Cyclogenesis : Monitoring and Prediction

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Presentation layout

- Introduction
- Cyclone Monitoring
  - Genesis
  - Location
  - Intensity
- Cyclone Prediction
  - Location/Track
  - Intensity
  - Adverse weather (Heavy rain, Gale wind, storm Surge)
- Problem areas and possible collaboration
- Conclusions

Definition of a tropical cyclone

- **World Meteorological Organization's official definition :**

  A tropical cyclone (hurricane, typhoon) **is**

  - **a** synoptic scale (≥100 km) **,**
  - non-frontal (no sharp gradient of temperature) **disturbance,**
  - **over** tropical or subtropical **waters ,**
  - **with** organized convection**, and**
  - **definite** cyclonic surface wind circulation.

Evolution of Cyclonic disturbances Over the Indian Seas

Low pressure system	Maximum sustained winds	
Low	< 17 knots	< 31 kmph
Depression	17 – 27 kts	31 – 51 kmph
Deep Depression	28 – 33 kts	52 – 62 kmph
Cyclone	34 – 47 kts	63 – 87 kmph
Severe Cyclone	48 – 63 kts	88 – 117 kmph
Very Severe Cyclone	64 – 119 kts	118 – 221 kmph
Super Cyclone	120 kts & above	222 kmph & above

System	Pressure deficit (hPa) at the centre
Low	1.0
Depression	1.0 – 3.0
Deep Depression	3.0 – 4.5
Cyclone	4.5-8.5
Severe Cyclone	8.5-15.5
Very Severe Cyclone	15.5-65.6
Super Cyclone	>65.6

Genesis : Monitoring and prediction

- Analysis of all synoptic, satellite and NWP model products for genesis, intensity and track monitoring and prediction using synergie
- Development of an objective conceptual model (Macro)

- Daily Watch and issue of tropical weather outlook for genesis
- Check list
- Road Map /Methodology

« Seasonal cyclogenesis parameter »

The climatological aspects of the seasonal frequency of tropical cyclone formation at any location are closely related to the product of 6 seasonally averaged parameters (Gray, 1975, 1979) :

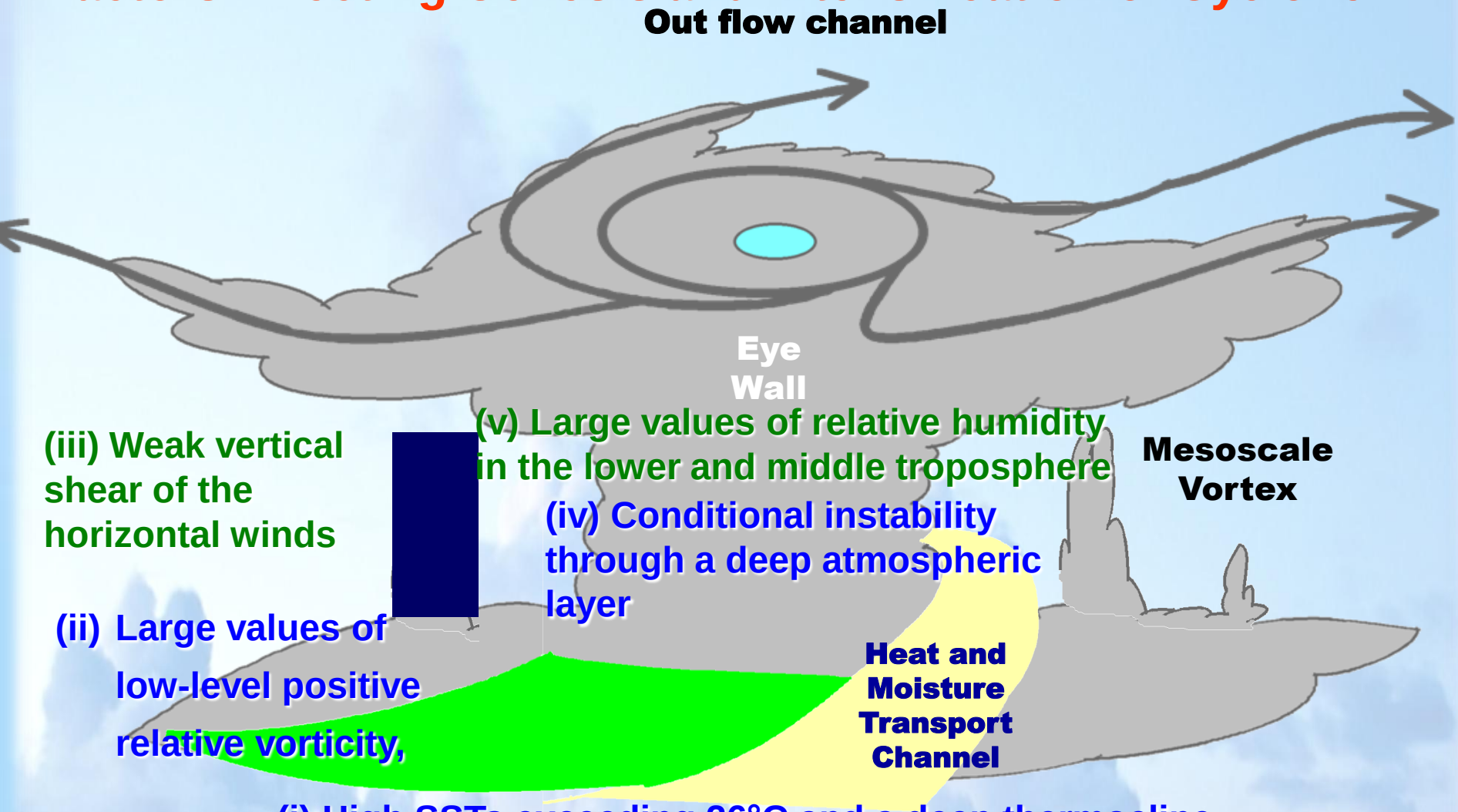
THERMAL POTENTIAL

- **Ocean thermal energy**
- **Humidity**
- **Instability**

DYNAMIC POTENTIAL

- **The Coriolis parameter**
- **Low level relative vorticity**
- **Inverse of the tropospheric vertical wind shear**

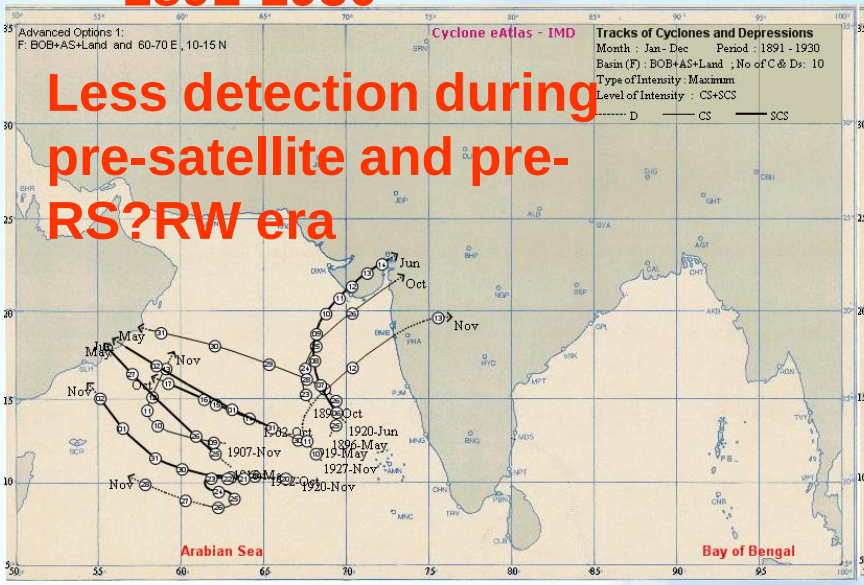
Factors Affecting Genesis and intensification of Cyclone



(Heavily dependent on Ocean observations)

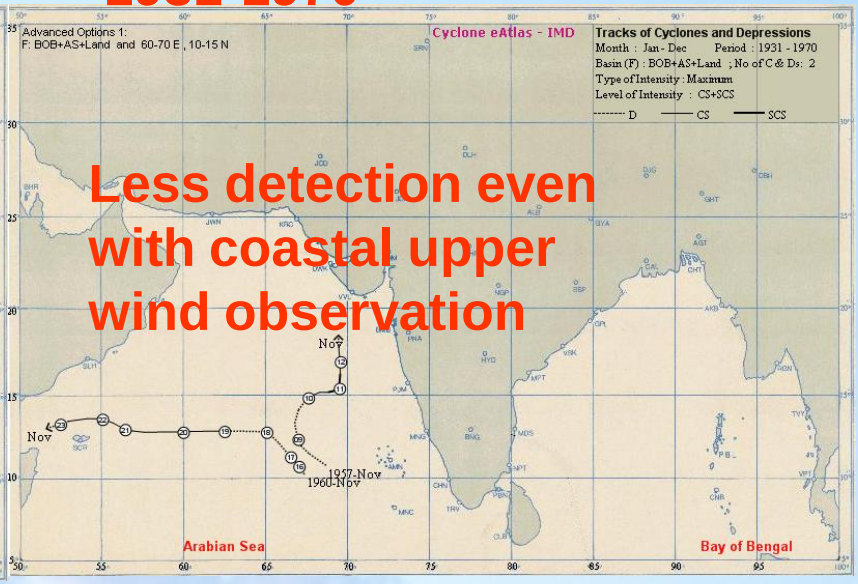
Cyclone Monitoring : Role of Satellite

1891-1930



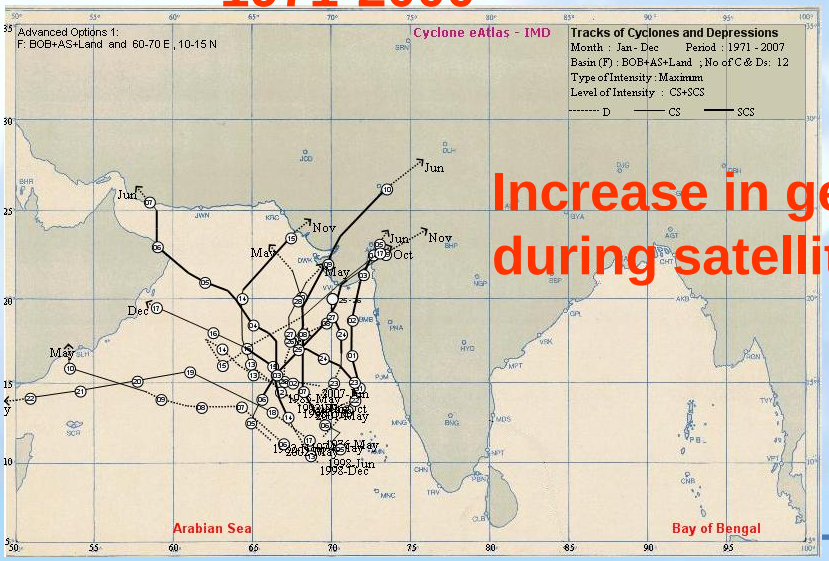
Less detection during pre-satellite and pre-RS?RW era

1931-1970



Less detection even with coastal upper wind observation

1971-2000



Increase in genesis during satellite era

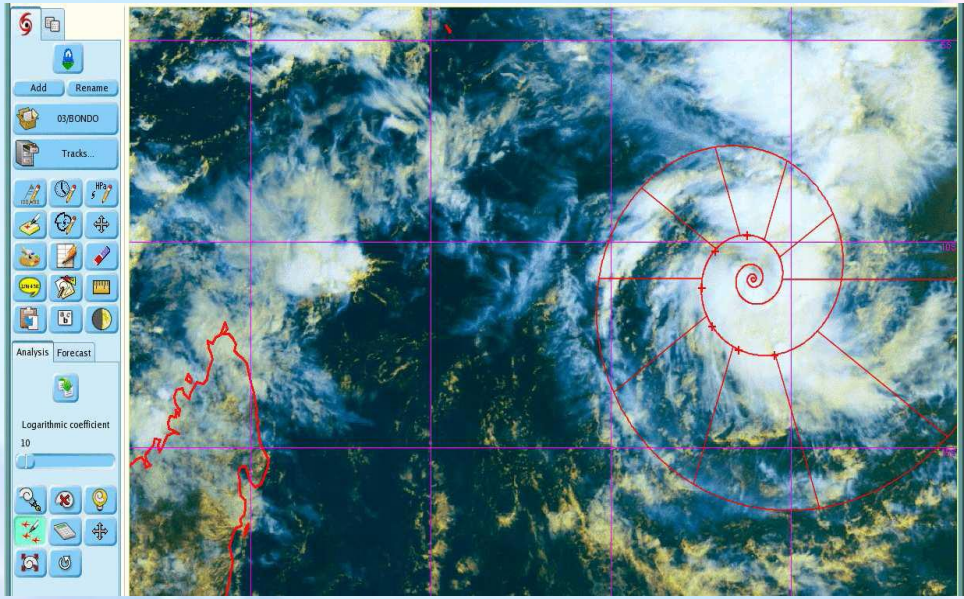
Frequency of cyclones over the region 10-15 N and 60-70 E

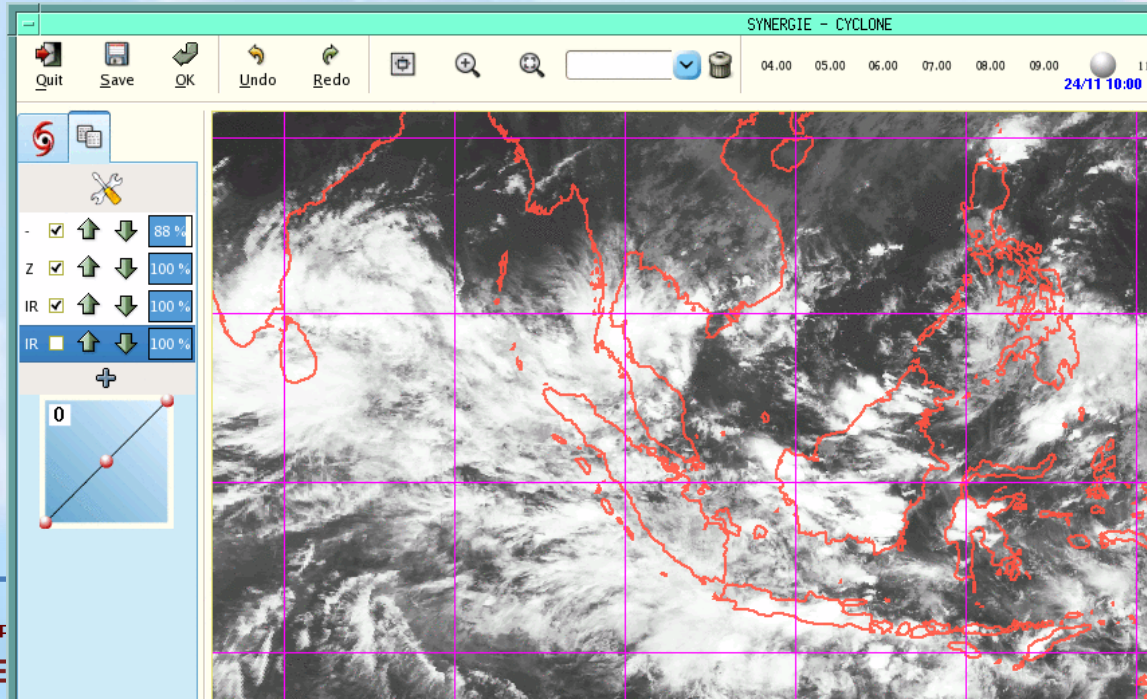
Met. Satellites of special relavance to TC analysis over NIO

- INSAT and Kalpana
- Oceansat
- DMSP
- NOAA
- METEOSAT
- METOPS
- MODIS
- TRMM
- VIS and IR images from polar orbiting satellites have been in use in IMD since 1960s for TC analysis
- Dvorak's technique for intensity classification is used for north Indian Ocean since 1974.

Basic Geostationary Imagery for Cyclone Monitoring

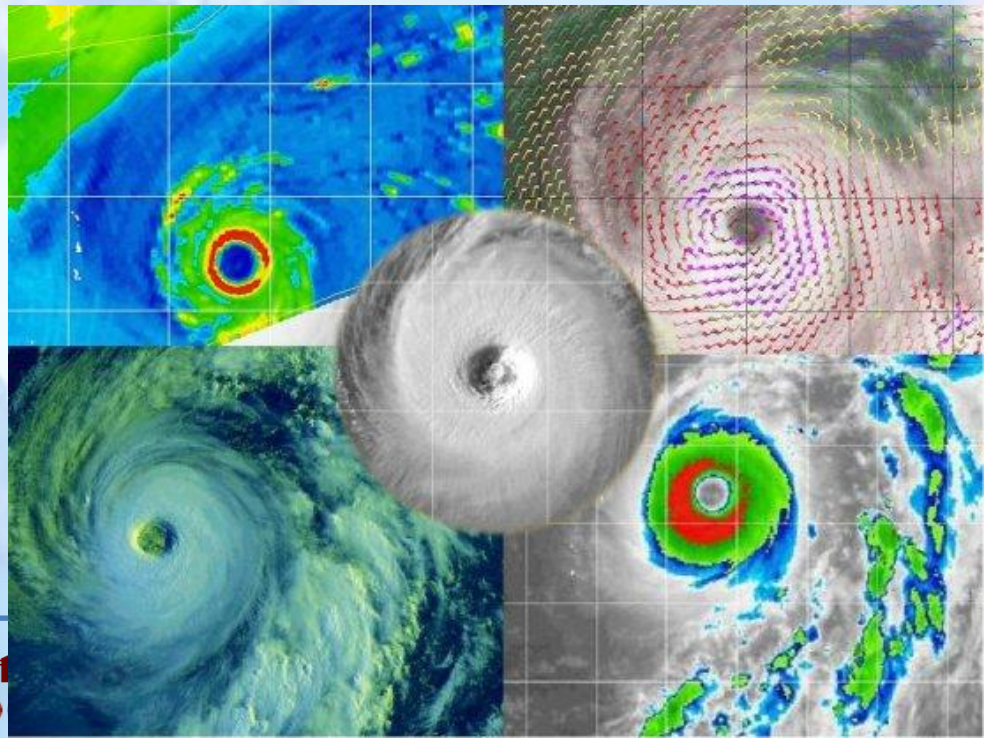
- **Visible**
  - Tracking (locating the centre)
  - For intensity analysis by Dvorak Technique
- **Infra-Red**
  - Tracking (locating the centre)
  - For structure analysis
  - For intensity analysis
- **Water Vapour**
  - For synoptic assessment of the storm environment



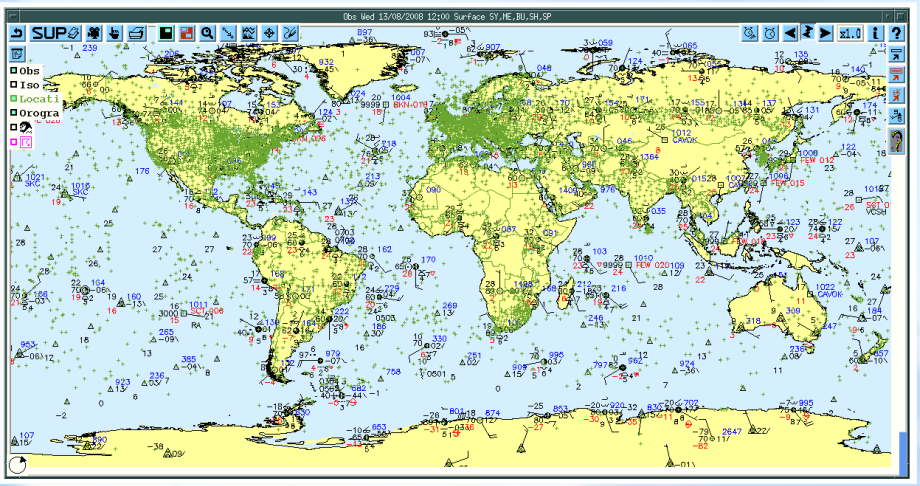


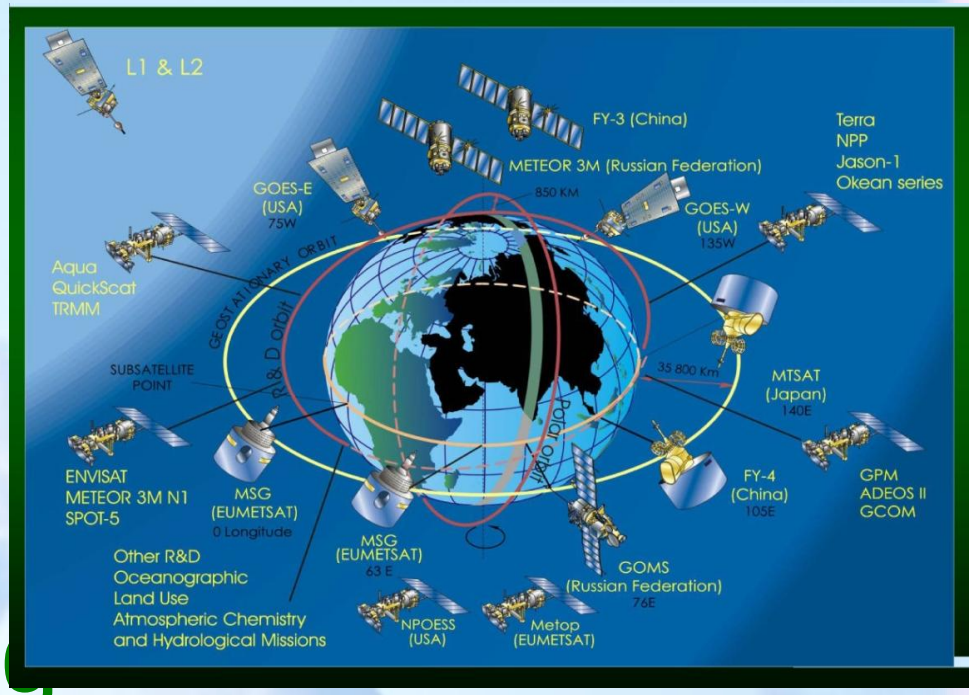
New prospects for TC analysis : the micro-wave data

- **Passive Microwave Imagers (PMW)**
  - **Passive Microwave imagers (PMW) may key TC structural rainband organization and eyewall development**
- **Microwave Sounders (MSU)**
  - **Microwave Sounders can be used to estimate the intensity of TC**
  - **The AMSU instrument is a cross-tracking microwave sounder containing 15 channels with frequencies ranging from 23.8 to 89 GHz.**
    - The AMSU-A oxygen band channels 5-8 are well-suited to monitor warm core temperature
- The Rain rate Data
  - TMI rain data
  - TRMM (Tropical Rainfall Measuring Mission) rain data
- Scatterometer Data

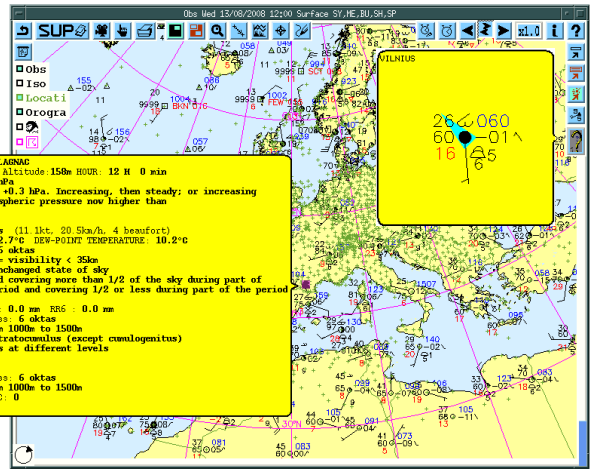


A typical daily products in Forecasting System during 2011

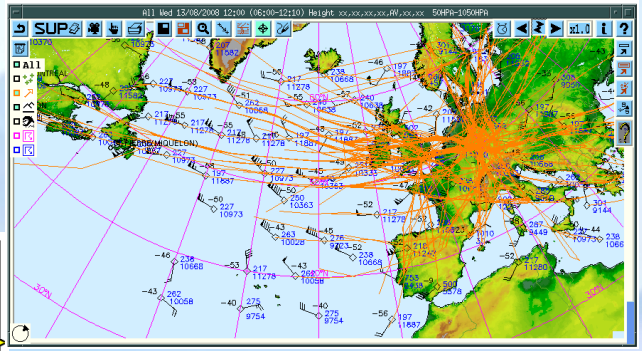




Global plotting

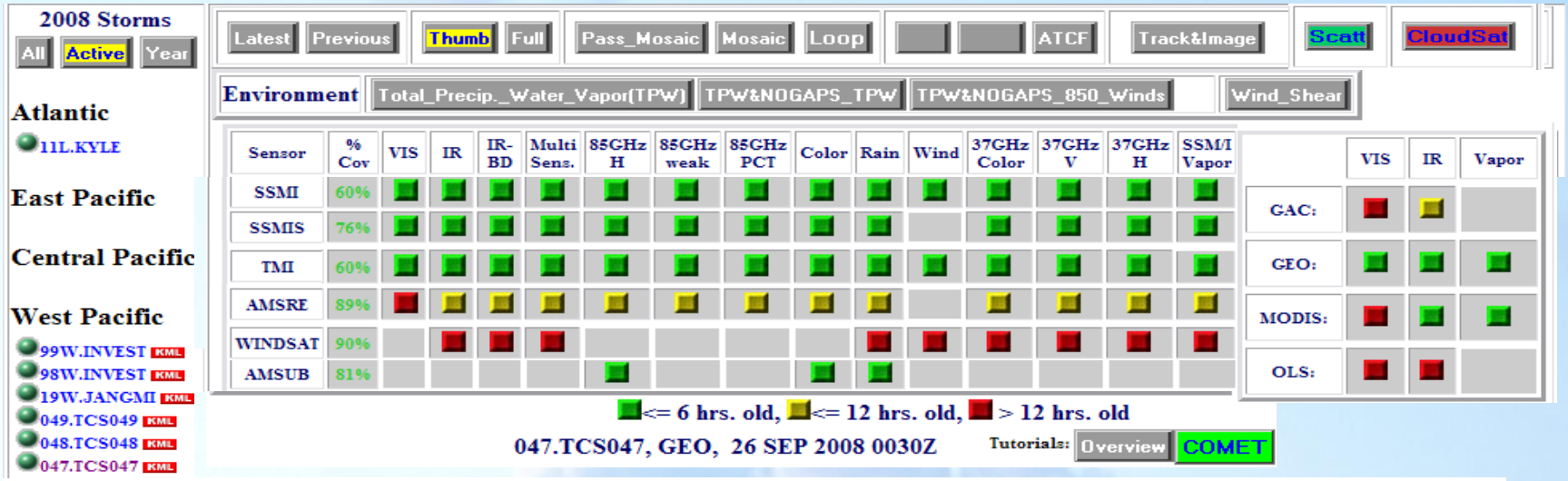


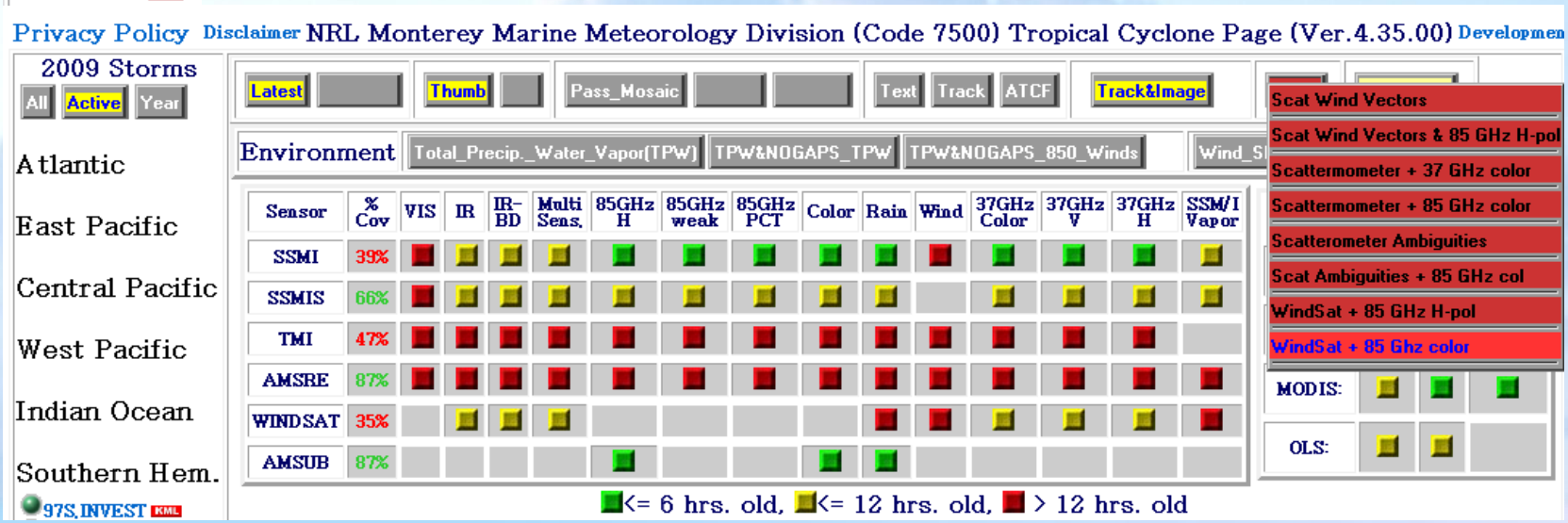
Gauges



Plane trajectories

Unprecedented Real-Time Satellite Capabilities: Data Fusion

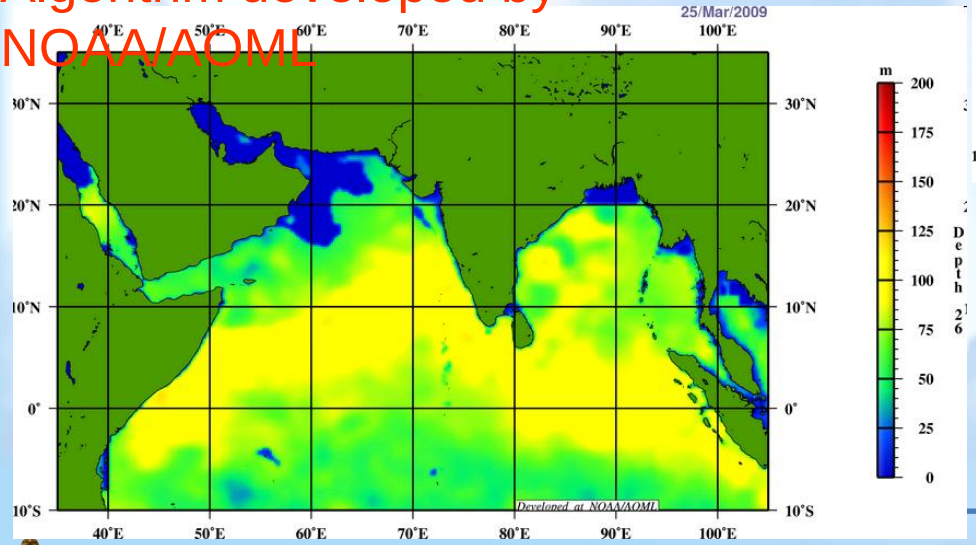


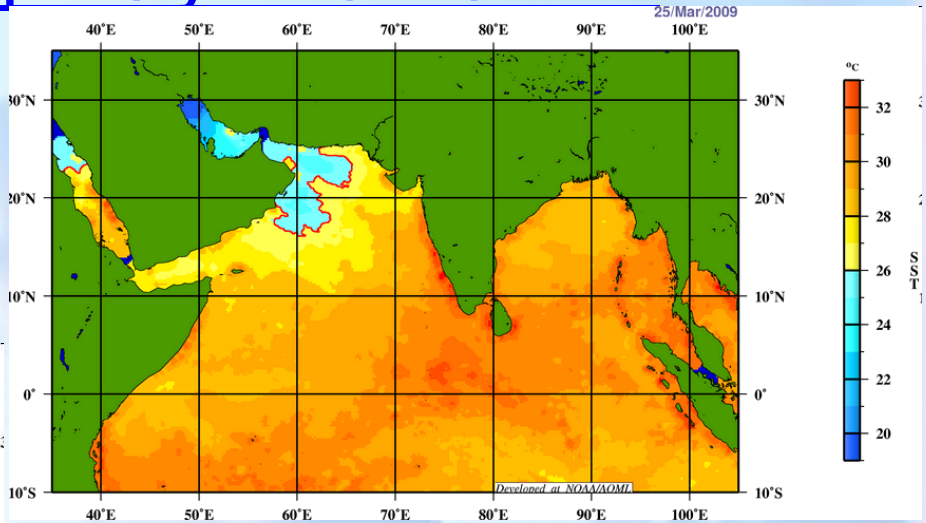


Conditions for tropical cyclone formation (1)

- **SST exceeding 26°C and a deep thermocline (50 m)**
  - **Analysis of SST in models available in Synergie**
  - **http://www.aoml.noaa.gov/phod/cyclone/data/ni.html**

Depth of the 26°C isotherm.
Estimation derived from See Height Anomaly on altimeter satellite observation.
Algorithm developed by NOAA/AOML



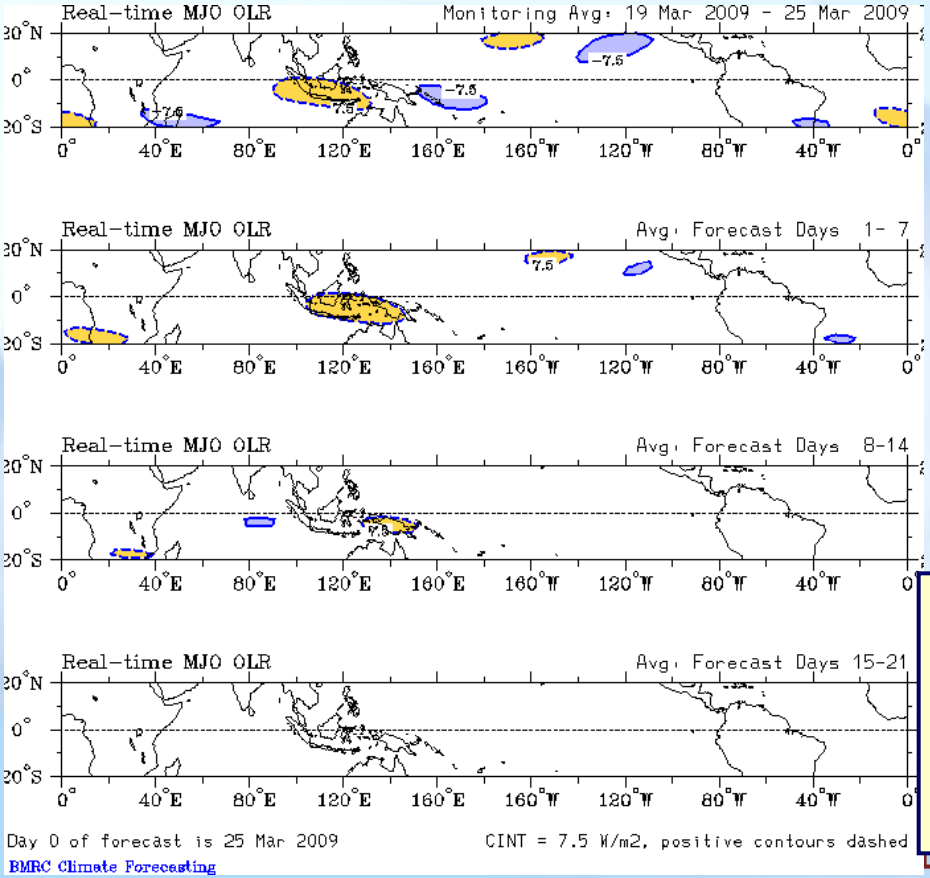


SST field.
Provided on a daily basis from TMI measurements (Tropical Rainfall Measuring Mission's Microwave Imager).

Conditions for tropical cyclone formation (2)

Conditional instability through a deep atmospheric layer

- **Area of deep convection on satellite imagery**
- **Favorable synoptic scale conditions for development of deep convection (Madden Jullian Oscillation/Outgoing Longwave Radiation) : http://www.bom.gov.au/bmrc/clfor/cfstaff/matw/maproom/OLR_modes/**



Maps of the MJO real-time filtered OLR anomalies, each averaged for a period of 7 days.

The first map is for the most recent 7 days of observed data. 3 subsequent maps are the forecasts of the MJO OLR anomalies.

Blue shading is an indication of enhanced convection and

Tropical lows mainly develop during enhanced or neutral convection phase.

