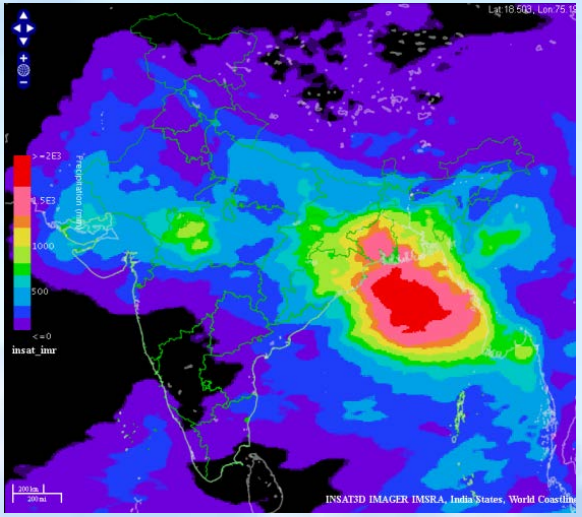
INSAT-3D PRODUCTS FOR THE MONSOON MONITORING and APPLICATIONS



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23-24 February 2016

National Satellite Meteorological Center,
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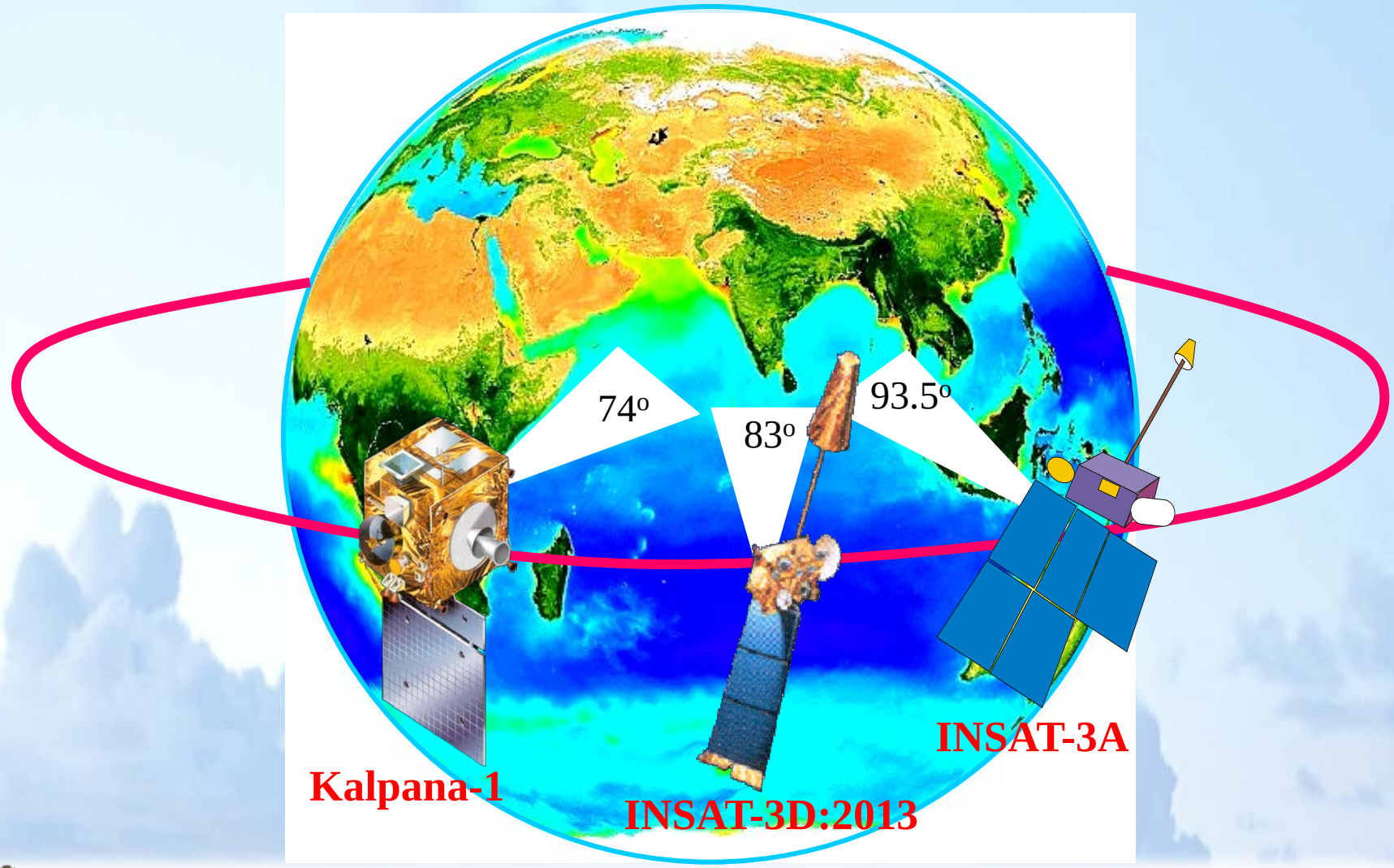
Current Indian Geostationary Meteorological Satellites



INSAT - 3D

Improved Understanding of Mesoscale Systems

6 Channel IMAGER

- Spectral Bands (μm)

Visible	: 0.55 - 0.75
Short Wave Infra Red	: 1.55 - 1.70
Mid Wave Infra Red	: 3.80 - 4.00
Water Vapour	: 6.50 - 7.00
Thermal Infra Red – 1	: 10.2 - 11.3
Thermal Infra Red – 2	: 11.5 - 12.5

- Resolution : 1 km for Vis, SWIR
  4 km for MIR, TIR
  8 km for WV

19 Channel SOUNDER

- Spectral Bands (μm)

Short Wave Infra Red	:	Six bands
Mid Wave Infra Red	:	Five Bands
Long Wave Infra Red	:	Seven Bands
Visible	:	One Band

- Resolution (km) : 10 X 10 for all bands
- No of simultaneous sounding per band : Four

No.	Parameters	Input Channels	No.	Parameters	Input Channels
1.	Outgoing Long wave Radiation (OLR)	TIR -1, TIR -2, WV	10.	Water Vapor Wind (WVW)	WV, TIR -1, TIR -2
2.	Quantitative Precipitation Estimation (QPE),IMSRA,HE	TIR -1, TIR -2, WV,Model FG.	11.	Upper Tropospheric Humidity (UTH)	WV, TIR -1, TIR -2
3.	Sea Surface Temperature (SST)	SWIR,TIR -1, TIR -2, MIR	12.	Temperature, Humidity profile & Total ozone	Sounder all channels
4.	Snow Cover	VIS, SWIR, TIR -1, TIR -2	13.	Value added parameters from sounder products	Sounder products
5.	Snow Depth	VIS, SWIR, TIR -1, TIR -2	14.	FOG	SWIR, MIR , TIR -1, TIR -2
6.	Fire	MIR, TIR -1	15.	Normalized Difference Vegetation Index	CCD
7.	Smoke	VIS, TIR -1, TIR -2, MIR	16.	Flash Flood Analyzer	TIR -1, TIR -2, VIS
8.	Aerosol	VIS, TIR -1, TIR -2	17.	HSCAS	VIS
9.	Cloud Motion Vector (CMV)	VIS, TIR -1, TIR -2	18.	Tropical Cyclone-intensity /position	AODT technique,TIR-

INSAT-3D Imager Products types and formats

S.No.	Data Product	Processing Level	Code	Format	Remarks
Standard Products					
1	Standard Product Full Disk	L1B	STD	HDF	Per Pixel Lat & Lon as viewed by Satellite
2	Standard Product Full Disk Fixed Grid	L1C	STD	HDF	Projected on Fixed Grid
3	Standard Sector Product	L1C	Sector mnemonic	HDF	Map Projected
Geo-Physical Parameters					
1	Outgoing long wave radiations	L2B	OLR	HDF	Per Pixel
2	Rainfall using Hydro Estimator	L2B	HEM	HDF	Per Pixel
3	FOG	L2C	FOG	HDF	Per Pixel
4	SNOW	L2C	SNW	HDF	Per Pixel
5	Cloud Mask	L2B	CMK	HDF	Per Pixel
6	Upper Troposphere Humidity	L2B	UTH	HDF	PerPixel
7	Sea Surface Temperature	L2B	SST	HDF	PerPixel
Geo-Physical Parameters					
1	FIRE	L2P	FIR	KML	Point
2	SMOKE	L2P	SMK	KML	Point
3	Atmospheric Motion Vectors	L2P	AMV	HDF	VIS, TIR, WV, MIR (Point)
Geo-Physical Parameters					
1	INSAT Multi-Spectral Rainfall Algorithm (IMSRA)	L2G	IMR	HDF	0.1 deg x 0.1 deg
2	Quantitative Precipitation Estimation	L2G	QPE	HDF	1 deg x 1 deg
3	Aerosol Optical Depth	L2G	AOD	HDF	0.1 deg x 0.1 deg

S.No.	Data Product	Processing Level	Code	Format	Remarks
Standard Products					
Binned Geo-Physical Parameters (Temporally Binned)					
1	Outgoing long wave radiations	L3B	OLR	HDF	Daily, Weekly, Monthly and Yearly Per Pixel
2	Rainfall using Hydro Estimator	L3B	HEM	HDF	Daily, Weekly, Monthly and Yearly (Per Pixel)
3	Sea Surface Temperature	L3G	SST	HDF	Daily, Weekly, Monthly and Yearly 0.5 deg X 0.5 deg
4	Upper Troposphere Humidity	L3G	UTH	HDF	Daily, Weekly, Monthly and Yearly,0.1 deg x 0.1 deg

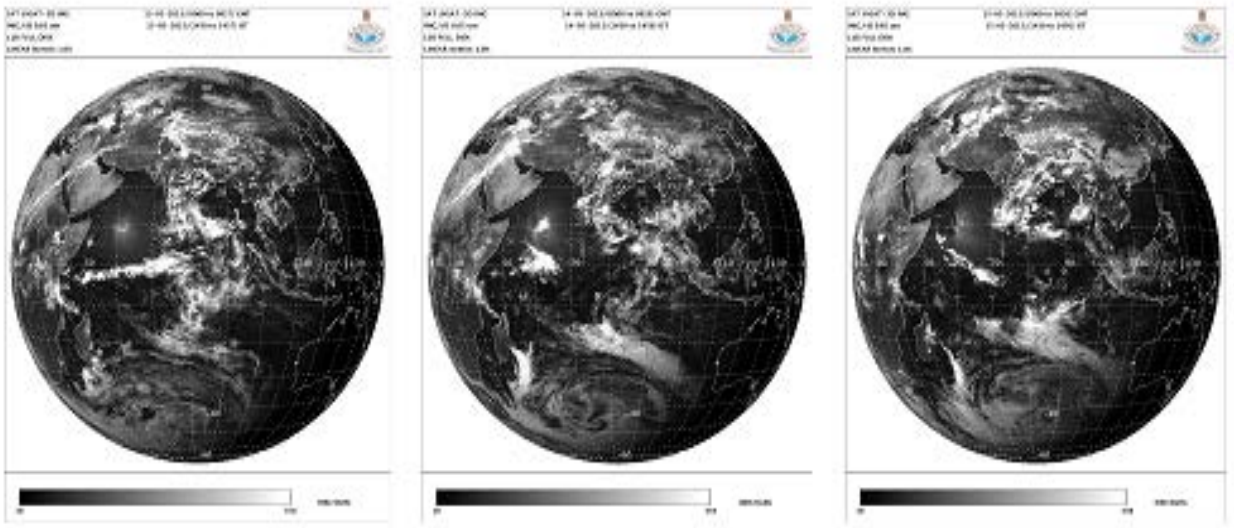
Overview

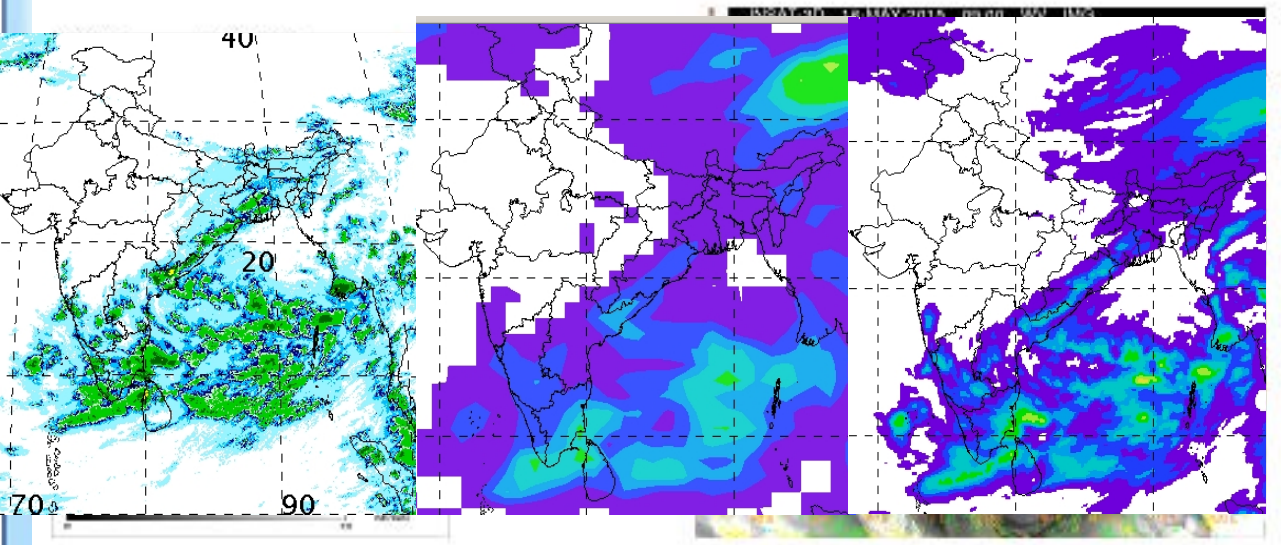
•INSAT-3D satellite data are used to analyze the characteristics of monsoon circulation features over India region during southwest monsoon, 2015 with the help of its imageries and derived products.

•The study can be taken as a better utilization of satellite observations for monitoring and prediction of monsoon circulation and precipitation over India.

•The rainfall estimations (HEM,IMR and QPE) have also observed and validated with the actual observations during June-September 2015.

Circulation features during onset and advance phase of southwest Monsoon, 2015
Advance of monsoon over Andaman Sea





•This year, the southwest monsoon set over the south Andaman Sea on 16th May, four days earlier than the normal date. Low level cross equatorial monsoon flow has started appearing over adjoining south Bay of Bengal.

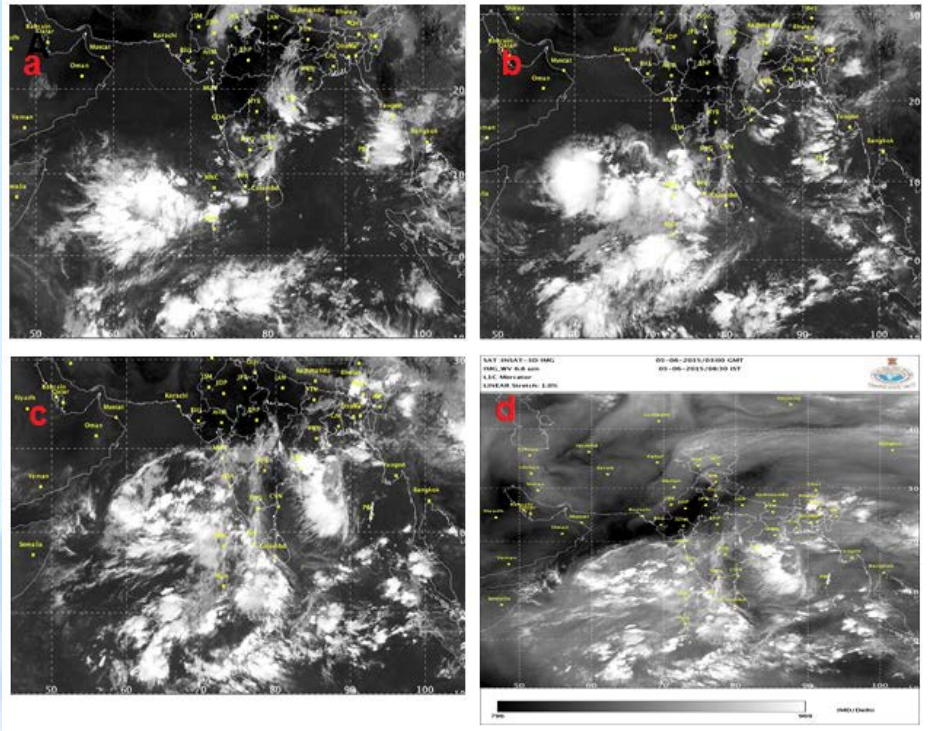
•During the last few days, considerable increase in the rainfall activity over the Bay of Bengal has also been observed

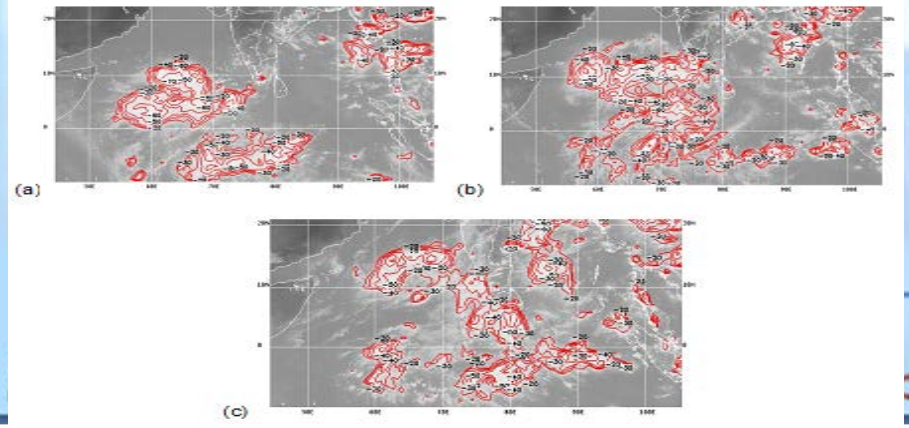
Onset of monsoon over Kerala

The actual onset of monsoon over Kerala on 5thJune 2015, 4 days later than its normal date of 1stJune.

It can be seen from the INSAT-3D Infra-red (IR) imageries that just before the onset of monsoon over Kerala, deep convective cloud area starts increasing over southeast Arabian Sea and neighboring areas.

Sequence of imageries of IR shows the rapid northward movement of the clouds from 3rd to5thJune 2015 i.e., the time of monsoon onset Fig. (a, b, c).The moisture influx can also be seen from the water vapor imagery on the same day Fig. (d).





