TROPICAL DISTURBANCES AND TROPICAL CYCLONES DURING POST MONSOON SEASON – AN OVERVIEW

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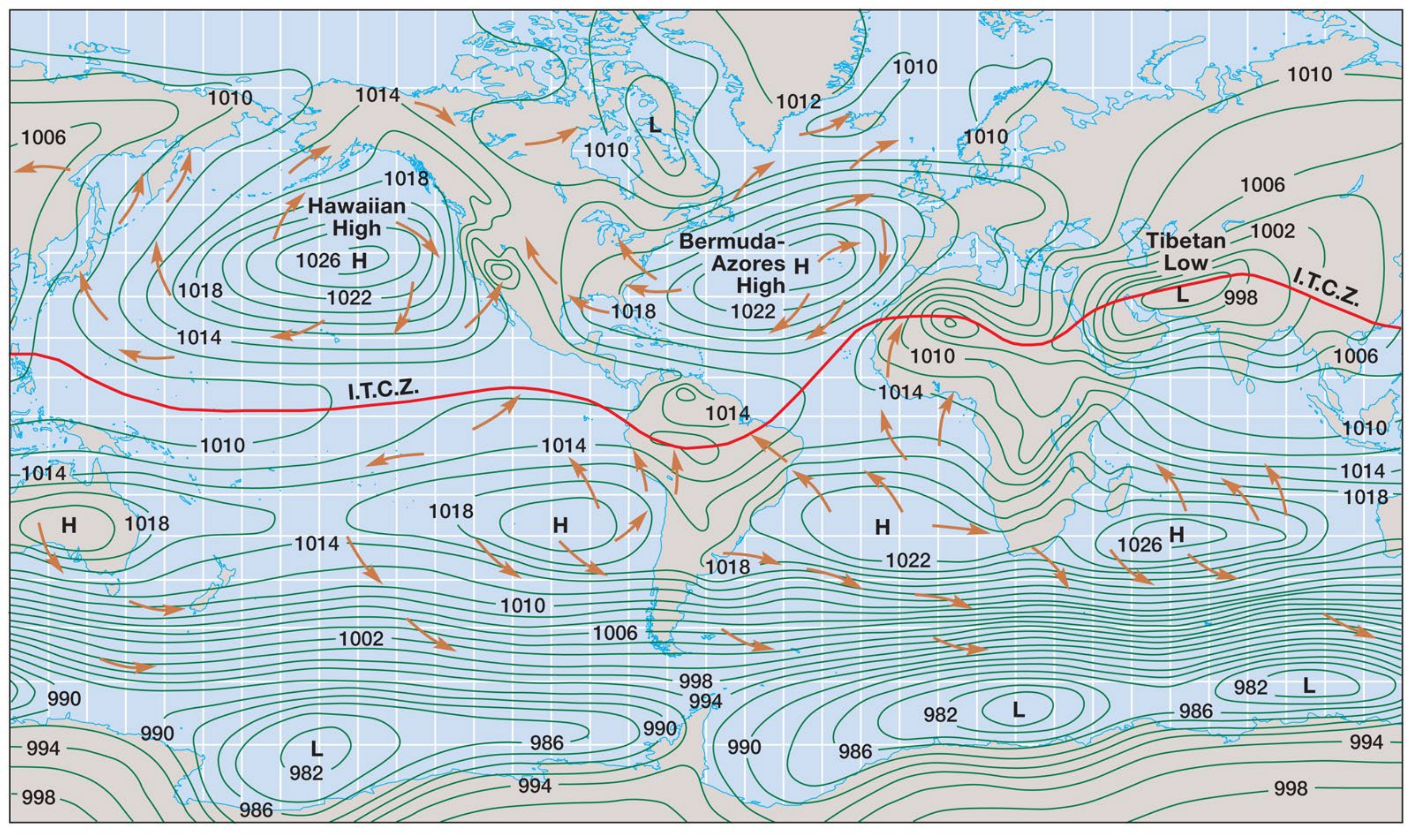
भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

MONSOON MISSION - 2019
PUNE.

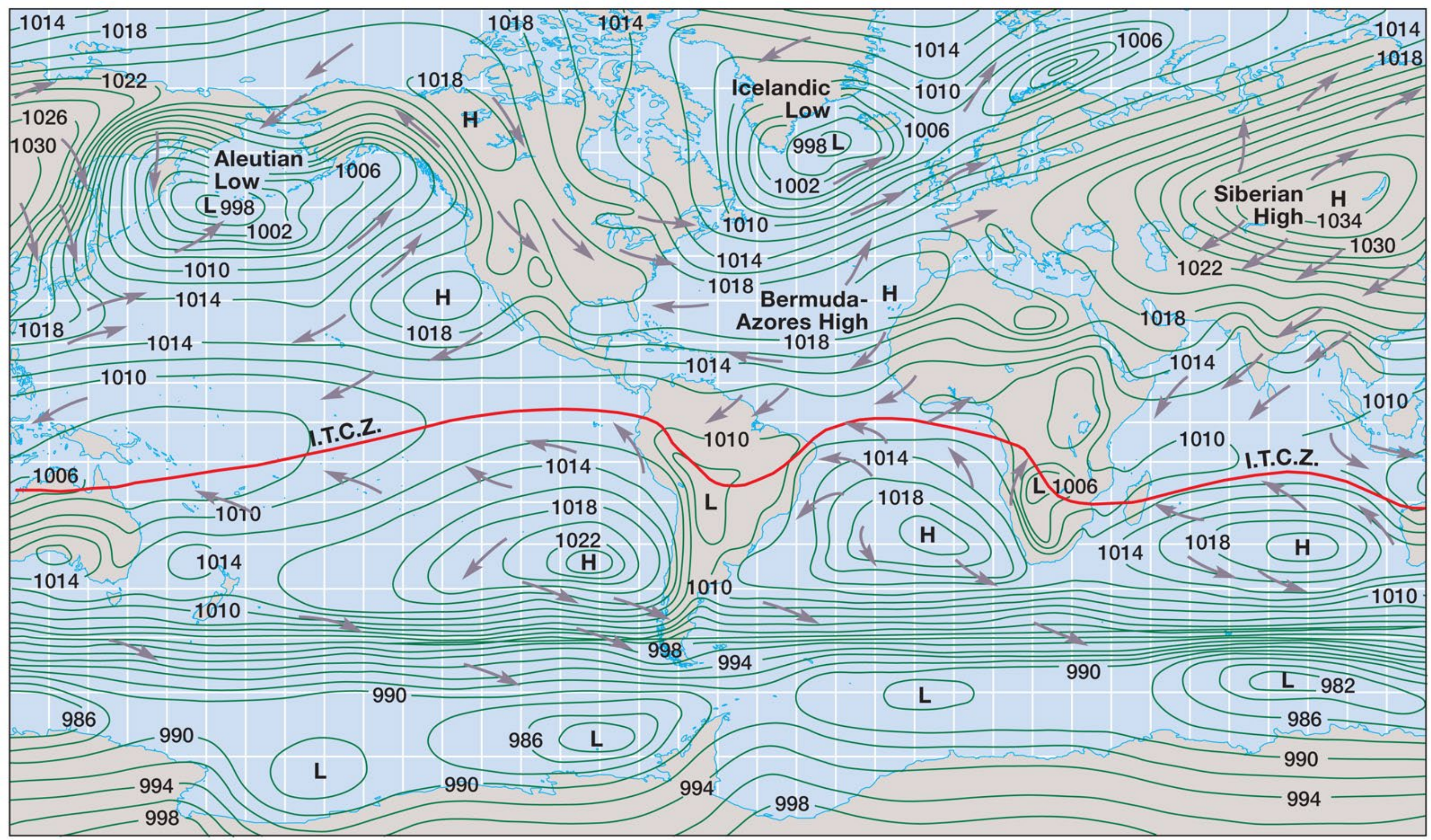
Semipermanent Pressure Cells and the ITCZ

July



Semipermanent Pressure Cells and the ITCZ

January



MONSOONS

JJAS→SW Monsoon **OND→ Post-Monsoon (NE Monsoon)**

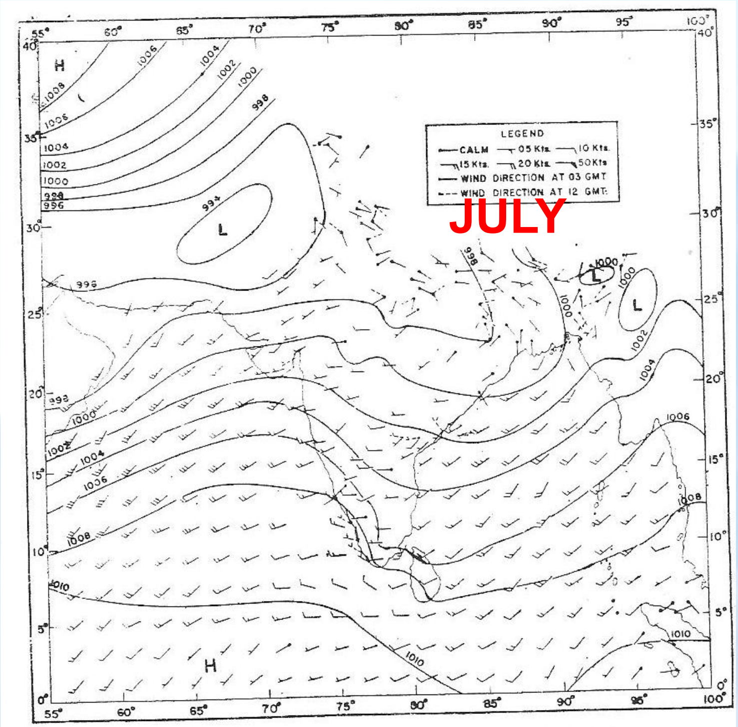


Figure 2.3 Mean pressure (mb) and surface winds July.

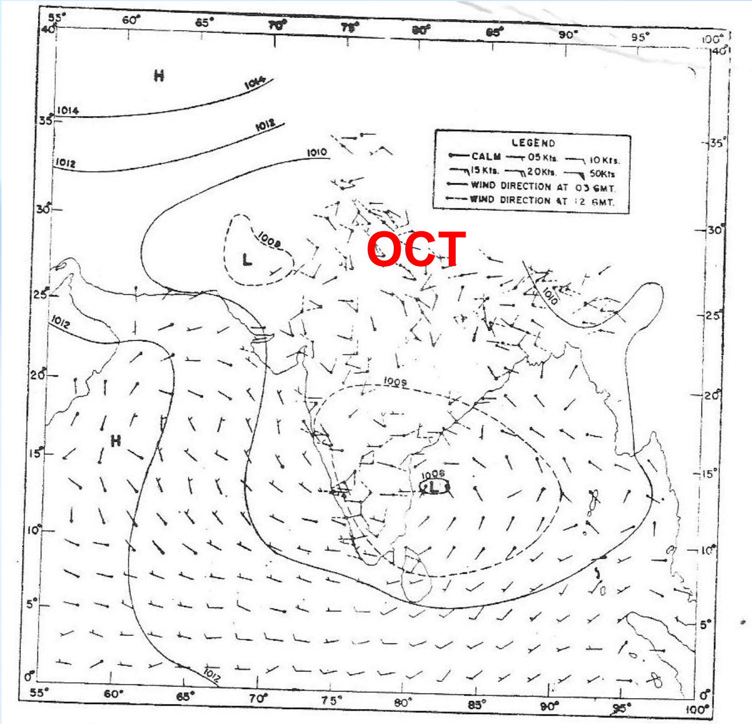
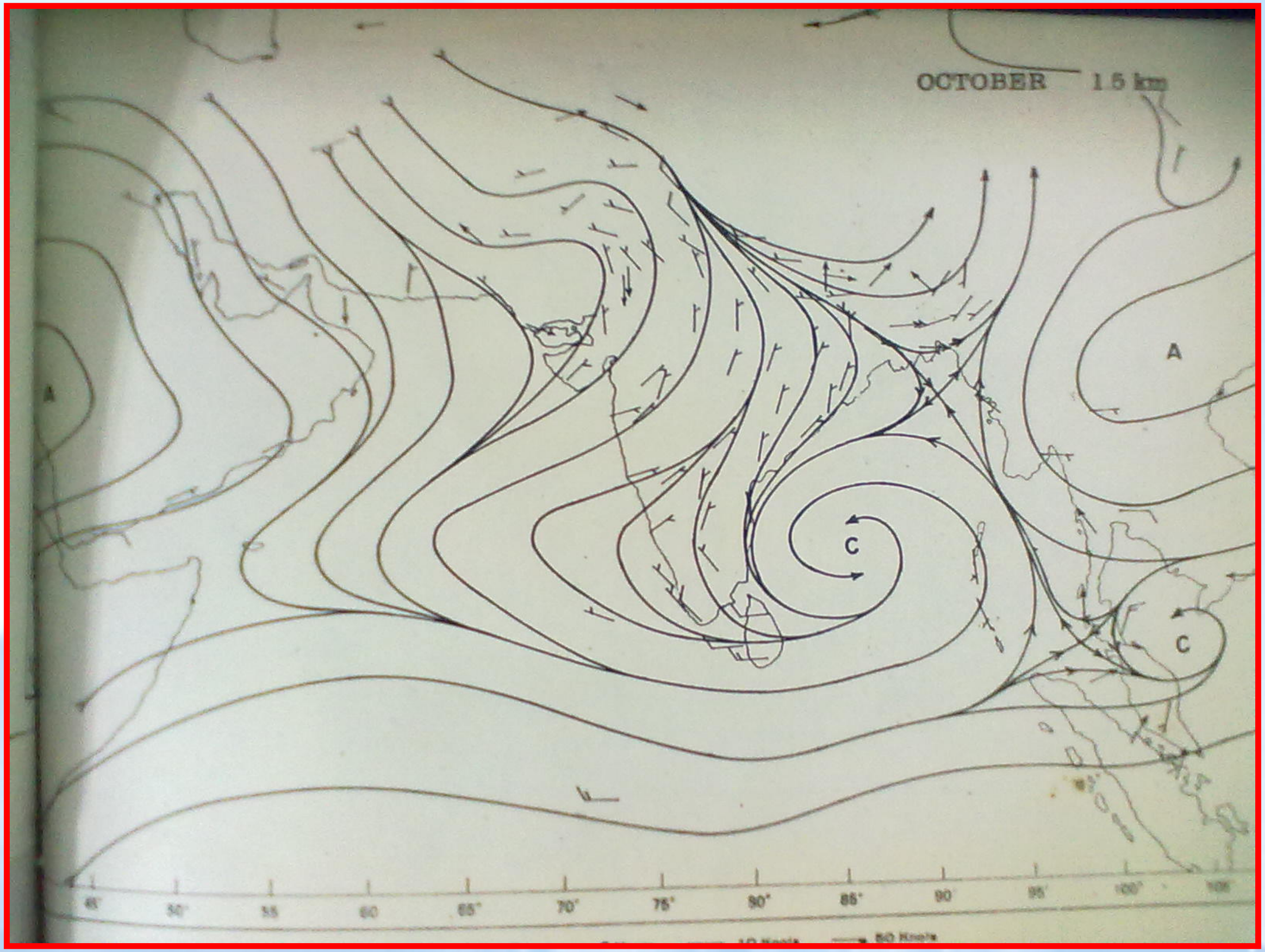
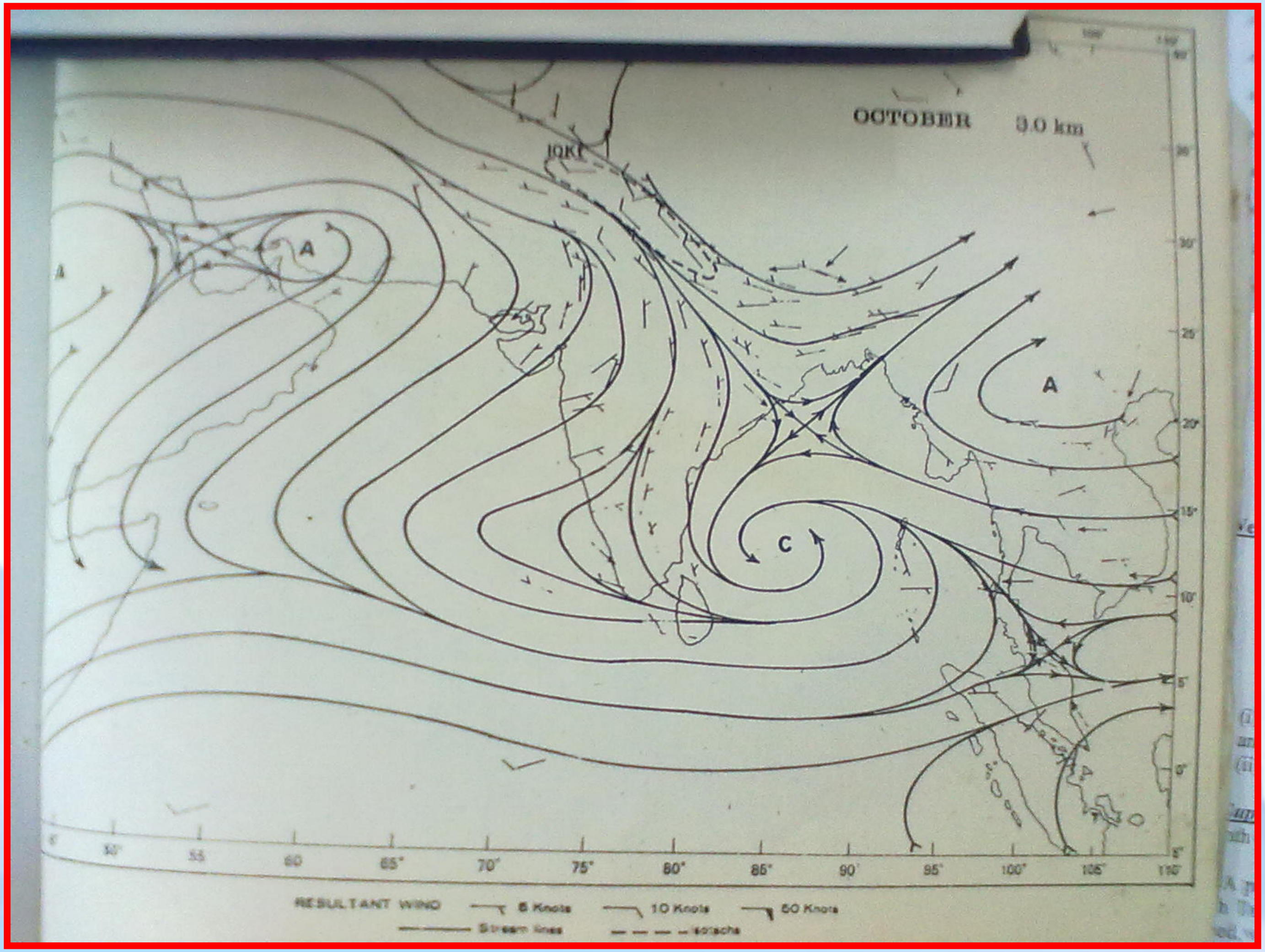


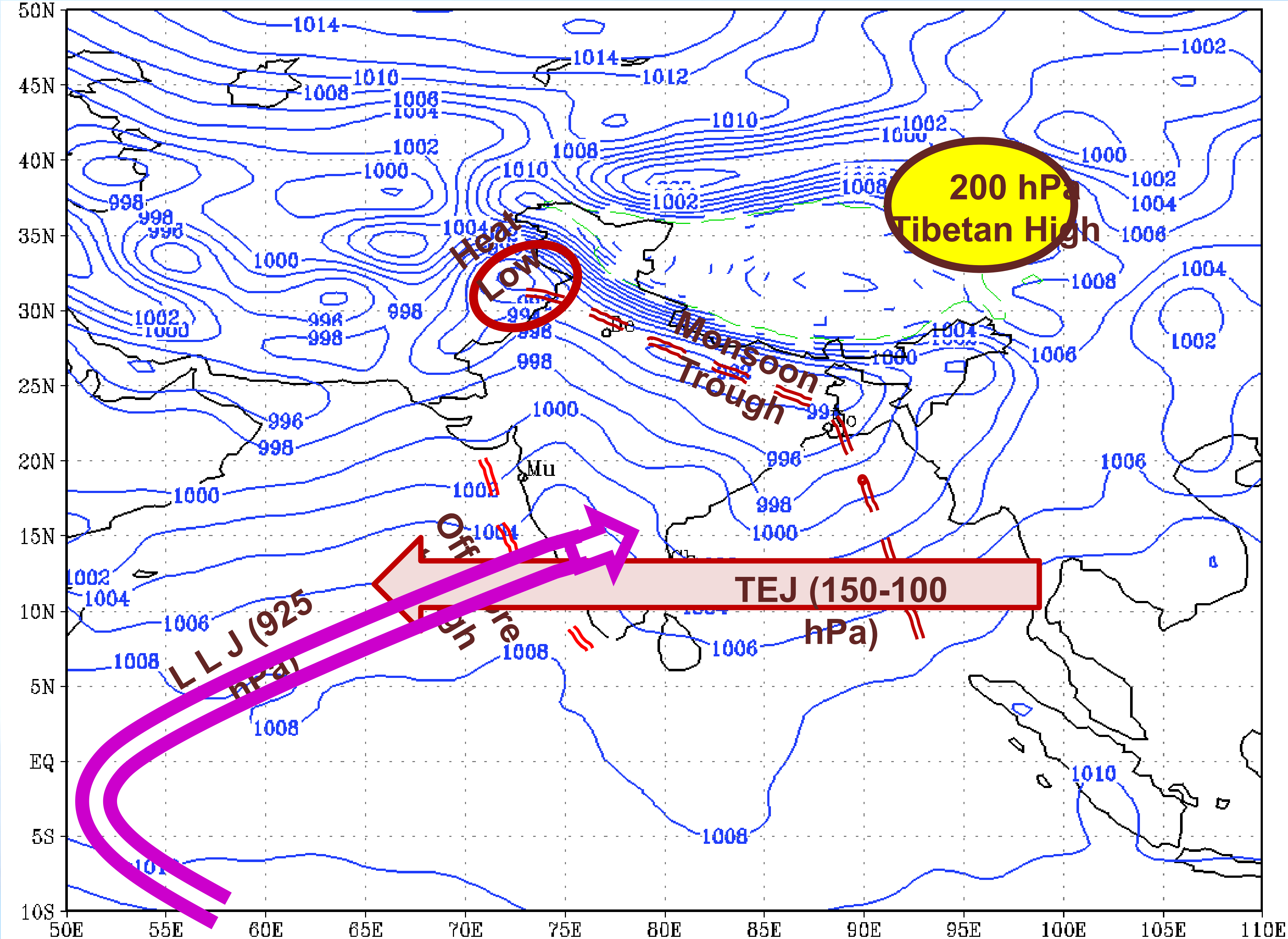
Figure 2.4 Mean pressure (mb) and surface winds October.