→ **Forecast of POOR (or NO) risk of development up to 7 days possible when dry phase is forecasted**

Conditions for tropical cyclone formation (3)

- Large values of relative humidity in the lower and middle troposphere.
- Location of deep convection areas on geostationnary satellite imagery (on Synergie)

❖ Presence of a pre-existing disturbance in the lower atmosphere : analysis of pre-extisting lows in the ITCZ (their location, organization, intensity)

- Satellite imagery
  - Animated visible and IR geostationnary imagery on Synergie : estimation of the areas of organizing deep convection, their evolution during the last 24 hours; first estimation of associated LLCCs (low level circulation centers); analysis of exposed LLCCs (when out of deep convection).
  - Micro-Wave imagery over suspected convective areas (Monterey website, or Synergie Cyclone), to see the low or mid-level improving cyclonic organization, under Cirrus clouds.

http://www.nrlmry.navy.mil/tc_pages/tc_home.html

Conditions for tropical cyclone formation (4)

- **Ocean surface winds derived from satellite :**
  - Oceansat-II **:** **http://manati.orbit.nesdis.noaa.gov/quikscat/ Ocean Surface Winds derived from the SeaWinds Scatterometer aboard the Oceansat-II satellite**
  - Ascat **: http://manati.orbit.nesdis.noaa.gov/ascat/ Ocean Surface Vector Winds derived from the Advanced Scatterometer (ASCAT - 50km) aboard the EUMETSAT METOP satellite**
  - Windsat **: http://manati.orbit.nesdis.noaa.gov/windsat/ Ocean Surface Winds derived from WindSat/Coriolis Measurements**

Relative Vorticity and wind shear:

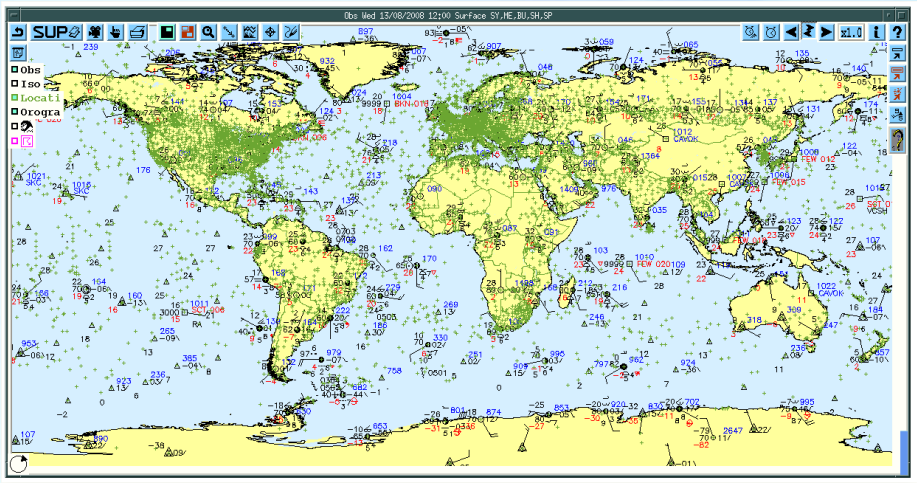
Satellite

NWP model analysis and forecast

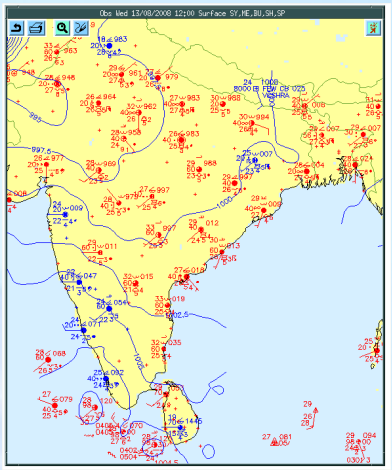
Tools to use for tropical activity daily watch

- Vis and IR geostationnary animation over the last 24 hours
  - Superimposed with EIR in Dvorak colors
  - Observations data
- Synergie Macro : for each avalaible numerical models
  - SLP (sea level pressure)
  - Absolute Vorticity at 850 hPa (only negative values) : measures the rotation of air over itself. A minimum of Ta850 shows deep convection organizing with circulation.
  - Low level winds (Favorable low level surges, or inflows, with trade wind or monsoon wind)
  - Upper level winds (200 hPa), threshold at 20 kt : upper level outflows, high or ridges favorable for good divergence, vertical wind sheared areas

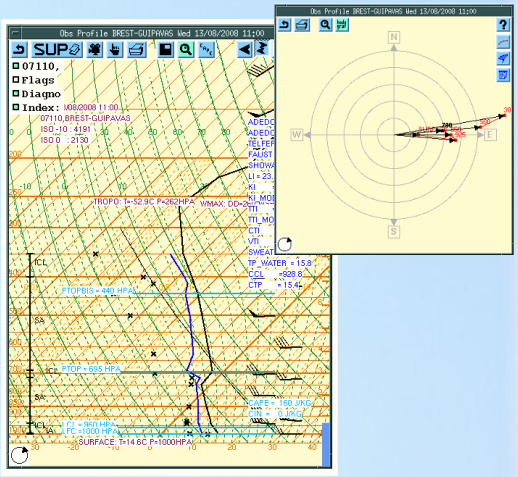
Modernised Forecasting System : Synergie



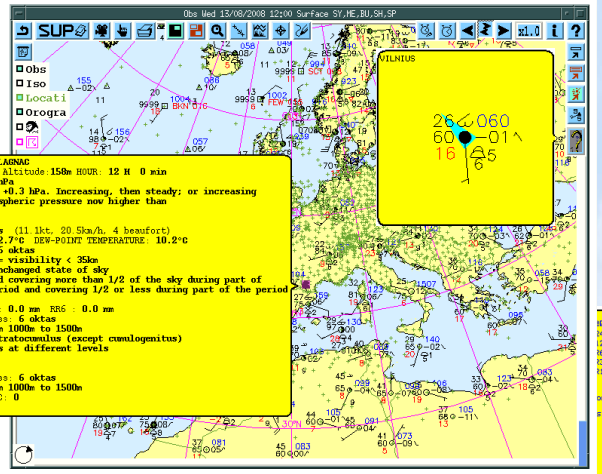
Global plotting



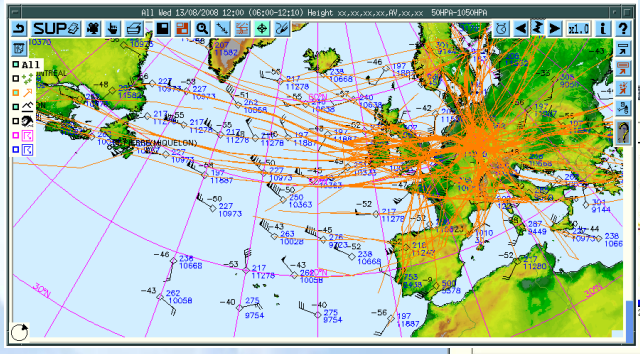
Conditional plotting



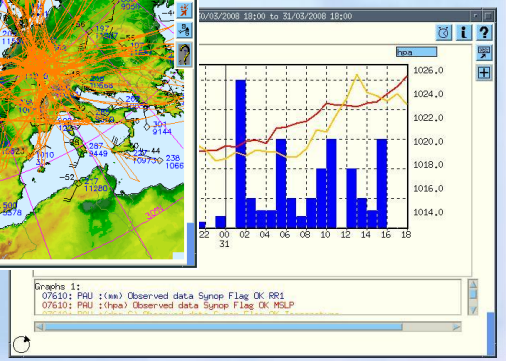
Profile



Gauges

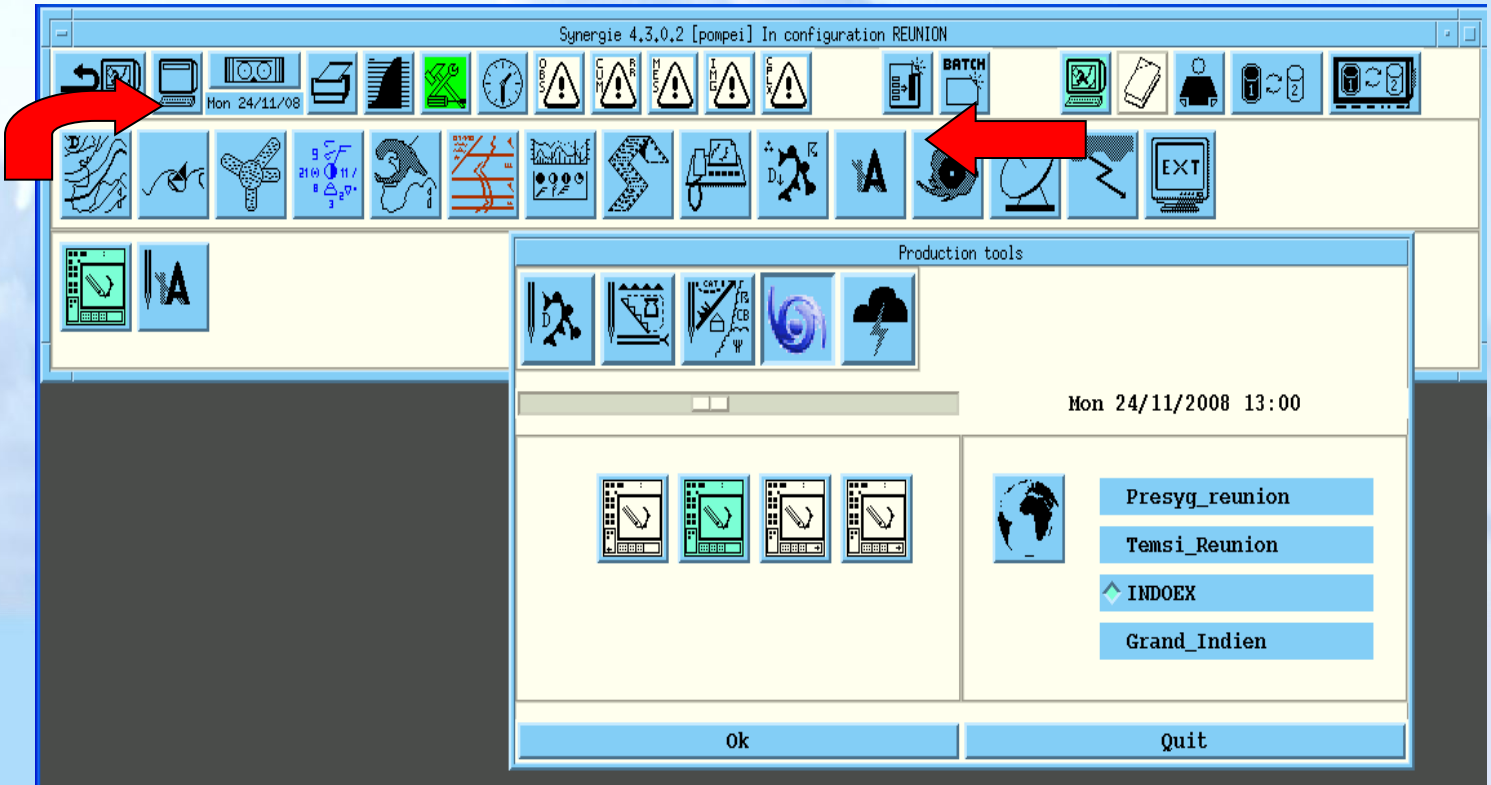


Plane trajectories



Tools to use for tropical activity daily watch

- **Internet data :**
  - **Scatterometry data**
  - **Micro-wave imagery for developing lows**
  - **CIMSS maps (vertical wind shear, upper level divergence)**
  - **MJO/OLR dry or enhanced convection phases.**



Tropical Cyclone Module is not sufficient

Data and products from various national and international agencies need to be tapped through website. A few are given below

Track and intensity forecast Products

MONTEREY Tropical Cyclones
CIMSS Tropical Cyclones
ECMWF-LatestTropicalCycones
TIGGI,
Tropical cyclone prediction centres

- Satellite derived winds
- Oceansat-II
- WindSat
- ASCAT

- SST and Heat Content
- NOAA SST & Tropical Cyclone Heat Potential
- Anomalies in SST (Nesdis_Noaa)
- Anomalies in SST (FNMOC)

- Satellite imageries and products
- Monterey
- CIMSS Tropical Cyclones
- TPC POLAR ORBITING SATELLITE DATA LINKS
- TRMM
- Interactive Weather Satellite Imagery Viewers from NASA GHCC
- Satellite INSAT
- Geostationaries from DUNDEE
- FNMOC Satellite Data Tropical Cyclone Homepage
- RSS / Tropical Cyclone Microwave Data Archive
- AMSU-A__NASA , AMSU__UW-CIMSS

- Large scale features
- OLR, MJO map- BOM
- CPC - Climate Weather Linkage: MJO
- OLR animations NOAA
- CDC Map Room Climate Products
- Probability of a Tropical Cyclone

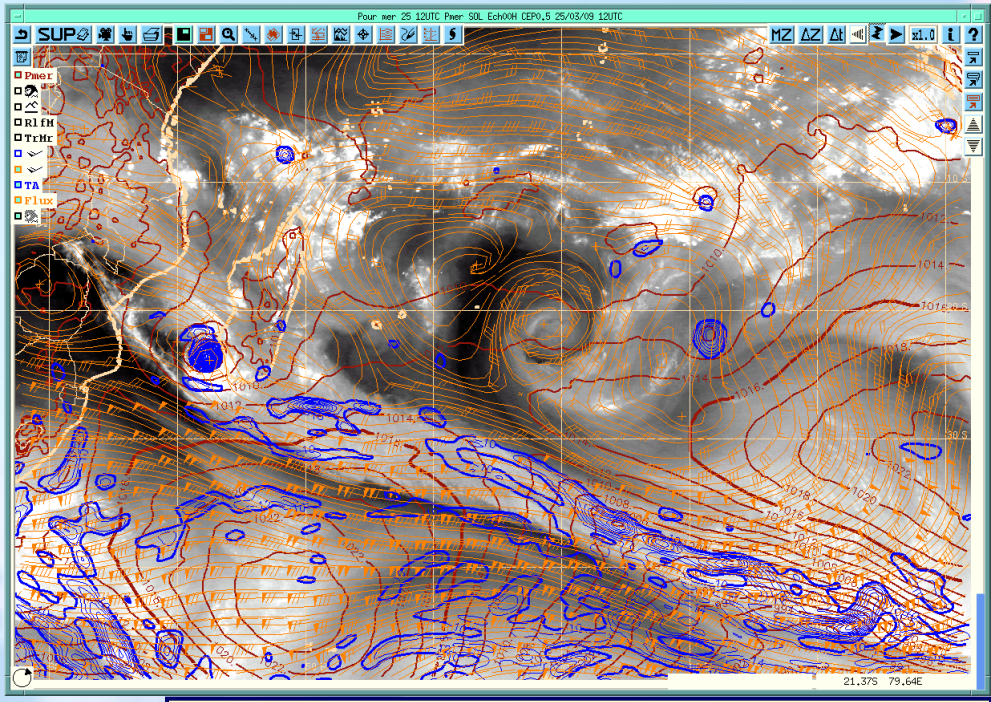
Methodology for tropical activity daily watch

First step: Rapid analysis of the tropical convective activity

- ❑ **Is it poor, moderate, strong ?**
- ❑ **What is its evolution during the last 24 hours ?**
  - ✓ **The deep convection has intensified or not (in geographical extension, in intensity – coldness of Cb's top –, in cyclonic organization)?**
  - ✓ **Comparison must be done with the days before at the same hours, to avoid to be influenced by the diurnal effect : over ocean, deep convection naturally intensifies (deepness and extension) during the night, between 18 UTC and 02 UTC (maximum of deep convective activity at the end of the night, near 23 UTC-01UTC).**

First Step of tropical activity daily watch

- Vis and IR geostationnary animation over the last 24 hours
  - Superimposed with EIR in Dvorak colors
  - Observations data
- Synergie Macro : for each avalaible numerical models
  - SLP (sea level pressure)
  - Absolute Vorticity at 850 hPa
  - Low level winds (Favorable low level surges, or inflows, with trade wind or monsoon wind)
  - Upper level winds (200 hPa), threshold at 20 kt : upper level outflows, high or ridges favorable for good divergence, vertical wind sheared areas



Water vapor

superimposed with :

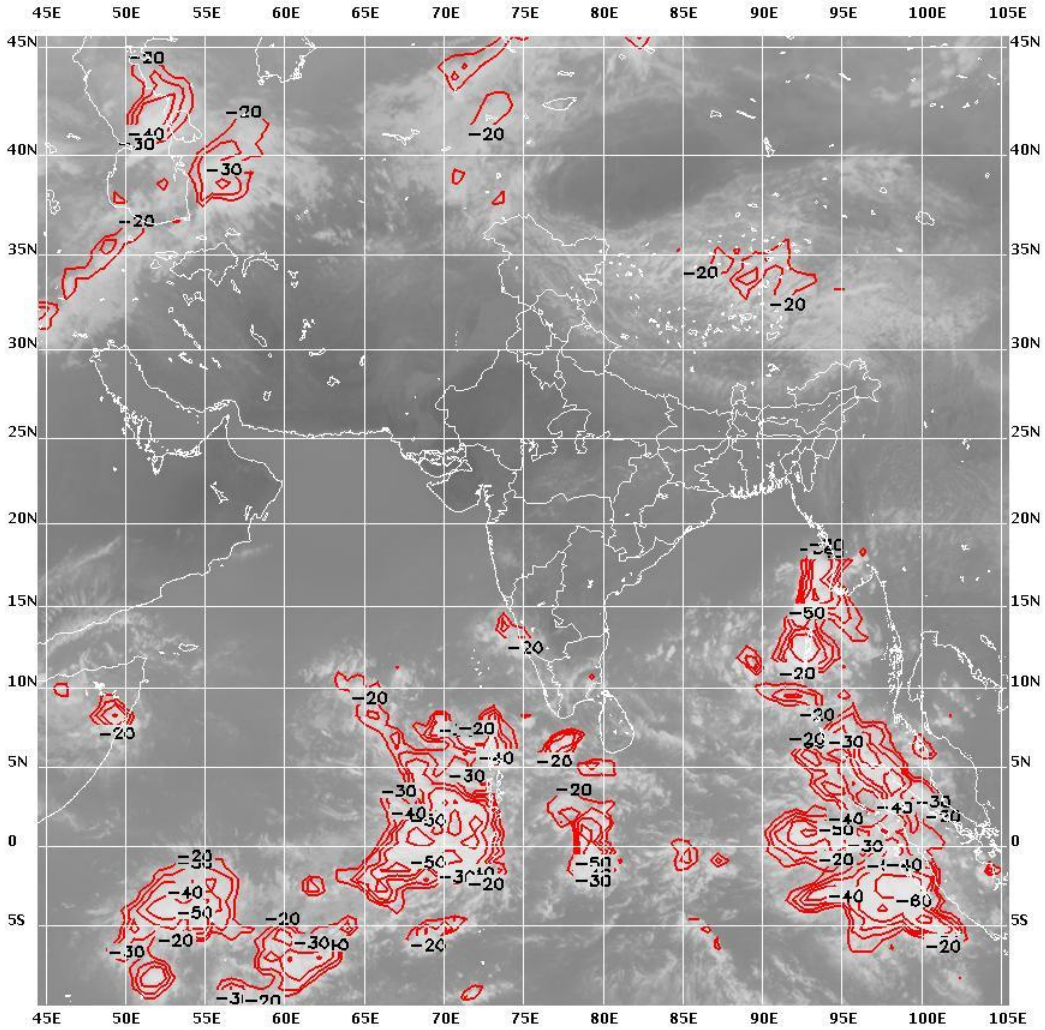
-Absolute vorticity at 850 hPa (Ta850).

-ECMWF SLP

-ECMWF's 200 hPa Winds

26OCT2012 0600UTC	Sensor : VHR	SAT : KALPANA-1
ASIA_MER	Proj : MERCATOR	Resolution : 8000 m

IR IR IR



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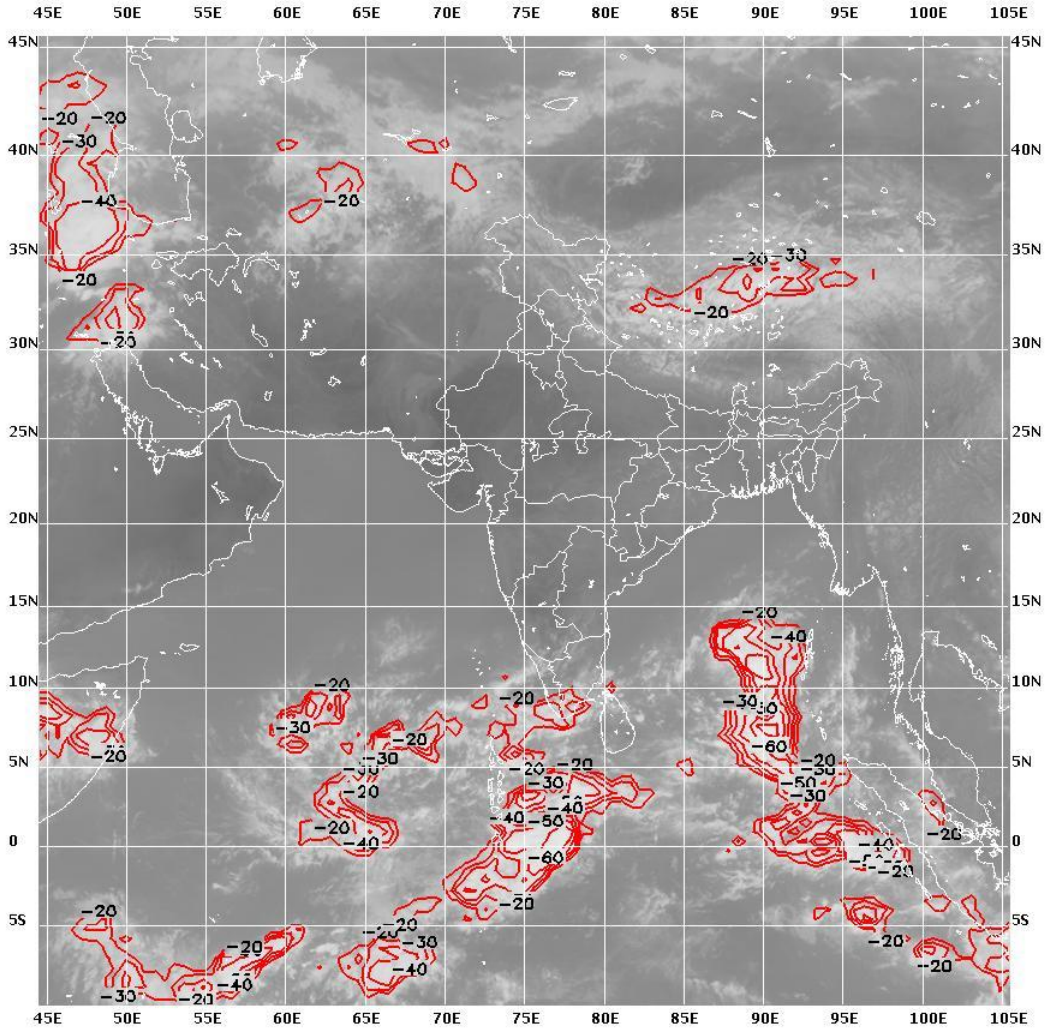
ASIA_MER	Proj : MERCATOR	Resolution : 8000 m
IR	IR	IR



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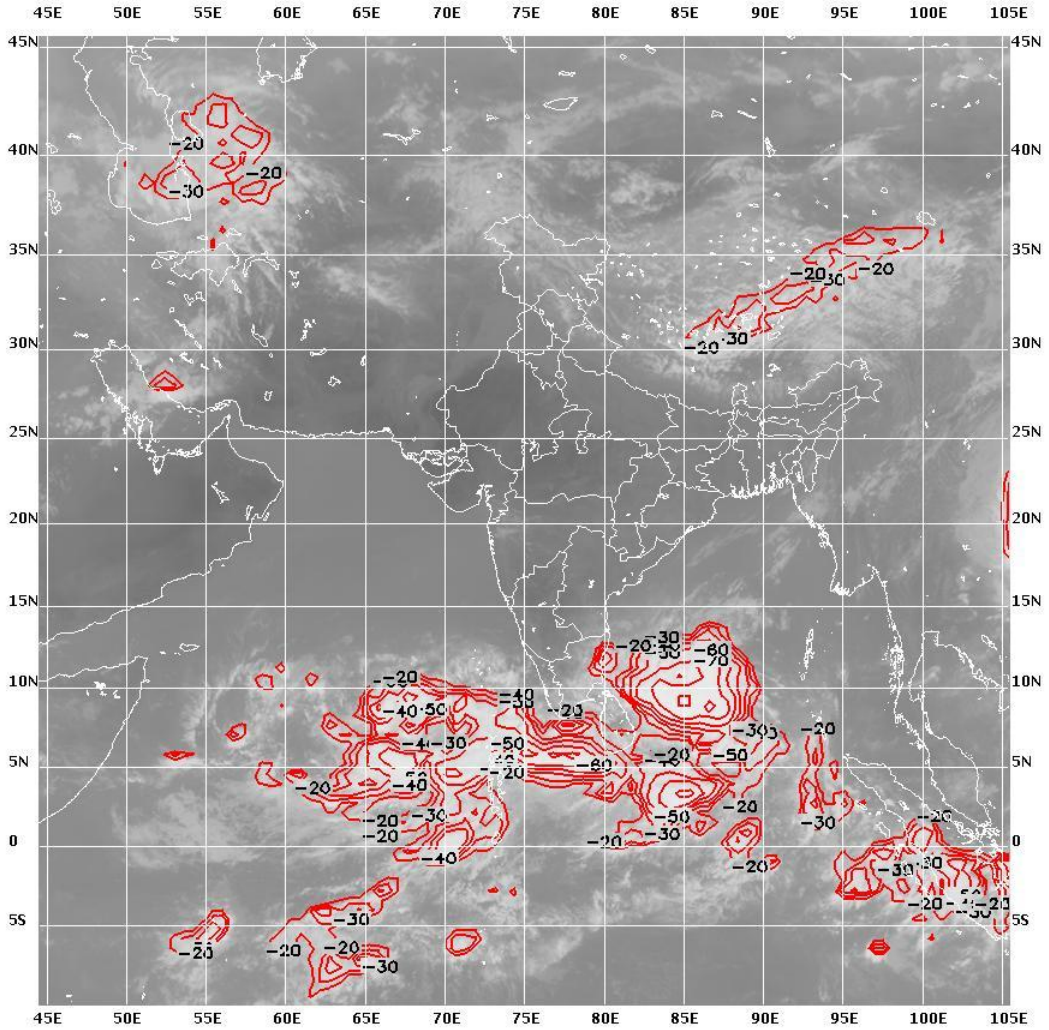
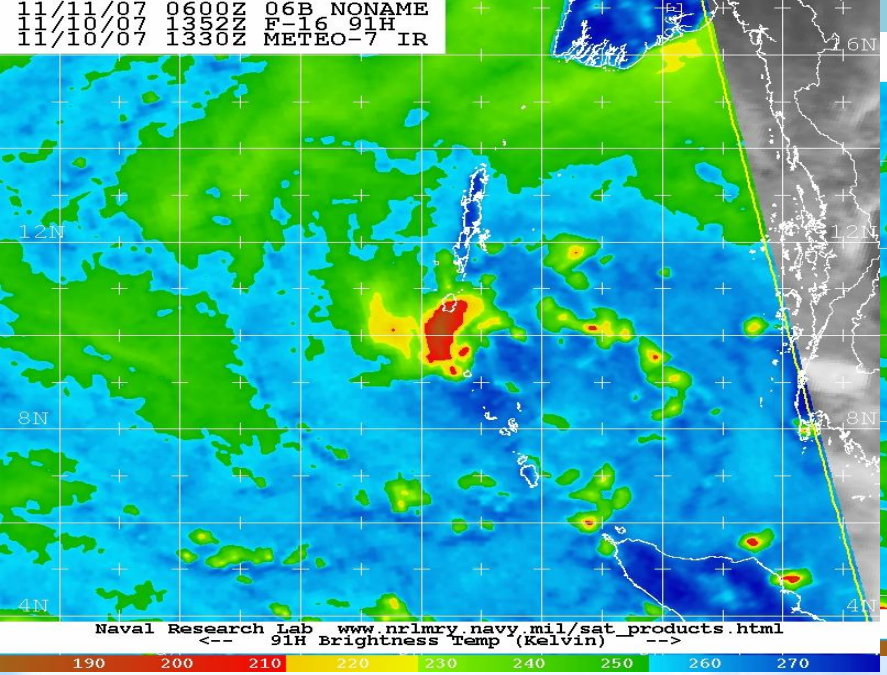
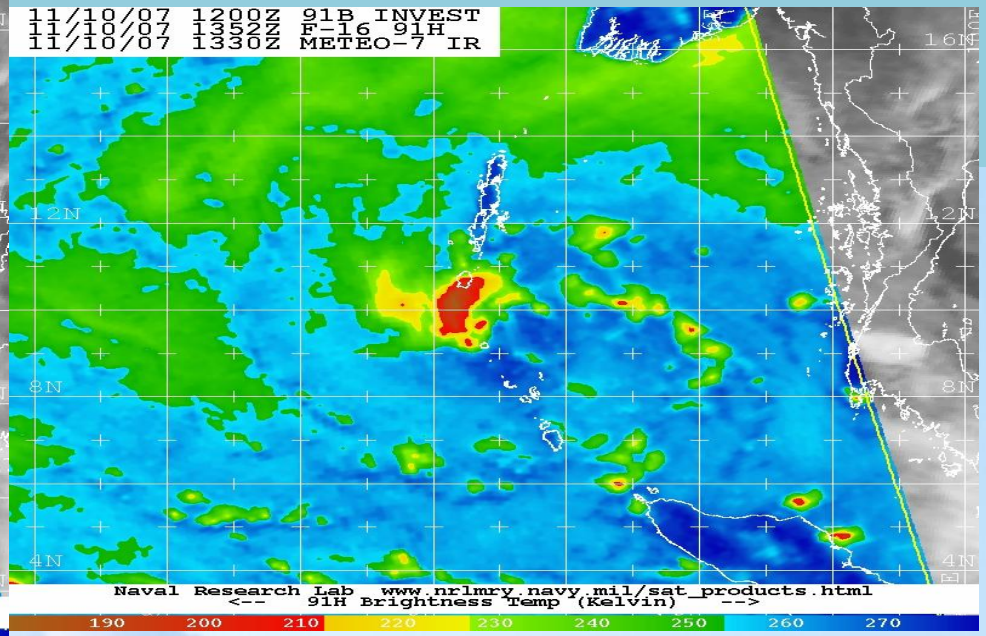
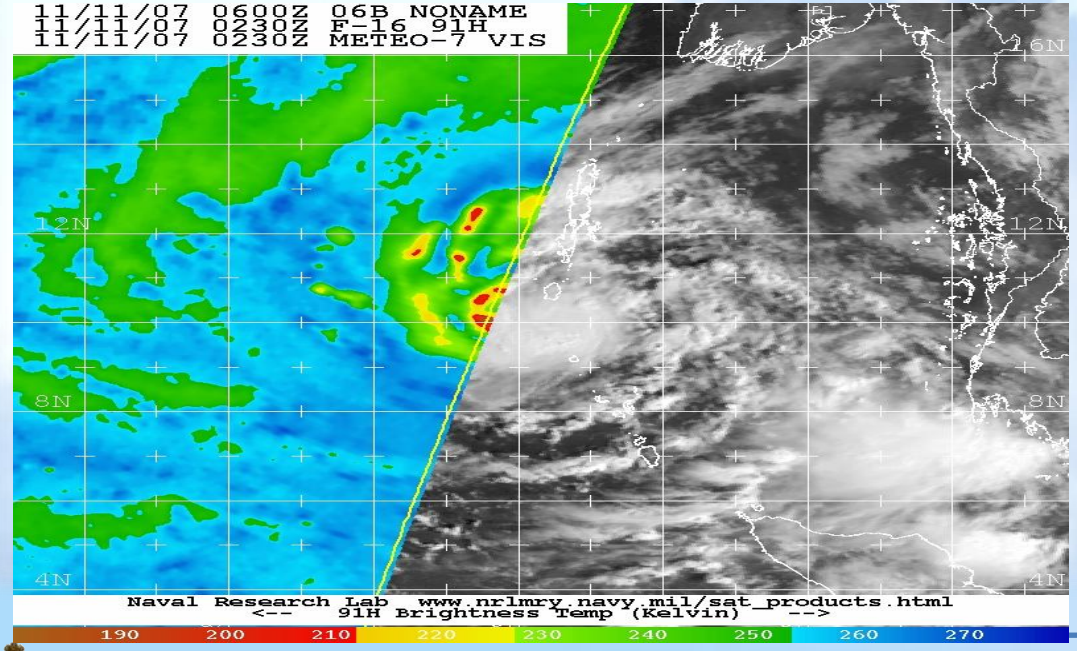
ASIA_MER	Proj : MERCATOR	Resolution : 8000 m
IR	IR	IR









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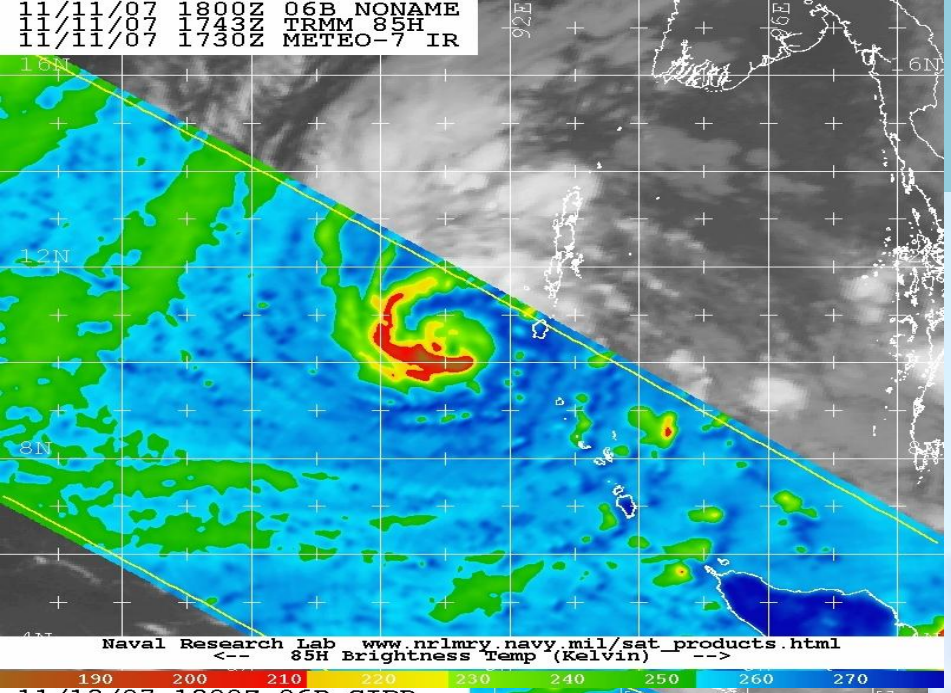
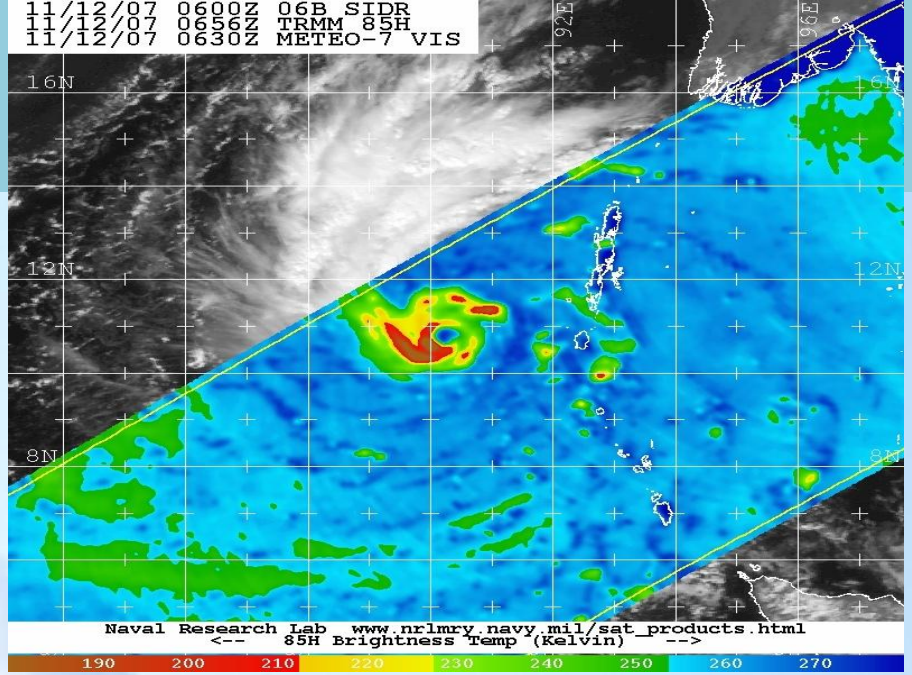

11/11/07 1800Z 06B NONAME
11/11/07 1743Z TRMM 85H
11/11/07 1730Z METEO-7 IR
16N
12N
8N
92E
96E
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 85H Brightness Temp (Kelvin) -->
190 200 210 220 230 240 250 260 270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11/12/07 0656Z TRMM 85H
11/12/07 0630Z METEO-7 VIS
16N
12N
8N
92E
96E
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 85H Brightness Temp (Kelvin) -->
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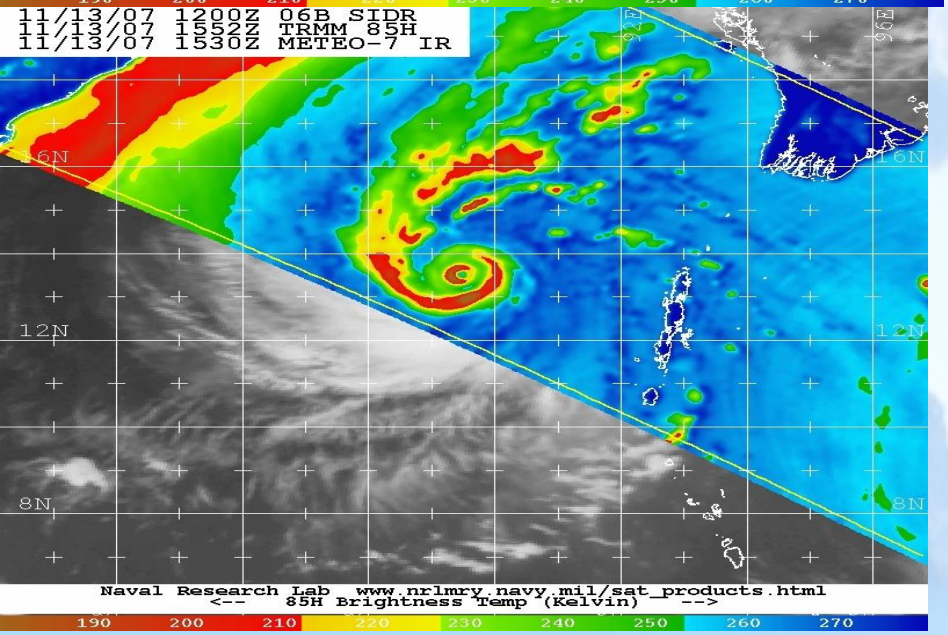
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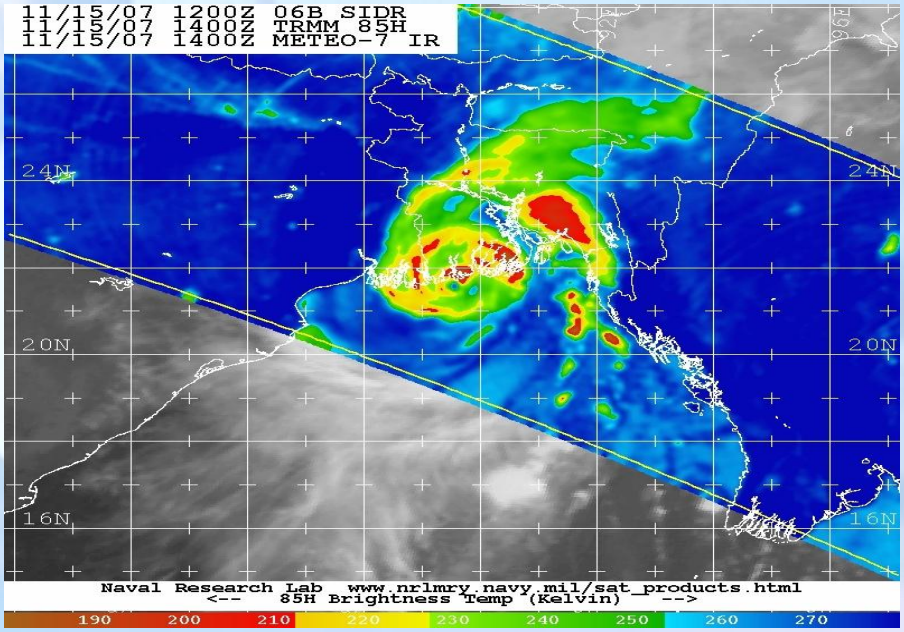
11/13/07 1552Z TRMM 85H
11/13/07 1530Z METEO-7 IR
16N
12N
8N
92E
96E
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 85H Brightness Temp (Kelvin) -->
190 200 210 220 230 240 250 260 270