Associated with this event, monsoon advanced into entire south Arabian Sea, some parts of central Arabian Sea, entire Lakshadweep area, some parts of coastal & south interior Karnataka and Tamil Nadu, most parts of south Bay of Bengal, some more parts of west central Bay of Bengal and some parts of northeast Bay of Bengal.

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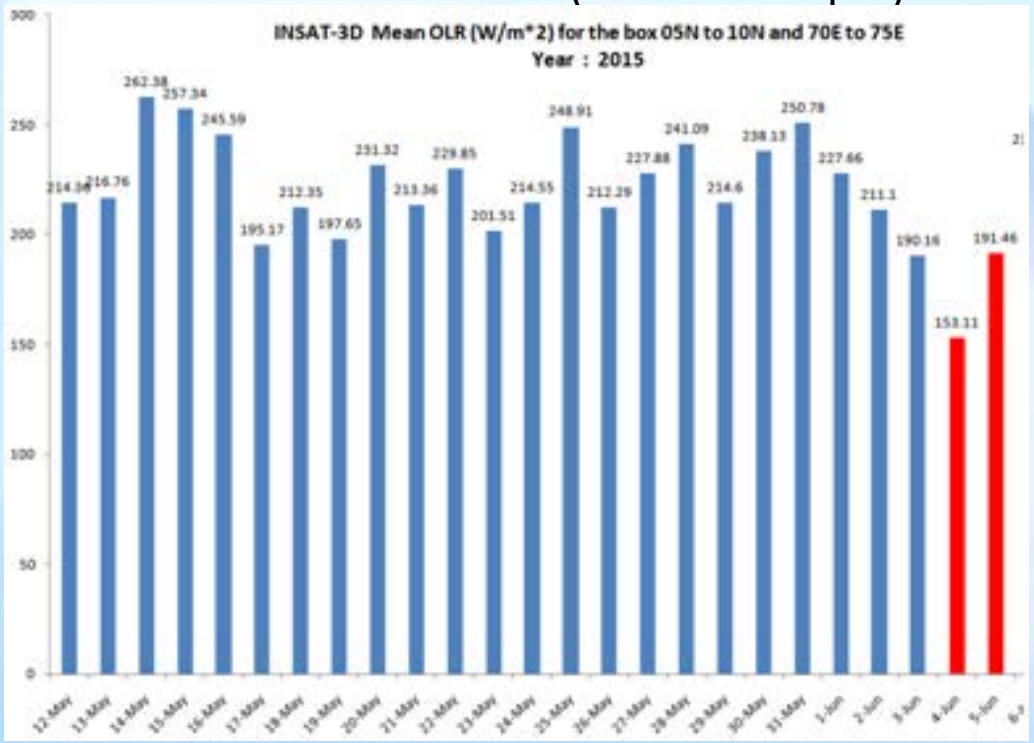
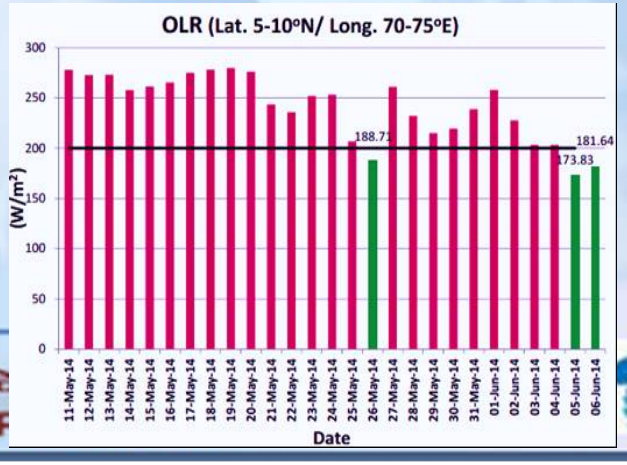
OGICAL DEPARTMENT

Outgoing Longwave Radiation (OLR) For Monitoring of Monsoon Features

The outgoing long wave radiation has been used traditionally for radiation budget studies of the Earth atmospheric system. This is mainly due to the fact that in the tropics, the OLR is largely modulated by cloudiness. In particular it varies with the cloud top temperature, and consequently, low values of OLR indicate major convective system. In general at IMDPS, total outgoing long wave radiation (OLR) flux, thermally emitted from earth atmosphere system, is estimated by applying regression equation relating OLR flux with geostationary Indian National Satellite (INSAT-3D) VHRR observed WV (5.7to 7.1µm) and infrared window radiances (10.5 to 12.5 µm).



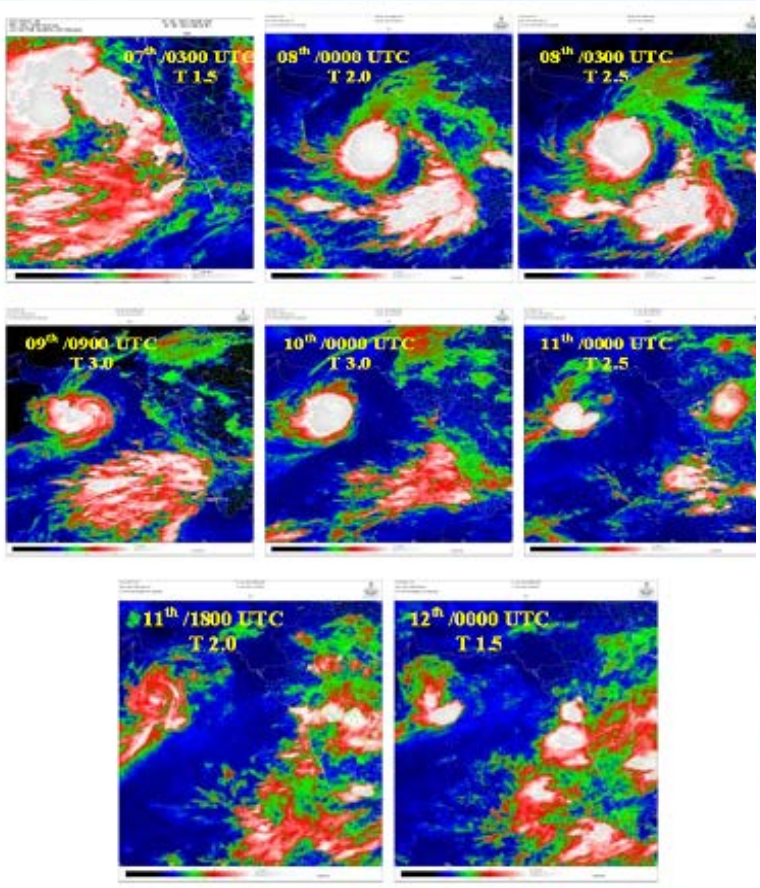
On 5th of June 2015, Fig. shows the OLR values were around 190 W/m2 over the south Arabian Sea. These values are confined to the box for consecutive last 2 days and can be seen on Fig..

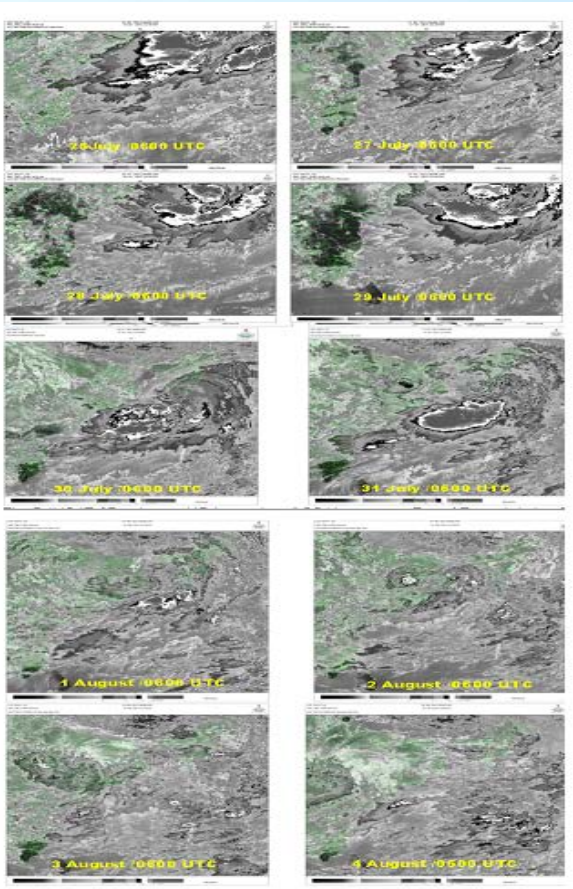


2014

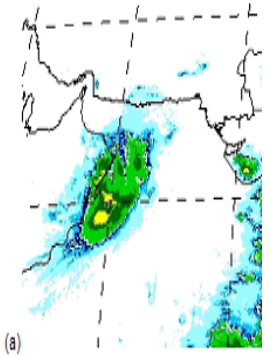
Chief Synoptic Features during Monsoon Season as Observed Through Satellite Imageries

During the southwest monsoon season, 11 low pressure systems (LPS) (low pressure areas and stronger systems) were formed. Out of these, 8 further intensified (Depression, deep depression, cyclonic storms) against a normal of 4-6 Depressions during the season. Two of which intensified into cyclonic storm 'Ashobaa' (7– 12 June) & 'Kemon' (26 July– 2 Aug.), over Arabian Sea and Bay of Bengal respectively and the 3 as Deep Depressions with 2 over land (27- 30 July & 16-19 Sept.) and one over Arabian Sea (22– 24 June).



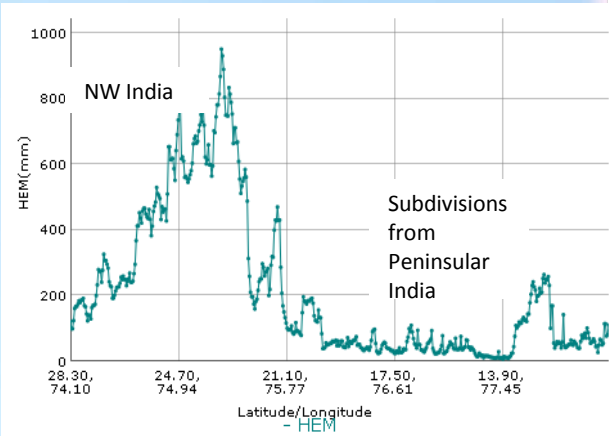


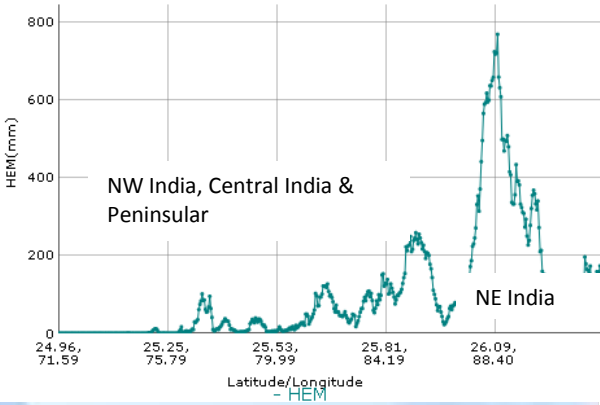
These two enhancements are named as i) BD Curve Enhancement and ii) NHC Curve Enhancement. For detailed methodology of these curves see http://tropic.ssec.wisc.edu/misc/other/faq/faq_enhance.html.

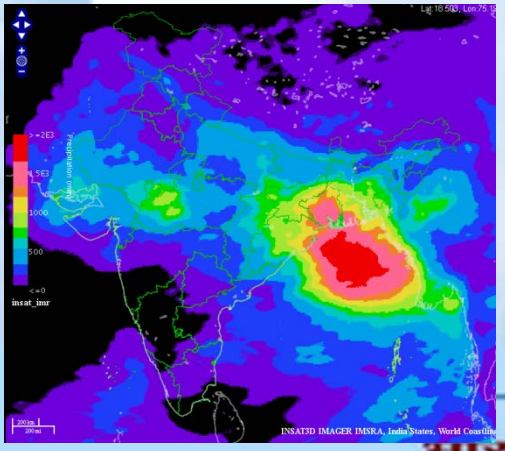


Analysis of Monsoon rainfall using INSAT-3D HE and IMR method

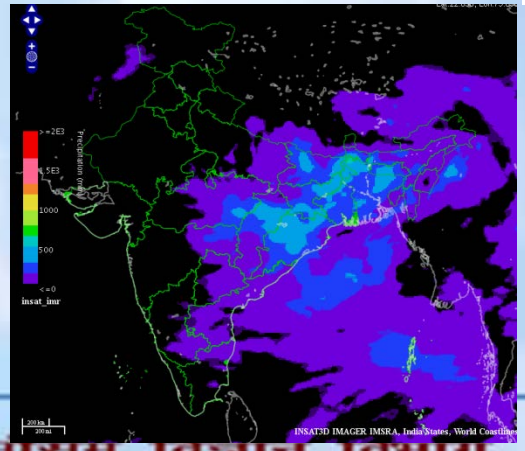
In July, majority of the subdivisions from Peninsular India and that from north India along the Himalayas received deficient or scanty rainfall. In total, 19 subdivisions received deficient rainfall, 4 subdivisions received scanty rainfall and 6 subdivisions received normal rainfall. Fig. shows the rainfall distribution of monthly Hydro Estimator(HE) and INSAT Multi-spectral rainfall (IMR) product for the month of July and August 2015 across the North, northwest to southern peninsular India. The product clearly depicts the less rainfall in Peninsular India as compared to north and northwest region in the month of July whereas In August, majority of the subdivisions from northwest India, central India and neighboring Peninsula received deficient/ scanty rainfall. On the other hand, majority of the subdivisions from northeast India received normal/ excess rainfall.







July 2015 (IMR)

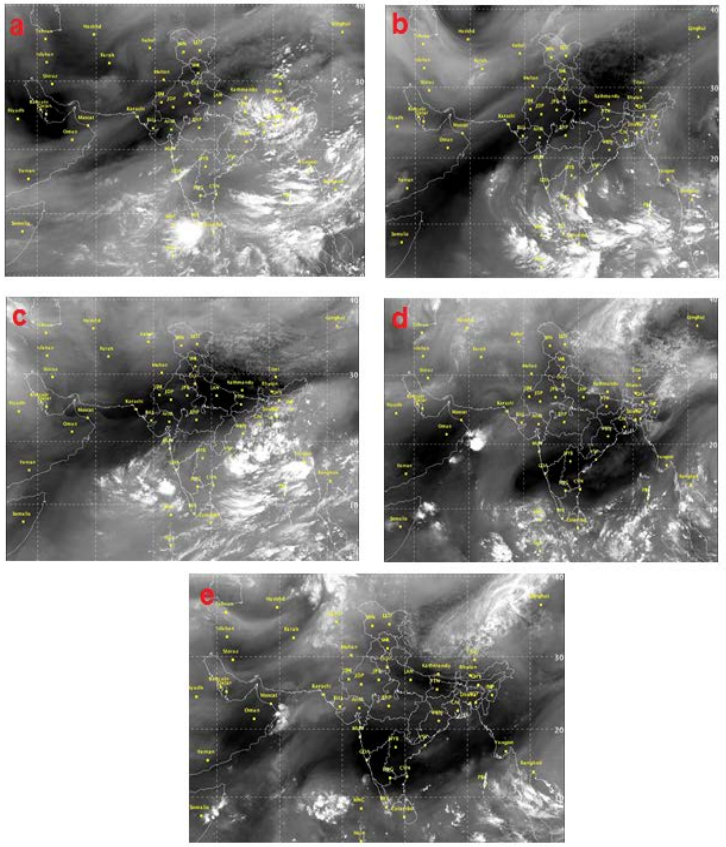


August 2015 (IMR)

Withdrawal of Southwest Monsoon

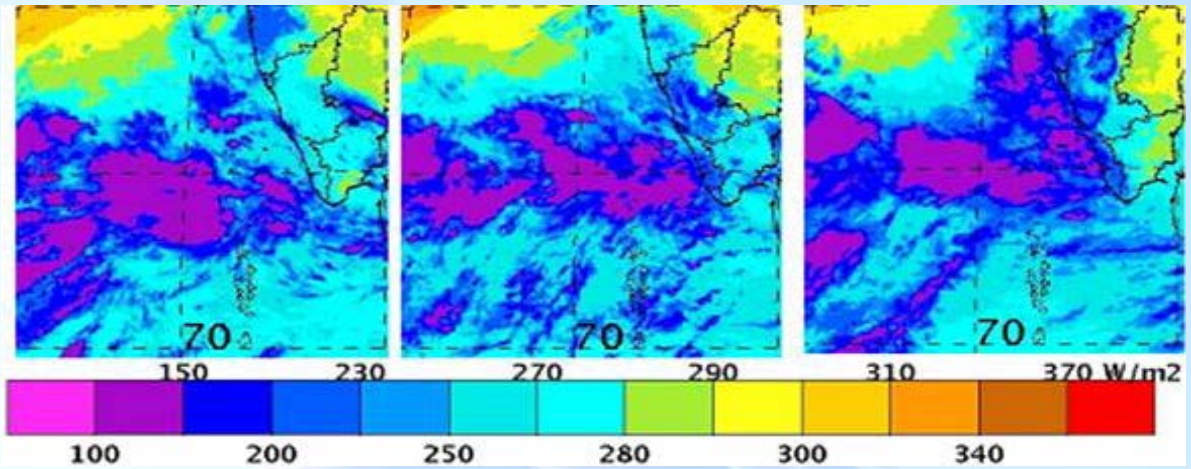
The monsoon withdrawal normally starts from the country around 1st September and continues till about 15 October, when it completely withdraws from the country. As per IMD, withdrawal over the country may be declared keeping the spatial continuity, reduction in moisture as usually depicted in the water vapor imageries and prevalence of dry weather for 5 days. From satellite imageries this can be observed by the water vapor imageries as it provides a measure of moisture content of the atmosphere at middle levels and helps in deciding the withdrawal of monsoon. It is mainly used to assess the monsoon withdrawal pattern along with the visible and IR imageries and derived products such OLR values.

A change over in the lower tropospheric circulation pattern over the region from cyclonic to anti cyclonic resulted in the withdrawal of southwest monsoon from the northwestern parts of Rajasthan on 4th September depicted in INSAT-3D water vapor imagery Fig. (a). On 29th September,Fig. (b), monsoon withdrew from remaining parts of Rajasthan, Punjab, Haryana, Chandigarh & Delhi. On 6th October, the monsoon further withdrew from some more parts of Bihar; remaining parts of Madhya Pradesh; some parts of Jharkhand, Chhattisgarh.