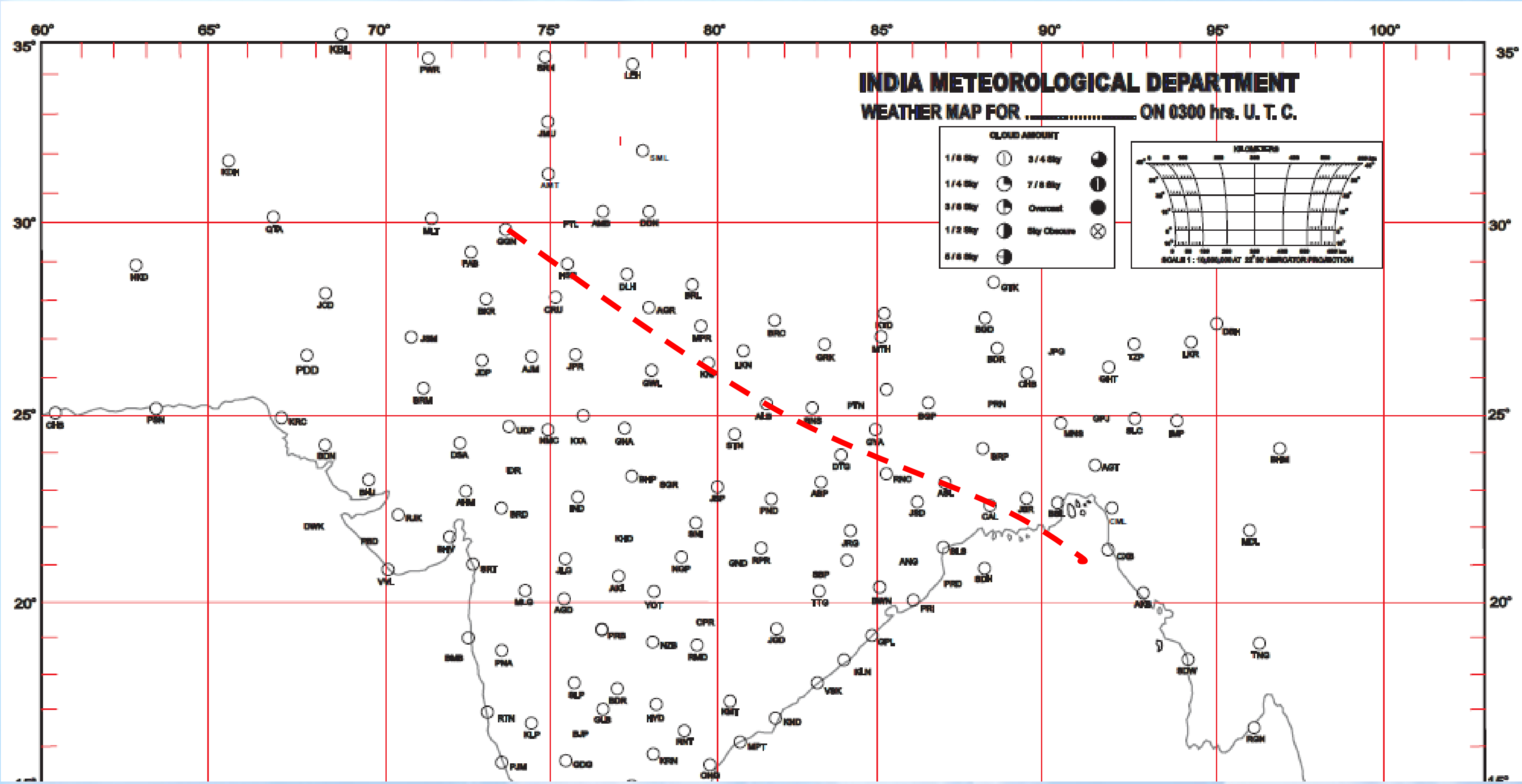
850hPa

700hPa

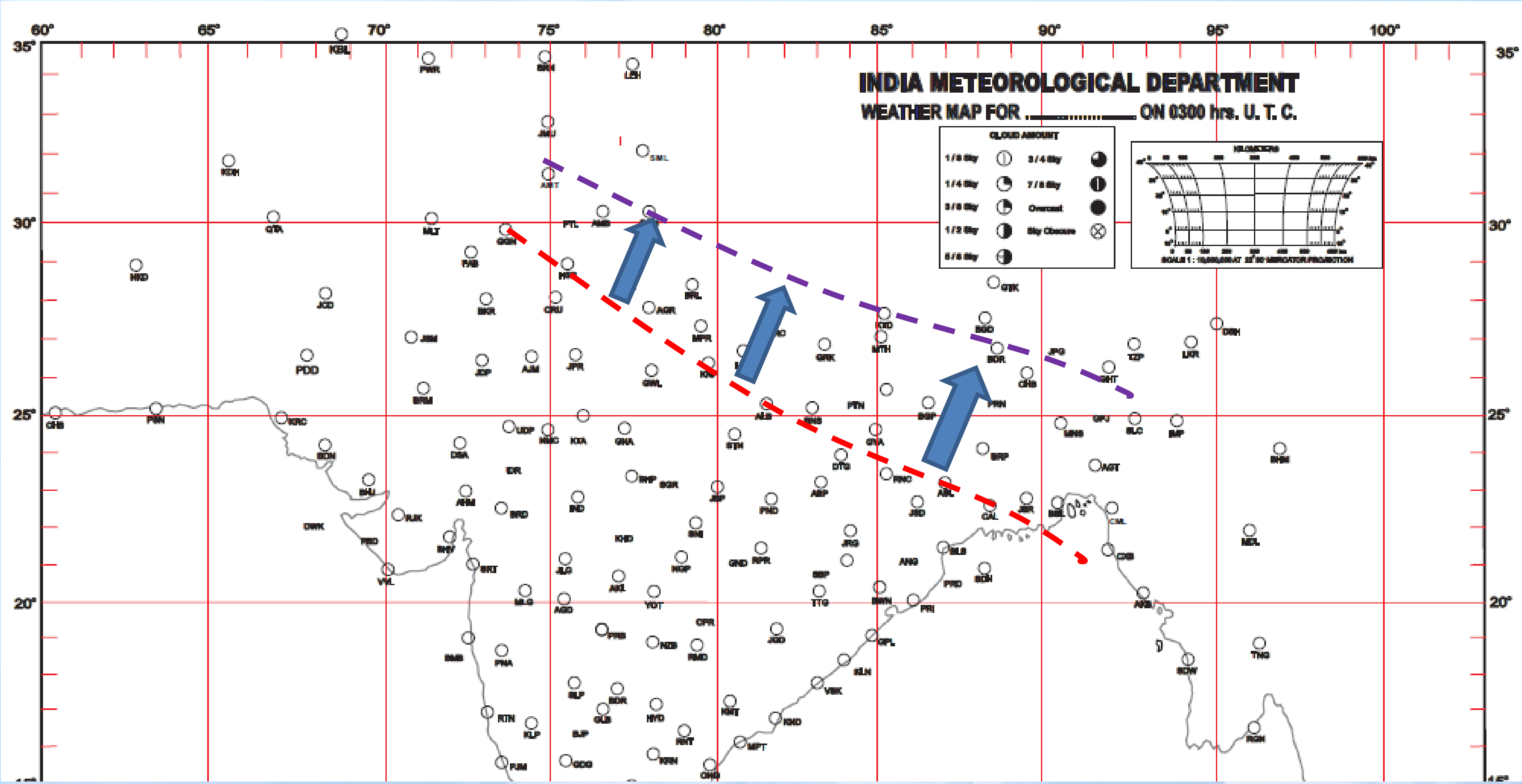

OCTOBER 3.0 km
A
A
C
RESULTANT WIND 5 Knots 10 Knots 50 Knots
Stream lines isotachs

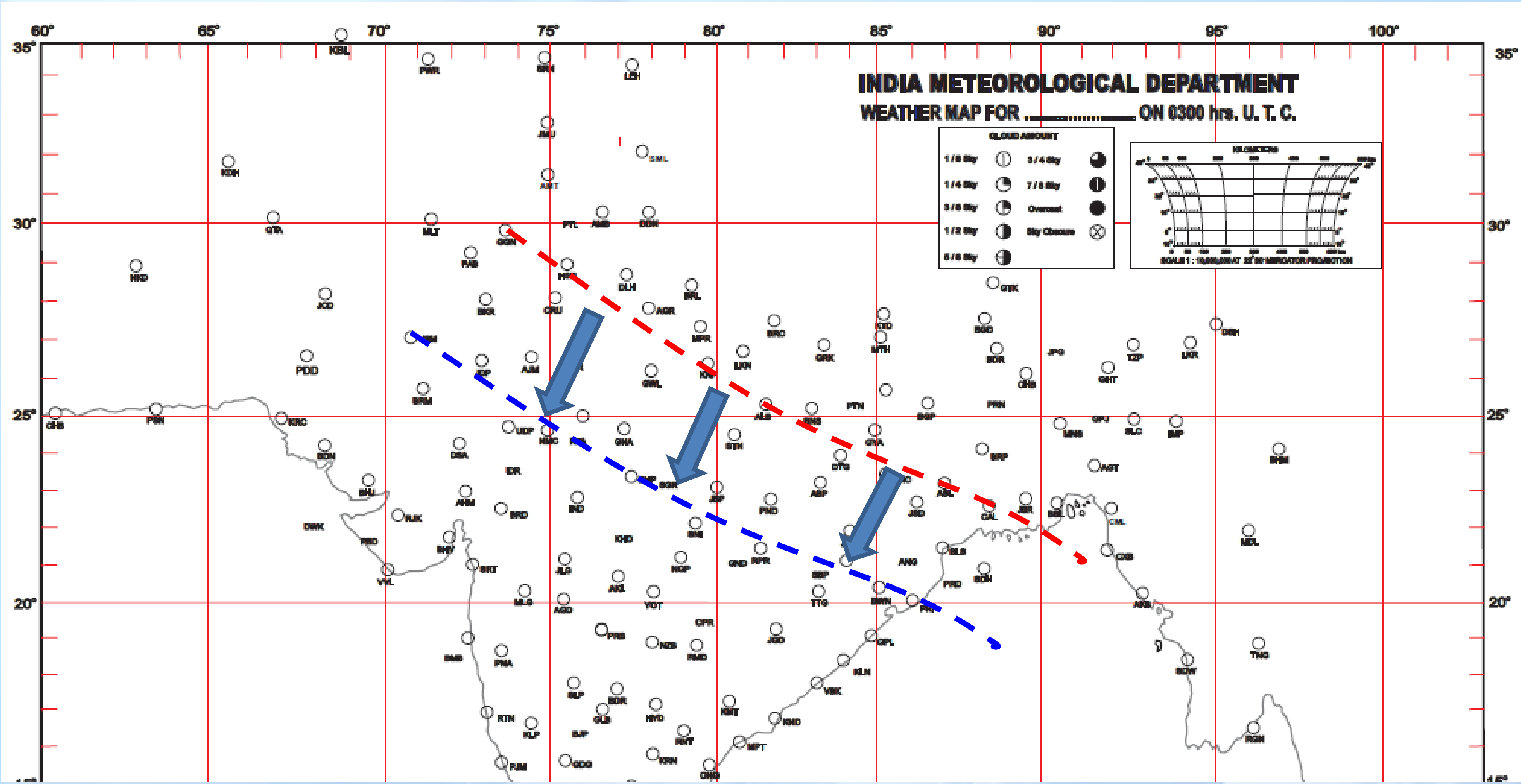


भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

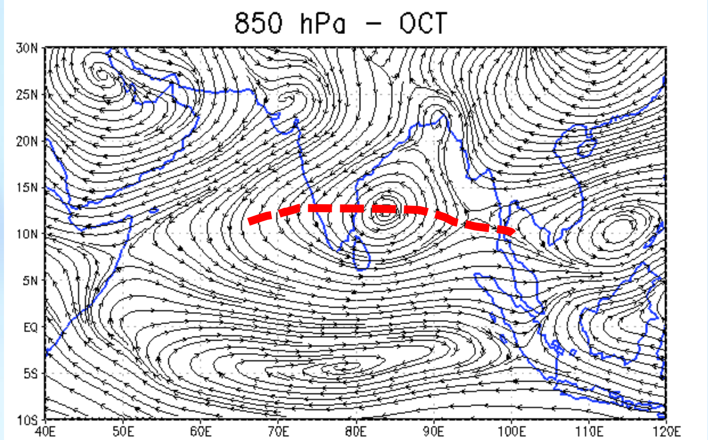


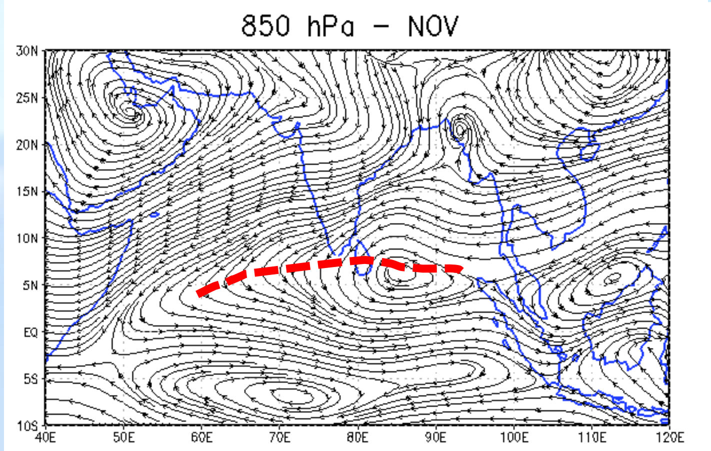
INDIA METEOROLOGICAL DEPARTMENT
WEATHER MAP FOR .... ON 0300 hrs. U. T. C.
60°
65°
70°
75°
80°
85°
90°
95°
100°
35°
30°
25°
20°

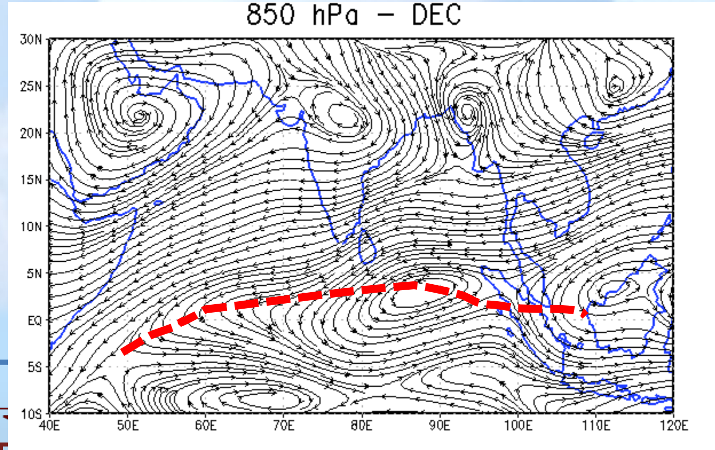

INDIA METEOROLOGICAL DEPARTMENT
WEATHER MAP FOR .... ON 0300 hrs. U. T. C.
CLOUD AMOUNT
60°
65°
70°
75°
80°
85°
90°
95°
100°
35°
30°
25°
20°


INDIA METEOROLOGICAL DEPARTMENT
WEATHER MAP FOR .... ON 0300 hrs. U. T. C.
60°
65°
70°
75°
80°
85°
90°
95°
100°
35°
30°
25°
20°

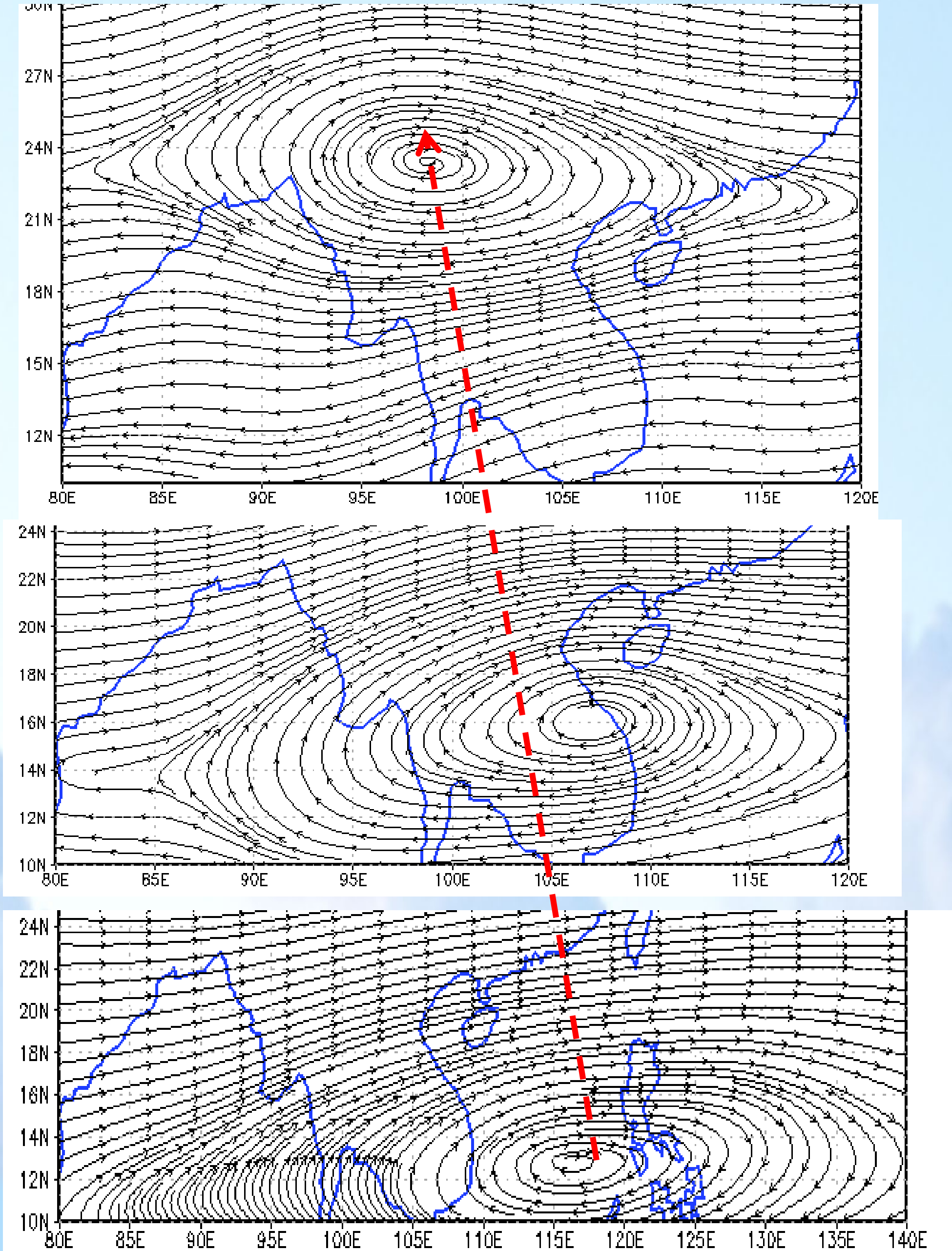
Transient equatorial trough – LTM (1981-2010)







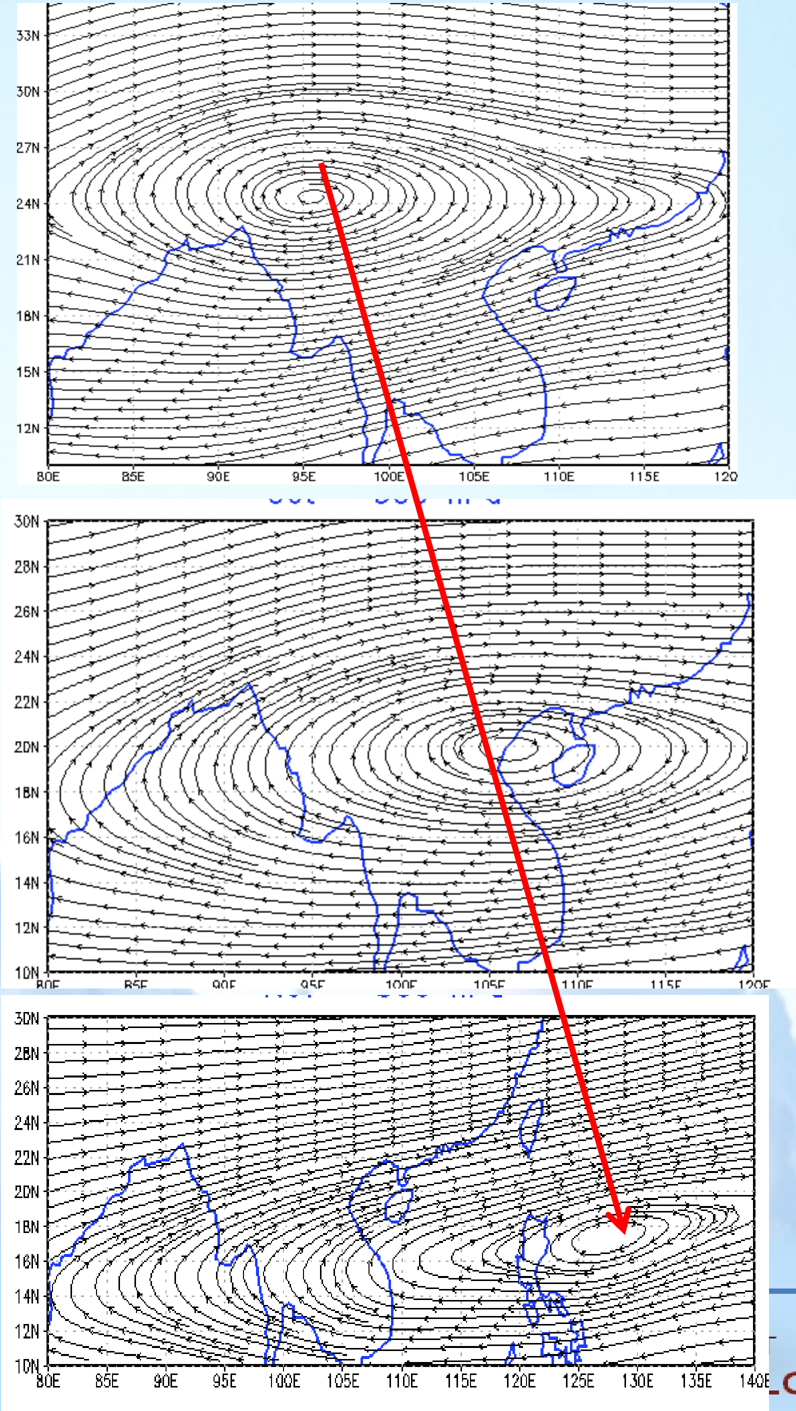
TIBETAN HIGH (300hPa)



JUNE

MAY

APR


33N 30N 27N 24N 21N 18N 15N 12N
80E 85E 90E 95E 100E 105E 110E 115E 120
30N 28N 26N 24N 22N 20N 18N 16N 14N 12N 10N
80E 85E 90E 95E 100E 105E 110E 115E 120E
30N 28N 26N 24N 22N 20N 18N 16N 14N 12N 10N
80E 85E 90E 95E 100E 105E 110E 115E 120E 125E 130E 135E 140E

Sep.

Oct.

Dec.

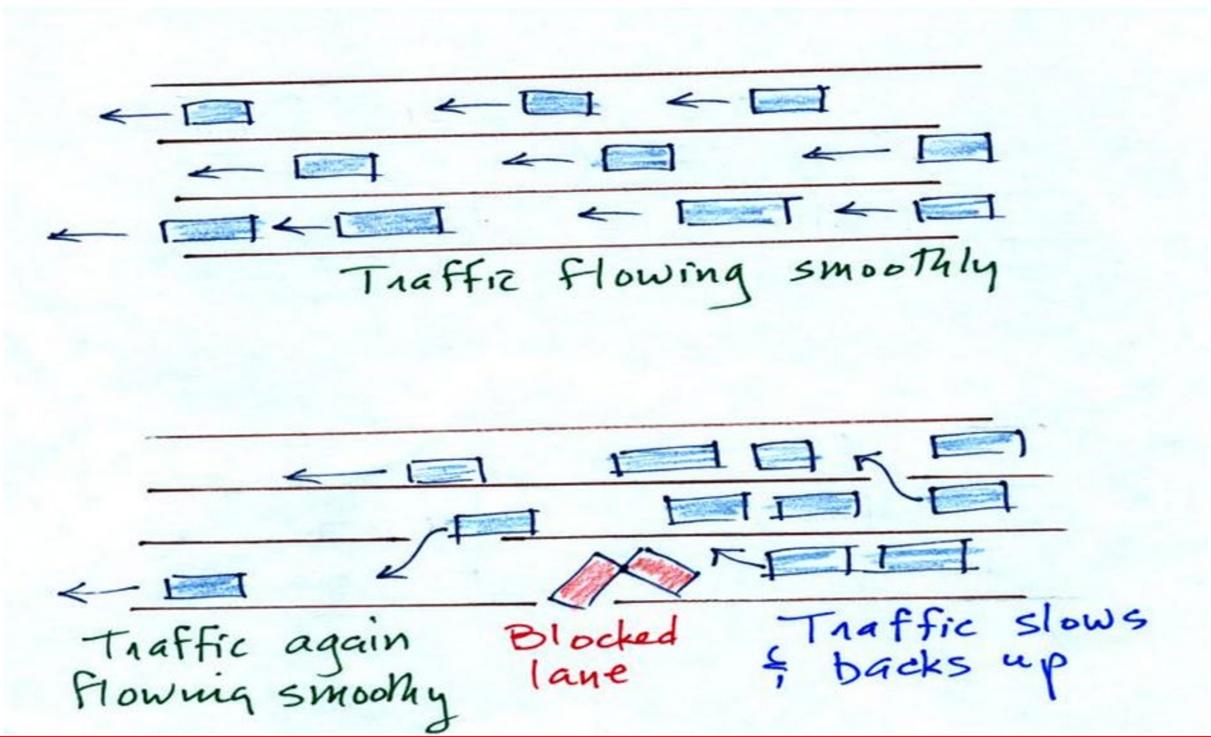
SYNOPTIC SYSTEMS

SYNOPTIC FEATURES

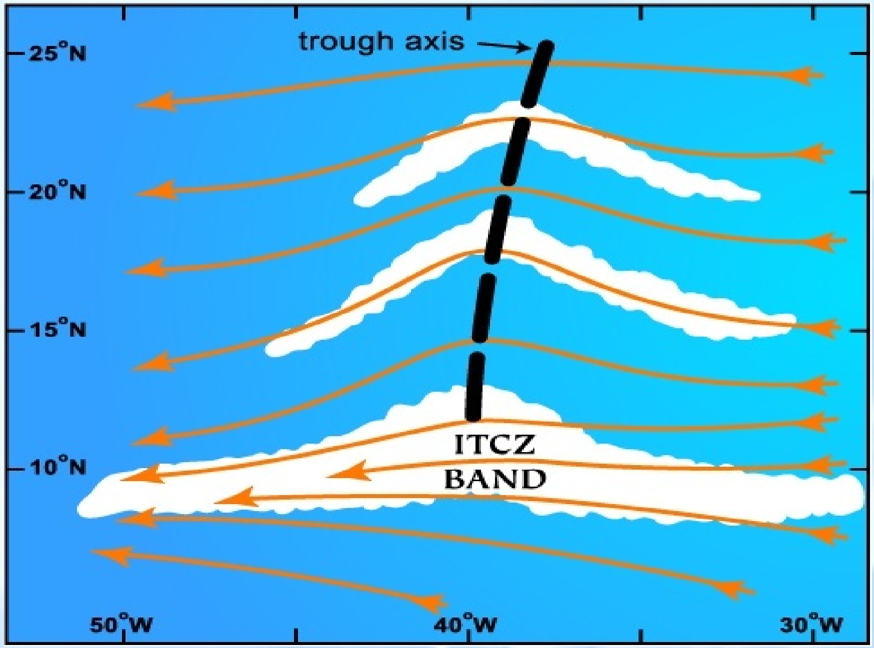
- Strength of Low level easterlies off SE coast of peninsular India
- EAST – WEST ORIENTED TROUGH IN LOWER LVELS
- Formation and movement of Low Pressure Systems (LPS)
- Easterly Waves
- Tropical cyclone

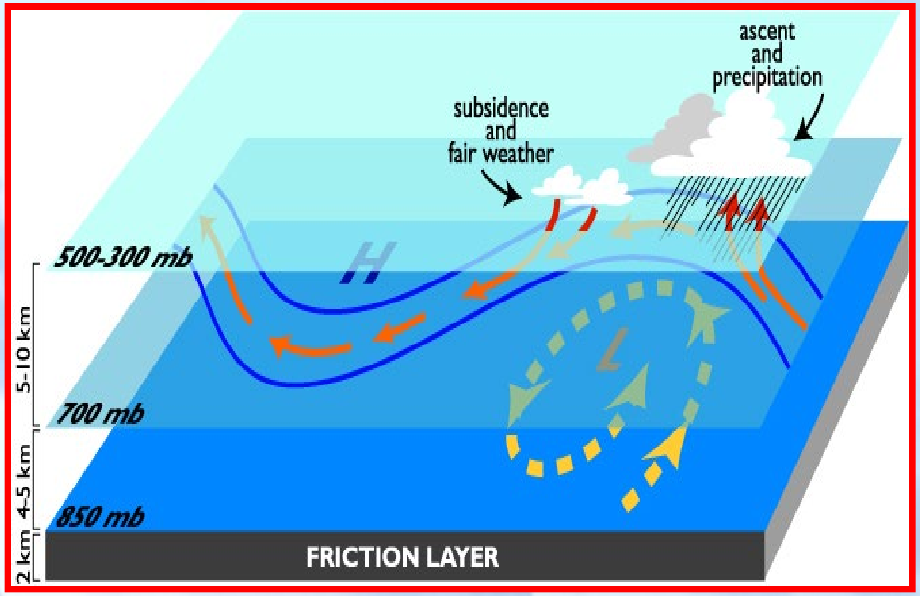
EASTERLY WAVES

an easterly wave resembles traffic on a multi-lane highway. Traffic will back up as it approaches a section of the highway with a closed lane.