11/15/07 1200Z 06B SIDR
11/15/07 1400Z TRMM 85H
11/15/07 1400Z METEO-7 IR
24N
20N
16N
92E
96E
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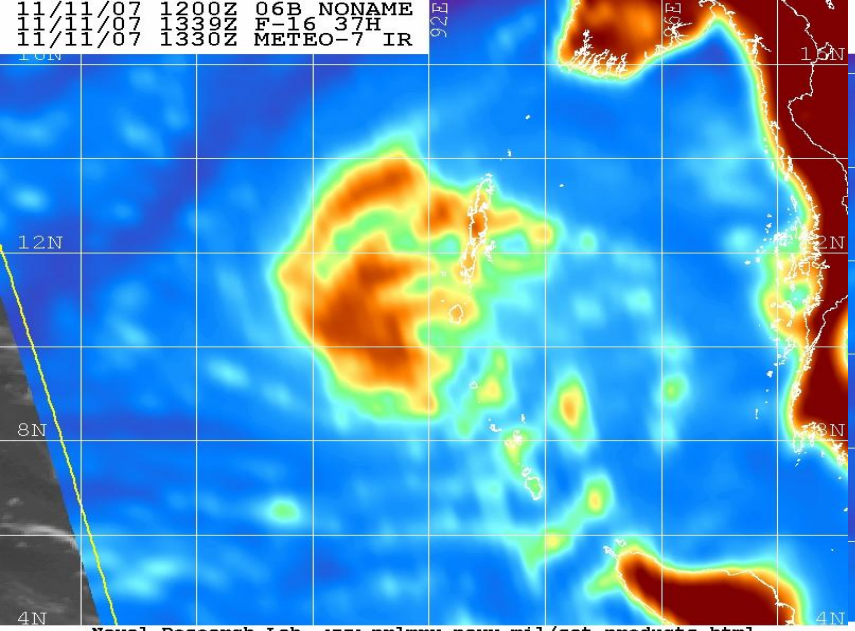
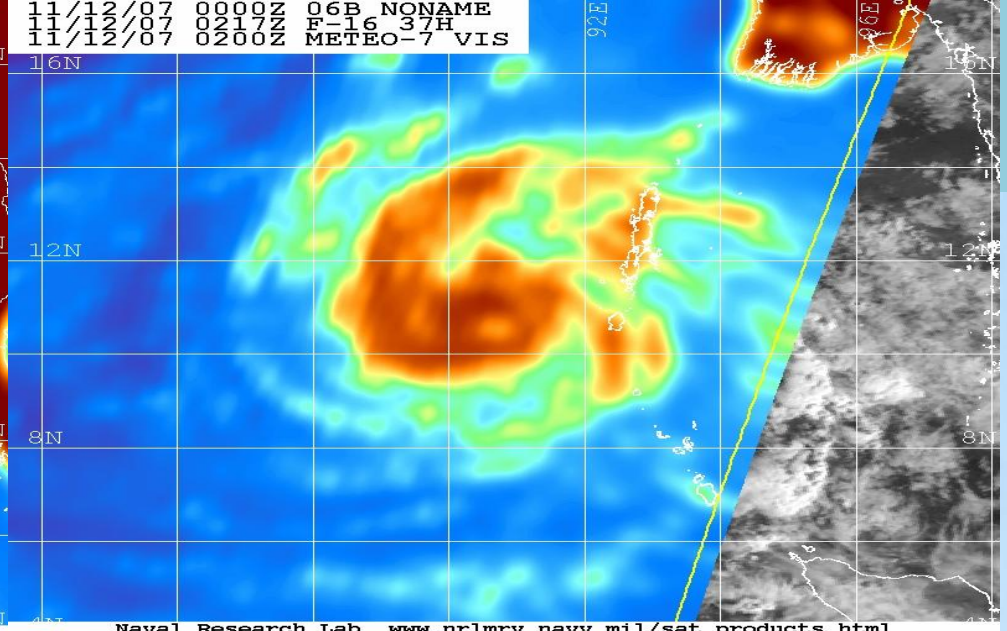
<-- 85H Brightness Temp (Kelvin) -->
190 200 210 220 230 240 250 260 270


11/11/07 1200Z 06B NONAME
11/11/07 1339Z F-16 37H
11/11/07 1330Z METEO-7 IR
16N
12N
8N
4N
92E
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 37H Brightness Temp (Kelvin) -->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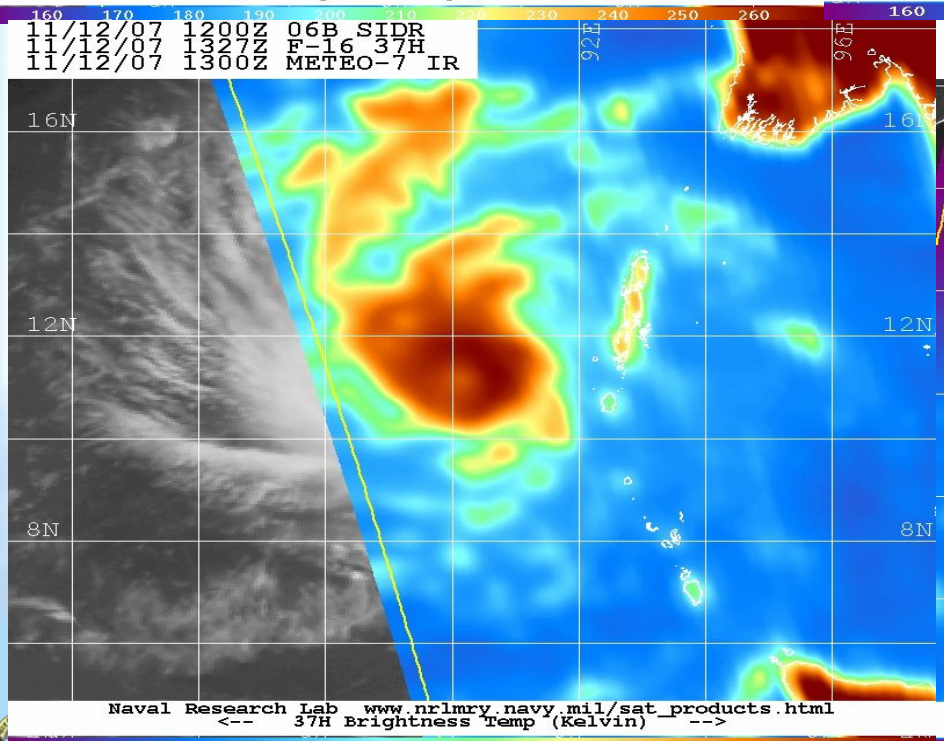
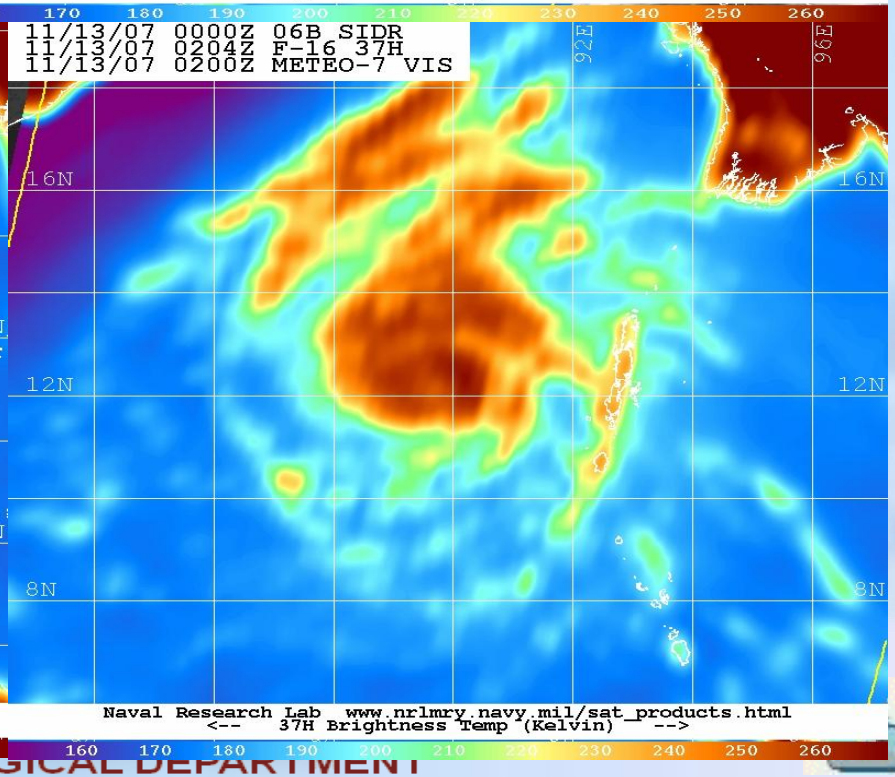
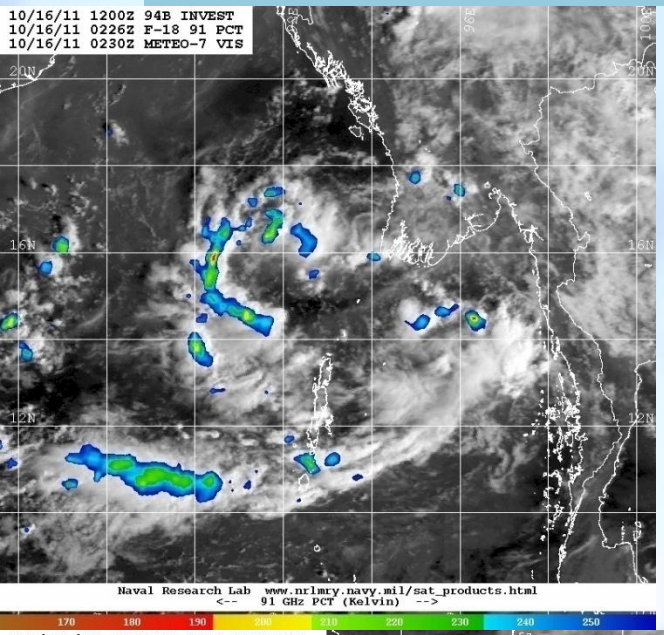
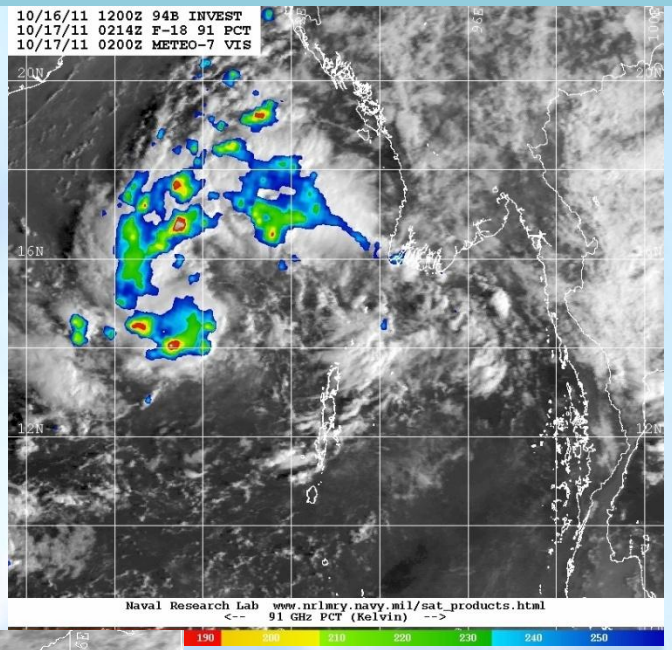
11/12/07 0217Z F-16 37H
11/12/07 0200Z METEO-7 VIS
16N
12N
8N
92E
96E
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 37H Brightness Temp (Kelvin) -->

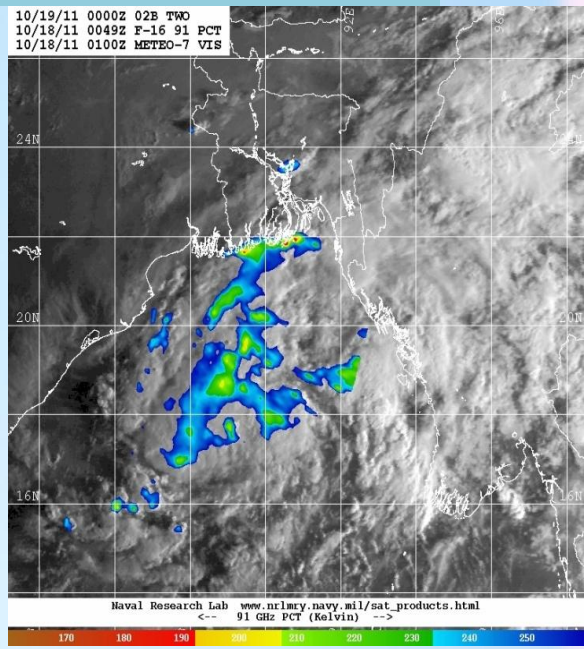

11/12/07 1200Z 06B SIDR
11/12/07 1327Z F-16 37H
11/12/07 1300Z METEO-7 IR
160 170 180 190 200 210 220 230 240 250 260
16N
12N
8N
92E
96E
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 37H Brightness Temp (Kelvin) -->

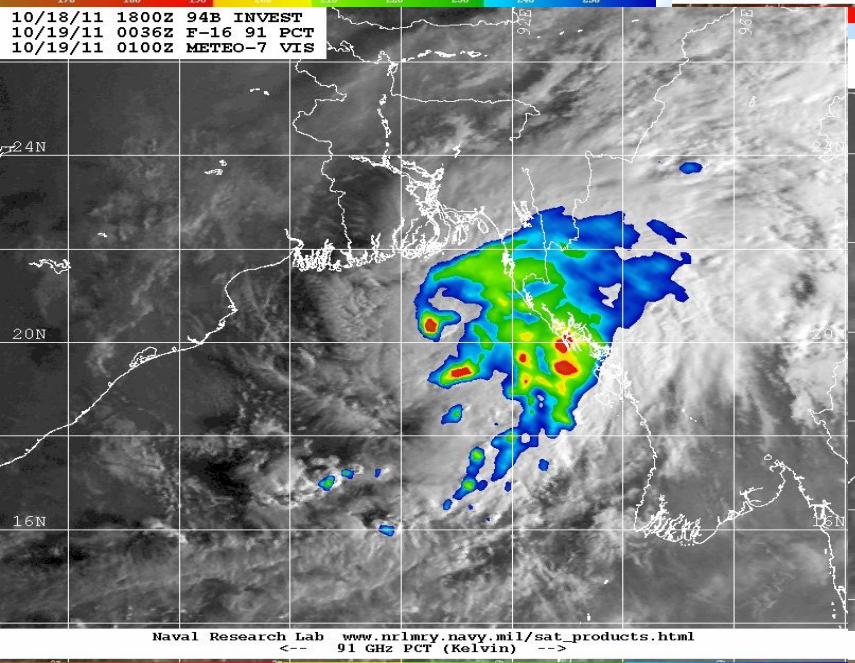

11/13/07 0000Z 06B SIDR
11/13/07 0204Z F-16 37H
11/13/07 0200Z METEO-7 VIS
160 170 180 190 200 210 220 230 240 250 260
16N
12N
8N
92E
96E
Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 37H Brightness Temp (Kelvin) -->

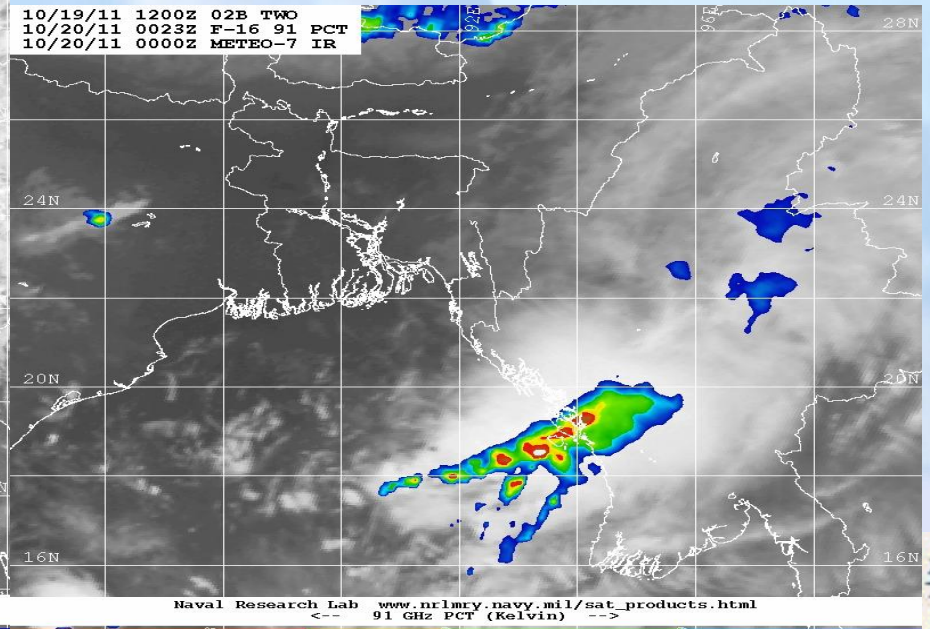
MICROWAVE IMAGERIES 85 GHZ DURING 19- 20 OCT 2011









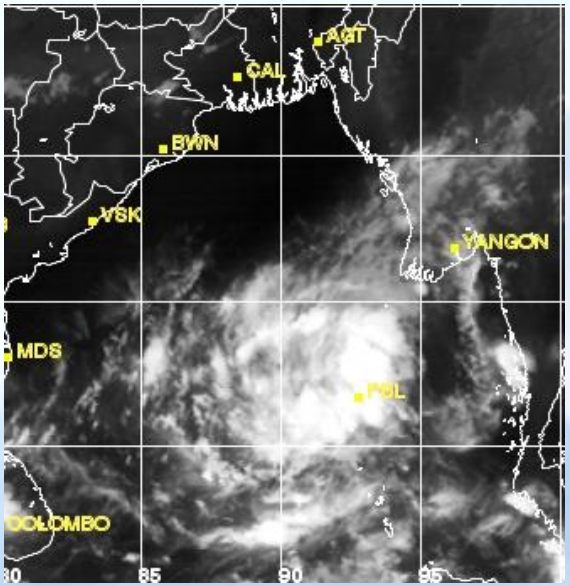


Position and Intensity Table

Date/ Time (UTC)	SAT MET POS			NOAA POS			JTWC POS			SYNOP POS		
	Lat.	Long.	T.No.	Lat.	Long.	T.No.	Lat.	Long.	T.No.	Lat.	Long.	T.No.
28 /00	11.0	87.5	1.0	9.8	85.2	1.5	-	-	-	9.5	86.0	1.5
28/06	9.5	87.0	1.5	9.7	84.6	1.5	9.4	84.0	1.5	9.5	86.0	1.5

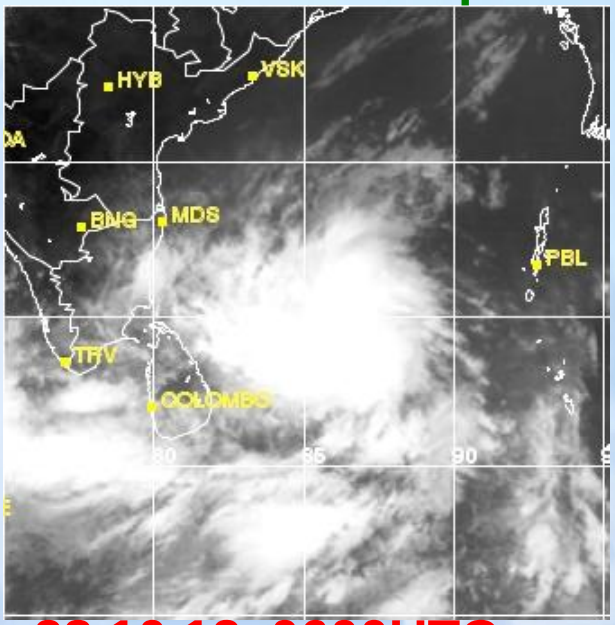
Satellite picture of the cyclone at different position

Formation of vortex



26.10.12, 1500 UTC (T1.0)

Intensified into Depression



28.10.12, 0600UTC (T1.5)

Date	Time (UTC)	Lat (E)	Long (E)	T. No.	C.T.T (C)
25.10.12	1200			LLC	
26.10.12	1500	12.0	91.5	1.0	-75
	1700	12.0	91.5	1.0	-71
	2100	12.2	91.5	1.0	-81
27.10.12	0000	12.2	91.5	1.0	-80
	0300	12.0	91.0	1.0	
	0600	12.0	91.0	1.0	-79
	0900	12.0	90.5	1.0	-76
	1200	12.0	90.0	1.0	-79
	1500	12.0	90.0	1.0	-85
	1700	12.0	89.5	1.0	-87
	2100	11.5	88.5	1.0	-88
28.10.12	0000	11.0	87.5	1.0	-91
	0300	10.0	87.5	1.0	-87
	0600	9.5	87.0	1.5	-84

Methodology for tropical activity daily watch

Second step: If existence of deep convection clusters since more than 24 hours.

- **Is there one (or several) associated low level circulation center(s) (LLCCs)?**

Estimation of their location, motion and intensity (MSLP and associated max mean winds):

- ✓ **satellite imagery (classical and Micro-wave), Scat data, surface observations.**

Estimation of their potential for intensification:

- ✓ **Numerical models forecasts**
- ✓ **Analysis of the environment : SST, OLR, Wind shear, low level inflows, upper level outflows, Potential vorticity, Potential temperature**

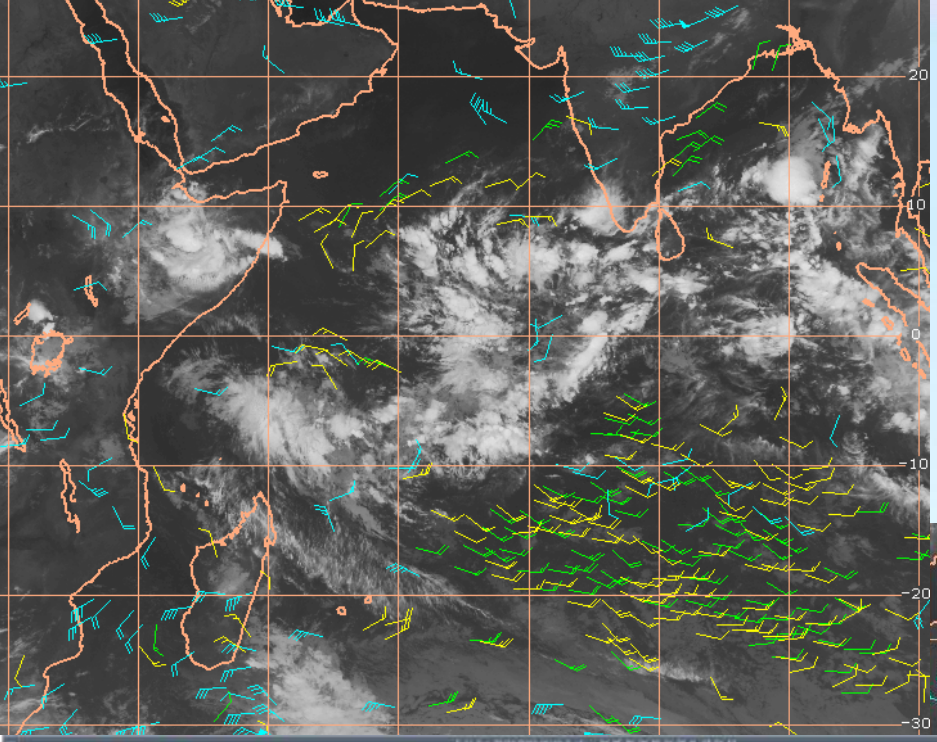
ECMWF Model prediction : Phet Cyclone (MSLP with track and intensity

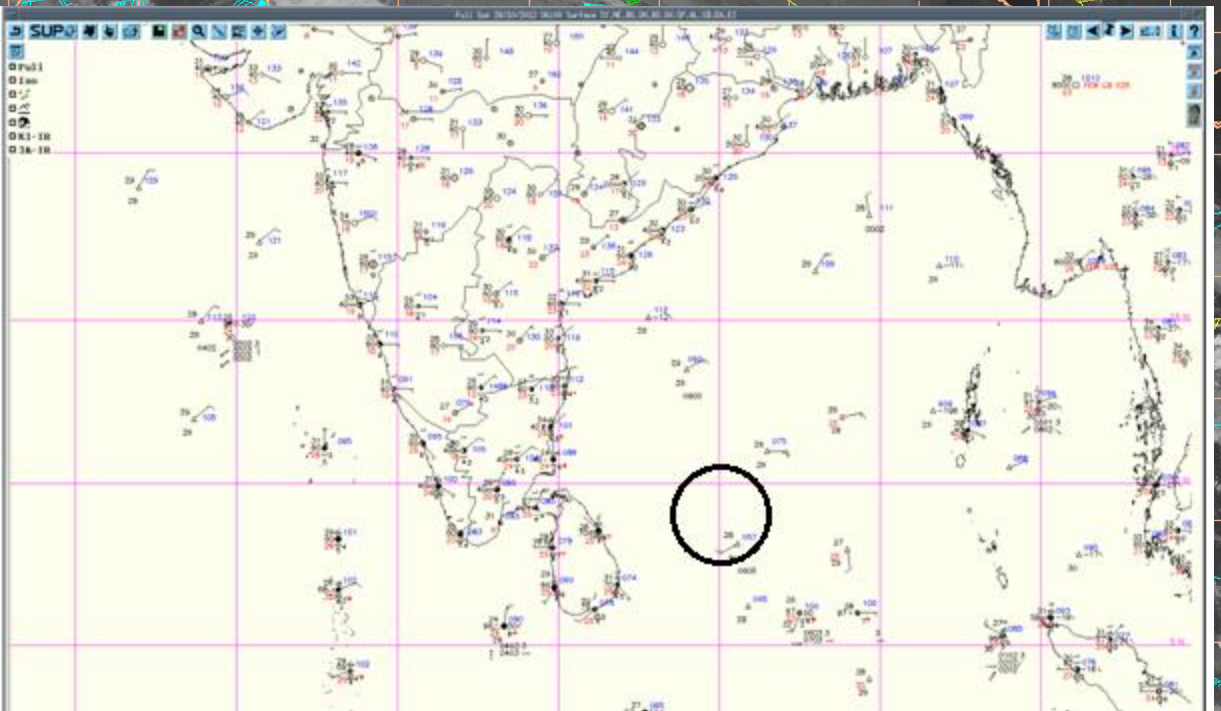
Third step: Global explanation of the situation (if not already done and if interesting)

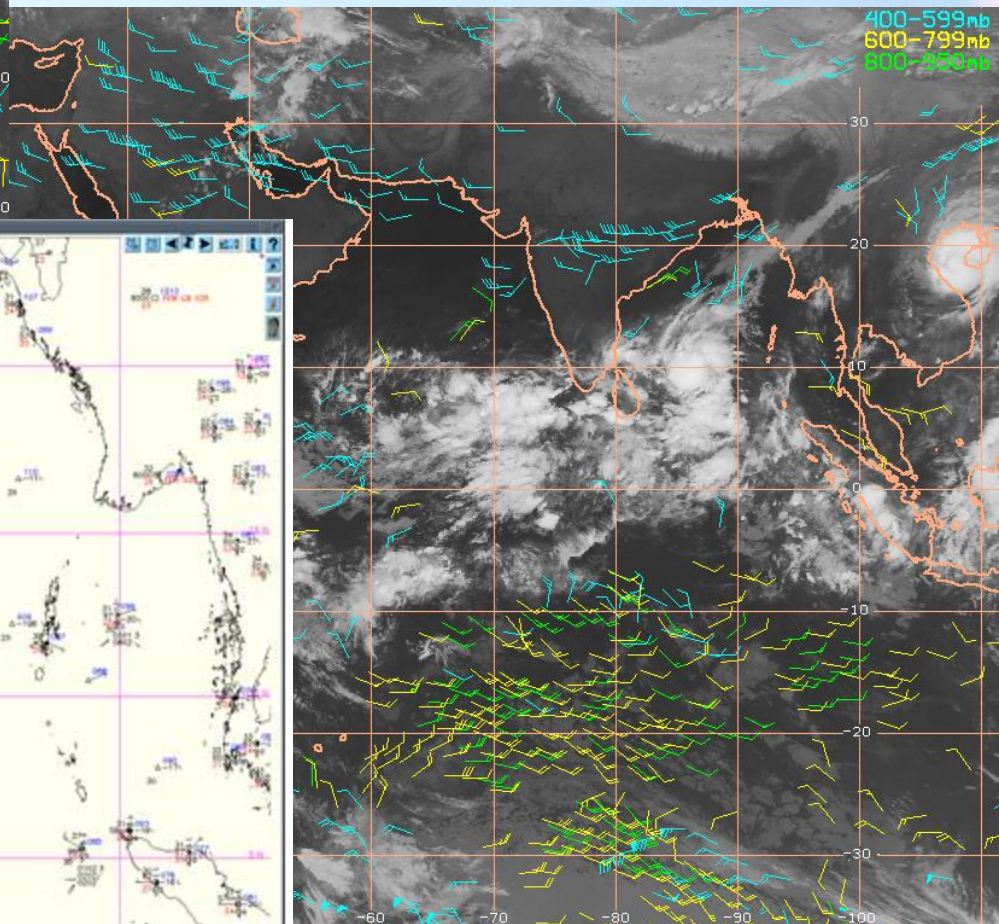
- ✓synoptic action centers (ridges and troughs, at each level : surface, mid level 500hPa for the steering flows, upper level 200 hPa)
- ✓What MJO phase and amplitude?
- ✓Wind shear environment ?
- ✓SST conditions? etc.
- ✓Monsoon (or equatorwards) and trade winds (or polewards) inflows?

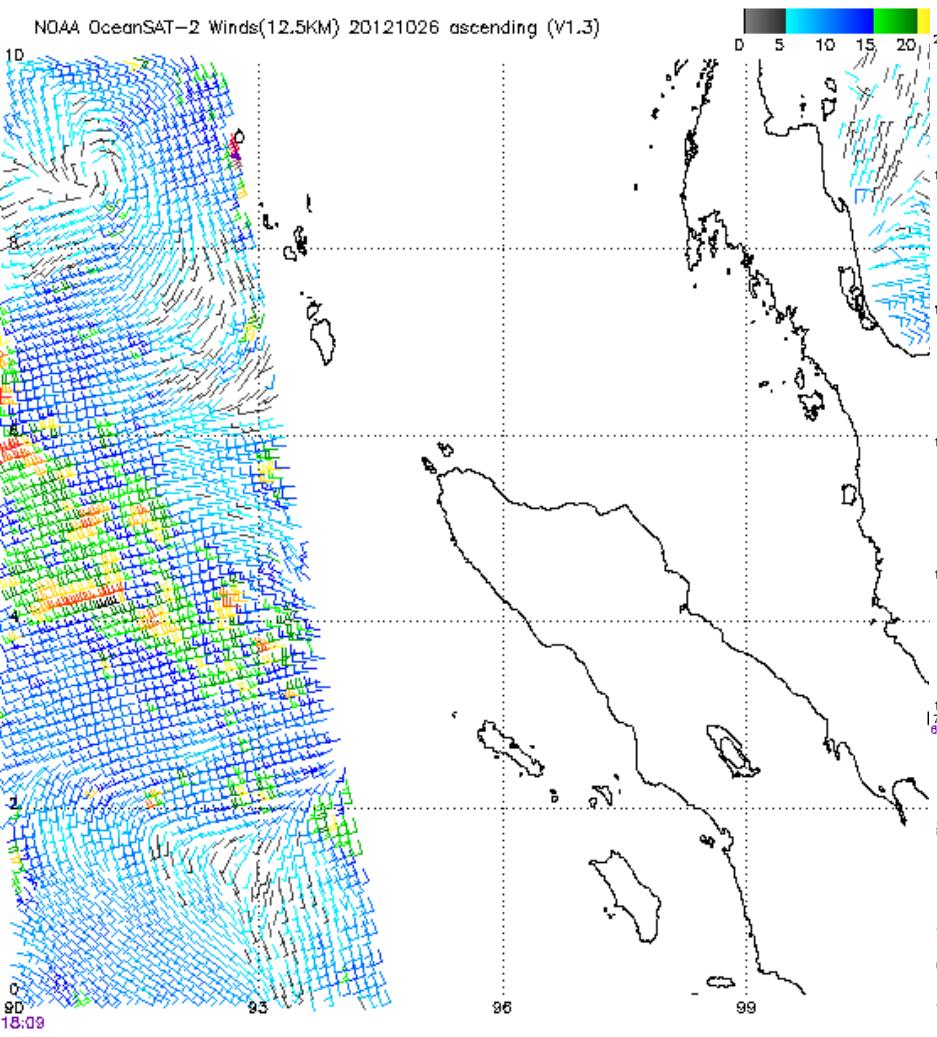
Fourth Step: Estimation of the probability for development of a depression

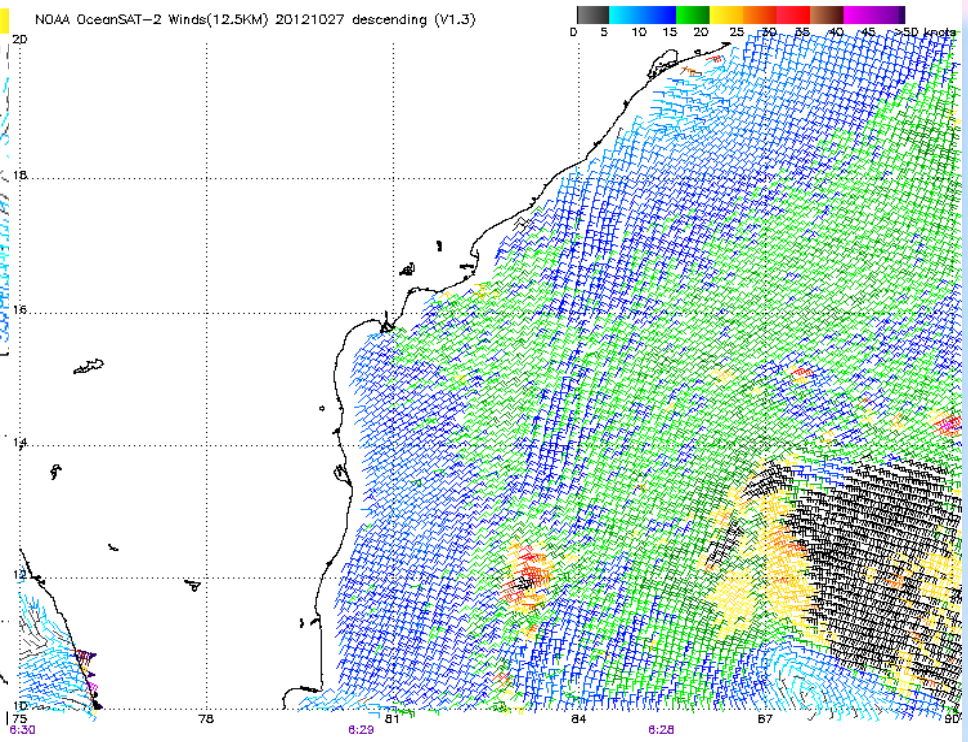
Methodology for tropical activity daily watch