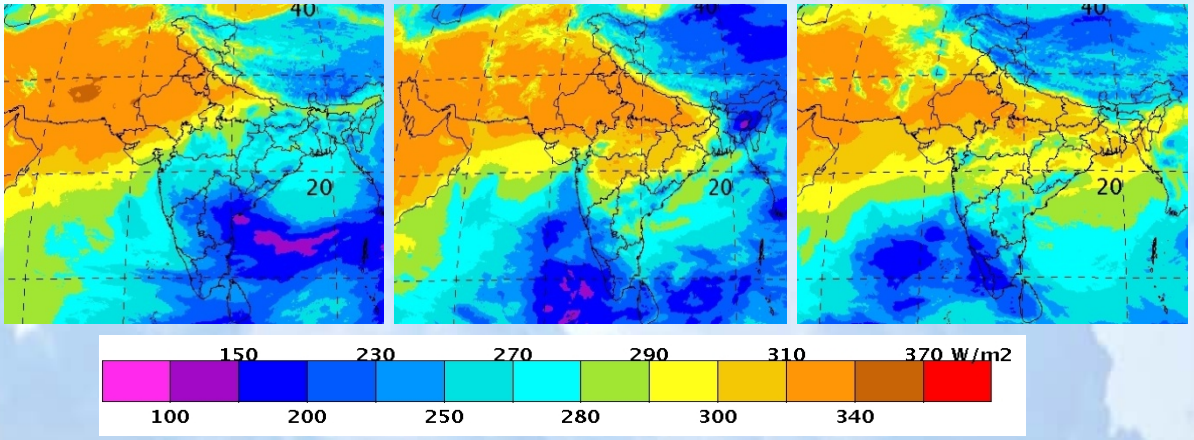


Onset and Withdrawal from INSAT OLR

Onset



Withdrawal



Rainfall Estimations from INSAT-3D

•There are three main objectives under the rainfall retrieval algorithms from INSAT-3D. These techniques are popularly known as GOES Precipitation Index (GPI) and INSAT Multispectral Rainfall Algorithm Technique (IMSRA) and Hydro-Estimator.

•All the algorithms are state-of-the-art and aimed at estimation of rainfall with different applications at different spatial and temporal requirements respectively. Here two of these techniques (GPI and IMSRA) would be modified for their applicability in the context of Indian subcontinent and adjoining oceans.

INSAT-3D Rainfall using Modified GPI Method

- This algorithm focuses on precipitation estimation using GPI technique with the implementation of the environmental moisture factor with relatively high spatial and temporal resolution. The steps of the algorithm are as below:

- To generate one a total day rainfall maps using 3 hourly brightness temperatures of IR(11 um) images for 1.0 x 1.0 deg latitude /longitude boxes using Arkin's GPI method.

  To generate mean and spatial variance of temperatures at 1.0 x 1.0 deg latitude/longitude and finally a total day rainfall accumulation.

  To derive QPE based on daily basis following the 3 hourly data of IR observations (8 images a day).

- The final objective (*proposed)* is to augment the GPI rainfall estimates possibly in better than the above resolutions based on environmental moisture correction factor applied to GPI, named as MGPI.

- The fractional area covered by clouds colder than a chosen threshold temperature (235 K) in a given area is correlated with the areal average precipitation over that area.

- Fractional Cloud Cover within a box can be estimated as

$$\frac{\text{No. of Pixels colder than 235 K}}{\text{Total No. of pixels}}$$

QPE is computed by the formula

$$QPE = K \times Fc \times N$$

where K is a regression coefficient

(71.2 mm/day)

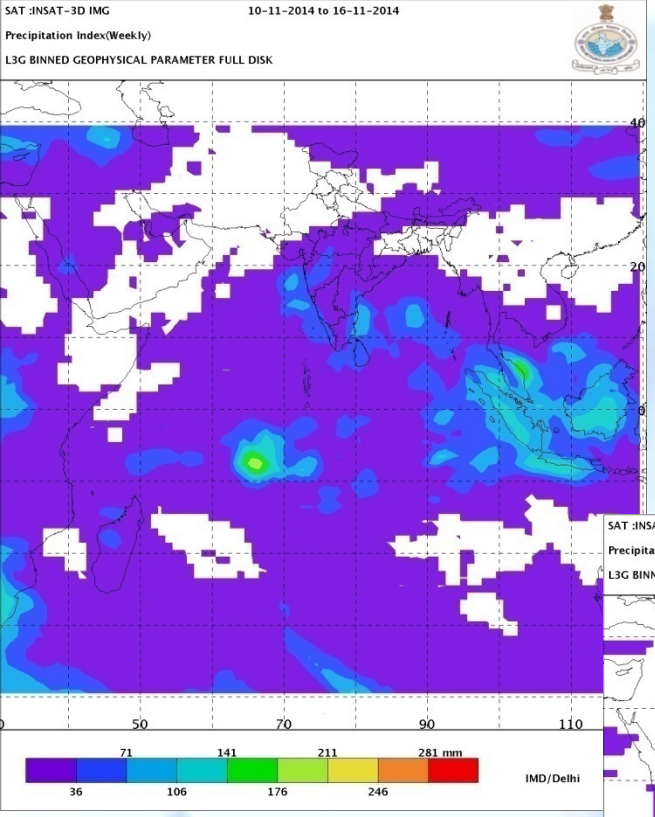
Fc is fractional cloud cover and

N is the number of days

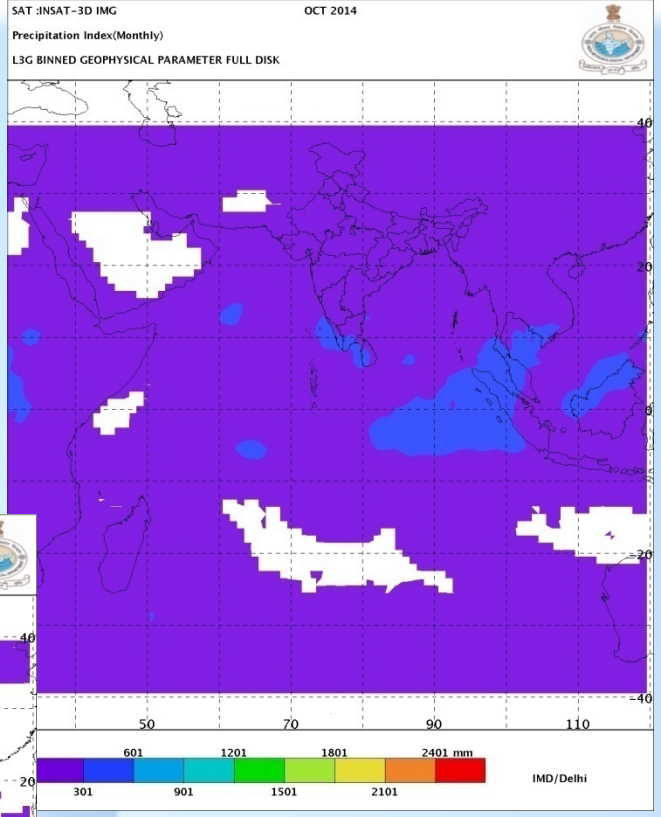
The area of computation of QPE is

N40 - S40 and E40 - E120

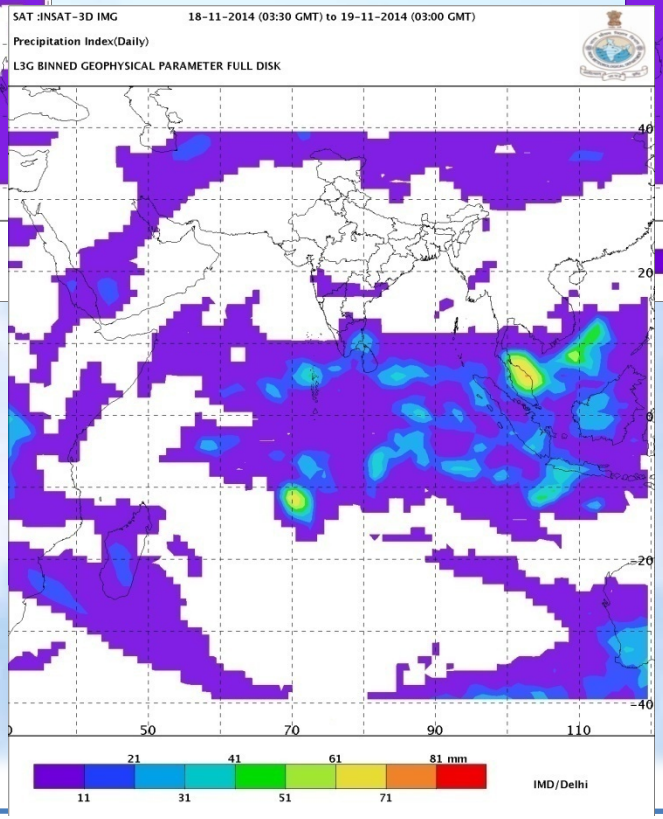
On regular basis, QPE is computed for every 3 hourly images over a grid box of 1 x 1 lat./long. Daily, weekly and monthly QPE also computed.



Weekly



Monthly



Daily

Yearly

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IMSRA

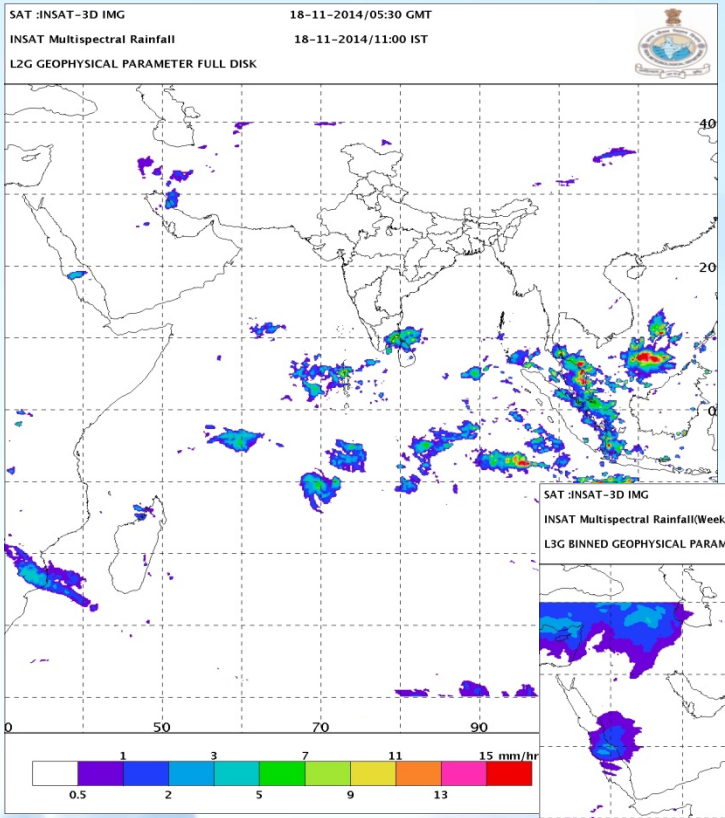
- **The main objectives here in IMSRA algorithm are to estimate rainfall by developing a Multispectral Rainfall Algorithm which is an optimal combination of GMSRA and some of the innovative proposed approaches that utilizes microwave remote sensing measurements from polar orbiting satellites.**

- **Here, the rainfall algorithm is with more advantageous that combines satellite water vapor channel data to account for limitations. Rainfall estimates are produced at the high spatial resolution and temporal frequency of the IR/WV data using rainfall information from the PMW data.**

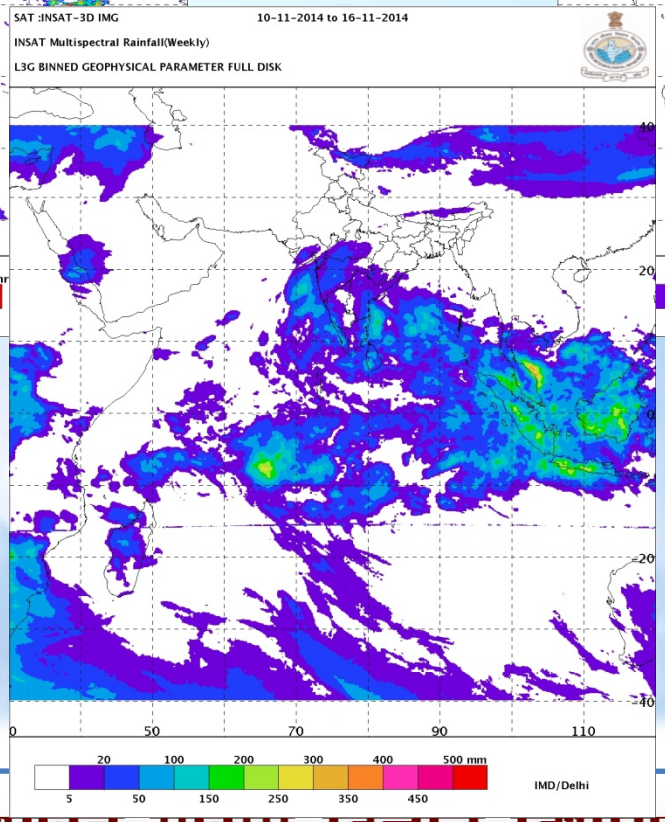
The technique has the following components:

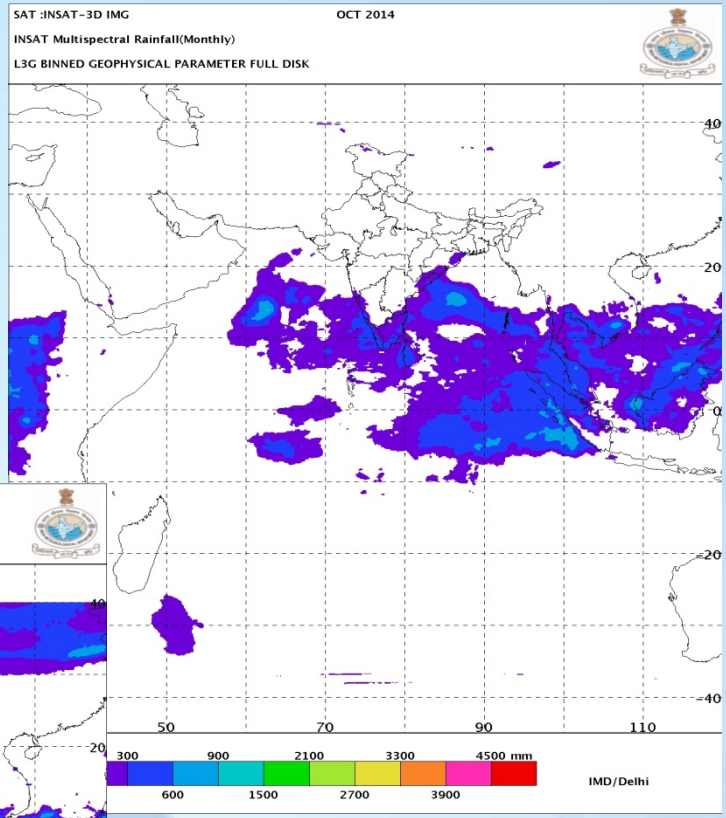
1. Identify areas for very deep convective cores from IR and WV channels (11mm-6mm.), which corresponds well with rainfall.
2. To screen mid-to upper level clouds with or without thin cirrus above the rain and non-rain baring clouds.
3. Cloud growth classification based on temporal gradients of TIR – TB's.
4. Filtering of low and non raining clouds along with the warm and semi-transperent clouds based on IR and WV when rainfall is estimated for clouds having brightness temperatures colder than 240K.
5. Spatial and temporal co-location of INSAT-TIR brightness temperature, and TRMM / SSM/I rainfall for creation of matched database.
6. To compute instantaneous rain rate using pre-calibrated rain rate for cloud top brightness temperature (11 mm) for each pixel classified as containing raining clouds along with Satellite Microwave Radiometric measurements (e.g TRMM Microwave Imager-TMI). 7. To adjust the rainfall estimates in association with the product of Integrated .Precipitable water and Relative Humidity from 500 mb – Surface (from Eta/IMD model).

- On the synoptic scale, the 6.7 mm water vapor is especially useful for detecting jet streaks, vorticity centers and other features that are associated with upward vertical motion and lift the moist, unstable air resulting in the production of clouds and precipitation.



Half Hourly





Monthly

RAINFALL ESTIMATION – H-E Method

The HE algorithm uses infrared (IR) brightness temperatures to identify regions of rainfall and retrieve rainfall rate, while using National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS) model fields to account for the effects of moisture availability, evaporation, orographic modulation, and thermodynamic profile effects.

Method utilizes the precipitable water (PW) and water vapour (WV) correction to make modifications for *dry/wet environment and saturation level adjustments for rain that comes from the warm clouds*. This method was very successful for precipitation measurement but was highly subjective and depends on seasonal characteristics of rainfall amount.

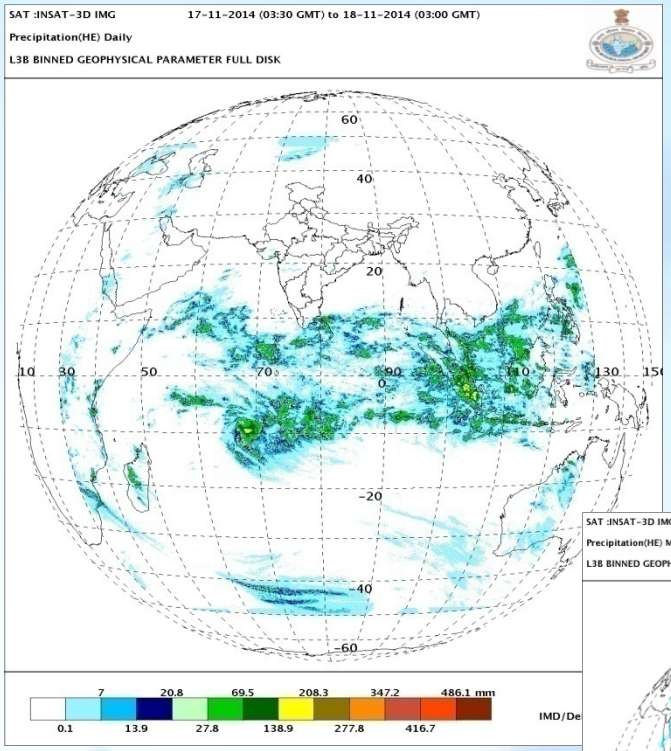
- Hydro-Estimator is most recent of the attempts by NESDIS to improve and make IFFA automated.
- Hydro-Estimator method for precipitation measurement over Indian region encompassing area between longitudes 30 E -to130 E and latitudes 50 N -50 S.