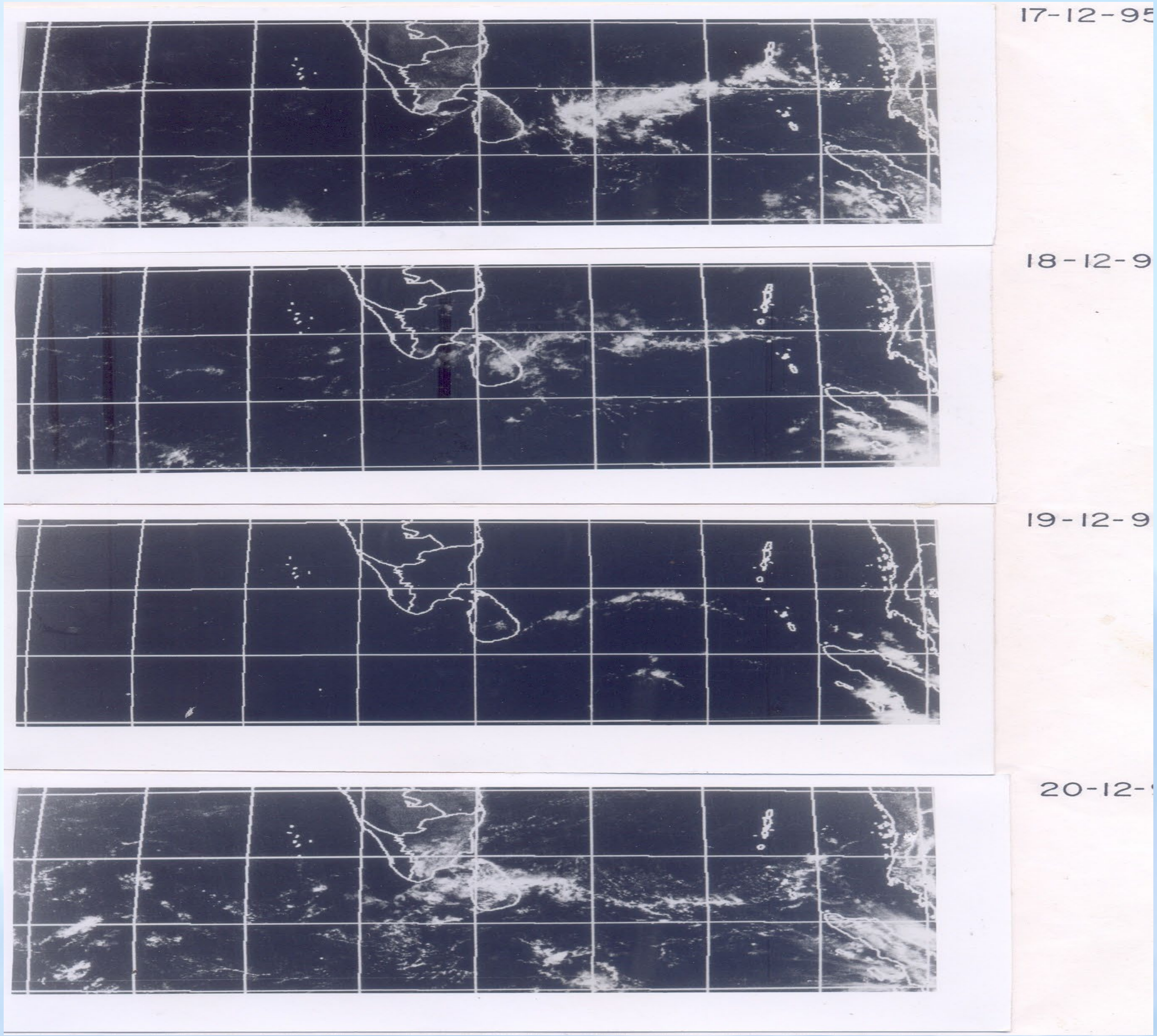


EASTERLY WAVES

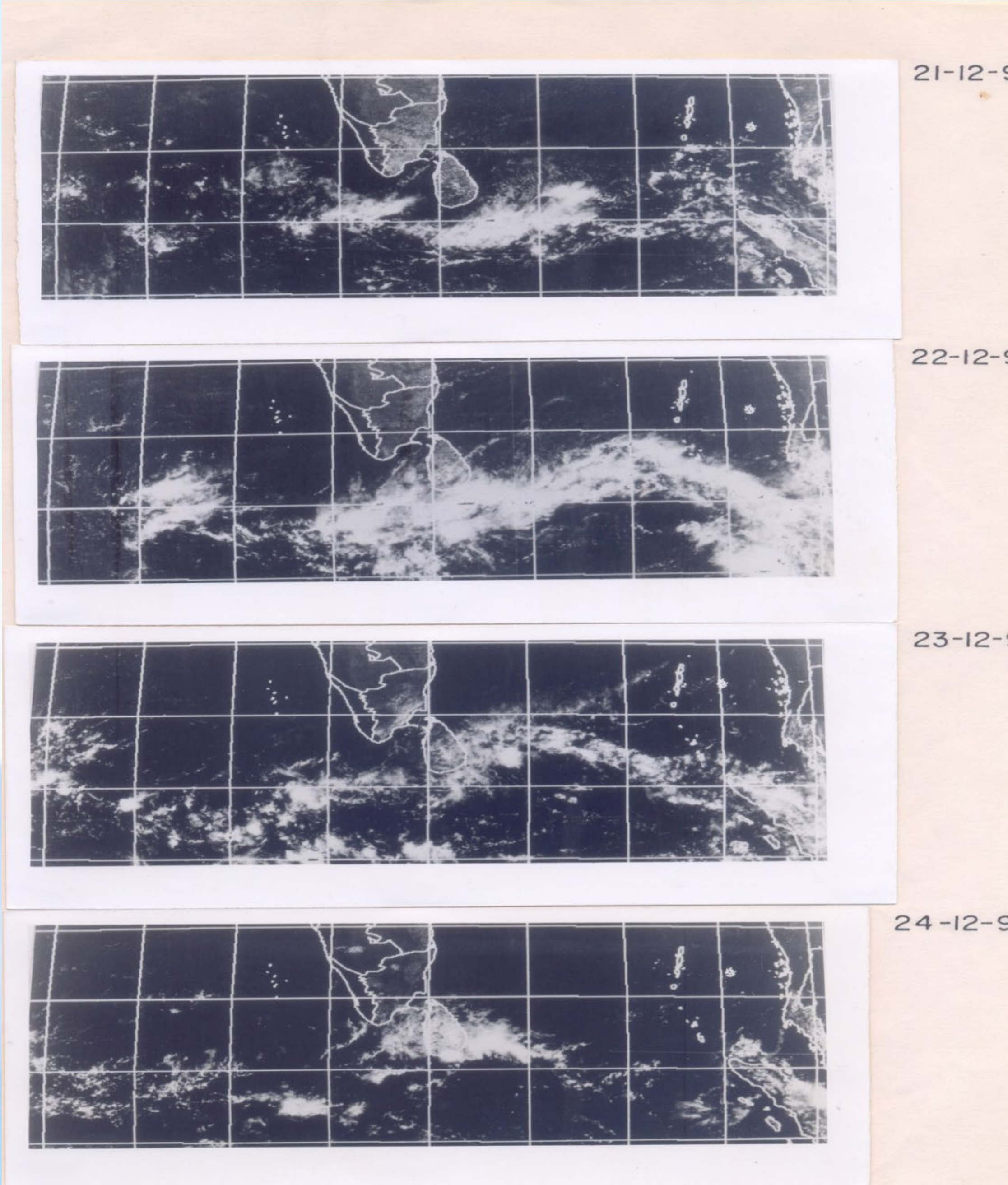




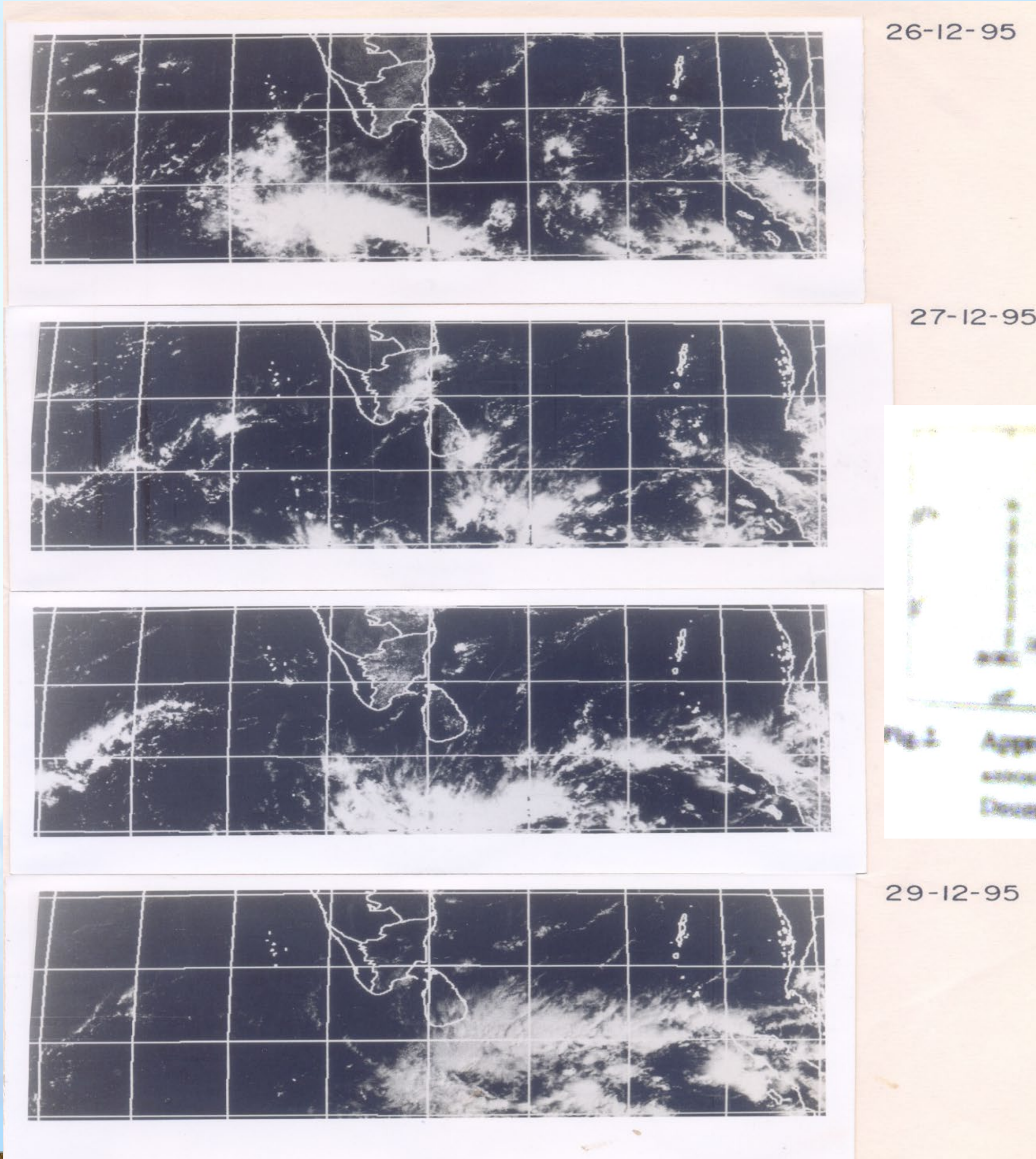
. **Inverted V cloud pattern caused by convection along an easterly wave.**



(Balachandran , Pai1998)



(Balachandran, Pai 1998)



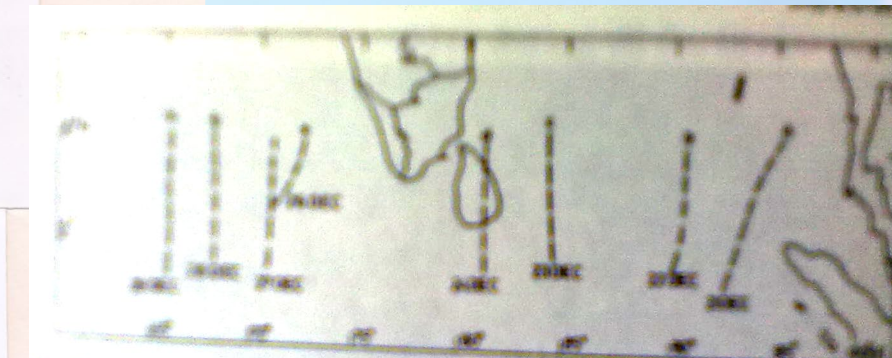


Fig. 2. Approximate day-to-day longitudinal positions of the trou
associated with the sinusoidal cloud pattern during 21-
December 1995.

(Balachandran, Pai,1998)

EW activity – NEM 2010

30-40% of seasonal rainfall during NEM 2010 was realised in association with EW acitivity

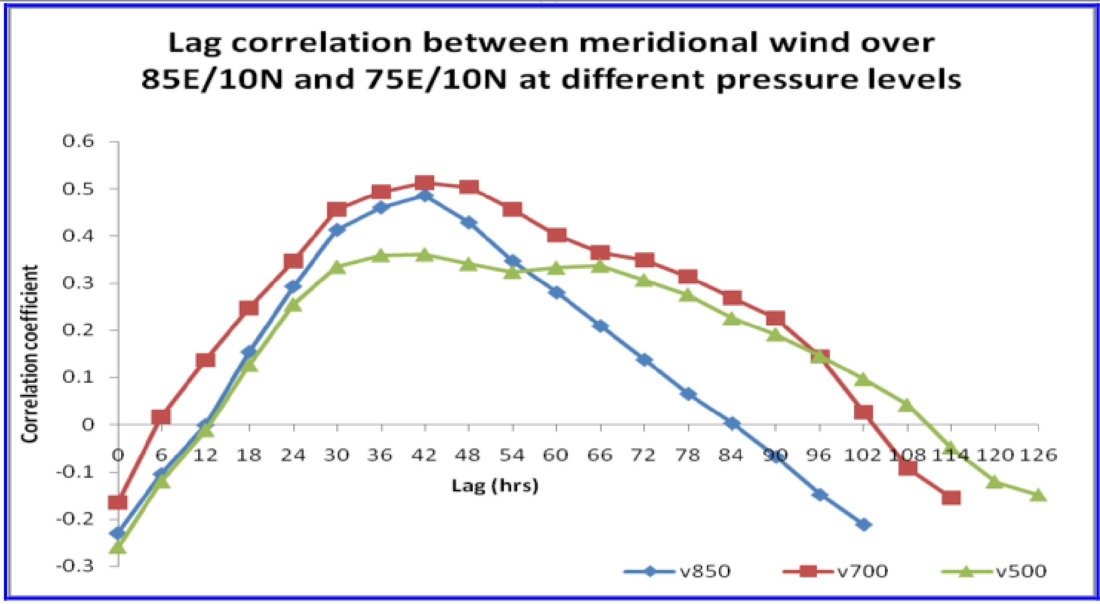
Characteristics:

Speed of movement: 7 m/s

Wavelength: 2800 km

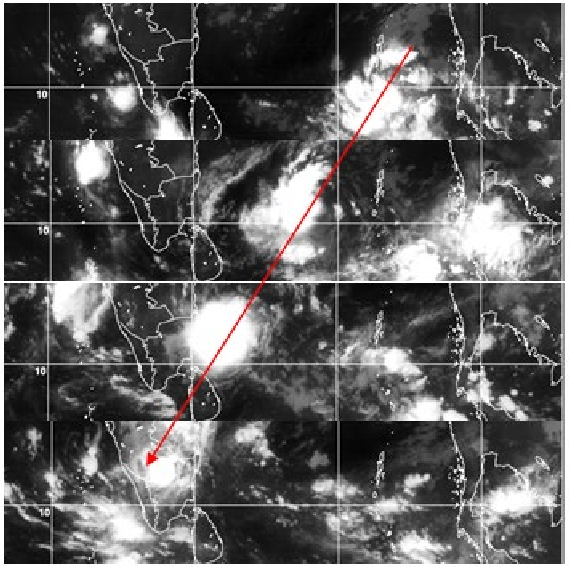
Time period: 3-4 days

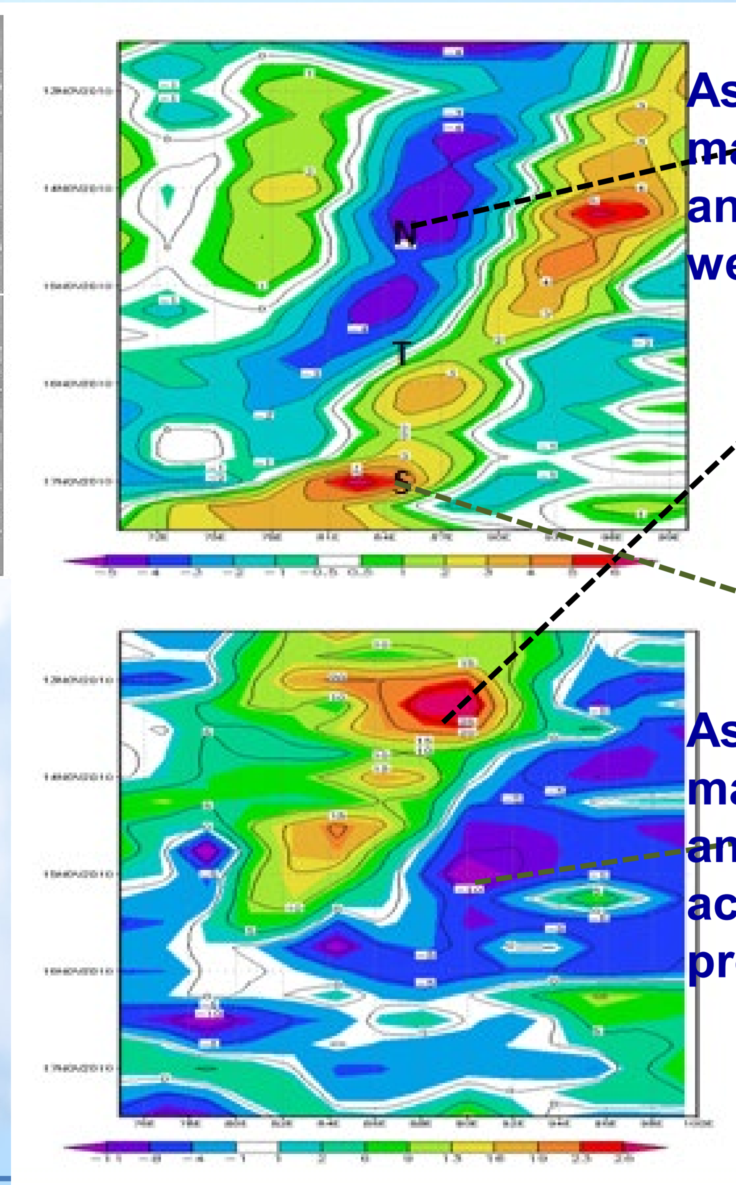
Amplitude: 6.7 m/s



(Geetha and Balachandran, 2014)

EASTERLY WAVES & NEM: 13-17 Nov 2010





Associated with Nly maxima, positive OLR anomalies indicating fair weather

Associated with Sly maxima, negative OLR anomlaies indicating active weather and precipitation

Hovmoller plots of meridional winds at 850 hPa & Net OLR during passage of an Ely wave over peninsular India

(13-17 Nov 2010)

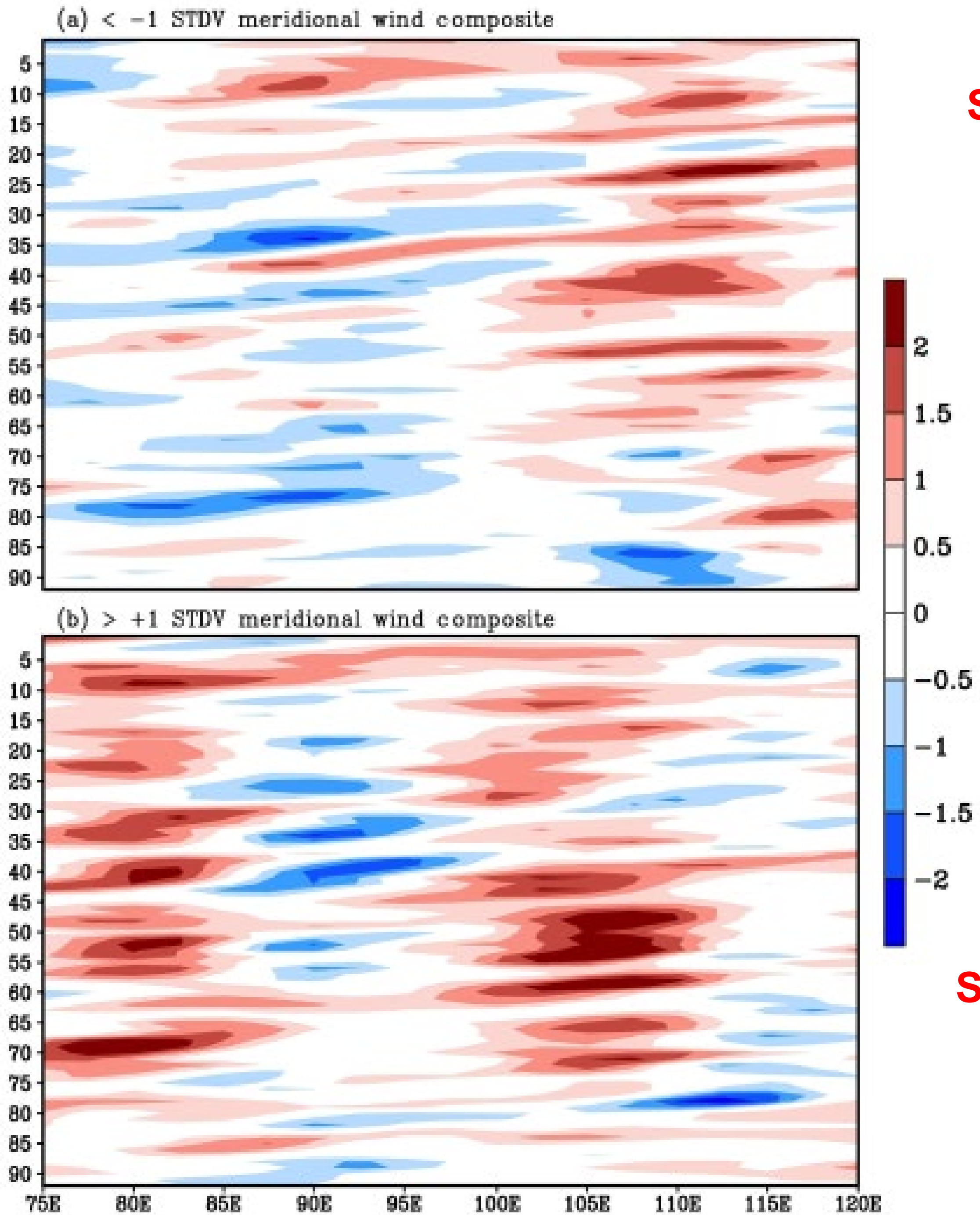
(Geetha & Balachandran, 2014)

EW ACTIVITY

- Easterly wave activity over Indian ocean plays significant role in occurrence of the heavy rainfall events during positive phase of the ENSO; it is weak during negative phase or neutral .
- Above normal SST over BOB, strong west-east SST gradient between SW BOB and tropical western Pacific ocean and anomalous strong low level easterly flow over tropical Indian ocean during El- Nino years offer favourable conditions for initiation and westward propagation of EWs.

