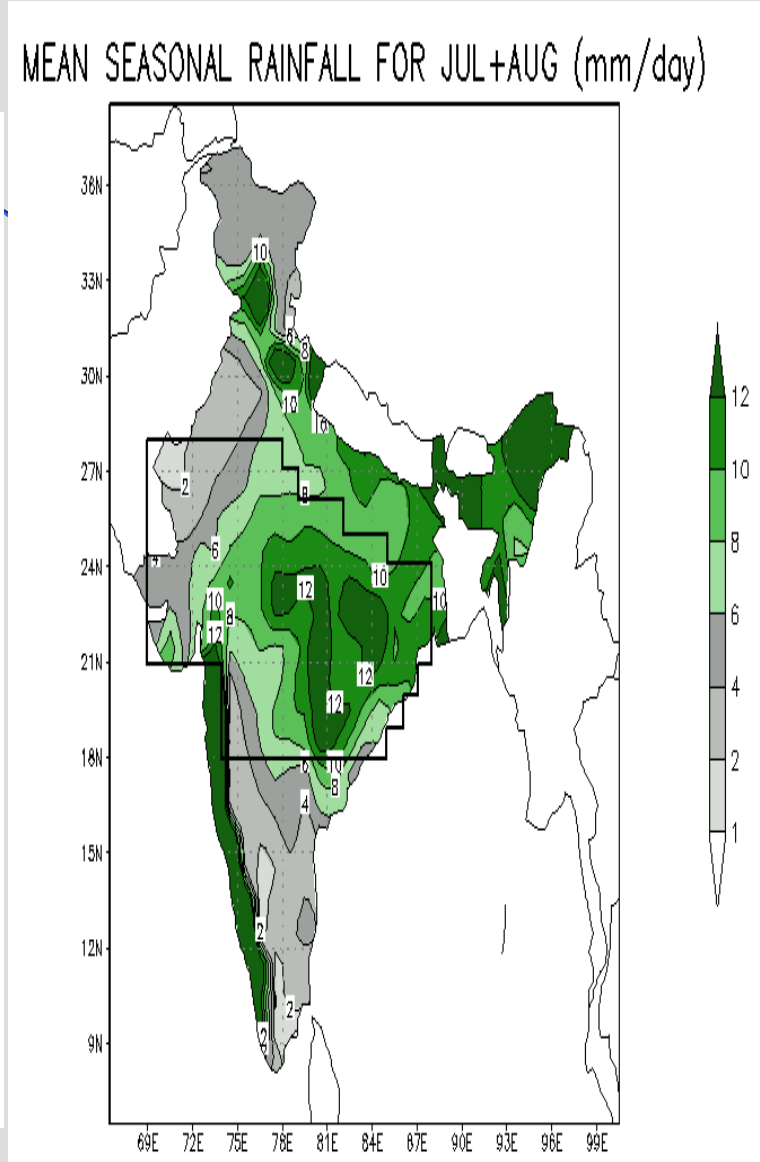

DAILY MEAN RAINFALL OVER THE COUNTRY AS A WHOLE (mm)
ACTUAL
NORMAL
RAINFALL(mm)
DATE


NORTHWEST INDIA
CENTRAL INDIA
SOUTH PENINSULA
NORTHEAST INDIA
ACTUAL
NORMAL
RAINFALL(mm)
DATE

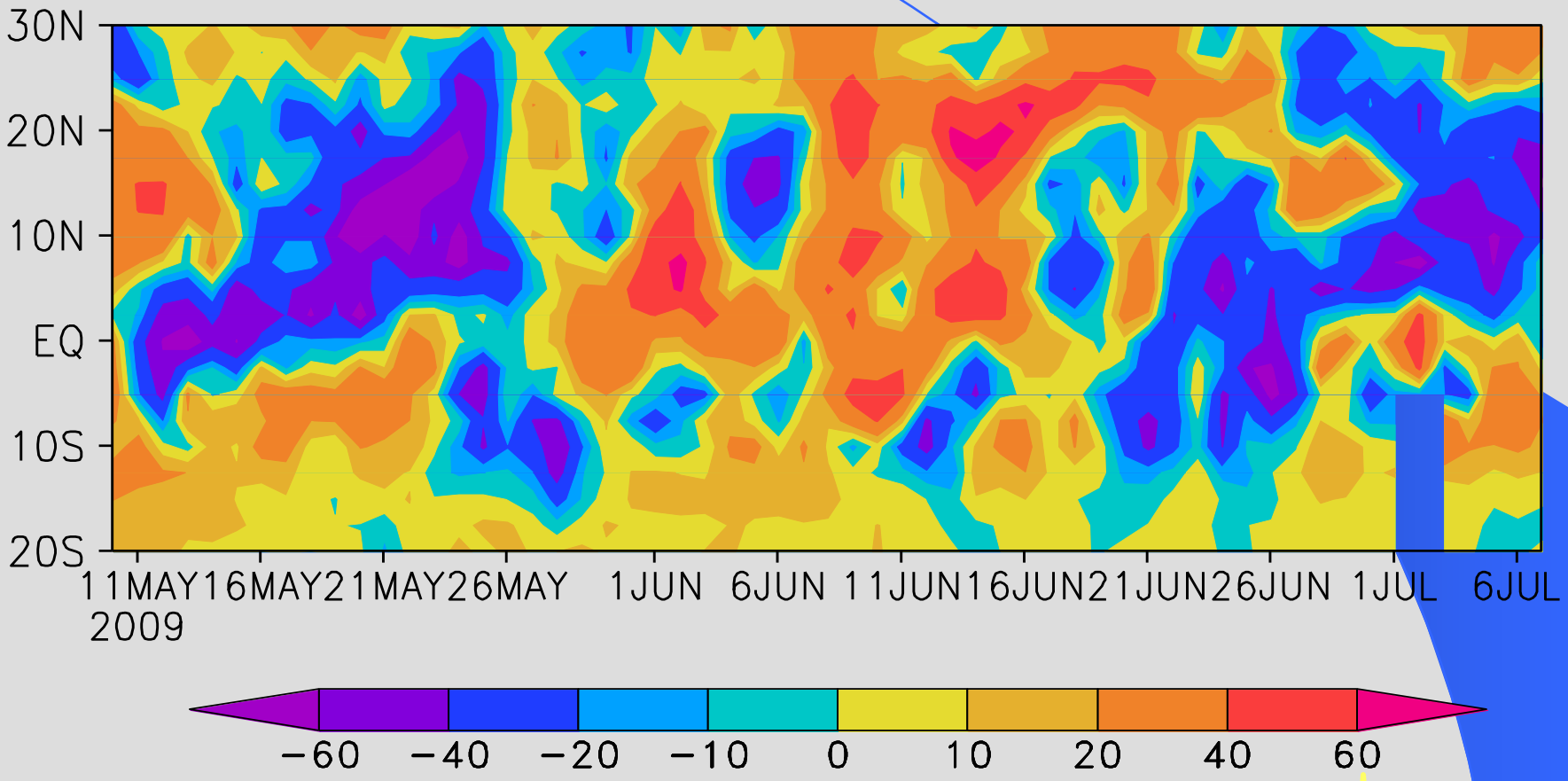
Active Break Time series over Central India

