Use of RAPID and RGB Products for Serve Weather using INSAT-3D Satellite

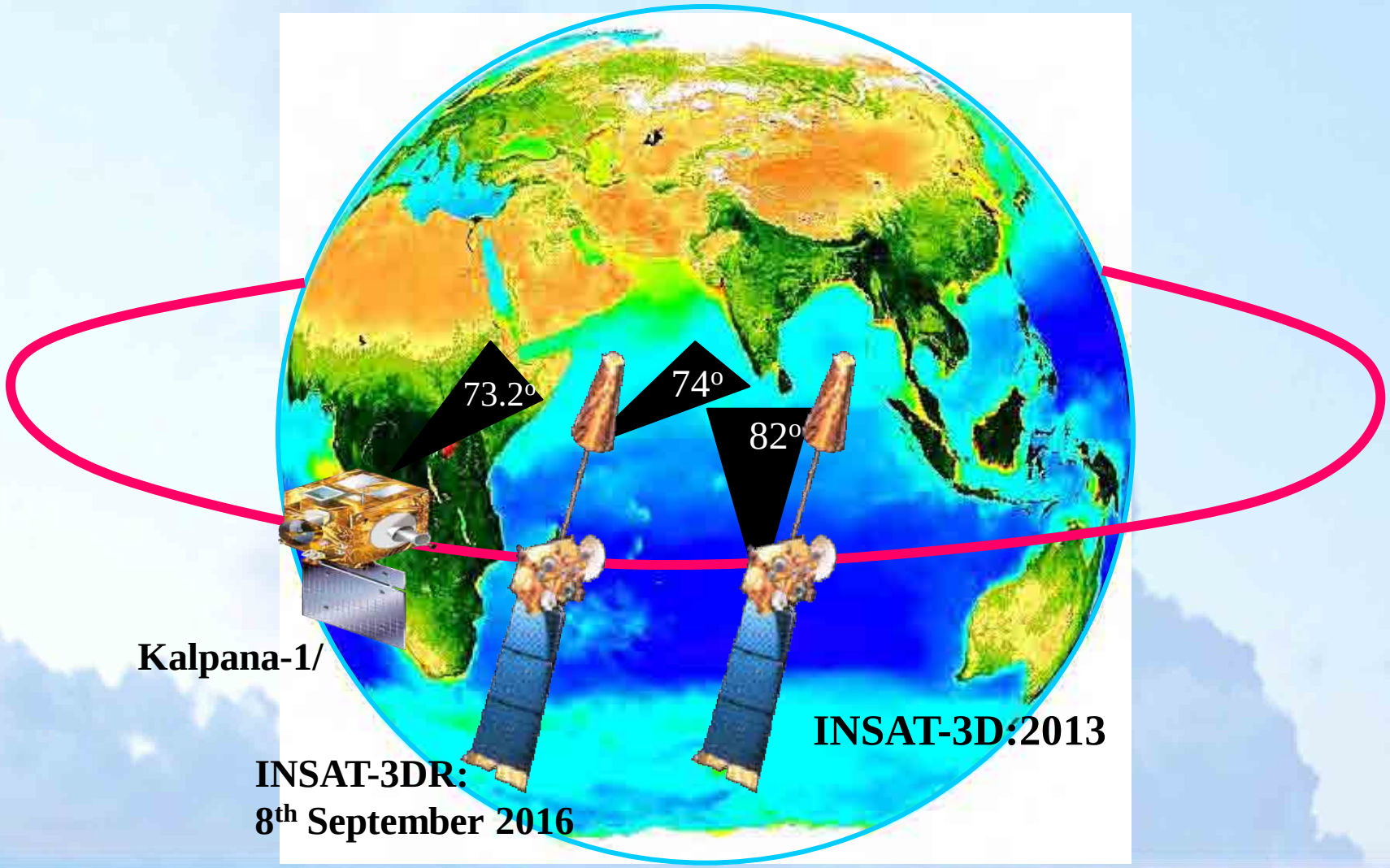
A.K Mitra

akmitra@imd.gov.in

24.05.2017

भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

Current Indian Geostationary Meteorological Satellites

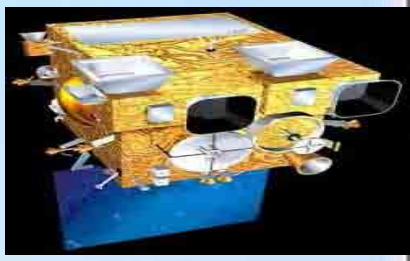


Current Indian Geo stationary Meteorological satellites

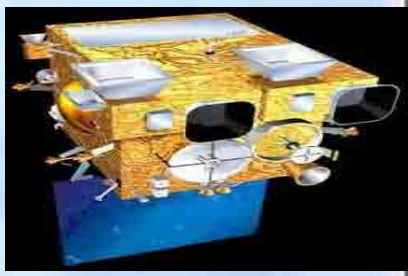
At present the following three INSAT satellites are in operation

Kalpana –1 is a metrological satellite which was launched in September 2002. It is located at 74^0 east. For meteorological observation, METSAT carries a Very High Resolution Radiometer (VHRR) capable of imaging the Earth in the visible, thermal infrared and water vapor bands. It also carries a Data Relay Transponder (DRT) for collecting data from unattended meteorological platforms

INSAT-3D is a India's advanced weather satellite and was launched in the early hours of July 26, 2013 from Kourou, French Guiana, and has successfully been placed in Geosynchronous orbit. It is a dedicated meteorological satellite and carries four payloads: Imager (Six Channels),Sounder (Nineteen Channels),Data Relay Transponder(DRT) &Satellite Aided Search and Rescue (SAS & R)



INSAT-3DR is a India's advanced dedicated meteorological satellite and was launched on 8th September, 2016 which carries four payloads: Imager (Six Channels),Sounder (Nineteen Channels),Data Relay Transponder(DRT) &Satellite Aided Search and Rescue (SAS & R).

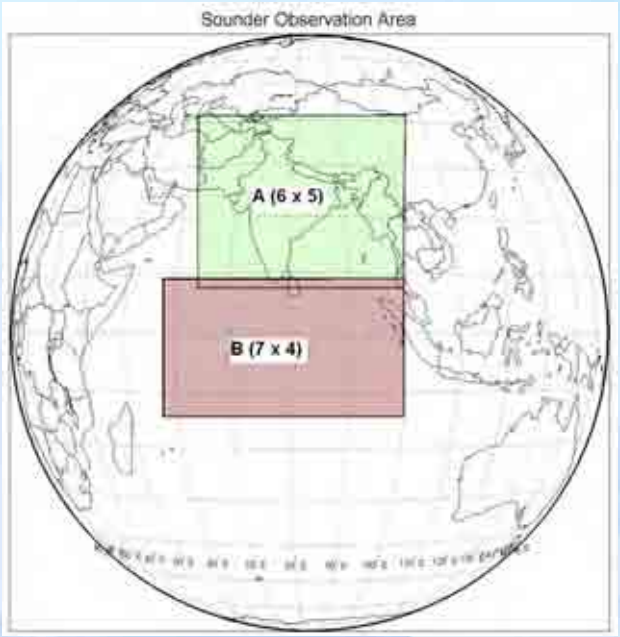


INSAT-3DR will be used in staggered mode with INSAT-3D in order to reduce temporal resolution to 15 minutes.

Present Operational Status

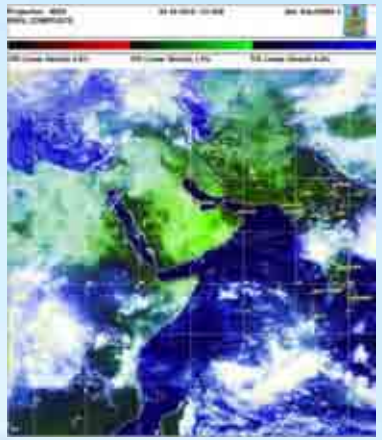
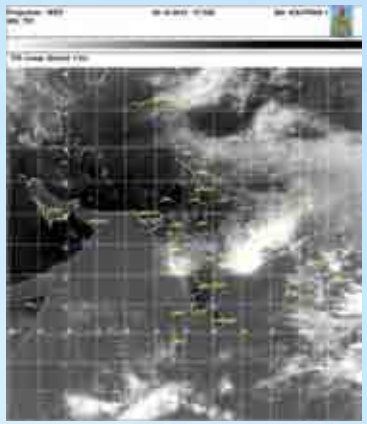
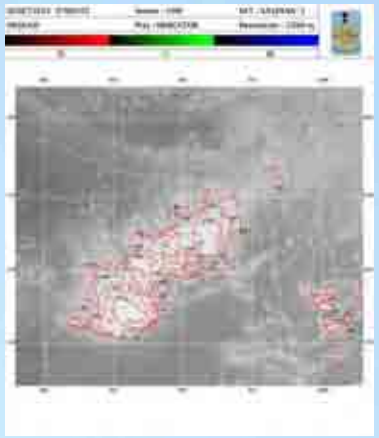
The present IMDPS system is used for processing and dissemination of data from all the three currently operational Geostationary satellites(Kalpana-1, INSAT-3D, INSAT-3DR).

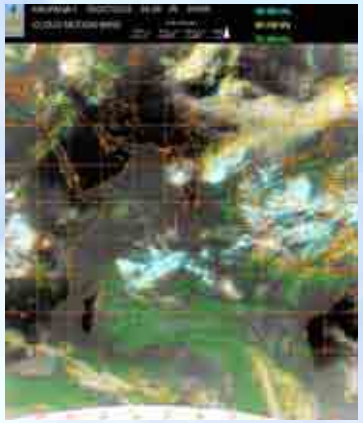
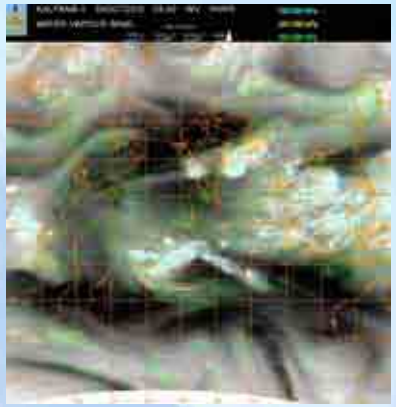
INSAT Series	Temporal Resolution
K1-VHRR	Half Hourly(0015 & 0045 UTC)
3D -Imager (6 Channel)	½ hourly (0000 & 0030 UTC)
3D -Sounder (19 Channel)	Hourly (Five times Region-A and sixth times region-B)
3DR -Imager (6 Channel)	½ hourly (0015 & 0045 UTC)
3DR -Sounder (19 Channel)	Hourly (Five times Region-A and sixth times region-B)



Kalpana-1 Satellite derived imageries

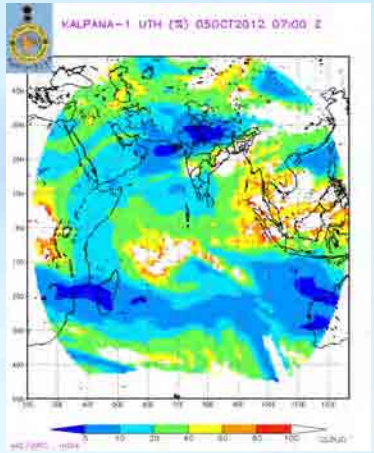
Name of Imageries	K1 VHRR
Full Disc (VIS,IR,WV,Colour composite)	Half hourly
Sectors-Asiamer/NE/NW(VIS,IR,WV,Colour composite)	Half hourly
Enhanced Images(IR,VIS)	Half hourly
Sectors with District boundaires-India/NE/NW/SI(VIS,IR)	Hourly
Average images of IR/WV	Daily
CMV/WVW	Half hourly
CCT,CCTbelow-40deg	Hourly

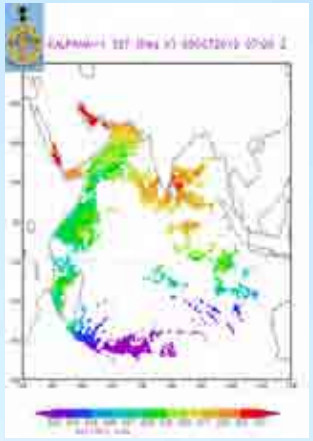





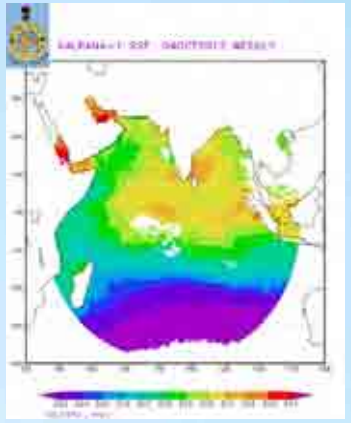



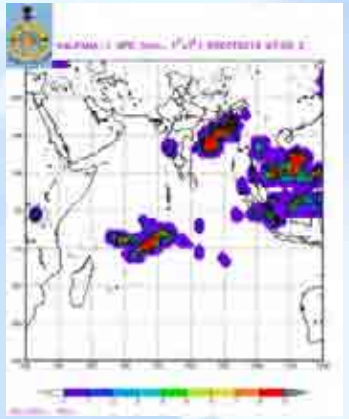
Kalpana-1 Satellite derived products

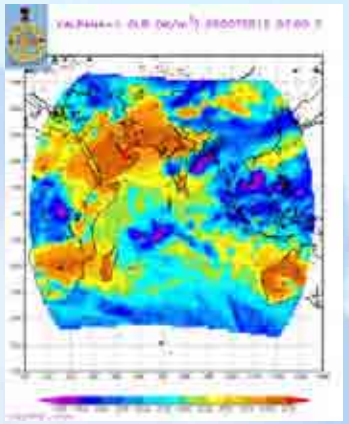
Products	Kalpana-1 VHRR
UTH	Half Hourly, Daily, Weekly and Monthly
SST	Half Hourly, Daily, Weekly and Monthly
OLR	Half Hourly, Daily, Weekly, Monthly and Seasonal
QPE	Half Hourly, Daily, Weekly, Monthly and Seasonal
Latitude/time OLR hovmoeller	Daily
Animated Images for last three Hours	Half hourly
Animated Images with CCT of Current and Previous day based on 06 UTC	Daily

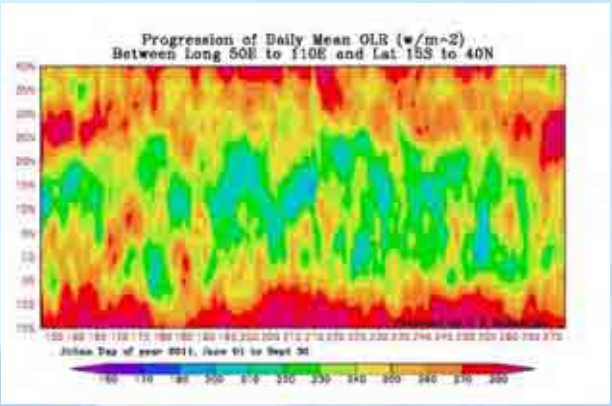












INSAT - 3D

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)

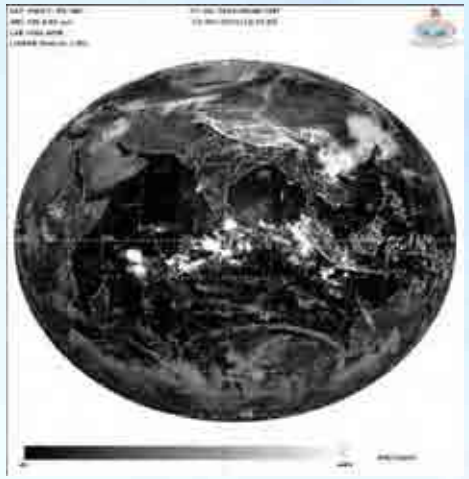
Short Wave Infra Red	: Six bands
Mid Wave Infra Red	: Five Bands
Long Wave Infra Red	: Seven Bands
Visible	: One Band

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

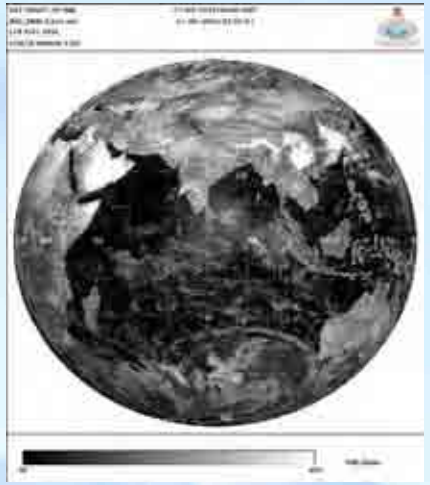
INSAT-3D Imager Channel Specification and their uses

Channels Number	Channel ID	Channel name	Spectral range (µm)	Resolution (Km)	Purpose
1.	VIS	visible	0.55 – 0.75	1.0	Clouds, Surface features
2.	SWIR	short wave infrared	1.55 – 1.70	1.0	Snow, Ice and water phase in clouds
3.	MIR	medium wave infrared	3.7 – 3.9	4.0	Clouds, Fog, Fire
4.	WV	water vapour	6.5 – 7.1	8.0	Upper-Troposphere Moisture
5.	TIR1	long wave infrared	10.3 – 11.3	4.0	Cloud top and surface temperature
6.	TIR2	split	11.5 - 12.5	4.0	Lower-Troposphere Moisture

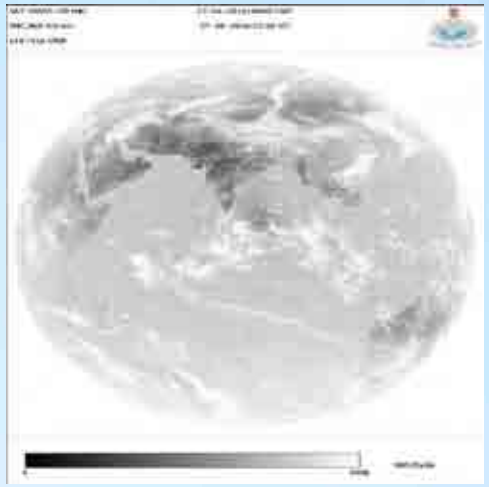
INSAT-3D Imager
Standard Products (L1B)



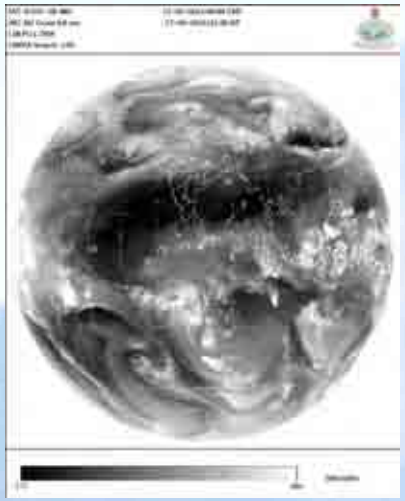
VIS (0.55-0.75µm)



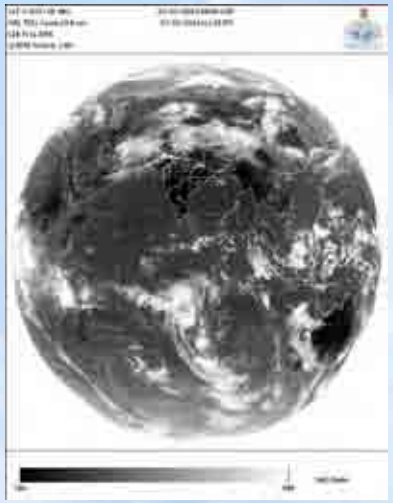
SWIR(1.55-1.70µm)



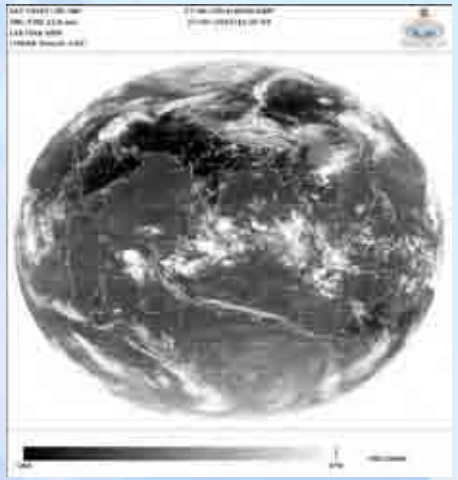
MIR(3.80-4.00µm)



WV(6.50-7.10µm)

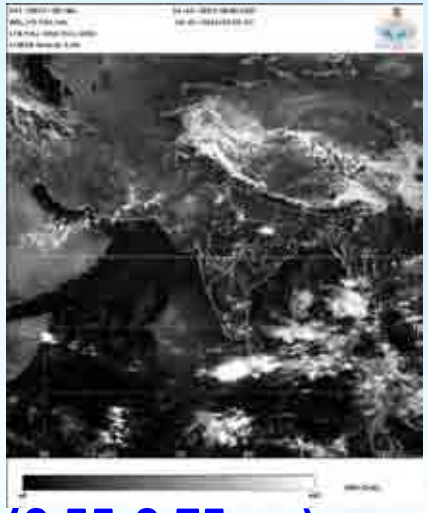


TIR-1(10.30-11.30µm)



TIR-2(11.50-12.50µm)

INSAT-3D Imager
Sector Products (L1C)



VIS (0.55-0.75µm)

SWIR(1.55-1.70µm)

MIR(3.80-4.00µm)

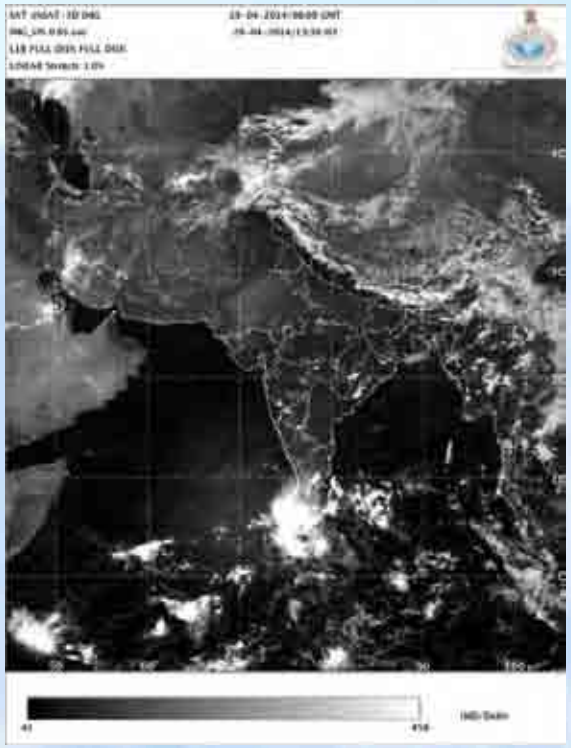
WV(6.50-7.10µm)