4.3.2 Image and preprocessing data (Dynamic)

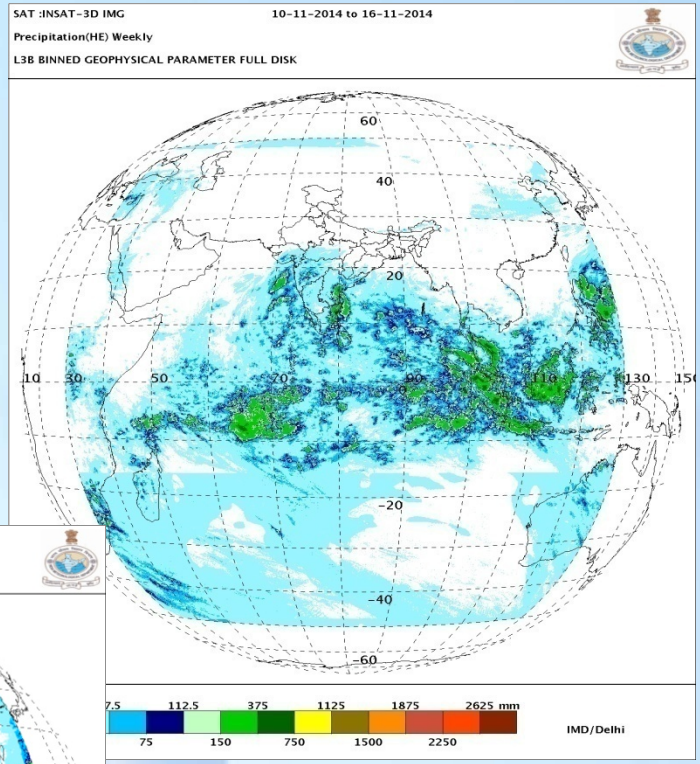
Parameter	Resolution	Quantization	Accuracy	Source
Radiometric and geometric corrected gray count values of TIR-1 channel (10.7 µm)	Spatial:pixel Temporal: 30 min	10 bit	-	Derived from raw data by DP
Gray value to brightness temperature conversion table	-	-	0.3 K	Derived by DP
Geolocation file	Spatial:pixel Temporal: 30 min	-	1 pixel	Derived by DP

4.3.3 Other Auxillary data and Model Inputs

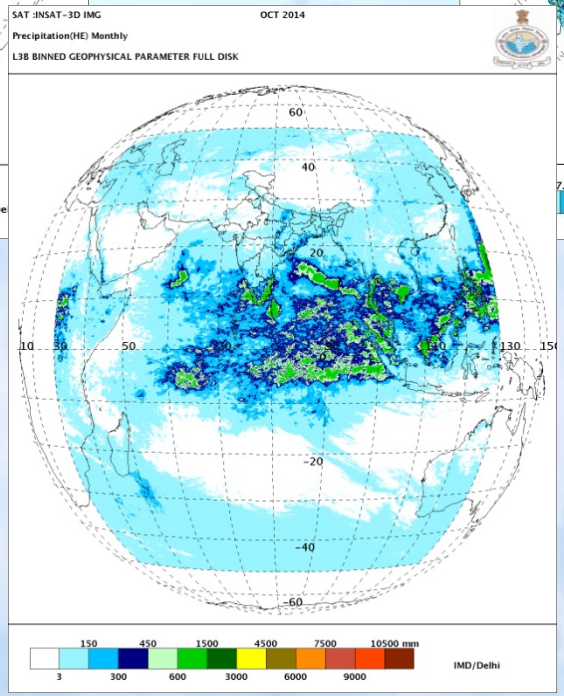
Parameter	Resolution	Quantization	Accuracy	Source
Eta Model - Equilibrium level in K	Spatial: pixel size Temporal: 3/6 hourly			Provided by IMD
Eta model- observations of wind at 850 hPa and relative humidity (%), and PW (inch)	Spatial: pixel size Temporal: 3/6 hourly			Provided by IMD
Eta model - Profiles of temperature and dew point	Spatial: pixel size Temporal: 3/6 hourly			Provided by IMD



Daily



Weekly



Monthly

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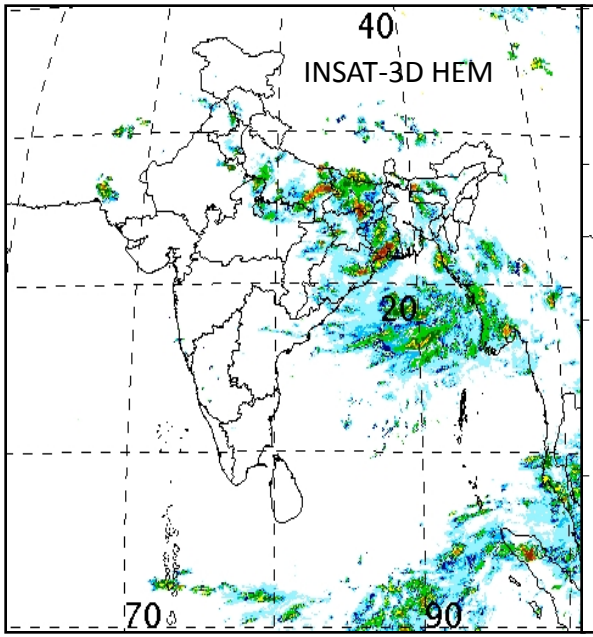
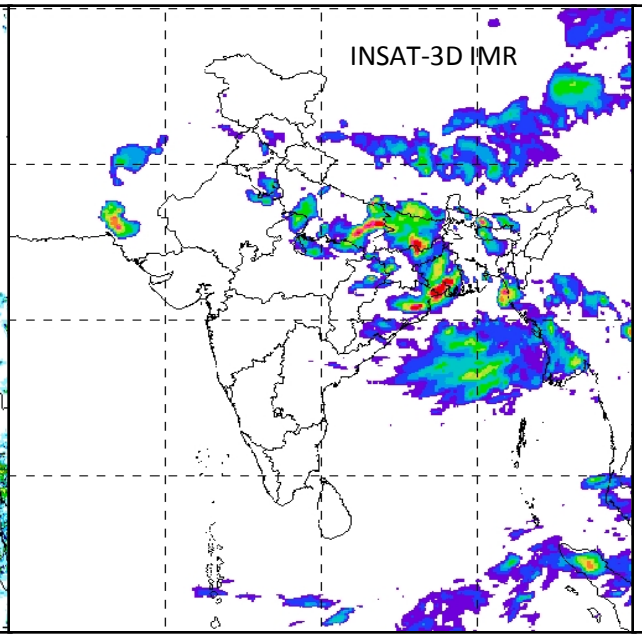
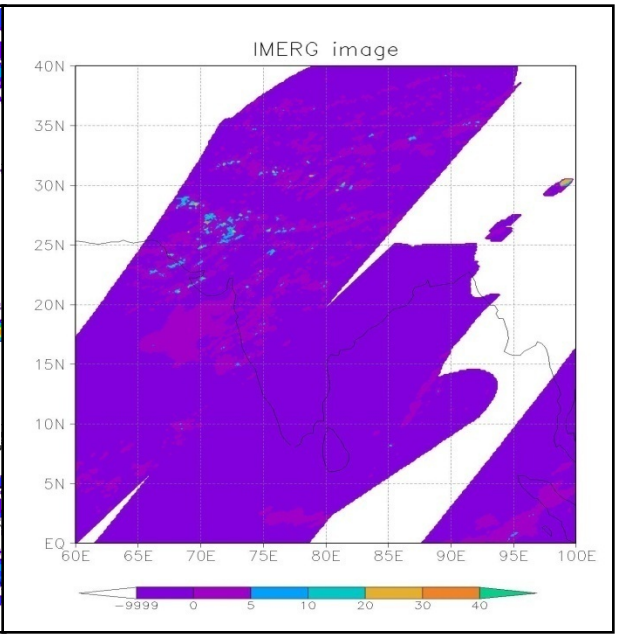






	IMD-NCMRWF (Daily Merged) Rain Estimation	INSAT-3D HEM	INSAT-3D IMR	INSAT-3D QPE	IMERG Data (GPM)	Surface Observations
Temporal Resolution	**Daily**	**Half Hourly, Daily**	**Half Hourly, Daily**	**3 Hourly, Daily**	**Half Hourly**	**Daily**
Spatial Resolution	**0.5 * 0.5**	**0.1X0.1**	**0.1X0.1**	**1 * 1**	**0.1X0.1**	**Rainguages+AWS and ARG Observatories**

The data from IMD-NCMRWF Rain estimation, INSAT-3D HE Method, INSAT-3D IMR method, INSAT-3D QPE method and Surface Observations have been considered on the daily basis for validation.

The data from **INSAT-3D HE method**, **INSAT-3D IMR method** and **IMERG data** has been considered for validation on the **half hourly** basis.

Data Availability

QPE(GPI)	HDF	Half Hourly,Daily, Monthly, Sesonal 1X1 Deg.
IMSRA	HDF	Half Hourly, Daily, Monthly, Sesonal 0.1X0.1 Deg,
HEM	HDF	Half Hourly, Daily, Monthly, Sesonal Per Pixel (around 0.1 X0.1 Deg)

Daily data is computed from 03 UTC to 03UTC

SATMET page

Mata Vaishno Devi Shrine | Special Fog Sector | RAPID NEW! INSAT-3D SRF

INSAT IMAGES															NOAA, MODIS & METOP	
INSAT-3D													KALPANA-1	INSAT-3A		IMAGES & PRODUCTS	
IMAGER IMAGES			SOUNDER IMAGES				SOUNDER IMAGES (PROFILES)							VHRR	CCD	DELHI SYSTEM	LINKS
FF & Sec	HR Sec	D/N Micro & Cyc Enh	All Ch 'A'	All Ch 'B'	BT 'A'	BT 'B'	Temp 'A'	Temp 'B'	Hum 'A'	Hum 'B'	GPH 'A'	GPH 'B'					
○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

INSAT PRODUCTS													
IMAGER/VHRR										SOUNDER		INSAT-3A CCD	SATELLITE BULLETINS	
AMV	OLR	SST	LST	INS	UTH	RAIN ESTIMATE	BT AVERAGE	CT BT	FOG, SNOW, FIRE, AOD, SMOKE & C MASK	SEC 'A'	SEC 'B'		Detailed	Special
○	○	○	○	○	○	◉	○	○	○	○	○	○	○	○

RAINFALL PRODUCTS : Quantitative Precipitation Estimate (QPE), Insat Multispectrial Rainfall (IMR) & Hydro-Estimator (HE)

INSAT-3D QPE (Three Hourly)	INSAT-3D QPE (Daily)	INSAT-3D QPE (Weekly)	INSAT-3D QPE (Monthly)	INSAT-3D QPE (Seasonal)
○	◉	○	○	○
INSAT-3D IMR (Half Hourly)	INSAT-3D IMR (Daily)	INSAT-3D IMR (Weekly)	INSAT-3D IMR (Monthly)	INSAT-3D IMR (Seasonal)
○	○	○	○	○
INSAT-3D HE (Half Hourly)	INSAT-3D HE (Daily)	INSAT-3D HE (Weekly)	INSAT-3D HE (Monthly)	INSAT-3D HE (Seasonal)
○	○	○	○	○
Kalpana-1 QPE (Three Hourly)	Kalpana-1 QPE (Daily)	Kalpana-1 QPE (Weekly)	Kalpana-1 QPE (Monthly)	Kalpana-1 QPE (Seasonal)
○	○	○	○	○
Kalpana-1 IMR (Half Hourly)	Kalpana-1 IMR (Daily)	Kalpana-1 IMR (Weekly)	Kalpana-1 IMR (Monthly)	Kalpana-1 IMR (Seasonal)

Validation

INSAT-3D satellite derived rainfall estimations i.e.,

- Hydro-Estimator Method (HEM)
- INSAT Multi-spectral rainfall (IMR) and
- Quantitative Precipitation Estimation (QPE)

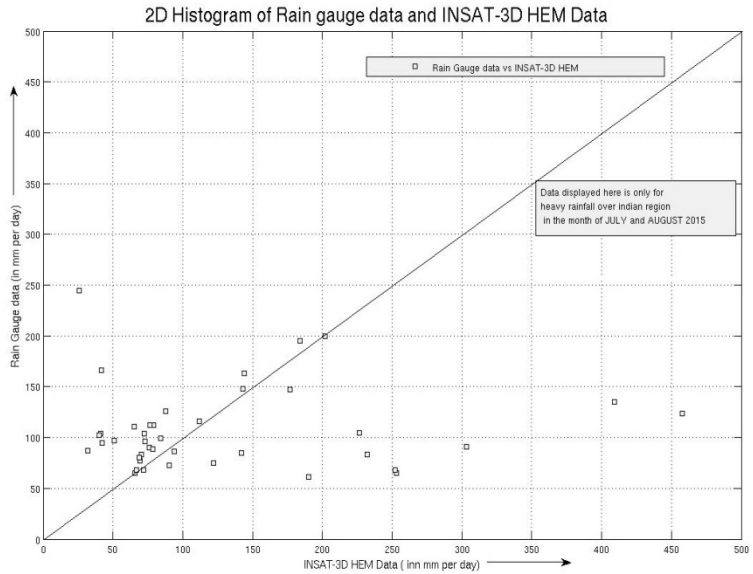
for the analysis of heavy rainfall episodes over the Indian region from operational INSAT Meteorological Data Processing System (IMDPS), New Delhi for the southwest monsoon season 2015. (*June to September ,2015)*

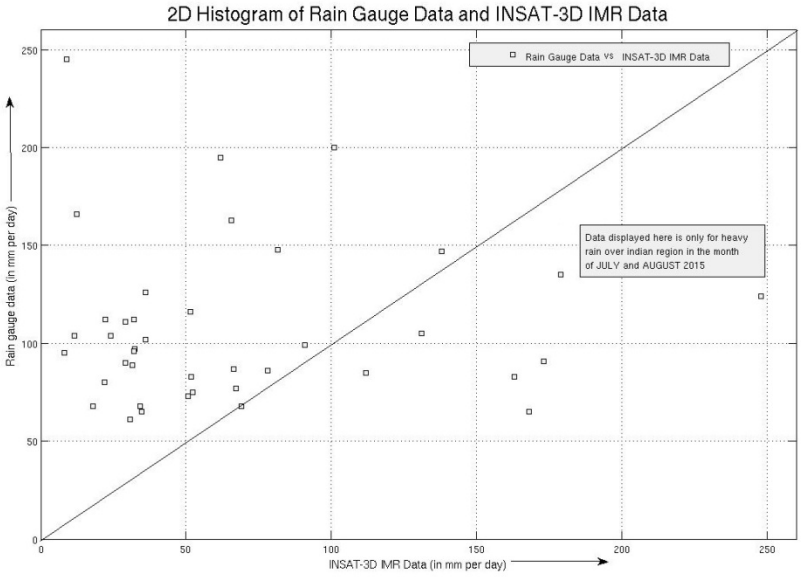
The data set used for the comparison and validations are,

- *Integrated Multi-satellitE Retrievals for GPM (IMERG) (0.1 x 0.1 degree) data, Huffman, G. J., and others 2014.*
- *IMD`s surface rainguage data and*
- *Daily merged satellite gauge rainfall data (0.5 x 0.5 degree) (Ashish Mitra et al, 2009) at locations approximately 12-km apart.*

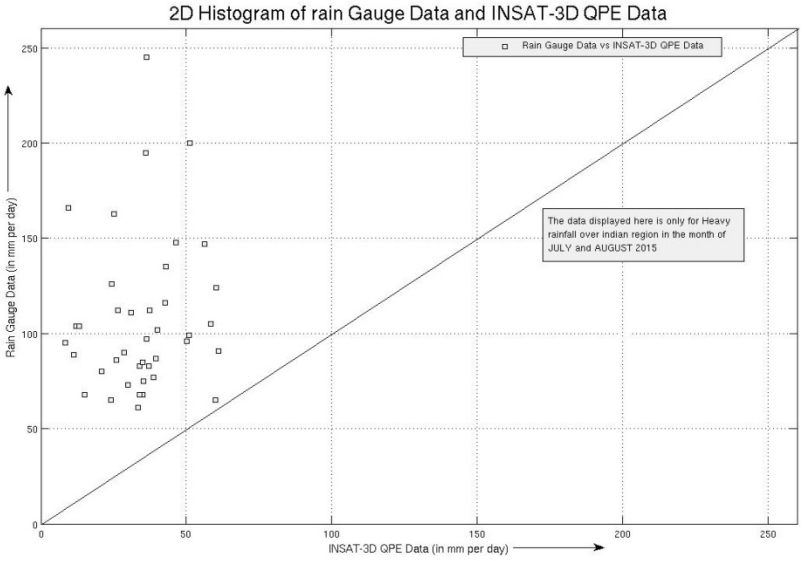
Overall 40 cases of heavy rainfall over the Indian region have been analysed.

2D Histogram of INSAT-3D Derived Heavy R/F data against surface observations (raingauge)

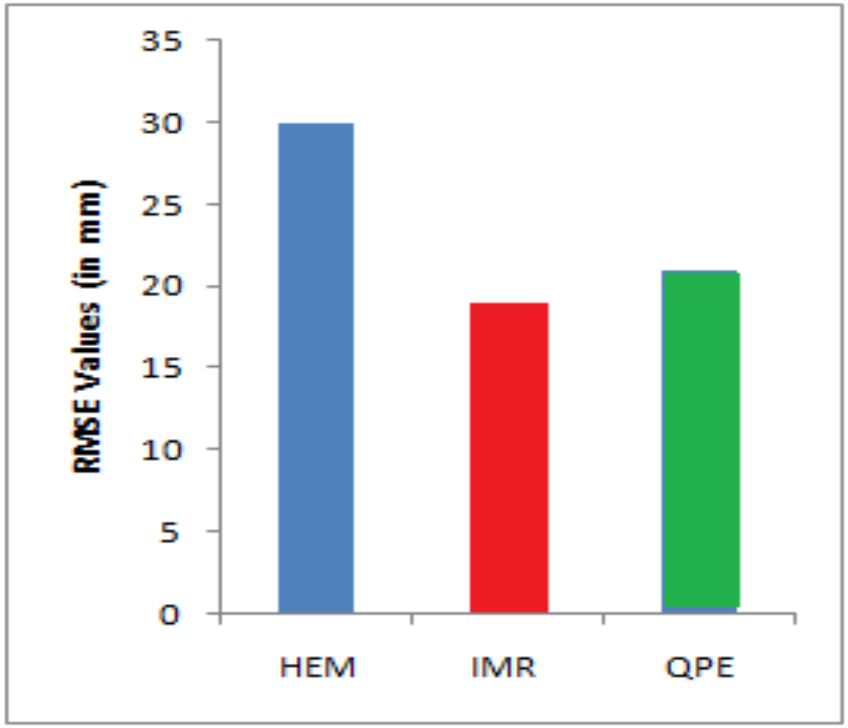


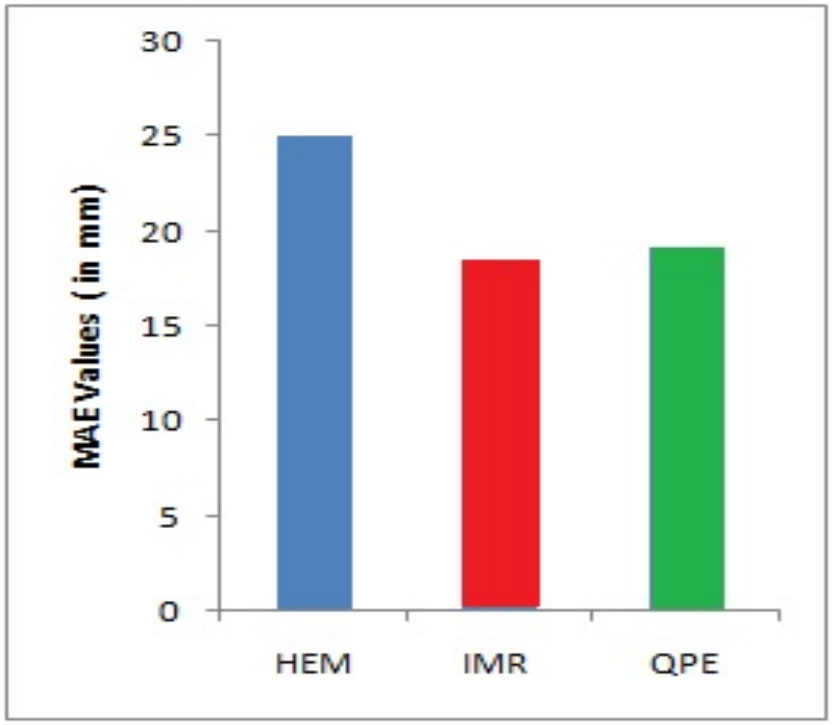


The records are located near the line of perfect agreement for HEM as compared to IMR and QPE, which is around 70%, 30% and 1 to 2% respectively with the accuracy of ±20mm. This indicates that when the HEM does estimate heavy rain, it agrees well with surface observations in general.