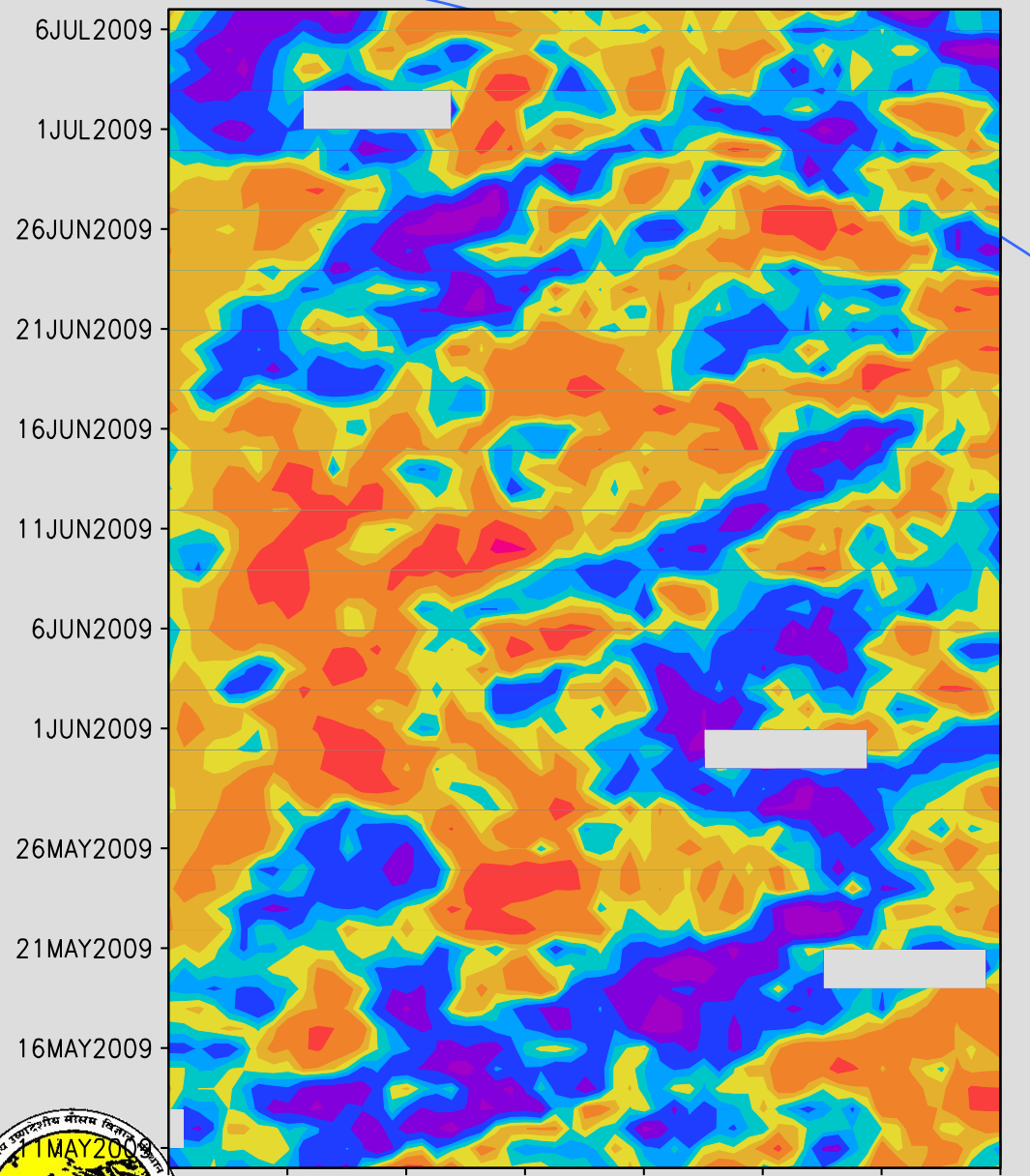




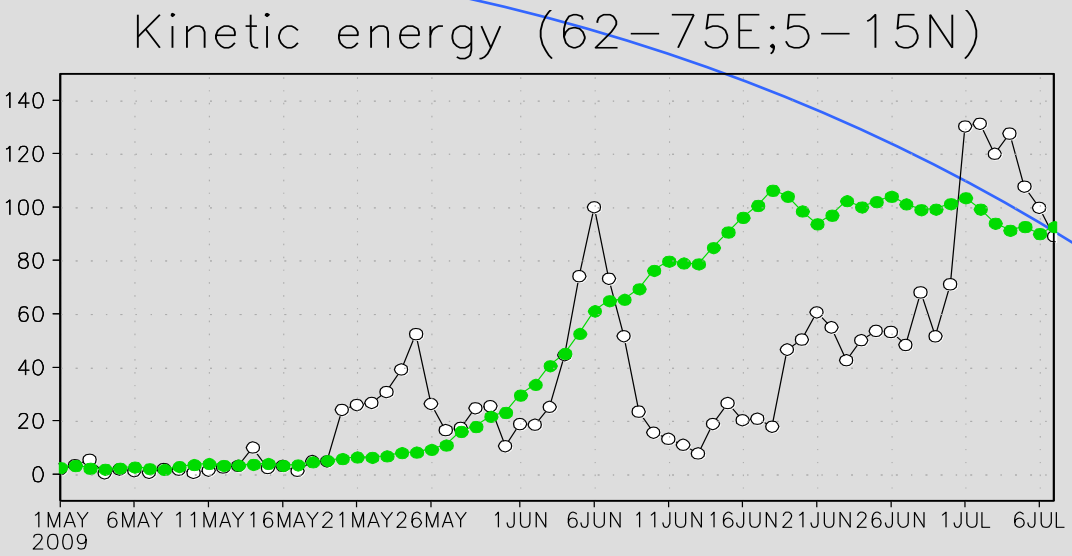


Northward propagation of OLR anomalies (70 – 90 E)