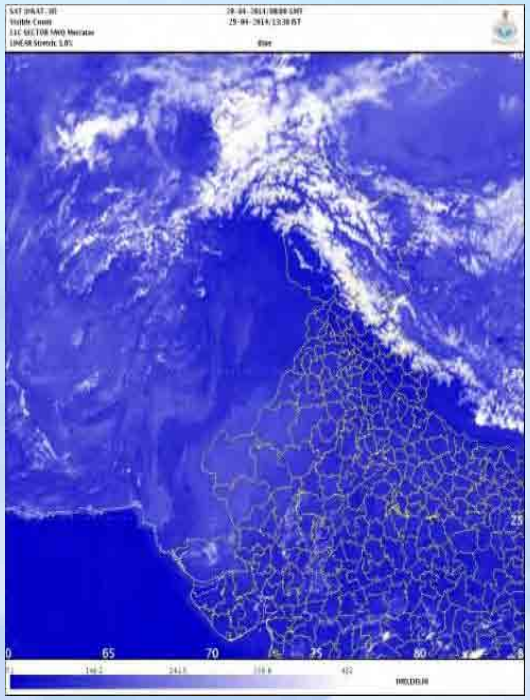
TIR-1(10.30-11.30µm)

TIR-2(11.50-12.50µm)

INSAT-3D Imager Visible band (0.55-0.75um) Images(Full Disk, Asiamer sector, NW sector, NE sector, High Resolution images with District Boundaries(NW,NE,SW,SE sectorS) of Indian region

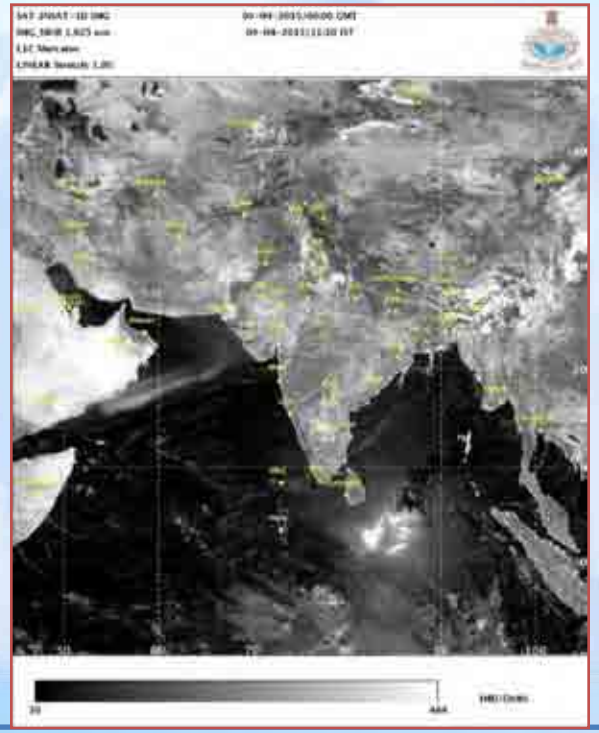
These Images are used for monitoring mesoscale weather features such as cloud cover, air mass boundaries, convergence zones, thunderstorms, and local snow cover. Limited to daytime use

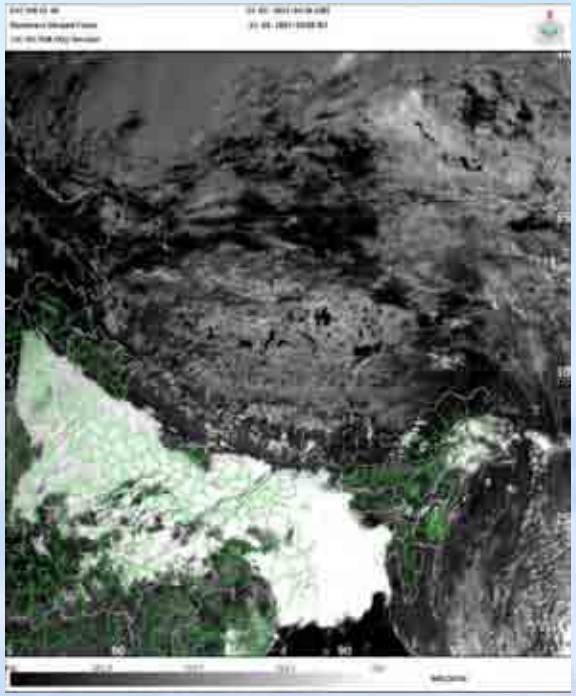




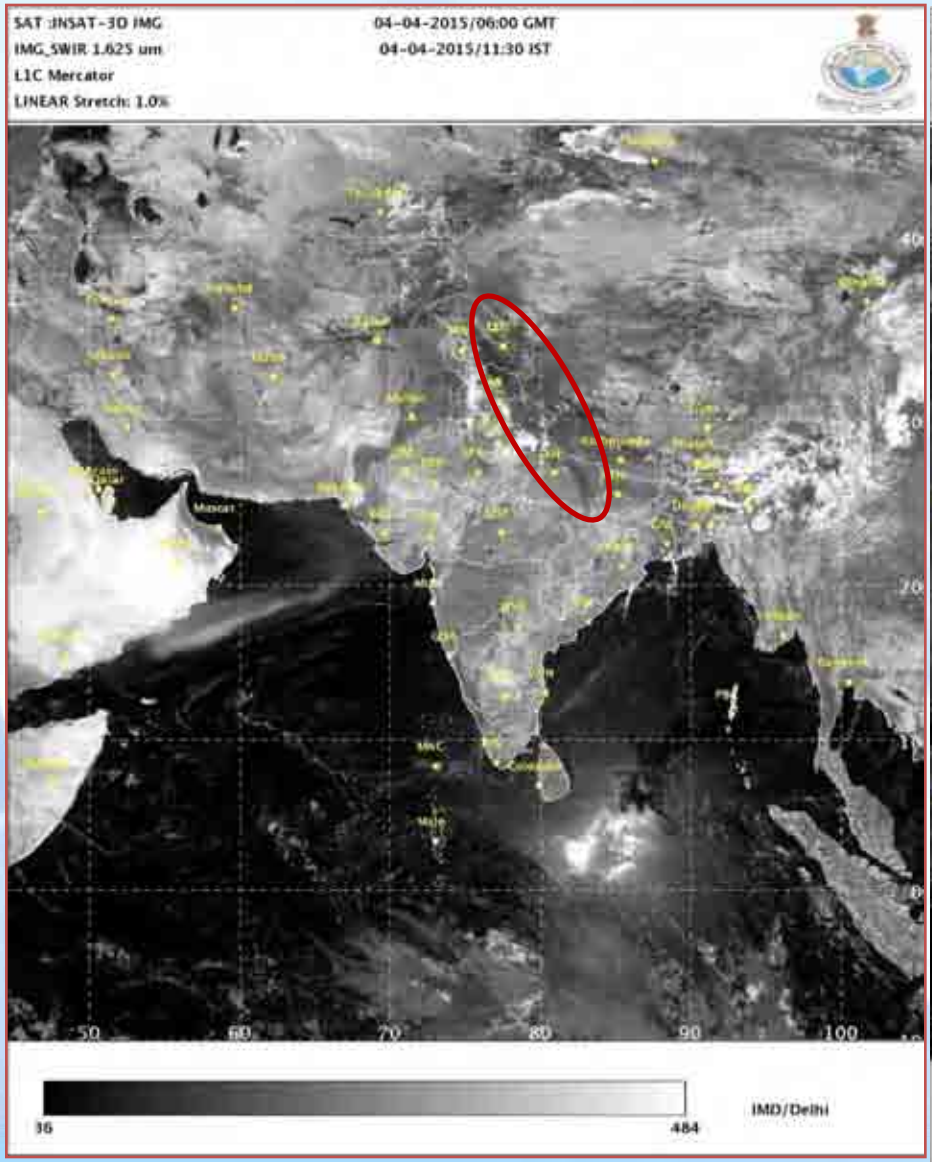
INSAT-3D Imager SWIR band(1.55-1.70 um) Images(Full Disk, Asiamer sector, NW sector, NE sector, High Resolution images with District Boundaries(NW,NE,SW,SE sector of Indian region

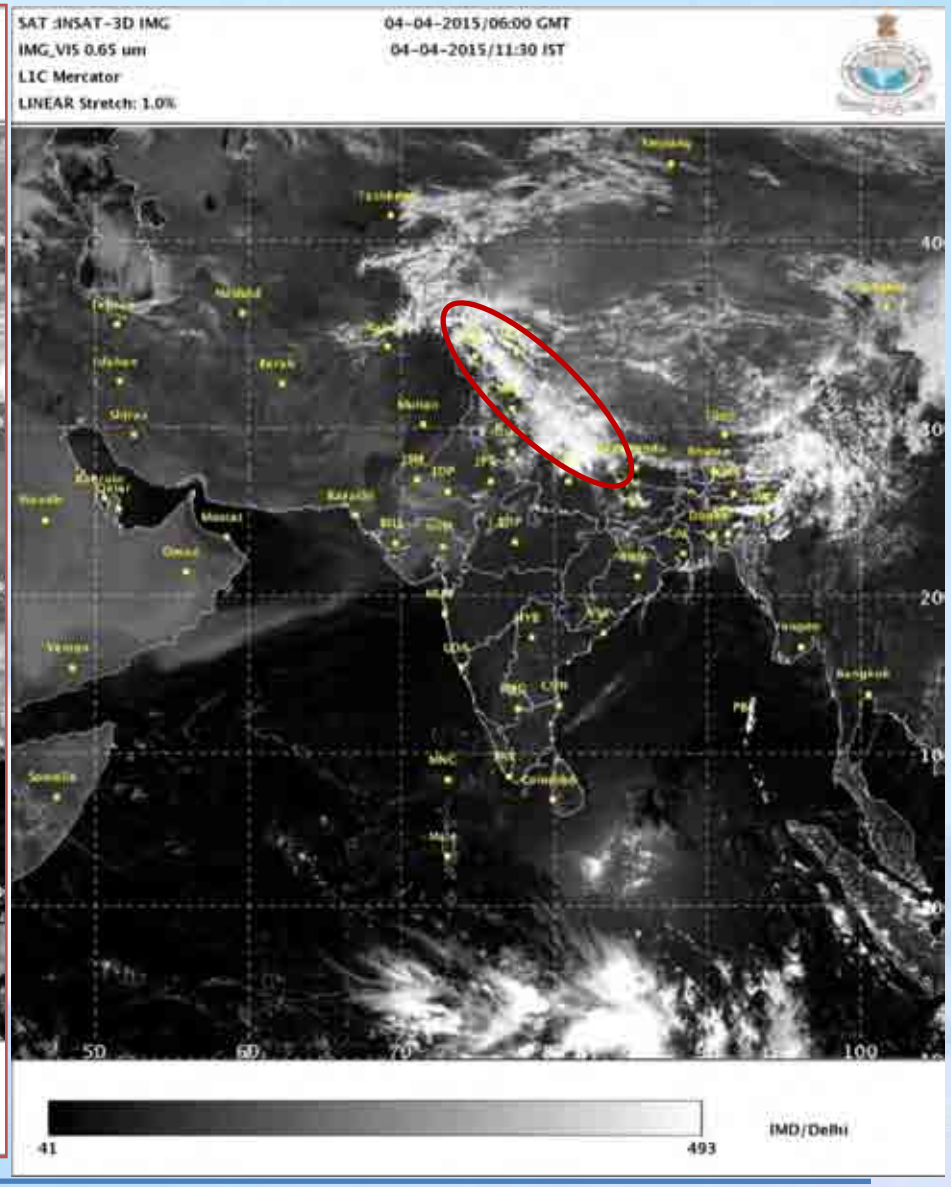
These Images are used for monitoring local snow cover, day time Fog, Convective R/F estimation, Cloud radiative properties, NDSI. Incident radiation in SWIR, Strongly absorbed by water, ice , snow and reflected by cloud While for visible spectrum these objects essentially transparent . Therefore melting snow patches or lake, ice are seen bright in the visible image while these appears dark in SWIR images and therefore SWIR images are used to differentiate the cloud, rain given cloud and snow.,. The SWIR band is sensitive to the moisture content soils recently irrigated field therefore appears in darker tones. Limited to daytime use.





SWIR V/S Visible Images 4/4/2015 0600UTC

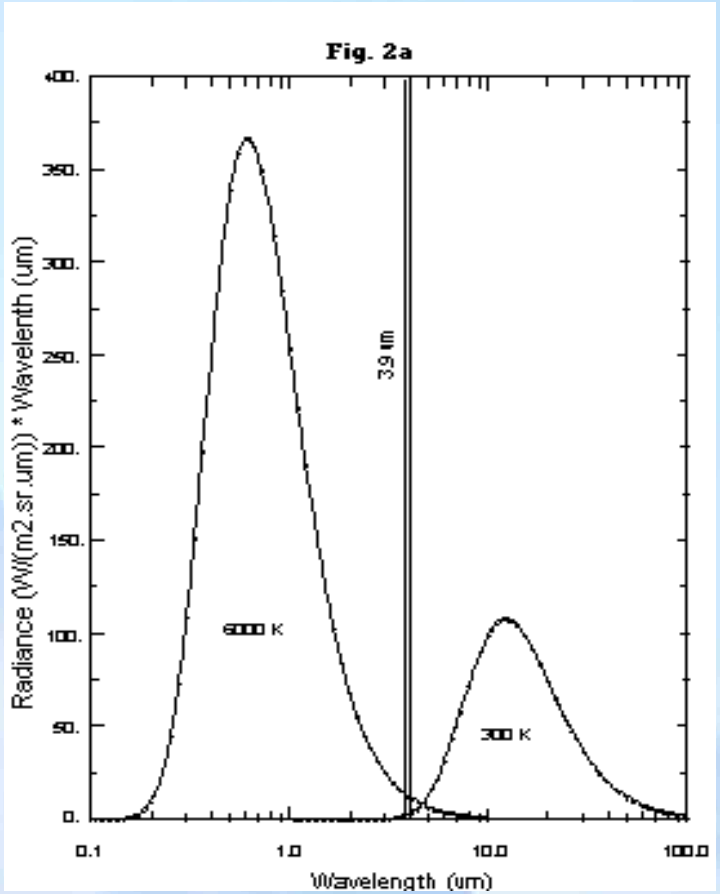




INSAT-3D Imager MIR band (3.80-4.00 um) Images(Full Disk, Asiamer sector, NW sector, NE sector, High Resolution images with District Boundaries(NW,NE,SW,SE sectors) of Indian region

Interpretation of 3.9 um data differs from that of the longer wavelength infrared bands, , since it contains both reflected solar, and emitted terrestrial, radiation. The 3.9 um spectral band, energy measured by the satellite can be a mixture of solar radiation that is reflected by the earth's surface or clouds and radiation that is emitted by the earth's surface or clouds. Characteristics of reflected and emitted radiation in this band are different from either the visible or the 10.7 um bands, thereby promoting enhanced capabilities of INSAT-3D IMAGER multispectral imagery

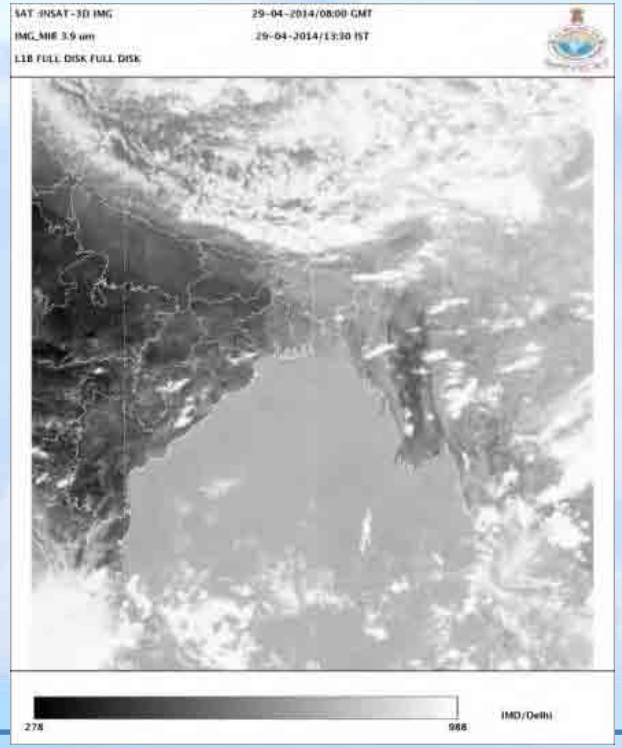
Useful for fog and other liquid water cloud identification, cloud phase changes, distinction of cloud cover over snow fields, and fire detection

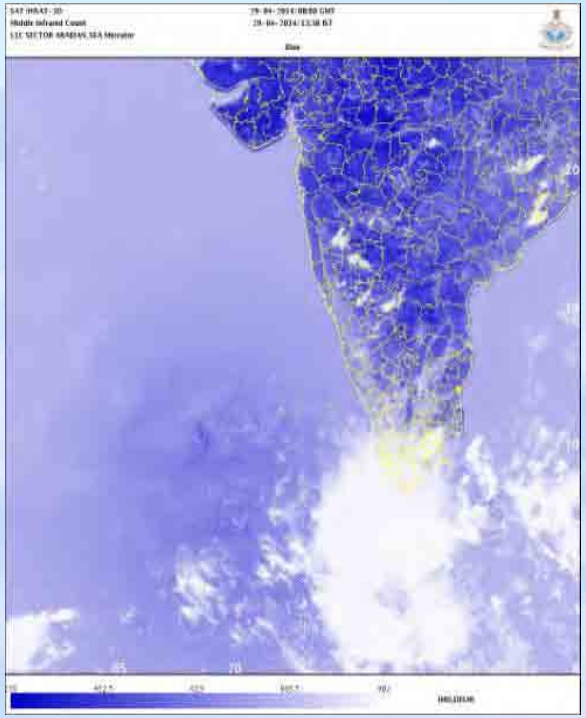


INSAT-3D Imager MIR band (3.80-4.00 um) cont.....

Thin Cirrus and Multi-layered Clouds

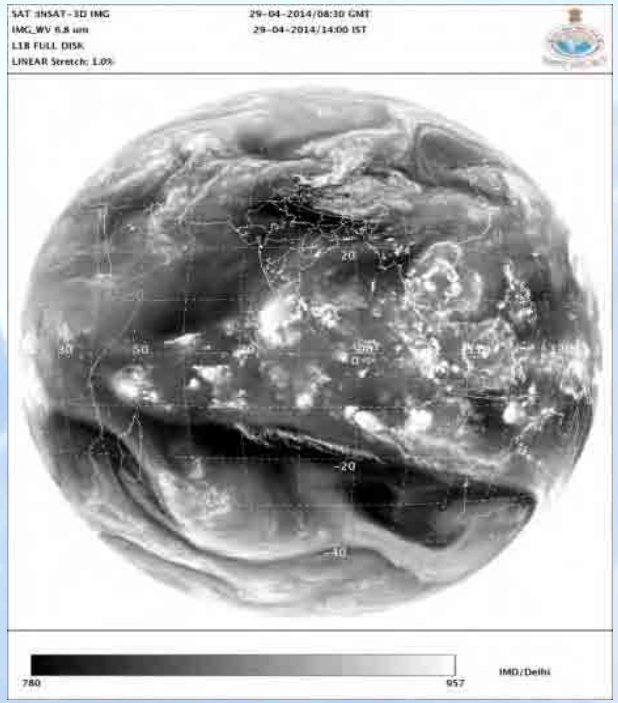
Radiation from below passes through thin cirrus clouds, making the satellite-measured IR temperatures warmer than the actual cloud top temperatures. This effect is more evident at 3.9 than at 10.7 um because of the stronger response at 3.9 um to the warm radiation from below. In addition, thin cirrus is often patchy and only partially fills an FOV, further enhancing response at 3.9 um. As a result, in regions of thin cirrus, 3.9 um images often reveal lower cloud layers. At night, the underlying clouds may have different motions, leading to their detection with animated imagery. During daytime, water clouds, with their higher reflectivity, can be detected at 3.9 um, while they are obscured, or very difficult to observe, in the VIS and 10.7 um imagery.