Heavy Rainfall Events over South-East Peninsular India during North-East Monsoon: Role of El-Niño and Easterly Wave Activity

S. D. Sanap[1*], P. Priya[2], G. K. Sawaisarje[3] and K. S. Hosalikar[4]



SST ANO. <-1 SD

SST ANO. > +1 SD

SANAP et.al.-2018

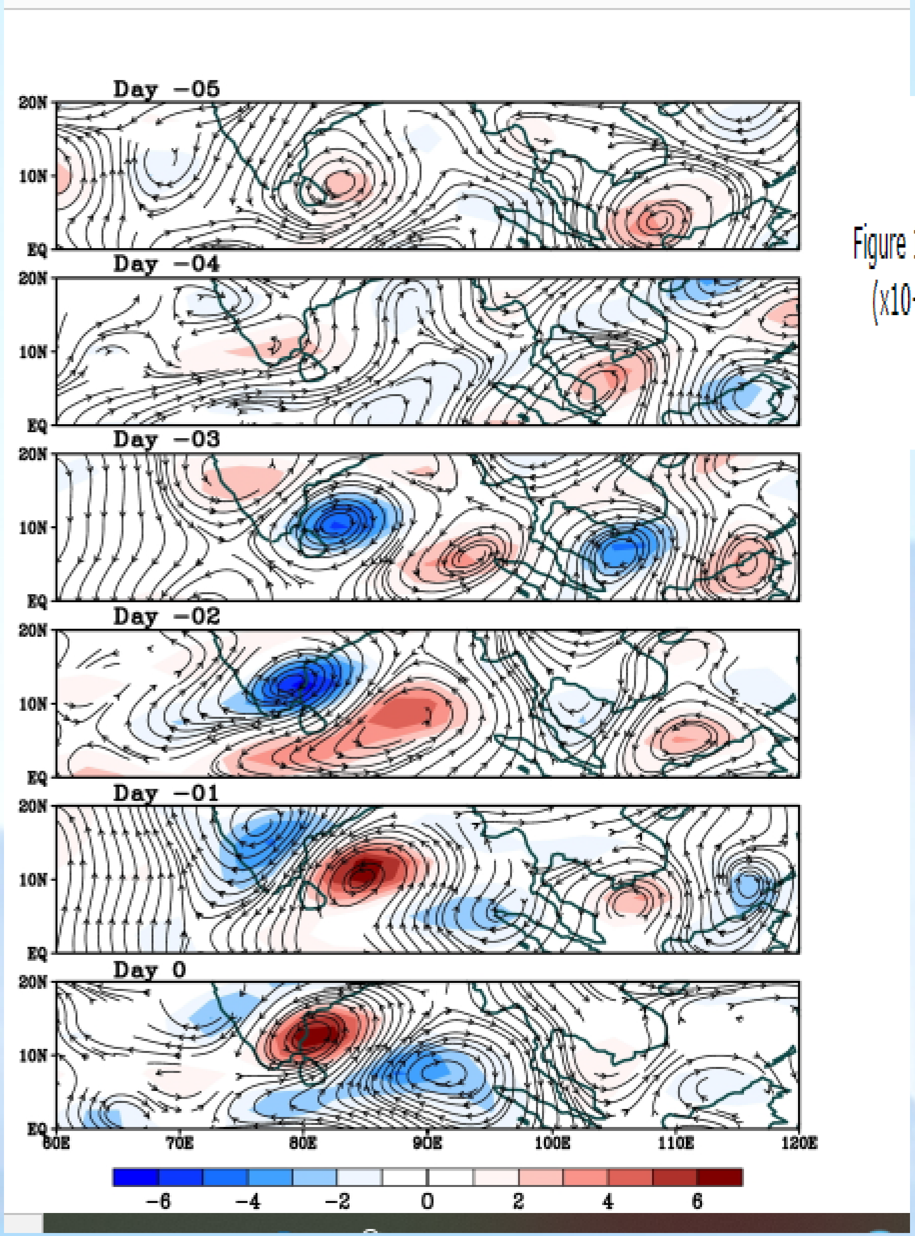
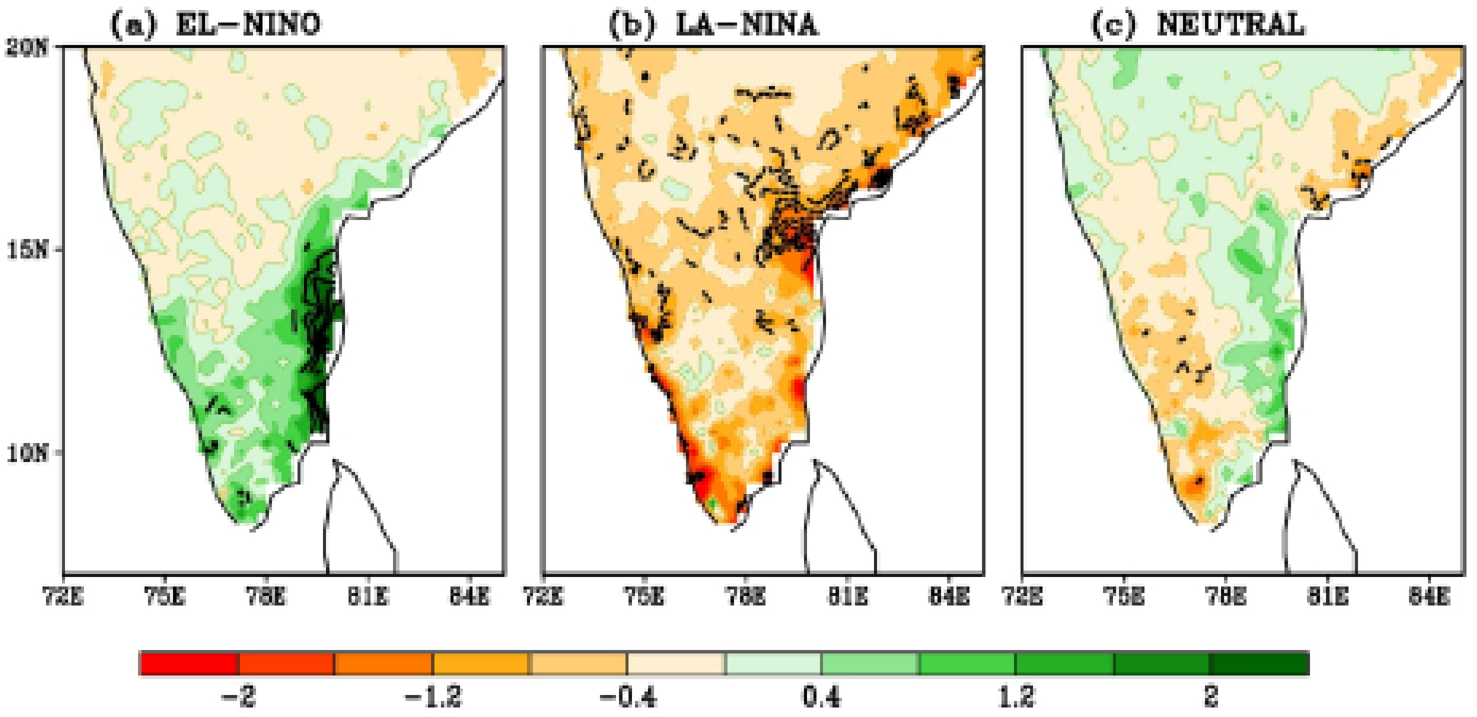


Figure 12: Time evolution of the 3-7 day filtered composite anomalies of 700 hPa wind and relative vorticity (x10−5 S −1 , shaded) for El-Nino years in which heavy rainfall occurred from day -05 to day 0 (day of occurrence of heavy rainfall).

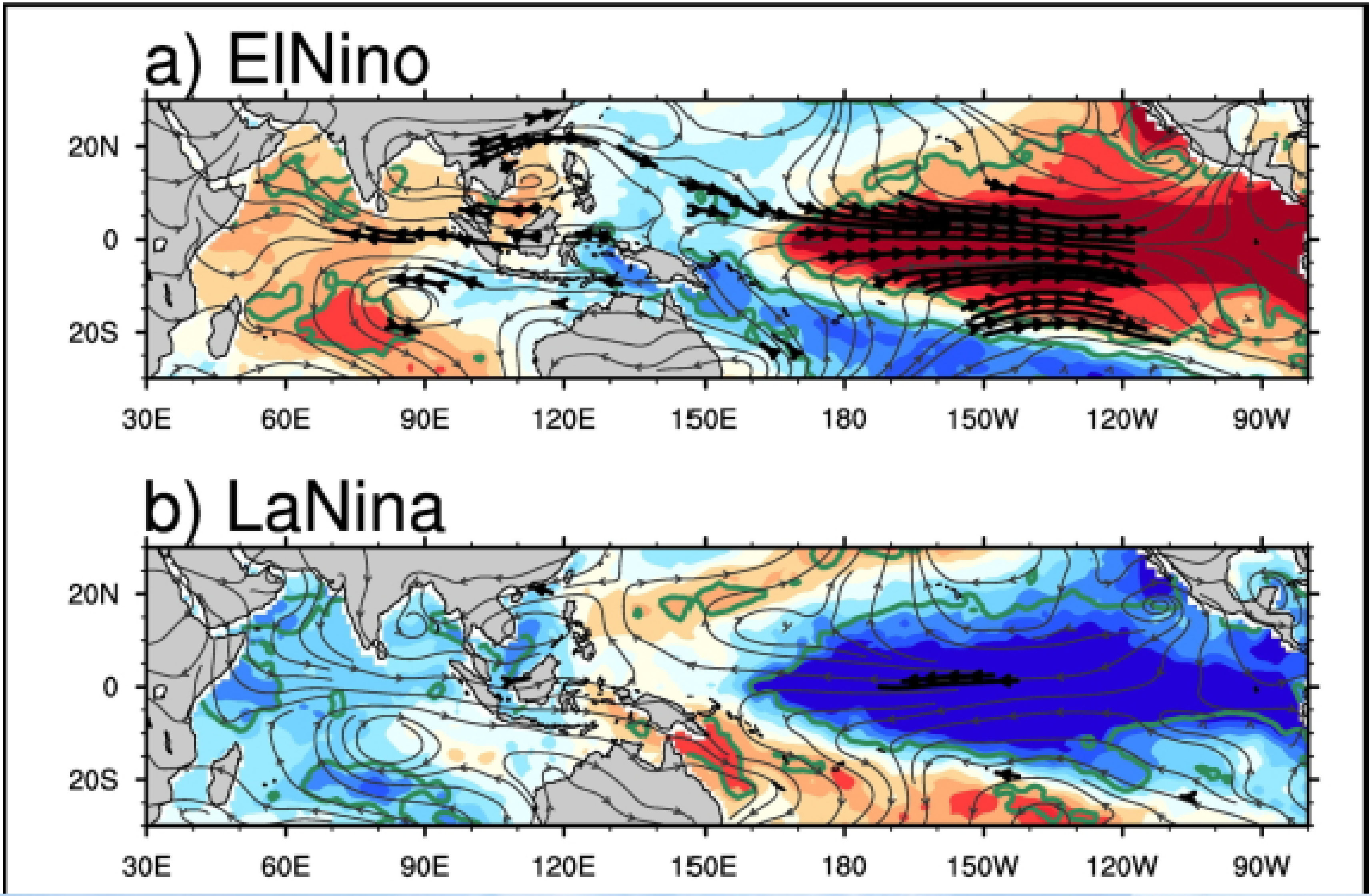
SANAP et.al.-2018

ENSO & Post monsoon

ENSO- NEM

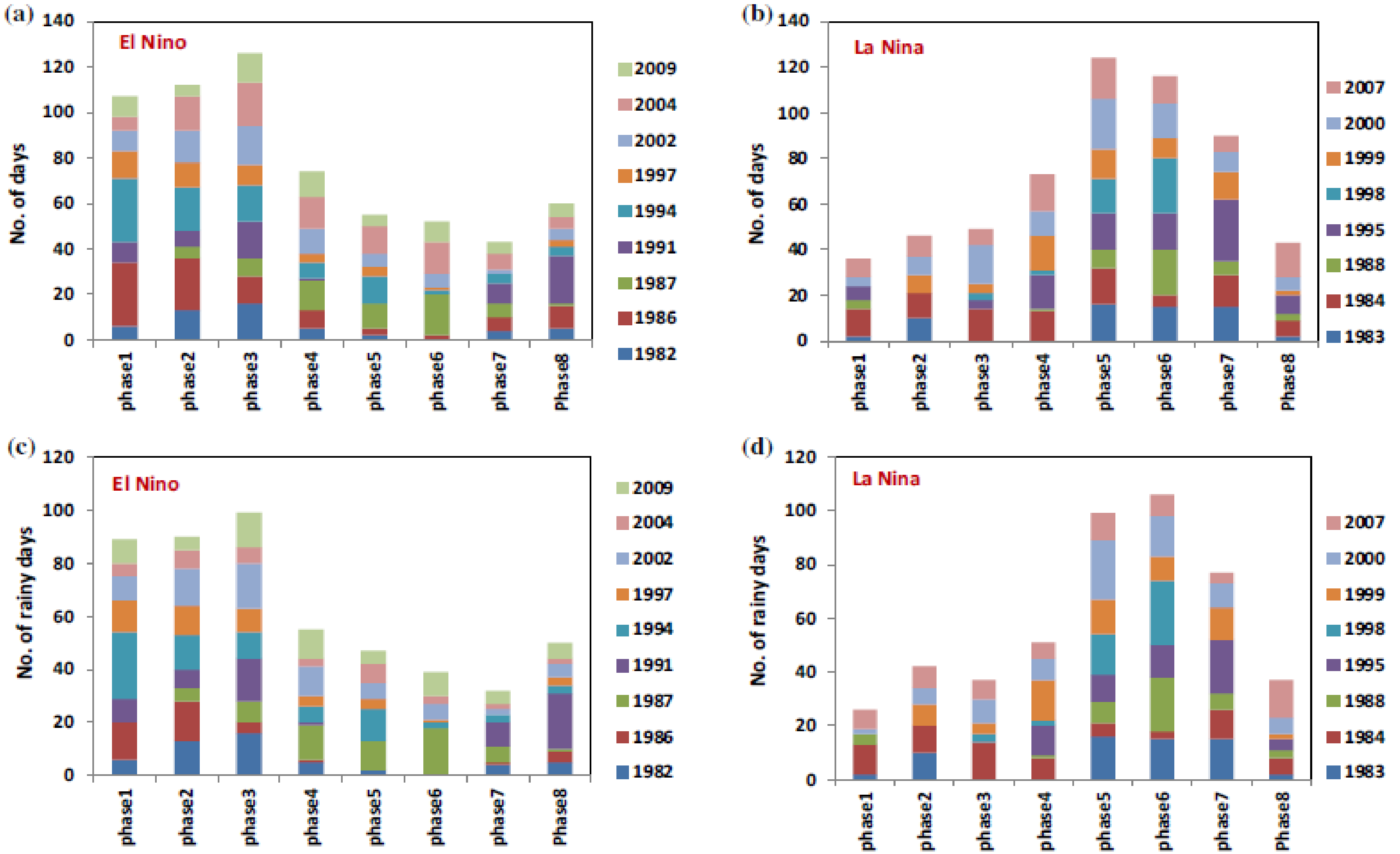


SANAP et.al


a) ElNino
20N
0
20S
30E
60E
90E
120E
150E
180
150W
120W
90W
b) LaNina
20N
0
20S
30E
60E
90E
120E
150E
180
150W
120W
90W

SANAP et.al

Life and rainy days - MJO Phases – El Nino

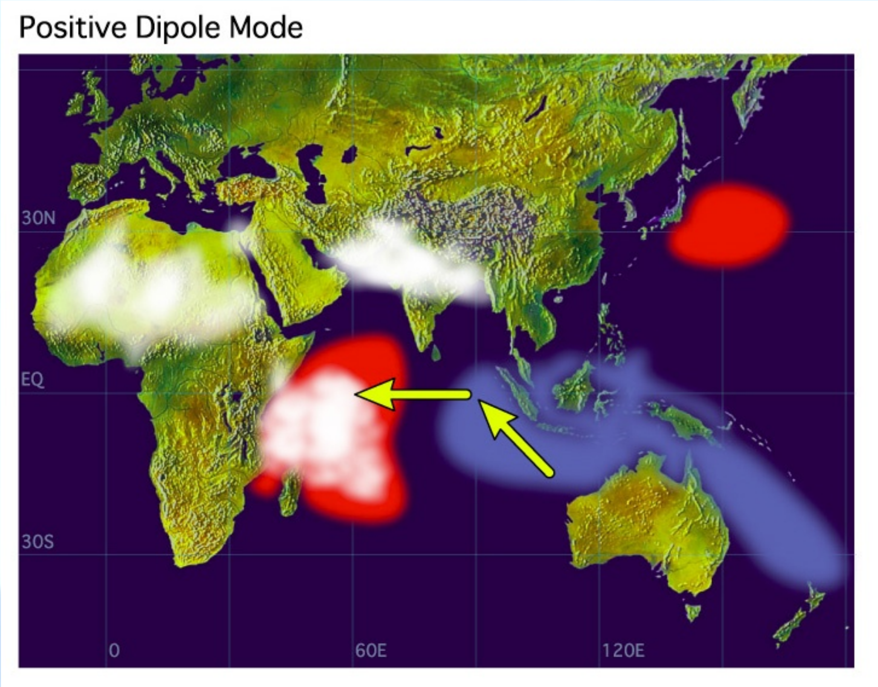


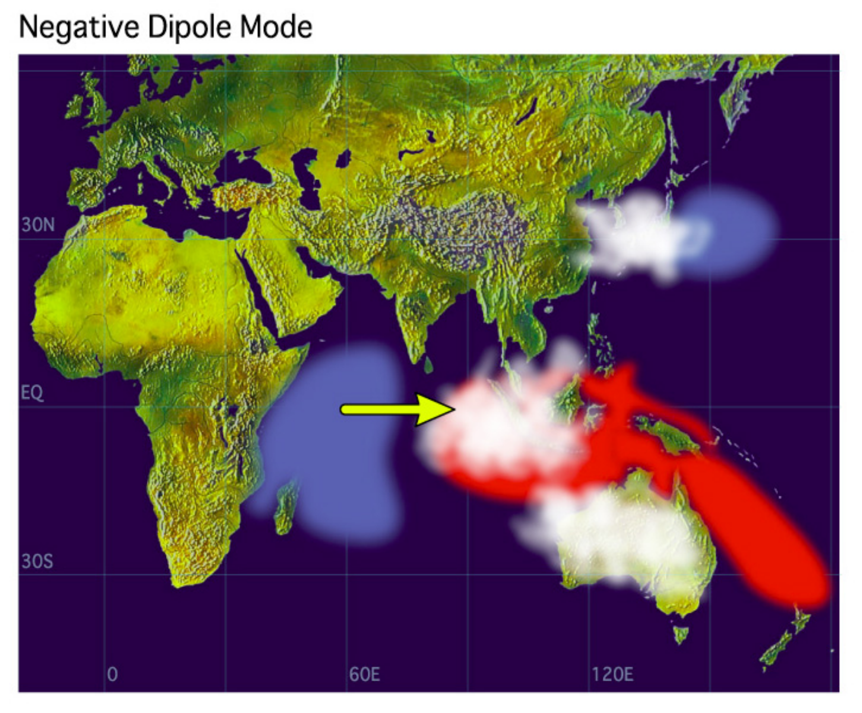
8 The number of days and number of rainy days under various phases of MJO during El Nino and La Nina years

P P SREEKALA et.al.-2018

Post monsoon & IOD

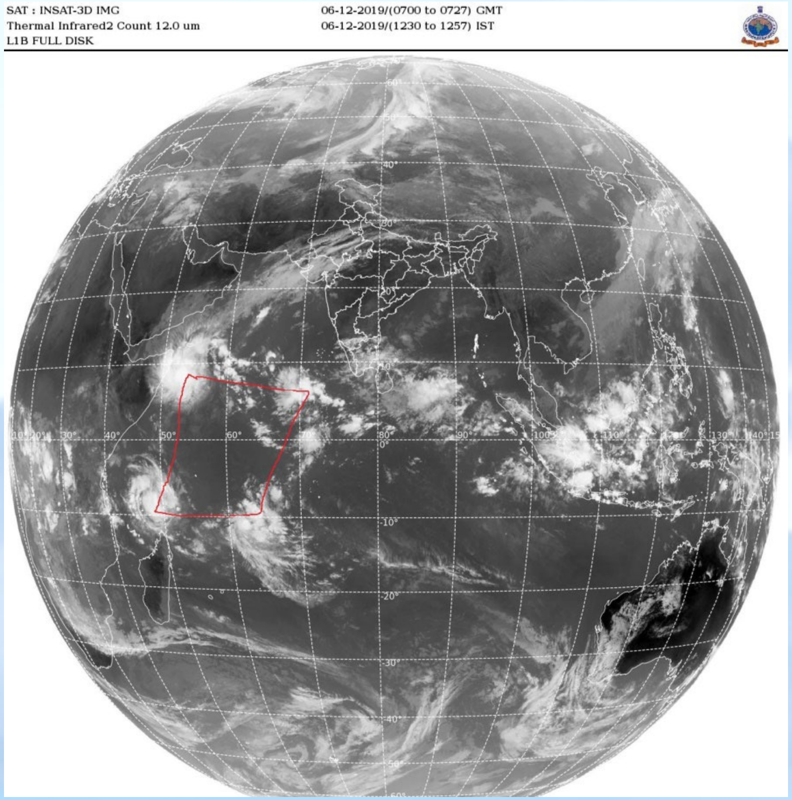
LARGE SCALE INFLUENCES
2. INDIAN OCEAN DIPOLE (IOD)

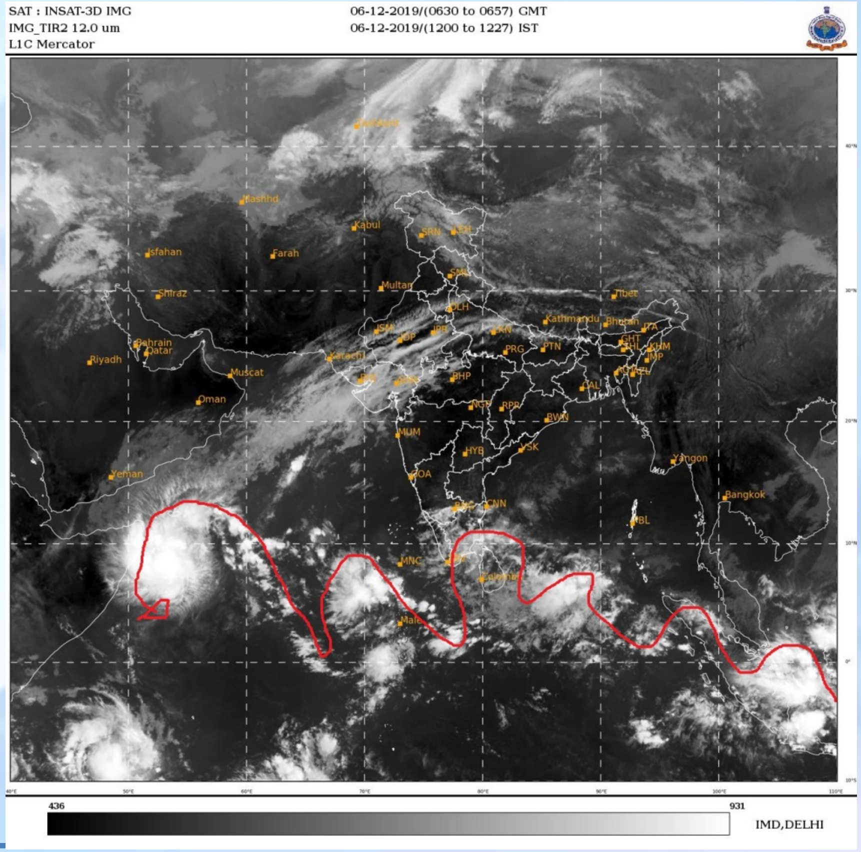




SST anomalies are shaded (red color is for warm anomalies and blue is for cold). White patches indicate increased convective activities and arrows indicate anomalous wind directions during IOD events.

2019 –PIO-EW activity





MJO & Post monsoon season

MJO - NEMR

- Intraseasonal variation of daily rainfall over south peninsular India during NEM season is associated with various phases of eastward propagating MJO life cycle.

- Positive rainfall anomaly over south peninsular India and surrounding Indian Ocean (IO) is observed during the strong MJO phases 2, 3 and 4; and negative rainfall anomaly during the strong MJO phases 5,6,7,8 and 1.