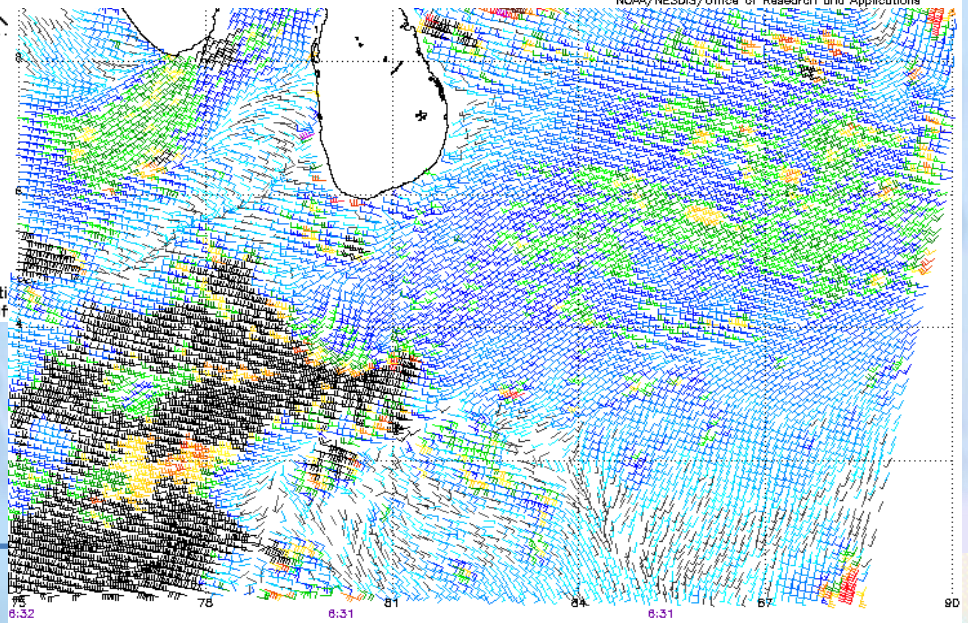








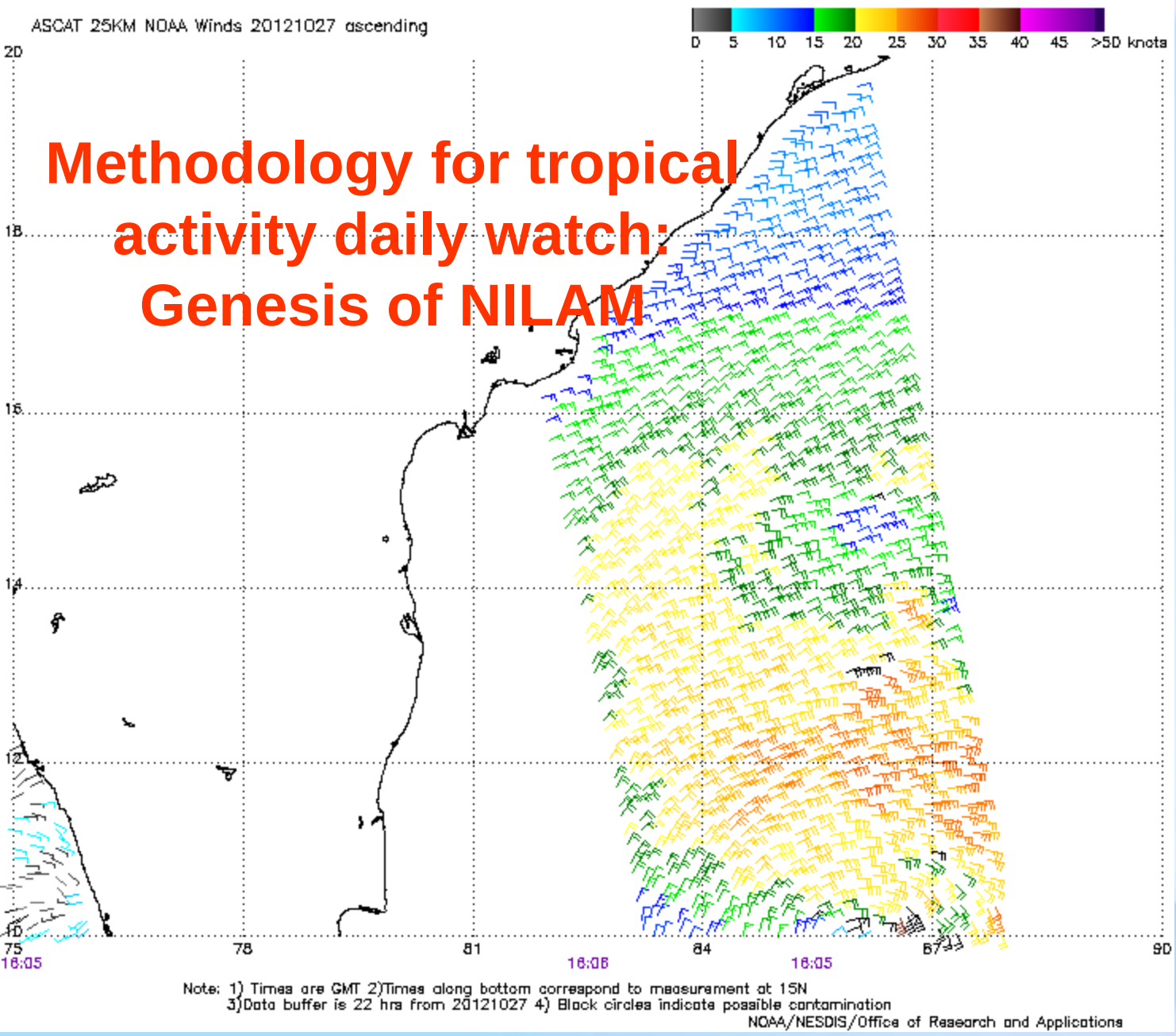




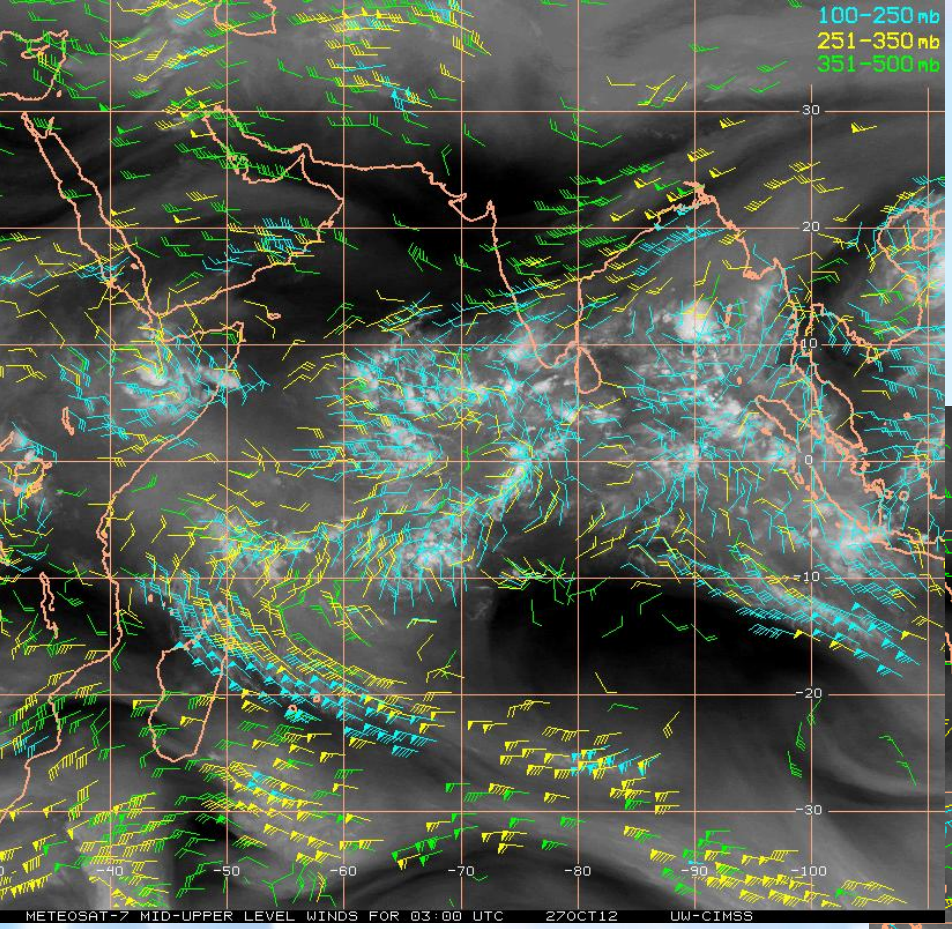
Methodology for tropical activity daily watch: Genesis of NILAM

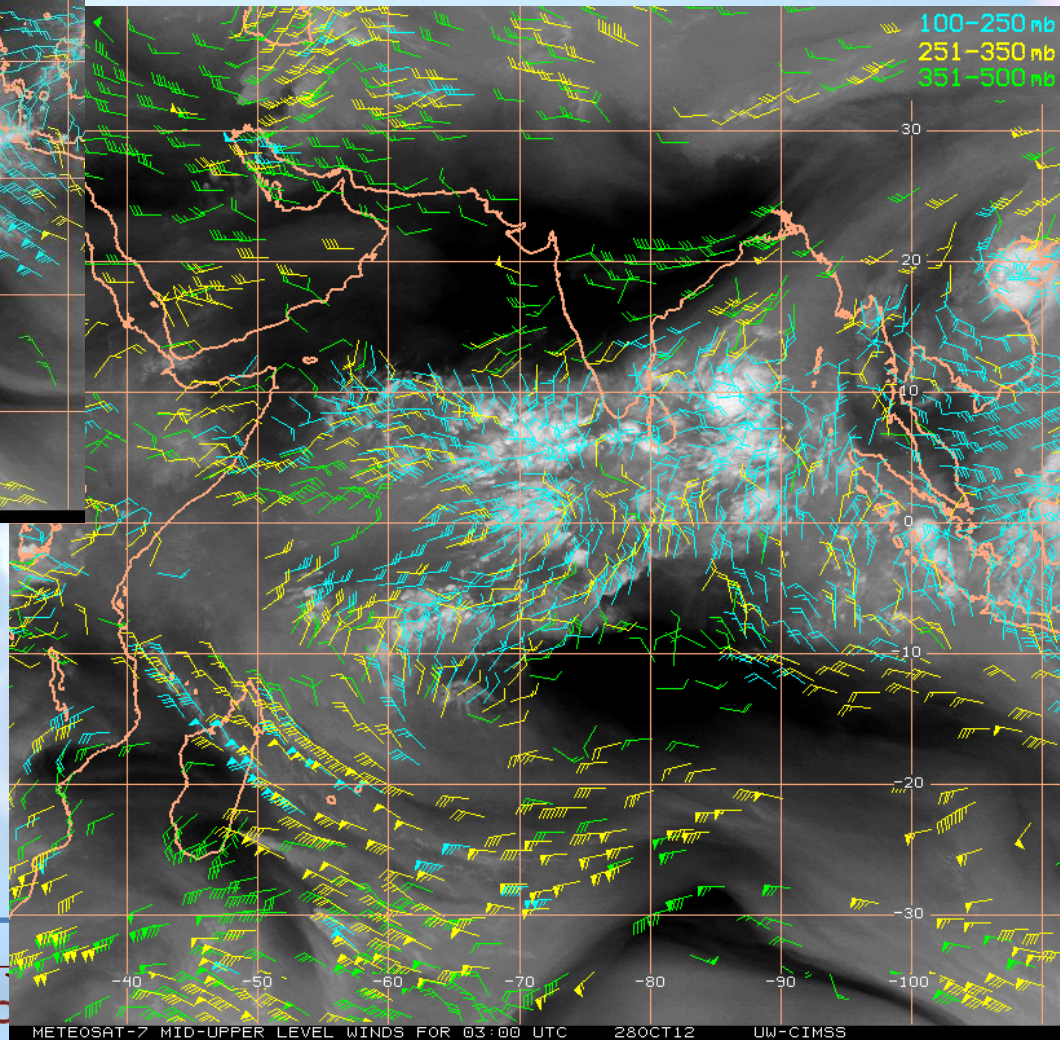
भारत मौसम
INDIA METEOROLO

Methodology for tropical activity daily watch: Genesis of NILAM

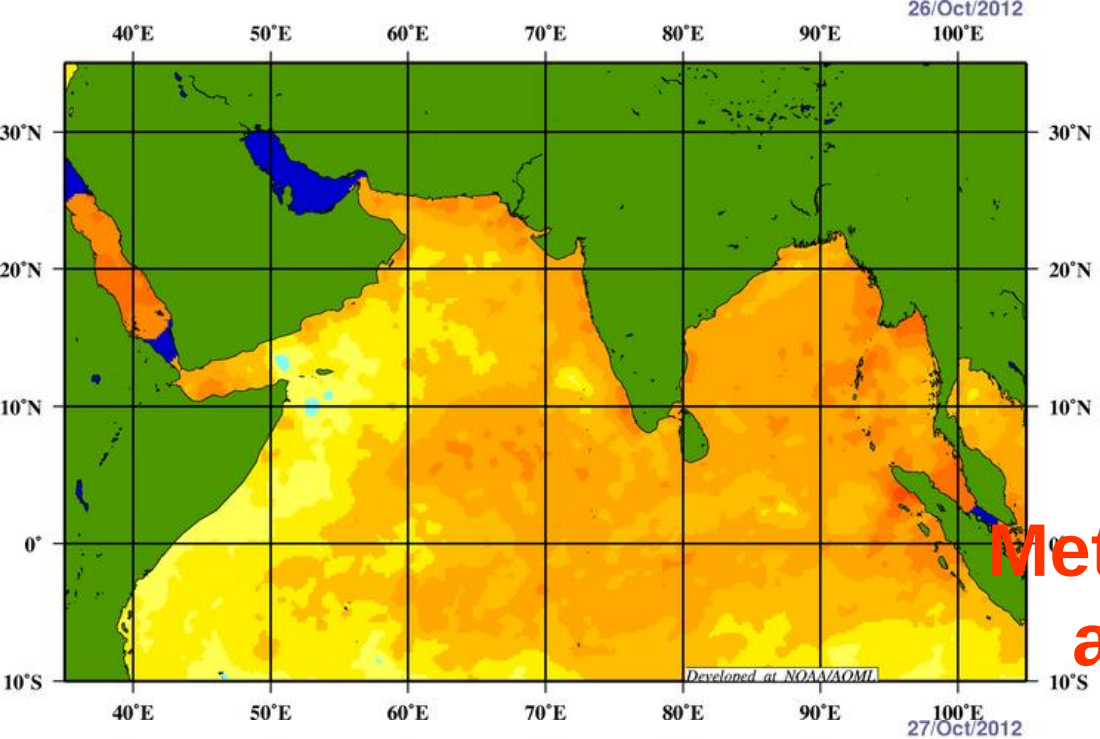


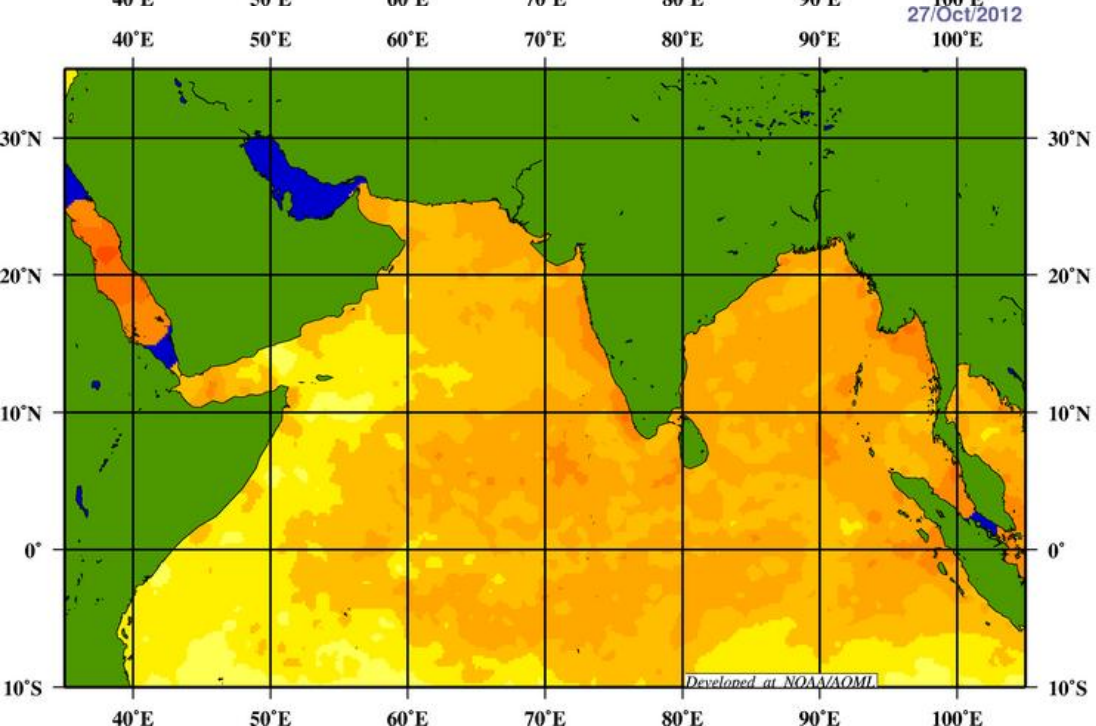
Methodology for tropical activity daily watch: Genesis of NILAM





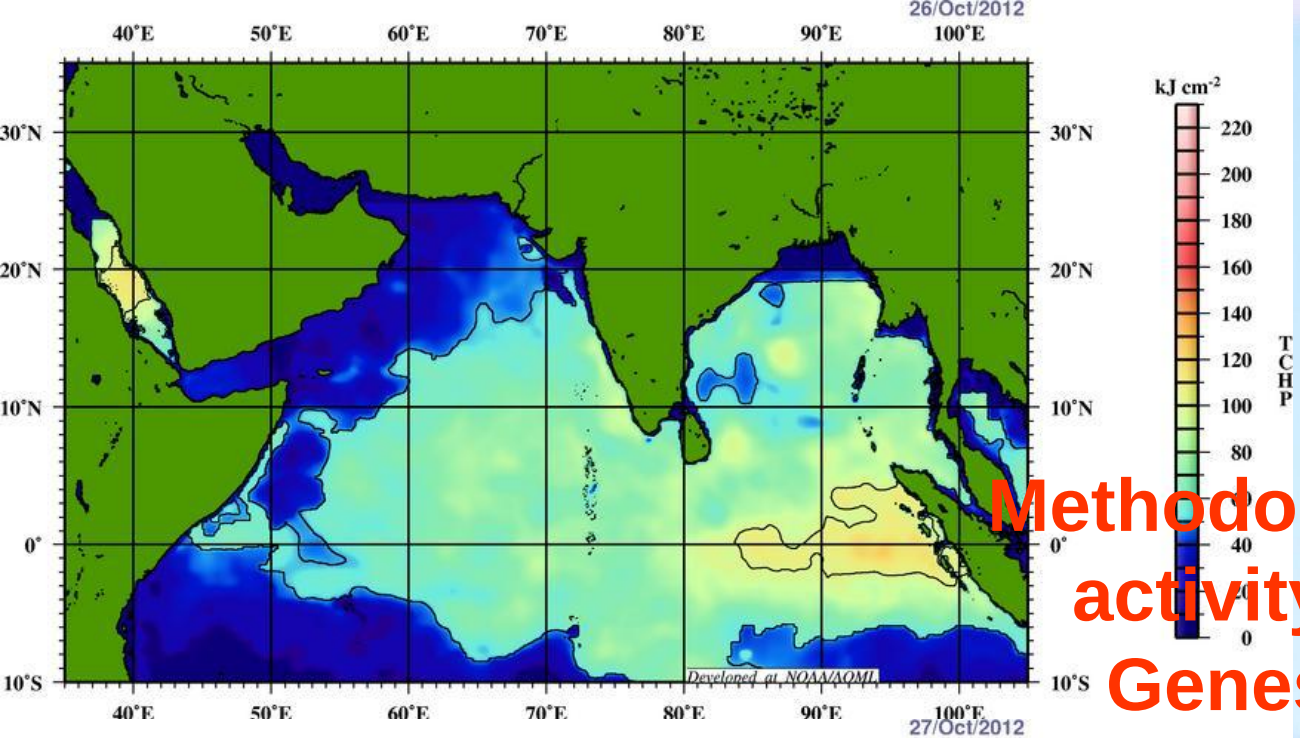
भारत मौस
INDIA METEORO

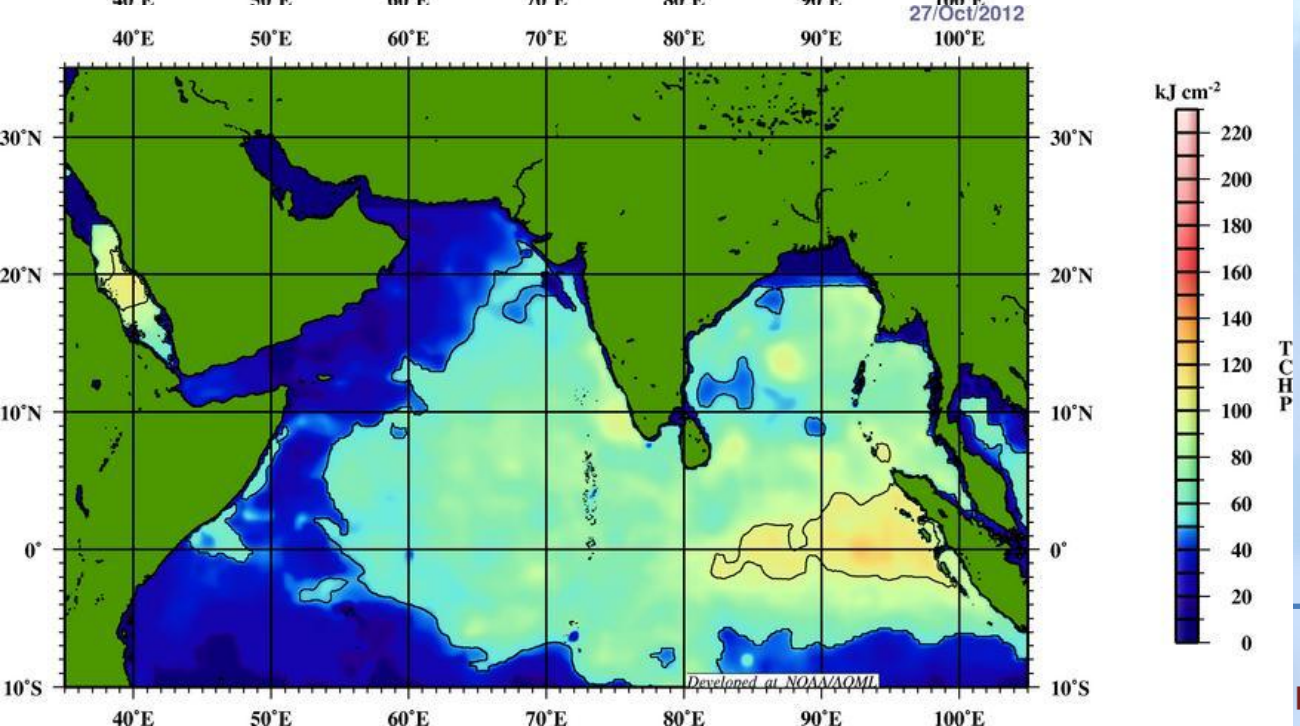




Methodology for tropical activity daily watch: Genesis of NILAM

MENT





Methodology for tropical activity daily watch: Genesis of NILAM

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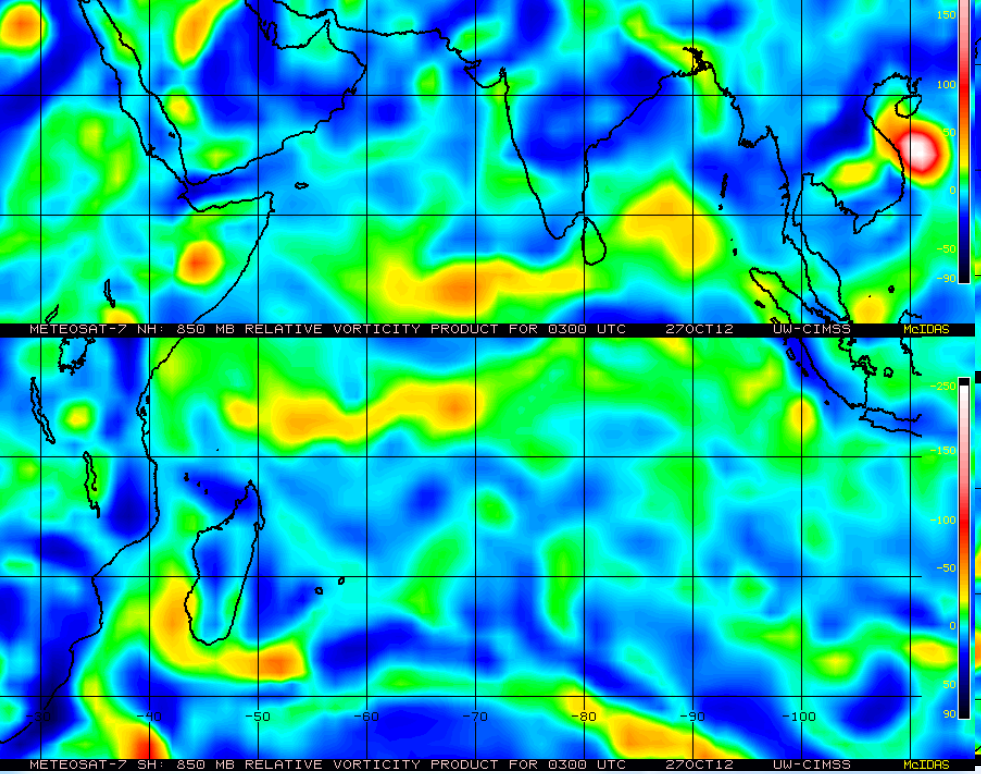
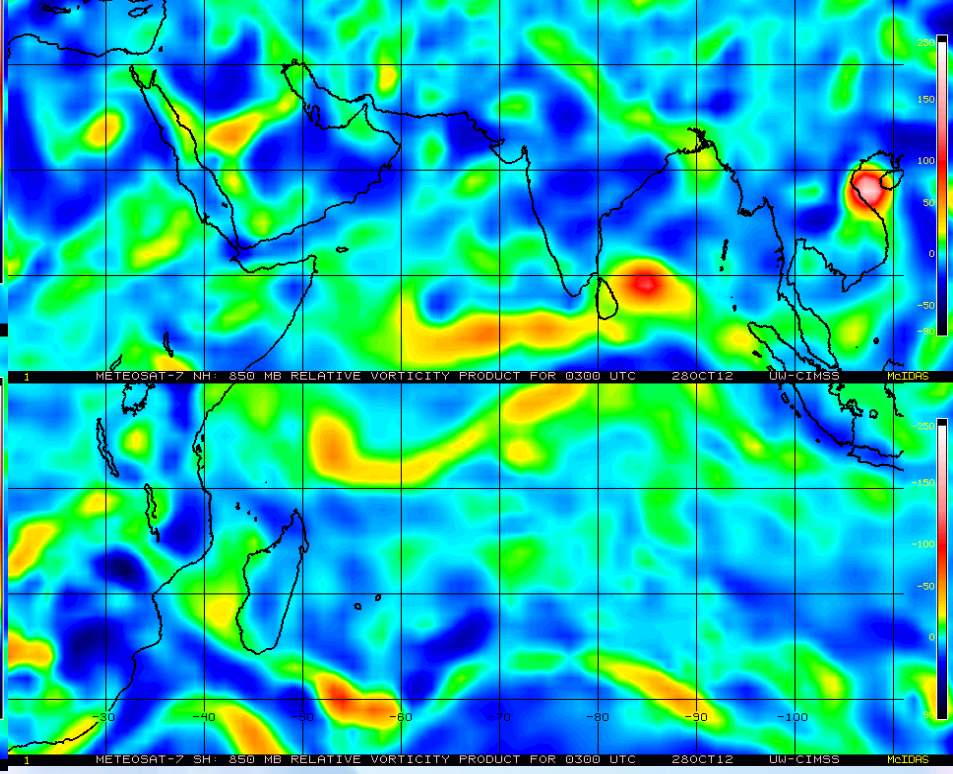
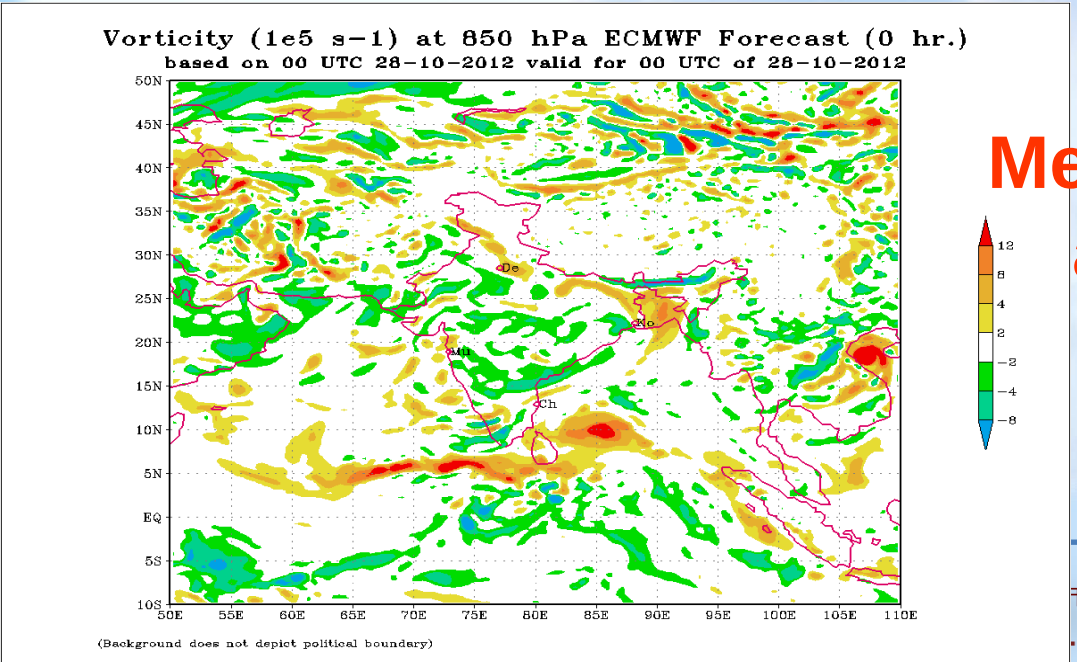


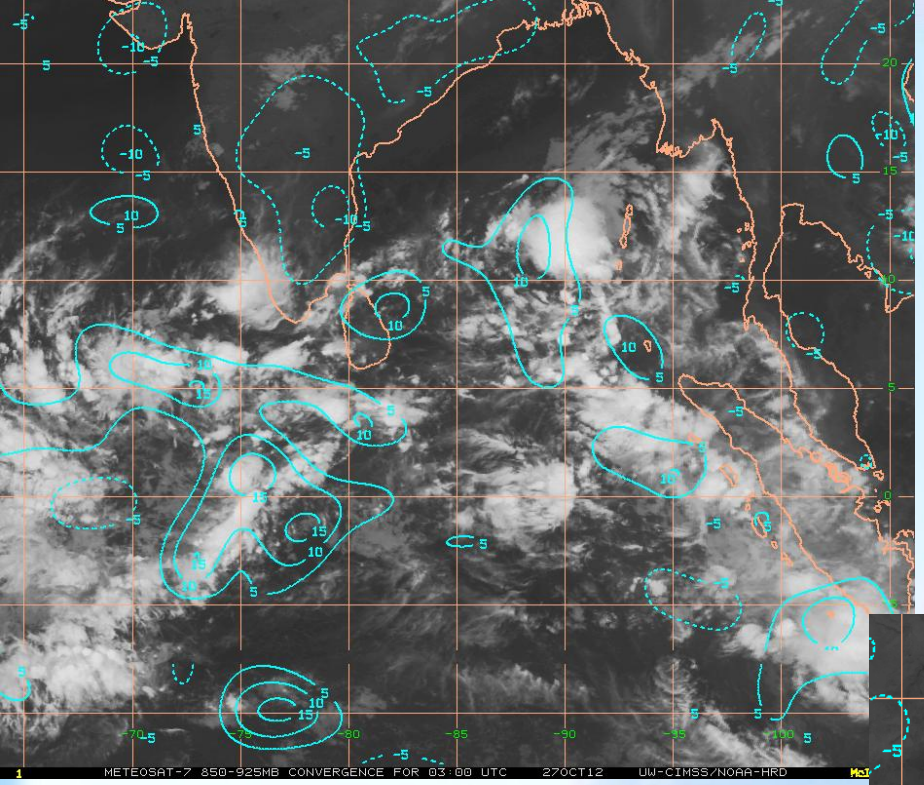


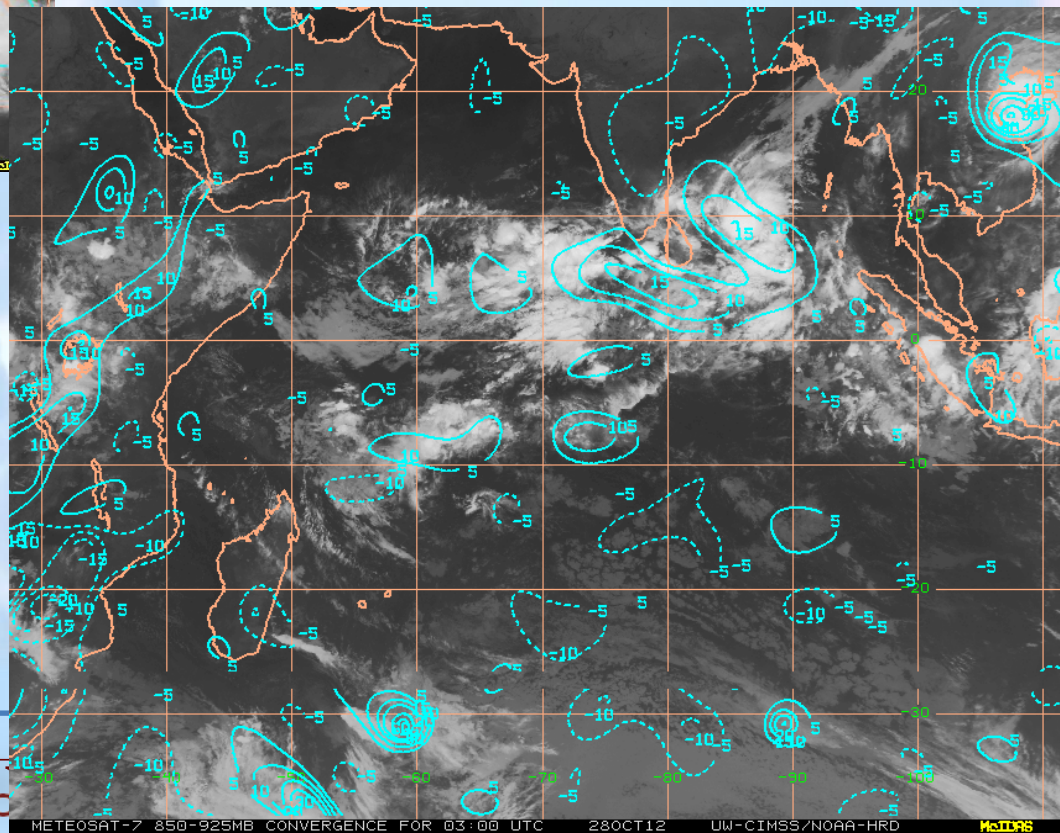


Methodology for tropical activity daily watch: Genesis of NILAM

विभाग
DEPARTMENT

Methodology for tropical activity daily watch: Genesis of NILAM





भारत मौस
INDIA METEORO

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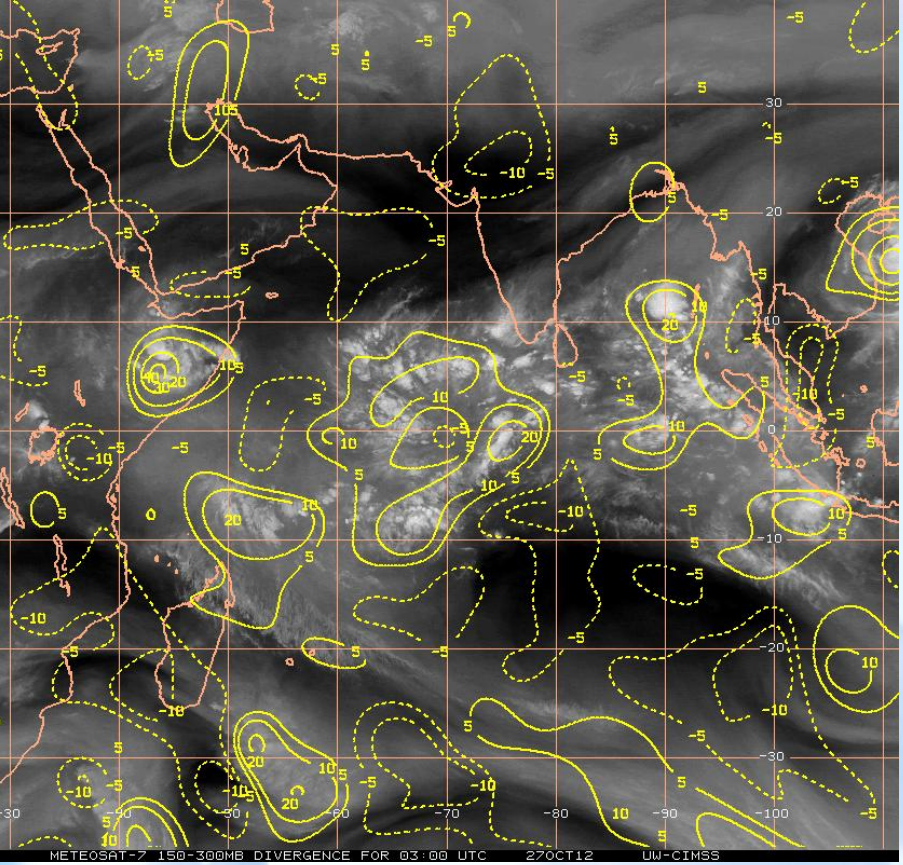

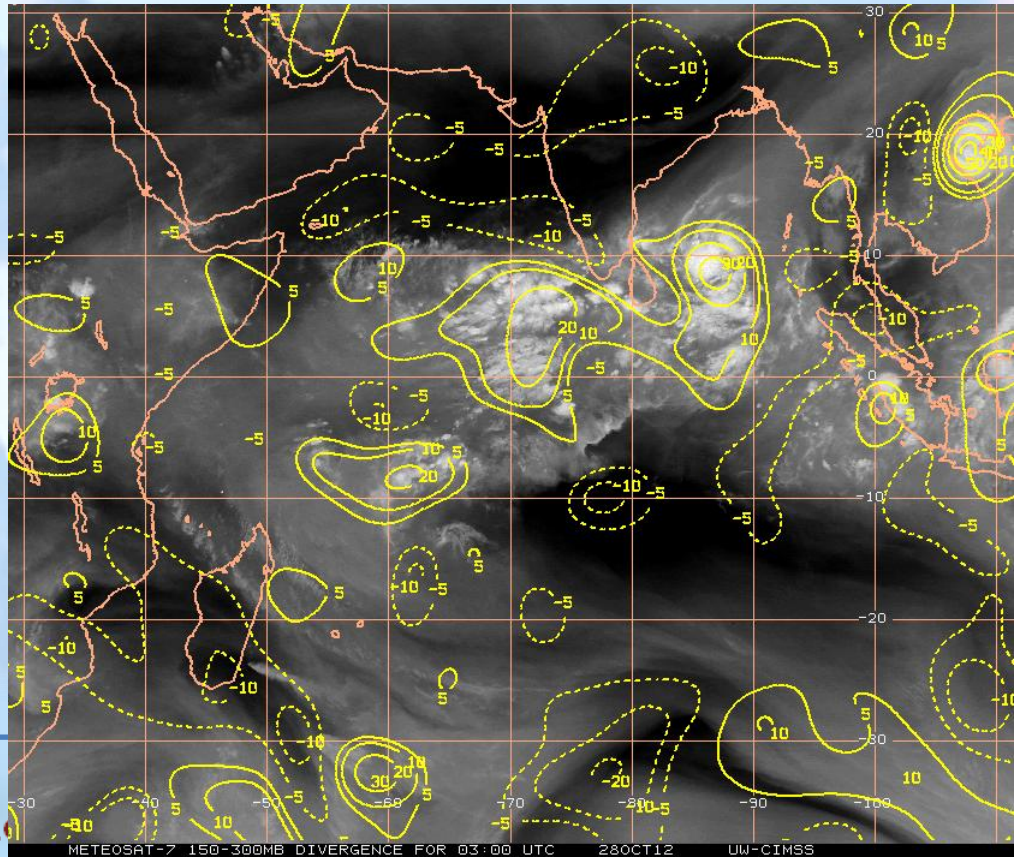

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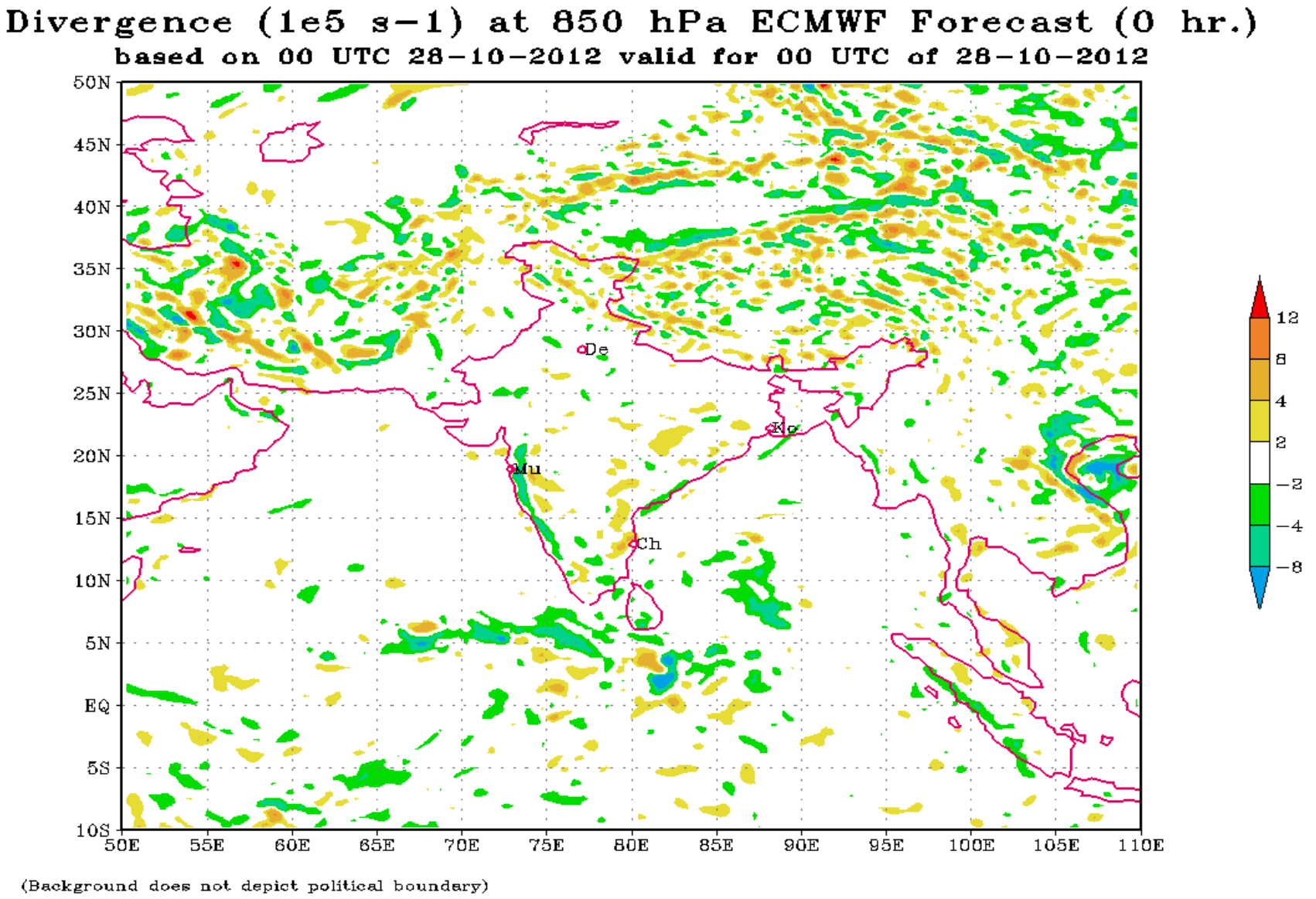