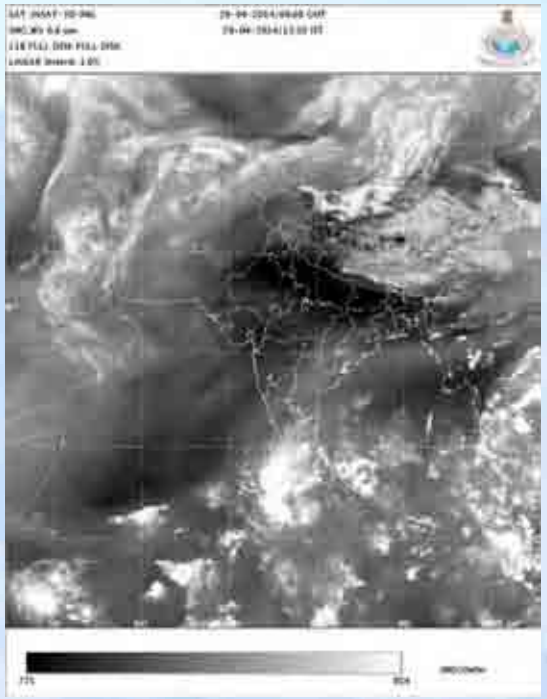


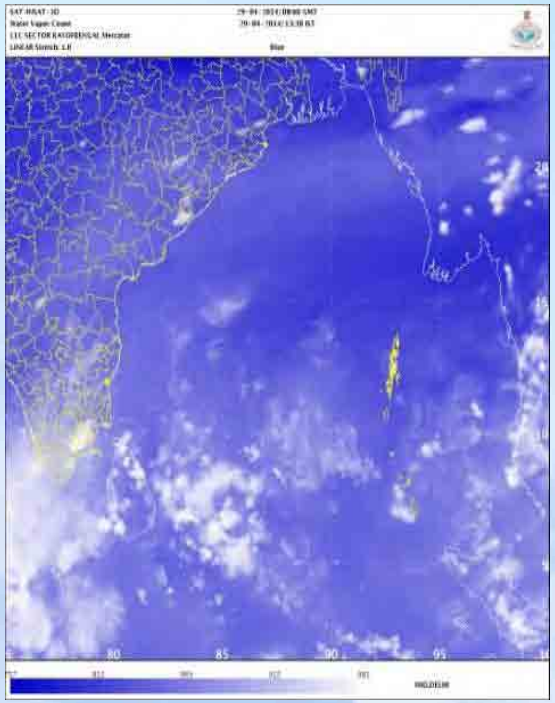


INSAT-3D Imager WV(6.5-7.10 um) band Images(Full Disk, Asiamer sector, NW sector, NE sector, High Resolution images with District Boundaries(NW,NE,SW,SE sectors) of Indian region

This broad water vapor band senses radiation emitted from high clouds and upper level water vapor. This imagery is used to define upper level flow patterns, upper level circulations, and shortwaves moving through the flow

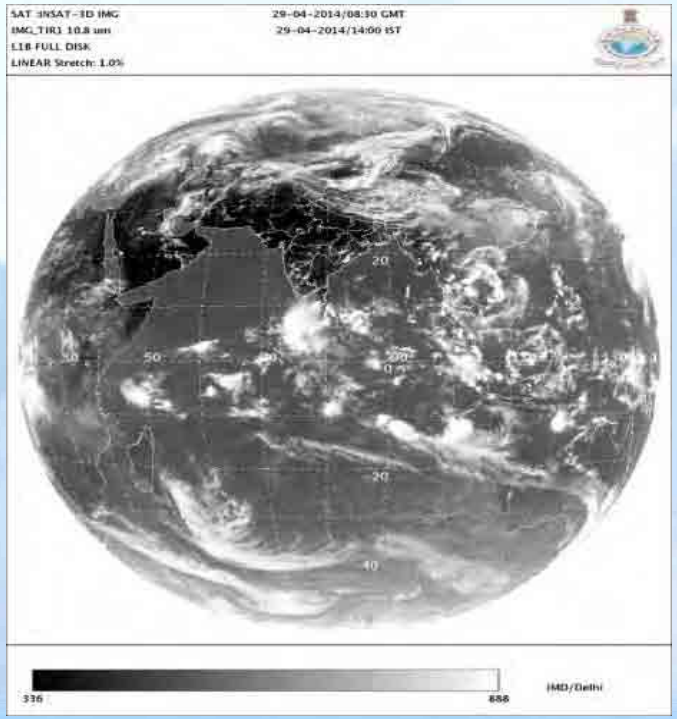


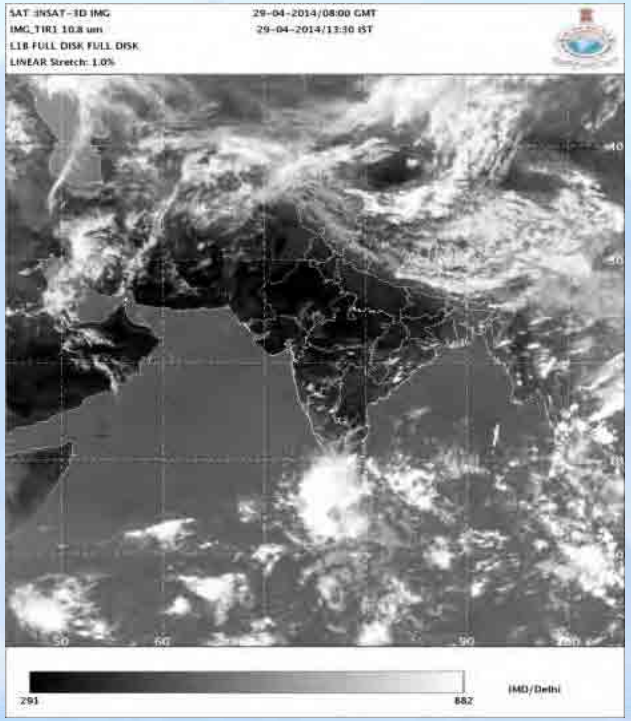


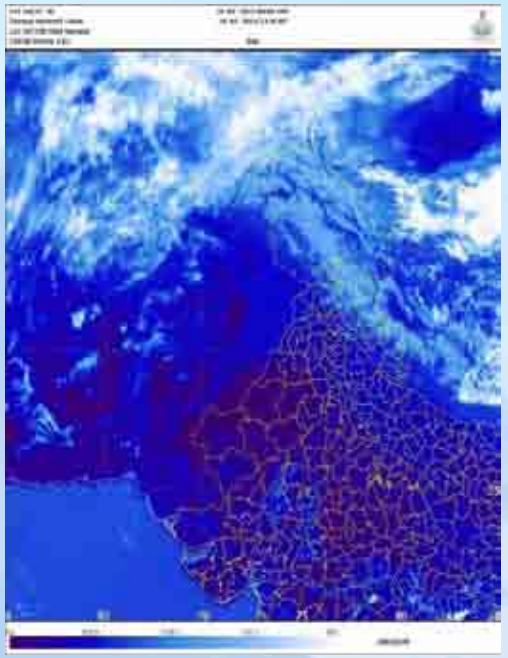


INSAT-3D Imager TIR1 band (10.3-11.3 um) Images(Full Disk, Asiamer sector, NW sector, NE sector, High Resolution images with District Boundaries(NW,NE,SW,SE sector of Indian region

Around the 10.7 um region, most of the energy radiated from the surface reach's the sensor, thus the term "atmospheric window" since the temperature measured is close to scene temperature. Used for monitoring cloud top and surface temperature, cloud cover, air mass boundaries, convergence zones, surface lows and thunderstorms both day and night

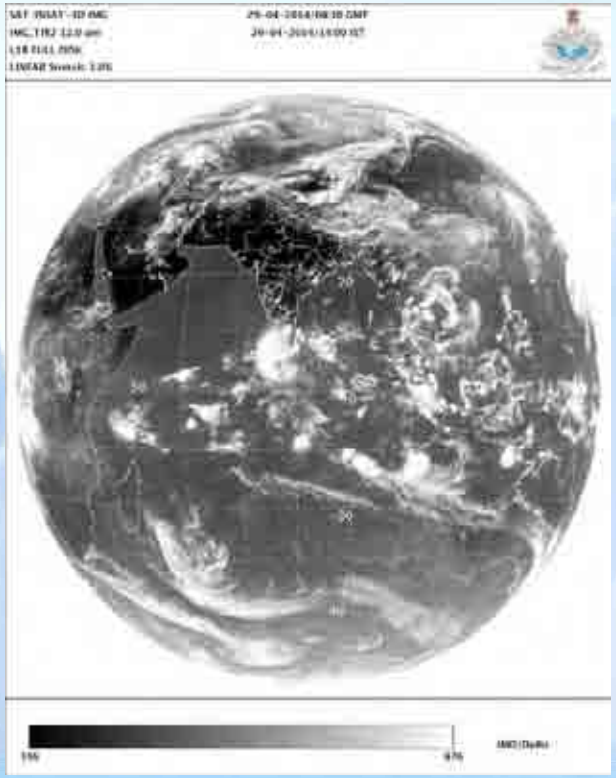


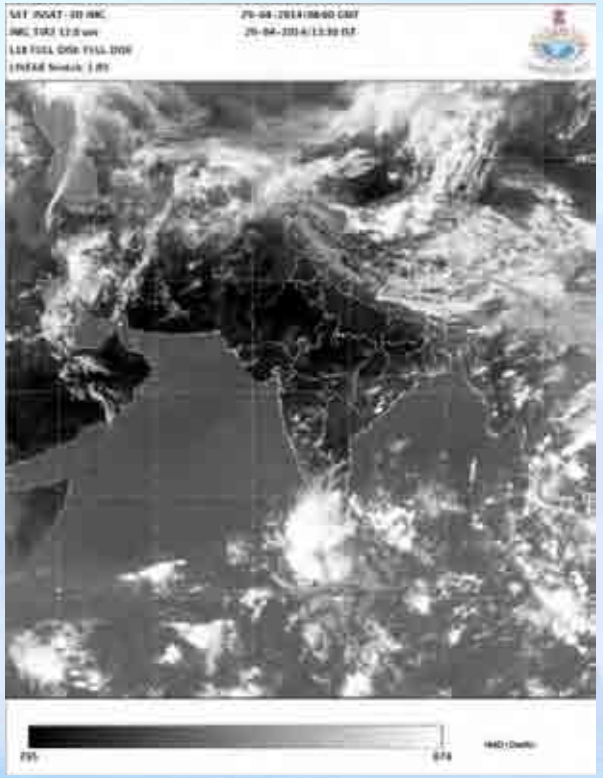


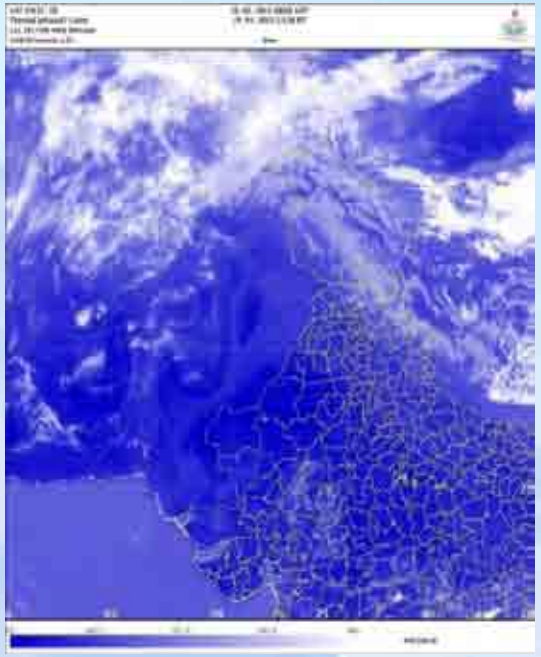


INSAT-3D Imager TIR2 band (11.5-12.5 um) Images(Full Disk, Asiamer sector, NW sector, NE sector, High Resolution images with District Boundaries(NW,NE,SW,SE sectors) of Indian region

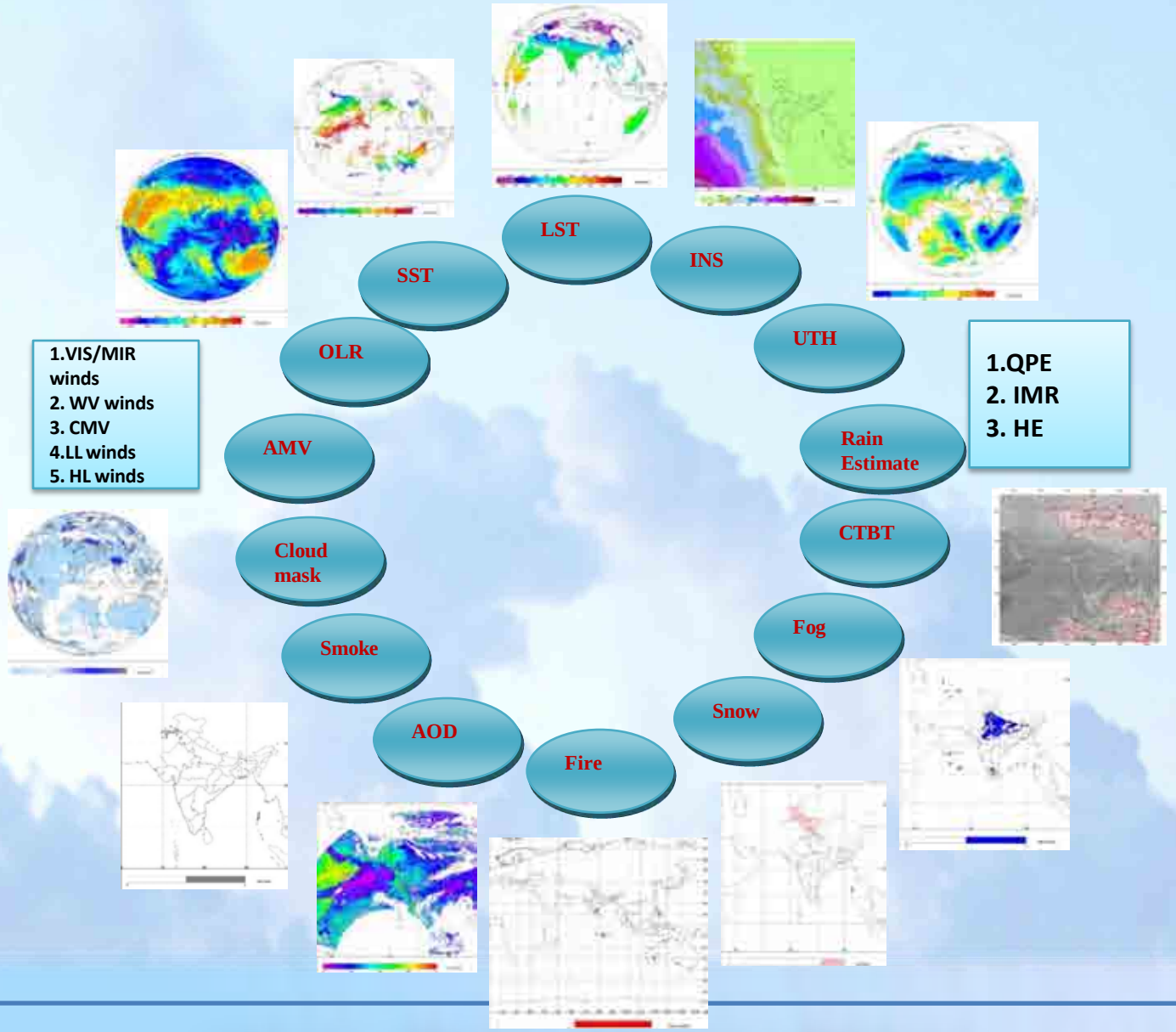
The another window region around 12 um, is contaminated by low level water vapor, and thus is called the "dirty window" and used to achieve higher accuracy SST and noise correction in RT model.



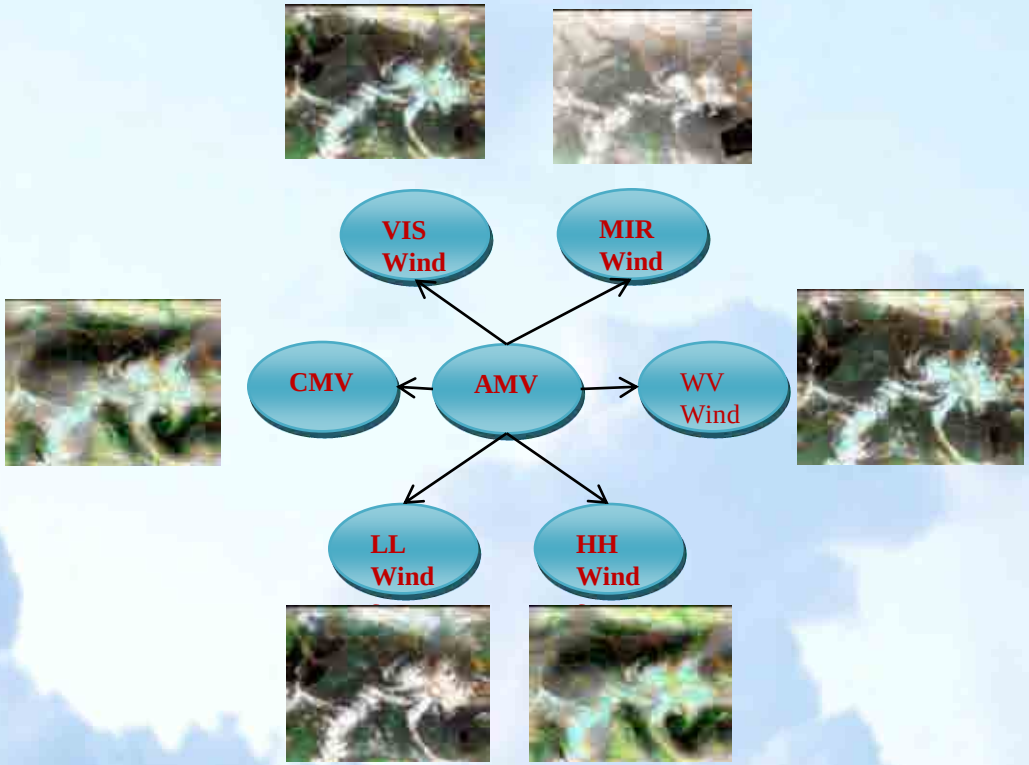


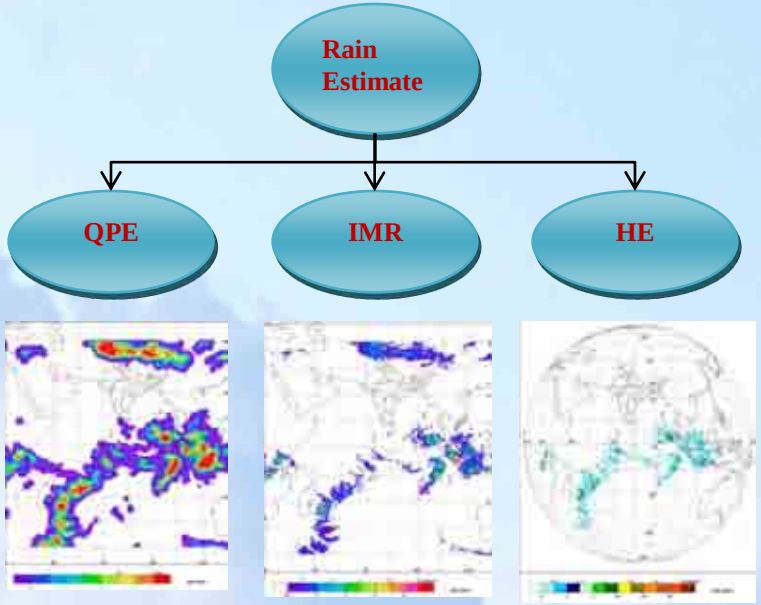


Geophysical parameters/products of INSAT-3D Imager

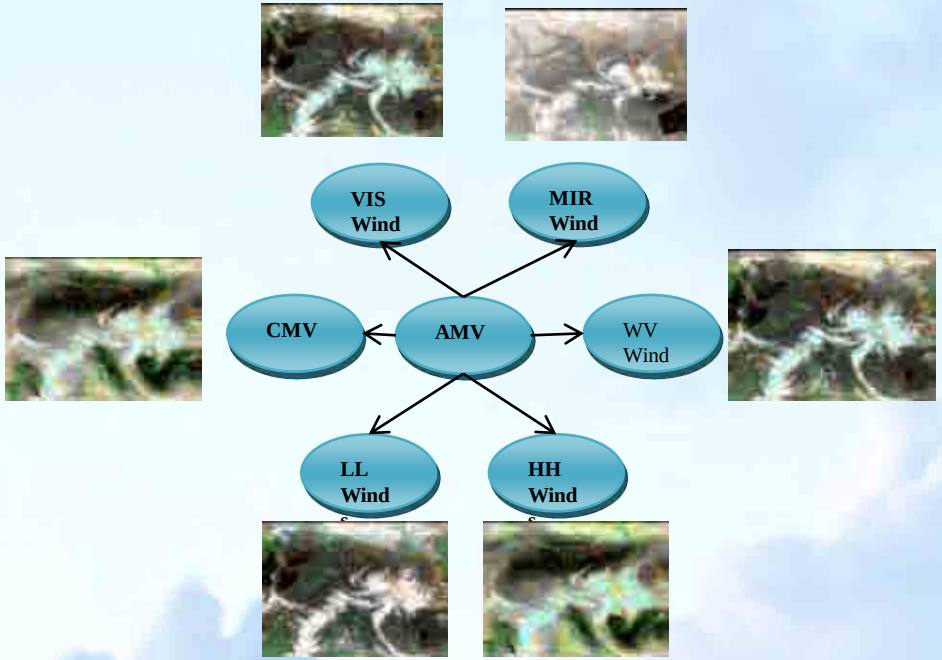


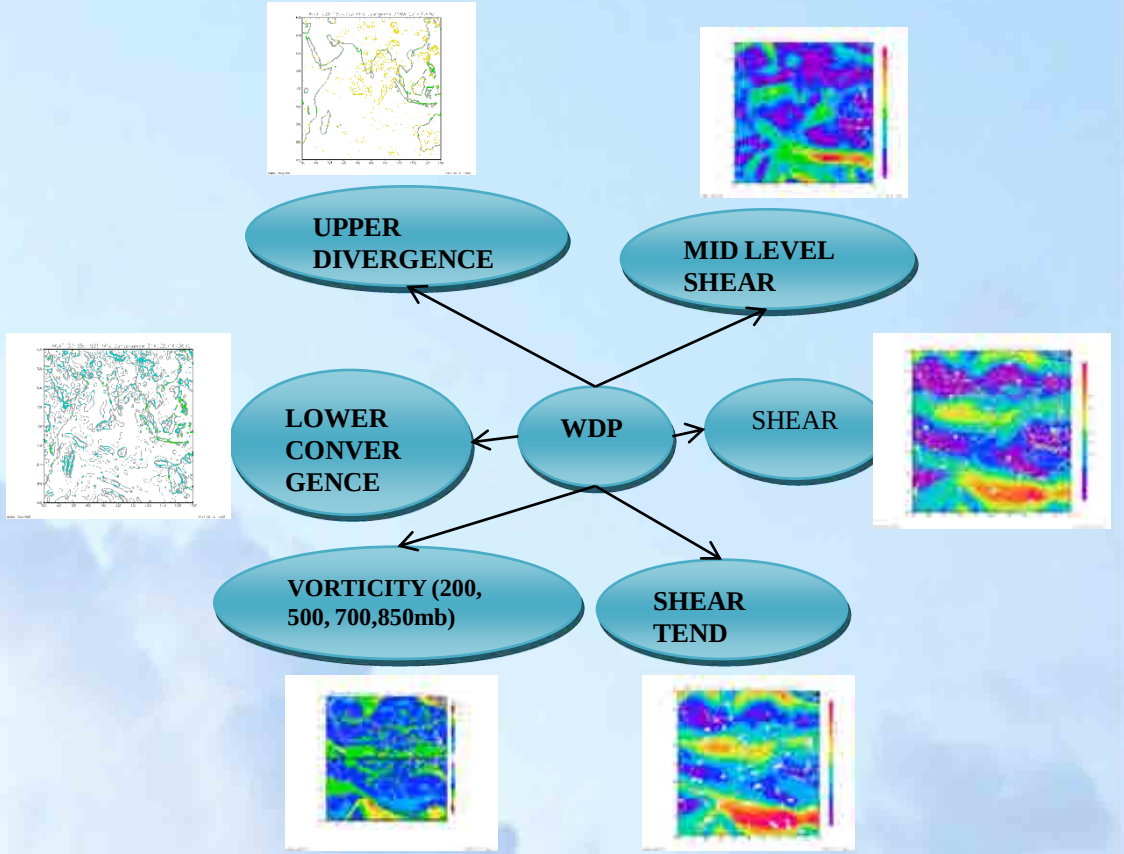
Geophysical parameters/products of AMV AND RE INSAT-3D Imager





Geophysical parameters/products of AMV AND Wind Derived Products from INSAT-3D Imager