- Above normal (below normal) convection over south peninsular India and suppressed convection over east Indian and West Pacific Ocean,

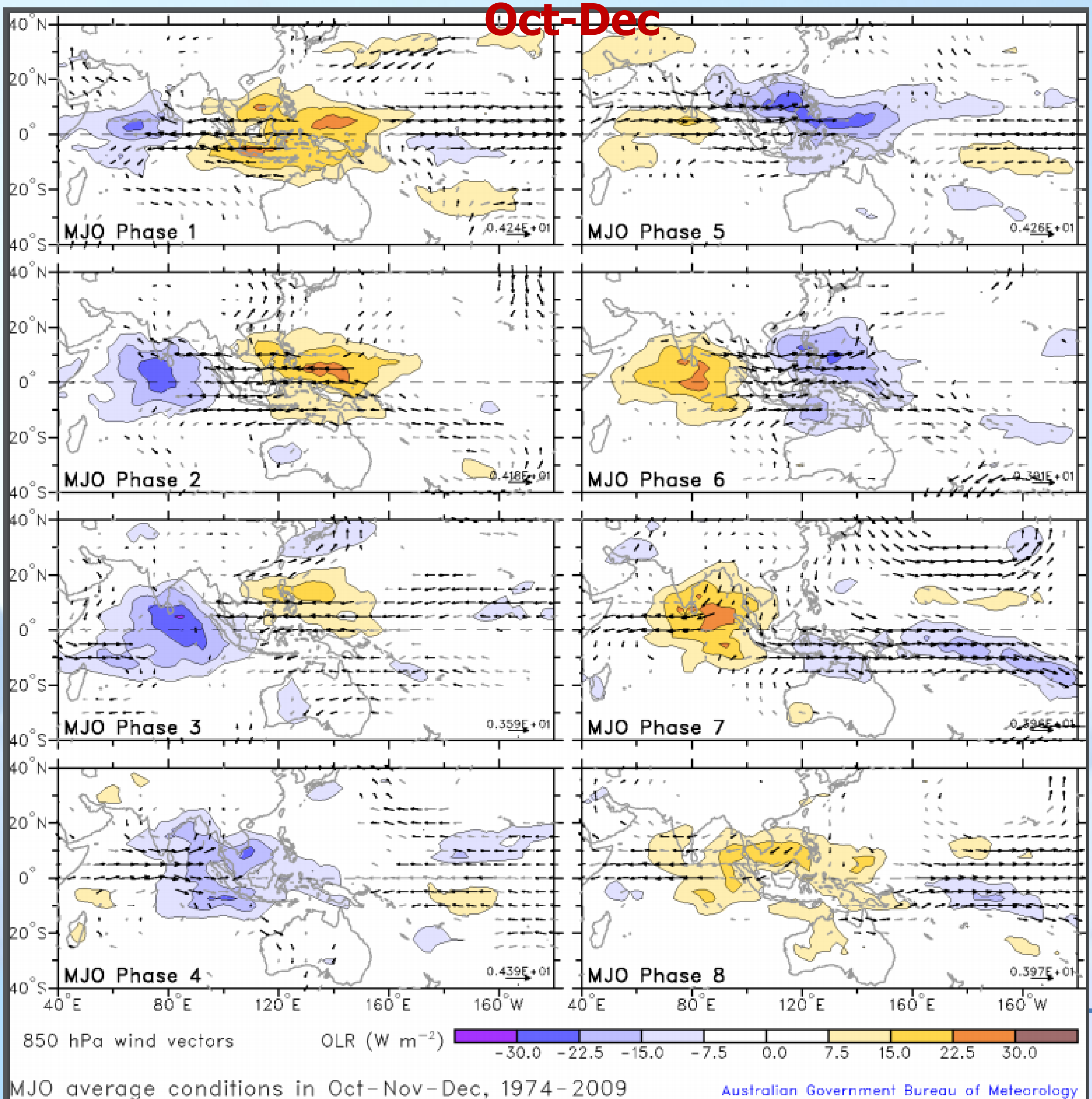
P P SREEKALA et.al.-2018

MJO - NEMR

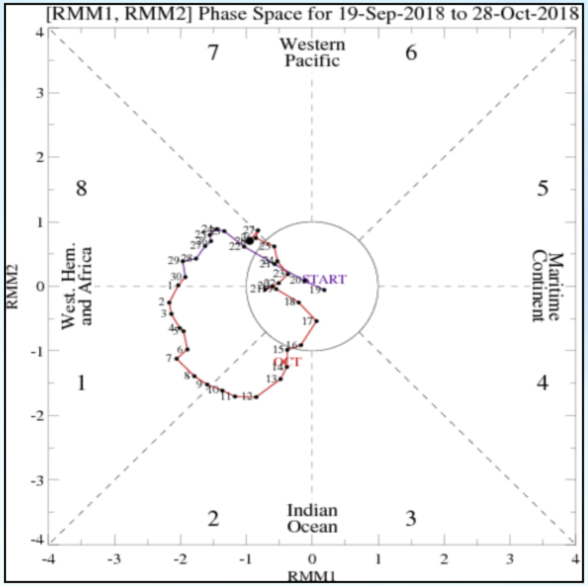
- high pressure (low pressure) anomaly over West Pacific Ocean, Positive (negative) SST anomalies over equatorial East and Central Pacific Ocean and easterly wind anomaly (westerly anomaly) over equatorial Indian Ocean are the observed features during the first three MJO (5, 6, 7) phases
- The number of days during the first three phases (last four phases) of MJO, where the enhanced convection and positive rainfall anomaly is over Indian Ocean (East Indian ocean and West Pacific Ocean), is more (less) during El Nino and PIOD years and less during La Nina and NIOD years and vice versa.

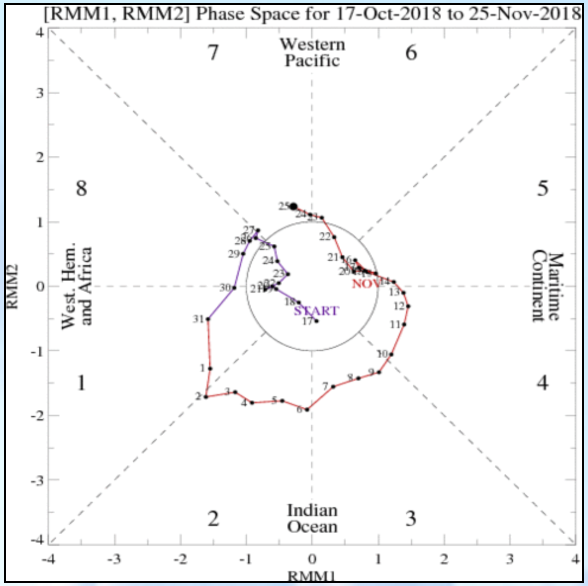
P P SREEKALA et.al.-2018

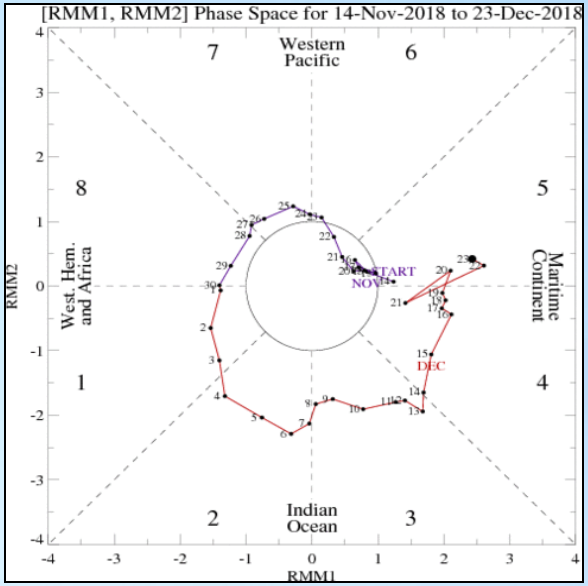
OLR anomalies during various MJO Phases during Oct-Dec



Intra seasonal oscillations - MJO evolution







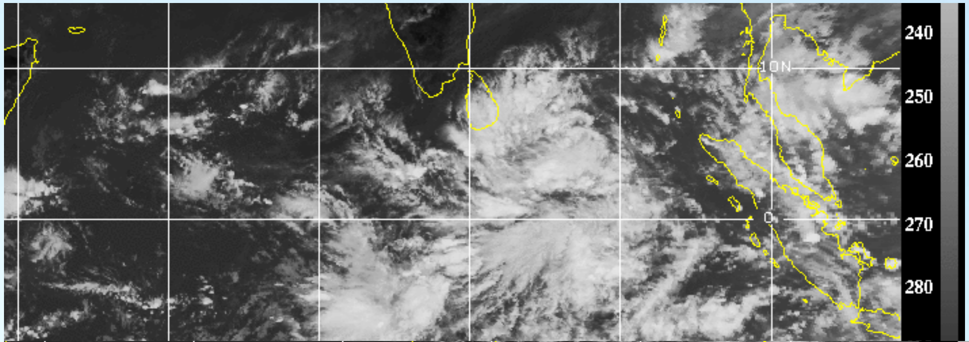
Month	Week-1	Week-2	Week-3	Week-4
Oct 2018	Ph:1, Amp:>1	Ph:2, Amp:>1	Ph:2-1 Amp: insig	Ph:1-8 Amp:1
Nov 2018	Ph:1-2 Amp:>1	Ph:3-4, Amp:>1	Ph:5-6, Amp: insig	Ph:7, Amp:1
Dec 2018	Ph:1-2 Amp:>1	Ph:3-4 Amp:>1	Ph:4-5 Amp:>1	Ph:5 Amp:>1
Ph: 2-4, Amp>1→	[redacted]			

2018
36 days in ph 2-4;
Amp >2: 8 days

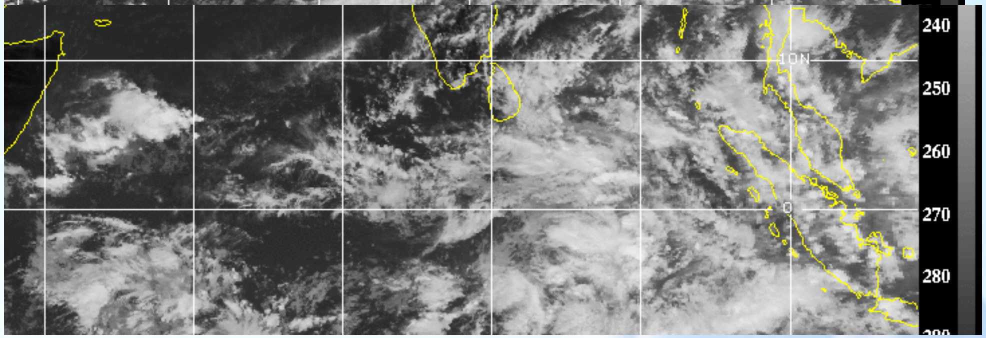
2015
55 days in ph 2-4;
Amp >2: 18 days

SCS Pethai – MJO initiation

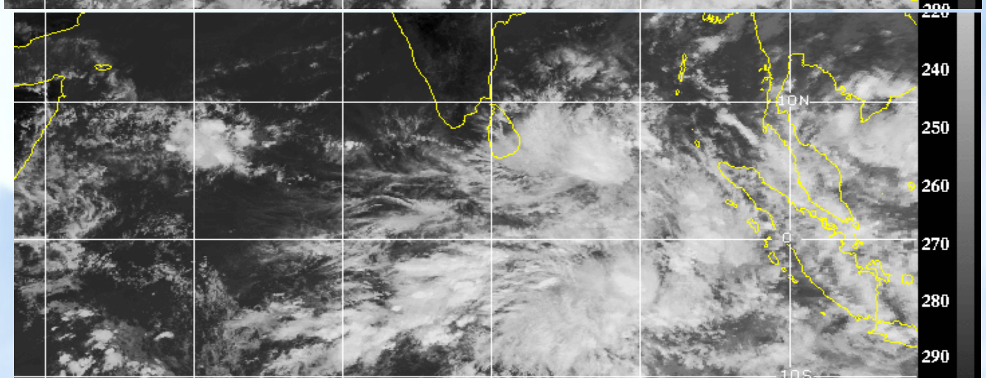
9 Dec



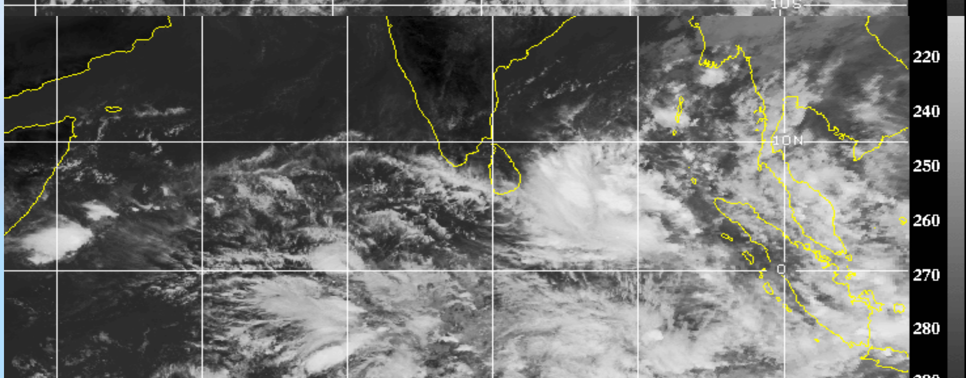
10 Dec



11 Dec

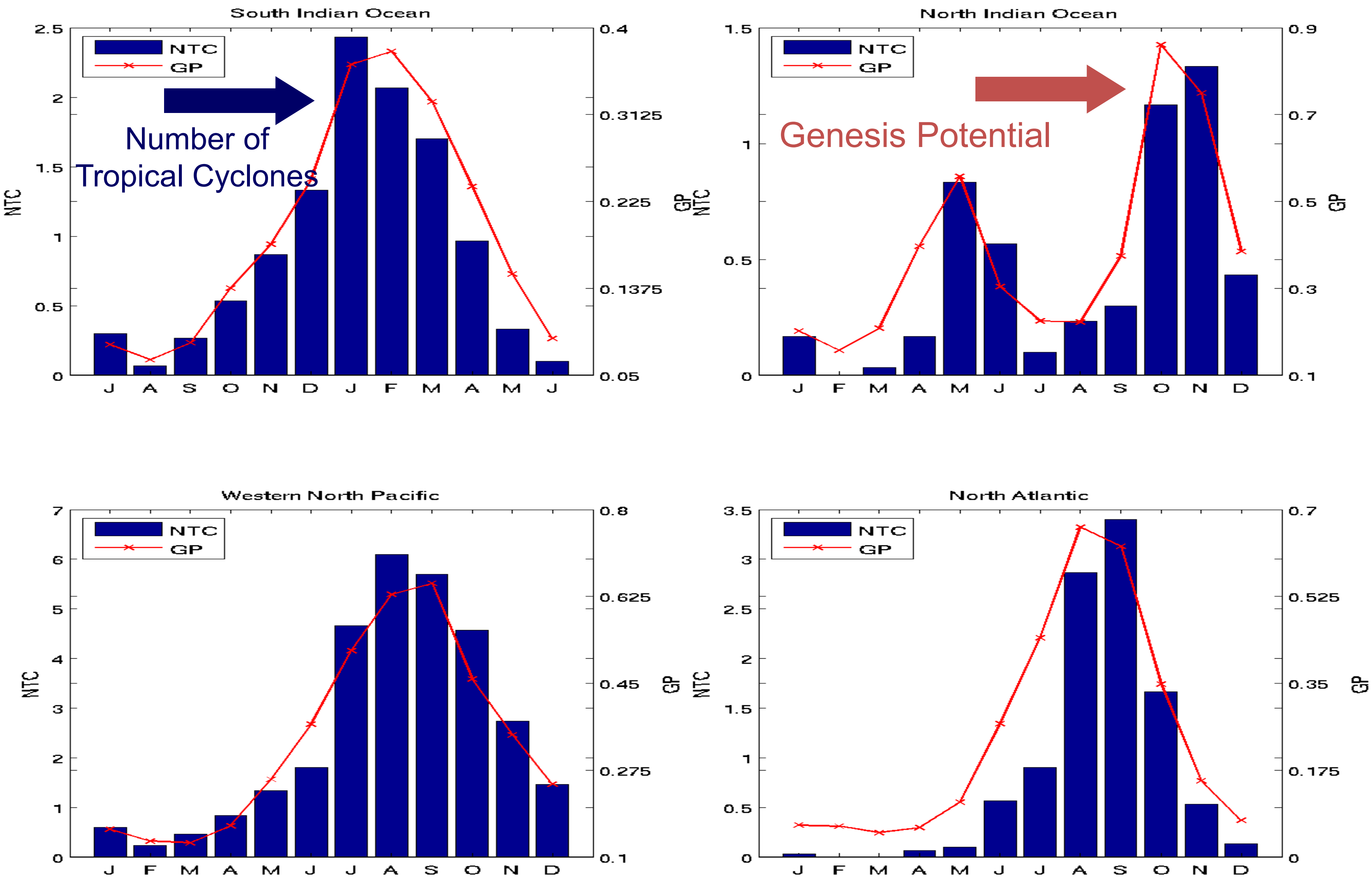


12 Dec

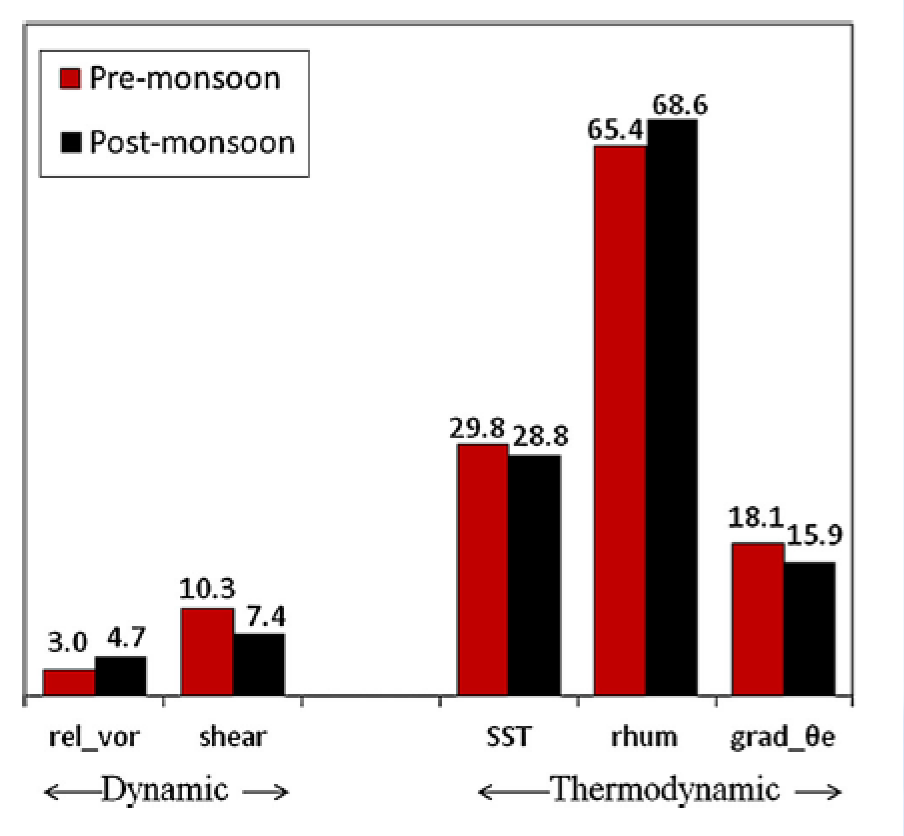


TROPICAL CYCLONES

Climatology - Basins



Climatology - Basins



Role of synoptic-scale forcing in cyclogenesis over the BOB
Nasreen Akter • Kazuhisa Tsuboki
Clim Dyn (2014) 43:2651–2662 DOI 10.1007/s00382-014-2077-9

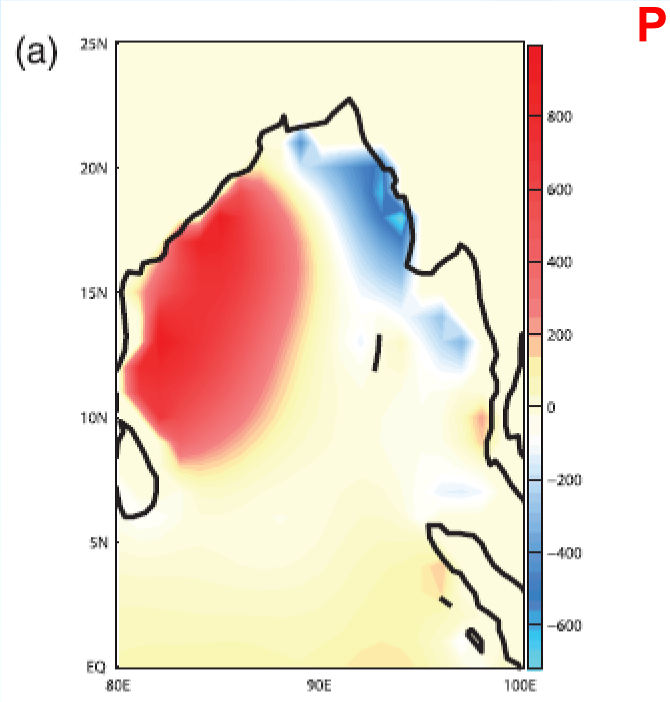
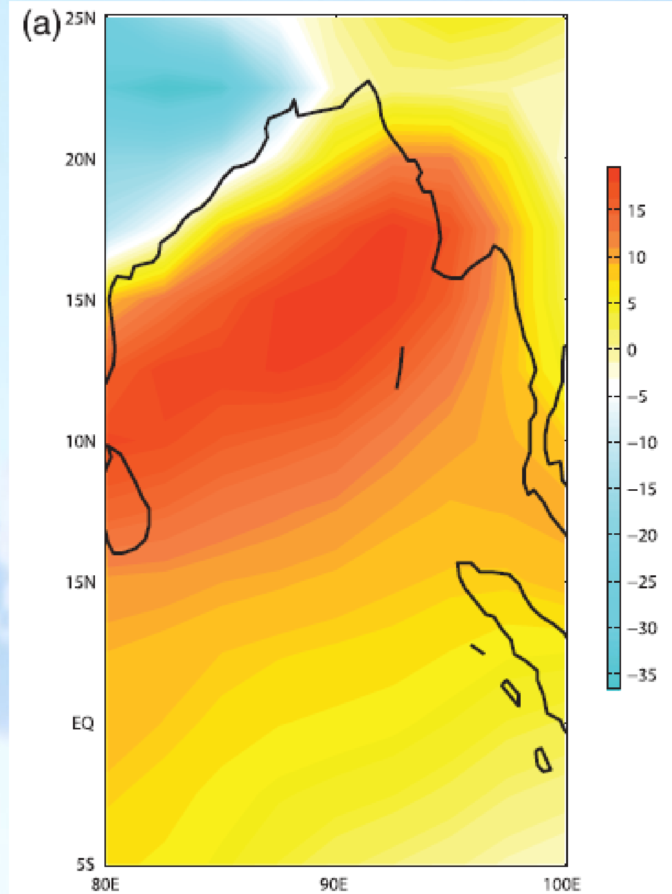


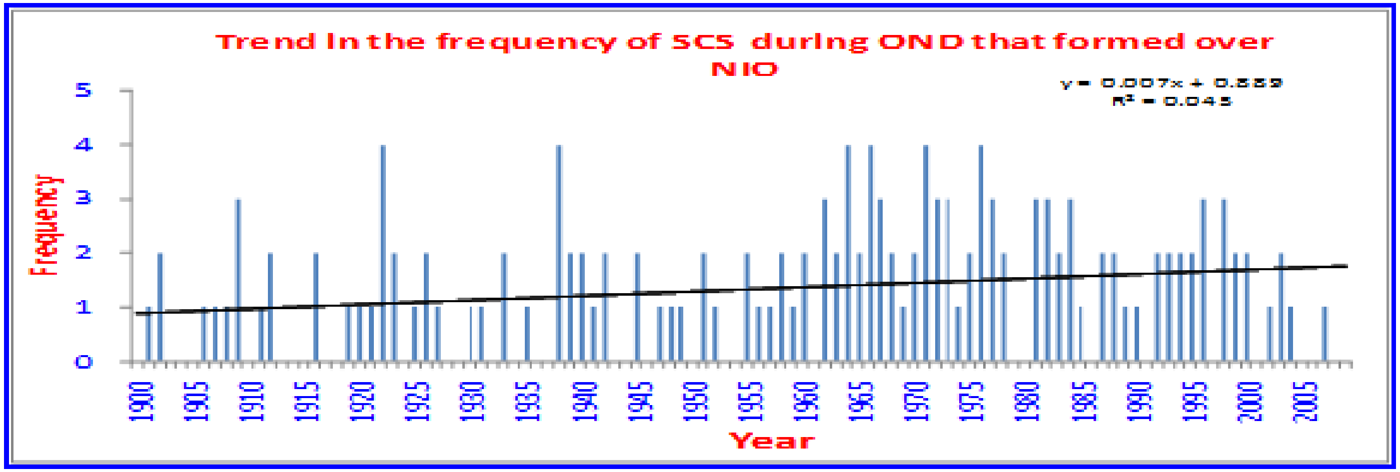
FIG. 6. (a) Difference (April–May minus October–November) of the upper-ocean heat content (unit: °C m^{-1}). (b) The PI indices (unit: m s^{-1}) calculated based on an equivalent upper-ocean temperature (red) and SST (blue).