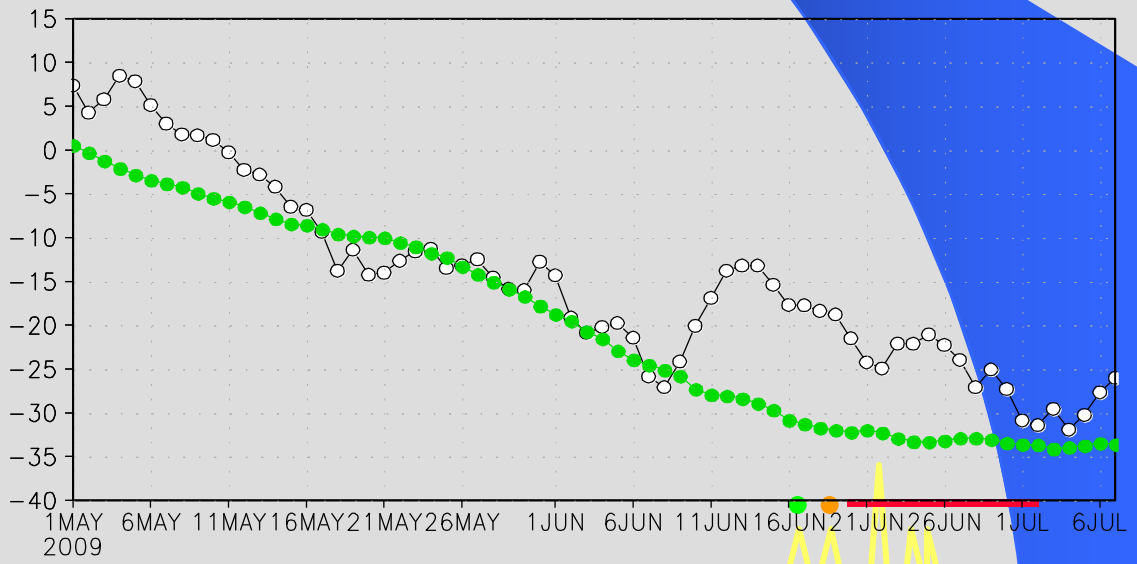


Eastward Propagation of OLR anomalies (5S – 5N)