Detail of Images Generated from INSAT-3D Imager

Sector Name	Channels	No. of Images
Full-Disk	IR1, IR1_Temp, IR2, IR2_Temp, MIR, MIR_Temp, VIS, SWIR, WV, WV_temp, MP	11
Asia-Sector	IR1, IR1_Temp, IR2, IR2_Temp, MIR, MIR_Temp, VIS, SWIR, WV, WV_temp, MP, CTBT	12
NEQUAD-Sector	IR1, IR1_Temp, IR2, IR2_Temp, MIR, MIR_Temp, VIS, SWIR, WV, WV_temp, MP	11
NWQUAD-Sector	IR1, IR1_Temp, IR2, IR2_Temp, MIR, MIR_Temp, VIS, SWIR, WV, WV_temp, MP	11
SGP-Sector	IR1, IR1_Temp, IR2, IR2_Temp, MIR, MIR_Temp, VIS, SWIR, WV, WV_temp, MP	11
NEQ (HR-Sector)	IR1_HR, IR1_HRBlue,IR1_Temp_BD, IR1_Temp_NHC, IR2_HR, IR2_HRBlue,VIS_HR, VIS_HRBlue, WV_HR, WV_HRBlue, MIR_HR, MIR_HRBlue, SWIR_HR, SWIR_HRBlue	14
NWQ (HR-Sector)	IR1_HR, IR1_HRBlue,IR1_Temp_BD, IR1_Temp_NHC, IR2_HR, IR2_HRBlue,VIS_HR, VIS_HRBlue, WV_HR, WV_HRBlue, MIR_HR, MIR_HRBlue, SWIR_HR, SWIR_HRBlue	14
Bay of Bengal (HR-Sector)	IR1_HR, IR1_HRBlue,IR1_Temp_BD, IR1_Temp_NHC, IR2_HR, IR2_HRBlue,VIS_HR, VIS_HRBlue, WV_HR, WV_HRBlue, MIR_HR, MIR_HRBlue, SWIR_HR, SWIR_HRBlue	14
Arabian Sea (HR-Sector)	IR1_HR, IR1_HRBlue,IR1_Temp_BD, IR1_Temp_NHC, IR2_HR, IR2_HRBlue,VIS_HR, VIS_HRBlue, WV_HR, WV_HRBlue, MIR_HR, MIR_HRBlue, SWIR_HR, SWIR_HRBlue	14
Amarnath Yatra (HR-Sector)	IR1_HR, IR1_HRBlue,IR1_Temp_HR, IR2_HR, VIS_HR, VIS_HRBlue, WV_HR, SWIR_HR, SWIR_HRBlue, MIR_HR, MIR_Temp_HR,	11
Vaishno Devi (HR-Sector)	IR1_HR, IR1_HRBlue,IR1_Temp_BD, IR1_Temp_NHC, IR2_HR, IR2_HRBlue,VIS_HR, VIS_HRBlue, WV_HR, WV_HRBlue, MIR_HR, MIR_HRBlue, SWIR_HR, SWIR_HRBlue	14
Nepal (HR-Sector)	IR1_HR, IR1_HRBlue,IR1_Temp_HR, IR2_HR, VIS_HR, VIS_HRBlue, WV_HR, SWIR_HR, SWIR_HRBlue, MIR_HR, MIR_Temp_HR, DMP	12
Fog (HR-Sector)	IR1_HR, IR1_HRBlue,IR1_Temp_HR, IR2_HR, VIS_HR, VIS_HRBlue, WV_HR, SWIR_HR, SWIR_HRBlue, MIR_HR, MIR_Temp_HR, DMP, NMP	13
	Total No of Images generated half hourly	162

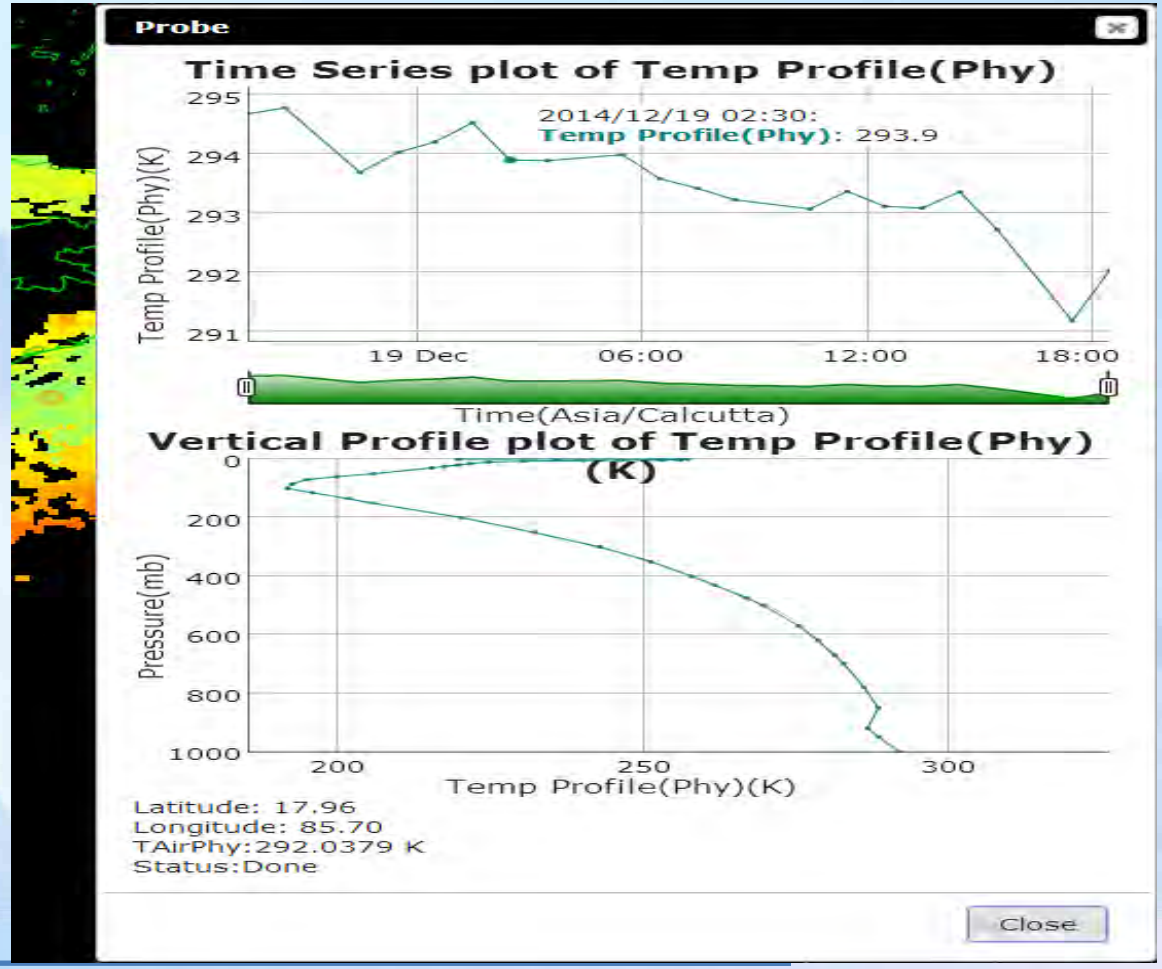
RAPID

RAPID(Real time Analysis of Products & Information Dissemination) :- It is a web based quick visualization and analysis tool for satellite data on a real time basis. This introduces Next Generation Weather Data Access & Advanced Visualization. http://www.rapid.imd.gov.in

- Connects atmospheric- and geosciences
- No specific OS/ software/ library / compiler required on the desktop. Acess through browserc
- Provides features of interest to scientific community
- Open standards OGC
  - Web Mapping Service (WMS) – For visualization
  - Extensions written for scientific community
- Zero learning curve

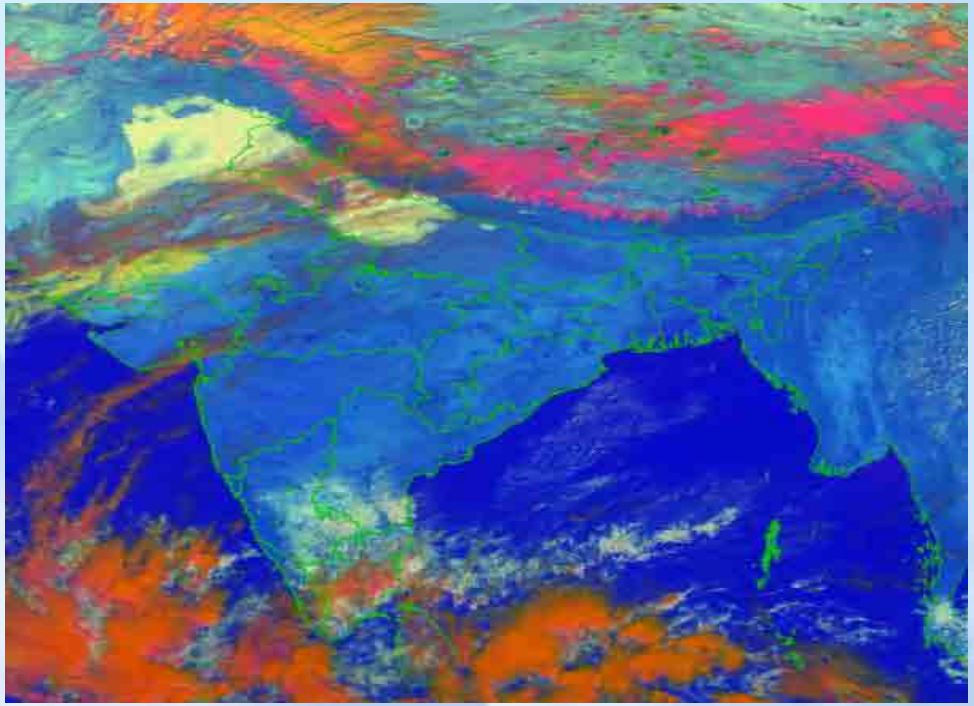
Features

- Overlay Map Boundaries (World Coastline, State, District Boundaries, Gridlines) with configurable:
  - Color
  - Opacity
  - Thickness
- Contrast Stretch
- Lookup Table Application
- Probe Data (on the fly)
  - Time Series
  - Vertical Profile
  - Transect
  - Area Measurement
  - Distance Measurement



Features (Contd.)

- Animation
- RGB Composites
- Contouring
- Change Map background
- Base layers:
  - Open StreetMap
  - Indian SubBasins
  - FMO Basins
  - True Marble
  - Blue Marble
  - Bhuvan



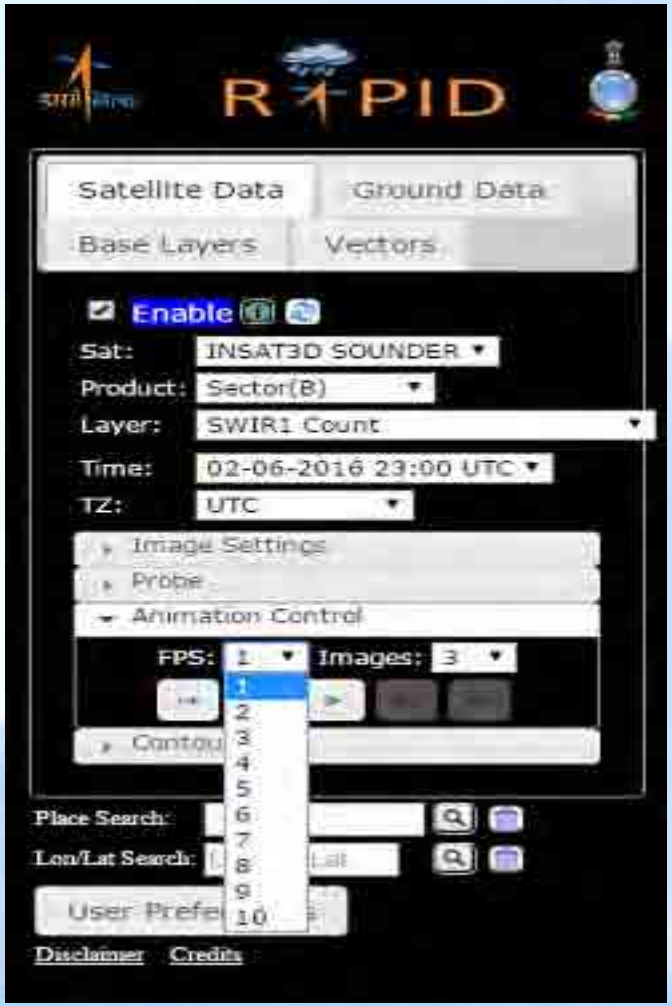
RGB Composite: Day Microphysics

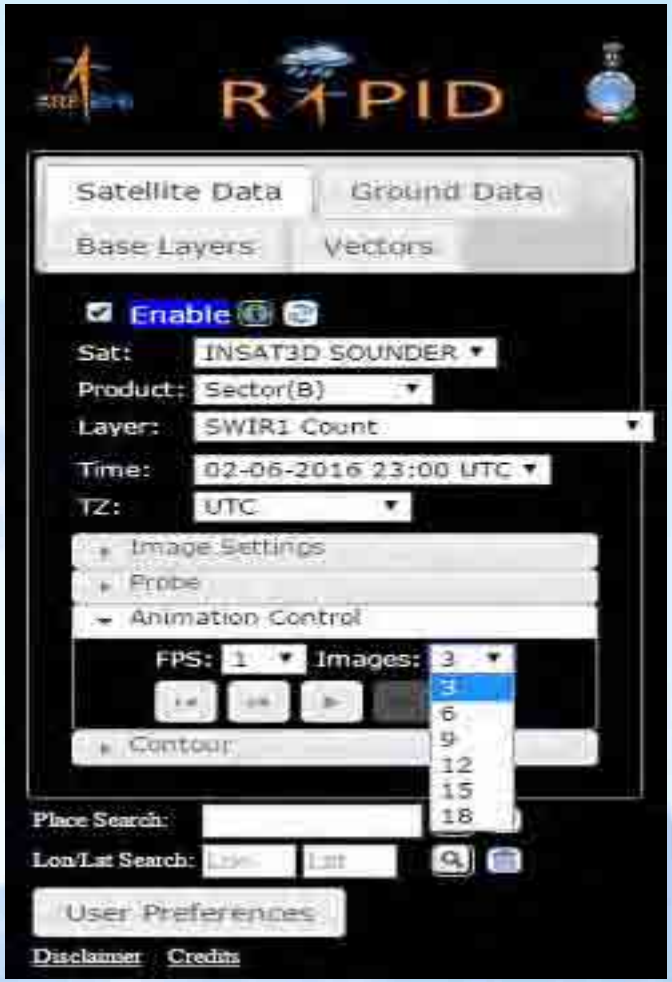
Step-1 http://www.rapid.imd.gov.in/
Step-2 one base layer may be selected depending requirement over which individual want to over lay any product
Step-3 selection vector/gridlines

Steps for Selecting AWS Data

Step 1: Select Ground Data.
Step 2: Select Source AWS , then Parameter, then corresponding date and time.

Step-9 Under Animation there is provision of selection of Number images want to see the in animation, select the number, click the forward button, wait for some time it collect all set data and then animation will start.





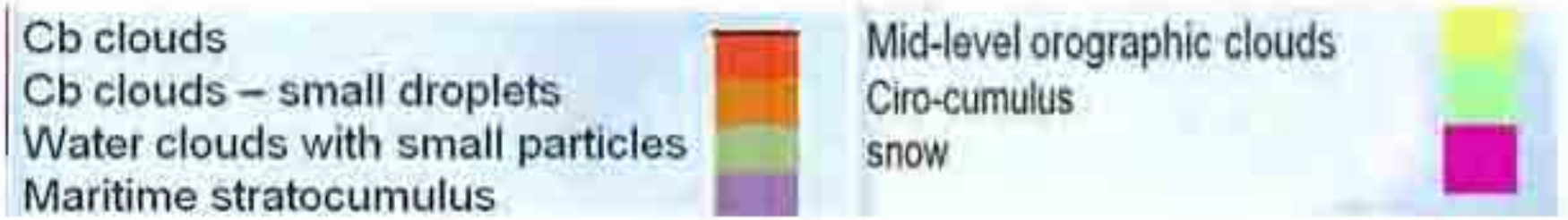
DMP RGB Scheme implemented in IMD

The Day Microphysics RGB was inherited from Rosenfeld and Lensky (1998): the VIS0.64 reflectance in red approximates the cloud optical depth and amount of cloud water and ice; the SWIR 1.67 solar reflectance in green is a qualitative measure for cloud particle size and phase, and the IR10.8 brightness temperature modulates the blue. This color scheme is useful for cloud analysis, convection, fog, snow, and fires. In this color scheme water clouds that do not precipitate appear white because cloud drops are small, whereas large drops that are typical to precipitating clouds appear pink, because of the low reflectance at SWIR1.5 manifested as low green. Supercooled water clouds appear more yellow, because the lower temperature that modulate the blue component. Cold and thick clouds with tops composed of large ice particles, e.g., Cb tops, appear red. Optically thick clouds with small ice particles near their tops appear orange.

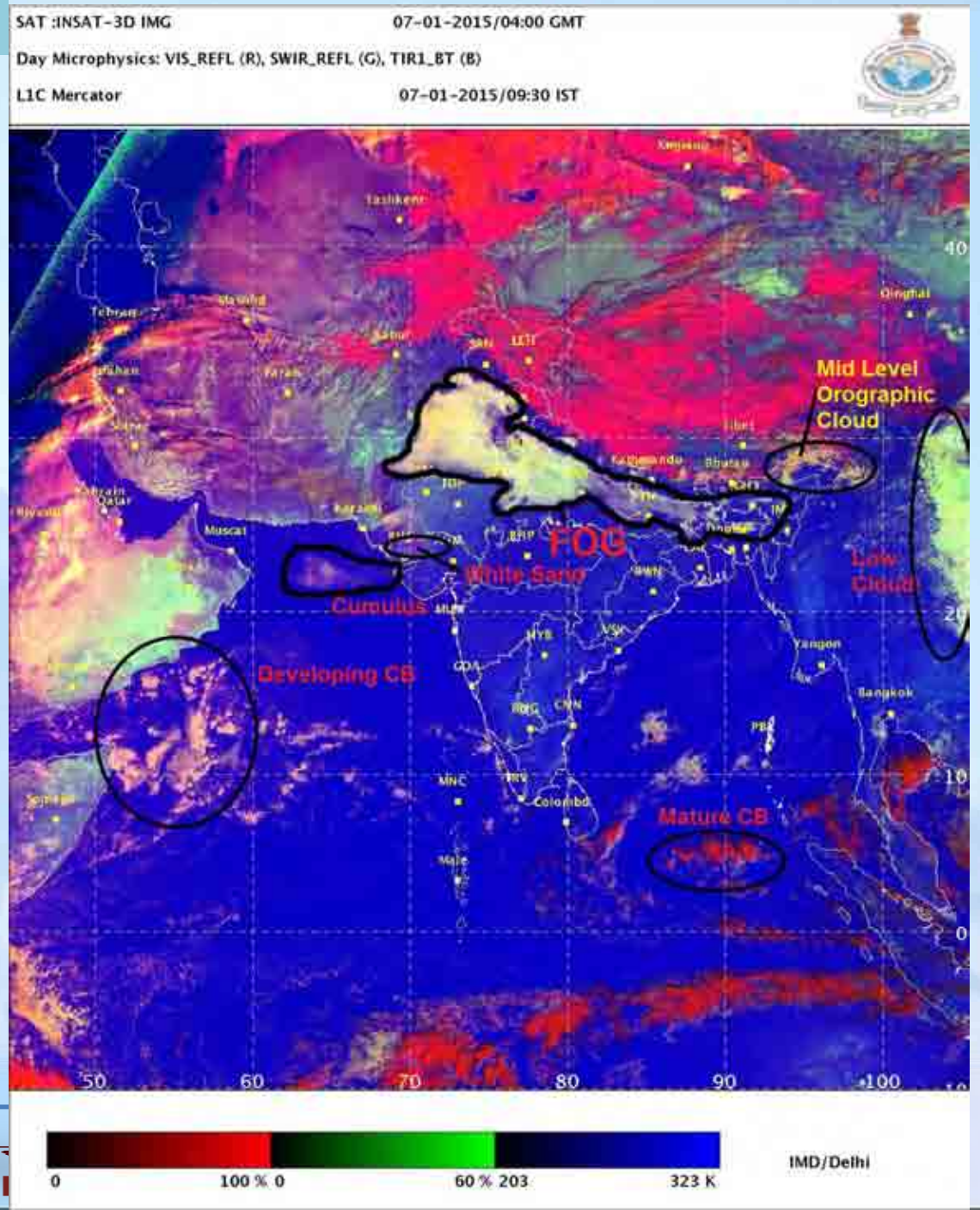
Day microphysics RGB scheme

Beam	Channel	Range	Gamma
Red	VIS(0.55-0.75 µm)	0 ...+100 %	1.0
Green	SWIR(1.67µm)	0 ... +60 %	1.0
Blue	IR(10.8 µm)	+203 ... +323 °K	1.0

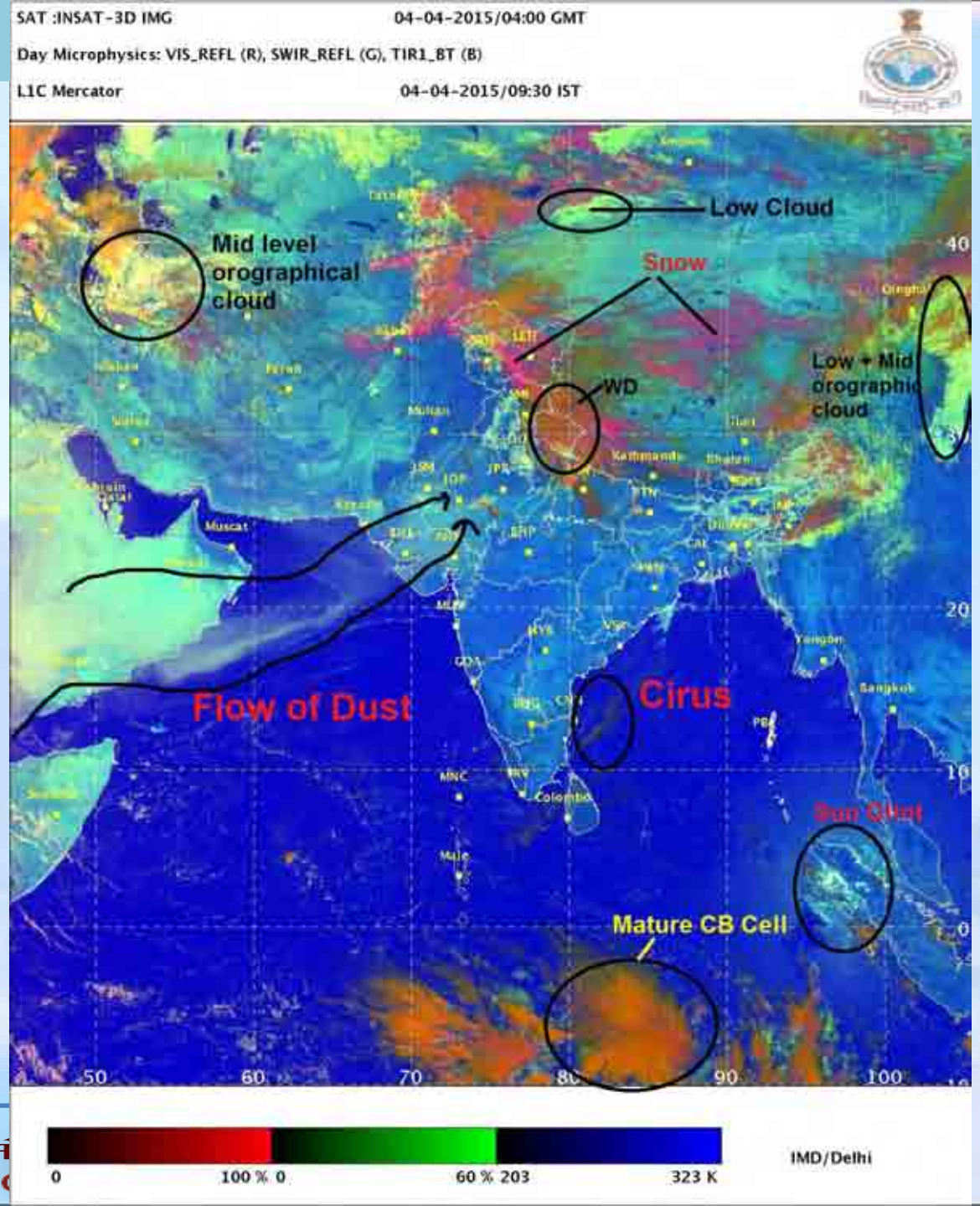
This product is used during the daytime because a solar reflectance component is adopted. Colors and their interpretation are based on I. M. Lensky and D. Rosenfeld:Clouds-Aerosols-Precipitation Satellite Analysis Tool (CAPSAT), Atmos. Chem. Phys.,8, 6739-6753, 2008i.