Pre-post OHC

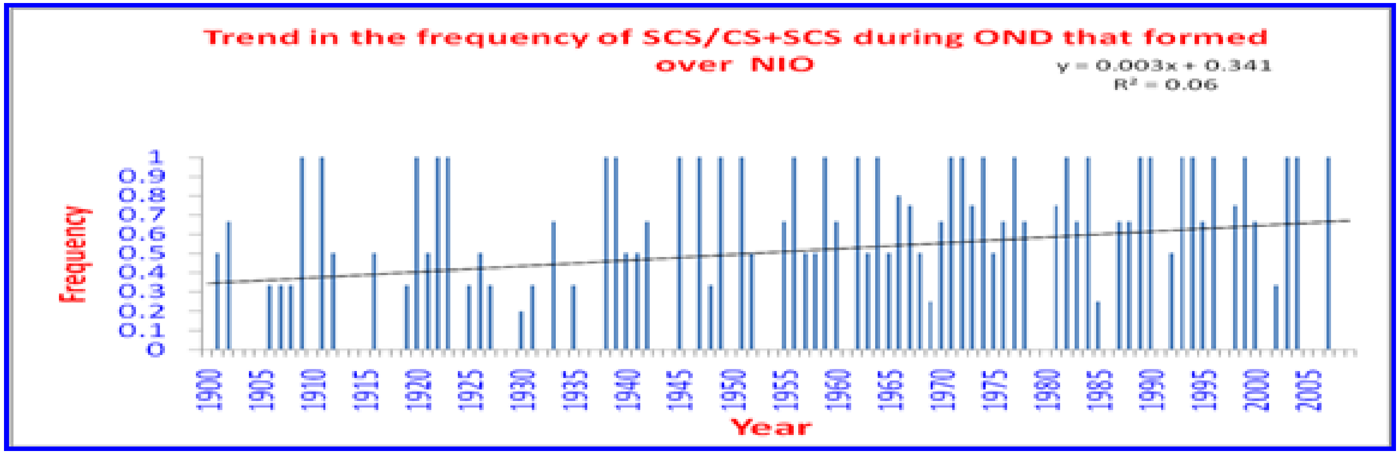


Post-pre 600hPa RH

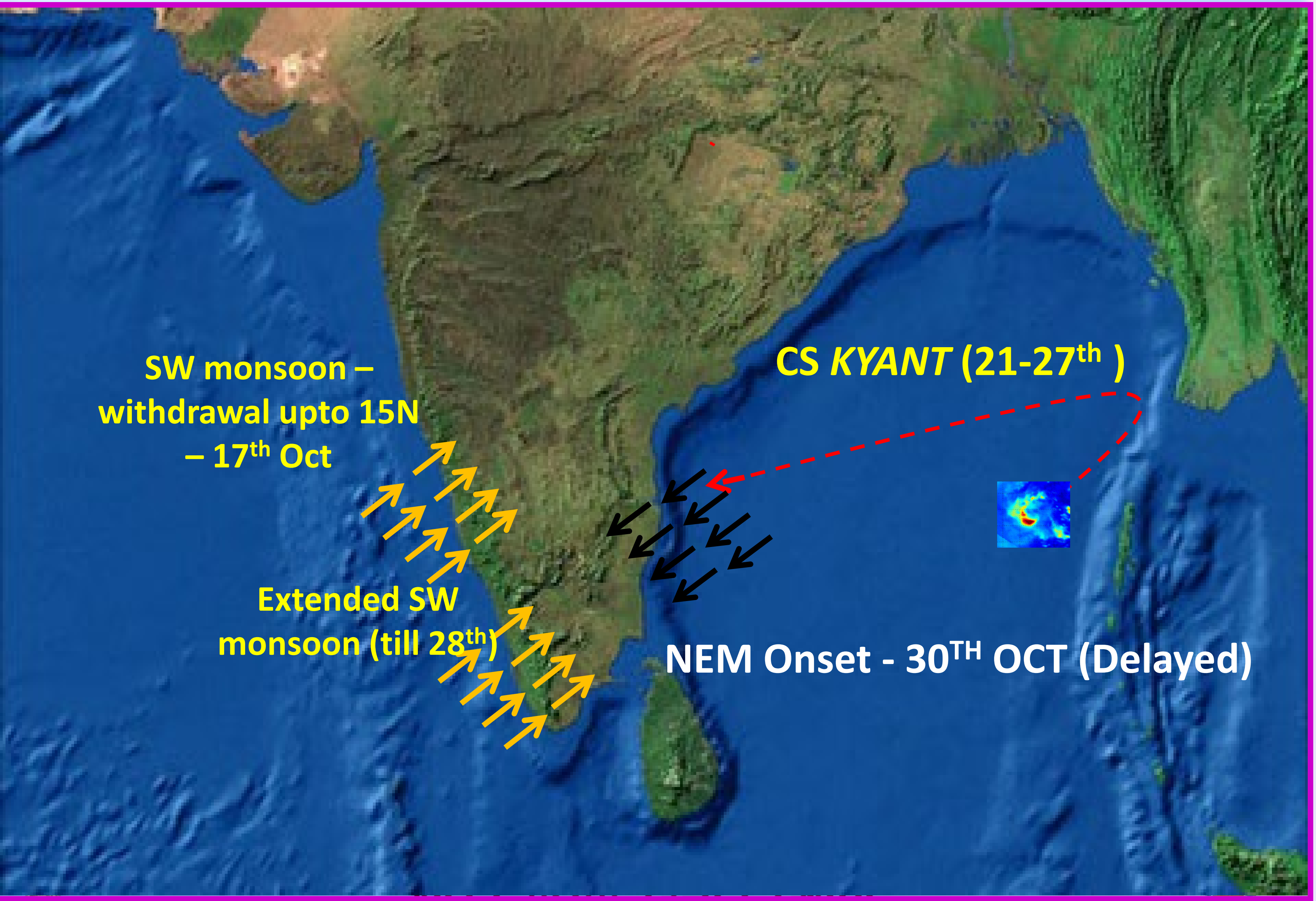
The higher background relative humidity during October– November than in April–May is the major factor that contributes to more frequent cyclone genesis in October– November. In contrast to the TC frequency, the most intense cyclones are observed to occur in April–May rather than in October–November. This due to the greater ocean heat content may lead to a greater TC potential intensity.


Trend in the frequency of SCS during OND that formed over NIO
y = 0.007x + 0.889
R^2 = 0.045
Frequency
Year
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

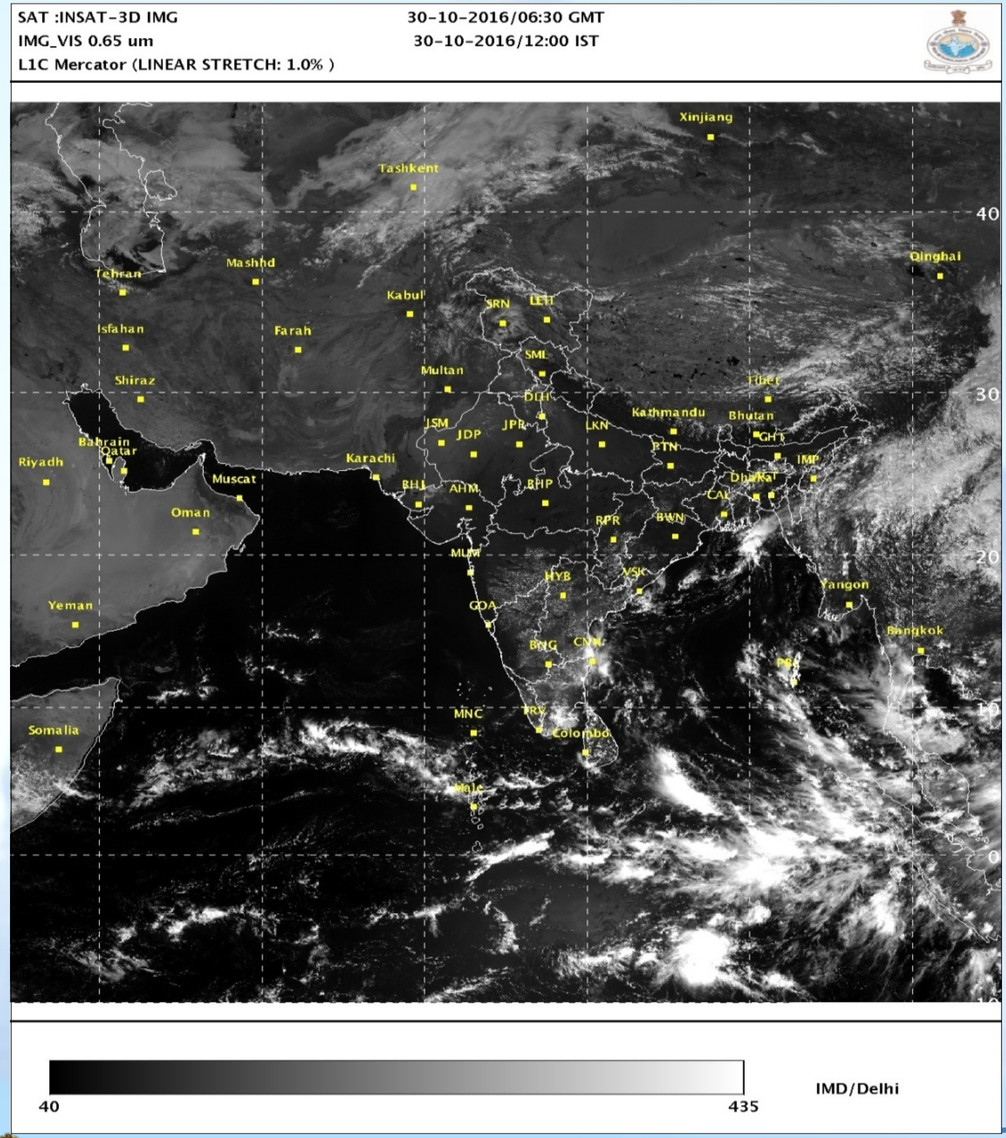
(b)

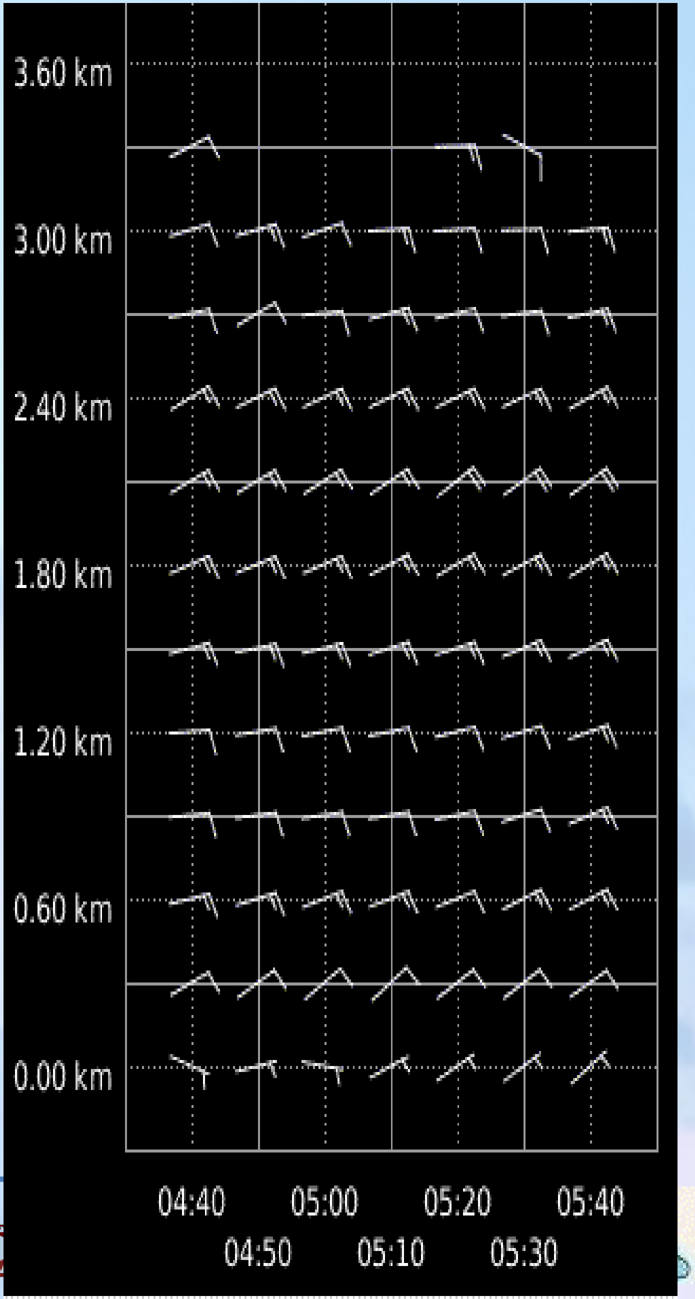

Trend in the frequency of SCS/CS+SCS during OND that formed over NIO
y = 0.003x + 0.341
R^2 = 0.06
Frequency
Year
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

Onset Phase – Oct 2016

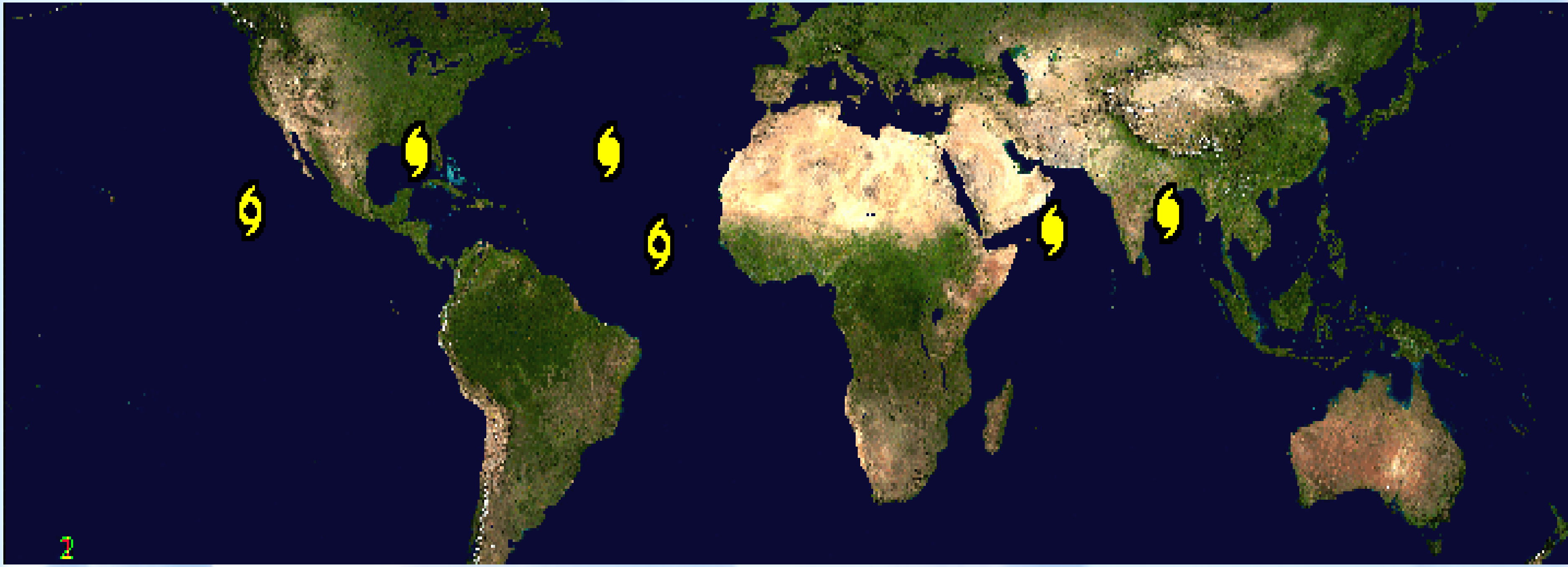


ONSET


SAT :INSAT-3D IMG
IMG_VIS 0.65 um
L1C Mercator (LINEAR STRETCH: 1.0%)
30-10-2016/06:30 GMT
30-10-2016/12:00 IST
IMD/Delhi
40
435


3.60 km
3.00 km
2.40 km
1.80 km
1.20 km
0.60 km
0.00 km
04:40
05:00
05:20
05:40
04:50
05:10
05:30

Clustering of Tropical cyclones



Hurricane Michael
Hurricane Leslie
Tropical storm Nadine
Hurricane sergio

ENSO & TC ACTIVITY DURING NEM SEASON

TC activity over BOB is greater during La Nina years.
Accumulated Cyclone Energy over NIO (1983-2008)

El Nino years ACE over BOB→ 1.13 kt^2

Table III. Variation of tropical cyclone activity parameters in El Niño years over the entire NIO basin (left), BB (center), and AS (right) during OND. Numbers in italics indicate values below the climatological mean (1983–2008).

El Niño year	NTC	NIO ACE(kt^2)	NIC	NTC	BB ACE(kt^2)	NIC	NTC	AS ACE(kt^2)	NIC
1986	*3*	*1.21*	*0*	2	*0.57*	*0*	1	0.64	*0*
1987	5	*4.36*	*0*	5	*4.36*	*0*	*0*	*0*	*0*
1991	*3*	*0.57*	*0*	3	*0.57*	*0*	*0*	*0*	*0*
1994	*2*	*3.11*	*0*	*1*	*0.79*	*0*	1	2.32	*0*
1997	*2*	*1.06*	*0*	*1*	*1.06*	*0*	1	*0*	*0*
2002	4	*1.68*	*0*	3	*1.68*	*0*	1	*0*	*0*
2004	5	*3.90*	*0*	*2*	*0*	*0*	2	3.90	*0*
2006	*1*	*0.49*	*0*	*0*	*0*	*0*	1	*0.49*	*0*
Mean	3.13	2.05	0.00	2.13	1.13	0.00	0.88	0.92	0.00
Climatological Mean (83–08)	3.65	5.62	0.50	2.77	4.71	0.46	0.81	0.91	0.04

La Nina years ACE over BOB→ 9.63 kt^2

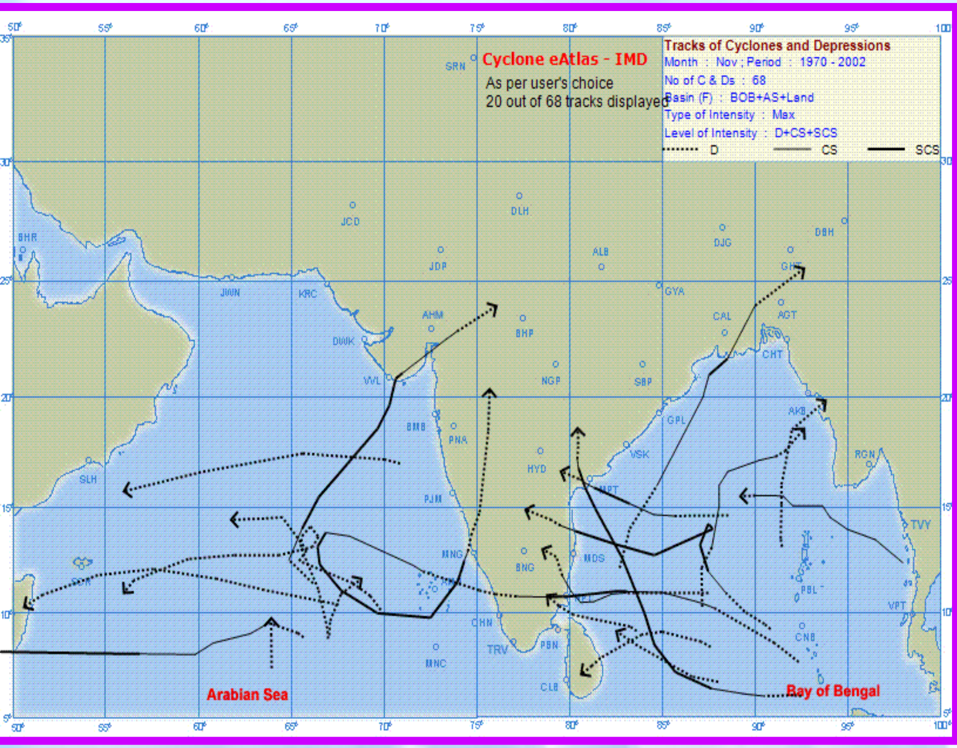
Table IV. Same as Table III, except for La Niña years. Numbers in italics indicate values above the climatological mean (1983–2008).

La Niña year	NTC	NIO ACE(kt^2)	NIC	NTC	BB ACE(kt^2)	NIC	NTC	AS ACE(kt^2)	NIC
1984	3	*16.34*	*2*	*3*	*16.34*	*2*	0	0	0
1988	*4*	*13.27*	*1*	*4*	*13.27*	*1*	0	0	0
1995	3	*9.15*	*1*	2	*7.76*	*1*	*1*	*1.38*	0
1998	*6*	*5.80*	*1*	*3*	2.79	*1*	*3*	*3.01*	0
1999	3	*18.17*	*2*	*3*	*18.17*	*2*	0	0	0
2000	*4*	*7.51*	*2*	*4*	*7.51*	*2*	0	0	0
2008	*5*	1.54	0	*4*	1.54	0	*1*	0	0
Mean	4.00	10.25	1.29	3.29	9.63	1.29	0.71	0.63	0.00
Climatological Mean (83–08)	3.65	5.62	0.50	2.77	4.71	0.46	0.81	0.91	0.04

Ng & Chan, 2011

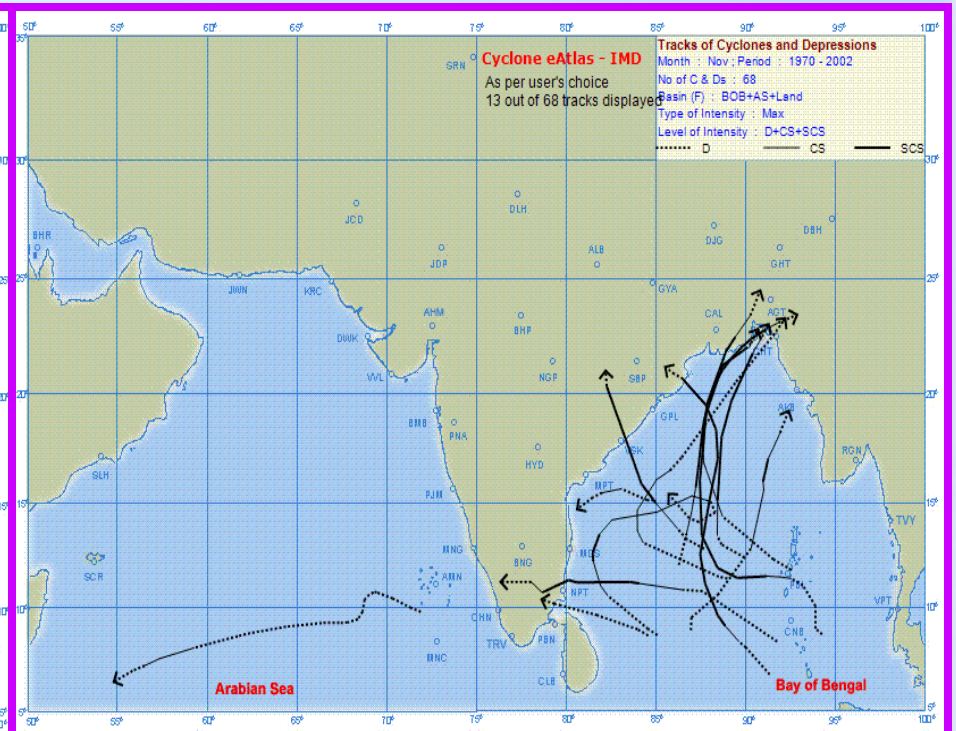
Tracks of tropical cyclones – El-Nino *vs* La-Nina

El Nino (1970 onwards; 8 years – Nov-1972,77,82,87,91,94,97,2002)



More westward tracks; Good TC activity over AS.