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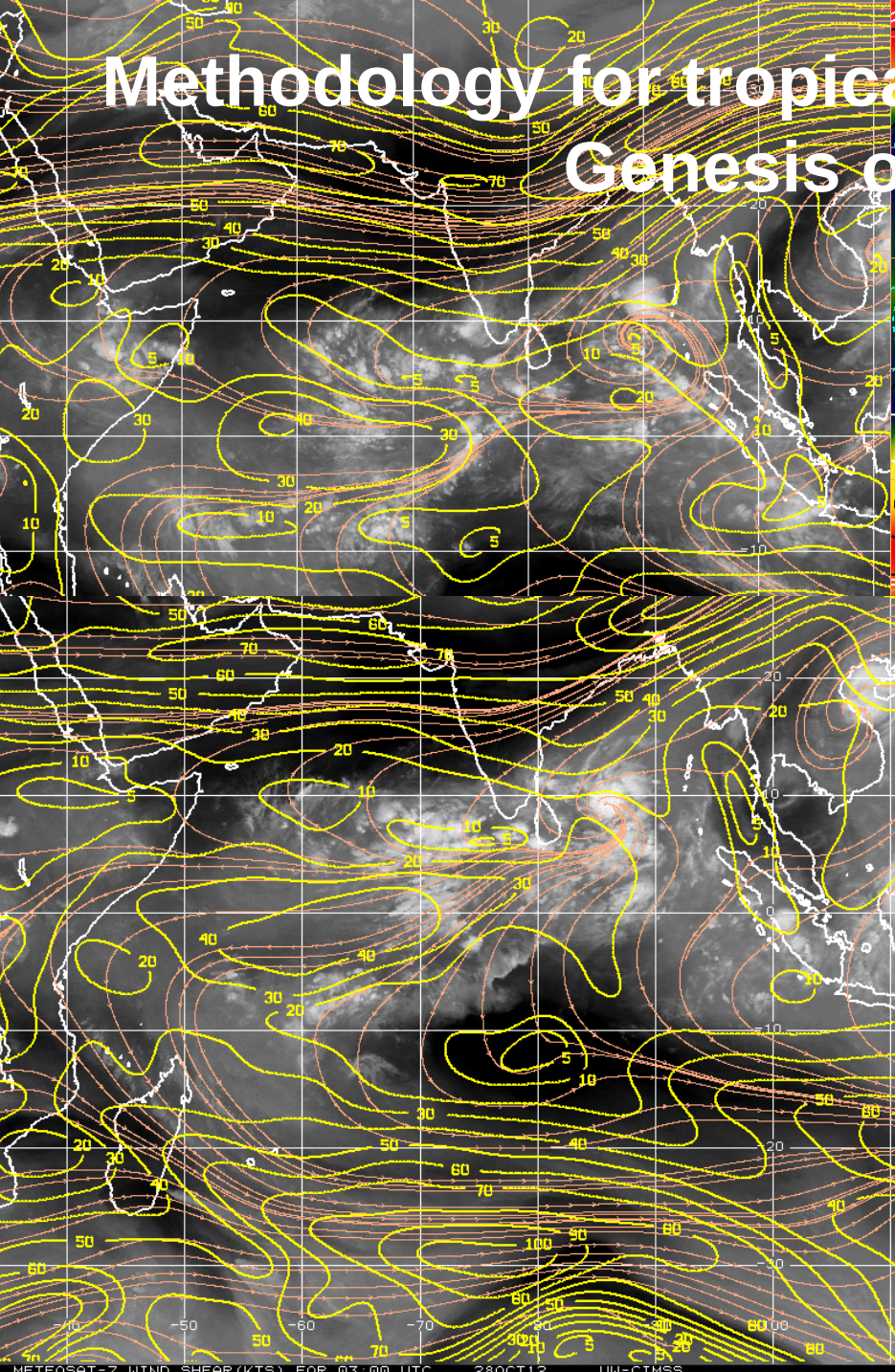

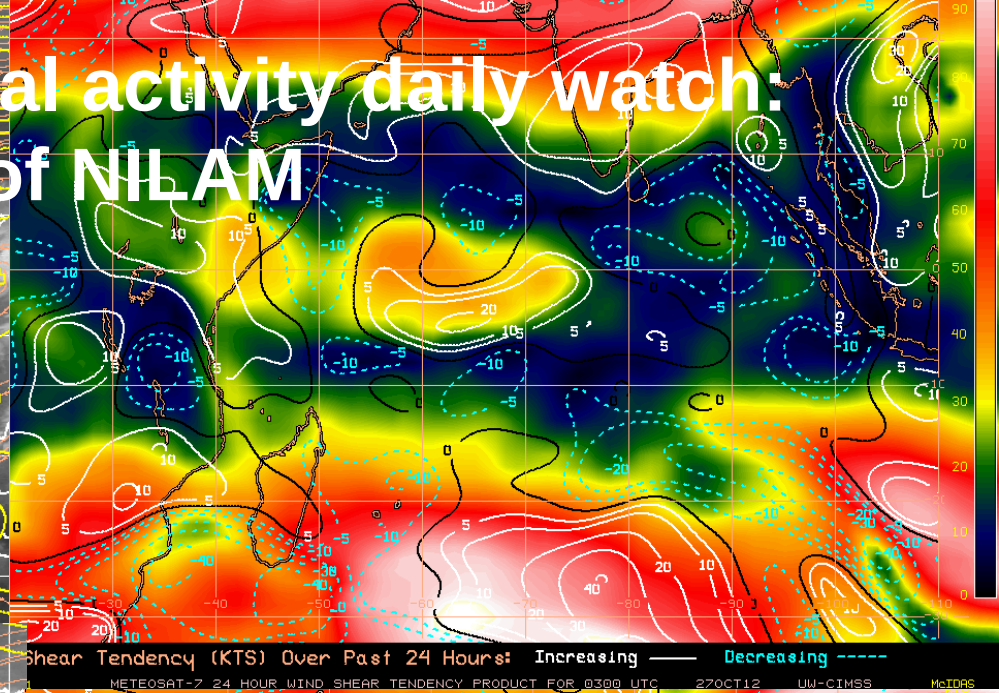

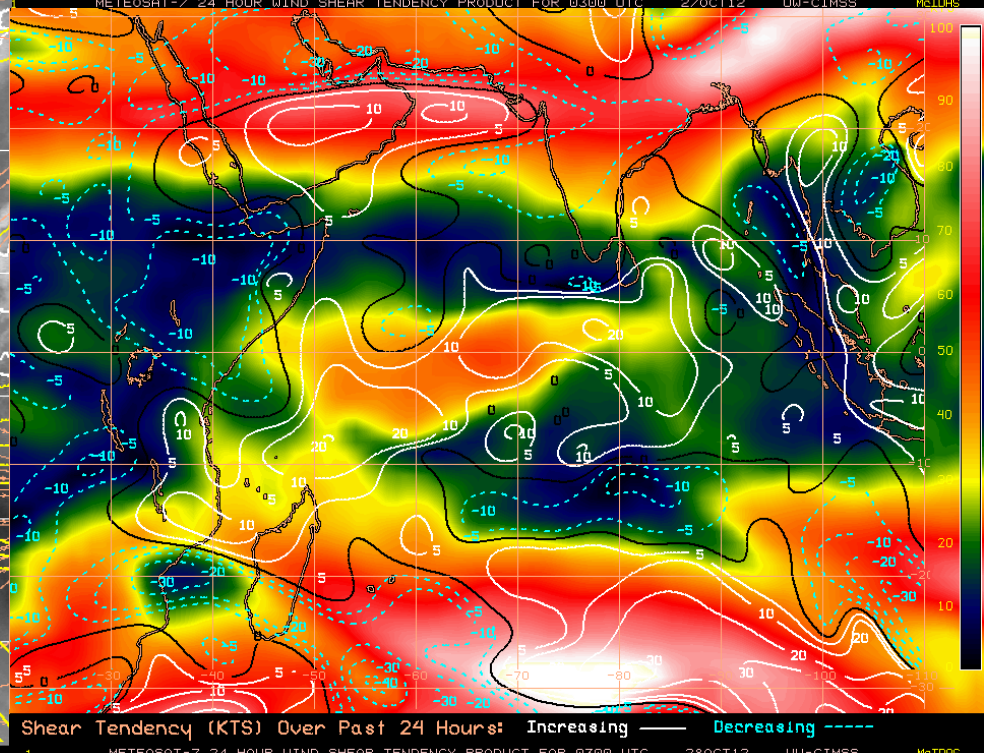

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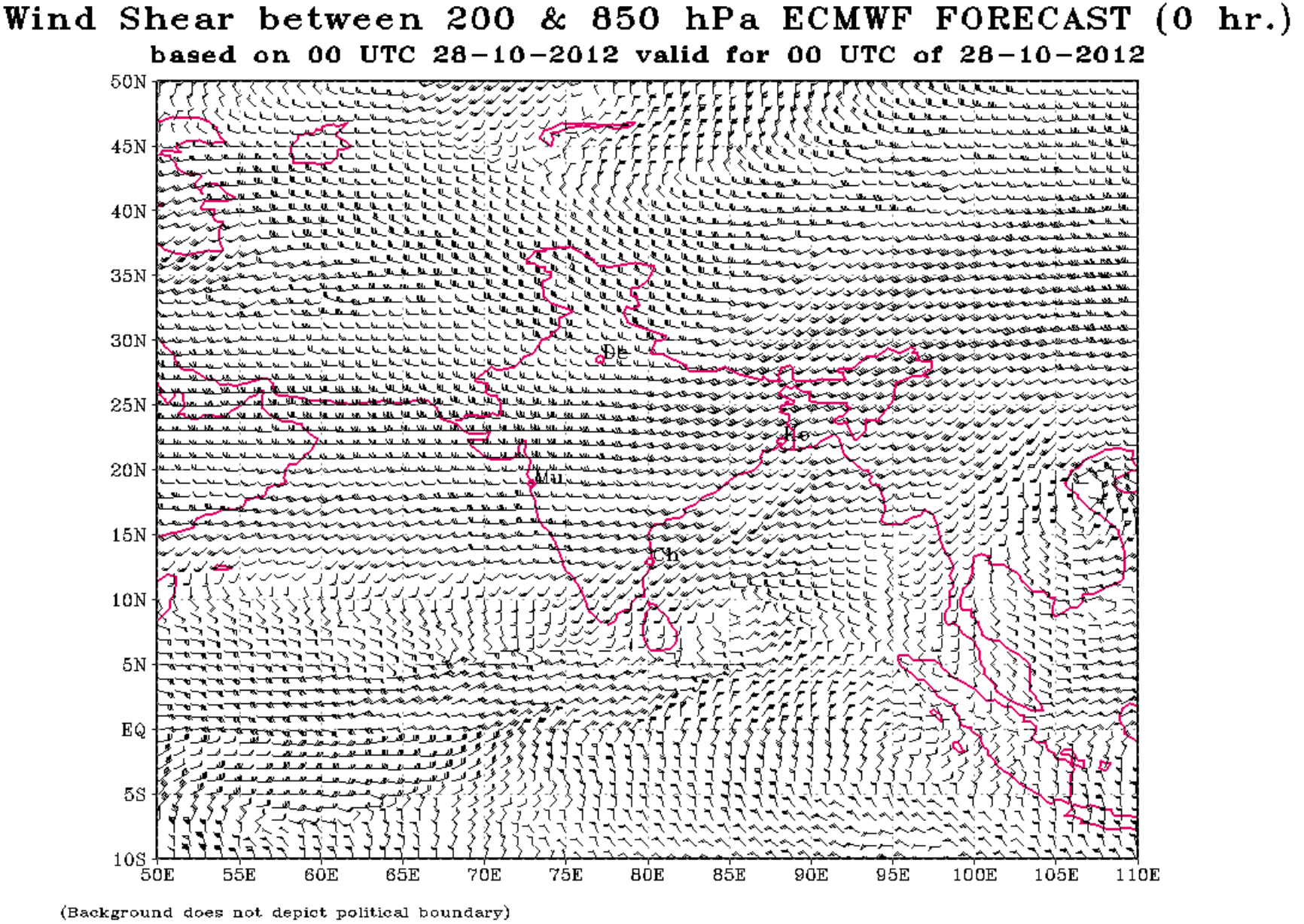

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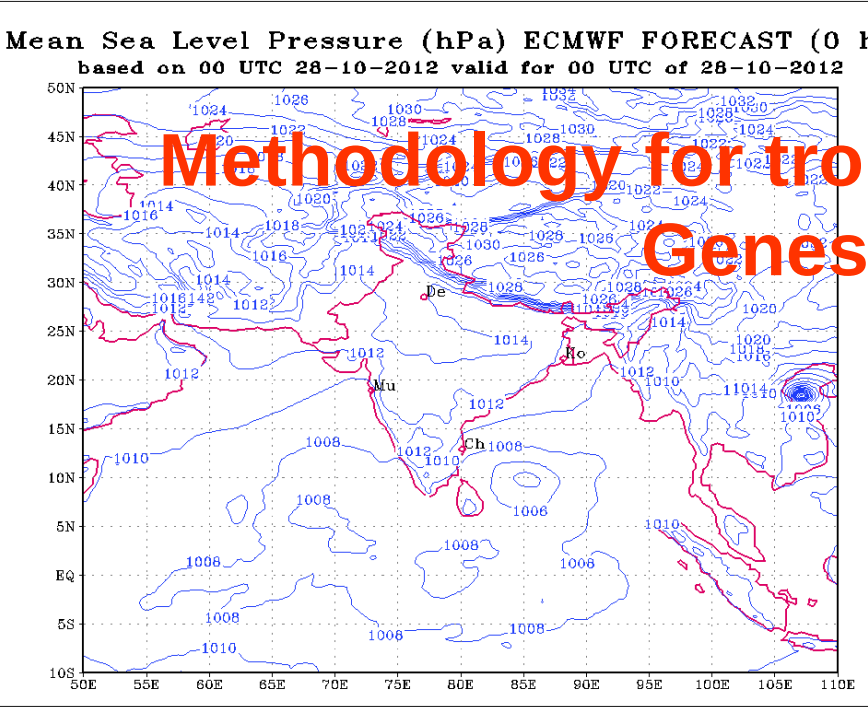

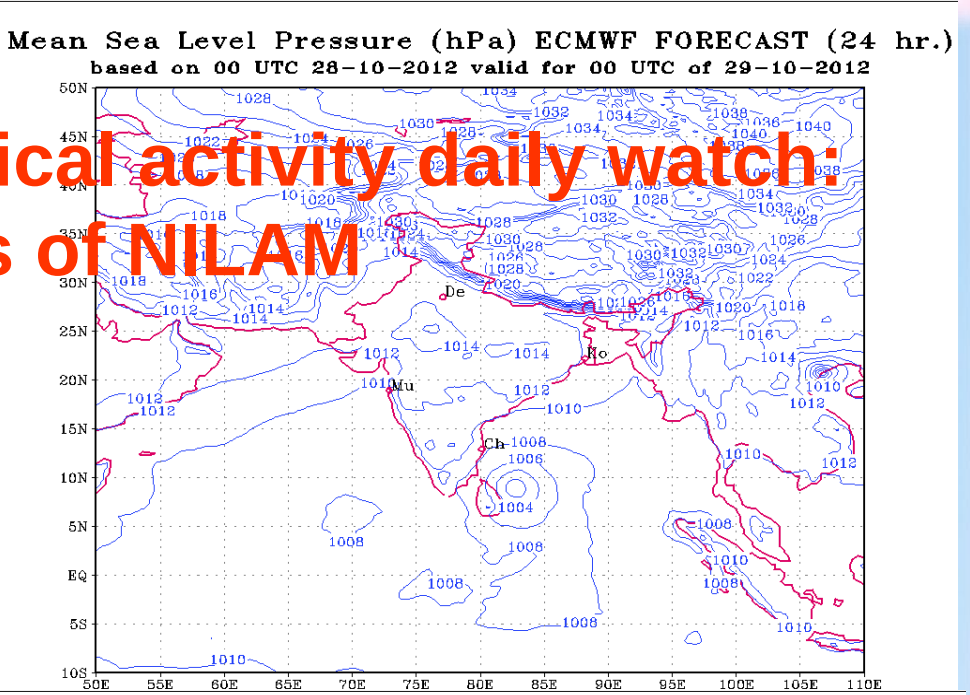

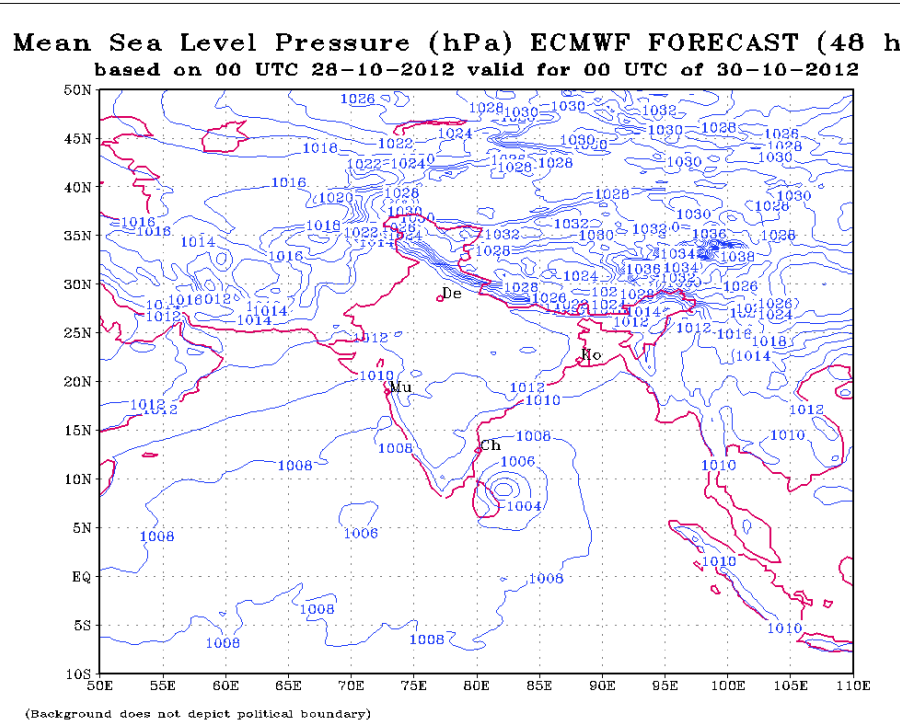

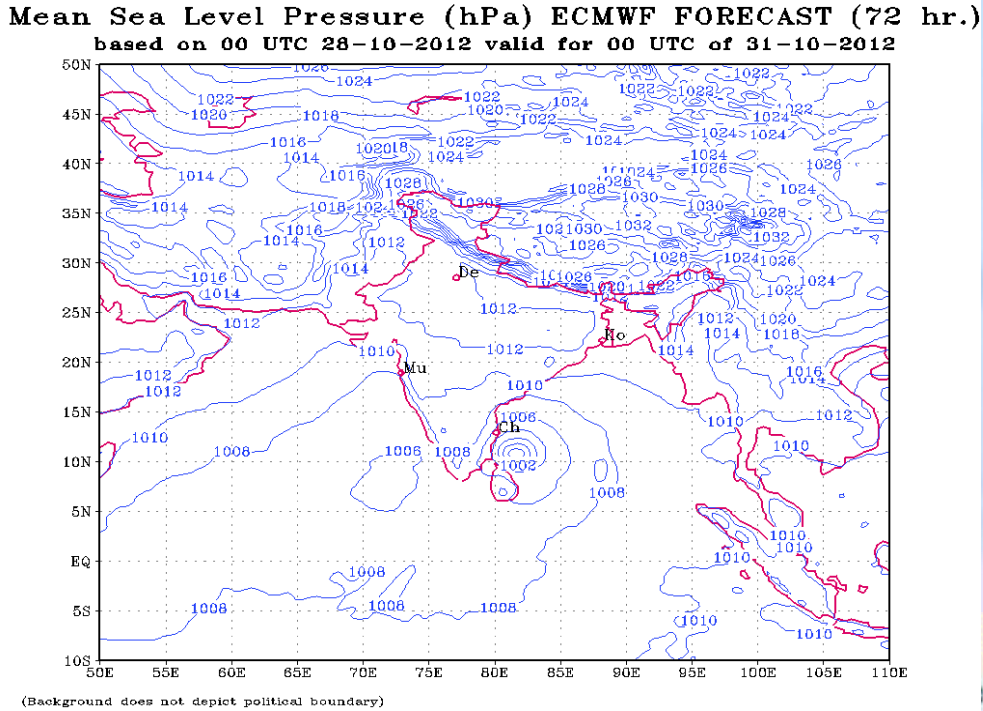

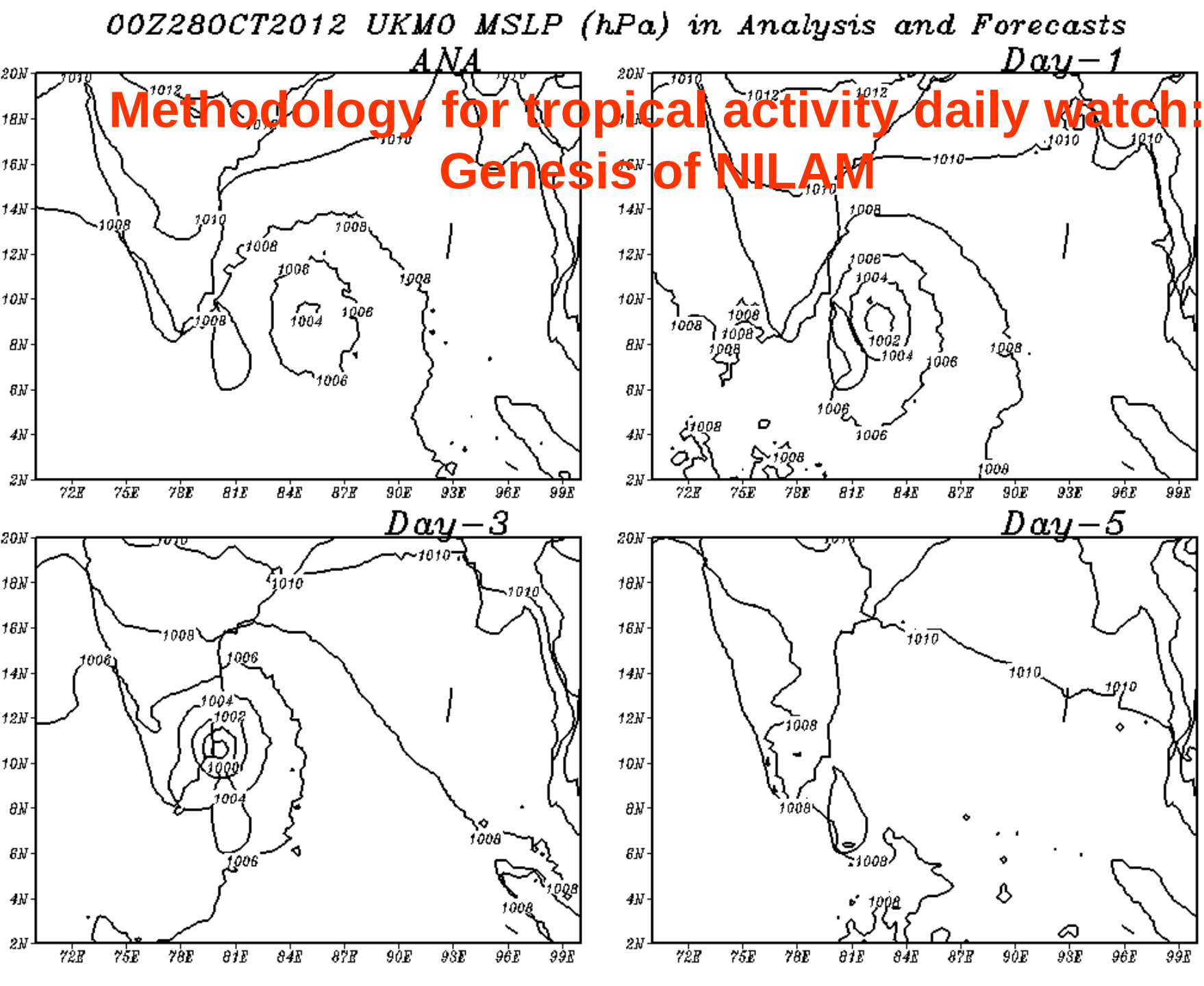

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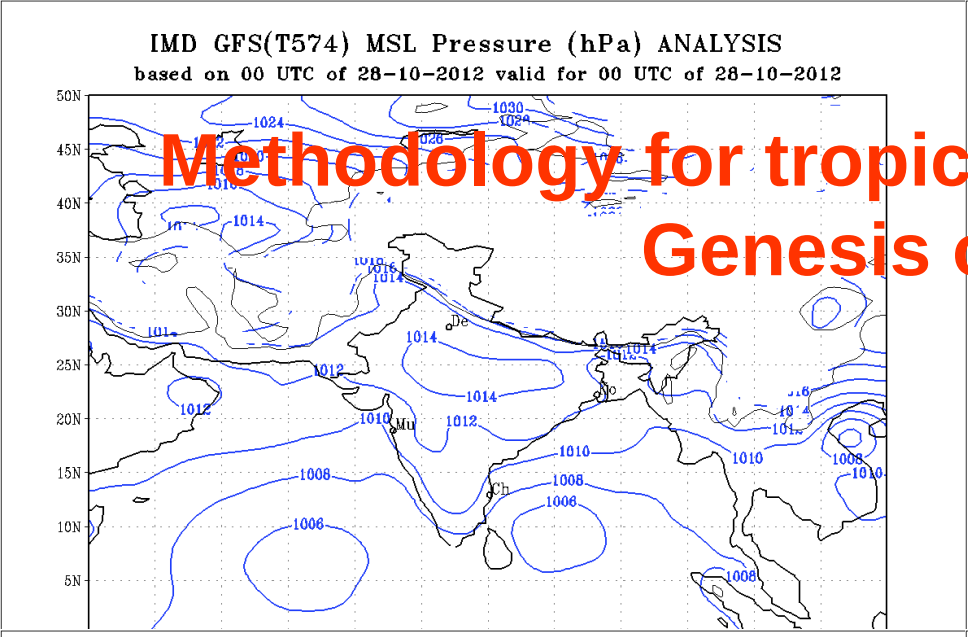

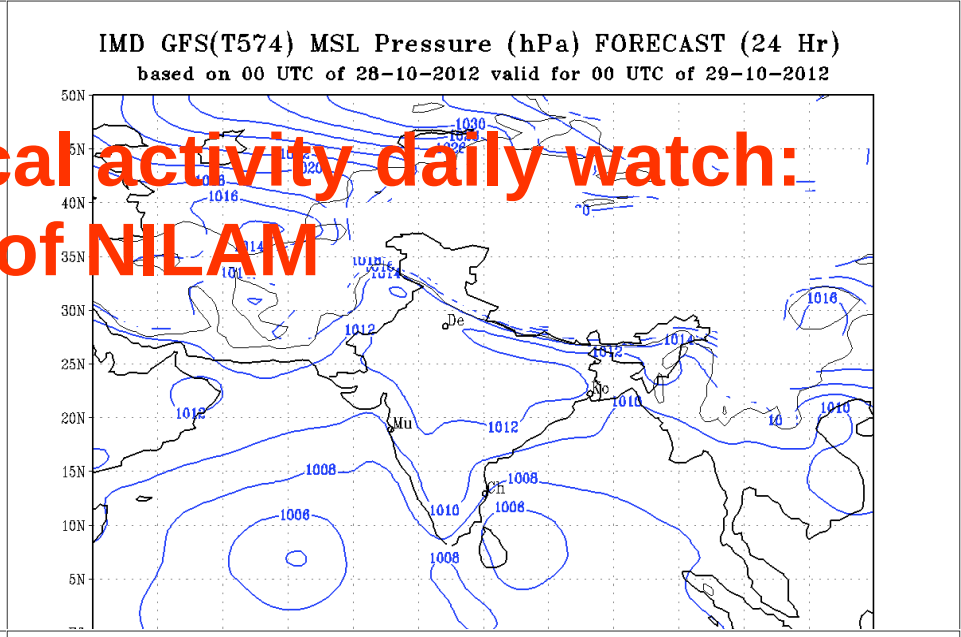

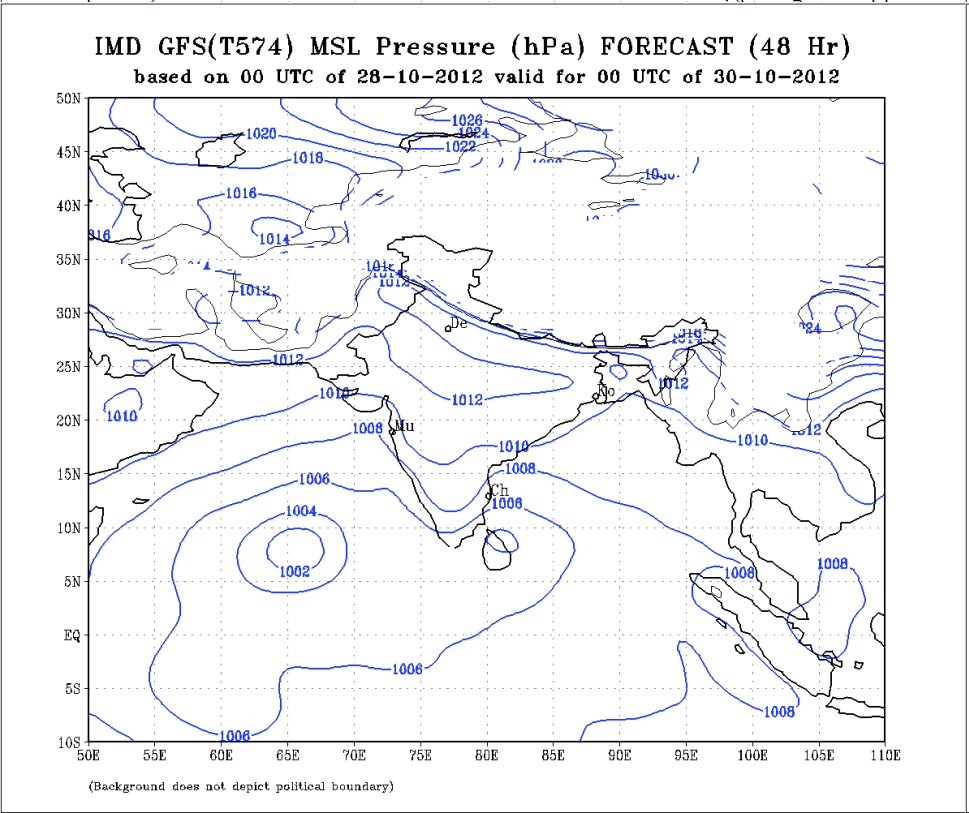

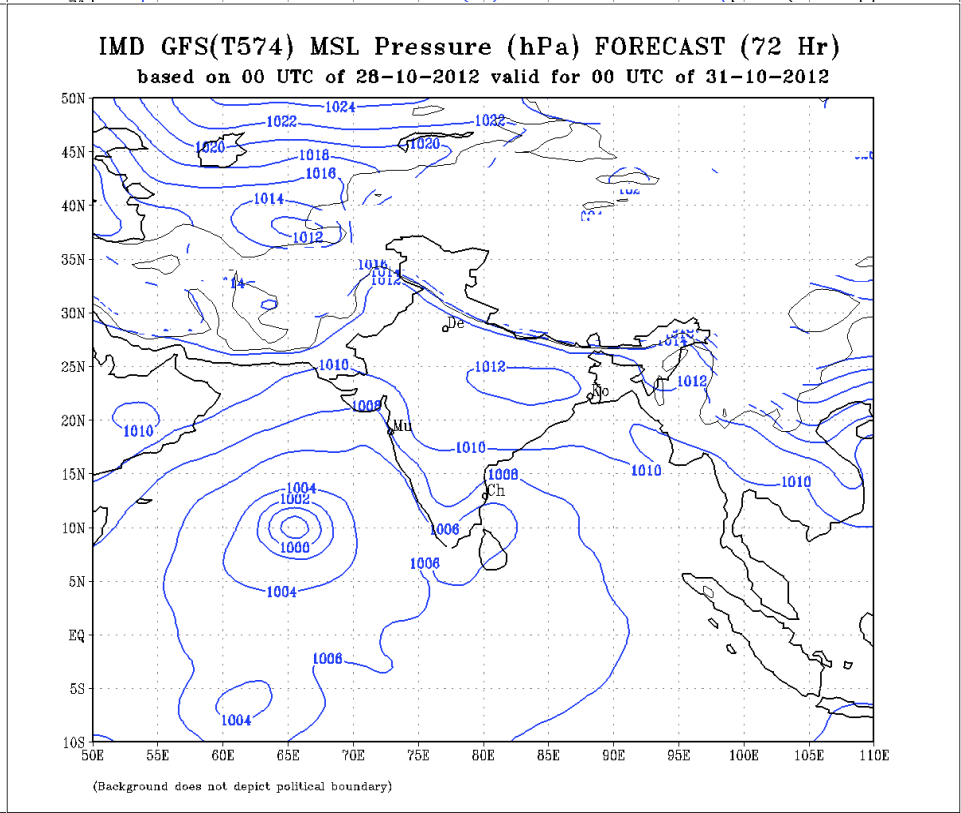

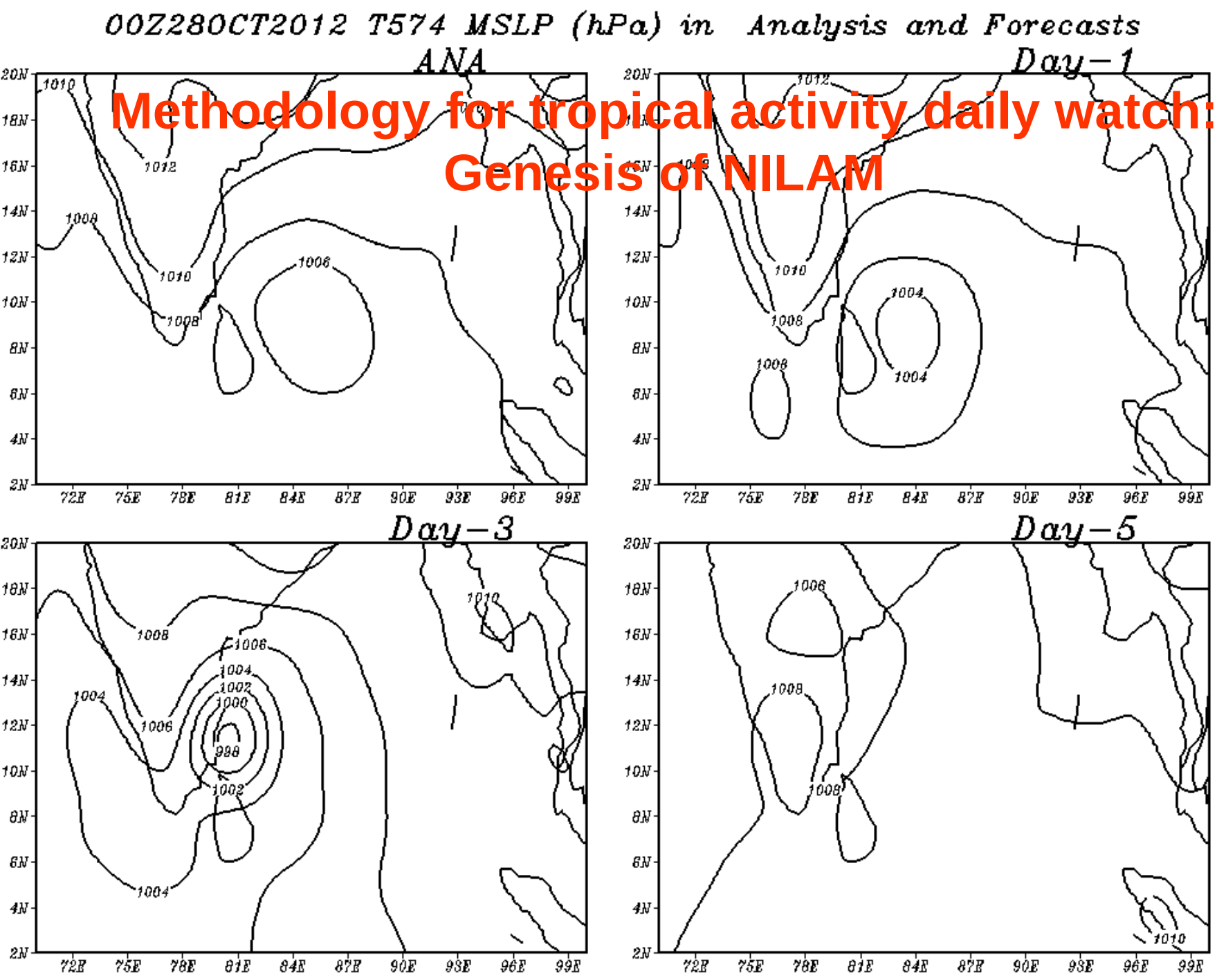
00Z28OCT2012 T574 MSLP (hPa) in Analysis and Forecasts
ANA
Day-1
Day-3
Day-5
Methodology for tropical activity daily watch:
Genesis of NILAM