DTMP RGB Imagery



DTMP RGB Imagery



NMP RGB Scheme implemented in IMD

It is designed and tuned to monitor the evolution of night-time fog / low stratus. Other (secondary) applications are the detection of fires, low-level moisture boundaries and cloud classification in general. It should be noted that as the product is tuned for night-time conditions, its use during day-time is very limited. The Fog / Low Clouds RGB is composed from data from a combination of the Imager MIR3.9, IR10.8 and IR12.0 channels

Night-time microphysics RGB scheme

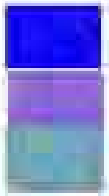
Beam	Channel	Range	Gamma
Red	IR12.0 µm - IR10.8 µm(TIR2-TIR1)	-4 … +2 K	1.0
Green	IR10.8 µm - IR3.9 µm (TIR1-MIR)	-4 … +6 K	1.0
Blue	IR10.8 µm (TIR1)	+243 … +293 K	1.0

Some of the identified clouds and features are listed below for reference,

Mature CB

Mature CB with ICE

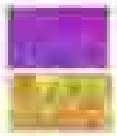
Cirus



Ocean

Land

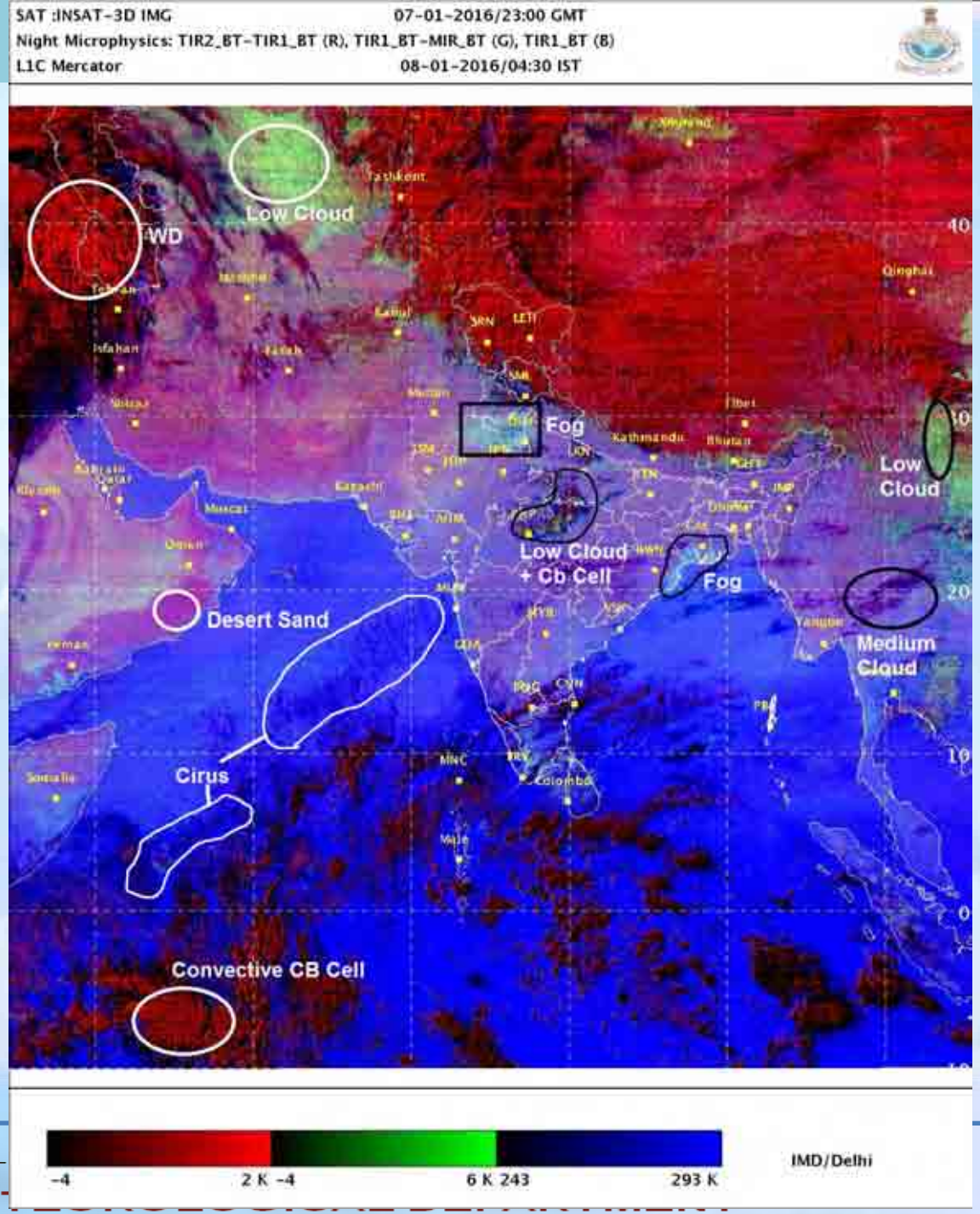
Low Cloud



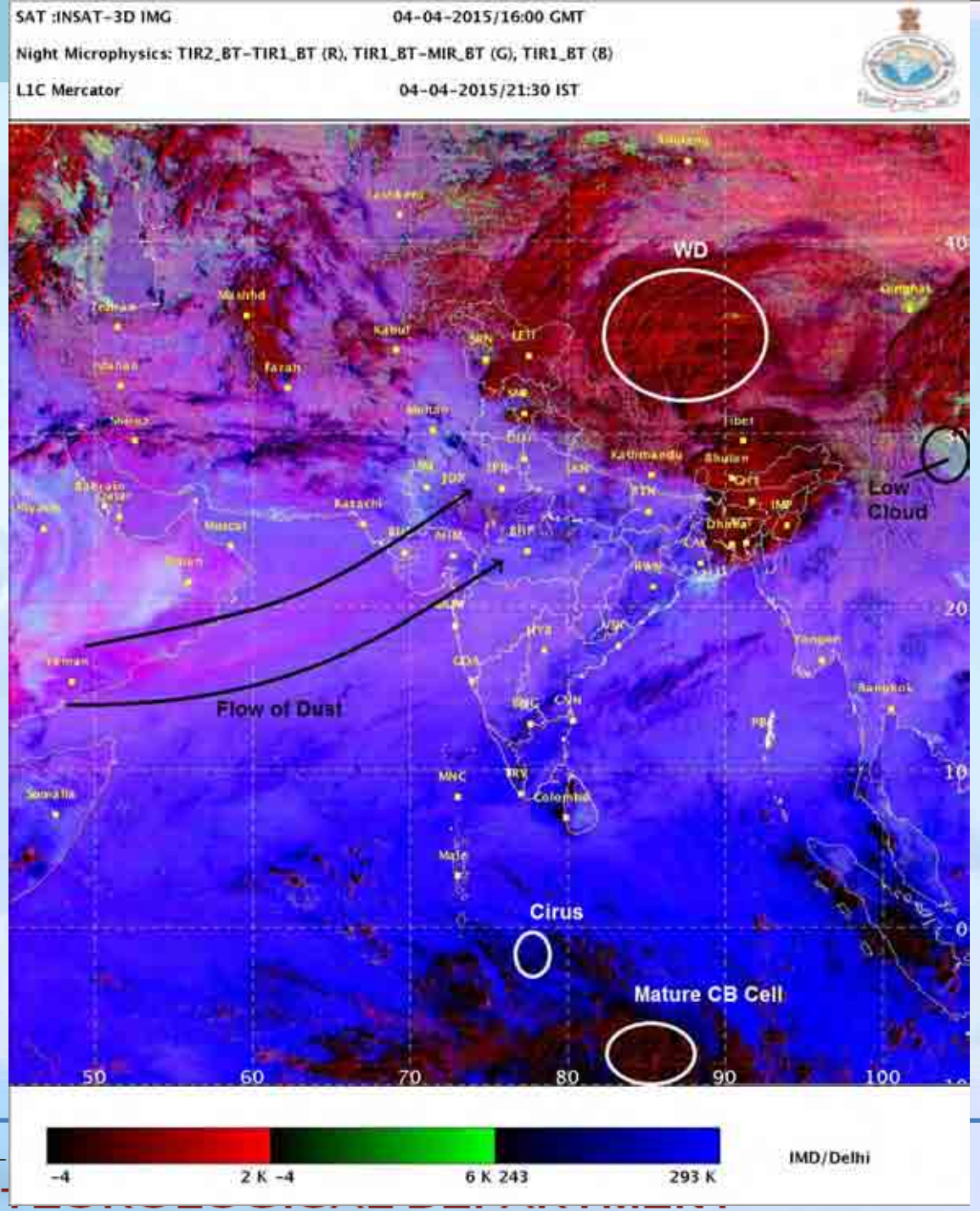
Sand / Dust

Medium Cloud

NTMP RGB Imagery



NTMP RGB Imagery



Identification of FOG in RGB Imagery and RAPID

Day time fog can be viewed and analyzed by visible imagery, SWIR imagery, Day-time Microphysics RGB Imagery. To distinguish between Fog and Low Clouds the user may use the following criteria,

- Fog will have sharp boundary, while low clouds will not have sharp boundary.
- In animation Fog will remain stationary while low clouds will show some movement.

In day time micro physics RGB imagery **Fog** look like this

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Fog pixels** value lies in the following range,

VIS Albedo	25 to 50 %
SWIR Albedo	35 to 60 %
TIR1	270°K to 290°K

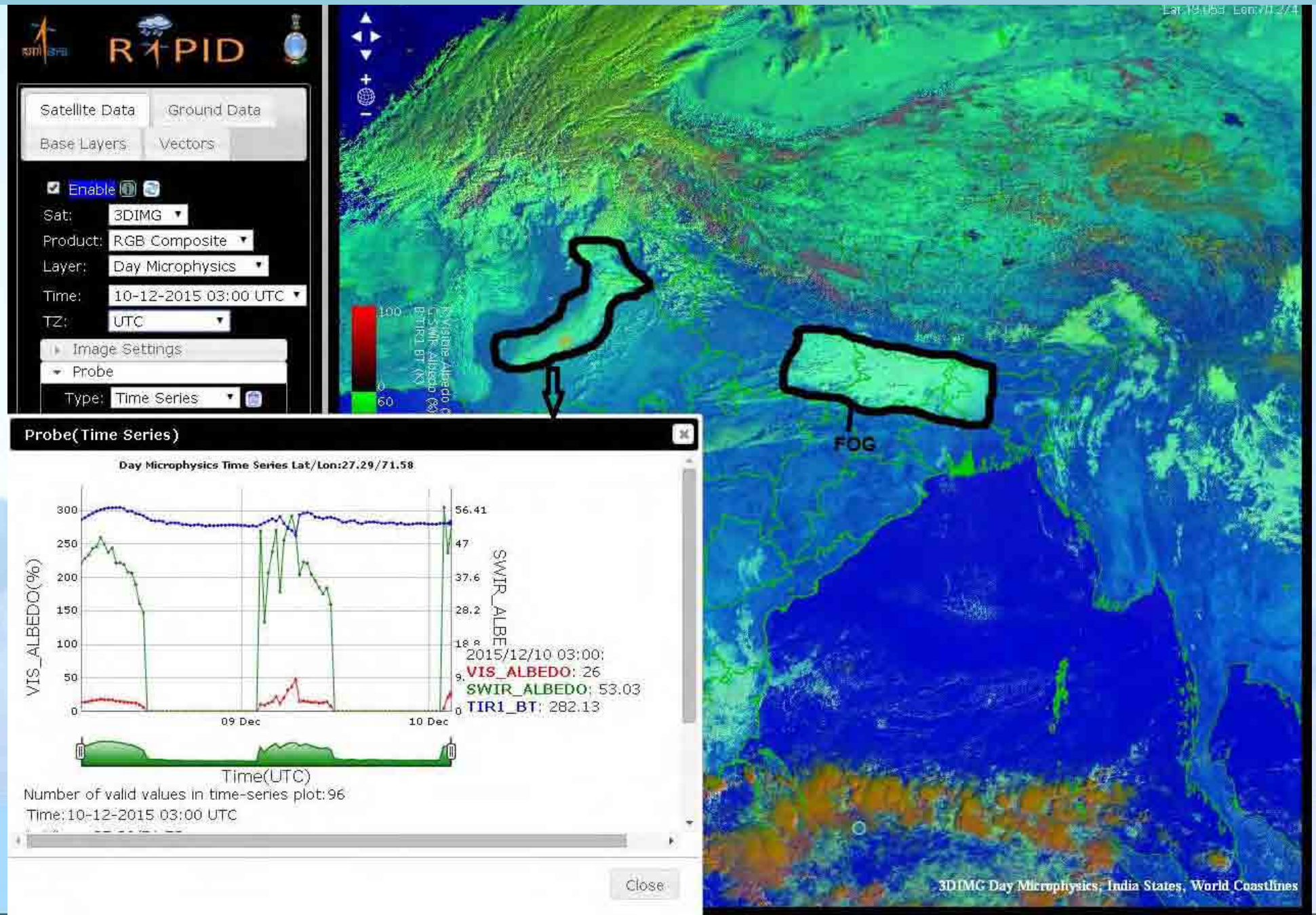
In night time microphysics RGB imagery, **Fog** look like this

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Fog pixel** value lies in the following range,

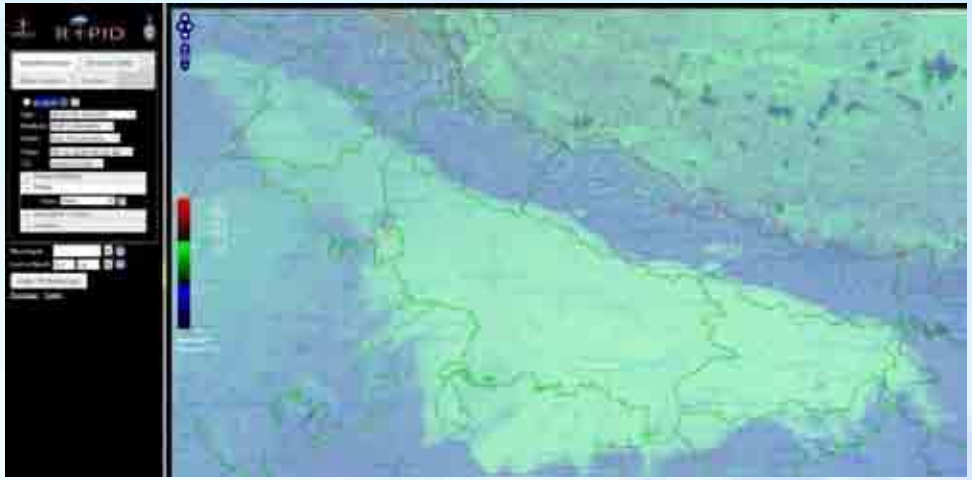
TIR2BT – TIR1BT	Negative value
TIR1BT - MIRBT	>2.5°K
TIR1BT	270°K to 290°K

Note: However these ranges may change from place to place and over time, user may work out the values of their areas.

Identification of Fog in RAPID (day-time)

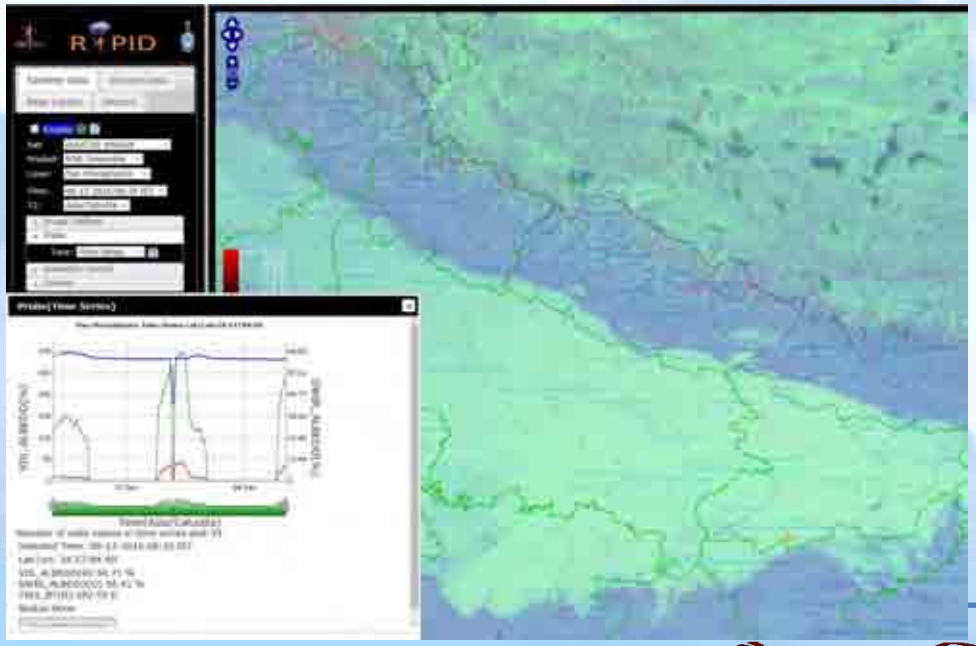


Identification of Fog in RAPID (day-time)