La Nina (1970 onwards; 6 years- Nov- 1970,73,75,88,98,2000)



More northward moving cyclones that sweep away moisture from S to N latitudes leading to suppressed NEM activity over southern India

Translational Speed of CD

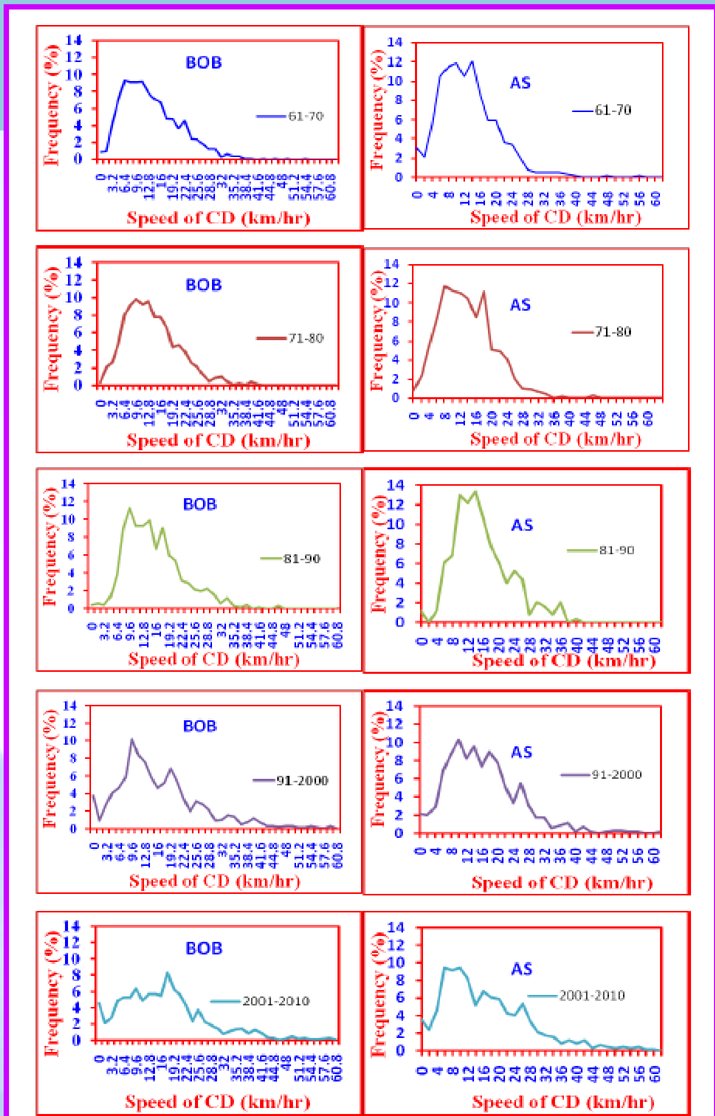


TABLE 2

Decade-wise mean speeds of movement and standard deviations

Decade	BOB			AS		
	N	Mean (km/hr)	S. D. (km/hr)	N	Mean (km/hr)	S. D. (km/hr)
1961-70	2005	12.64	7.55	659	12.03	7.56
1971-80	1367	12.86	7.7	798	12.55	6.84
1981-90	655	14.74	7.18	246	14.82	7.46
1991-00	1254	16.3	12.4	691	15.86	11.8
2001-10	1379	16.64	12.3	752	16.32	14.3

DECADAL VARIATIONS IN TRANSLATIONAL SPEED OF CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN GEETHA, BALACHANDRAN MAUSAM, 65, 1 (January 2014), 115-136

Translational speed of CD

BOB

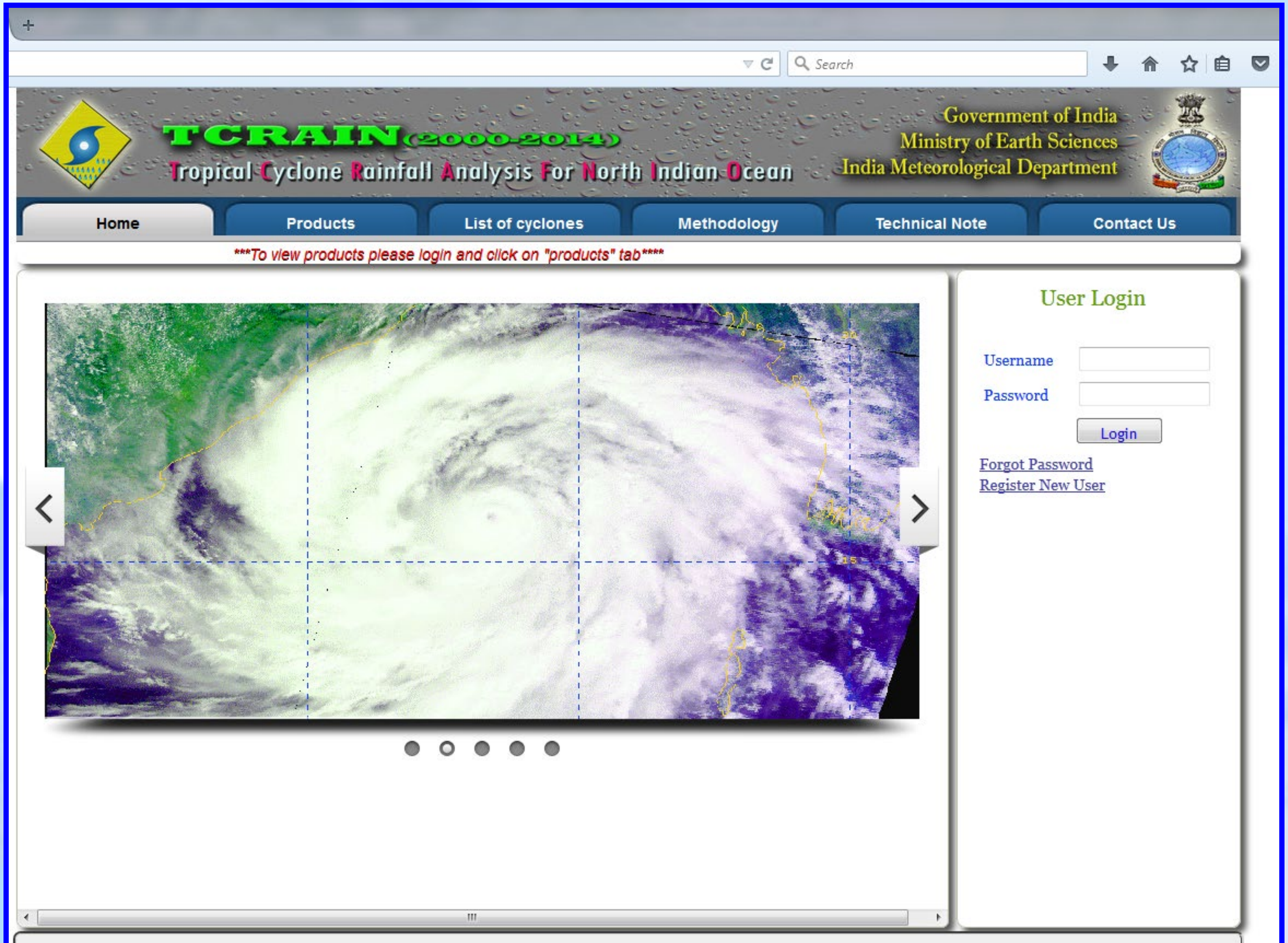
Decade	Modal values
1961-1970	6.4 km/hr (9.3%), 11.2 km/hr (9.2%)
1971-1980	9.6 km/hr (9.8%), 12.8 km/hr (9.5%)
1981-1990	9.6 km/hr (11.3%), 14.4 km/hr (9.9%), 17.6 km/hr (9%)
1991-2000	9.6 km/hr (10.2%), 19.2 km/hr (7%)
2001-2010	17.6 km/hr (8%), 25.6 km/hr (4%) & 9.6 km/hr (3%).

ARB.

Decade	Modal values
1961-1970	14 km/hr (12%), 10 km/hr (11.8%)
1971-1980	8 km/hr (11.7%), 18 km/hr (11.1%)
1981-1990	14 km/hr (13.4%), 10 km/hr (13%)
1991-2000	10 km/hr (10.3%), 14 km/hr (9.6%), 18 km/hr (9%)
2001-2010	6 km/hr (9.4%), 10 km/hr (9.4%), 16 km/hr (6.8%)

DECADAL VARIATIONS IN TRANSLATIONAL SPEED OF CYCLONIC DISTURBANCES OVER NORTH INDIAN OCEAN GEETHA,BALACHANDRAN MAUSAM, 65, 1 (January 2014), 115-136

Cyclone Rainfall Atlas- TC RAIN – WEB TOOL (based on TRMM data : 2000-2014)



TC RAIN

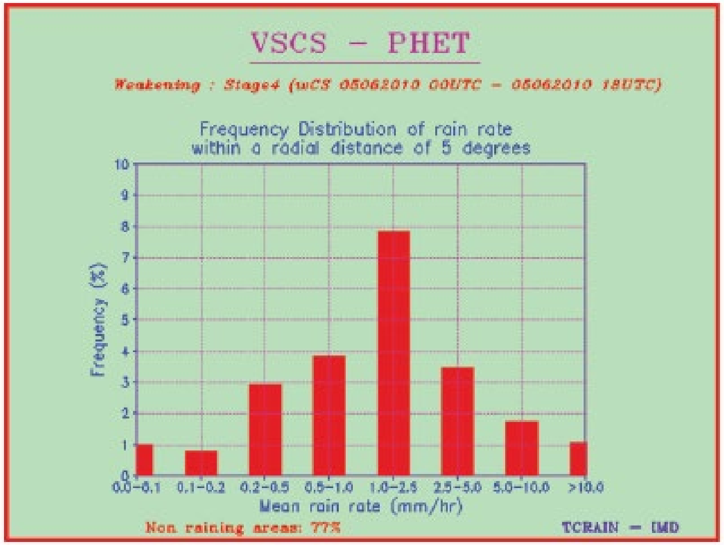


Fig. 2. Sample product of Frequency distribution of rain rates within 5° radial distance

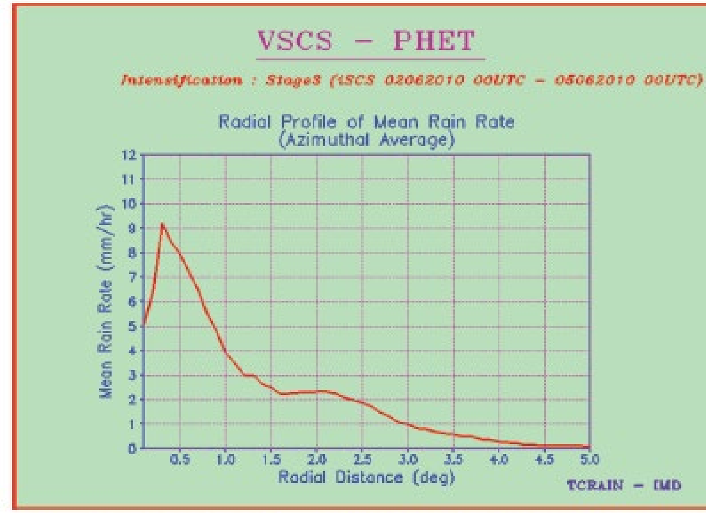


Fig. 3b. A sample product of Radial Profile of rain rates within 5° radial distance

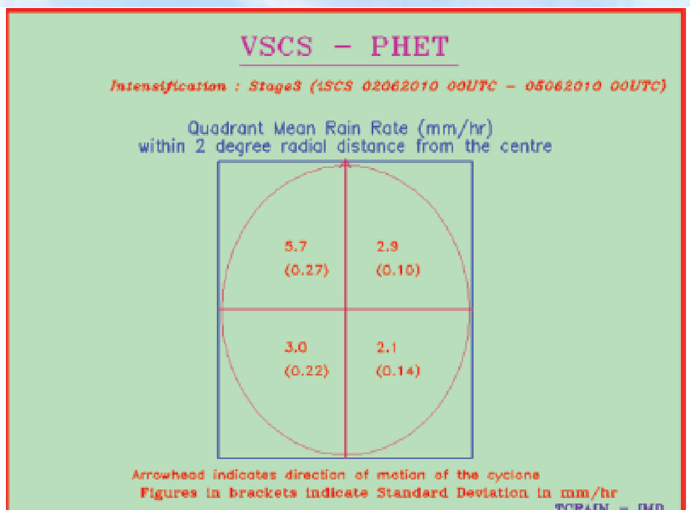


Fig. 4b. A sample product of quadrant mean rain rates within 2° radial distance

Cyclone Rainfall Atlas- TC RAIN – WEB TOOL

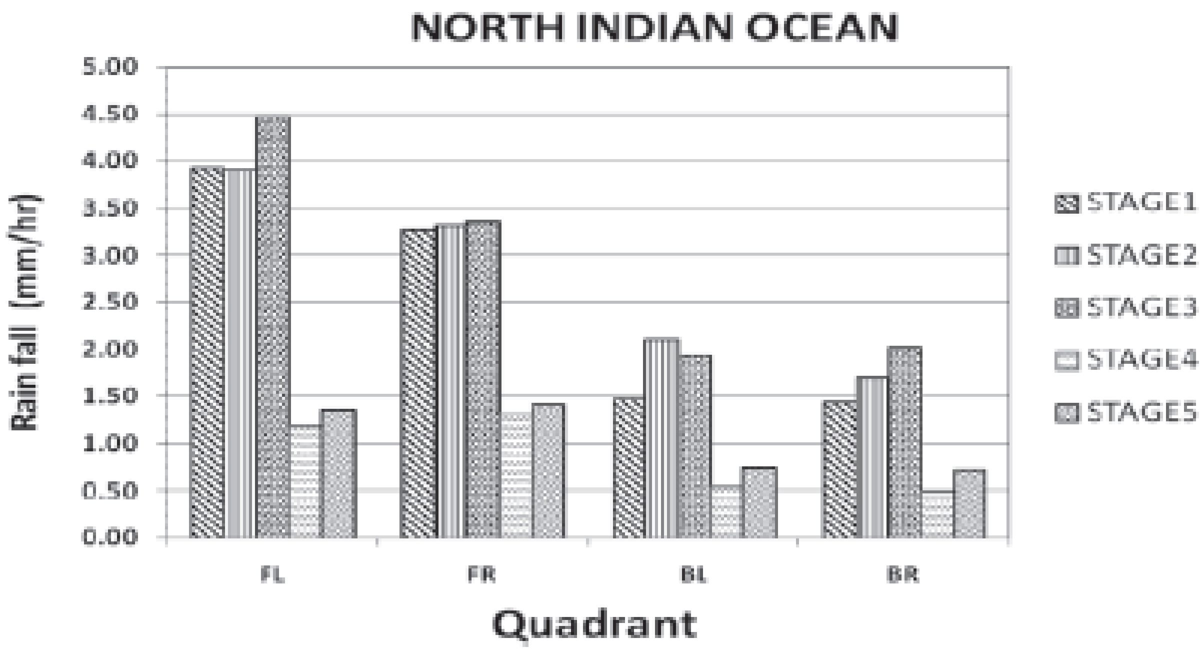
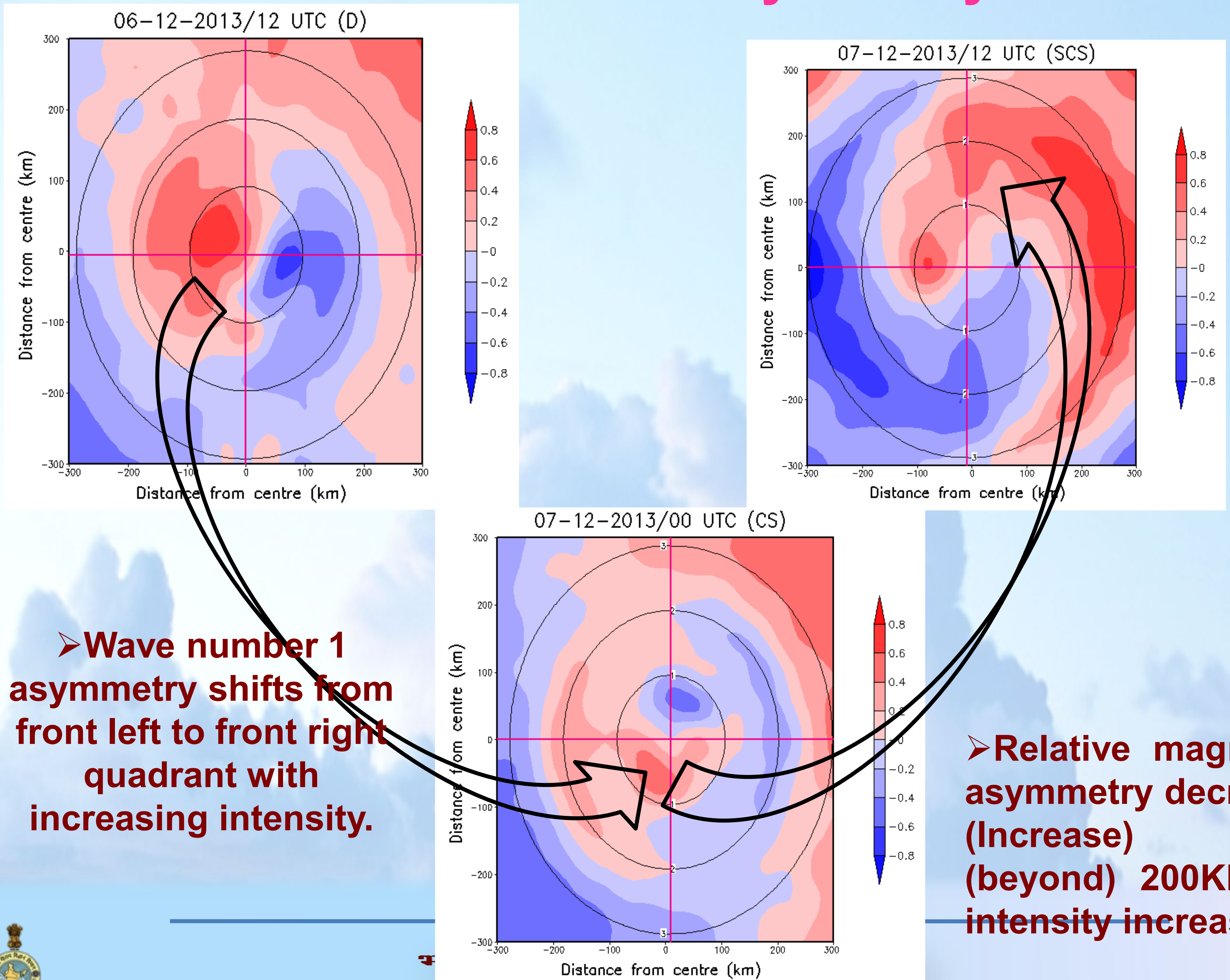


FIG. 6a. Quadrant mean rain rates during various stages of intensity of TCs of NIO. FL: front left, FR: front right, BL: back left and BR: back right quadrants

TCRAIN – A DATABASE OF TROPICAL CYCLONE RAINFALL PRODUCTS FOR NORTH INDIAN OCEAN
S. Balachandran et. al , DOI: 10.6057/2014TCRR02.05

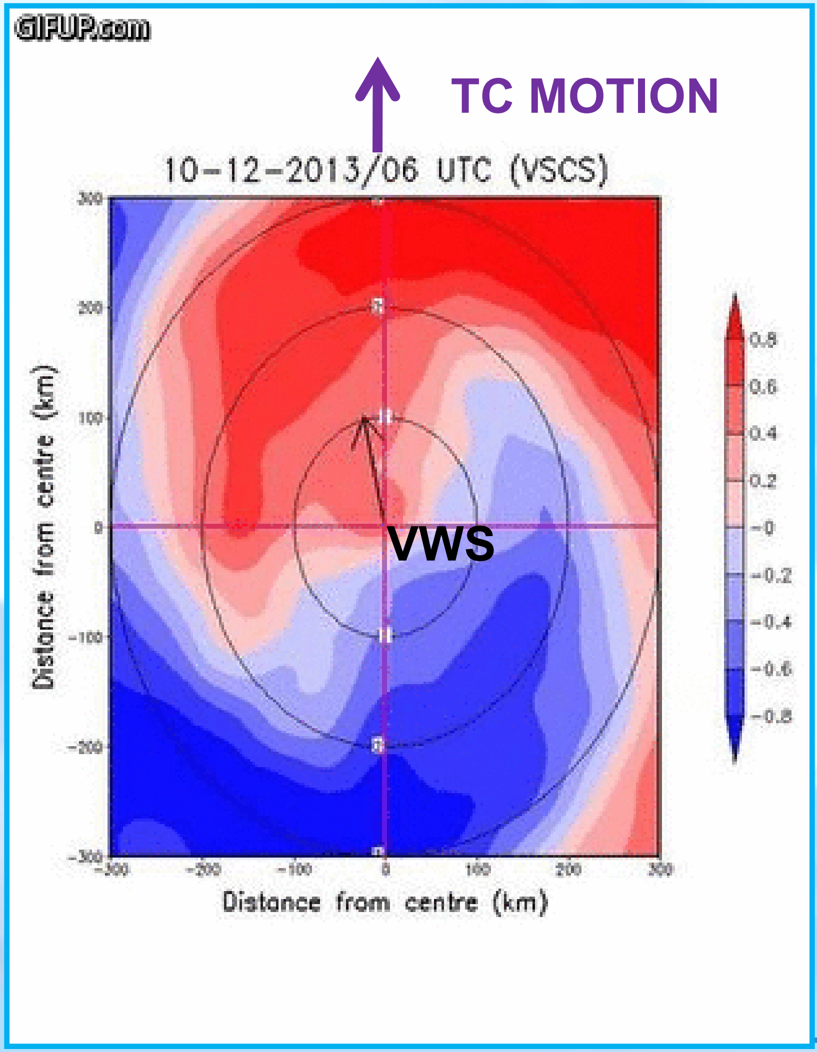
Time evolution of rainfall asymmetry –VSCS MADI



➢**Wave number 1 asymmetry shifts from front left to front right quadrant with increasing intensity.**

➢**Relative magnitude of asymmetry decrease (Increase) within (beyond) 200KM as TC intensity increases.**

Asymmetry during recurving and looping stages w.r.t TC movement and VWS- VSCS MADI



- During Recurvature, there was change in orientation between shear and TC motion vectors And the R/F maximum was noted in down shear – left quadrant

Table 1a. Rapid intensification cases of TCs considered for the study

TC name, month & basin of occurrence	RI instance – date & time in UTC From	To	Change in MSW in 24 hrs (kt)
SuCS *Gonu* -Jun 2007, AS	03/1200 (55)	04/1200 (115)	+60
VSCS *Sidr* -Nov 2007, BOB	12/0000 (30)	13/0000 (90)	+60
VSCS *Giri* -Oct 2010, BOB	21/1200 (45)	22/1200 (105)	+60
VSCS *Phailin* -Oct 2013, BOB	10/0000 (45)	11/0000 (110)	+65
VSCS *Nilofar* - Oct 2014, AS	27/1800 (70)	28/1800 (110)	+40

TC: Tropical Cyclone; RI: Rapid intensification; MSW: Maximum sustained surface wind speed

AS: Arabian Sea; BOB: Bay of Bengal;

VSCS: Very severe cyclonic storm (MSW:64-119 kts);

SuCS: Super cyclonic storm (MSW: ≥120 kts)

Figures in brackets indicate MSW in kts.

Table 1b. Rapid weakening cases of TCs considered for the study

TC name, month & basin of occurrence	RW instance – date & time in UTC From	To	Change in MSW in 24 hrs (kt)
SuCS *Gonu* -Jun 2007, AS	04/1800 (127)	05/1800 (77)	-50
SCS *Jal* - Nov 2010, BOB	06/1200 (60)	07/1200 (30)	-30
VSCS *Lehar* -Nov 2013, BOB	26/1800 (75)	27/1800 (45)	-30
VSCS *Madi* -Dec 2013, BOB	10/0600 (65)	11/0600 30	-35
VSCS *Nilofar* - Oct 2014, AS	29/0600 (95)	30/0600 (45)	-50

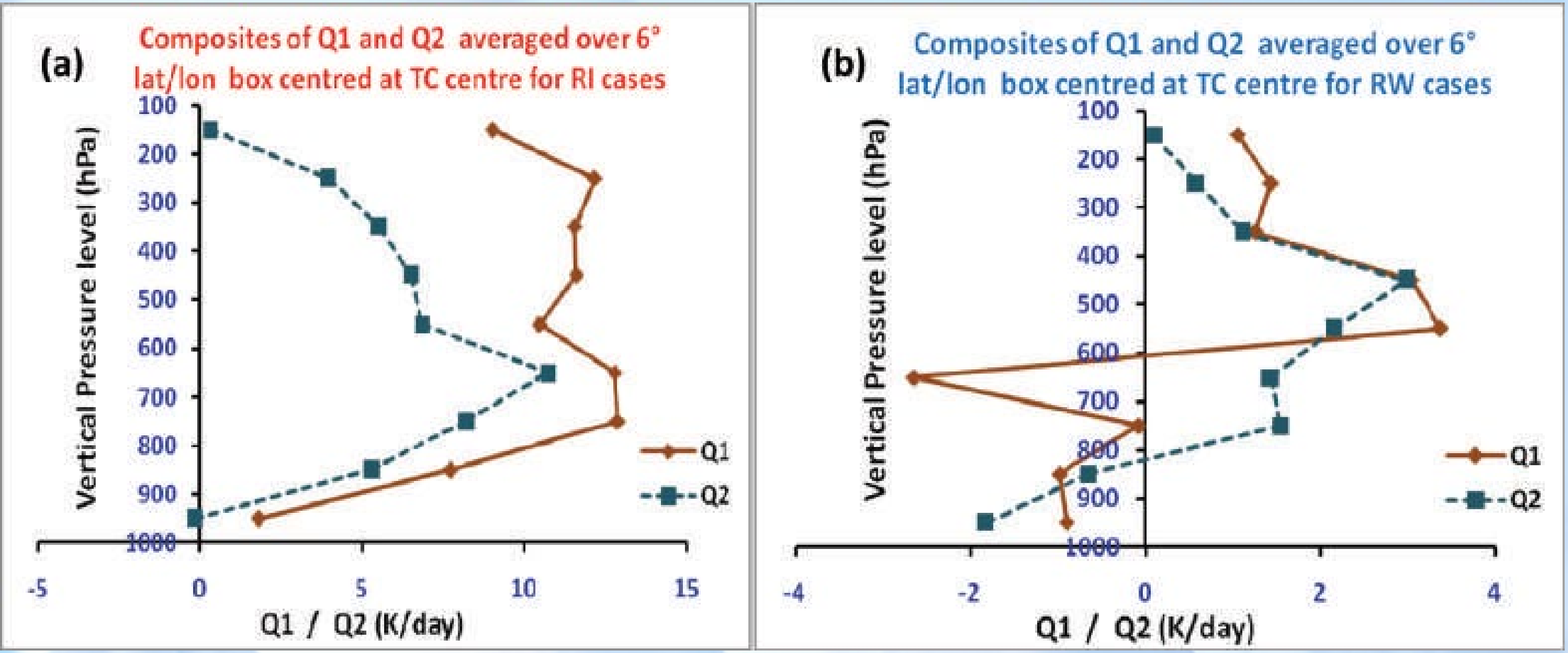
RW: Rapid weakening; TC, MSW, AS, BOB, VSCS, SuCS: as in Table 1a

SCS: Severe cyclonic storm (MSW:48-63 kts)

Figures in brackets indicate MSW in kts.