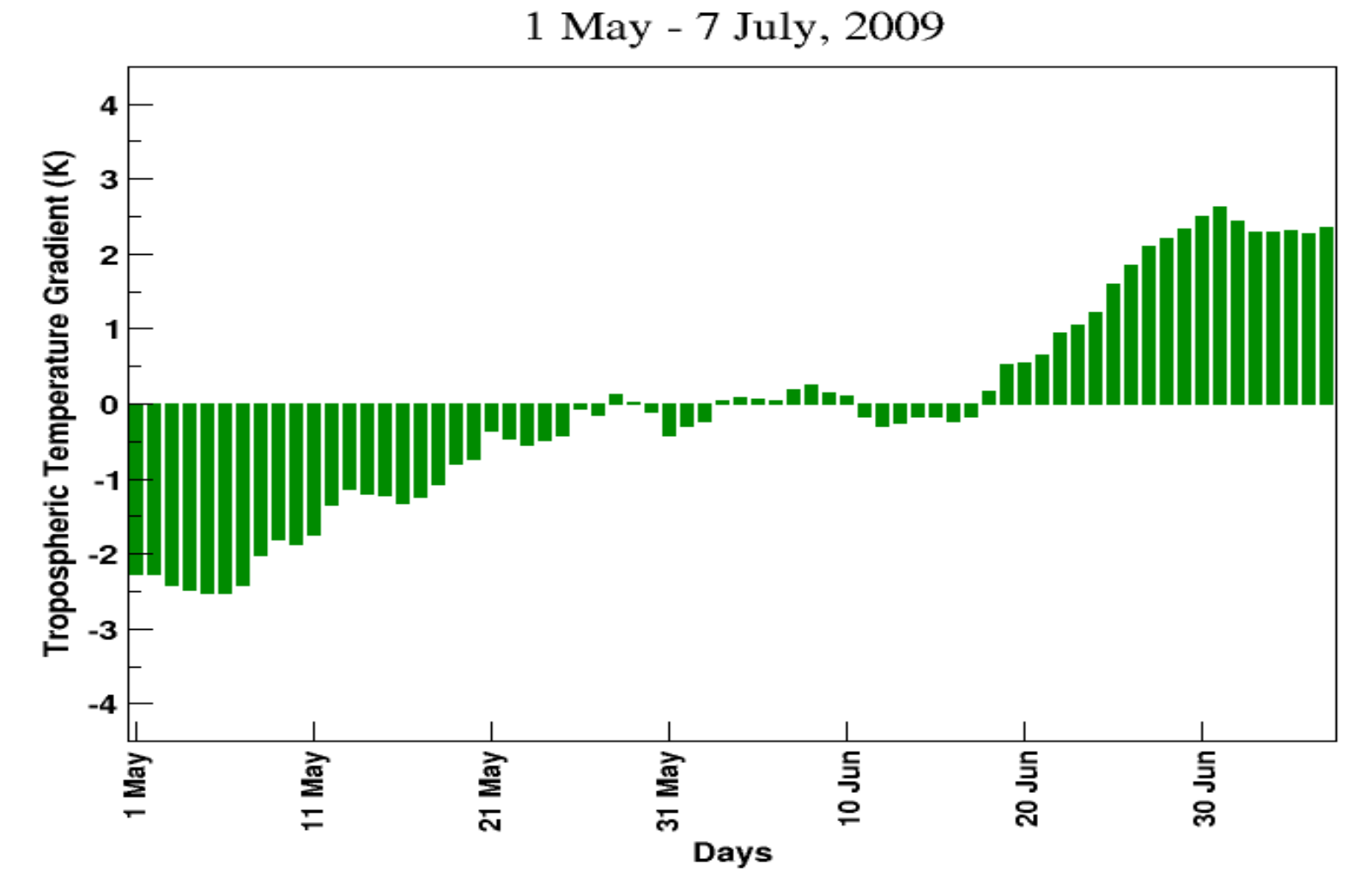


K.E of LLJ

Vertical Easterly Shear
50 – 100 E; 5 – 25 N

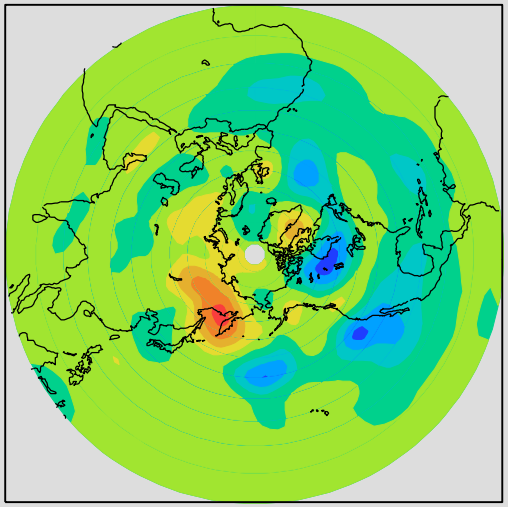


Tropospheric temperature averaged between 600mb and 200mb, is area averaged over two regions: 40 - 100 E; 5° - 35°N (TTN) & 40° - 100°E;15°S - 5°N (TTS). When the tropospheric temperature gradient, TTN-TTS changes sign from negative to positive, onset occurs within two days and when it becomes positive to negative, withdrawal takes place.