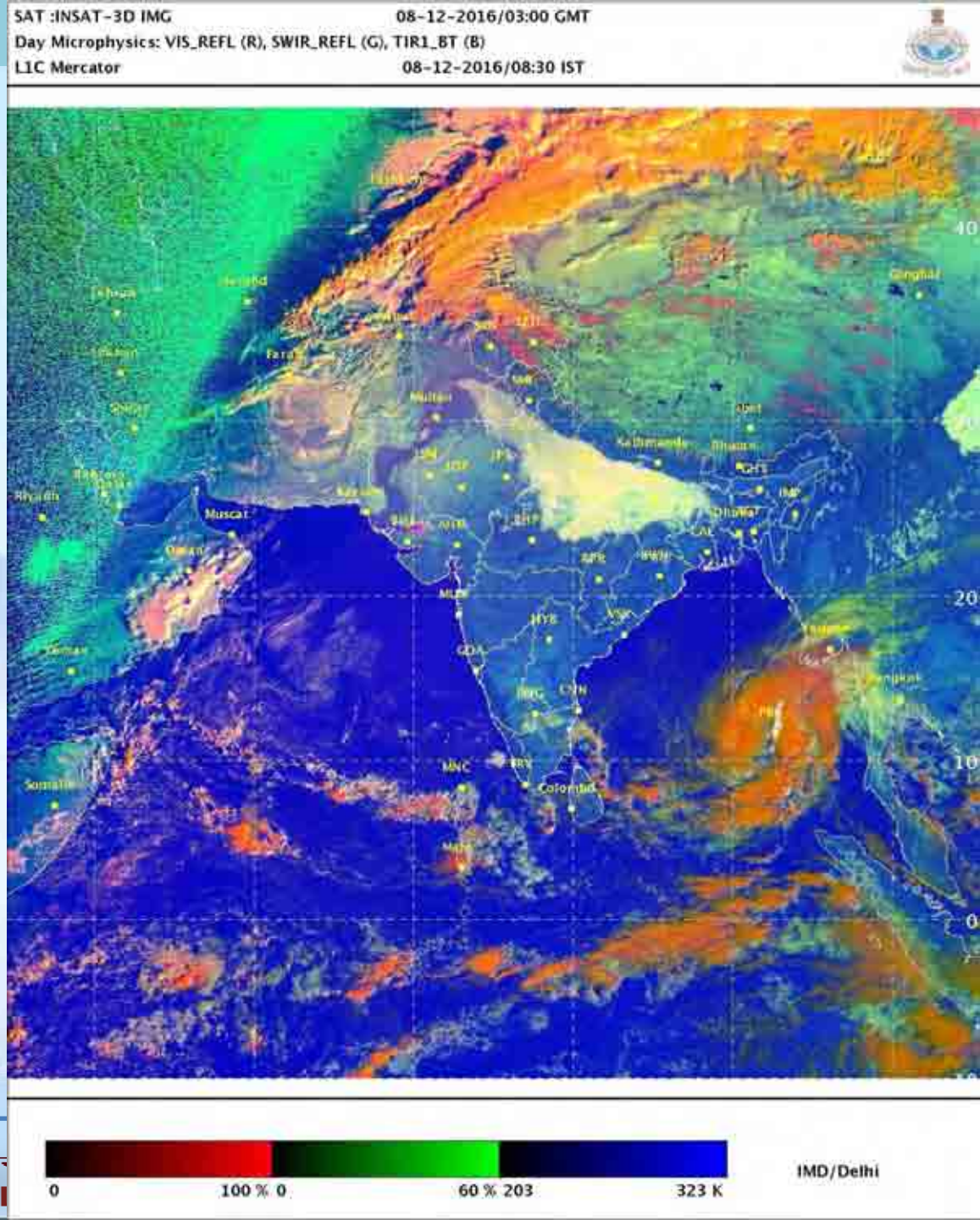
Transect View

Over Aerodromes

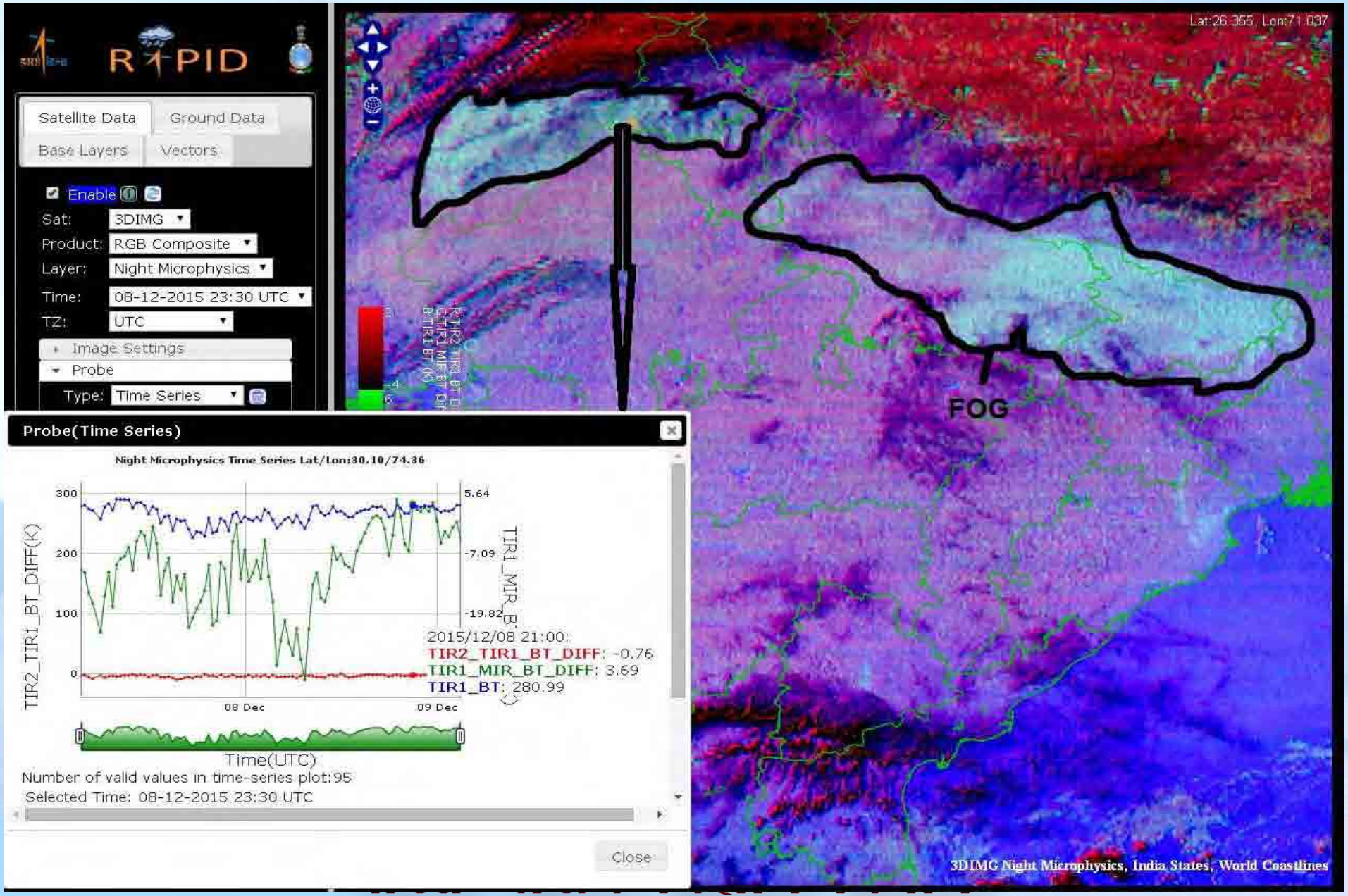


Over Railway Tracks

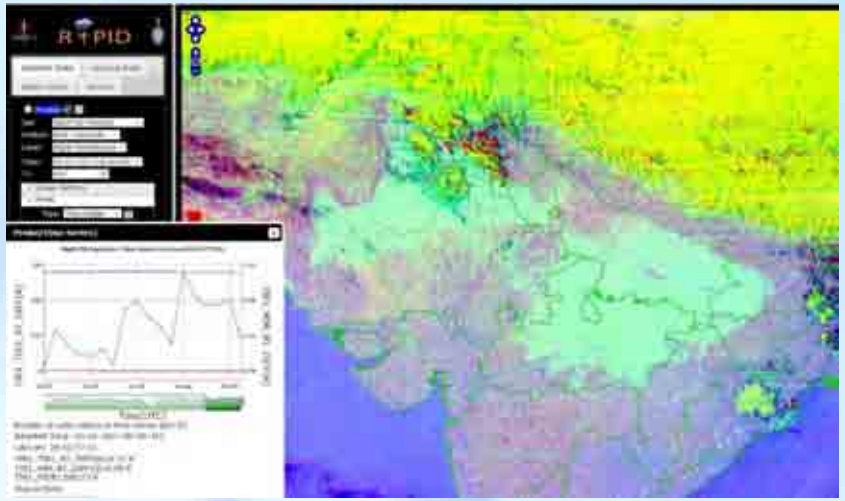
Identification of Fog in RAPID (day-time)



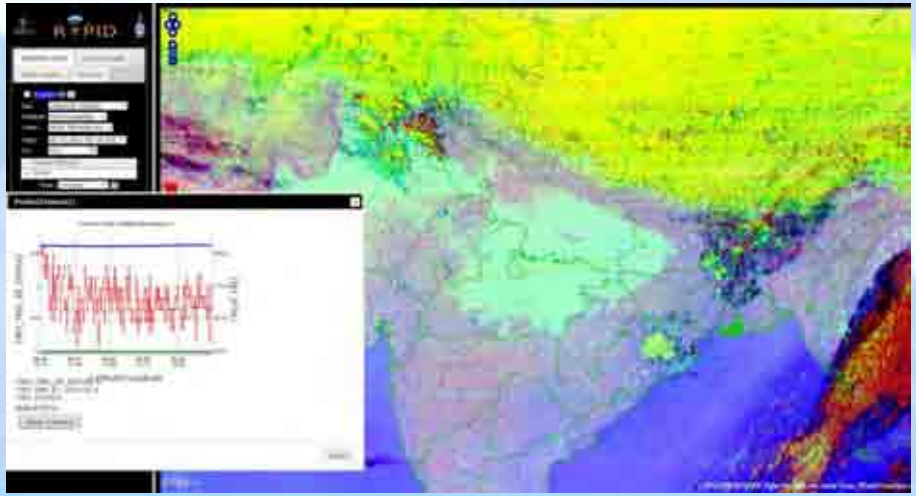
Identification of FOG in RAPID (night-time)



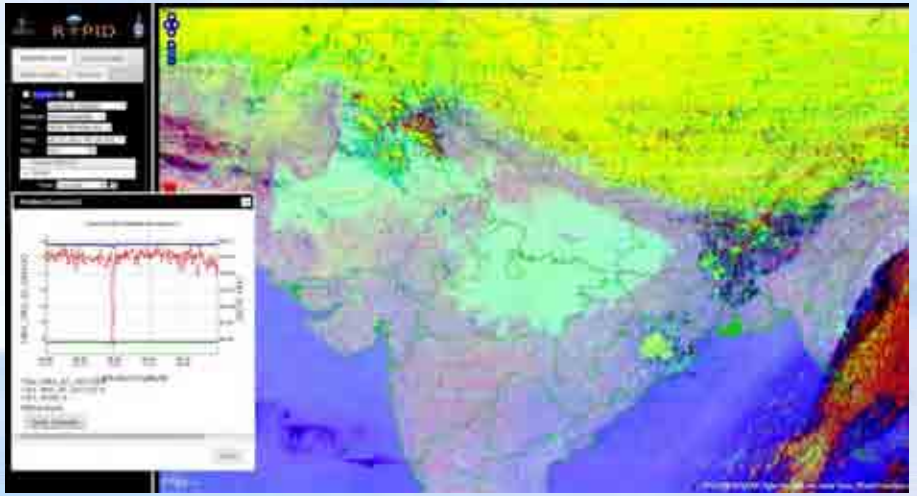
Identification of FOG in RAPID (night-time)



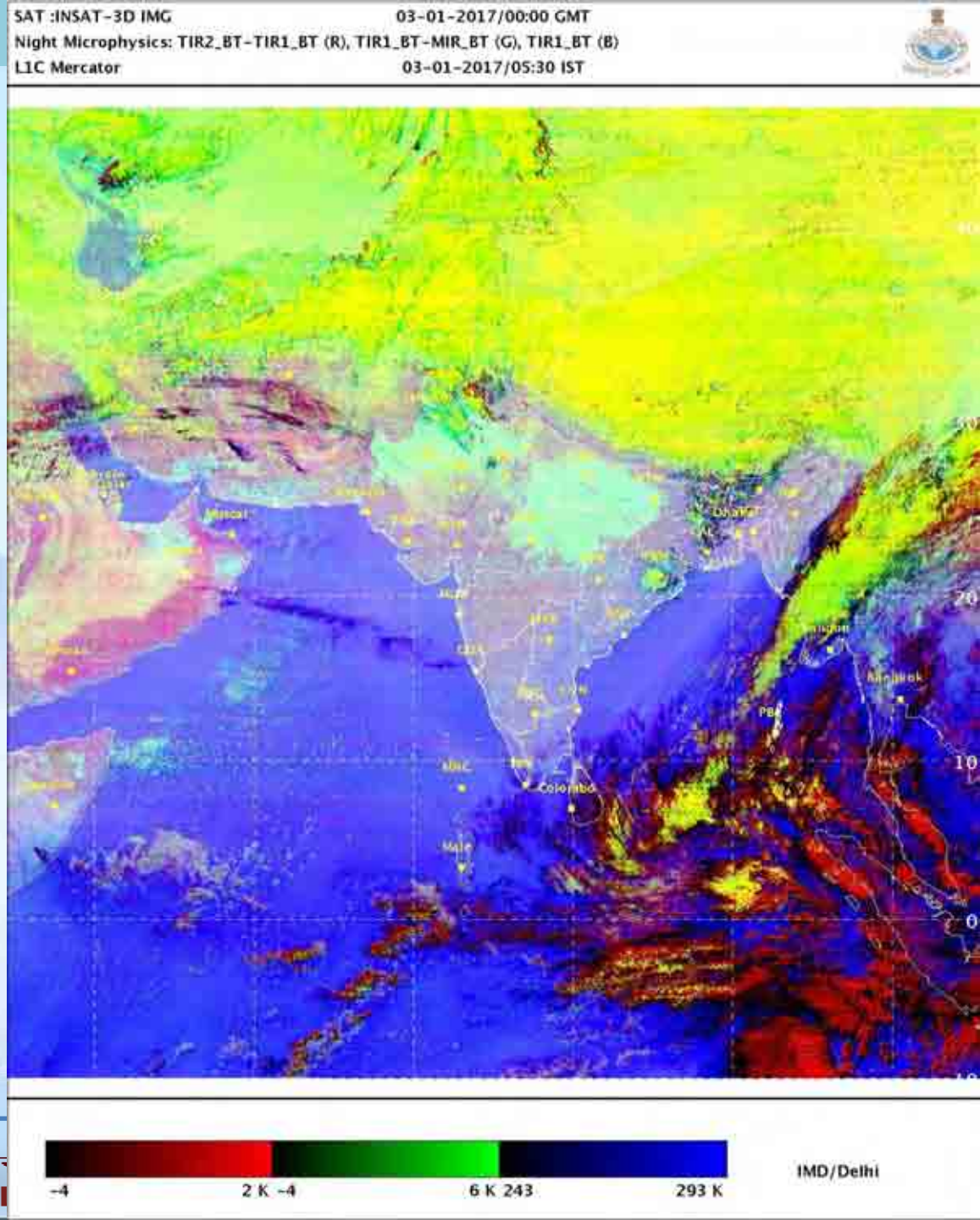
Transect

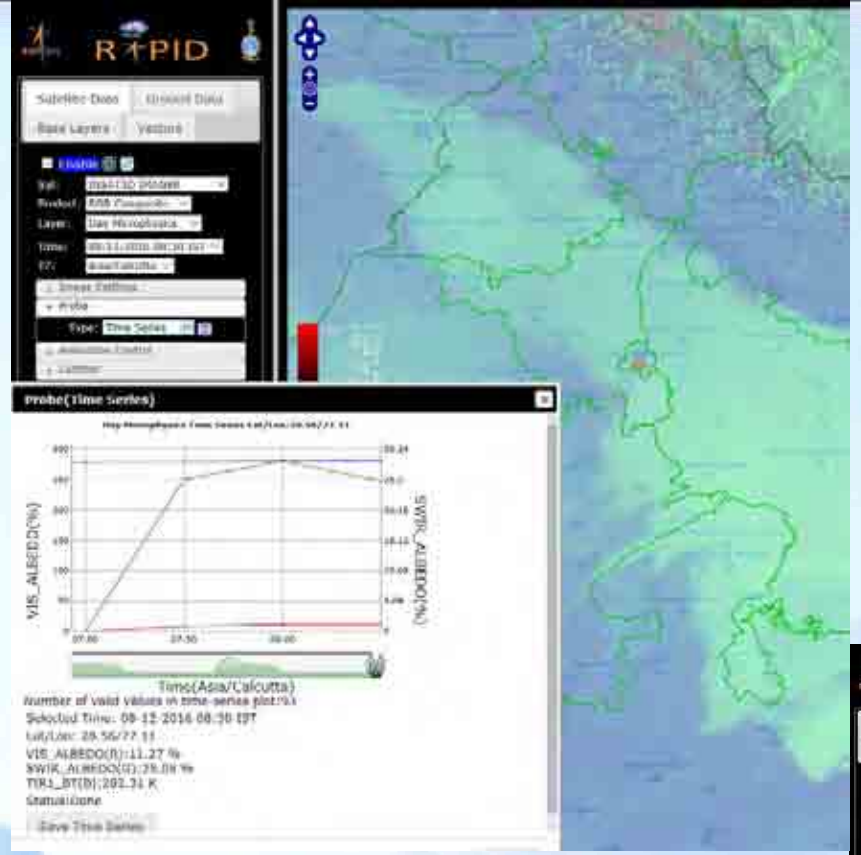


Transect



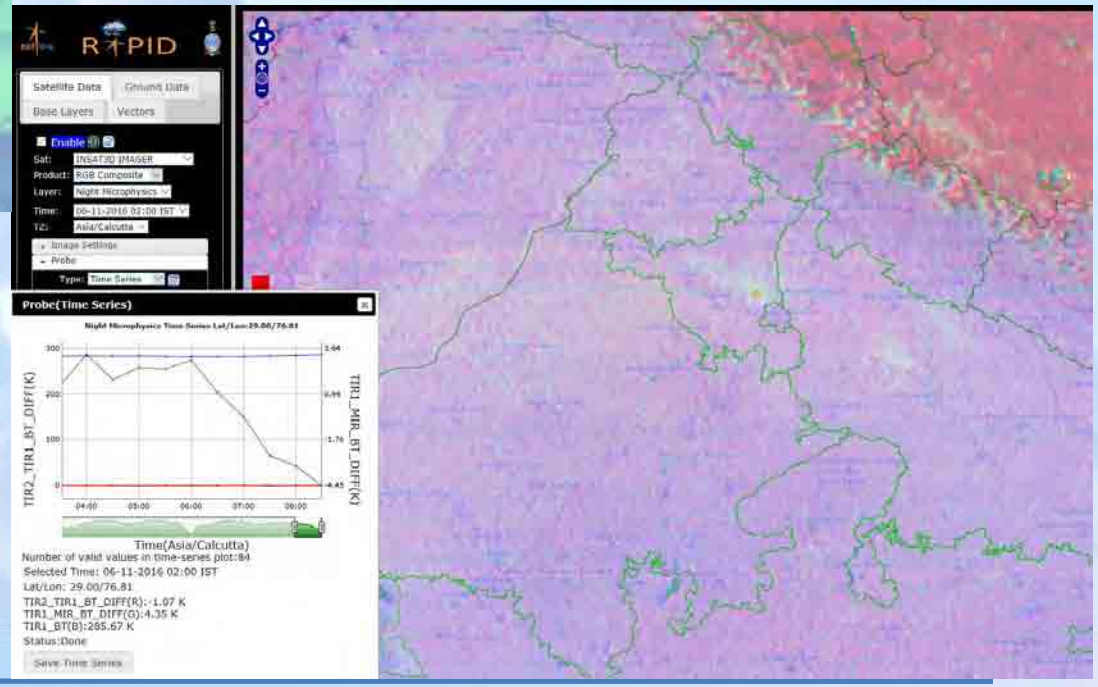
Identification of FOG in RAPID (night-time)





Fog over Aerodrome

Night time Fog



Identification of LOW CLOUD in RGB Imagery and RAPID

In day time microphysics RGB imagery, **Low clouds** look like this.

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Low clouds pixel** value lies in the following range,

VIS Albedo	30% to 45%
SWIR Albedo	40% to 60%
TIR1	255ºK to 270 ºK

In night time microphysics RGB imagery, **Low clouds** look like this.

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Low clouds pixel** value lies in the following range,

TIR2BT – TIR1BT	Positive
TIR1BT - MIRBT	Positive
TIR1BT	250ºK to 265ºK

Note: However these ranges may change from place to place and over time, user may work out the values of their areas.

Identification of Mid Level Orographic Cloud in RGB Imagery and RAPID

In day time micro physics RGB imagery **Mid Level Orographic Cloud** look like this

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Mid Level Orographic Cloud pixels** value lies in the following range,

VIS Albedo	30% to 50%
SWIR Albedo	40% to 60%
TIR1	245°K to 260 °K

In night time microphysics RGB imagery, **Medium clouds** look like this.

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Medium clouds pixel** value lies in the following range,

TIR2BT – TIR1BT	Positive
TIR1BT - MIRBT	Positive
TIR1BT	245°K to 260°K

Note: However these ranges may change from place to place and over time, user may work out the values of their areas.

Identification of CB Cells in RGB Imagery and RAPID

In day time micro physics RGB imagery **CB cell** look like this

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **CB cell pixels** values lies in the following range,

VIS Albedo	>50 %
SWIR Albedo	<25 %
TIR1	<245°K

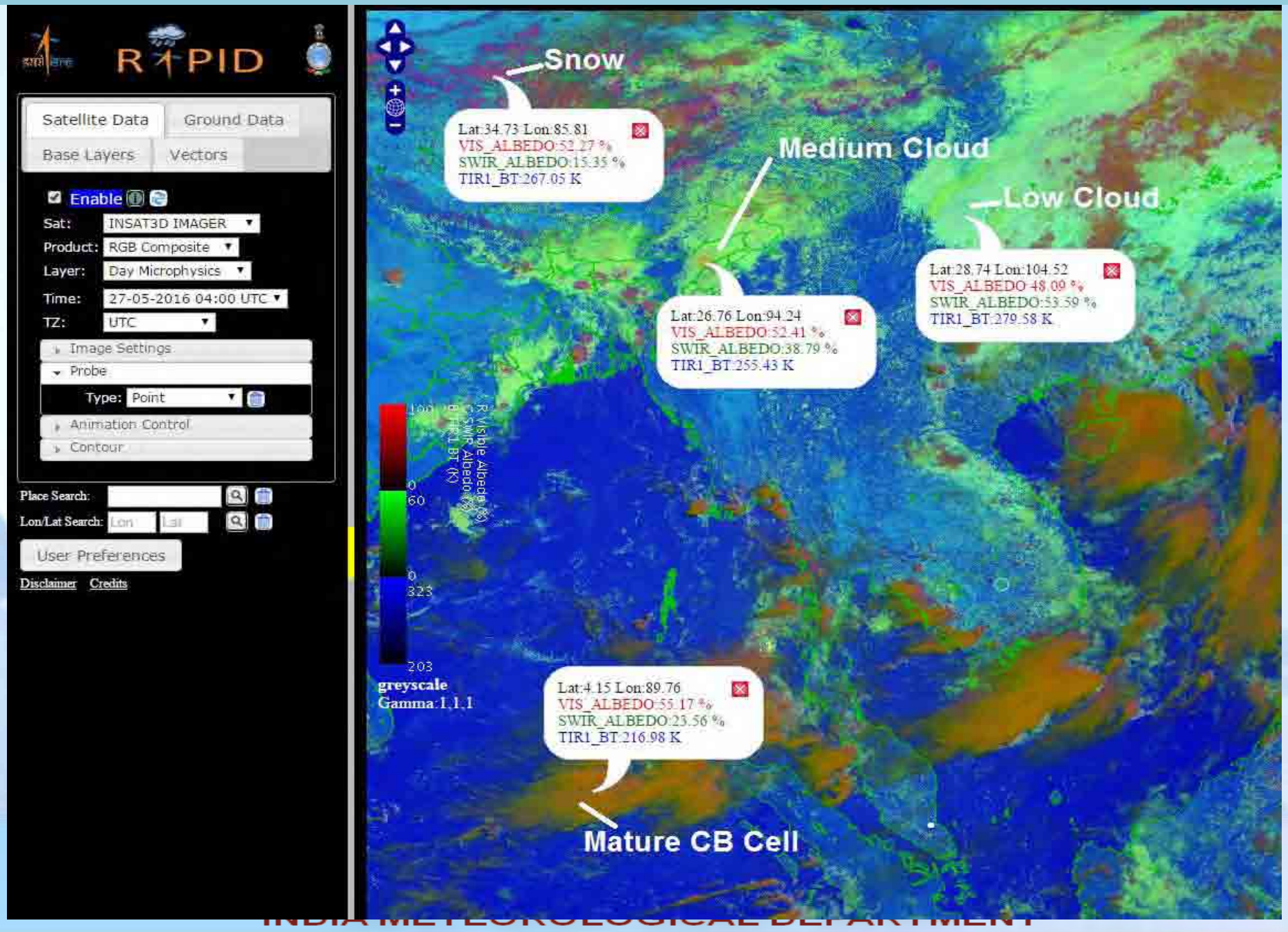
In night time microphysics RGB imagery, **CB Cell** look like this

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **CB Cell pixel** value lies in the following range,

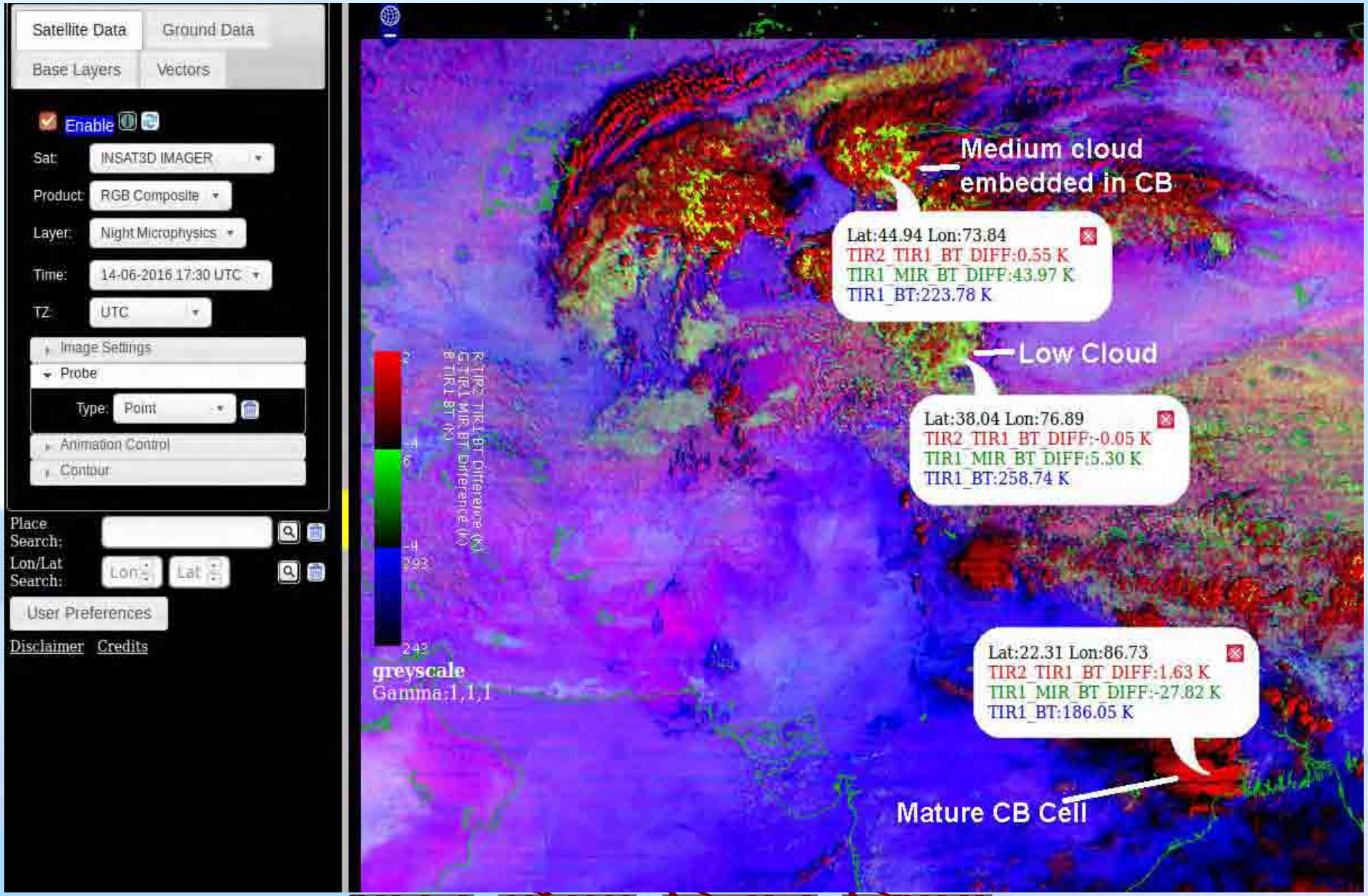
TIR2BT – TIR1BT	Positive
TIR1BT - MIRBT	Negative
TIR1BT	<245°K

Note: However these ranges may change from place to place and over time, user may work out the values of their areas.