B.Geetha and S.Balachandran*
India Meteorological Department, Regional Meteorological Centre, Chennai, India

Diabatic heating during Rapid intensity changes



Convection asymmetry during Rapid Intensity changes

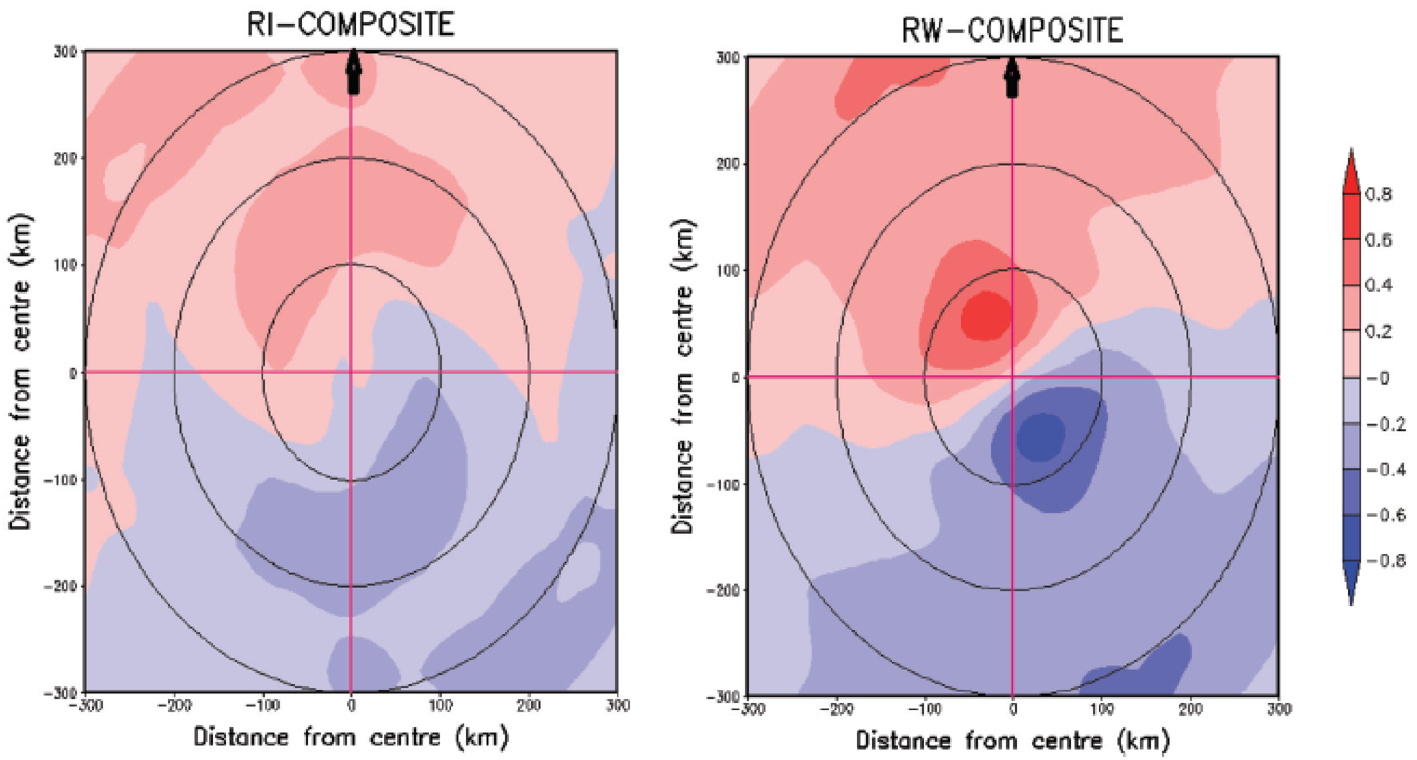


FIG. 6c. Fourier first order wave number -1 asymmetry composites for RI and RW events. The asymmetry amplitude values are the fraction of wavenumber 1 to wavenumber 0 (azimuthal average) asymmetry, i.e., a value of 0.2 indicates that the wavenumber-1 asymmetry is 20% of the azimuthal mean value. Arrow head indicates the direction of TC movement.

TCG location variability

Table 7: Seasonal normal latitude and longitude of formation over BOB and AS during 1951-1980 and 1981-2010

Season/ Basin	*No. formed*		*Mean lon. of formation (E)*		*Mean lat. of formation*		*S.D of lon. of formation*		*S.D of lat. of formation*	
	1951-1980	1981-2010	1951-1980	1981-2010	1951-1980	1981-2010	1951-1980	1981-2010	1951-1980	1981-2010
					MAM					
AS	14	8	**69.59**	**65.86**	**10.99**	**12.68**	3.55	6.46	2.92	1.64
BOB	34	28	89.47	88.92	12.65	12.90	3.95	3.28	3.74	4.08
					JJAS					
AS	31	23	69.92	69.38	18.88	18.72	2.44	3.29	4.19	4.09
BOB	194	97	88.46	87.58	19.55	19.97	2.64	3.30	2.54	2.55
					OND					
AS	32	27	69.47	68.43	12.18	11.46	3.29	3.58	4.02	3.77
BOB	126	100	88.22	87.62	**10.82**	**11.91**	3.91	4.41	3.80	3.81

Climate Dynamics
https://doi.org/10.1007/s00382-019-04794-1

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Meridional oscillation in genesis location of tropical cyclones in the postmonsoon Bay of Bengal

Kaigui Fan[1] · Xidong Wang[1,2] · Gregory R. Foltz[3] · Karthik Balaguru[4]

Received: 11 December 2018 / Accepted: 29 April 2019

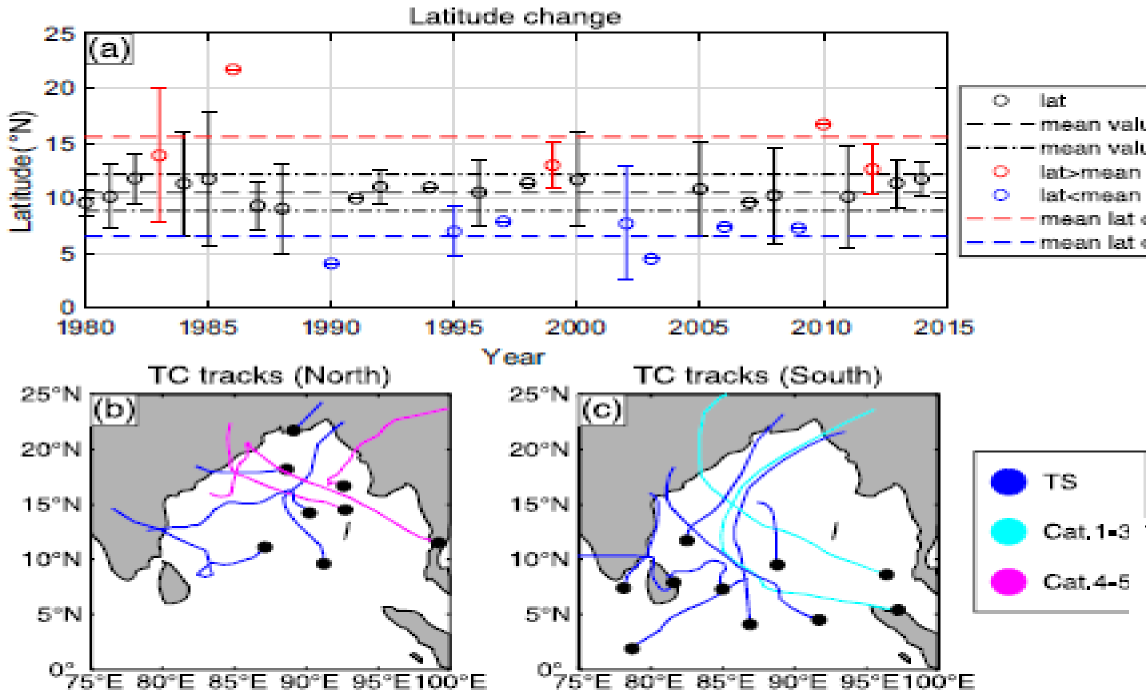

Fig. 1 **a** Time series of the average genesis latitude of TCs in the postmonsoon (October–December) BoB during 1980–2015. The error bar represents the standard deviation of latitudes in each year. **b**, **c** TC tracks in north-years and south-years of TC genesis locations. In **b** and **c**, the black dots denote the genesi lines represent the TC tracks. The blue, c tropical storm (TS), category 1–3 TC and tively

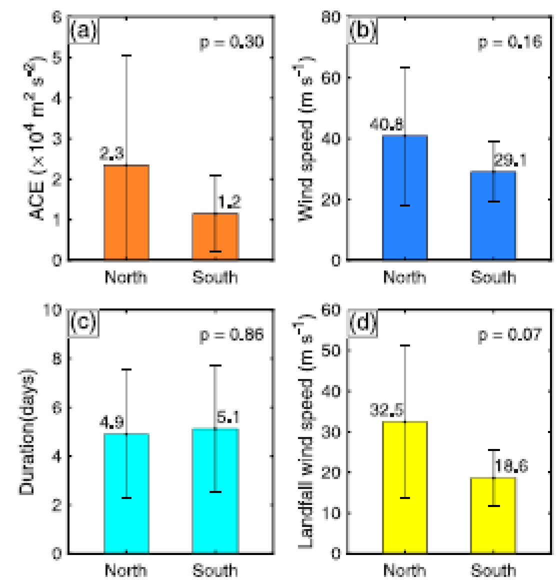

Fig. 2 Average of **a** ACE, **b** maximum sustained wind speed, **c** duration and **d** landfall maximum sustained wind speed for each TC in north-years and south-years of TC genesis locations. The error bar represents the standard deviation. The p-value in each panel is based on a two-tailed Student's *t* test for difference of means between north-years and south-years

Climate Dynamics
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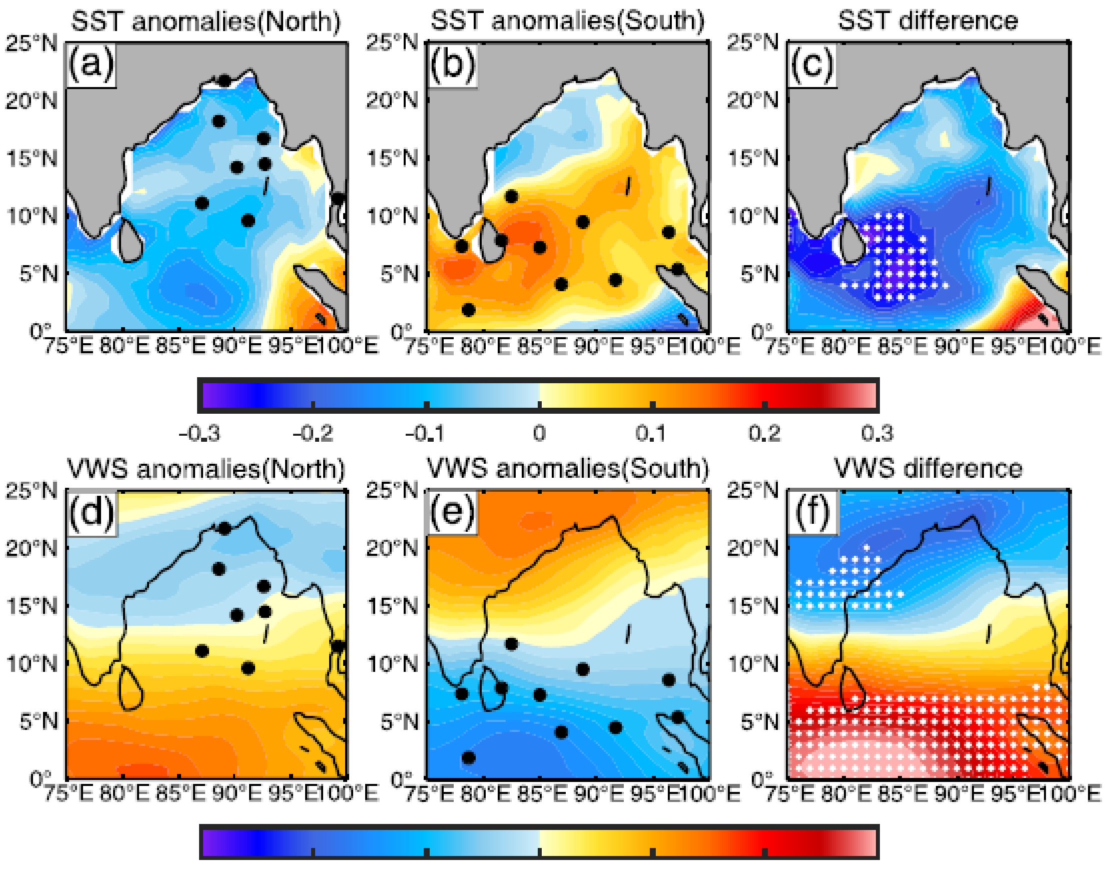
Fig. 3 Composites of **a**, **b** SST (°C) anomalies, **d**, **e** vertical wind shear (m s^{-1}) anomalies, **g**, **h** 600 hPa relative humidity (%) anomalies, and **j**, **k** 850 hPa relative vorticity (10^{-6} s^{-1}) anomalies for north-years and south-years of TC genesis locations, averaged over October–December. The black dots denote the genesis locations during north-years and south-years of TC genesis locations. Also shown is the composite differences of **c** SST (°C), **f** vertical wind shear (m s^{-1}), **i** 600 hPa relative humidity (%) and **l** 850 hPa relative vorticity (10^{-6} s^{-1}). The composite difference is defined as the composite for north-years minus that of south-years of TC genesis locations. The white dots denote values that are statistically significant at the 90% level



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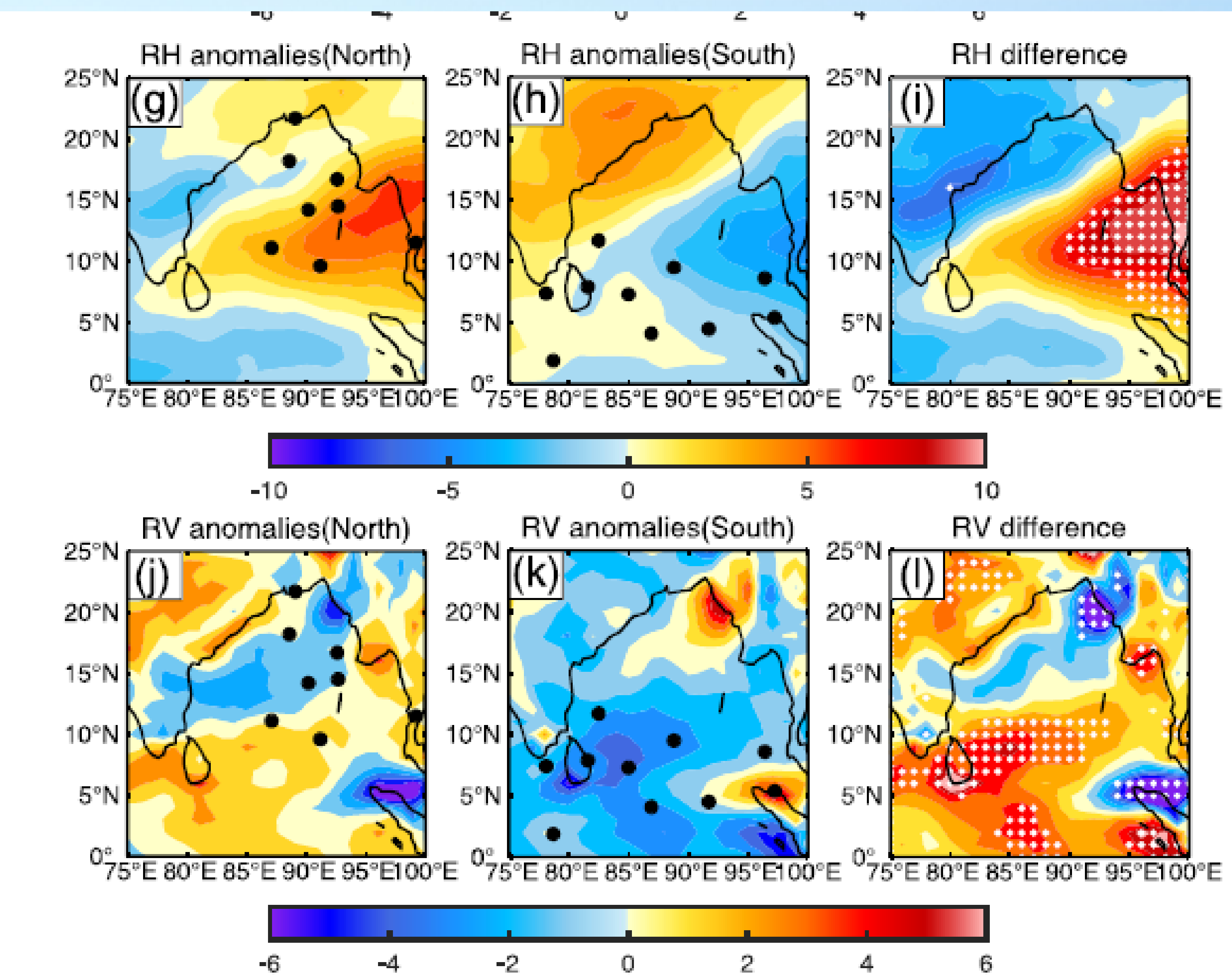

RH anomalies(North)
RH anomalies(South)
RH difference
(g)
(h)
(i)
25°N
20°N
15°N
10°N
5°N
0°
75°E 80°E 85°E 90°E 95°E 100°E
-10
-5
0
5
10
RV anomalies(North)
RV anomalies(South)
RV difference
(j)
(k)
(l)
-6
-4
-2
0
2
4
6

MJO-TC

TABLE 3(c)

Number of days and probability of different intensities of CDs with respect to different phases of MJO during post monsoon season

MJO Phase (α)	No. of days with α	D days		C days		S days		C+S days	
		No. of days	Probability (%)	No. of days	Probability (%)	No. of days	Probability (%)	No. of days	Probability (%)
1	342	27*	7.89*	7	2.05	6	1.75	13*	3.8*
2	380	56	14.74	16	4.21	13	3.42	29	7.63
3	370	59*	15.95*	17	4.59	17#	4.59#	34*	9.19*
4	379	68*	17.94*	18	4.75	16	4.22	34#	8.97#
5	399	76*	19.05*	19	4.76	13	3.26	32	8.02
6	353	31*	8.78*	10	2.83	9	2.55	19	5.38
7	393	18*	4.58*	6*	1.53*	7	1.78	13*	3.31*
8	351	29*	8.26*	13	3.7	7	1.99	20	5.7
Total	2967	364		106		88		194	
Mean	370.88	45.5	12.15	13.25	3.55	11	2.95	24.25	6.5

* : Number of days and probability significantly different from the average at 95 % level of confidence according to Z test.
# : Same as * but at 90 % level of confidence.

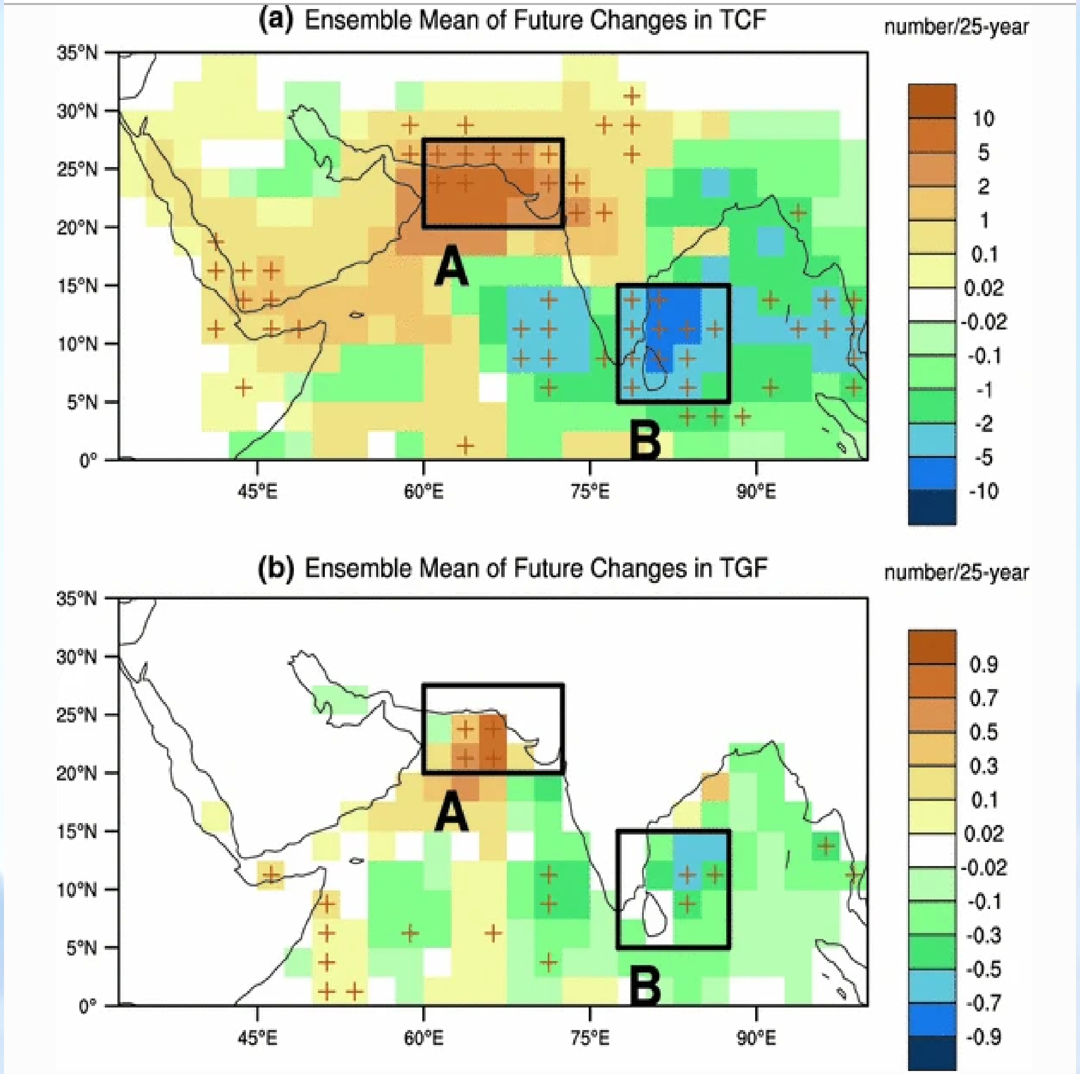
Mohapatra ,2011

MJO-TC

(*iii*) The anomalous cyclonic circulation at lower levels over central and north Bay of Bengal in association with MJO at phase 4 and 5 favours enhanced probability of cyclogenesis over the Bay of Bengal during monsoon season. The anomalous easterlies in association with MJO at phase 1 and development of anomalous ridge over south India in association with MJO at phase 7 and 8 which are weak monsoon features lead to suppressed cyclogenesis over north Indian Ocean during this season. The

anomalous north-south trough in easterlies embedded with cyclonic circulation over the south west/west central Bay of Bengal in association with southerly surge over the region during active MJO in phase 3 and 4 most favourably influences the convection and enhances the probability of cyclogenesis over the north Indian Ocean during post-monsoon season.

Mohapatra ,2011



Future changes in tropical cyclone activity in the North Indian Ocean projected by high-resolution MRI-AGCMs

Murakami et.al Climate dynamics , 40,1949-68,2013

a Ensemble mean future changes in tropical cyclone frequency (TCF) [number/25 years]. The *plus symbols* indicate that the differences are statistically significant at the 99 % confidence level or above (two-sided Student's *t* test) and that more than 80 % of the ensemble members project mean changes of the same sign. **b** As in **a**, but for tropical cyclone genesis frequency (TGF). The regions labelled in the figure (*A*, *B*) are discussed in the text

Summary

- The genesis, intensity and movement of tropical disturbances and Tropical cyclones during Post monsoon season play significant role in the rainfall activity over southern peninsular region.

- With increased availability of Satellite, Radar and high resolution NWP would help in further understanding of dynamics and intricacies of activity of these systems and hence improved predictive skill of NEM.


THANK YOU
REUTERS/Yannis Behrakis

Statistical Prediction of Seasonal Cyclonic Activity over the North Indian Ocean

Statistics of number of CD days during OND over NIO for the period 1971-2010.

Month	Mean (days)	SD (days)
Oct	7.3	4.09
Nov	8.9	5.19
Dec	3.3	3.34
OND	19.57	7.99

Categorisation of No. of CD days for qualitative description of cyclonic activity

- Based on mean number of CD days (20 days) and half of the standard deviation of the number of CD days (4 days) during OND over NIO for the period 1971-2010, the following criteria is adopted for the categorisation of cyclonic activity (CA) :

Category	Activity
No. of CD days less than 12	: subdued CA.
No. of CD days between 12 and 16 days	: below normal CA.
No. of CD days between 16 and 24 days	: Normal CA.
No. of CD days greater than 24 days	: above normal CA.

- Here, half of the standard deviation is considered for categorisation in order to get sufficient number of samples in each of the defined categories.

Final predictors

(i) **PR1**: meridional wind at 200 hPa level over 95-105˚E & 5˚S to 2˚N during August (v200,Aug)

(ii) **PR2**: zonal wind at 200 hPa level over 30-42˚E & 7˚S to 5˚N during August (u200,Aug)

(iii) **PR3**: SST over 46-56˚E & 38-34˚S during July& Aug (SST,Jul-Aug).

(iv) **PR4**: zonal wind at 700 hPa level over 73-80˚E & 5˚S to Equator during August (u700,Aug)

Regions over which the four chosen predictors PR1,PR2, PR3 and PR4 are selected.