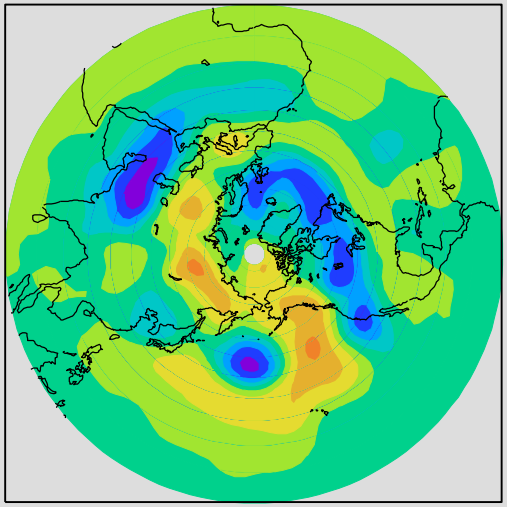


TT anomaly

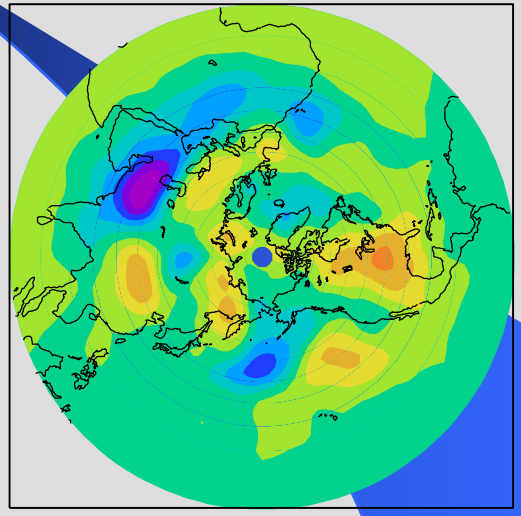
25 May – 5 June

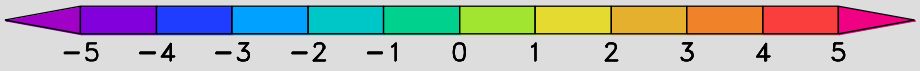


5 – 15 June

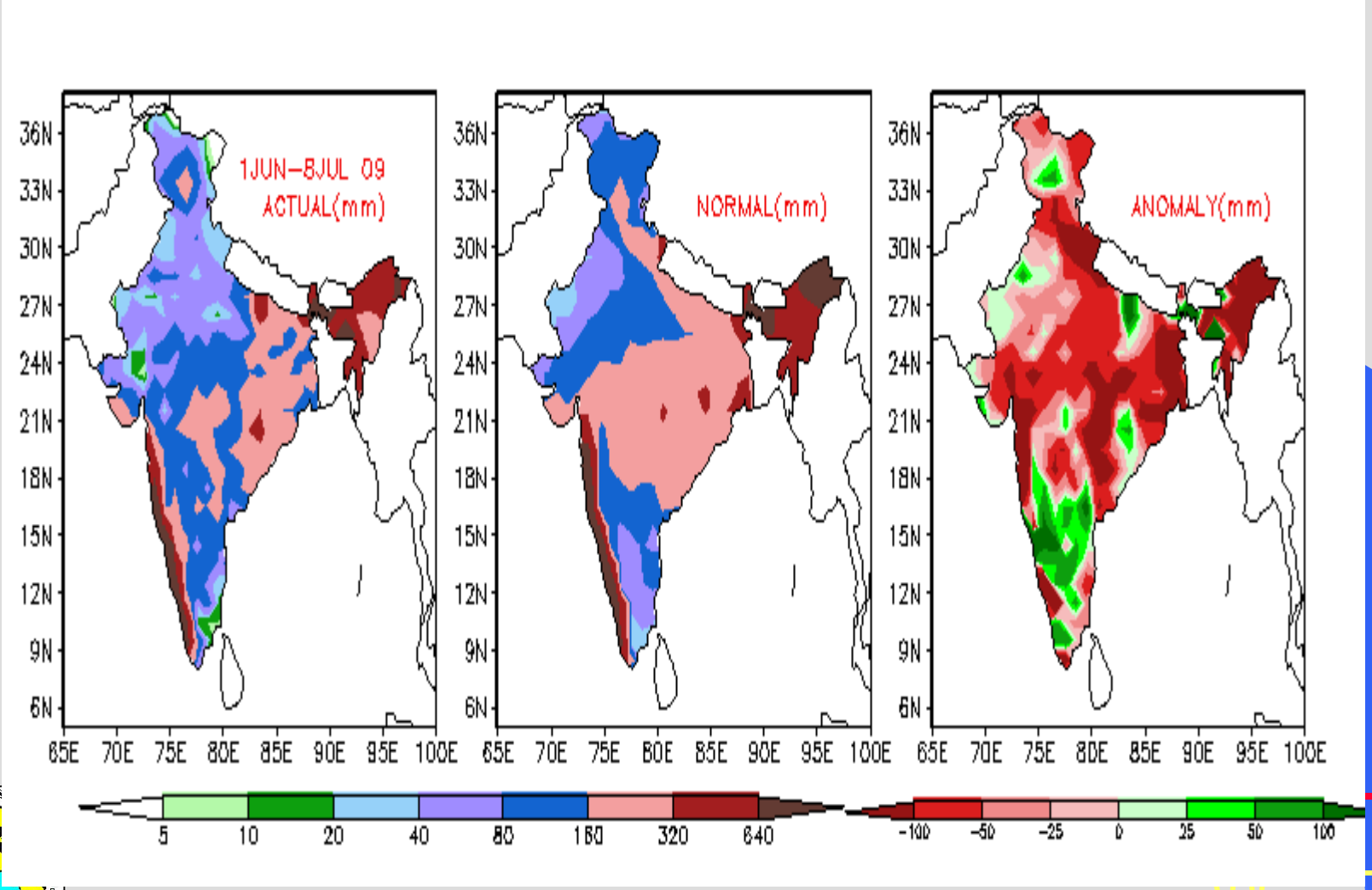


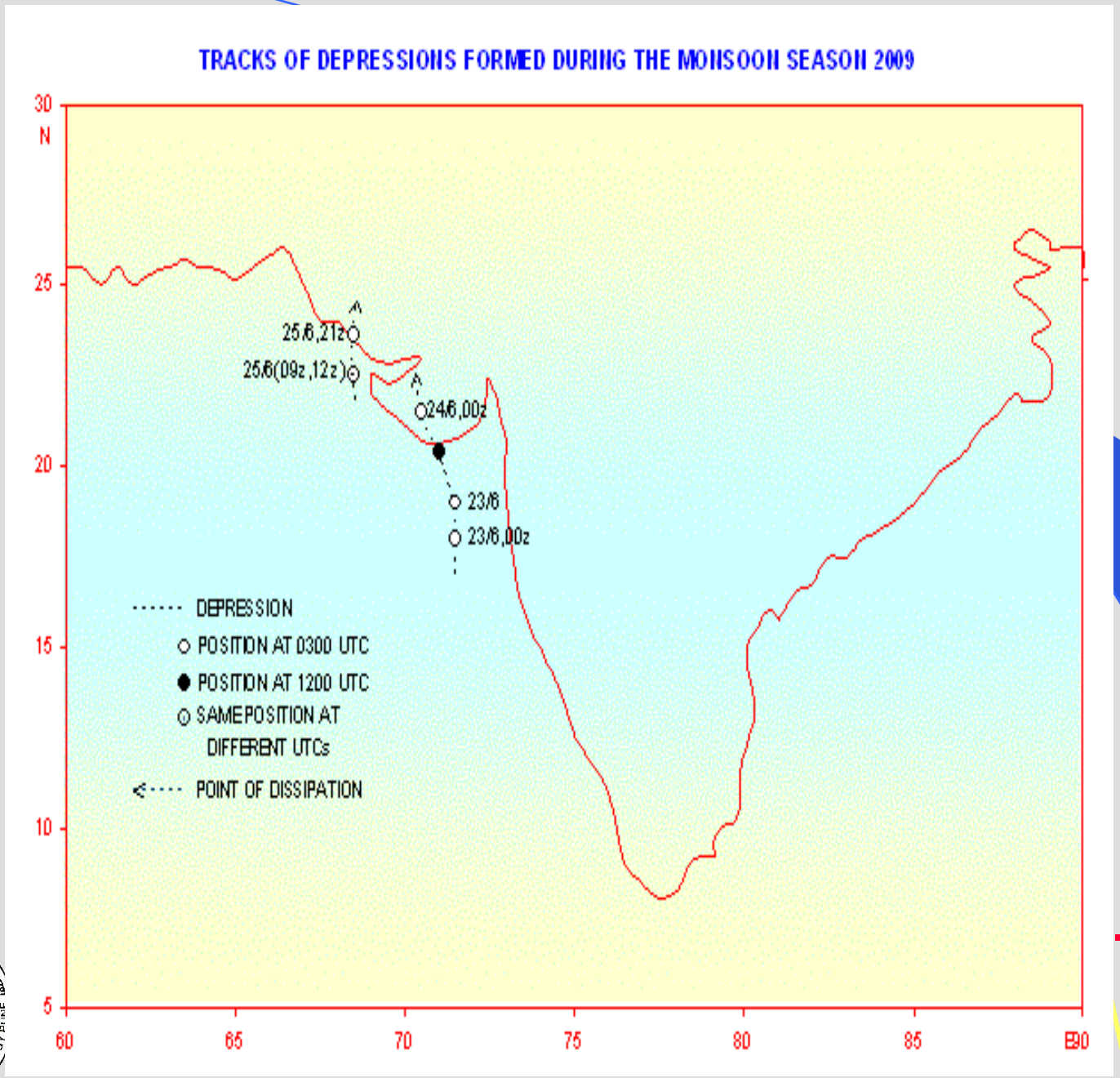
15 – 25 June





Spatial plot of Rainfall Anomaly

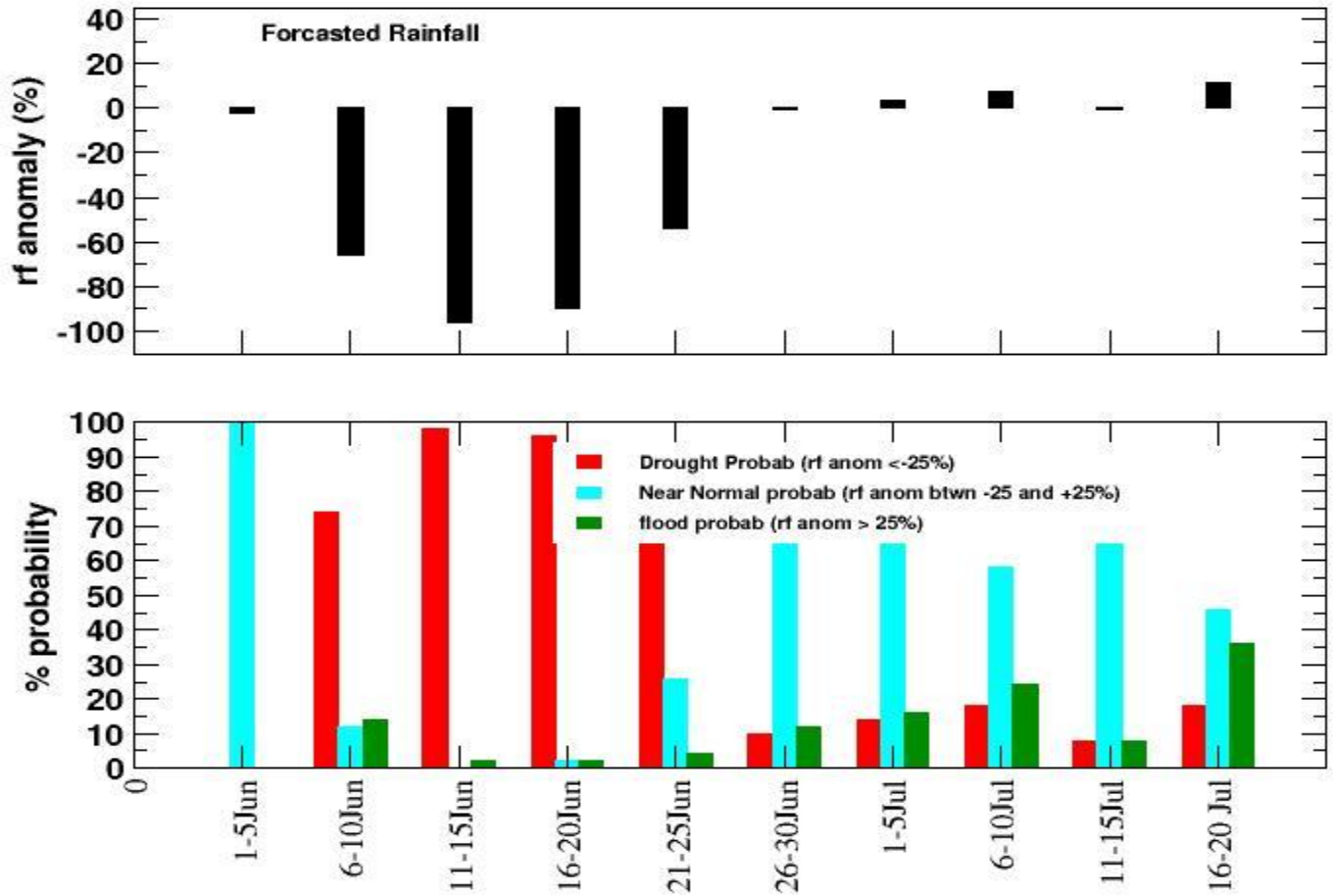



TRACKS OF DEPRESSIONS FORMED DURING THE MONSOON SEASON 2009
30
N
25
20
15
10
5
60
65
70
75
80
85
90
25/6,21z
25/6(09z,12z)
24/6,00z
23/6
23/6,00z
DEPRESSION
POSITION AT 0300 UTC