Identification of Low/Medium/CB Clouds and Snow in RAPID

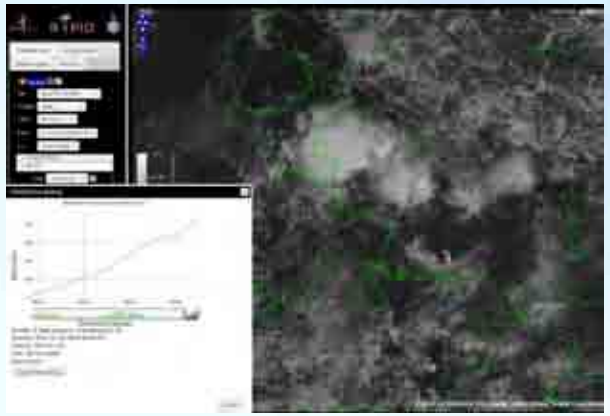


Identification of Low/Medium/CB Clouds in RAPID

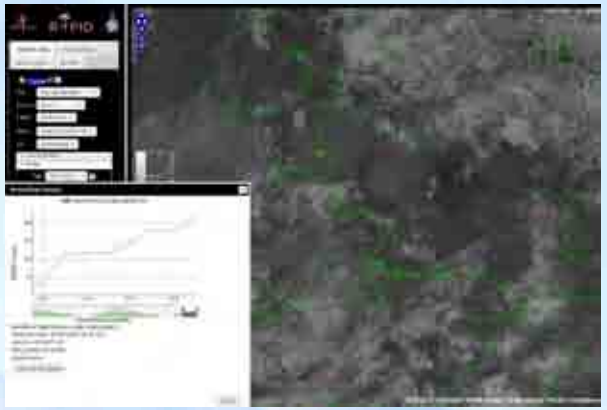


BT Plots of Heavy Rain – Delhi 31st August 2016

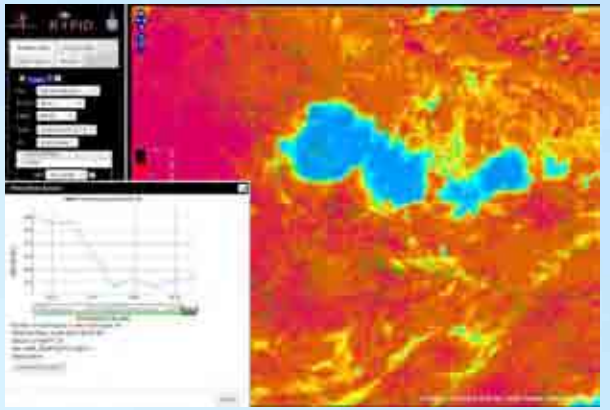
VIS Count

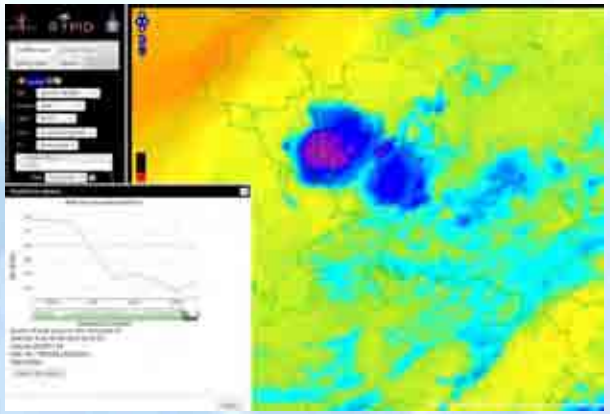


SWIR Count

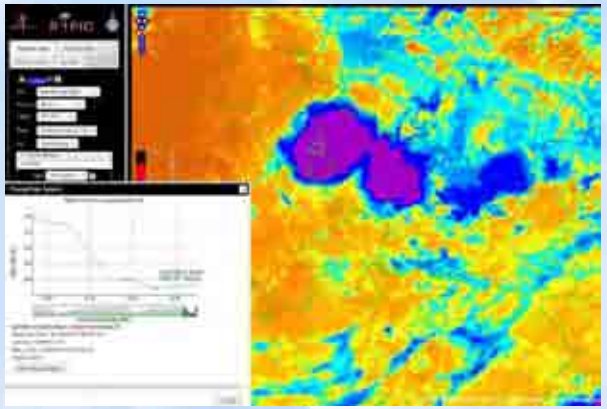


MIR BT

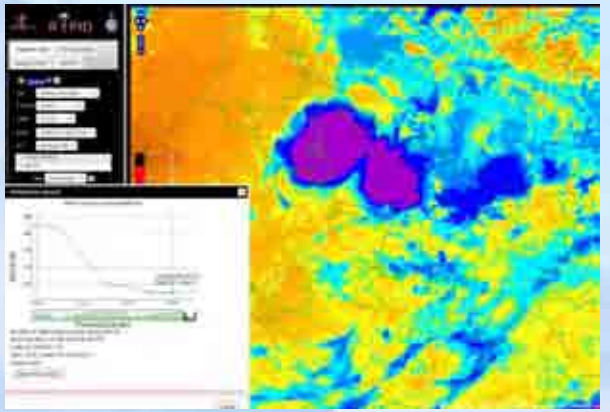




WV BT

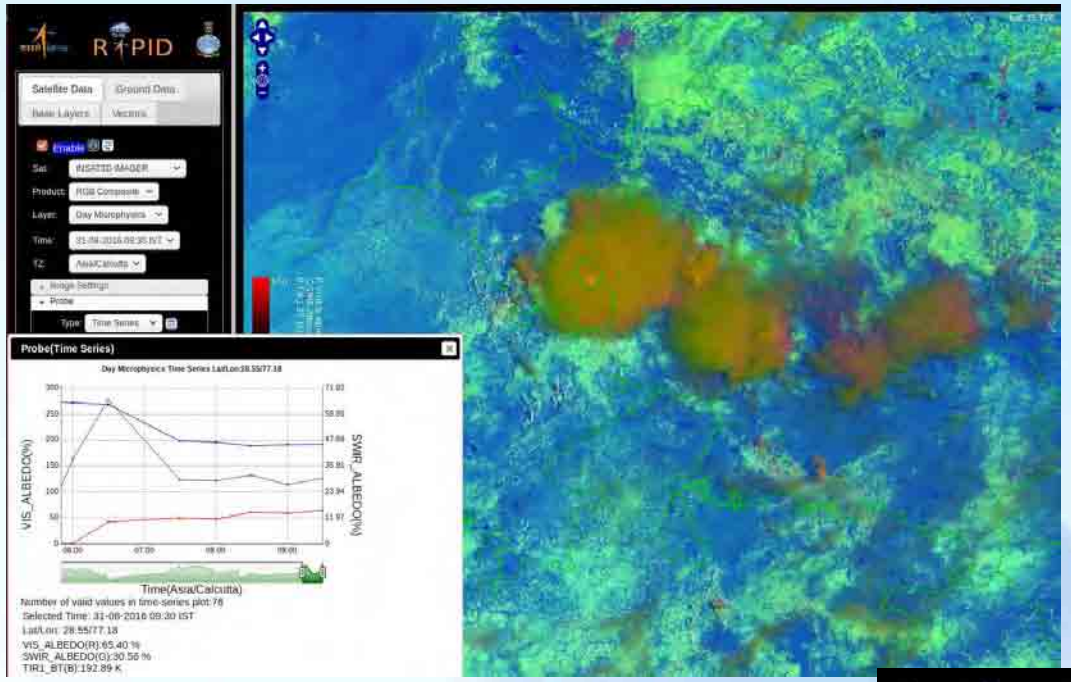


TIR1 BT



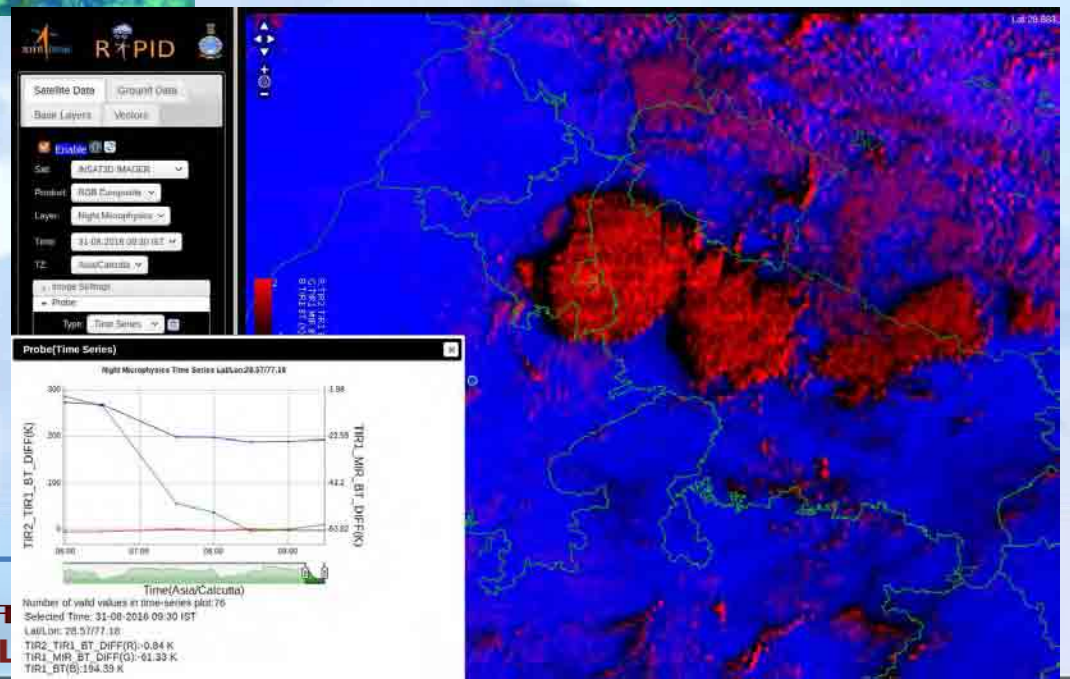
TIR2 BT

Time series Plot of Heavy Rain – Delhi 31st August 2016

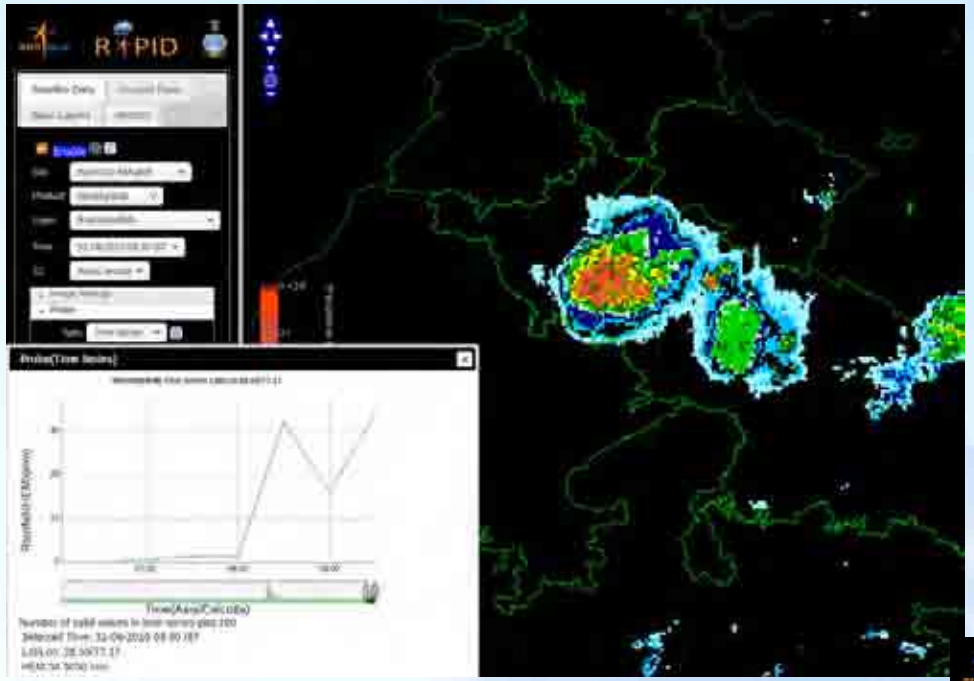


DMP showing fall in SWIR & rise in VIS Albedo & fall in TIR1 BT

NMP showing sharp fall in TIR1-MIR BT & TIR1 BT

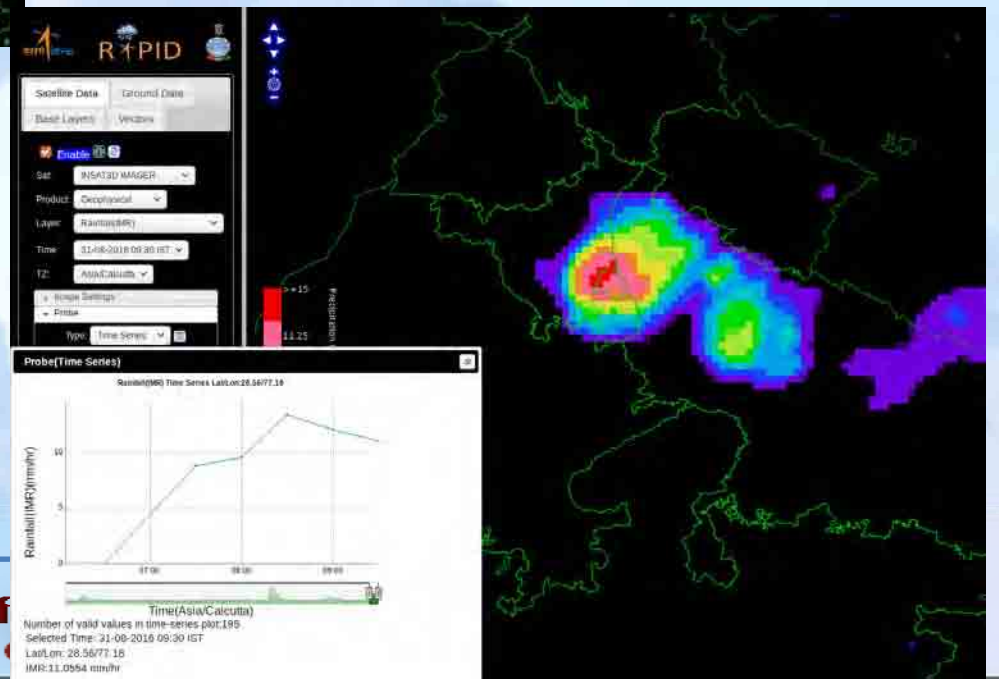


Time series Plot of Heavy Rain – Delhi 31st August 2016 Cont..

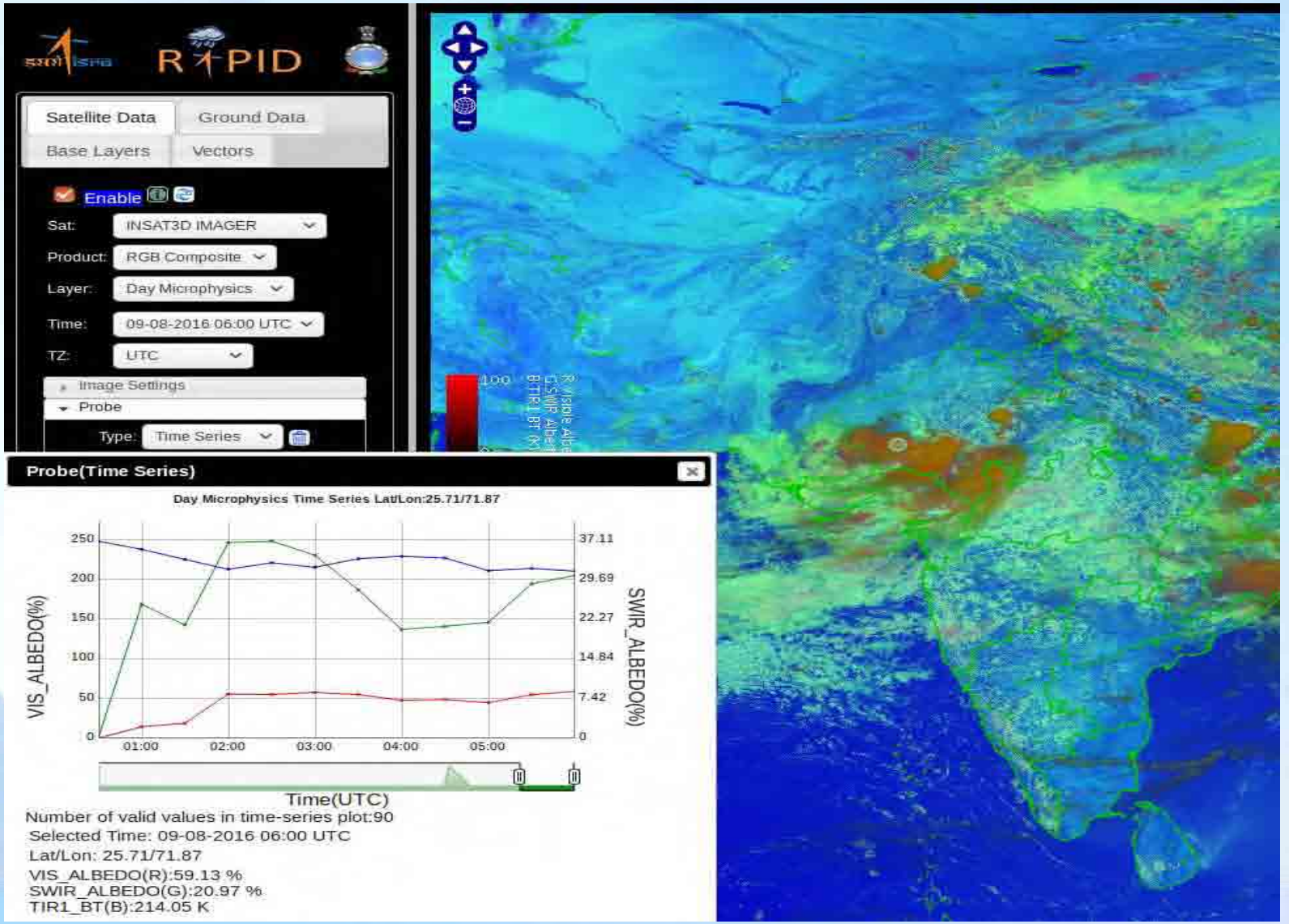


HEM showing estimated R/F

IMR showing estimated R/F

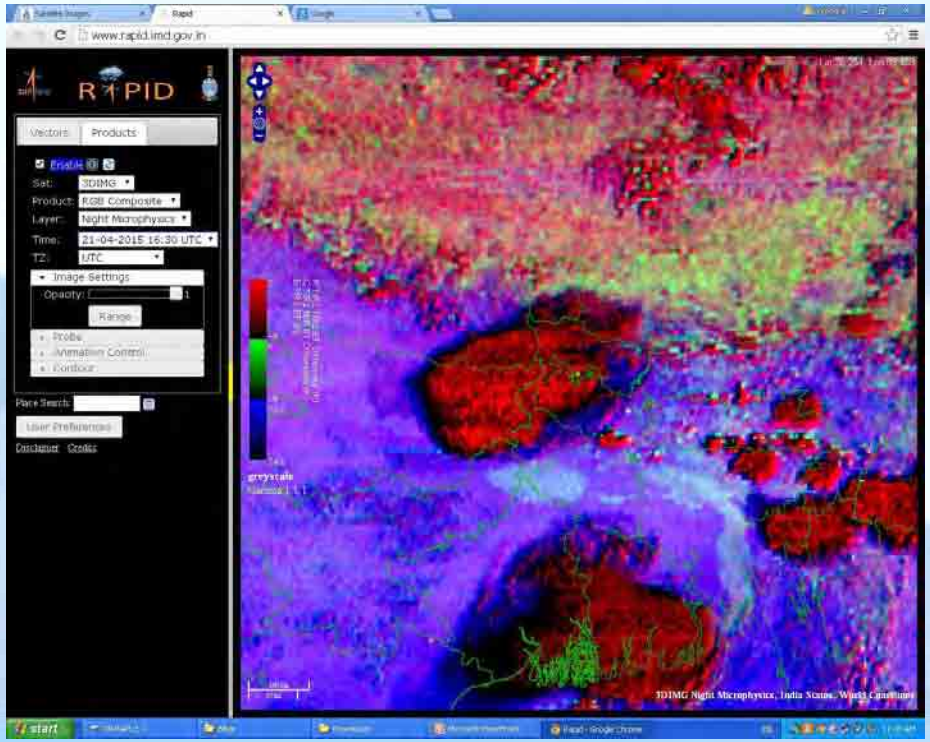


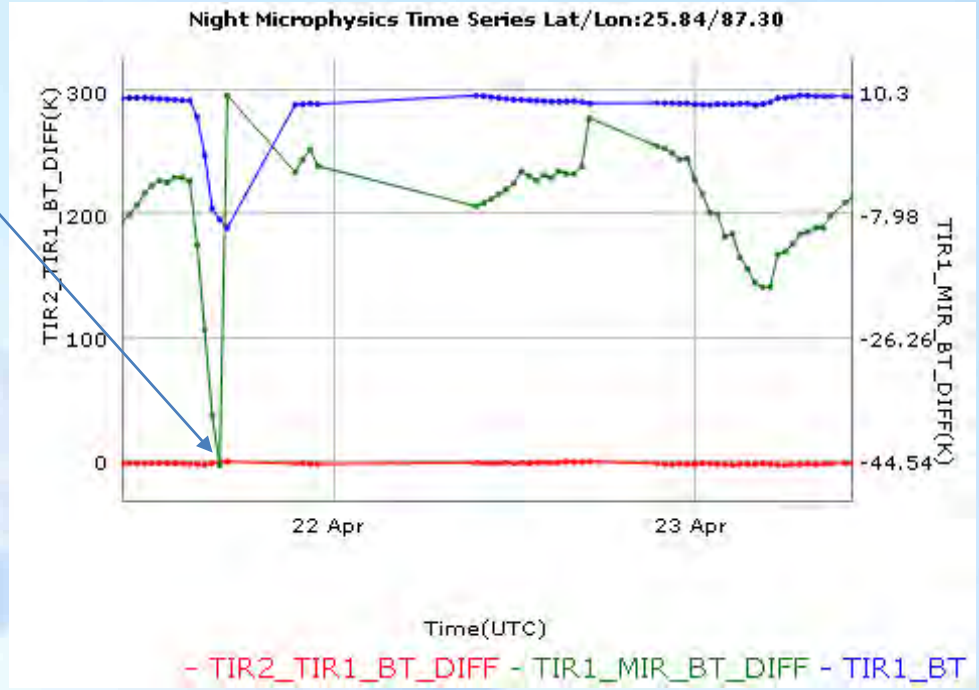
Heavy Rainfall in Jodhpur 9-11 August 2016(DMP)