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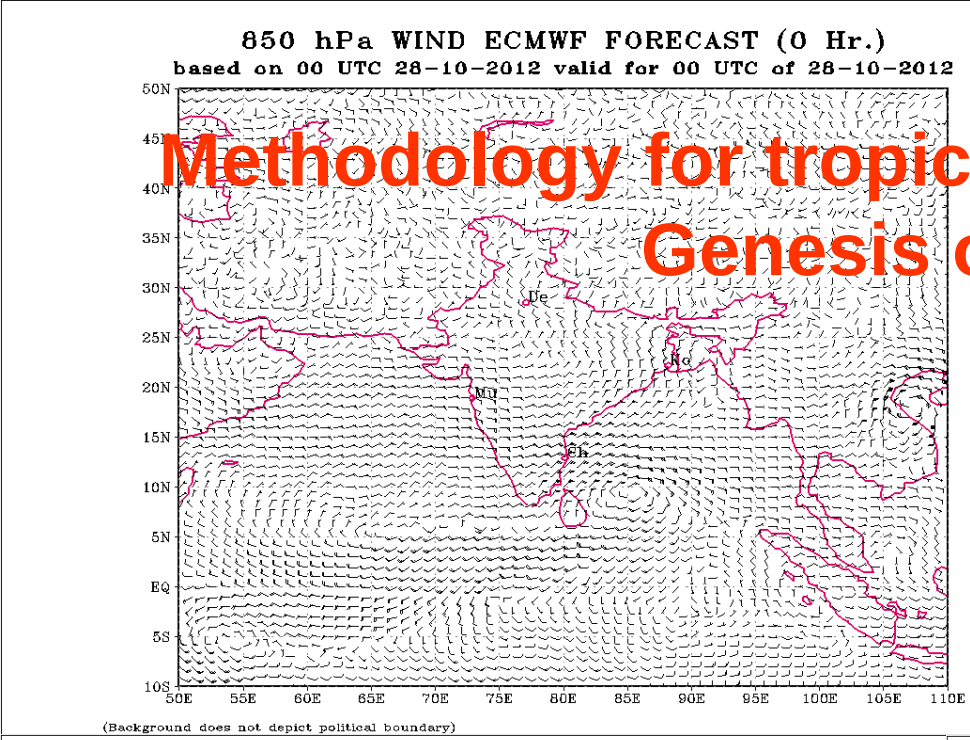
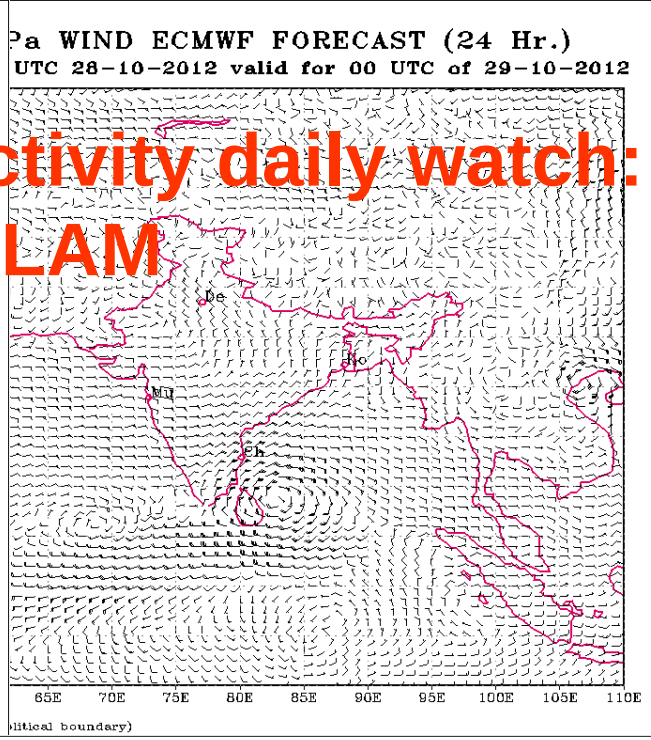
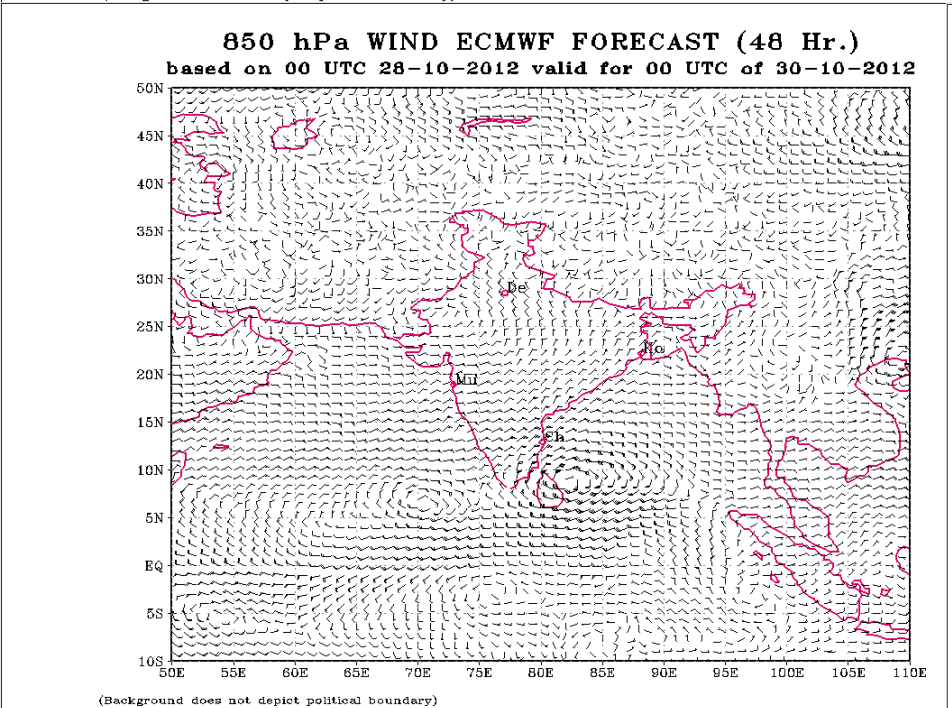
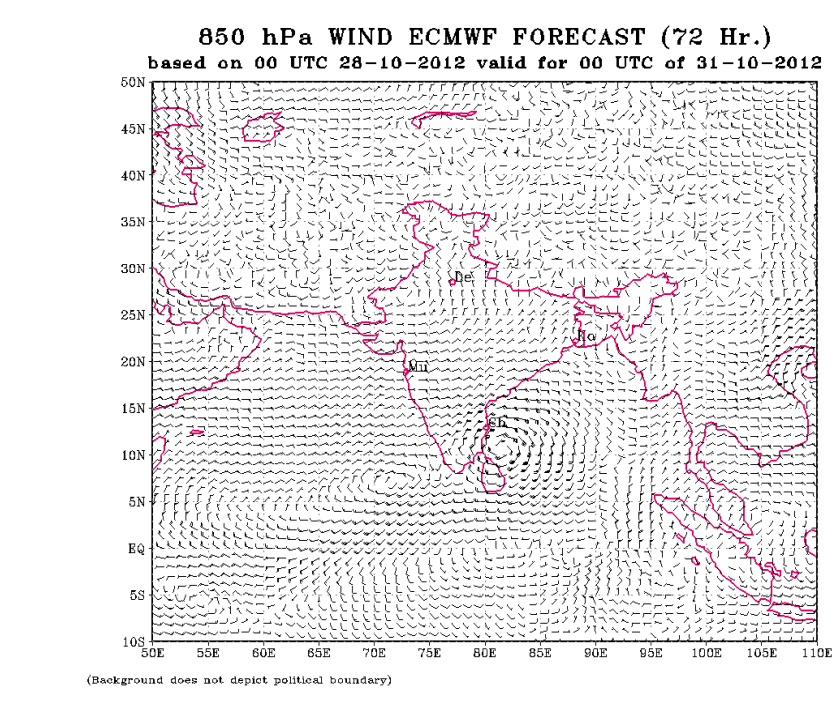
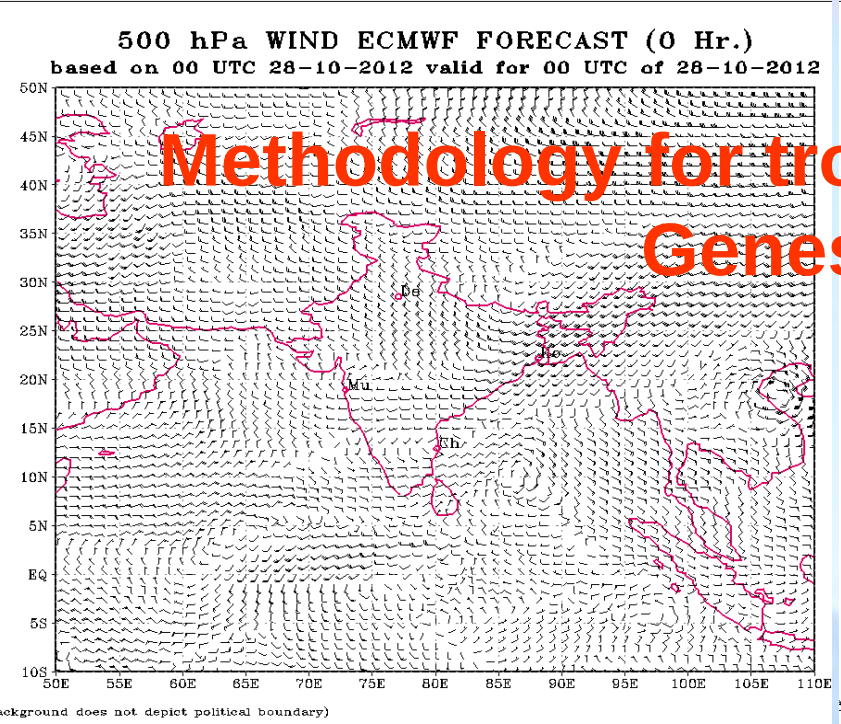


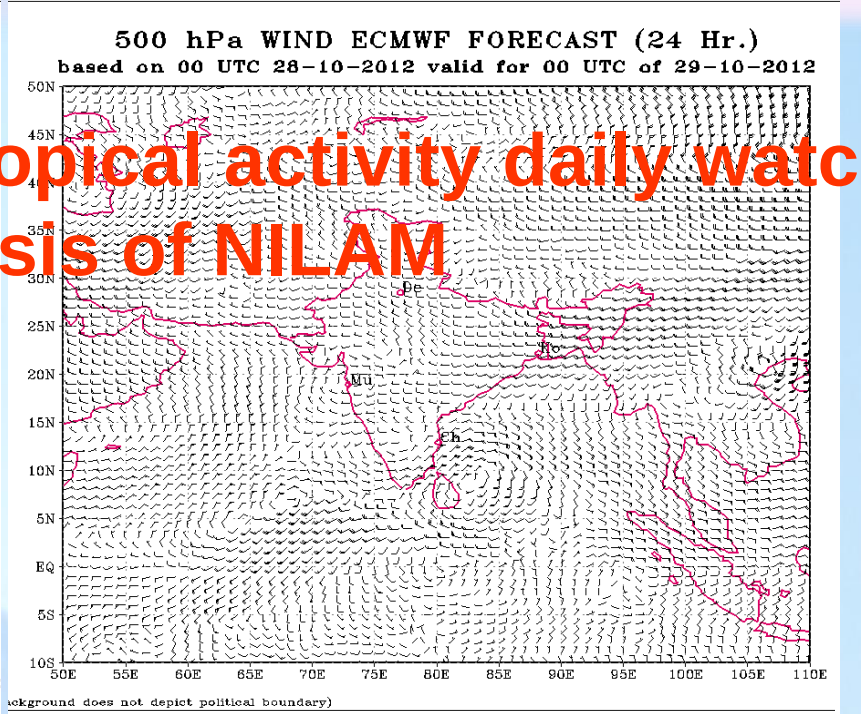


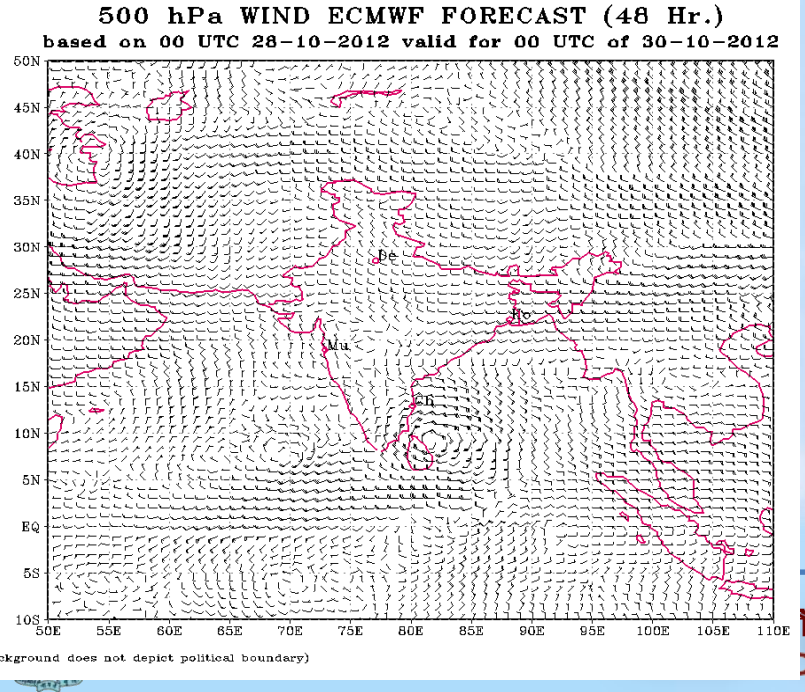


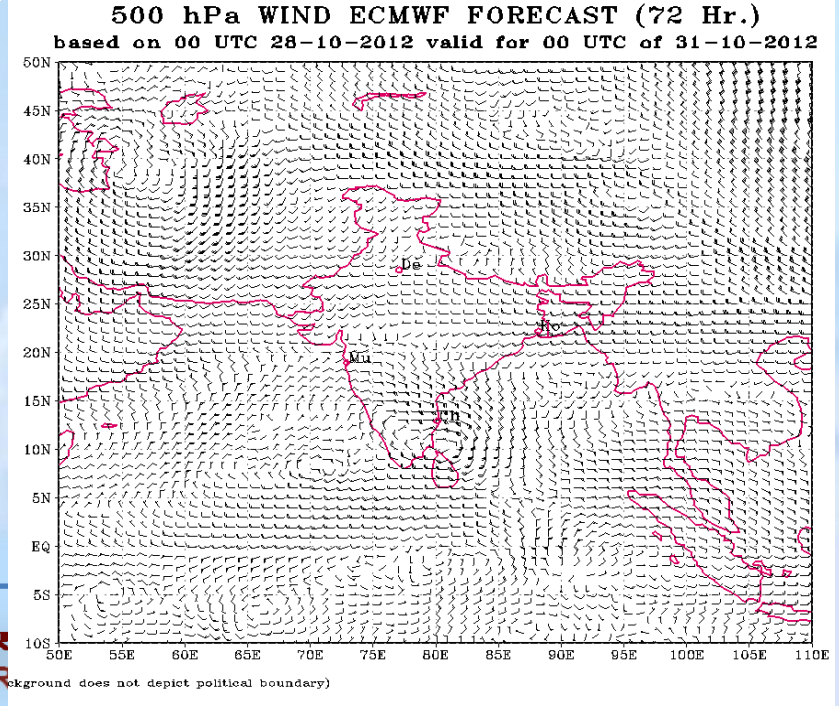


Methodology for tropical activity daily watch: Genesis of NILAM

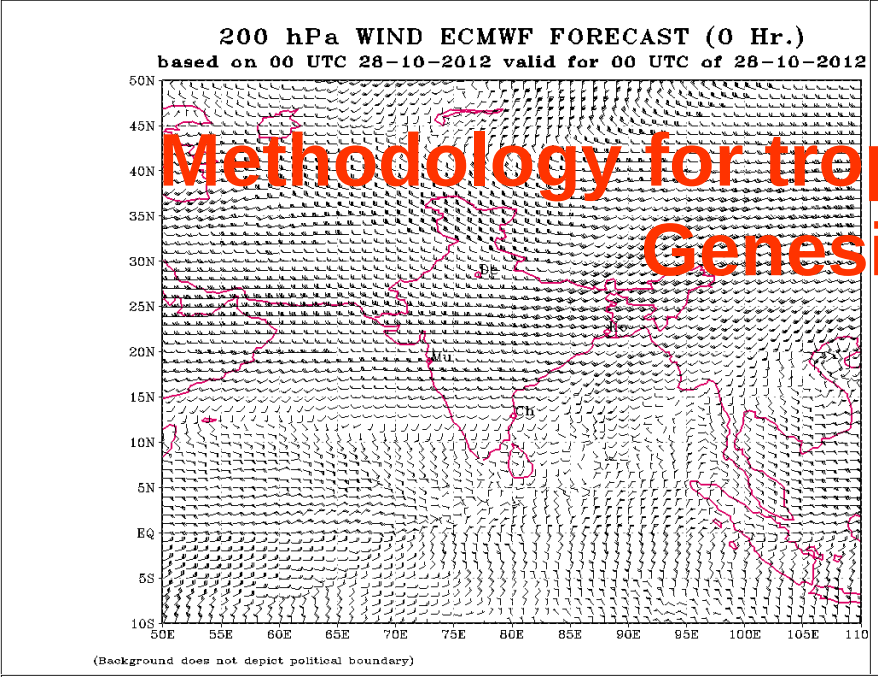


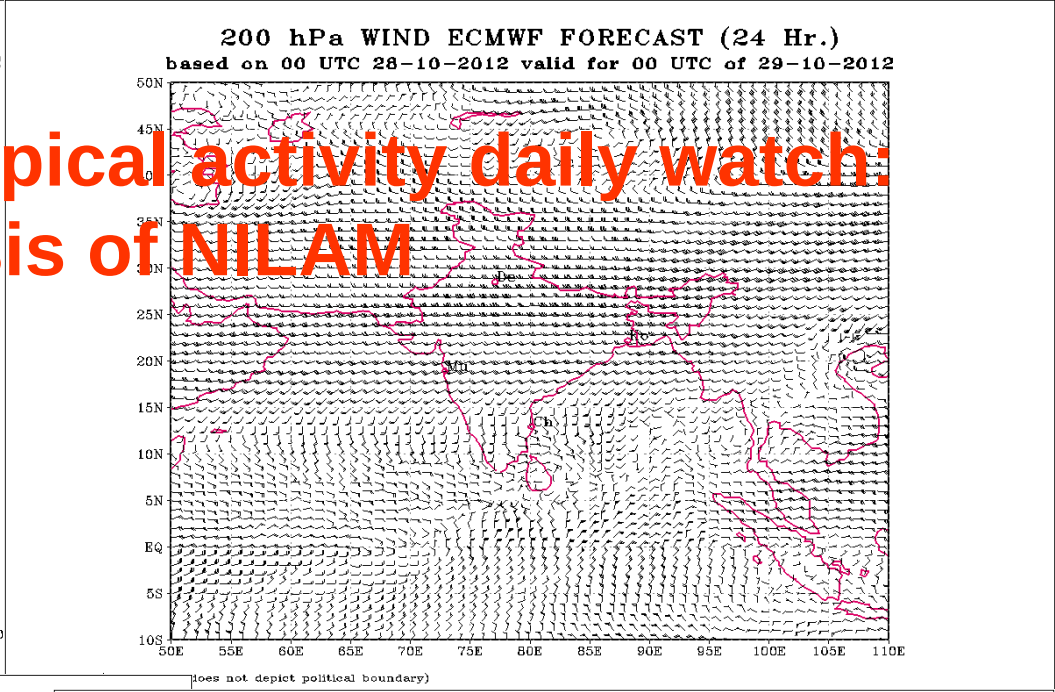


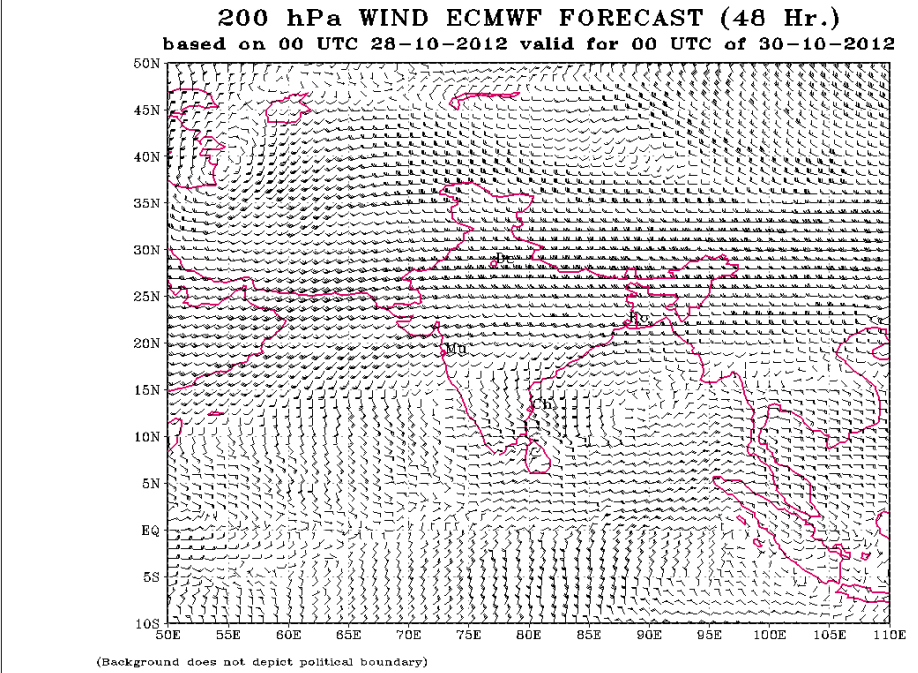


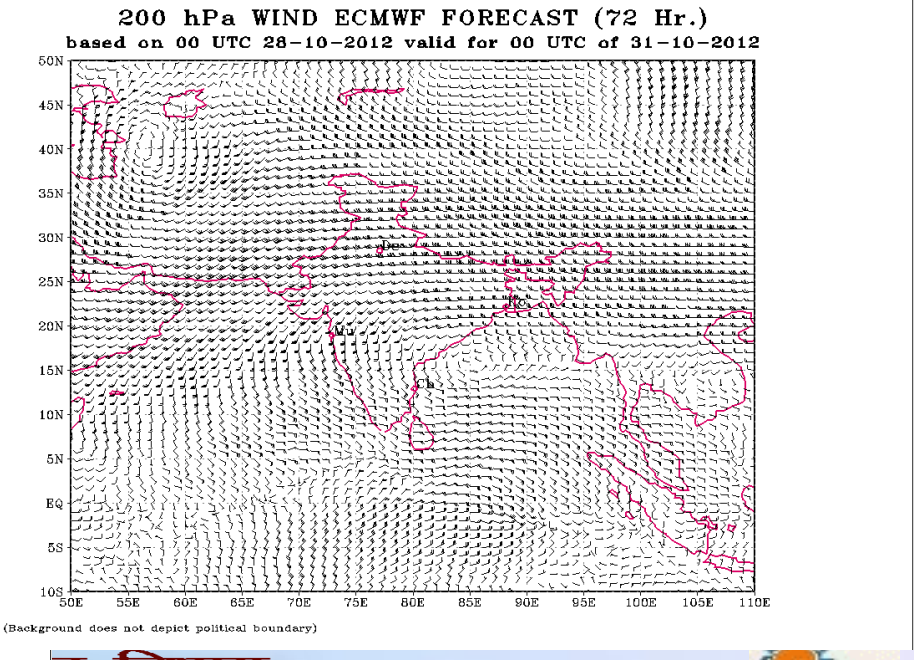


Methodology for tropical activity daily watch: Genesis of NILAM









GENESIS POTENTIAL PARAMETER (GPP)

The GPP is defined as:

(Natural Hazards, 2009, 50,389-402)

$$GPP = \frac{\xi_{850} x M x I}{S}$$ if $\zeta_{850} > 0$, M > 0 and I > 0

= 0 if $\zeta_{850} \leq 0$, M ≤ 0 and I ≤ 0

Where , ζ_{850} = Low level relative vorticity (at 850 hPa) in 10^{-5} s^{-1}

S = Vertical wind shear between 200 and 850 hPa (ms^{-1})

$M = \frac{[RH4]}{30}$ = Middle troposphere relative humidity

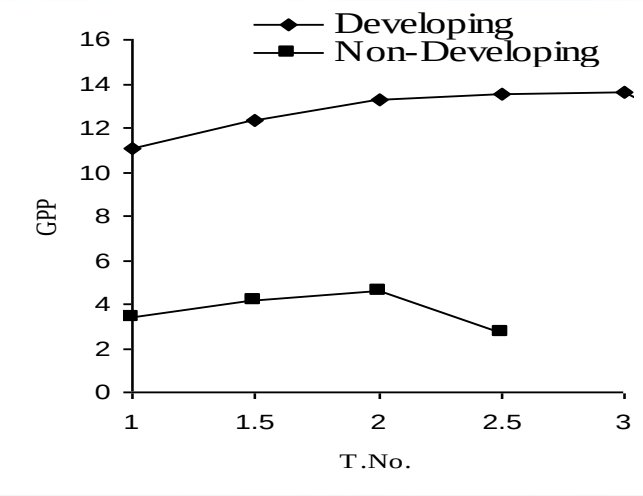
Where RH is the mean relative humidity between 700 and 500 hPa

I = ($T_{850} - T_{500}$) °C = Middle-trpospheric instability

(Temperature difference between 850 hPa and 500 hPa)

Genesis potential parameter for developing versus non- developing systems:

GPP($x10^{-5}$) →					
T.No. →	1.0	1.5	2.0	2.5	3.0
Developing	11.1	12.3	13.3	13.5	13.6
Non-Developing	3.4	4.2	4.6	2.7	-



Threshold value of GPP = 8.0

Applications of GPP

- Area average GPP to identify the potential of a system to intensify into a Cyclonic Storm at the early stage of development.
- Grid point analysis of GPP as a predictive signal to identify the potential cyclogenesis zone over the North Indian Sea.

Methodology for tropical activity daily watch: Genesis of PHET

Date/Time	16.05.2010 1200 UTC	17.05.2010 0000 UTC	17.05.2010 1200 UTC
T.No. →	**1.0**	**1.0**	**2.0**
Developing	11.1	11.1	13.3
Non-Developing	3.4	3.4	4.6
LAILA	**17.4**	**13.5**	**16.5**

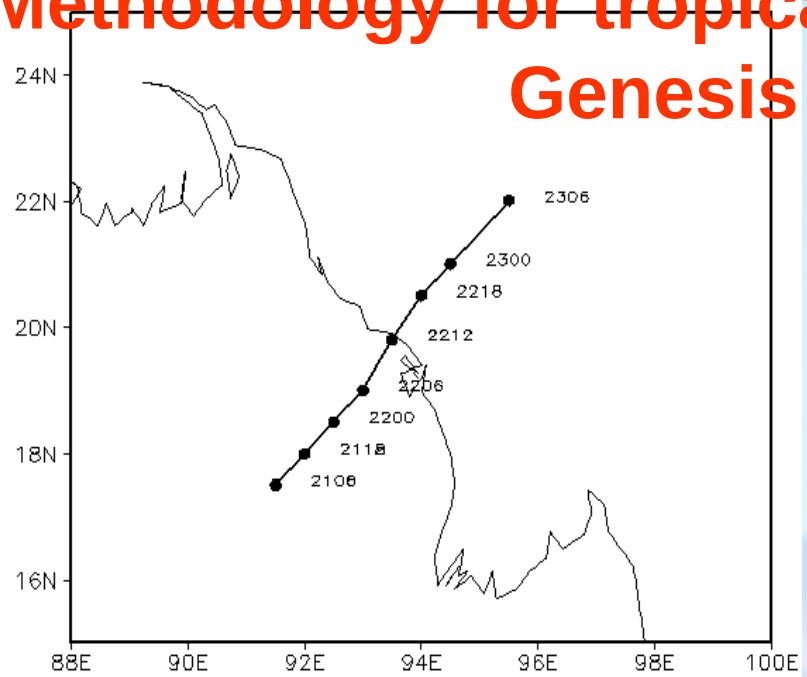
Date/Time	31.05.2010 0000 UTC	31.05.2010 1200 UTC	01.06.2010 0000 UTC
T. No.→	1.0	1.5	2.0
Developing	11.1	12.3	13.3
Non-Developing	3.4	4.2	4.6
PHET	09.7	14.2	17.3

Methodology for tropical activity daily watch: Genesis of GIRI

Date/Time	20.10.2010 0000 UTC	20.10.2010 1200 UTC	21.10.2010 0000 UTC
T. No.→	1.0	1.5	2.0
Developing	11.1	12.3	13.3
Non-Developing	3.4	4.2	4.6
GIRI	16.1	16.2	15.9

Date/Time	03.11.2010 0000 UTC	04.11.2010 0000 UTC	05.11.2010 0000 UTC
T. No.→	1.0	1.5	2.0
Developing	11.1	12.3	13.3
Non-Developing	3.4	4.2	4.6
JAL	12.7	13.5	17.4

Methodology for tropical activity daily watch: Genesis of GIRI



L-19 Oct

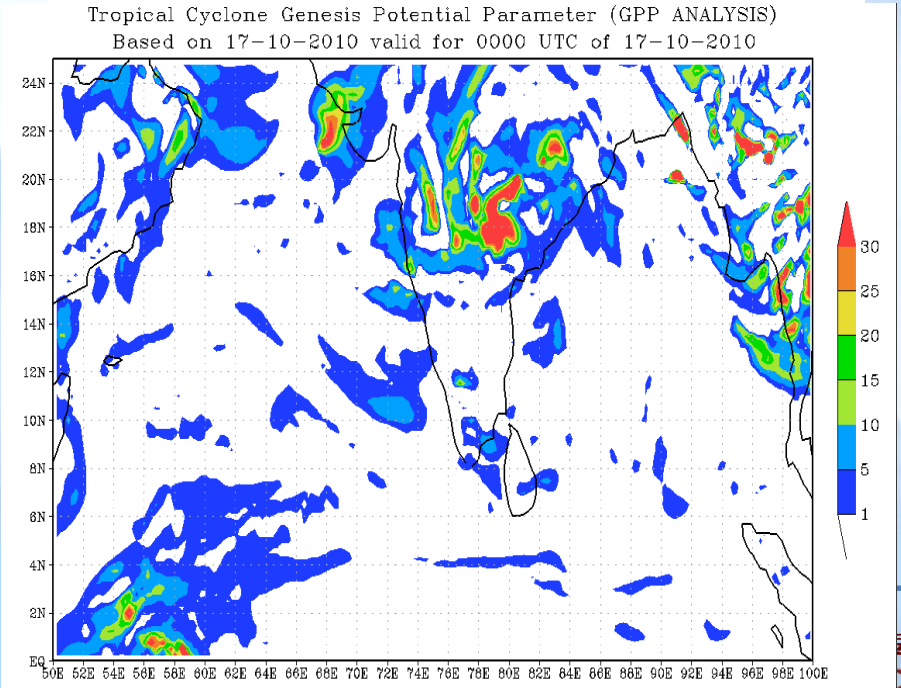
D-12Z/20

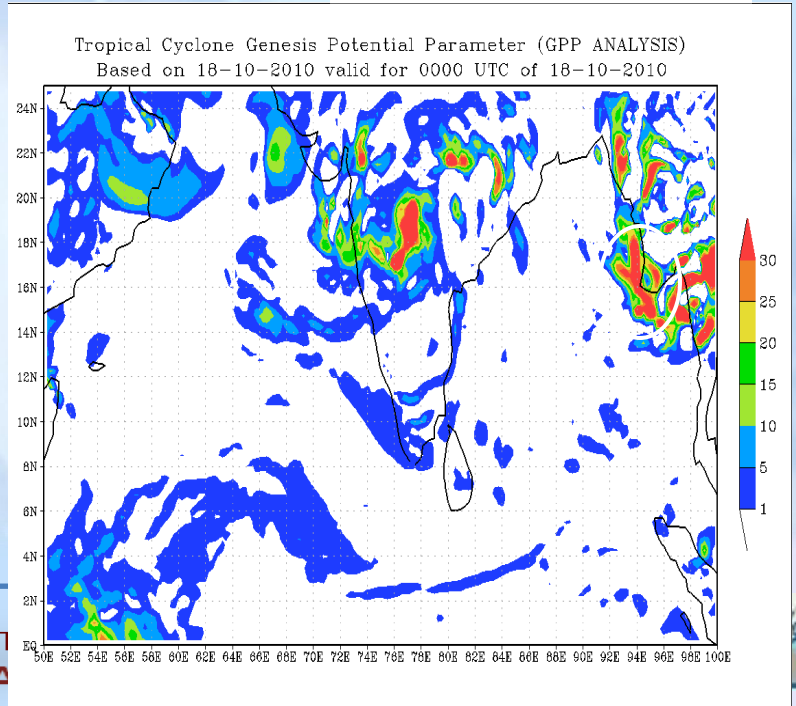
DD-03Z/21

CS-06Z/21

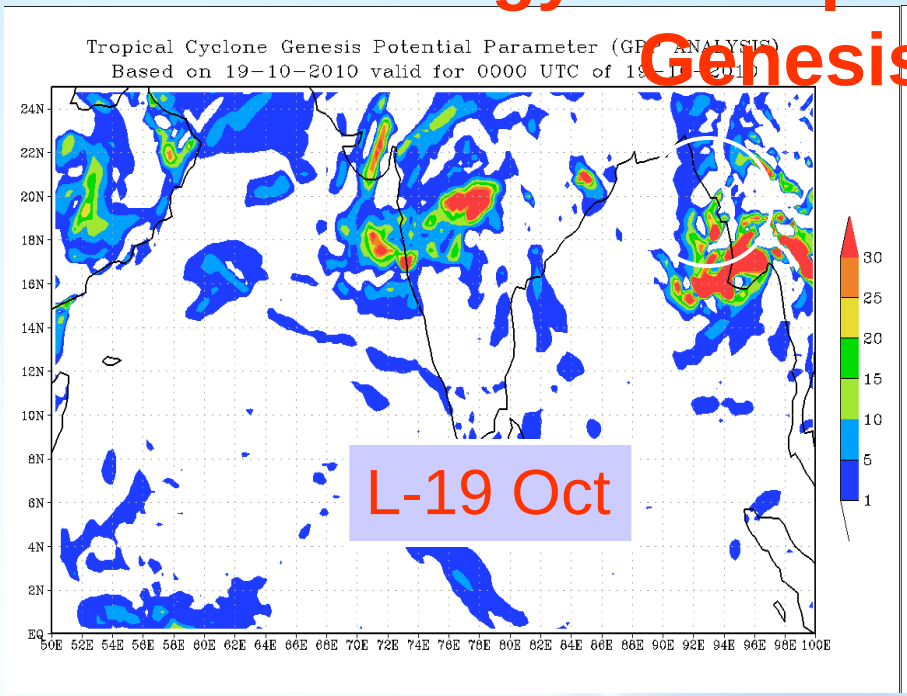
SCS-00Z/22

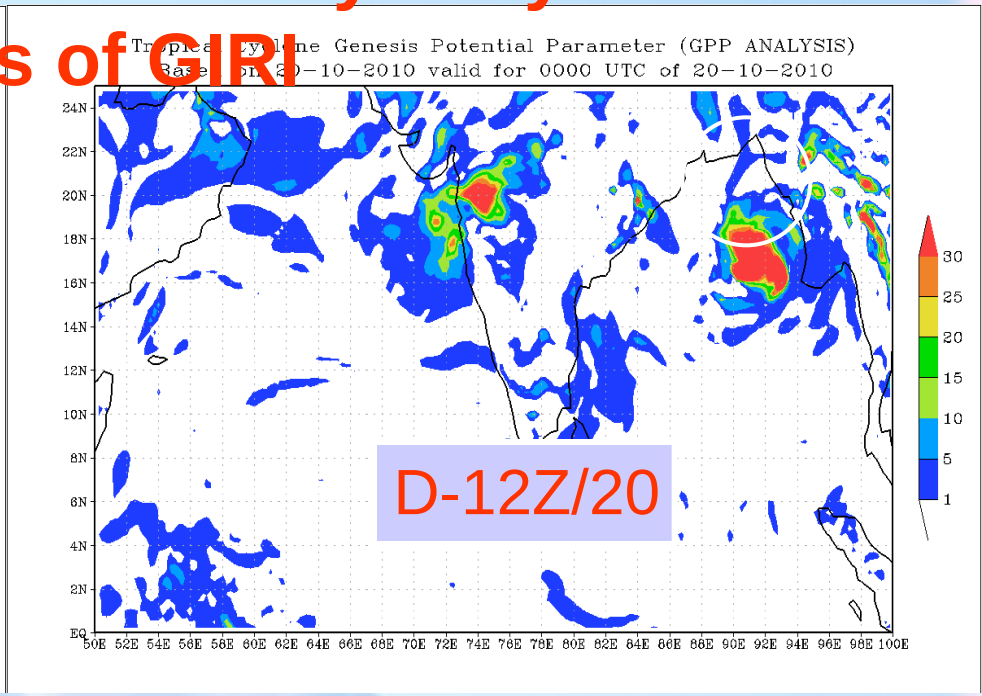
VSCS-03Z/22

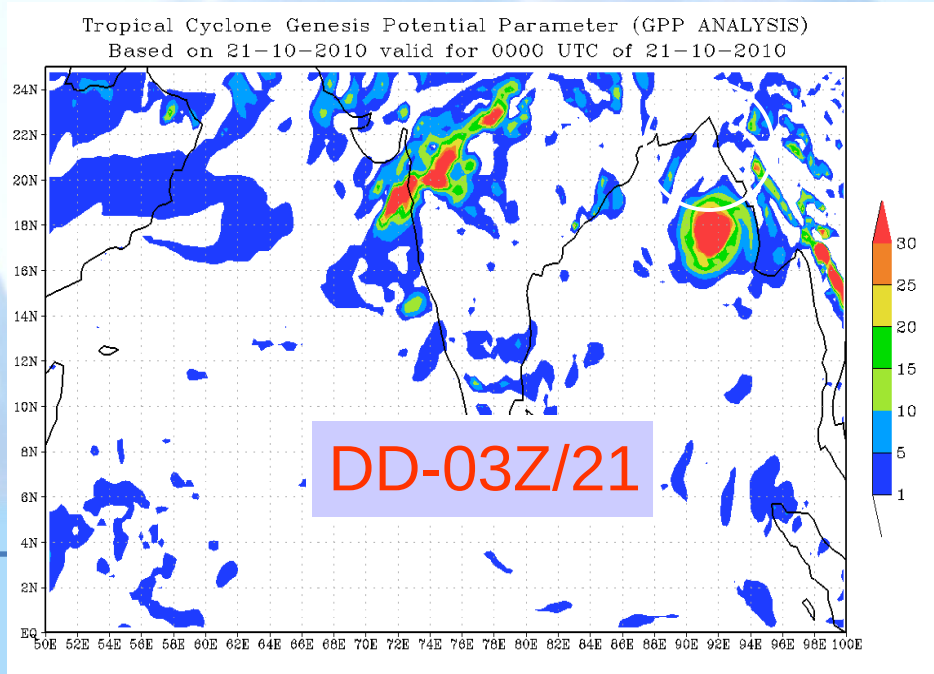




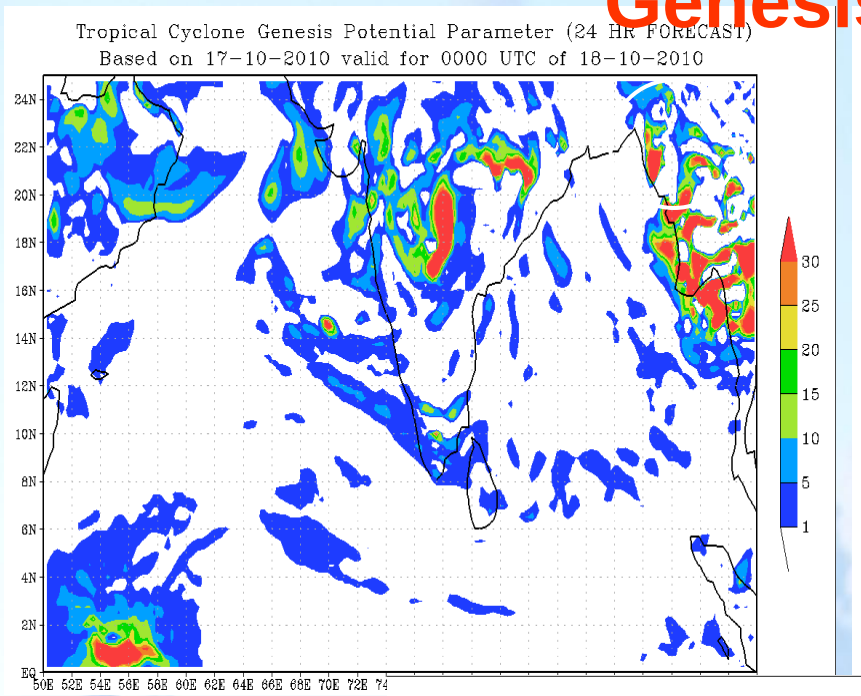
Methodology for tropical activity daily watch: Genesis of GIRI