POSITION AT 1200 UTC
SAME POSITION AT DIFFERENT UTCs
POINT OF DISSIPATION

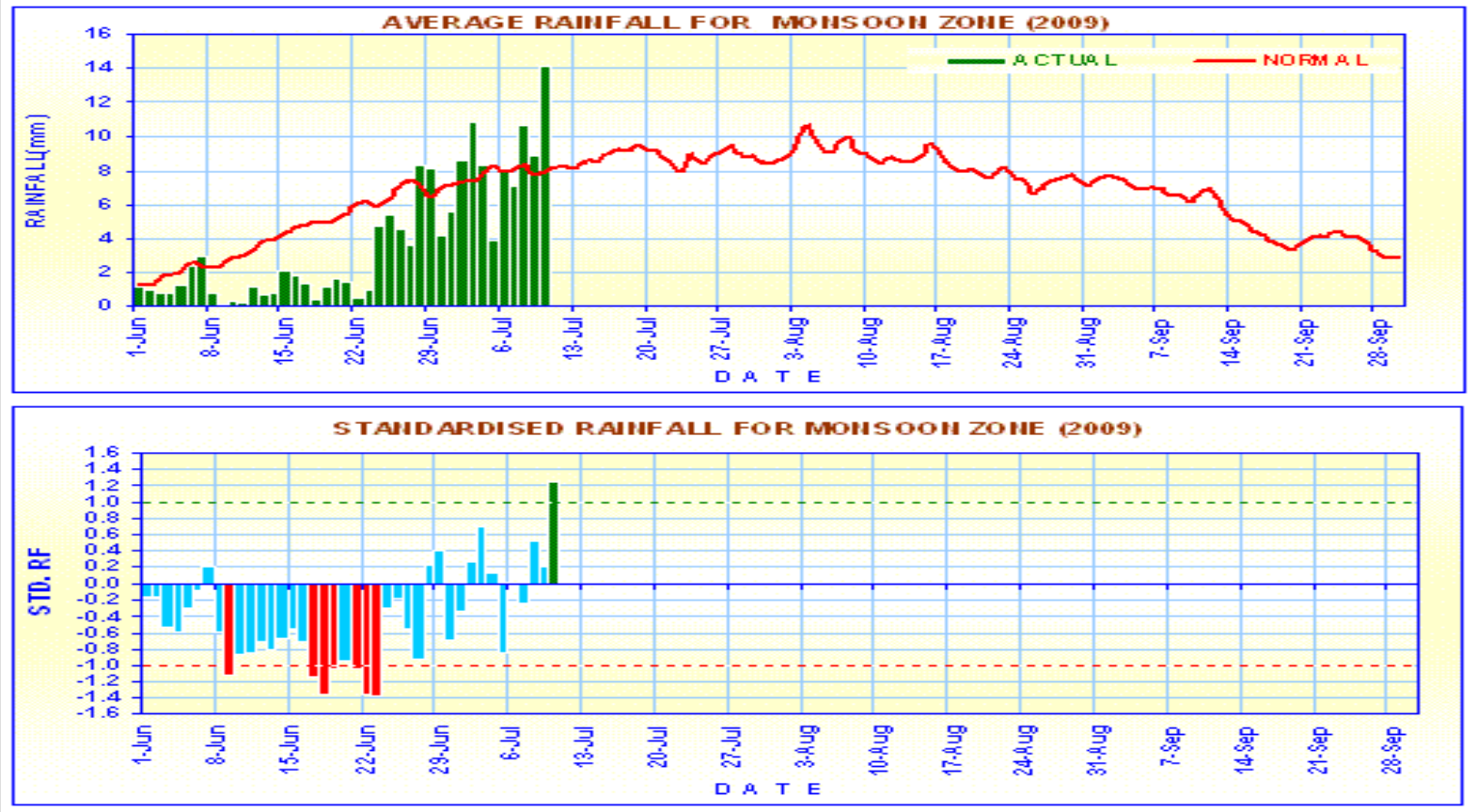
Probabilistic Prediction using SOM technique

- Here we used 13 parameter for SOM prediction.
- 20X20 SOM nodes
- Forecast based on past 9 days information
- Out of 5856 days (122 days X 48 years) 50 random ensemble are chosen to create the past analogs (ISO pattern) each having 2928 (5856/2) days of data.
- Ensemble mean forecast and the % of forecast in a particular category (drought, normal, flood) are shown here.