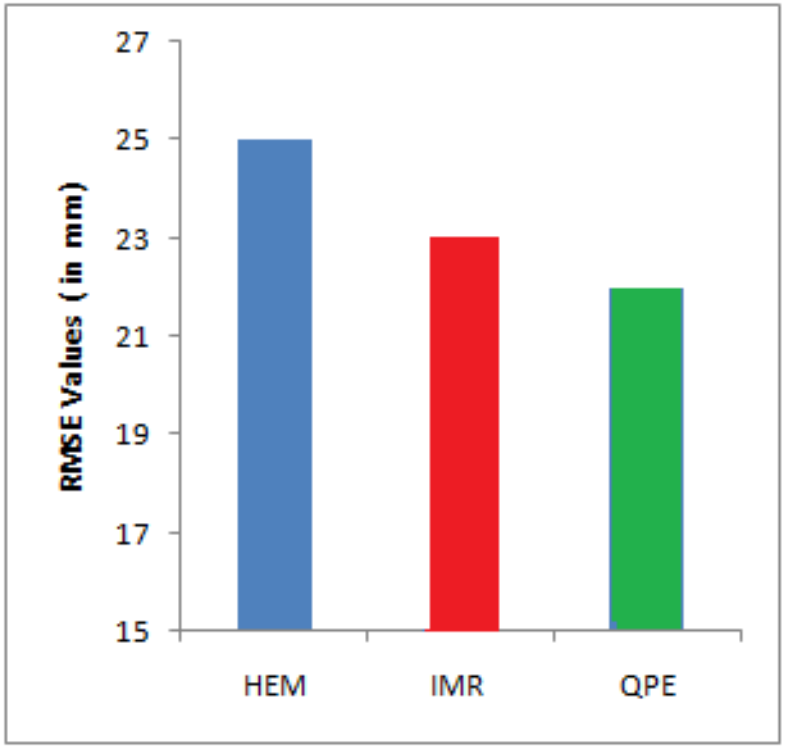
Overall Daily Performance for the Monsoon Season 2015(surface observations)

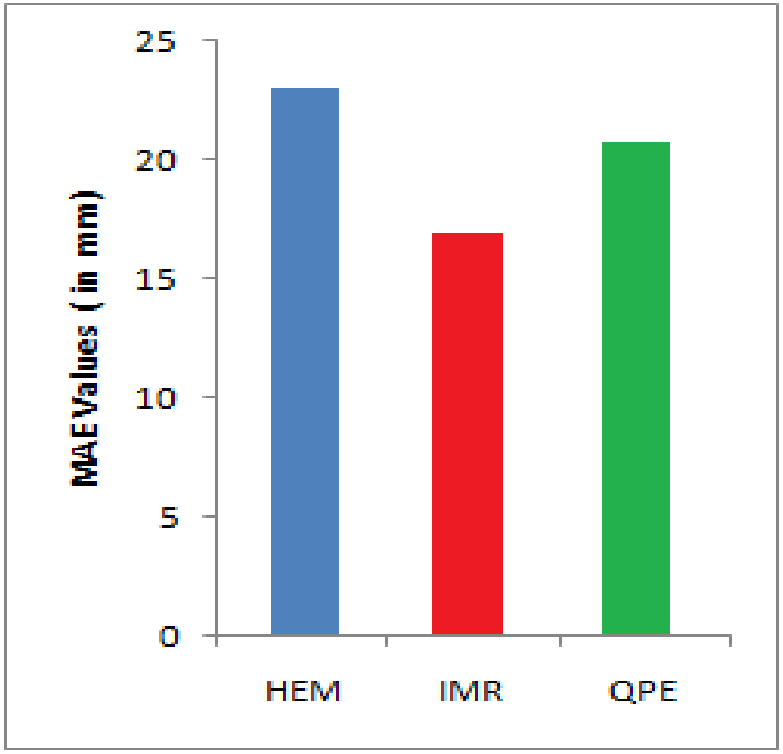




The performance statistics with surface observation with over all data set (no rain, light rain, moderate/heavy/very heavy) shows that HEM correlate well with the data set, but deviations are also quite high. HEM tends to overestimate light rain but underestimates moderate to high rain over the land whereas IMR and QPE have better skills for light to moderate rainfall.

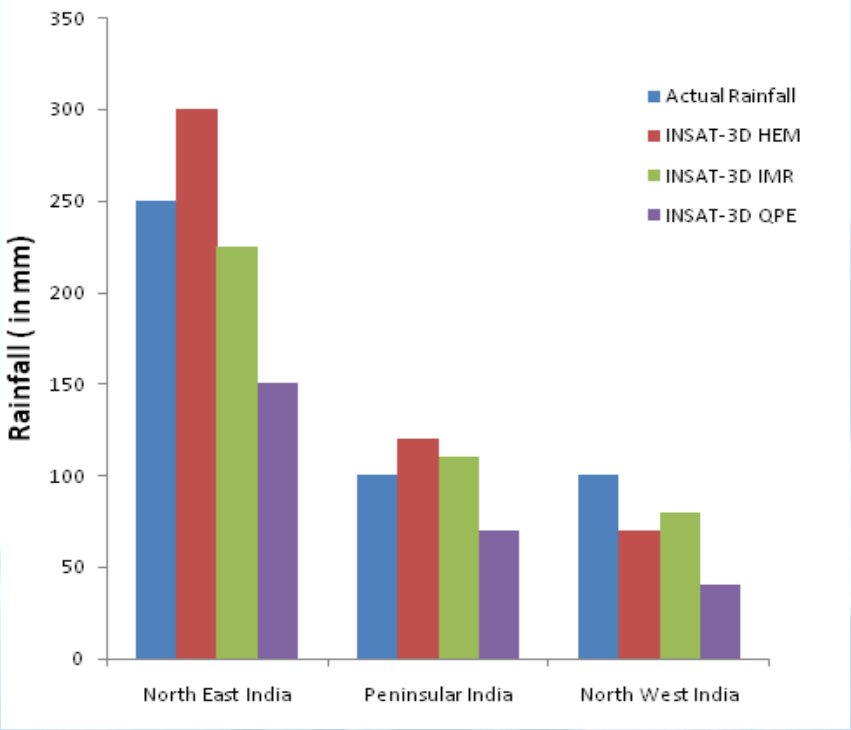
Overall Performance for the Monsoon Season 2015(GPM data)

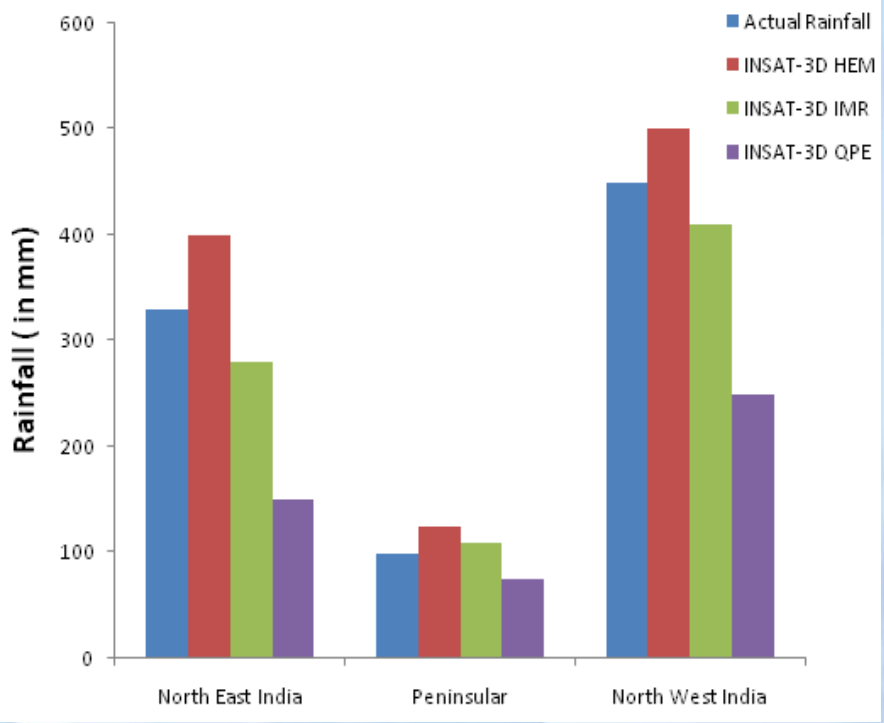




The performance statistics with IMERG data (no rain, light rain, moderate/heavy/very heavy) shows that QPE correlate well with the data set, but deviations are also not that much high. It is just because it is a 3-hourly comparison. So, QPE have better skills for light to moderate rainfall. HEM tends to overestimate light rain.

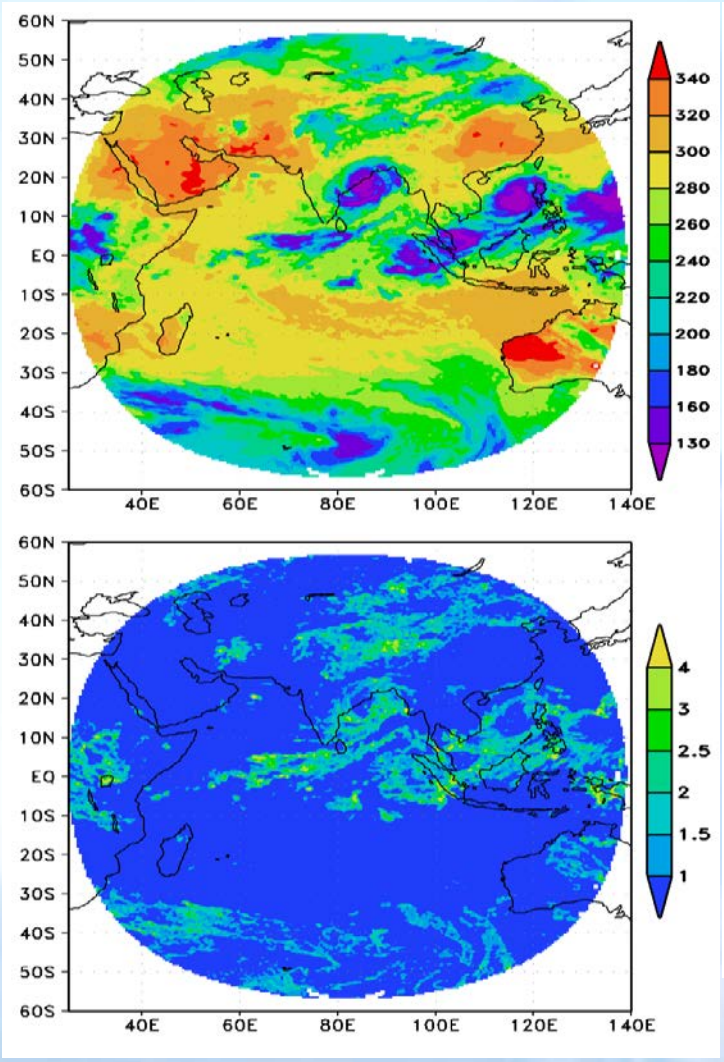
Monthly comparison with actual observations

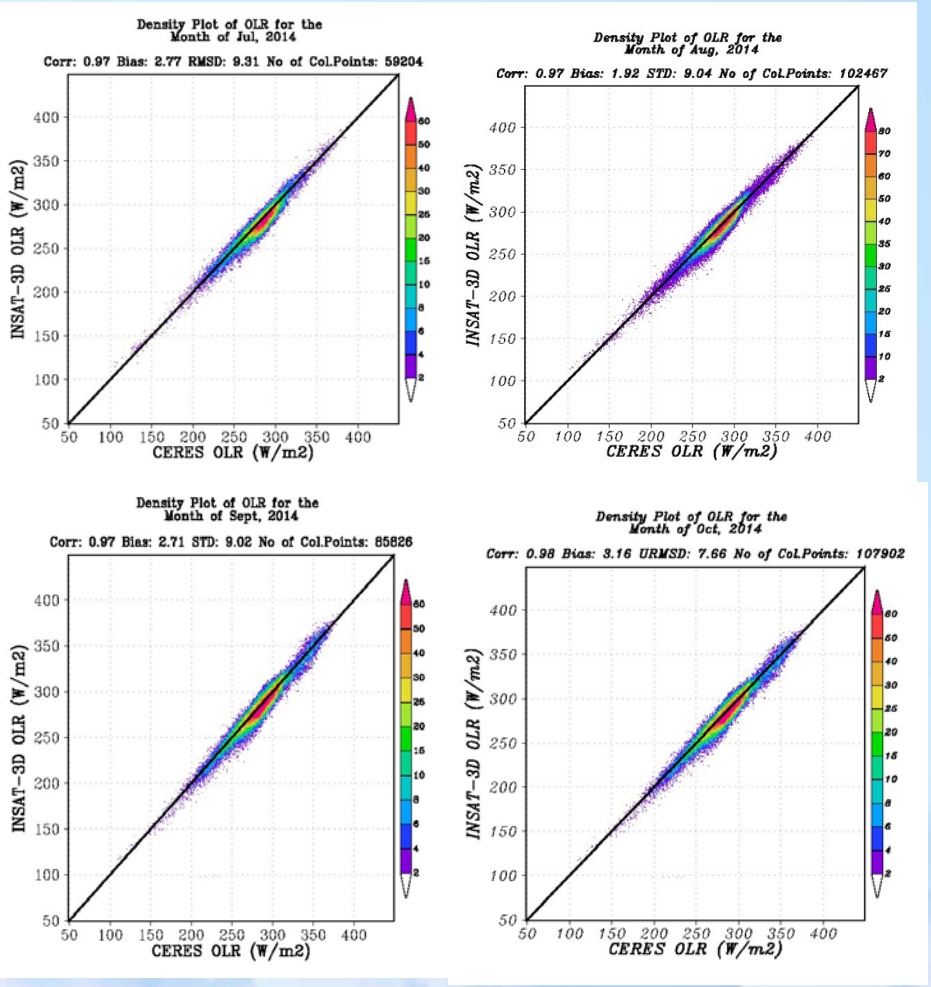




July **August**

Performance of OLR





INSAT-3D mean OLR (Wm-2) in 3x3 pixels (upper panel) and coefficient of variation (%) in 3x3 pixels (lower panel), 0630 UTC 12 October 2013.

Summary

❖Monsoon advancement over Andaman and onset over Kerala has been very well captured by the high resolution of INSAT-3D visible images. The circulation pattern over Andaman has also been depicted by water vapor winds.

❖During onset, the depth of convection can be very well monitored with the help of cloud top temperature (CTT).

❖The minimum INSAT-3D OLR during onset of monsoon was around 190 W/m2.

❖The intensification and weakening of the cyclones can be very well monitored by the NHC and BD curve.

❖The rainfall distribution of the southwest monsoon season 2015, over the country as a whole have been very well captured by the INSAT-3D derived rainfall products i.e., HE and IMR.

❖The withdrawal of monsoon from the country can be very well monitored with the water vapor imageries and derived OLR product. These two features are important criteria for declaring withdrawal of monsoon from northwest India apart from the rainfall.

❖ Estimates of rainfall from satellites can provide critical rainfall information in regions where data from gauges or radar are unavailable or unreliable, such as over oceans or sparsely populated regions.

❖we found , HE methods have potential to use for rainfall analysis over IMSRA and GPI techniques.(Specially Heavy Storms/Thunderstorm/Heavy rainfall). HEM is better able to detect heavy rain events (64-124 mm/day) with the accuracy of ±20mm.

❖The performance statistics with surface observation with over all data set (no rain, light rain, moderate/heavy/very heavy) shows that HEM correlate well with the data set, but deviations are also quite high. HEM tends to overestimate light rain but underestimates moderate to high rain over the land whereas IMR and QPE have better skills for light to moderate rainfall.

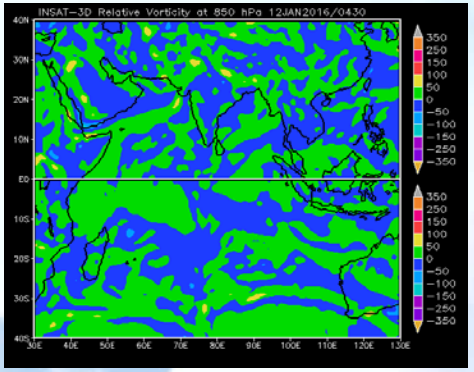
❖ HEM shows good skill and correlation ($r > 0.5$) in detecting heavy rainfall with good pattern matching, whereas IMR and QPE correlation are less than 0.3 and 0.5 respectively.

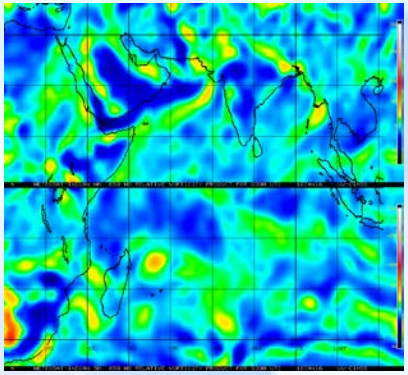
❖The INSAT-3D OLR was compared with the CERES on board NPP satellite from July to December 2014.