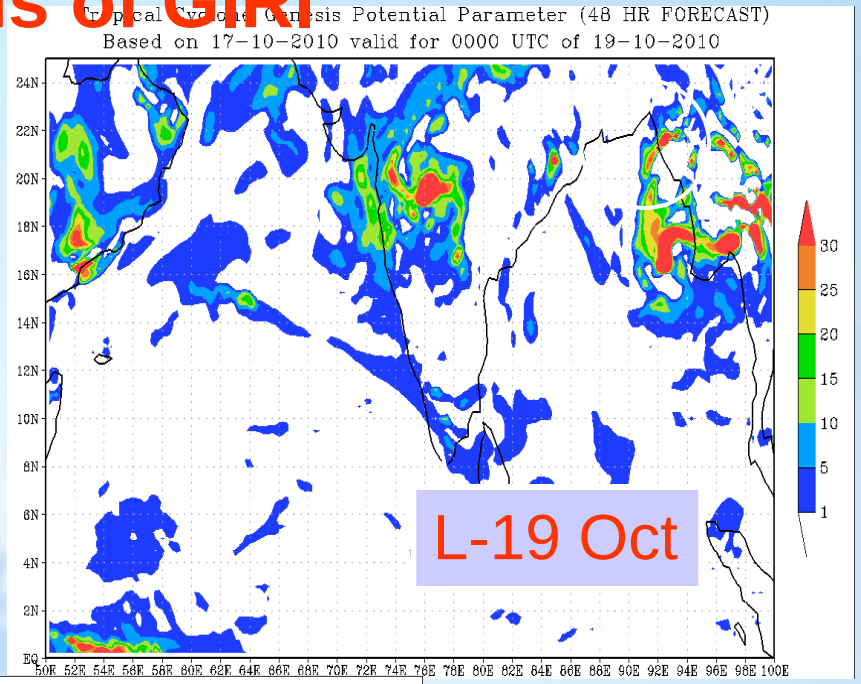


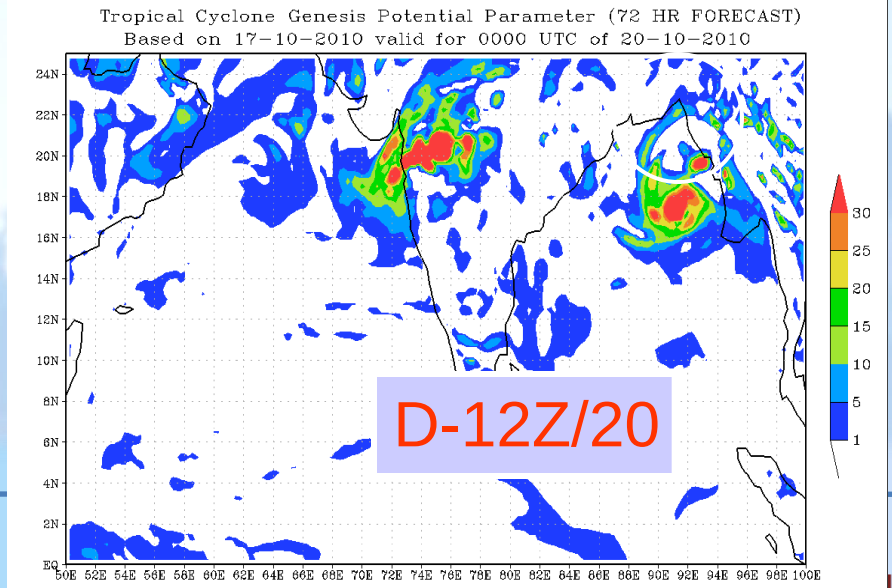




Methodology for tropical activity daily watch: Genesis of GIRI

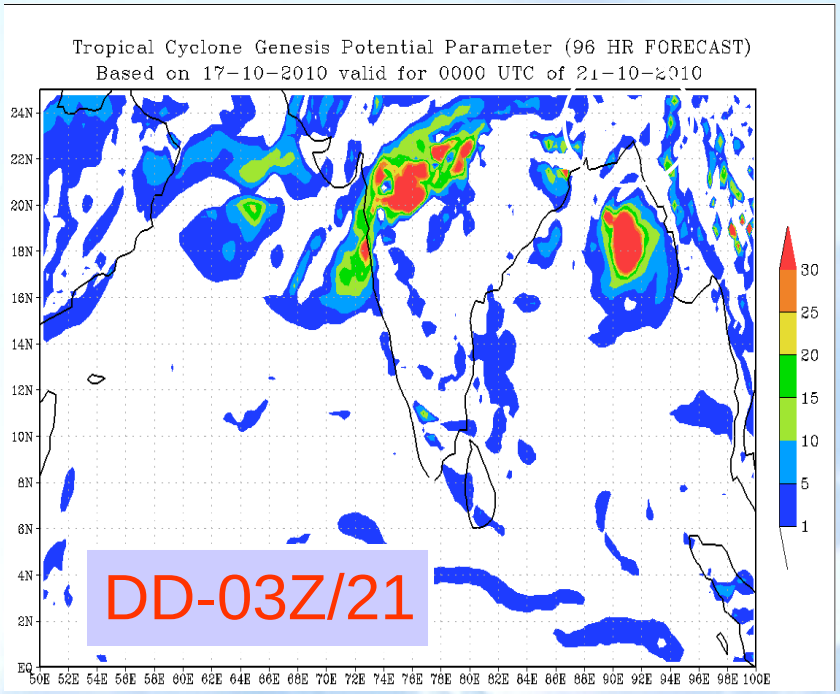


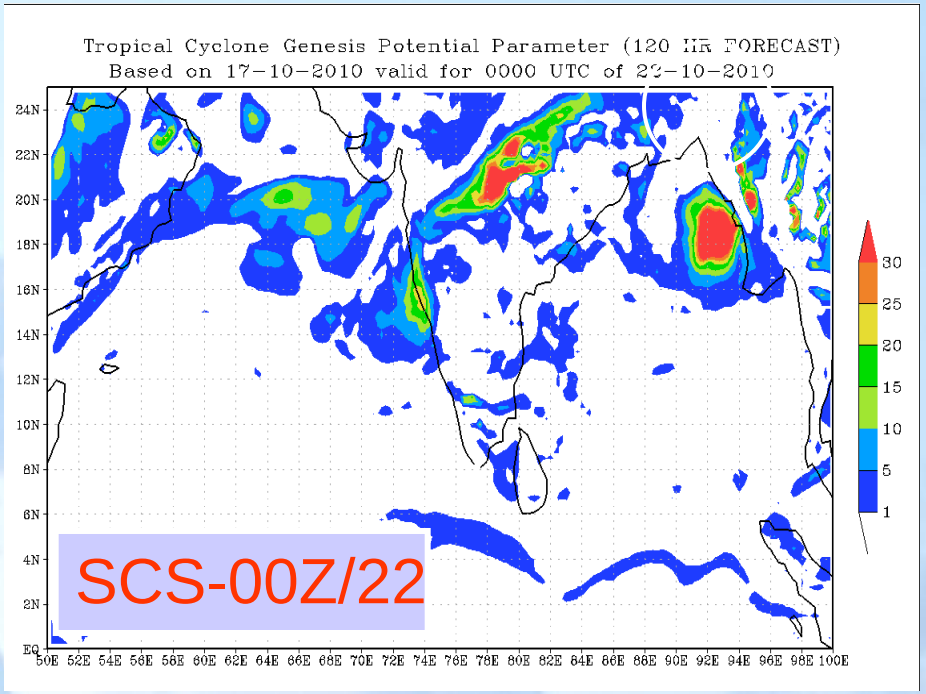




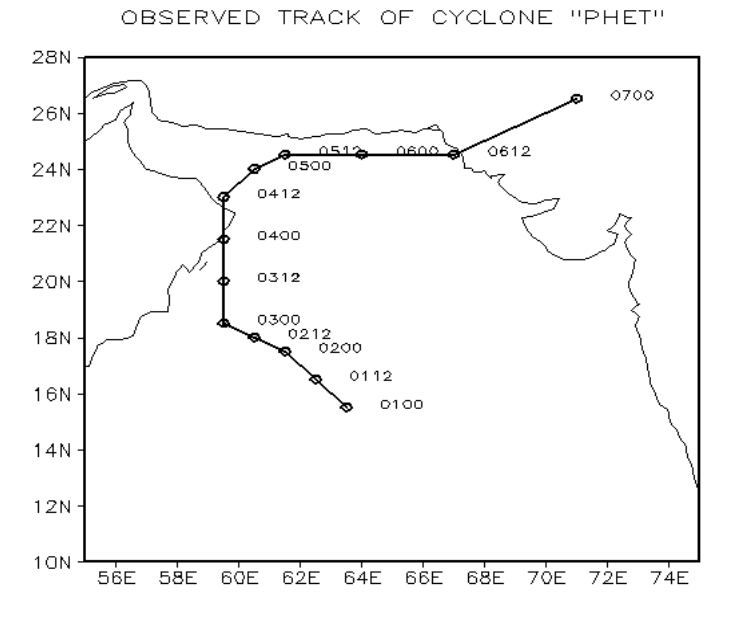
Methodology for tropical activity daily watch: Genesis of GIRI

Potential Cyclogenesis Zone for GPP ≥ 30





Methodology for tropical activity daily watch: Genesis of PHET



L-30 May

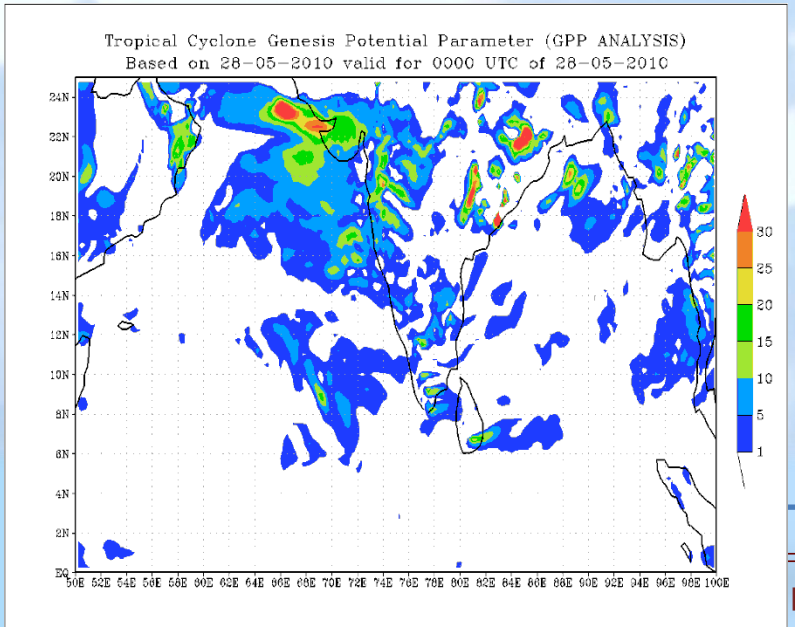
D-00Z/31 May

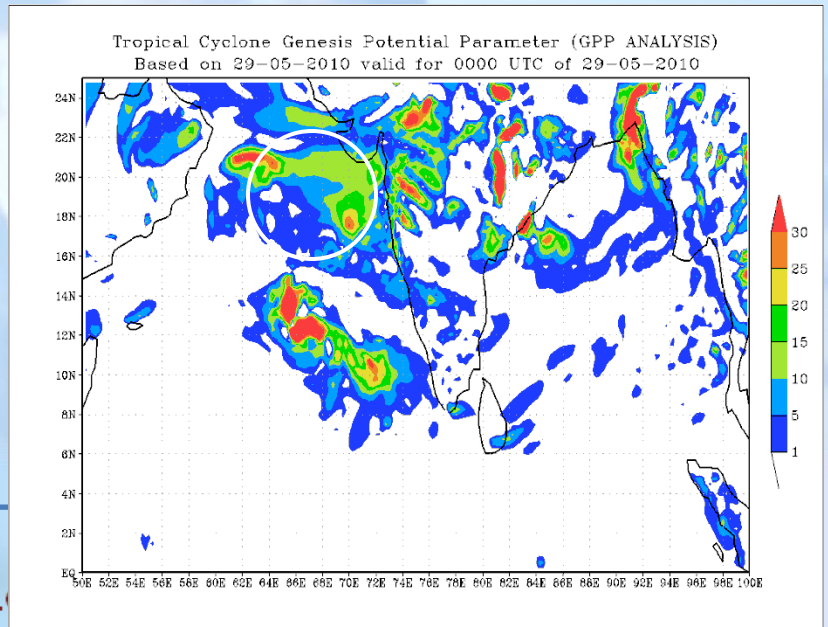
DD-00Z/1 June

CS-09Z/1

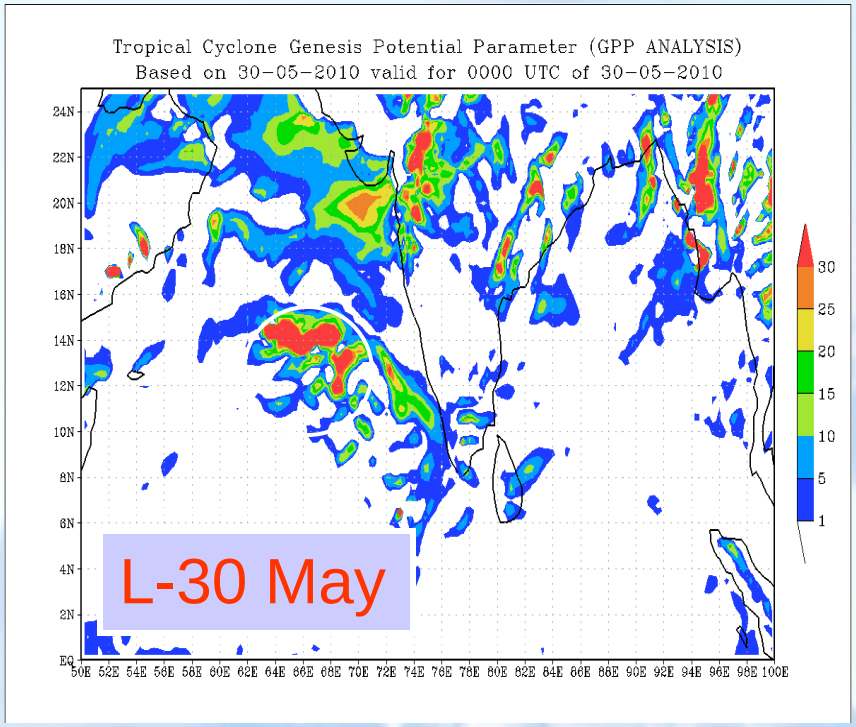
SCS-00Z/2

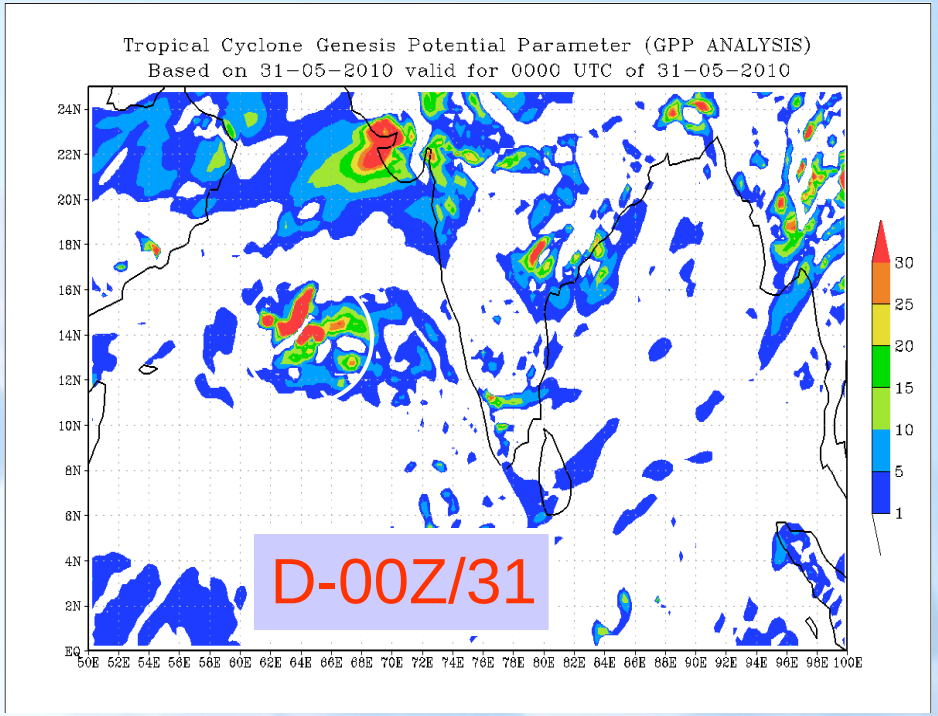
VSCS-06Z/2



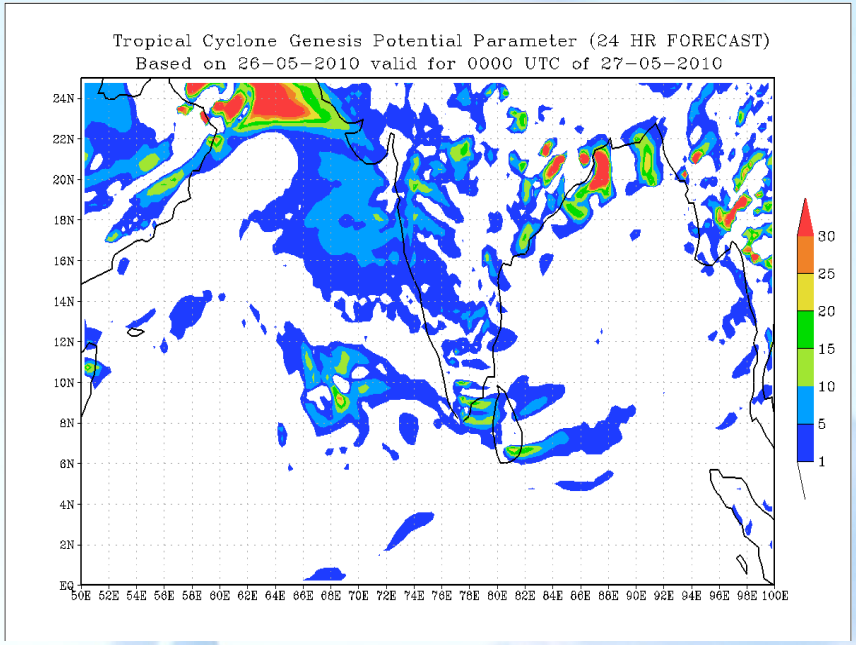


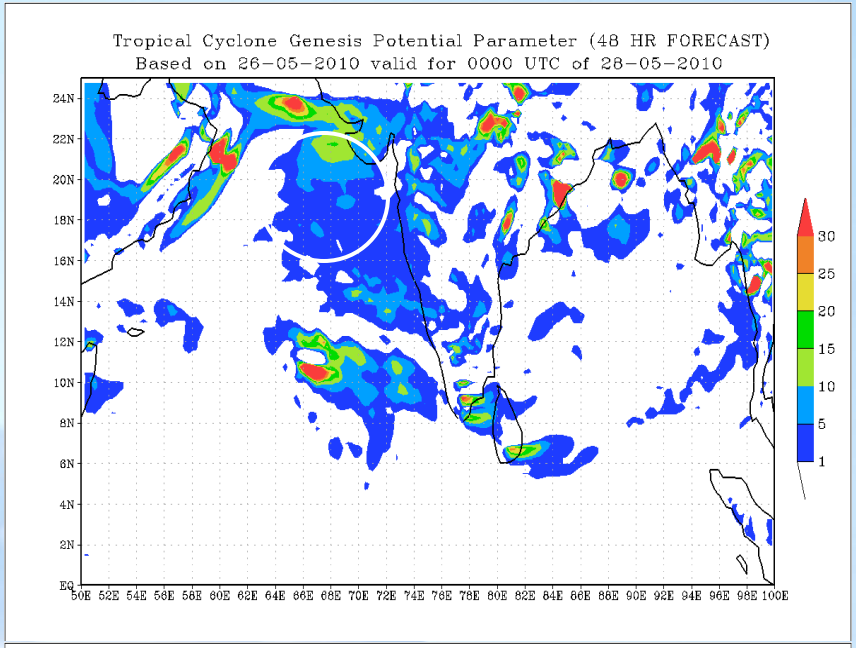
Methodology for tropical activity daily watch: Genesis of PHET

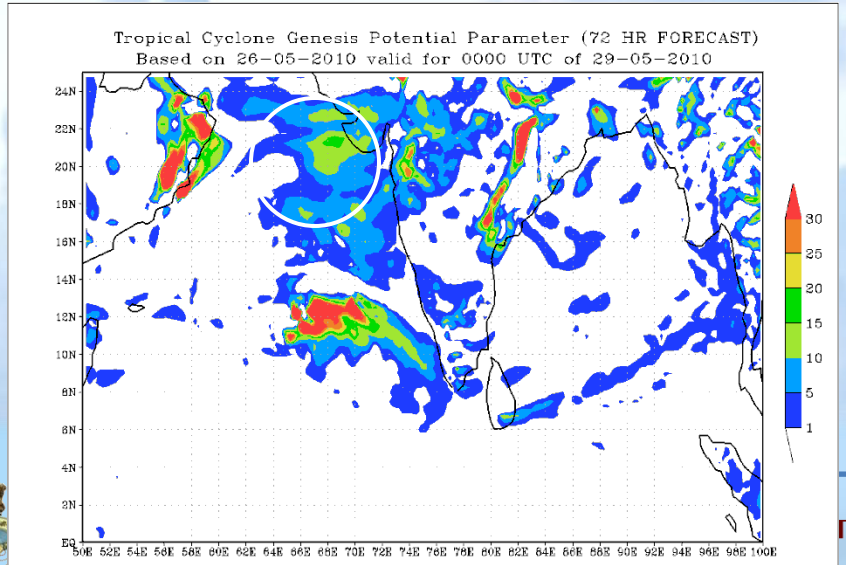


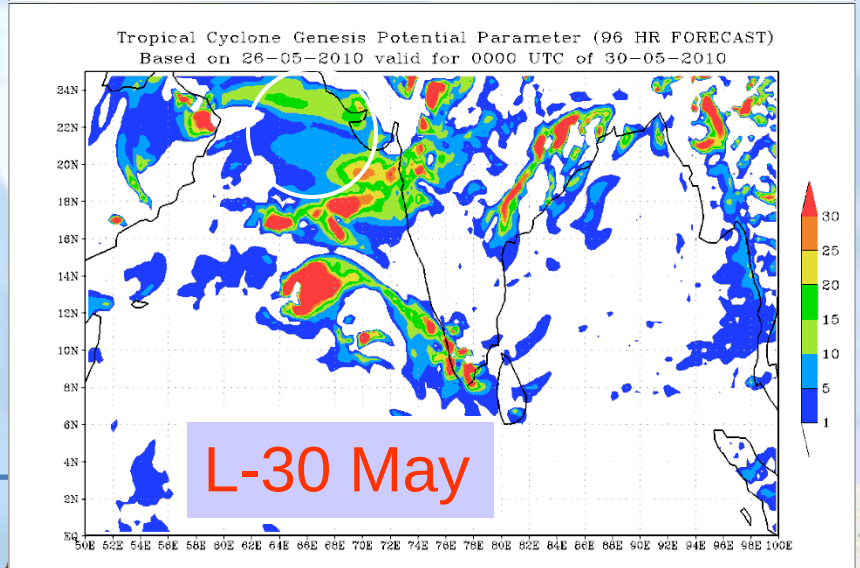


Methodology for tropical activity daily watch: Genesis of PHET

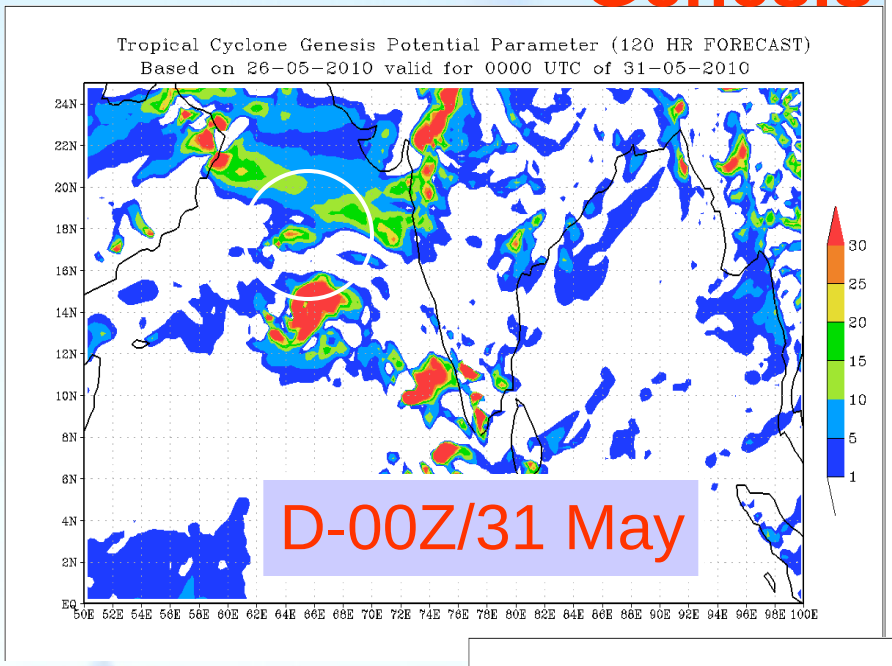


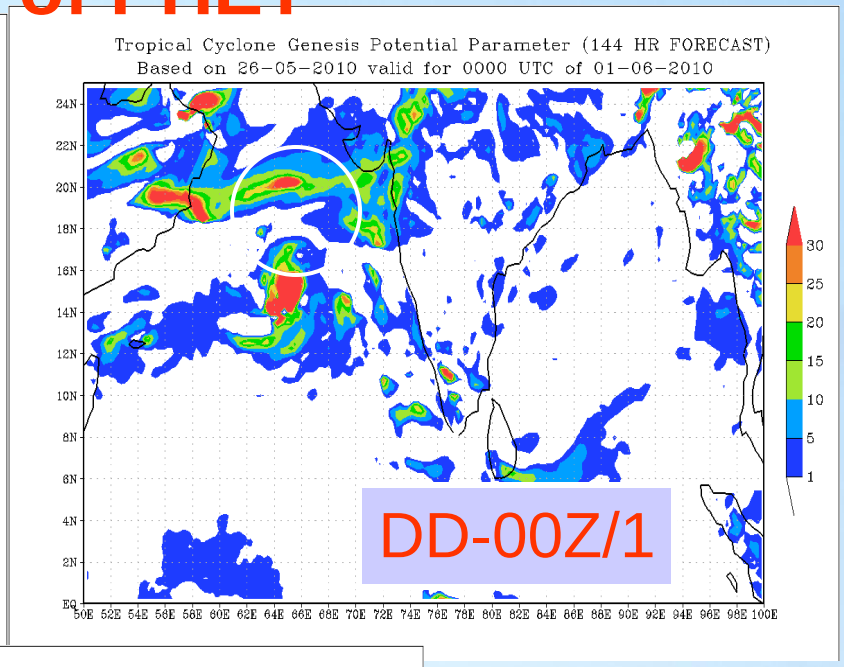


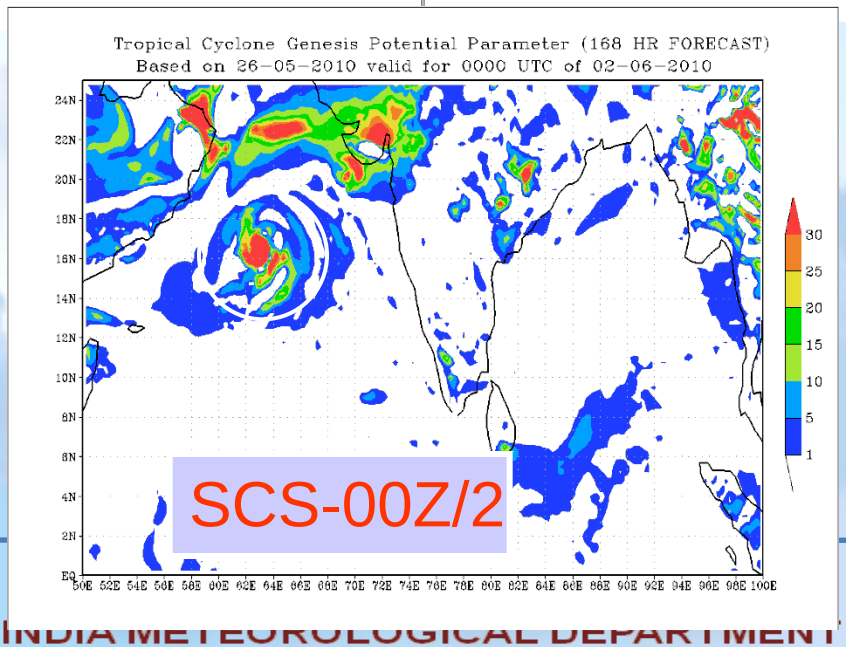




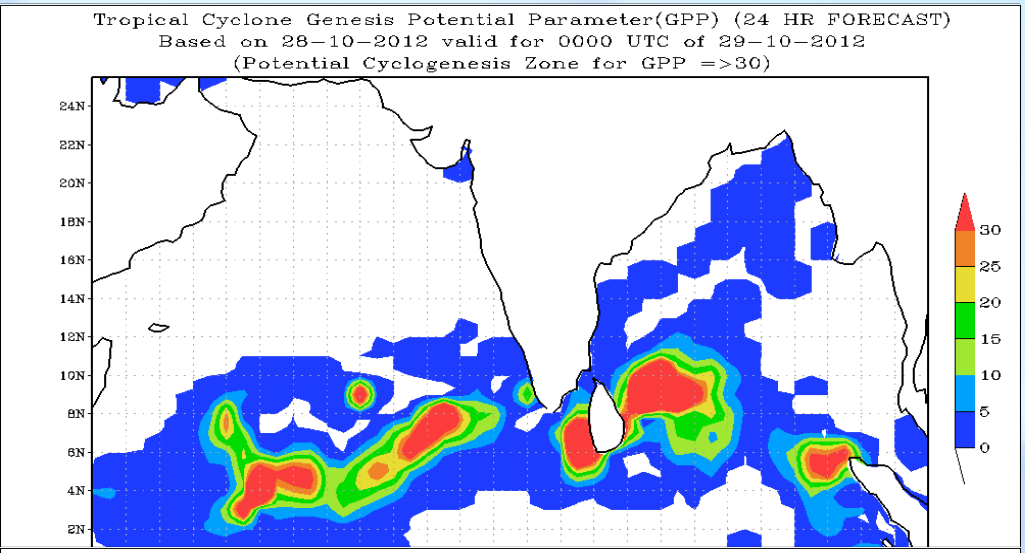
Methodology for tropical activity daily watch: Genesis of PHET

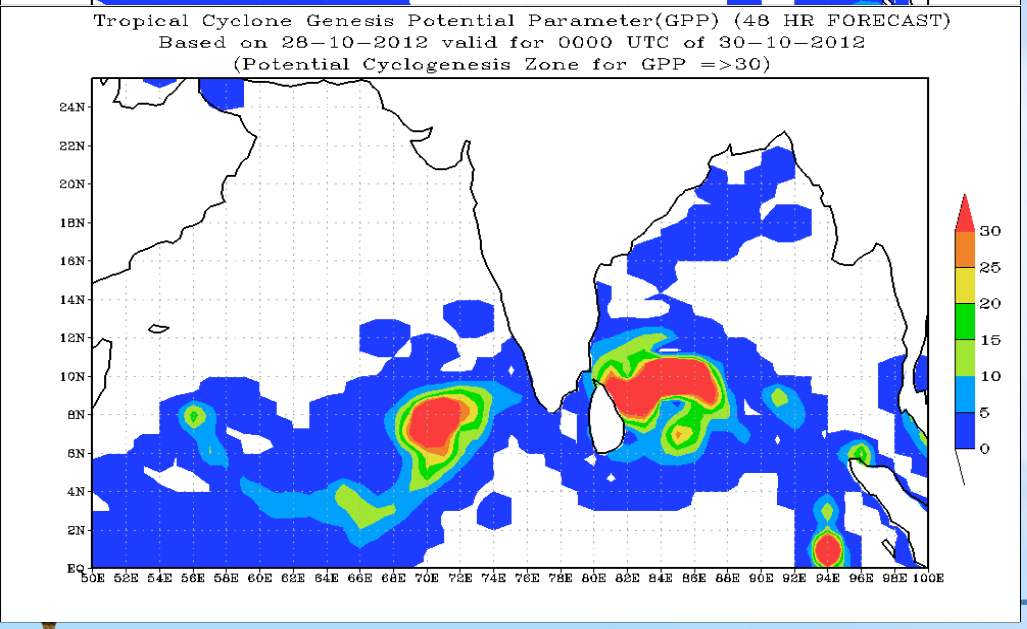






Methodology for tropical activity daily watch: Genesis of NILAM





Genesis potential parameter (GPP) based on 00 UTC of 20121028

Hr	V	M	I	S	GPP
0	5.97	1.60	23.06	10.77	20.45

GPP =>8.0 For Maximum T.No.=>3.0
GPP < 8.0 For Maximum T.No.<=2.5

Extended Range Prediction of Cyclogenesis

Arabian Sea systems, 2011

(i) "Keila" (29 Oct-4 Nov)
(ii) Depression (6-10 Nov)

MME forecast

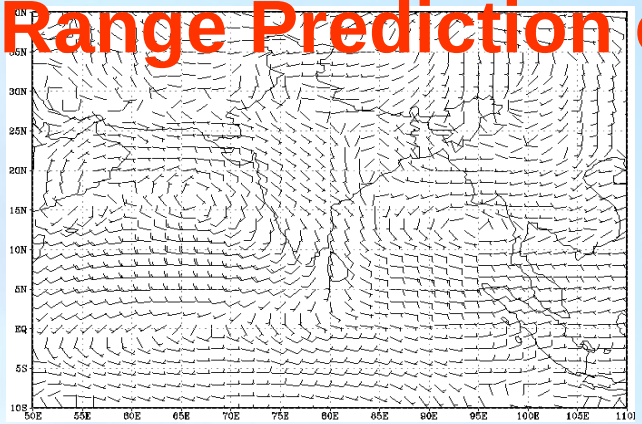
- wind anomaly,
- Vorticity
- rainfall anomaly

Based on 27 Oct 2011 and valid for

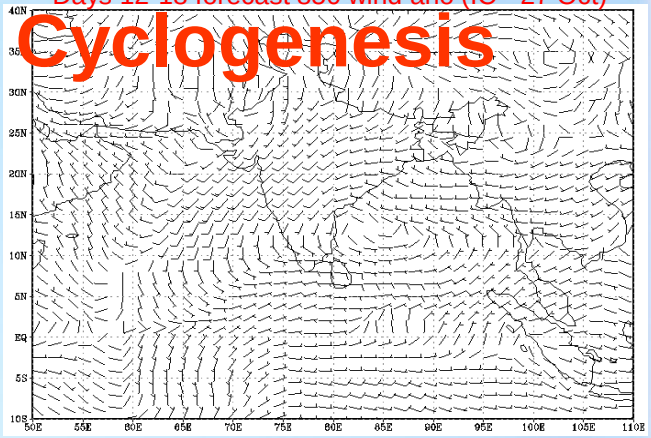
(i)days 5-11 (31 Oct – 6 Nov, 2011)

(i)Days 12-18 (7-13 Nov, 2011)