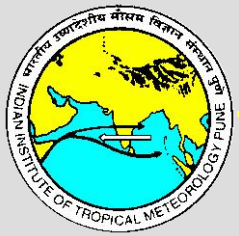
Fourth Pentad Rainfall Forecast



Actual Rainfall data from IMD



Thank You

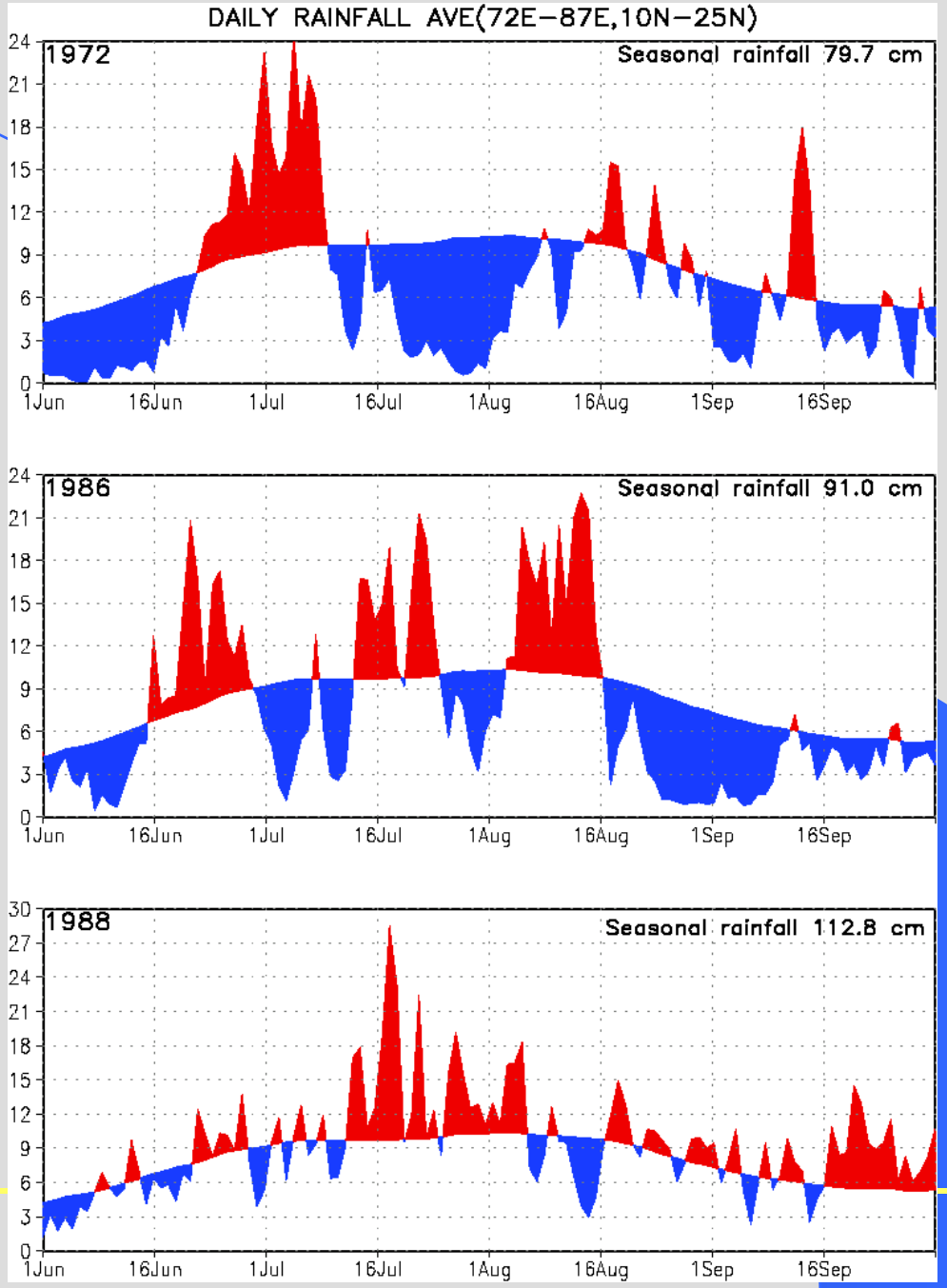


Active-break spells (cycles)

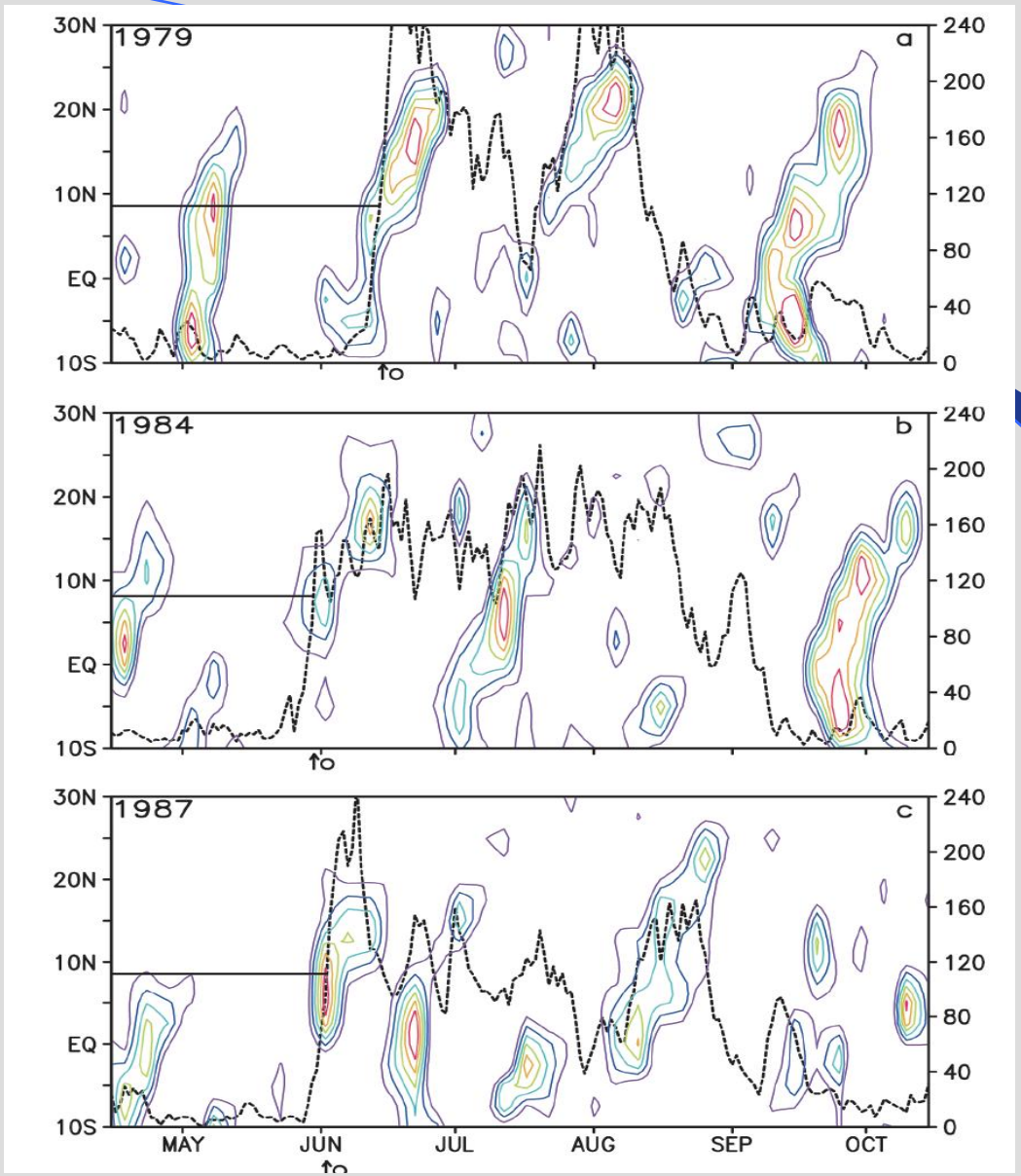
Daily rainfall (mm/day) over central India for three years, 1972, 1986 and 1988