❖On instantaneous time scale and for the uniform scenes, the bias and the standard deviations of differences between CERES and INSAT-3D OLR are about 1.92 to 4.60 Wm-2 and 7.66 to 9.31 Wm-2, respectively. Thus, the preliminary validation results suggest that the OLR estimated using INSAT-3D Imager radiance is of good quality (error is ~3 %) and could be used in the various applications studies.

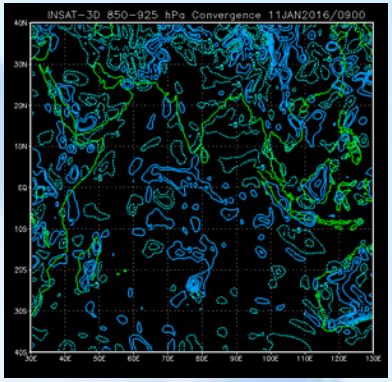
New Satellite products

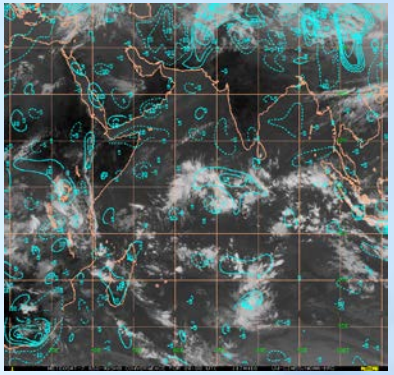
- Owing to frontal system a sudden non-monsoonal precipitation occurs over mountainous region of India, the system is driven by westerlies. So remote observation of this phenomenon using two geostationary satellites , INSAT 3D and Metosat-7, will be effective in visual analysis of comparison of wind-driven parameters (vorticity, convergence and wind shear) which are indicator of storm development in the atmosphere.
- At different pressure levels 850, 700, 500, 200 hpa, vorticity derived from AMV(Atmospheric motion vector) has been analyzed visually from Metosat-7 & INSAT-3D images.



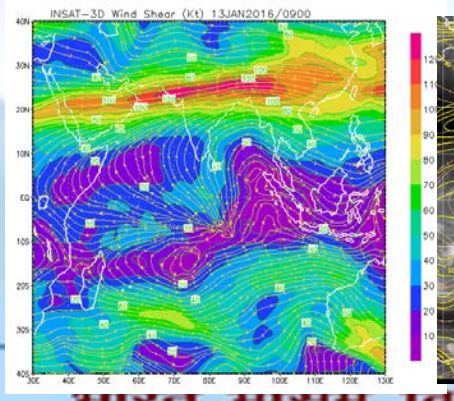


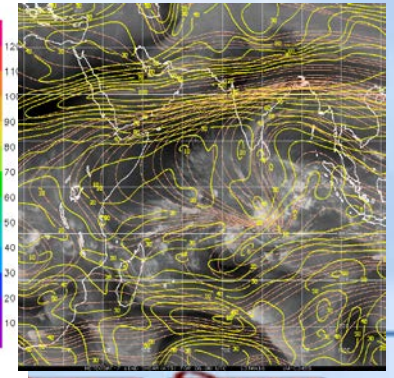
Vorticity





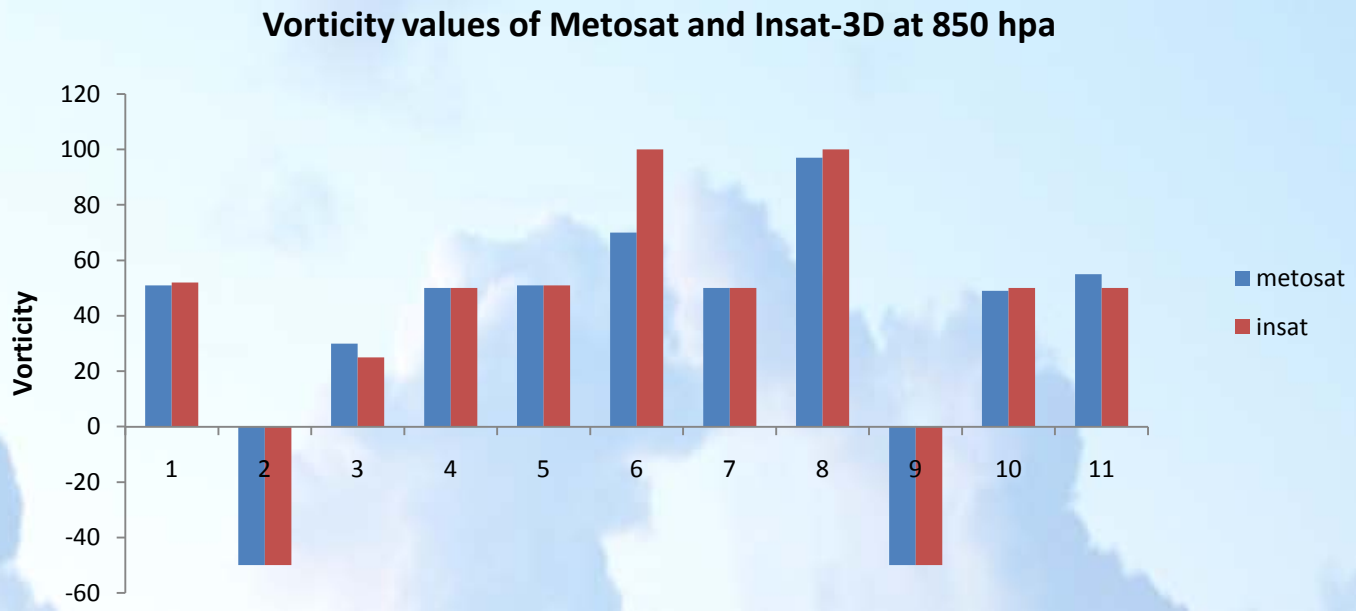
Low level convergence





Wind shear

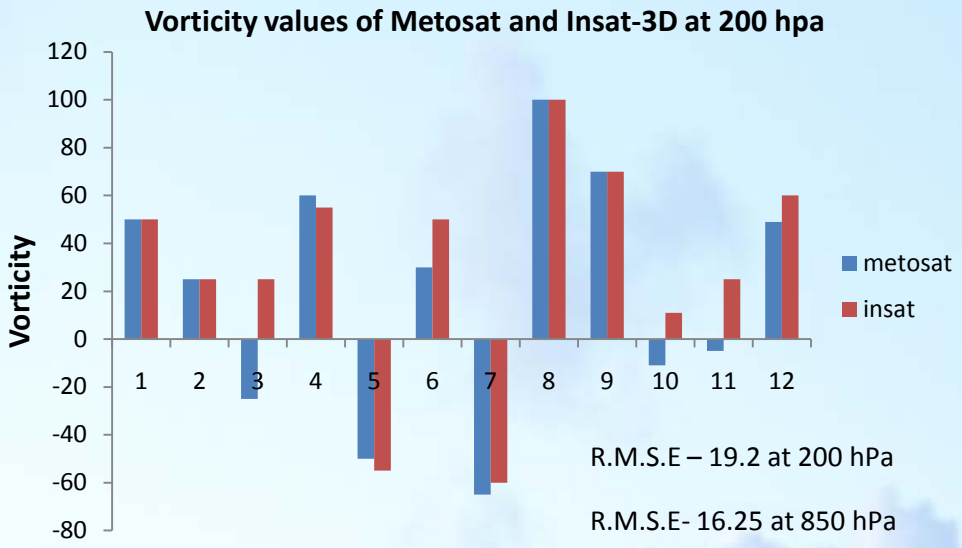
Using the gridded AMV output, vorticity is computed using finite differencing of (dv/dx – du/dy) where v and u are meridional and zonal component. X and Y are the horizontal and vertical grid spacing. Vorticity unit is second inverse.

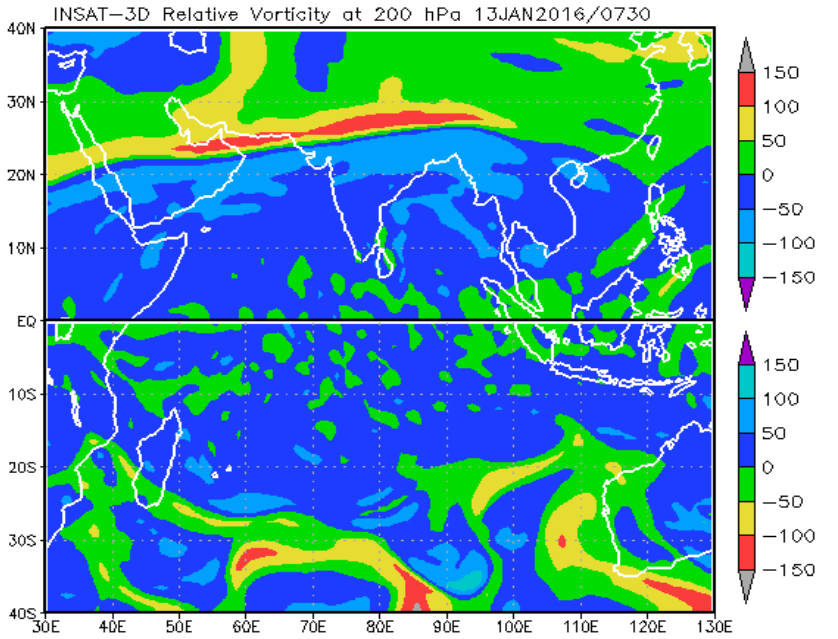


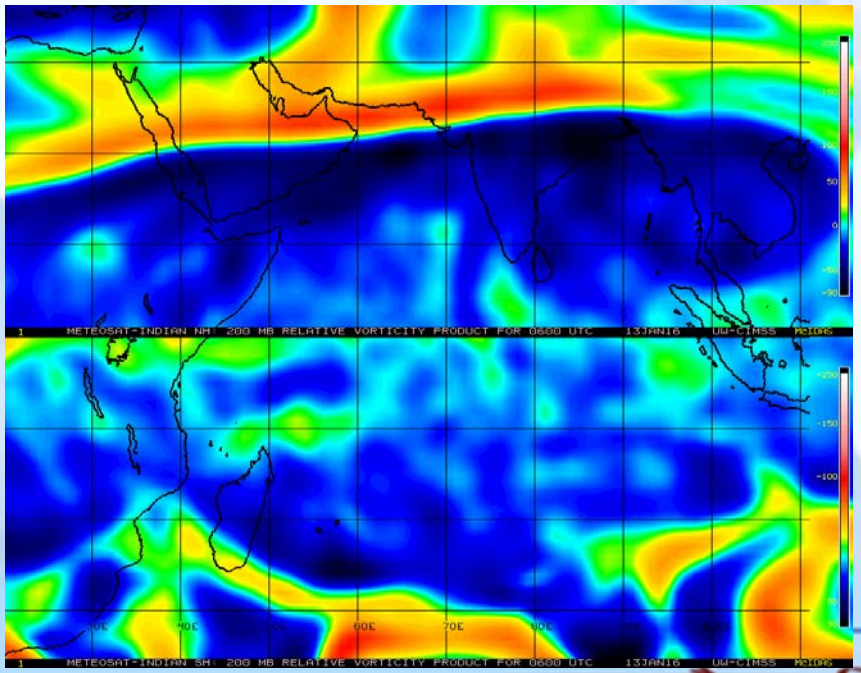
R.M.S.E - 9.34

Only those values are taken into consideration for analysis which have higher vorticity values indicating a tendency to cyclonic or anti-cyclonic formation over Indian region. This analysis is subject to individual analysis. Negative value indicates cluster of pixels representing clockwise motion in northern hemisphere .

Looping of satellite images of two satellites at 850 hpa



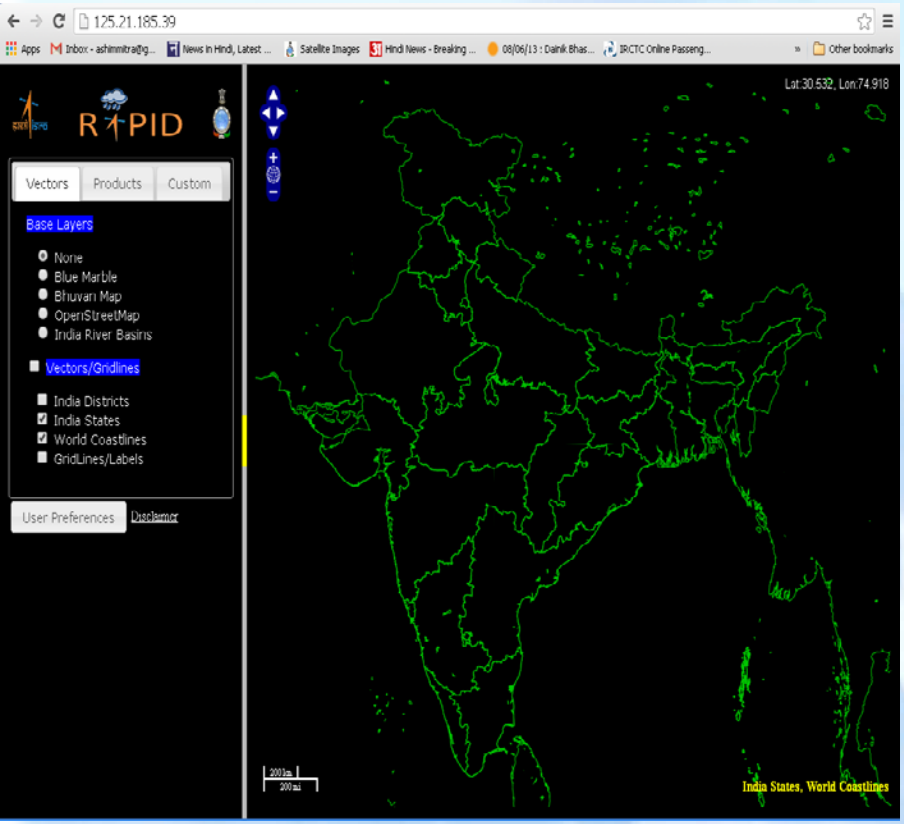




The graph showing the respective values of vorticity of different sequential images over India. The R.M.S.E error is around 19.2. Both the Insat-3D (upper) and Metosat 7 (Left) images are representing vorticity at 200 hpa. There is an elongated long narrow vorticity formation over the upper northern side of India indicating arrival of extra tropical disturbance at the altitude of around 10 km.

On-line INSAT-3D Data Visualization Tool RAPID

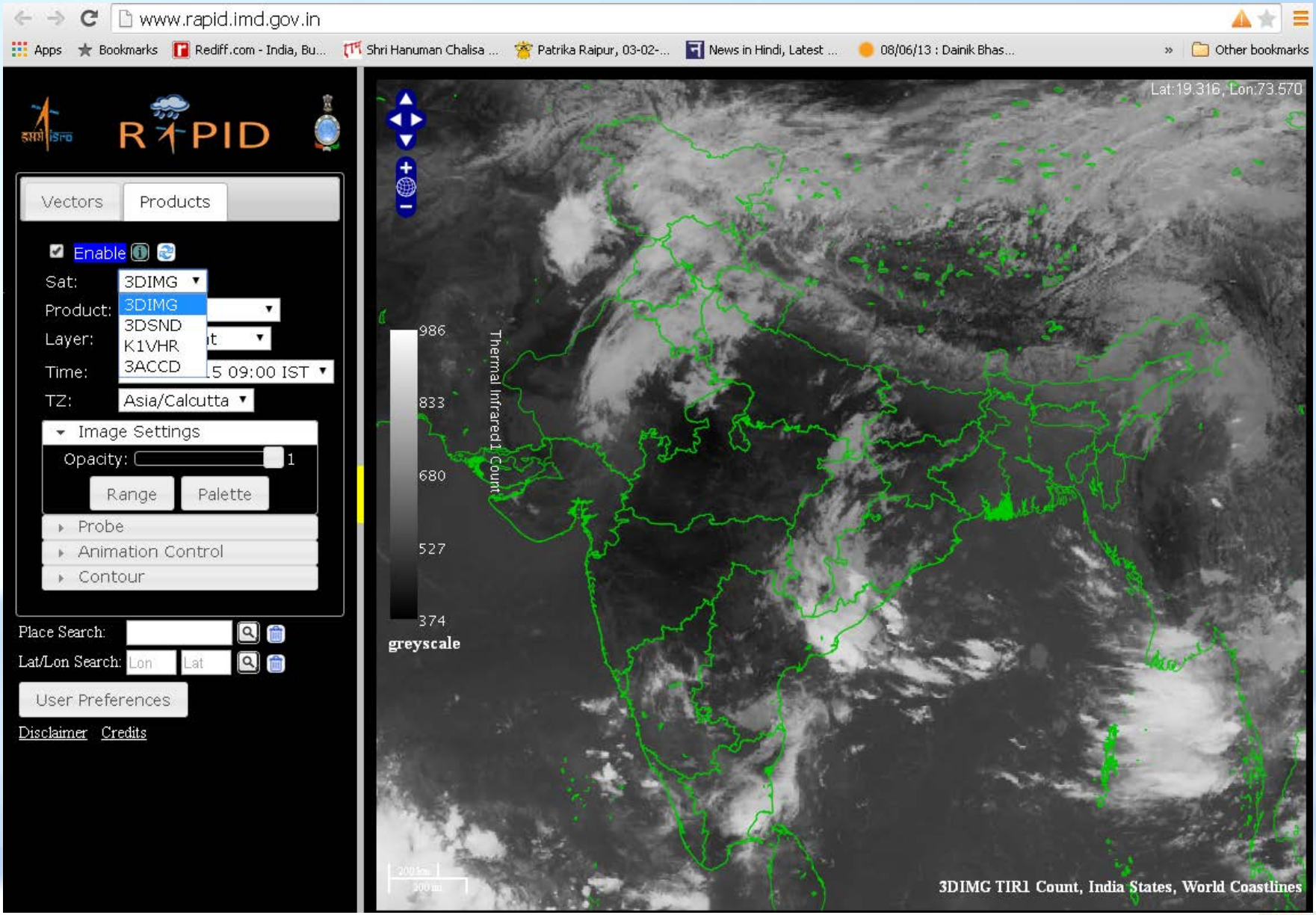
- http://www.rapid.imd.gov.in/



❖In SATMET Division, an on-line INSAT data visualization tool called 'RAPID' have been introduced to analyses live INSAT-3D/3A and Kalpana-1 satellite data for weather forecast and climate studies.

❖The software is opened on the following URL:(www.rapid.imd.gov.in or http://125.21.185.39, and has the GIS capability to map the digital satellite data onto the user specific tasks.

❖The software has been exclusively prepared by the SAC/ISRO team in consultation with SATMET Division. The user can see the data on half hourly, daily, weekly and monthly time period.