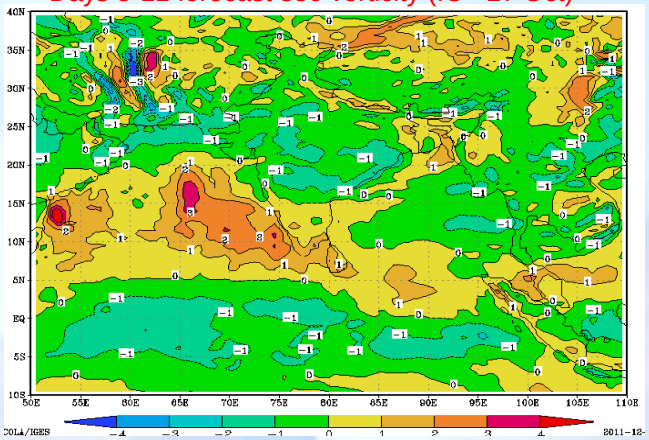
Days 5-11 forecast 850 wind ano (IC= 27 Oct)



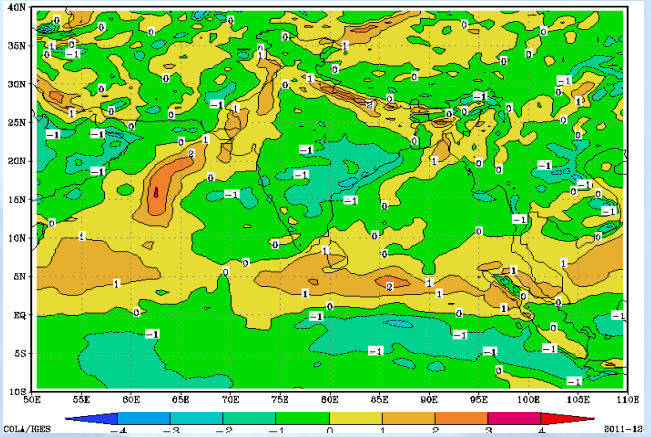
Days 12-18 forecast 850 wind ano (IC= 27 Oct)



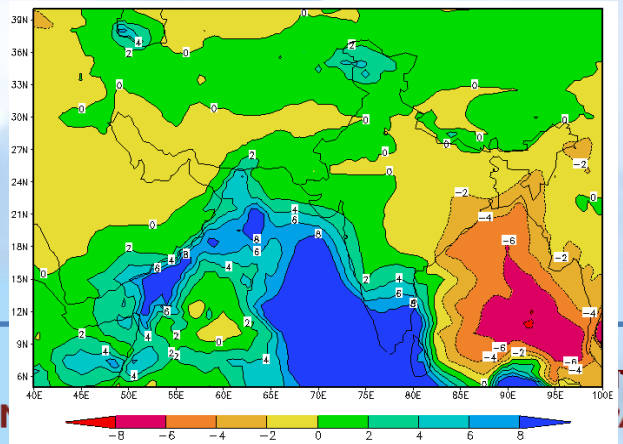
Days 5-11 forecast 850 vorticity (IC= 27 Oct)



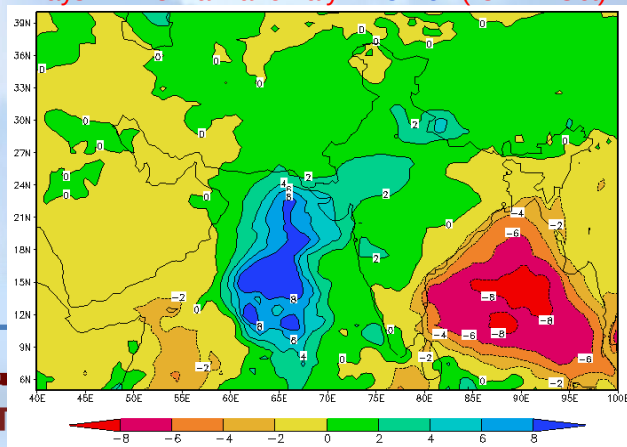
Days 12-18 forecast 850 vorticity (IC= 27 Oct)



Days 5-11 Rain anomaly 31 Oct-6 Nov (IC= 27 Oct)

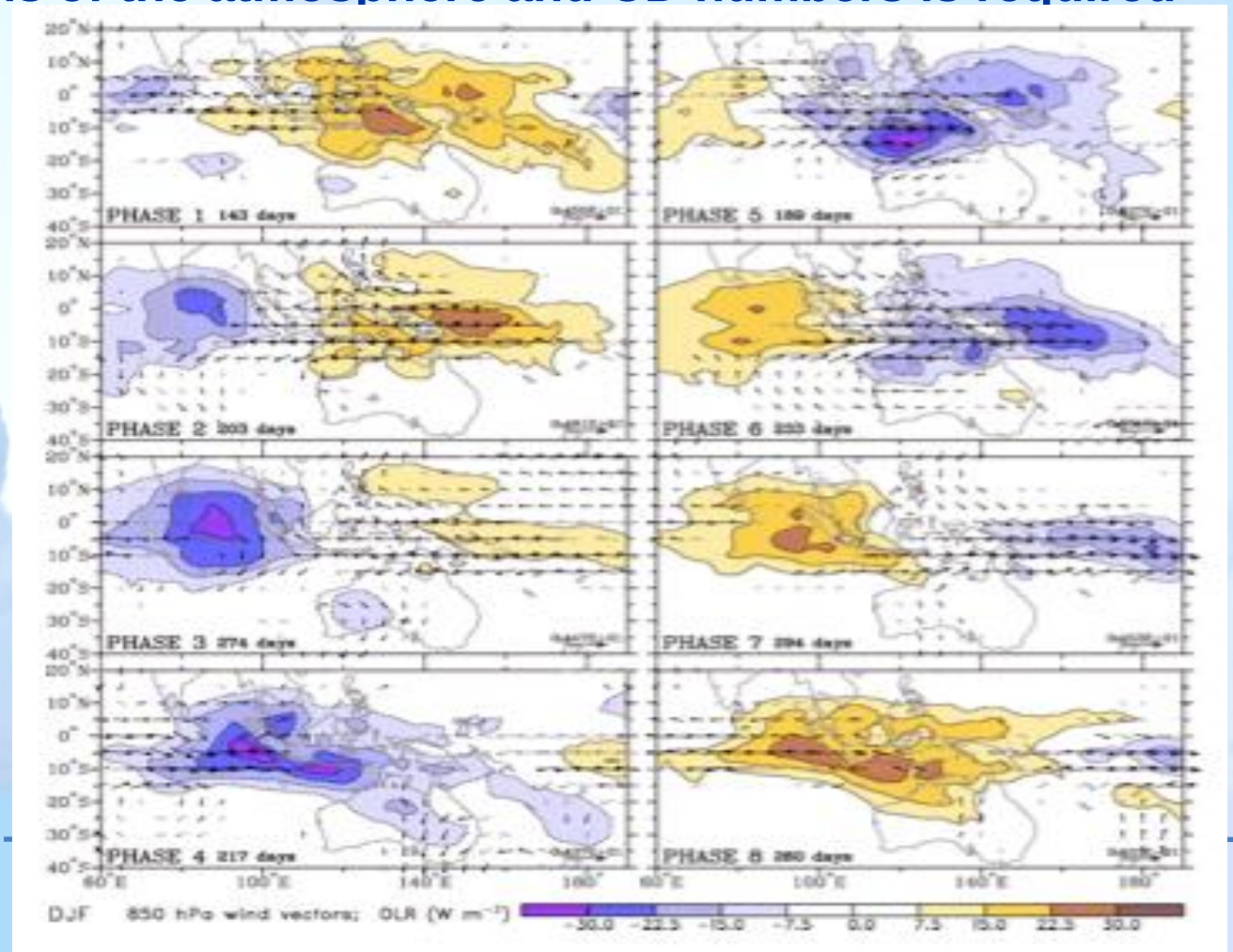


Days 12-18 Rain anomaly 7-13 Nov (IC= 27 Oct)

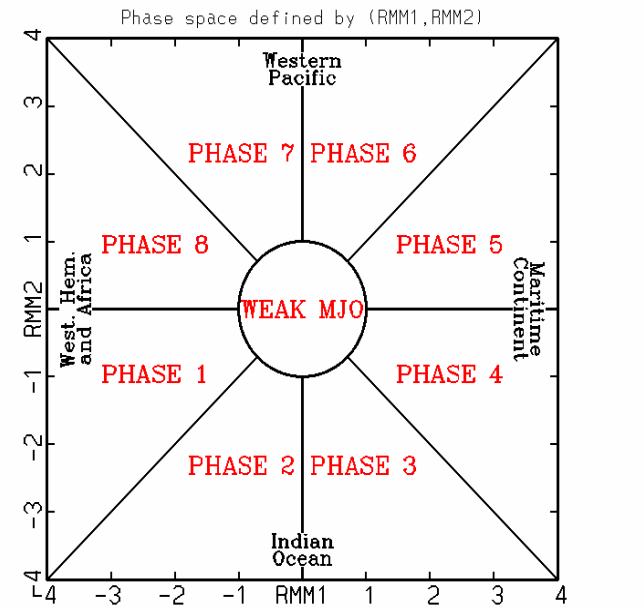


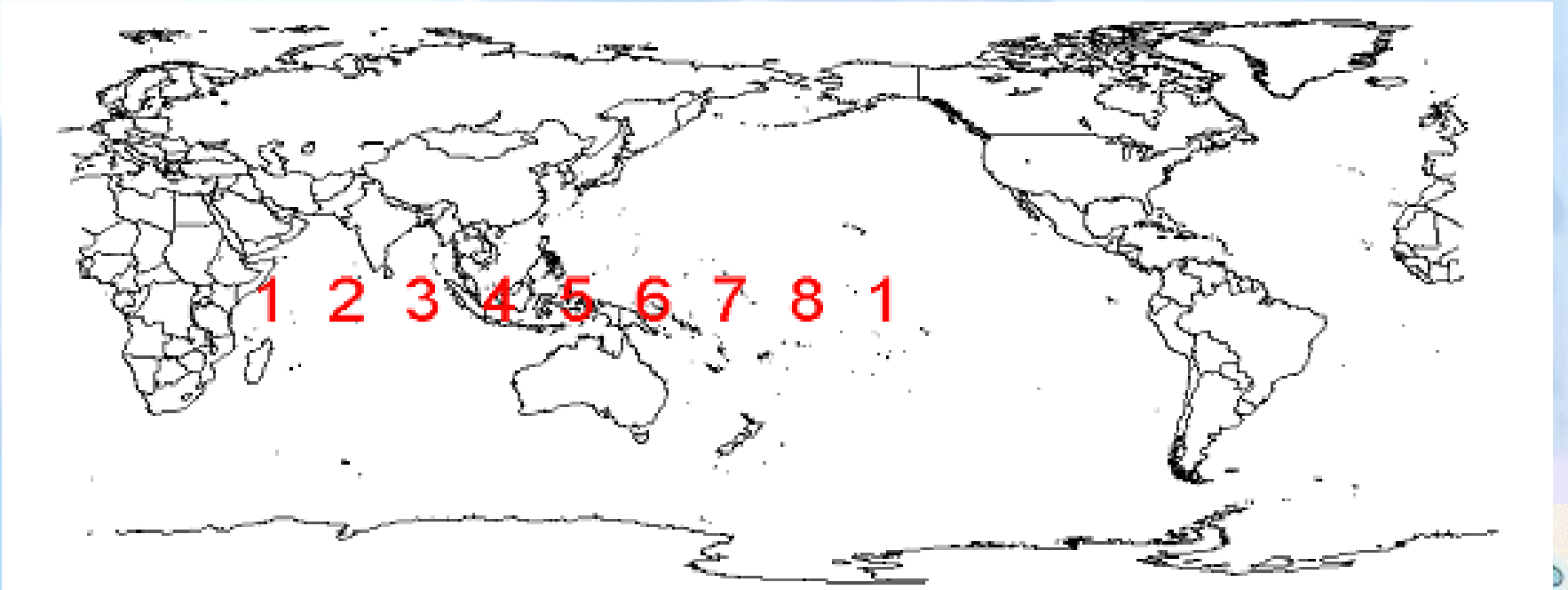
MJO for Mediim range prediction of genesis

- Guidance of expected CD activity during 5–20 days in the future is a valuable asset
- Dynamical Models generally give short term forecast.
- Work on establishment of relationships between long-period oscillations of the atmosphere and CD numbers is required



Different phases of MJO





Definition of MJO

- The Madden–Julian oscillation (MJO) is an equatorial travelling pattern of anomalous rainfall that is planetary in scale.

- The MJO is characterized by an eastward progression of large regions of both enhanced and suppressed tropical rainfall, observed mainly over the Indian Ocean and Pacific Ocean.

- The wet phase of enhanced convection and precipitation is followed by a dry phase where thunderstorm activity is suppressed.

- Each cycle lasts approximately 30–60 days. Because of this pattern, The MJO is also known as the 30–60 day oscillation, 30–60 day wave, or intra-seasonal oscillation.

Characteristics of MJO

- There are distinct patterns of lower-level and upper-level atmospheric circulation anomalies which accompany the MJO-related pattern of enhanced or decreased tropical rainfall across the tropics.

- The Madden-Julian oscillation moves eastward at 5 metres per second (11 mph)

- Active phase of the MJO tracked using the degree of outgoing longwave radiation which is measured by infrared-sensing geostationary weather satellites. The lower the amount of outgoing longwave radiation, the stronger the thunderstorm complexes, or convection, is within that region

Characteristics of MJO

- There is evidence that the MJO modulates this activity (particularly for the strongest storms) by providing a large-scale environment that is favourable (or unfavourable) for development.

- MJO-related descending motion is not favourable for tropical storm development.

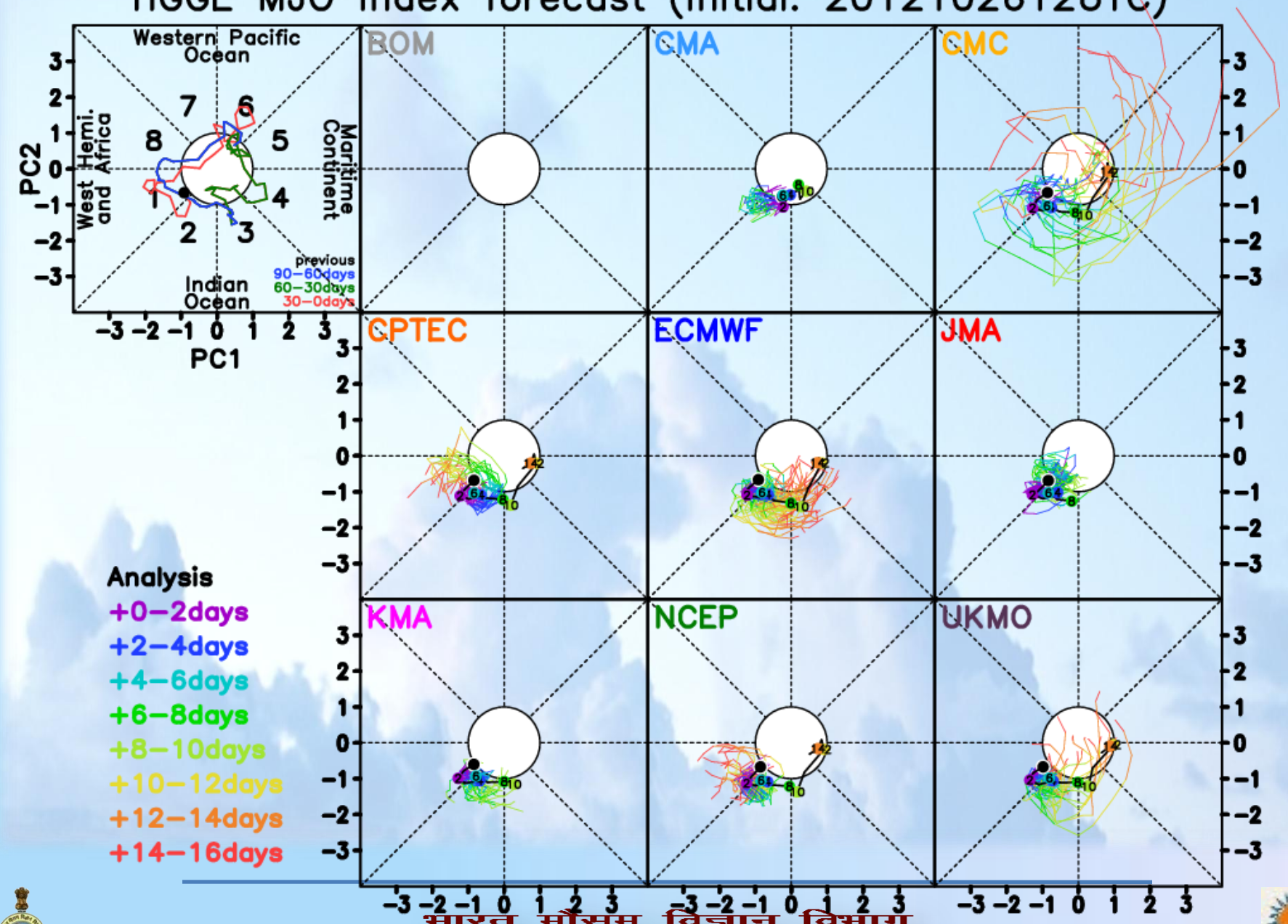
- MJO-related ascending motion is a favourable pattern for thunderstorm formation within the tropics, which is quite favourable for tropical storm development.

- As the MJO progresses eastward, the favoured region for tropical cyclone activity also shifts eastward from the western Pacific to the eastern Pacific and finally to the Atlantic basin.

Forecast with MJO

- The MJO strongly modulates the genesis and intensity of CDs over the north Indian Ocean
- The genesis and intensity of CDs are significantly higher in association with active phase of MJO over east Indian Ocean and adjoining maritime continent
- The genesis and intensity of CDs are less in association with the active phase of MJO over western hemisphere, Africa, eastern part of west Pacific and mid Pacific Ocean region. Though less in number, the genesis and intensification of CDs can take place with MJO phase over these region only if the amplitude is significantly less than the normal
- The genesis and intensity of CDs are more sensitive to phase than the amplitude, as the CDs can develop and intensify in favourable phases of MJO even when amplitudes are as low as < 0.4

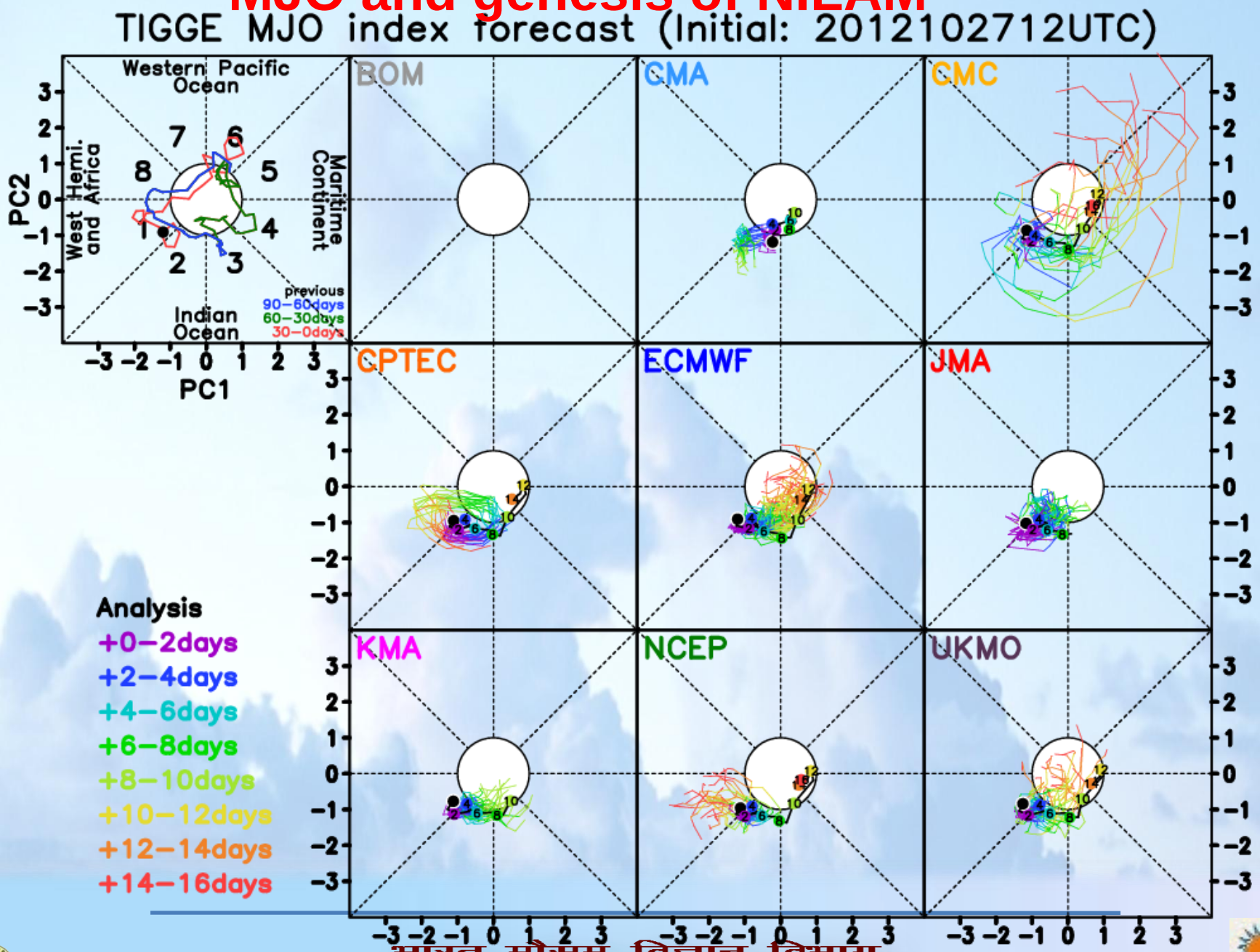
MJO and genesis of NILAM



भारत मौसम विज्ञान विभाग

INDIA METEOROLOGICAL DEPARTMENT

MJO and genesis of NILAM



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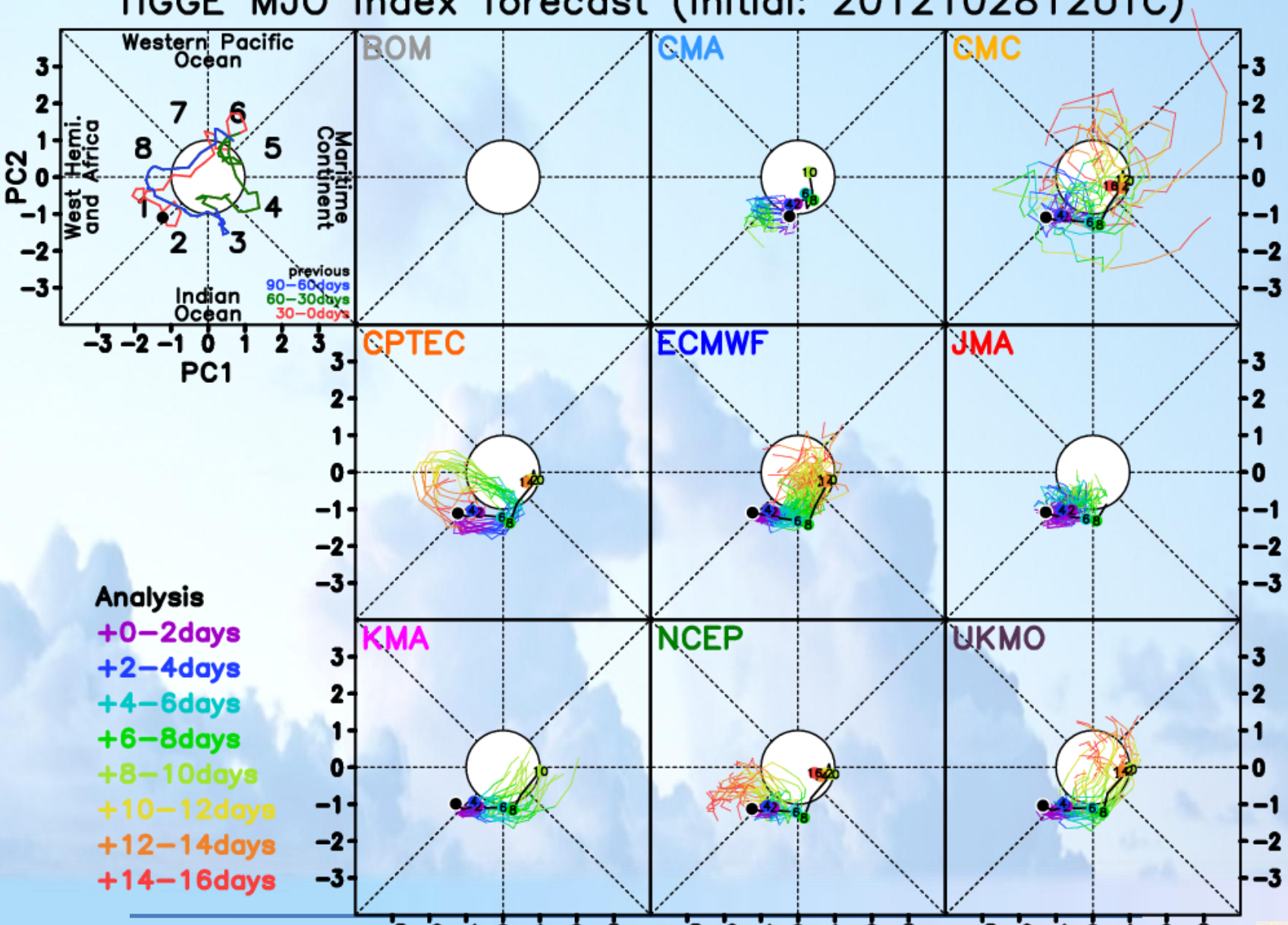

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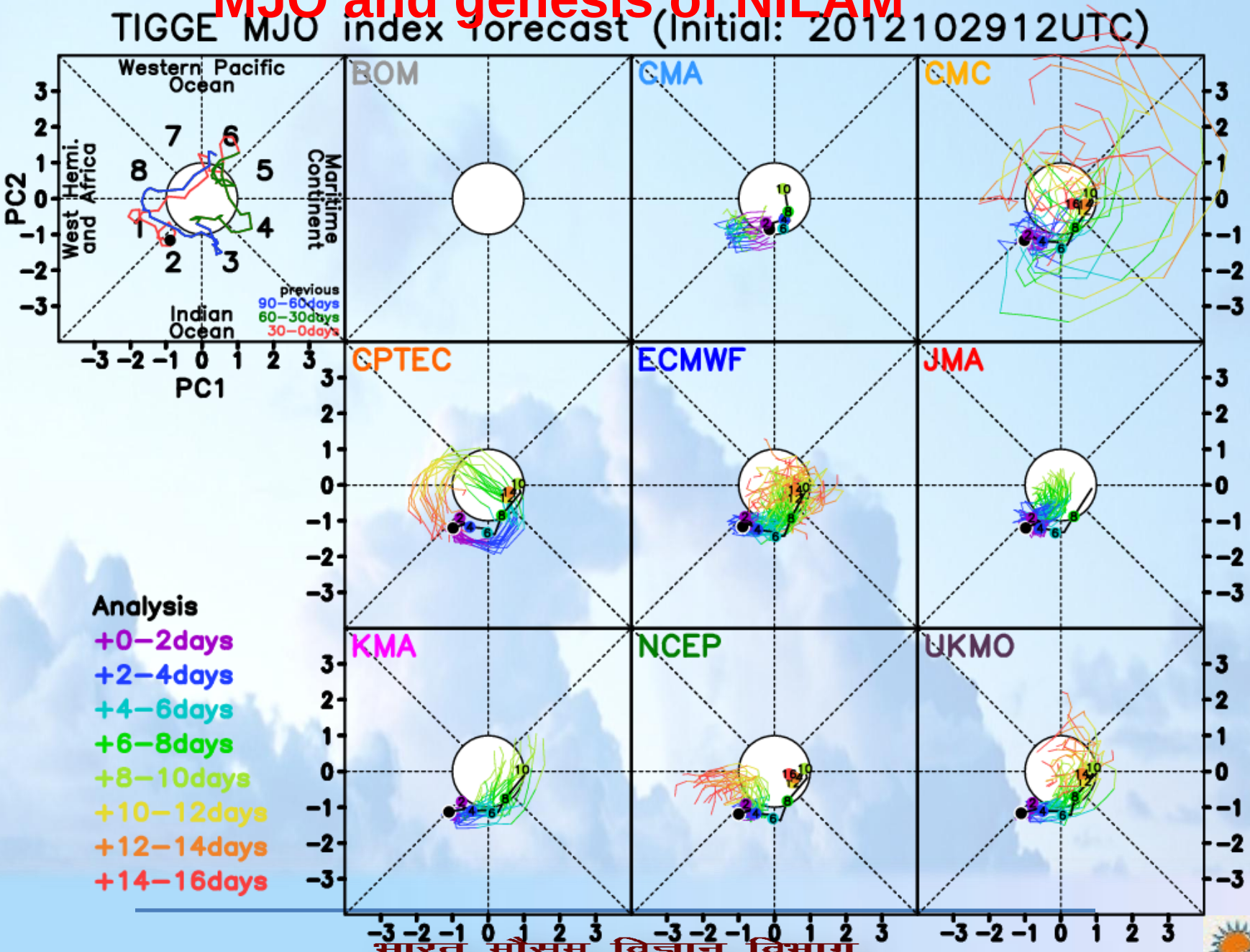

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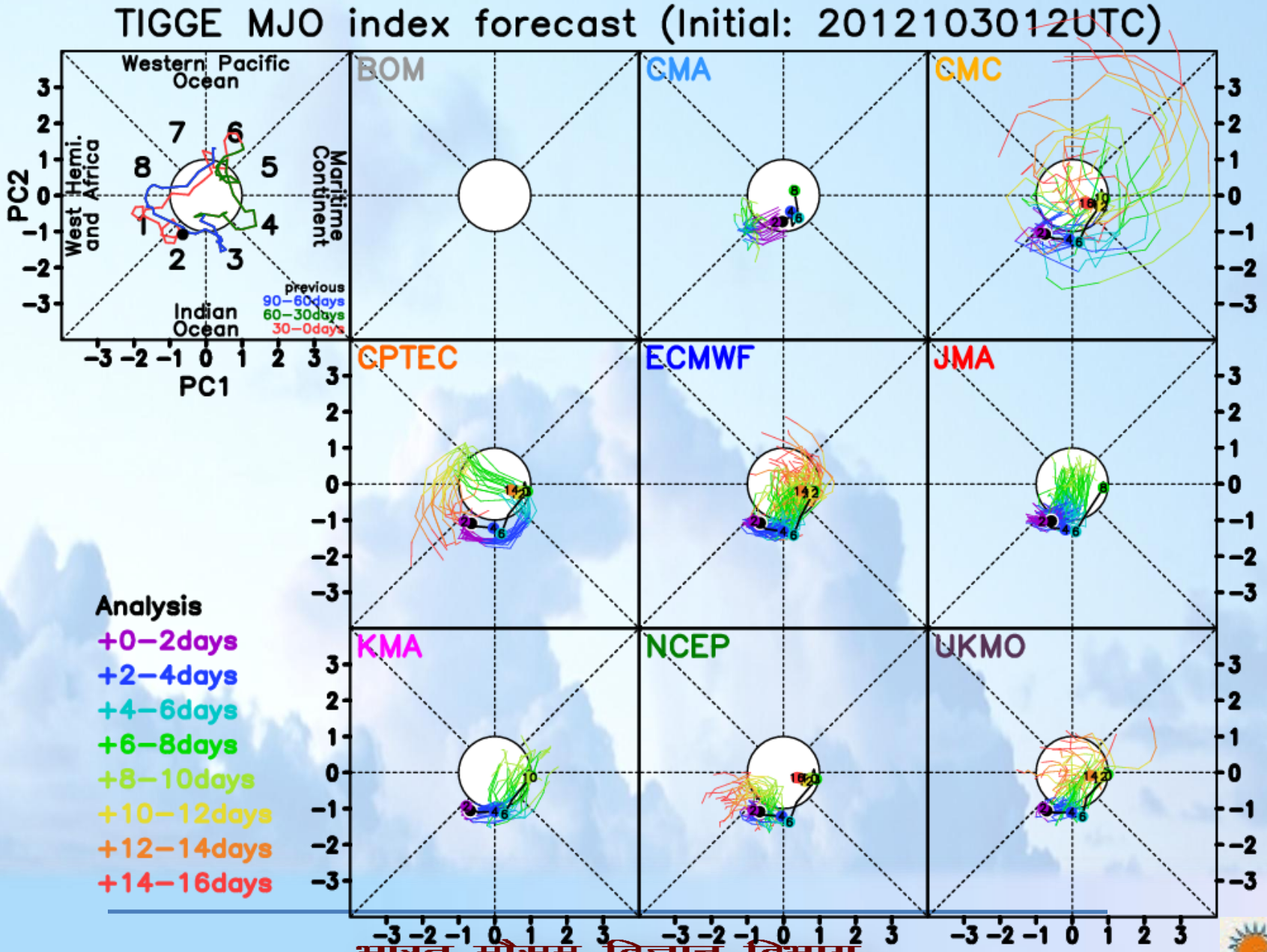

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Special Tropical Weather Outlook

- DEMS–RSMC TROPICAL CYCLONES NEW DELHI 28-10-2012
- TROPICAL WEATHER OUTLOOK FOR NORTH INDIAN OCEAN (THE BAY OF BENGAL AND ARABIAN SEA) VALID FOR NEXT 24 HOURS ISSUED AT 0900 UTC OF 28 OCTOBER, 2011 BASED ON 0600 UTC OF 28 OCTOBER, 2012 (.)
- LATEST SATELLITE IMAGERY AND BUOY OBSERVATIONS INDICATE THAT A DEPRESSION HAS FORMED OVER SOUTHEAST AND ADJOINING SOUTHWEST BAY OF BENGAL AND LAY CENTRED AT 0600 UTC OF TODAY, THE 28TH OCTOBER 2012 NEAR LATITUDE 9.5^{0}N AND LONGITUDE 86.0.^{0}E, ABOUT 730 KM SOUTHEAST OF CHENNAI (43279), 550 KM EAST-NORTHEAST OF TRINCOMALEE (43418).

Special Tropical Weather Outlook

- THE SYSTEM WOULD INTENSIFY INTO A DEEP DEPRESSION AND MOVE INITIALLY WESTWARDS TOWARDS TAMIL NADU COAST.
- ACCORDING TO SATELLITE IMAGERIES, THE INTENSITY OF THE SYSTEM IS T 1.5.
- LOW/MEDIUM CLOUDS WITH EMBEDDED INTENSE TO VERY INTENSE CONVECTION SEEN OVER BAY OF BENGAL BETWEEN LAT 07.0^{0}N AND 13.0^{0}N AND LONG 85.0^{0}E TO 89^{0}E. BROKEN LOW/MEDIUM CLOUDS WITH EMBEDDED MODERATE TO INTENSE CONVECTION LIES OVER REST SE BAY BET LAT 5.0N TO 7.0N LONG 85.0E TO 90.0E.
- THE ASSOCIATED CONVECTION HAS INCREASED GRADUALLY WITH RESPECT TO HEIGHT AND ORGANISATION DURING PAST 12 HRS.
- THE LOWEST CLOUD TOP TEMPERATURE (CTT) IS ABOUT -70^{0}C.
- SUSTAINED MAXIMUM SURFACE WIND SPEED IS ESTIMATED TO BE ABOUT 25 KNOTS GUSTING TO 35 KNOTS AROUND SYSTEM CENTRE..
- THE STATE OF THE SEA IS ROUGH TO VERY ROUGH AROUND THE SYSTEM CENTRE.
- THE ESTIMATED CENTRAL PRESSURE IS ABOUT 1004 HPA.

Special Tropical Weather Outlook

- THE BUOY OBSERVATIONS AROUND SYSTEM CENTRE SHOWS 20-25 KNOTS WIND IN THE NORTHERN SECTOR AND ABOUT 15 KNOTS IN THE SOUTHERN SECTOR.
- AT 0600 UTC OF 28TH OCTOBER 2012, BUOY (POSITION NEAR 8.1^{0}N AND 85.5^{0}E) REPORTED WIND OF 240/18 KNOTS WIND AND 1005 HPA AS MEAN SEA LEVEL PRESSURE (mslp); BUOY (POSITION NEAR 11.0^{0}N AND 86.5^{0}E) REPORTED MSLP OF 1007.5 HPA AND WIND OF 090/23 KNOTS.
- EARLIER SCATTEROMETRY DATA INDICATED 25-30 KNOTS WIND IN THE NORTHERN SECTOR OF THE SYSTEM.
- ONSIDERING THE ENVIRONMENTAL FEATURES, THE SEA SURFACE TEMPERATURE IS ABOUT 29-30 DEG. C. OVER SOUTH BAY OF BENGAL.
- THE OCEAN THERMAL ENERGY IS 50 - 80 KJ/CM SQUARE AROUND THE SYSTEM CENTRE. IT IS LESS TOWARDS THE NORTH OF THE SYSTEM.
- THE MADDEN JULIAN OSCILLATION INDEX CURRENTLY LIES OVER PHASE 2. AS PER STATISTICAL AND NWP MODEL PREDICTIONS, IT IS EXPECTED TO LIE IN PHASE 2 DURING NEXT 3 DAYS.
- THE UPPER TROPOSPHERIC RIDGE LIES ALONG 13 DEG.N AND HENCE PROVIDES REQUIRED POLEWARD OUTFLOW FOR INTENSIFICATION OF THE SYSTEM.

Special Tropical Weather Outlook

- THE LOW LEVEL CONVERGENCE AND RELATIVE VORTICITY HAVE INCREASED DURING PAST 24 HRS AS WELL AS UPPER LEVEL DIVERGENCE.
- THE VERTICAL WIND SHEAR BETWEEN 200 AND 850 HPA LEVELS IS MODERATE (10-20 KNOTS) AROUND SYSTEM CENTRE. HOWEVER, IT INCREASES TOWARDS NORTH TAMIL NADU AND ADJOINING SEA AREAS.
- CONSIDERING THE NWP MODEL GUIDANCE, MOST OF THE MODELS SUGGEST THE INTENSIFICATION OF THE SYSTEM INTO A DEEP DEPRESSION AND SUBSEQUENTLY INTO A MARGINAL CYCLONIC STORM BY NEXT 48 HRS.
- DYNAMICAL- STATISTICAL MODEL OF IMD ALSO SUGGESTS THE SYSTEM TO INTENSIFY INTO A CYCLONIC STORM.
- WITH RESPECT TO TRACK, MOST MODELS SUGGEST WESTWARD/ WEST-SOUTHWESTWARD MOVEMENT DURING NEXT 48 HRS. HOWEVER, THERE IS DIVERGENCE IN NWP MODEL GUIDANCE THEREAFTER AS SOME MODELS SUGGEST NORTHWESTWARD MOVEMENT TOWARDS NORTH TAMIL NADU COAST AND SOME OTHER MODELS SUGGEST CONTINUOUS WESTWARD MOVEMENT TOWARDS NORTH SRI LANKA COAST.

Thank you