The smooth curve shows long term mean.

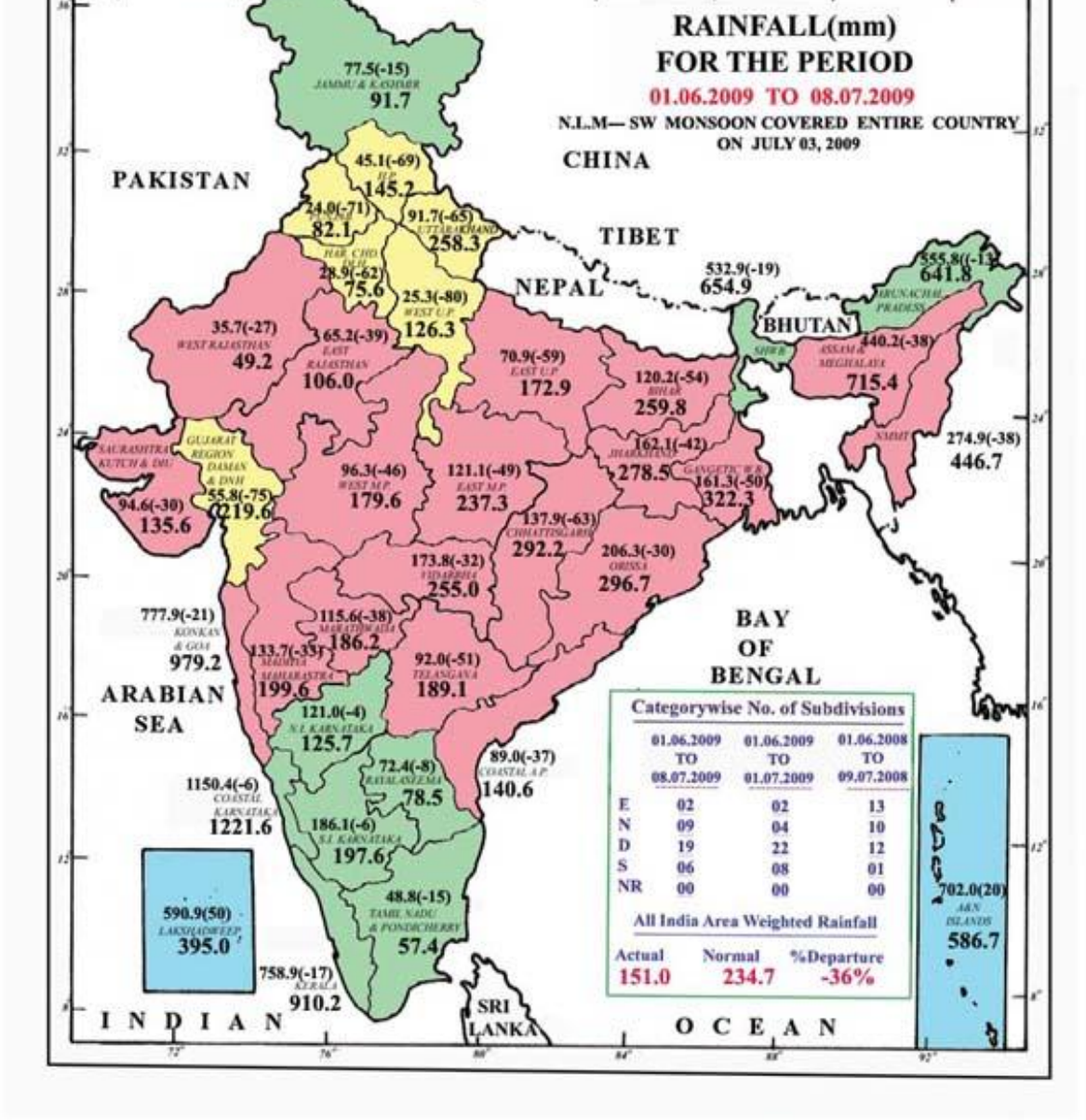
Red shows above normal or wet spells while blue shows below normal or dry spells



Relationship between Monsoon ISOs and monsoon onset



Onset



LEGEND : EXCESS (E) + 20% OR MORE; NORMAL (N) +19% TO -19%; DEFICIENT (D) -20% TO -59%; SCANTY (S) -60% TO -99%; NO RAIN (NR) -100%; NO DATA

NOTES:

(a) Rainfall figures are based on operational data.

(b) Small figures indicate actual rainfall (mm), while bold figures indicate normal rainfall (mm). Percentage departures of rainfall are shown in brackets.