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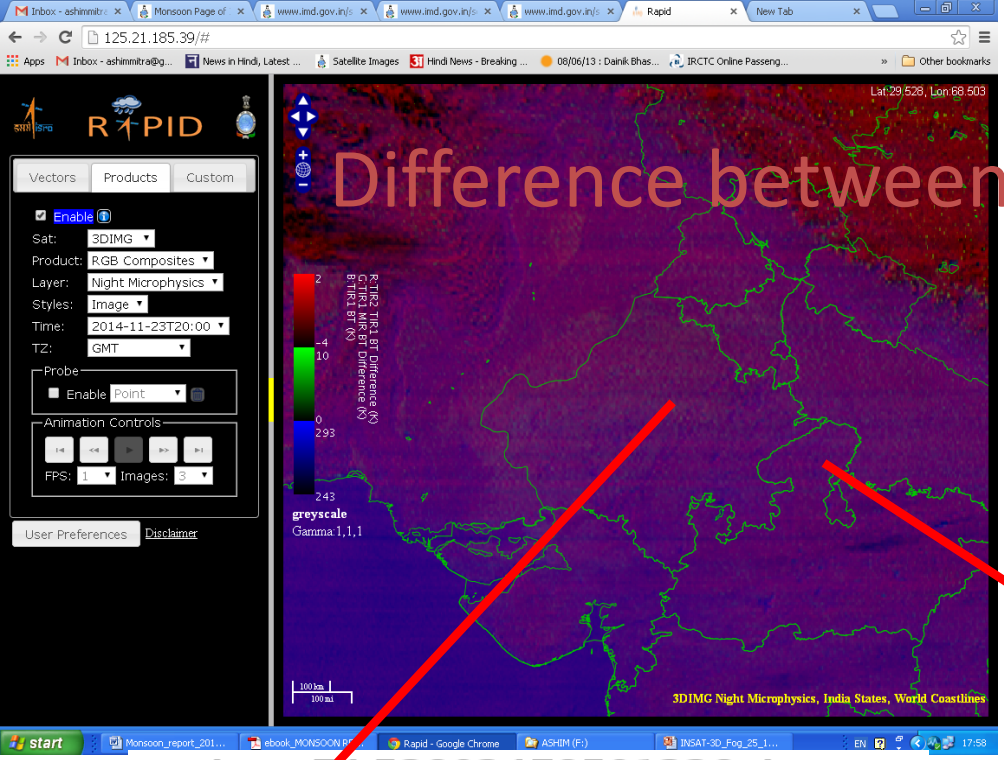
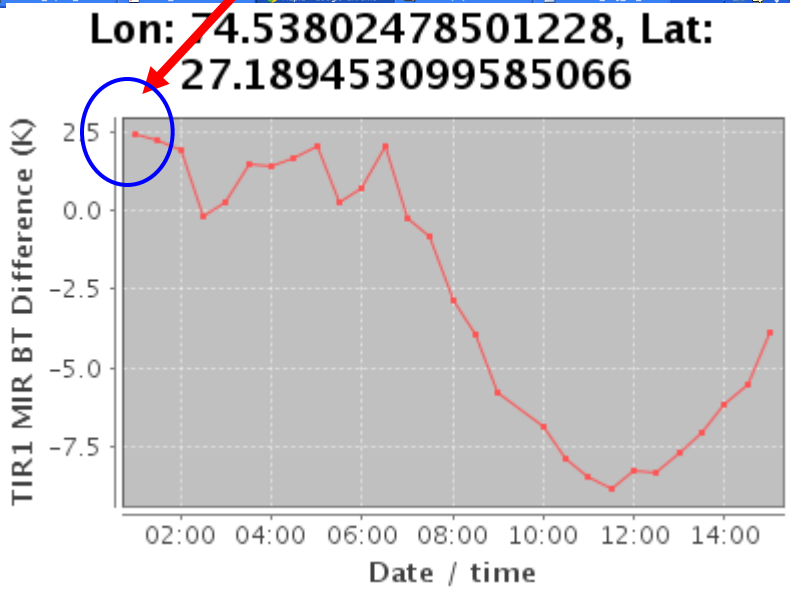
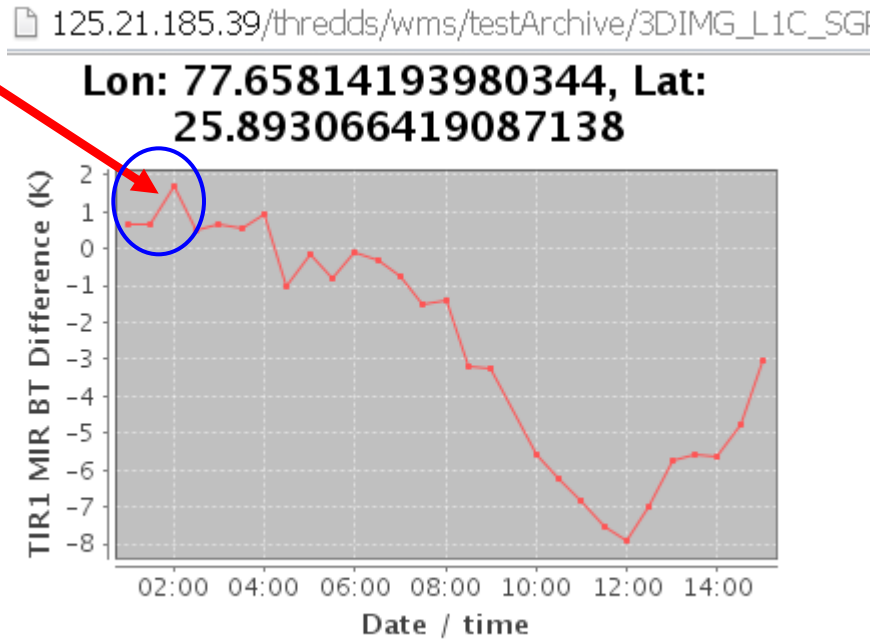
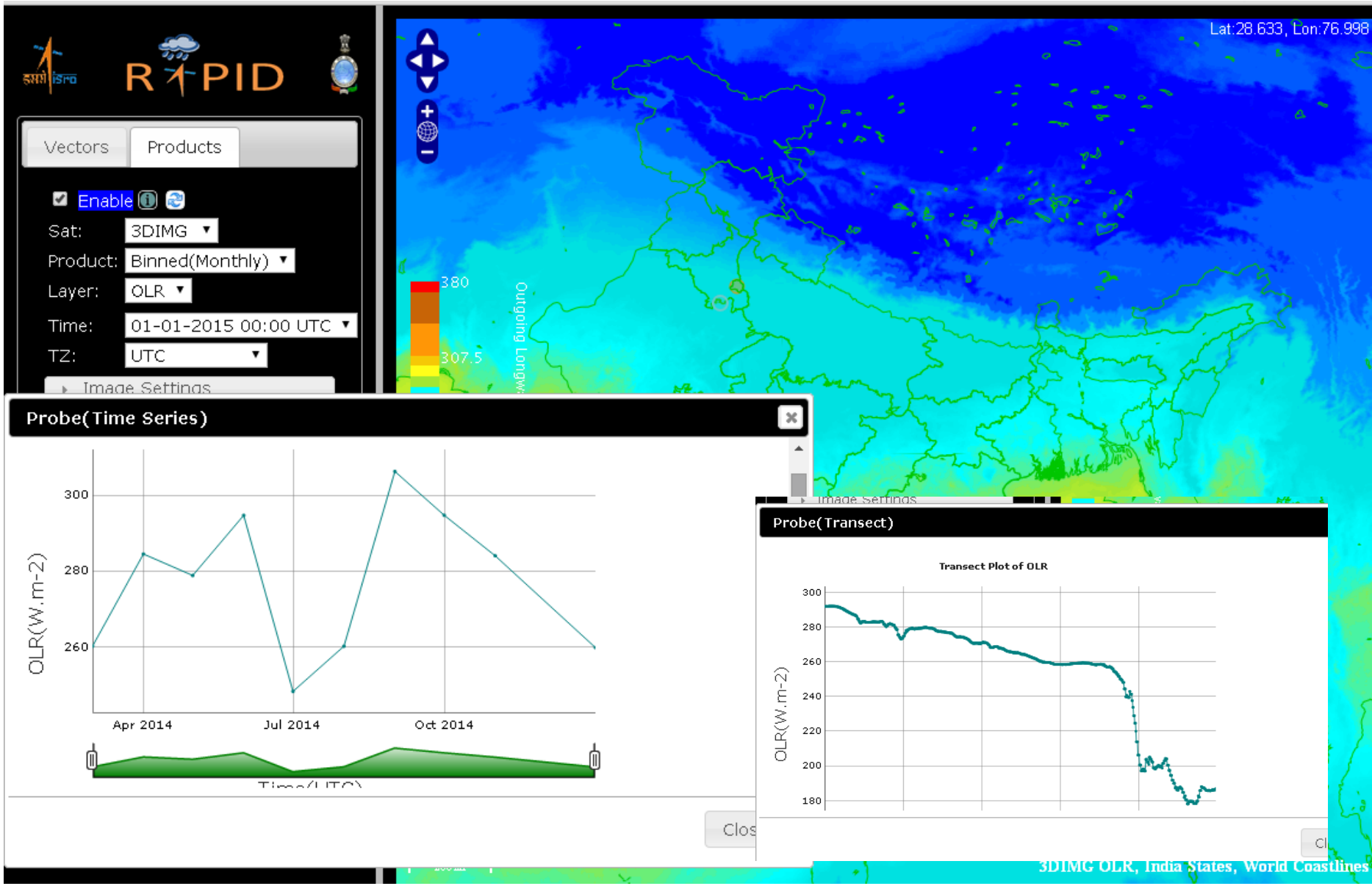
Difference between Fog/Haze/Cloud



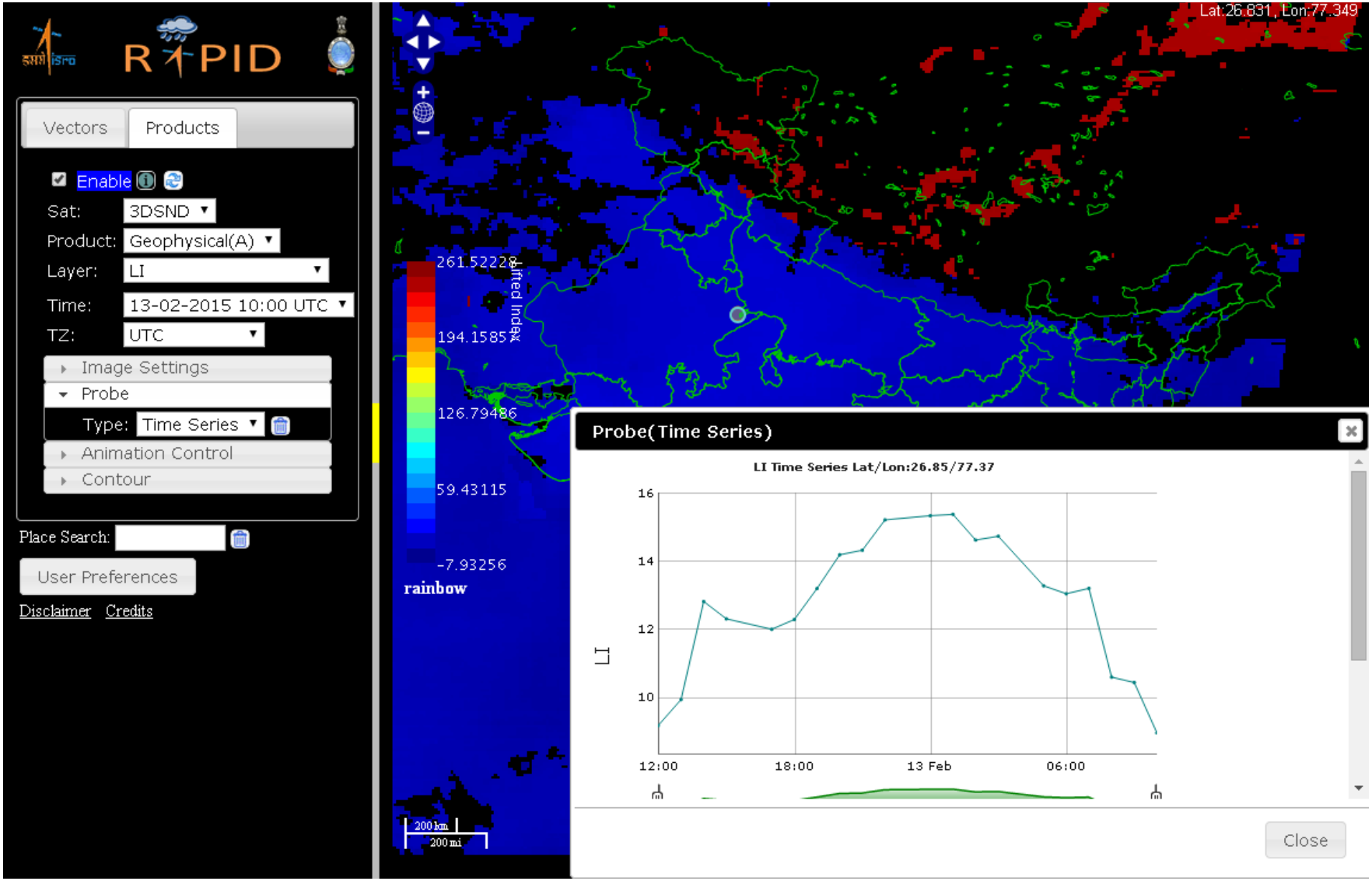




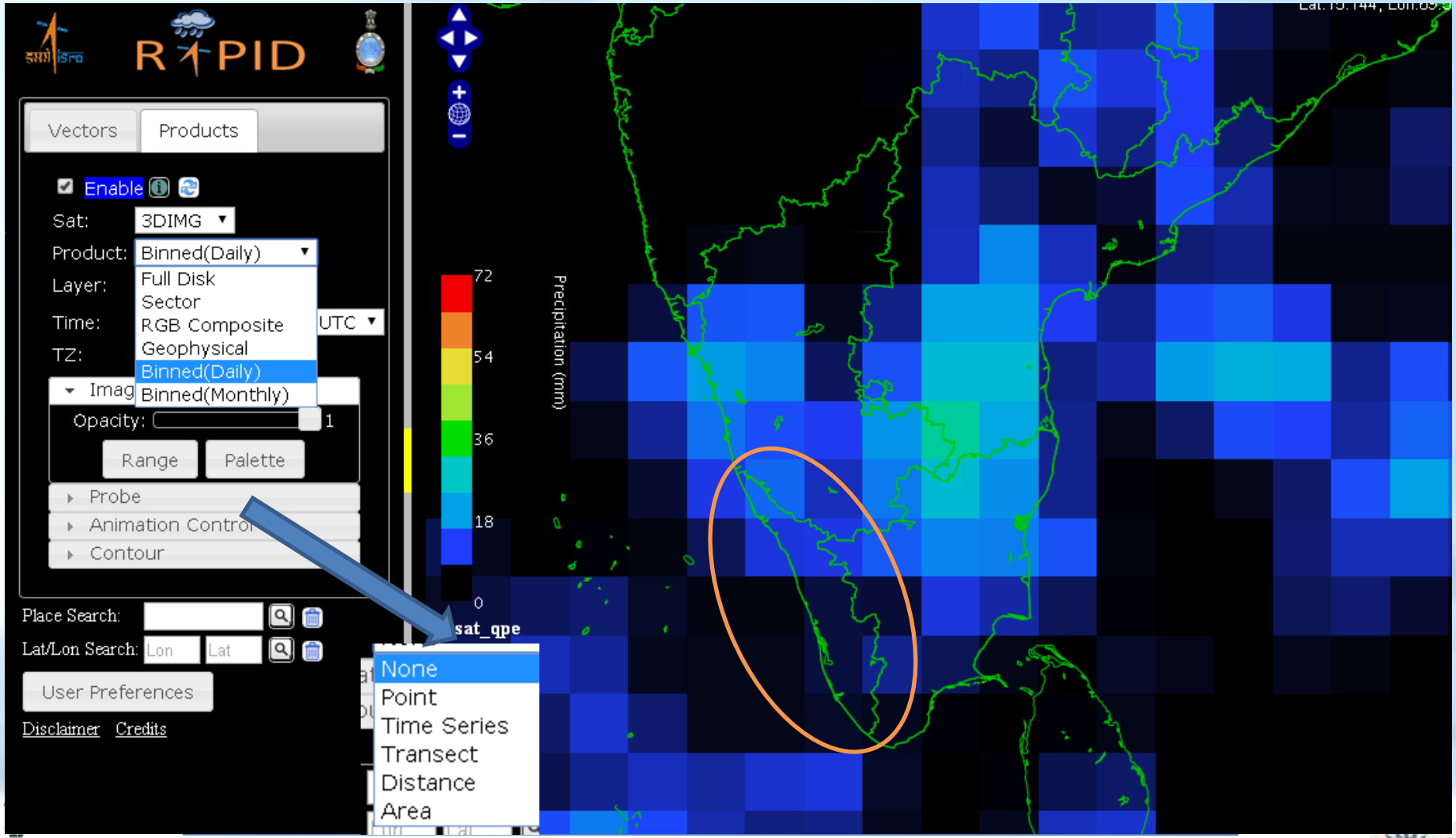
Monthly Products such as OLR,UTH etc



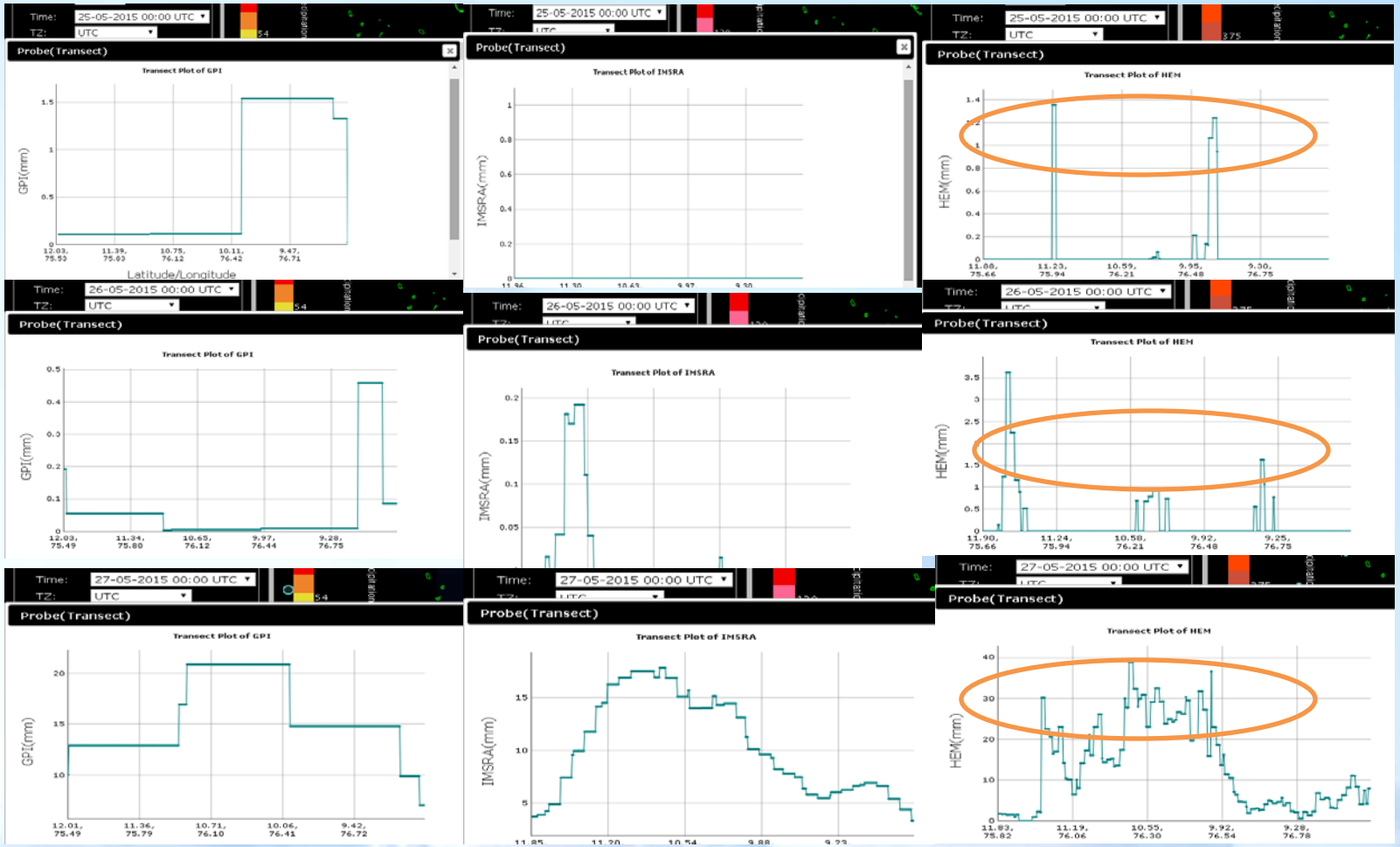
INSAT-3D Sounder Products, Li, TPW



Rainfall analysis over Kerala



QPE IMSRA HEM



25/05/15

26/05/15

27/05/15

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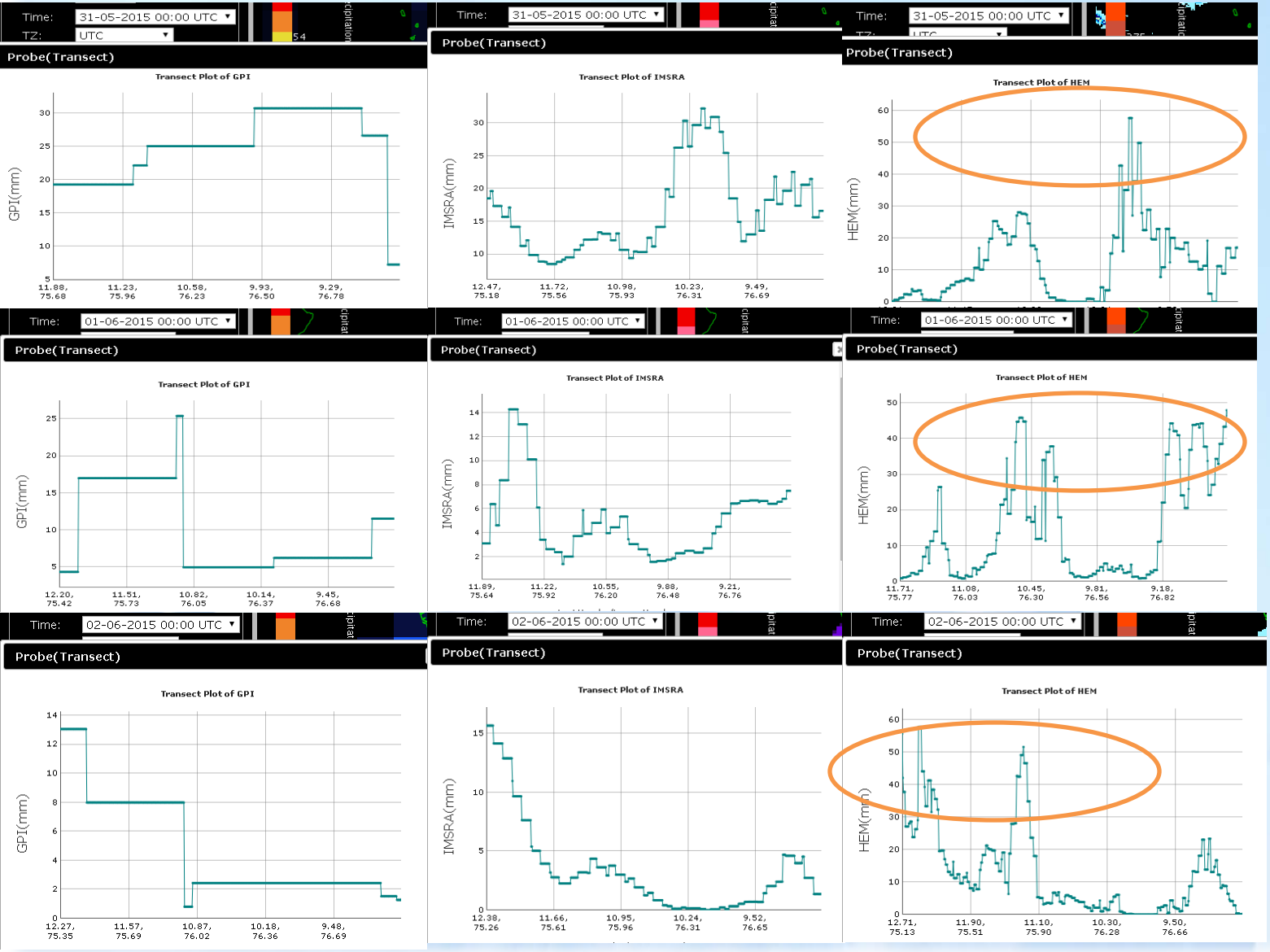
QPE IMSRA HEM



31/05/15

01/06/15

02/06/15

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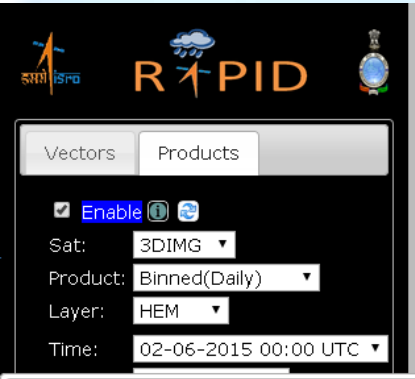
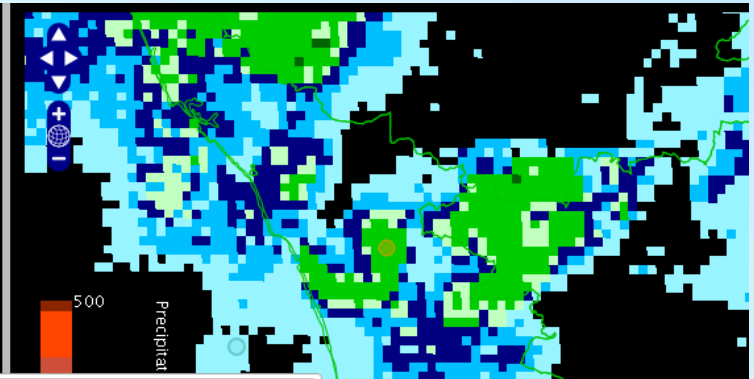
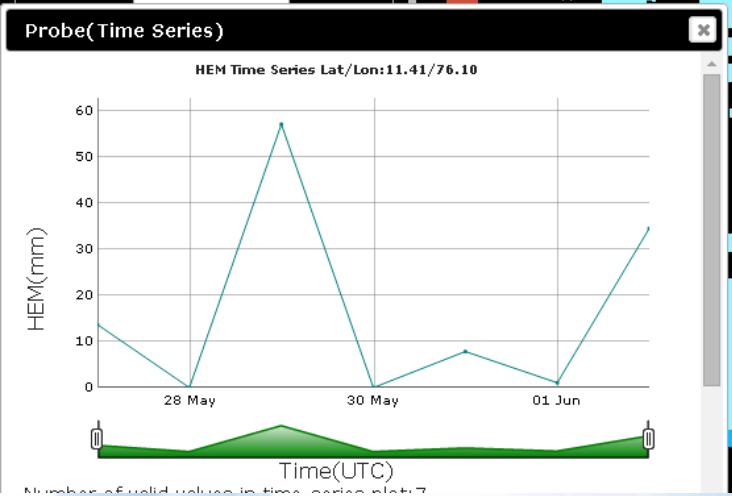
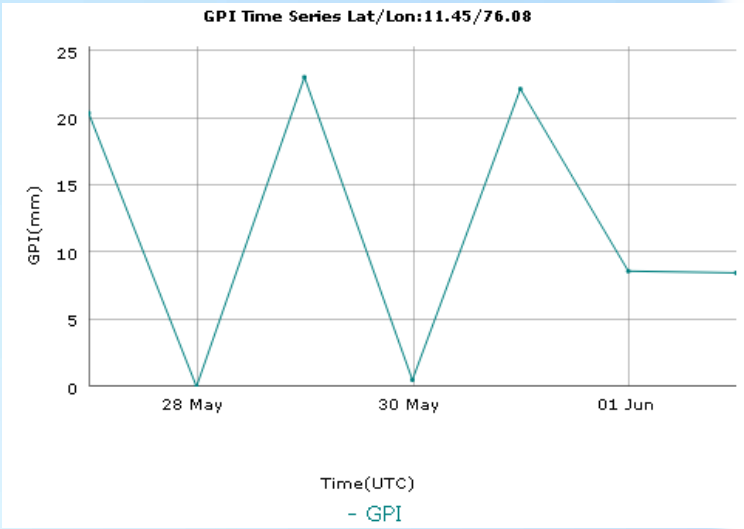
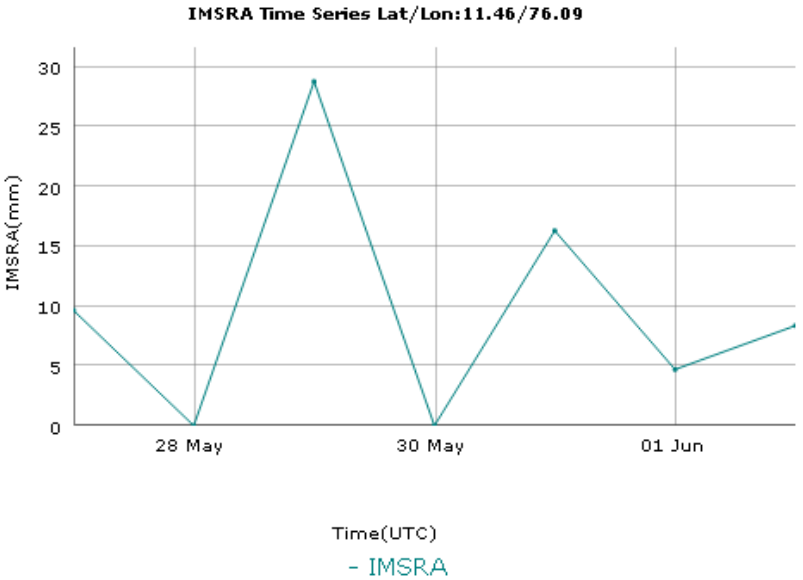
Pixel Level Time Series











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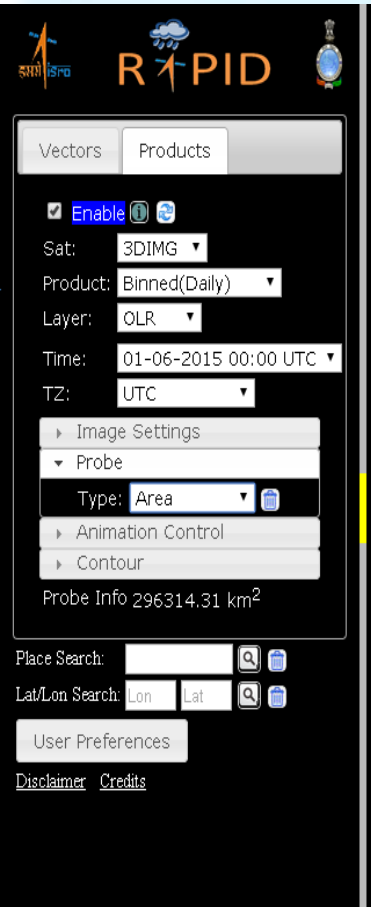
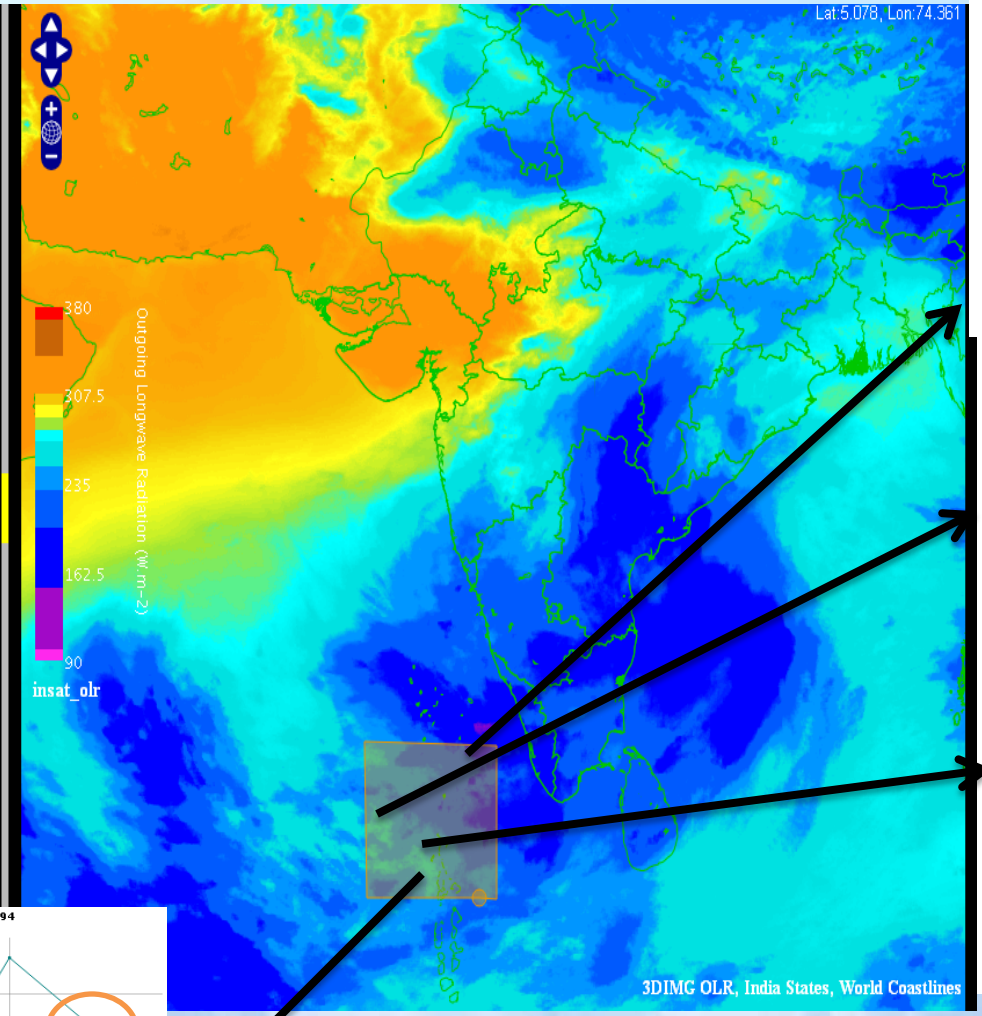
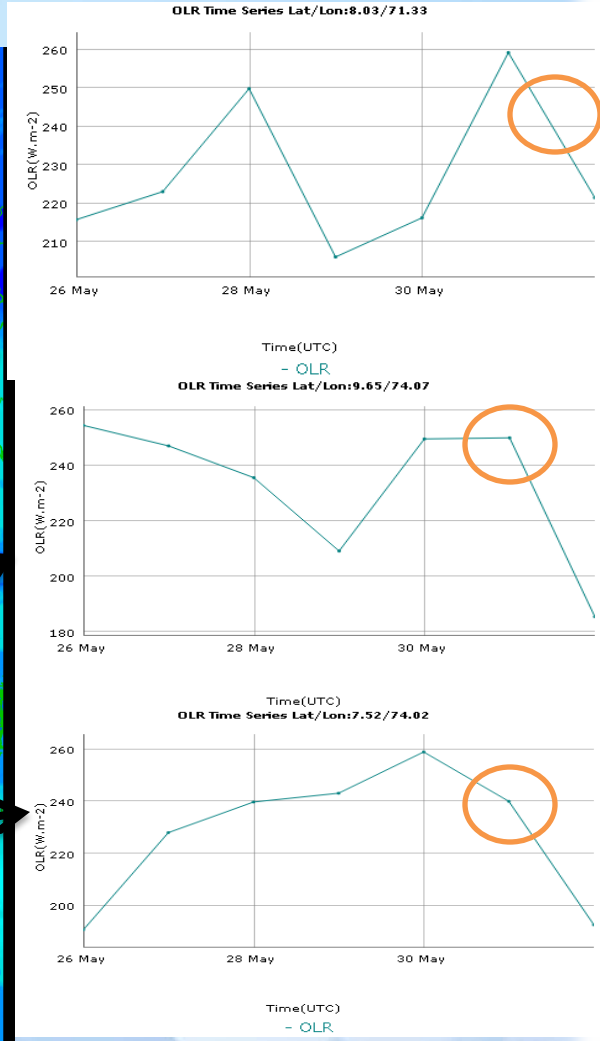
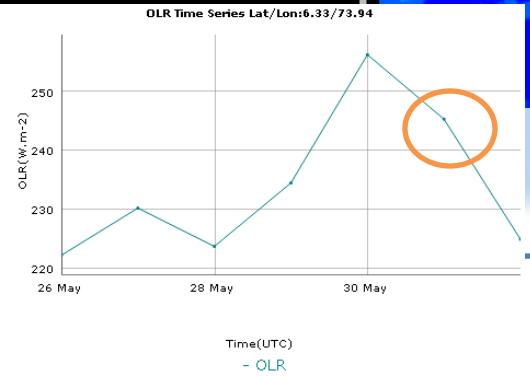
INDIA METEOROLOGICAL

OLR Monitoring









भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Thank you

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