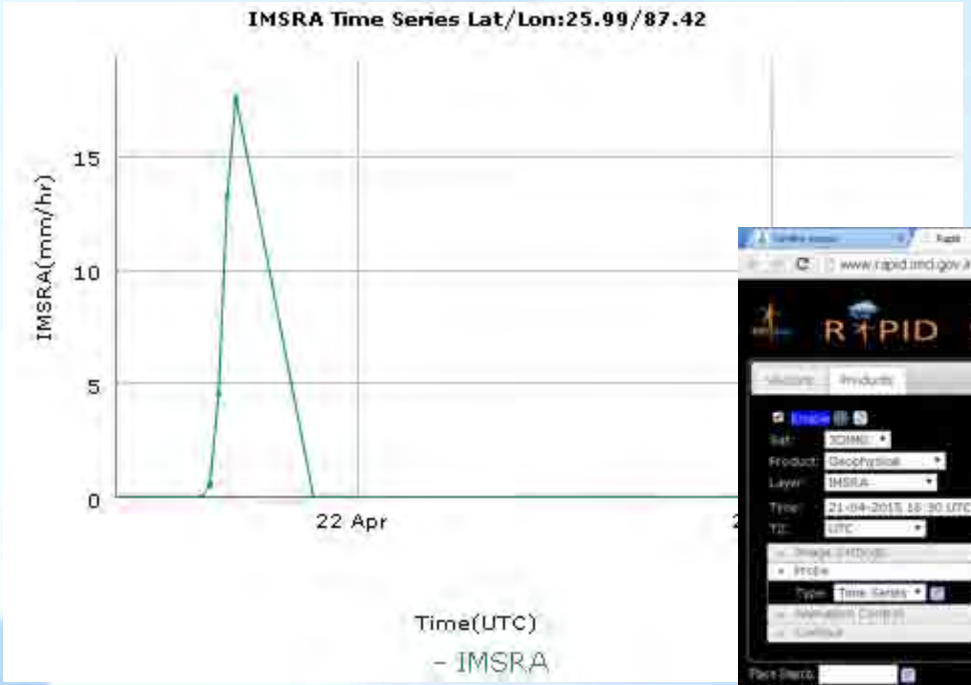
Time series plot of NMP at 25.84/87.30 of 21/04/2015 at 1430 UTC

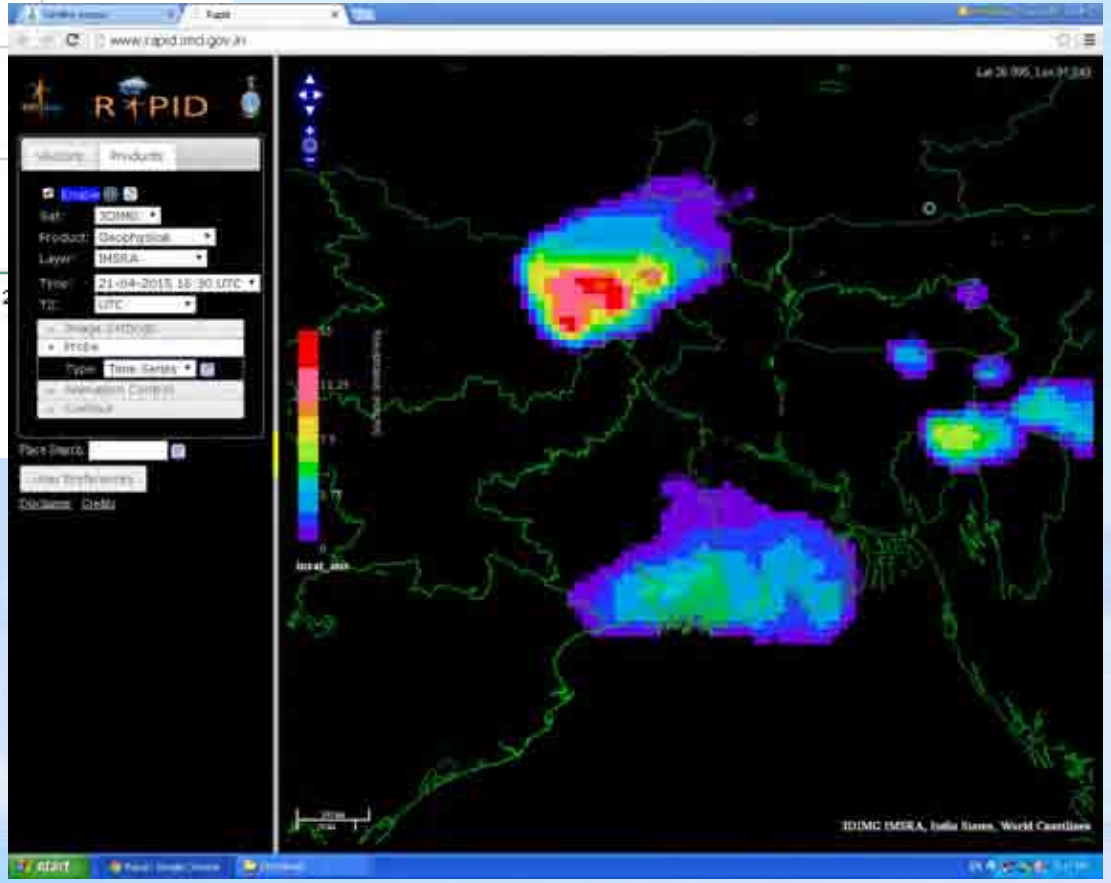
It can be seen that there is a sharp dip in TIR1-MIR BT indicating large instability.



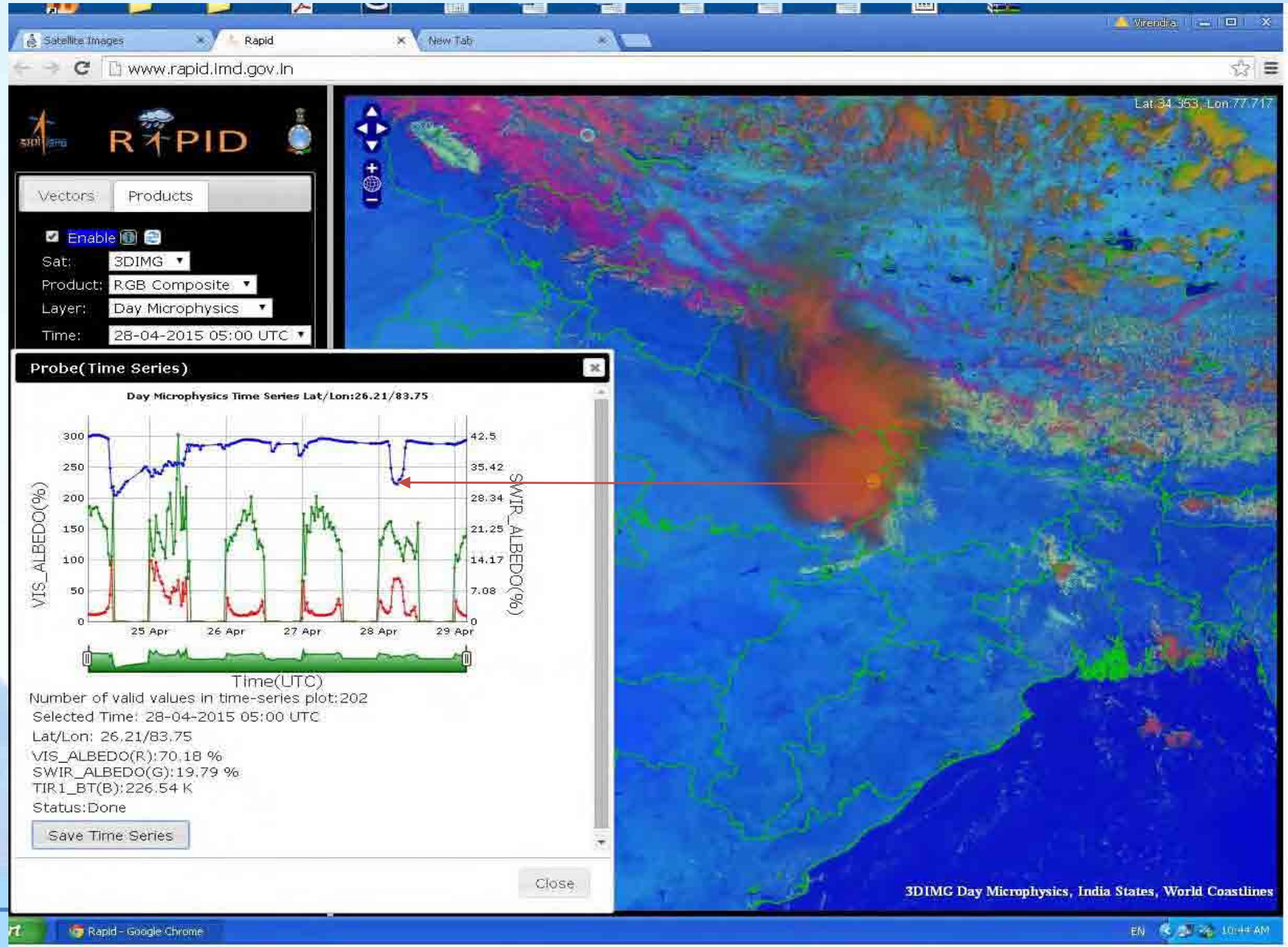


Time series plot of IMSRA at 25.99/87.42 and RAPID image of IMSRA of 1630 UTC on 21/04/2015

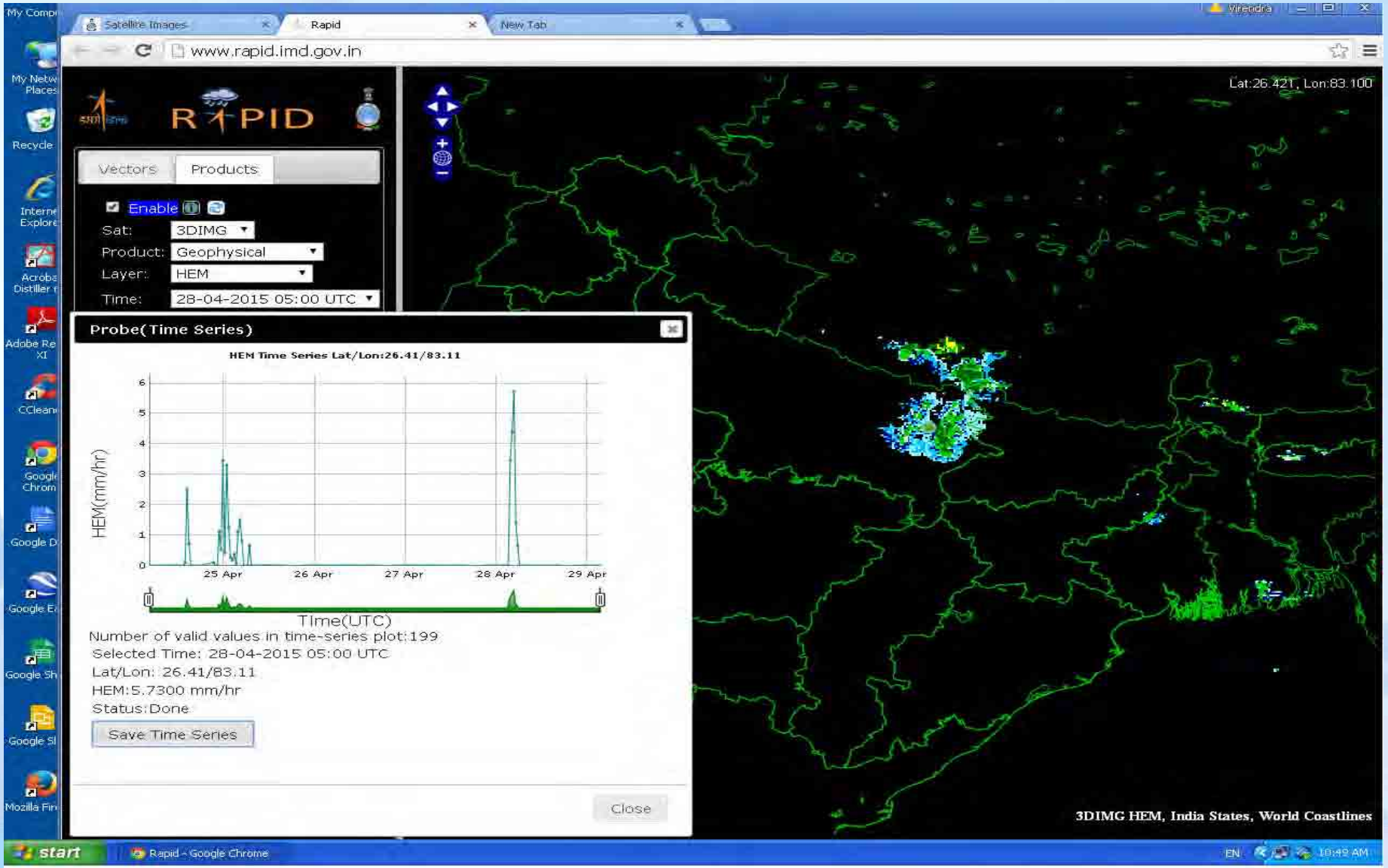


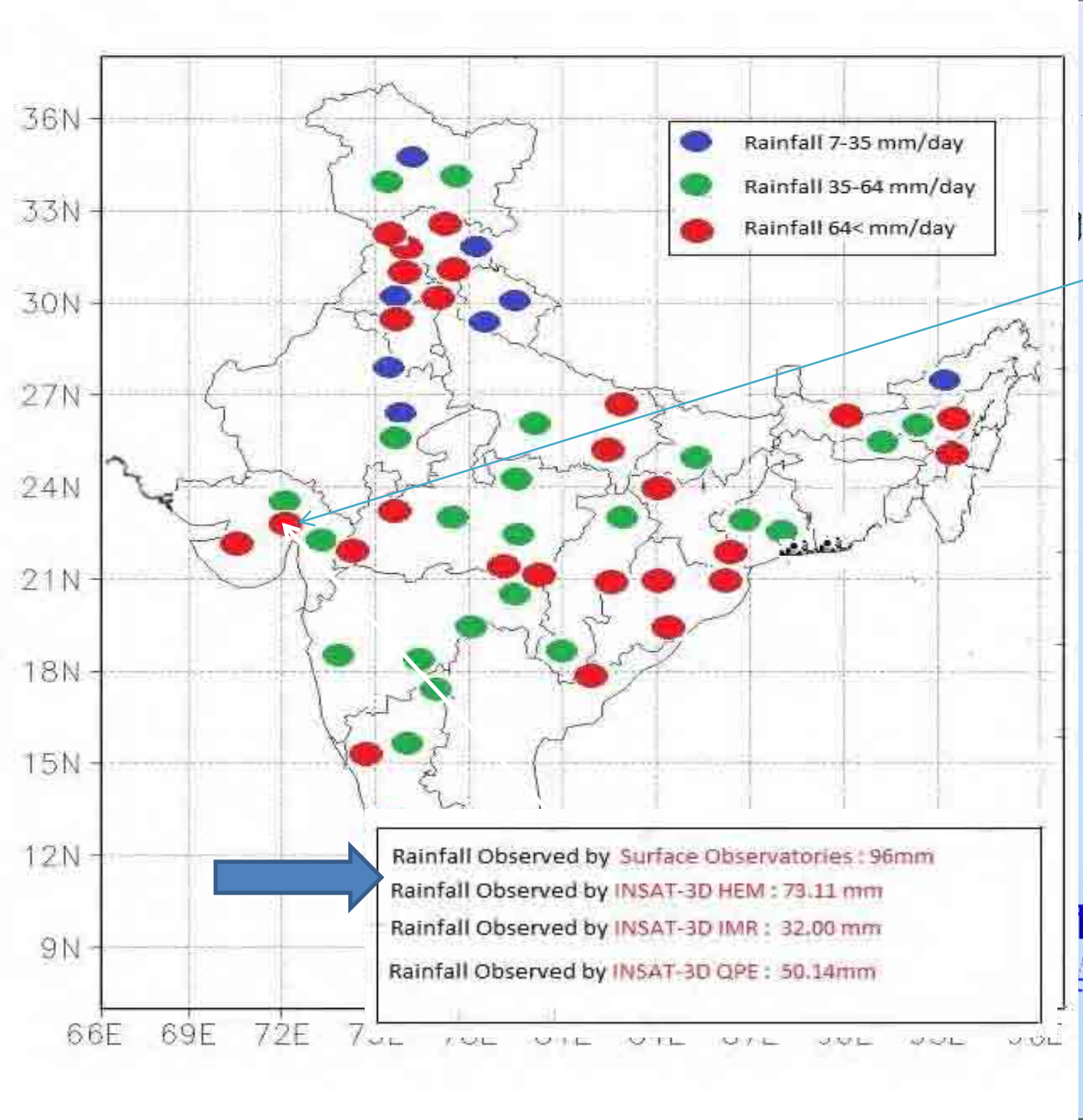


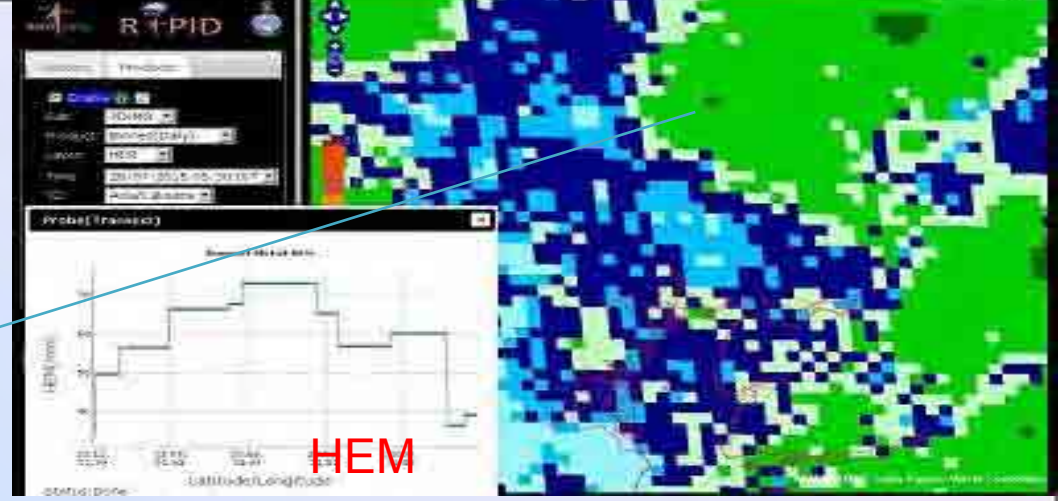
TS seen DMP of 28/04/2015 of 0500UTC over East UP



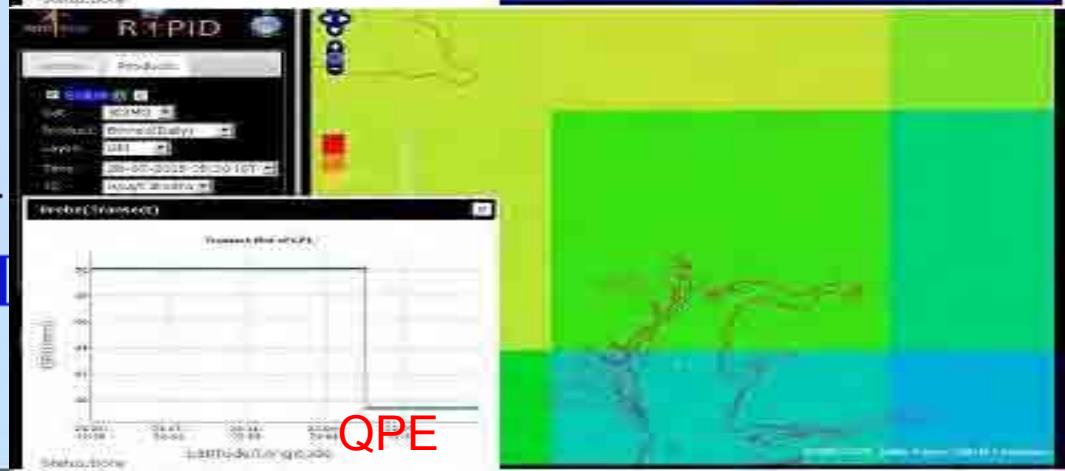
Time series of HE Rain rate of 28/04/2015 of 0500UTC over East UP

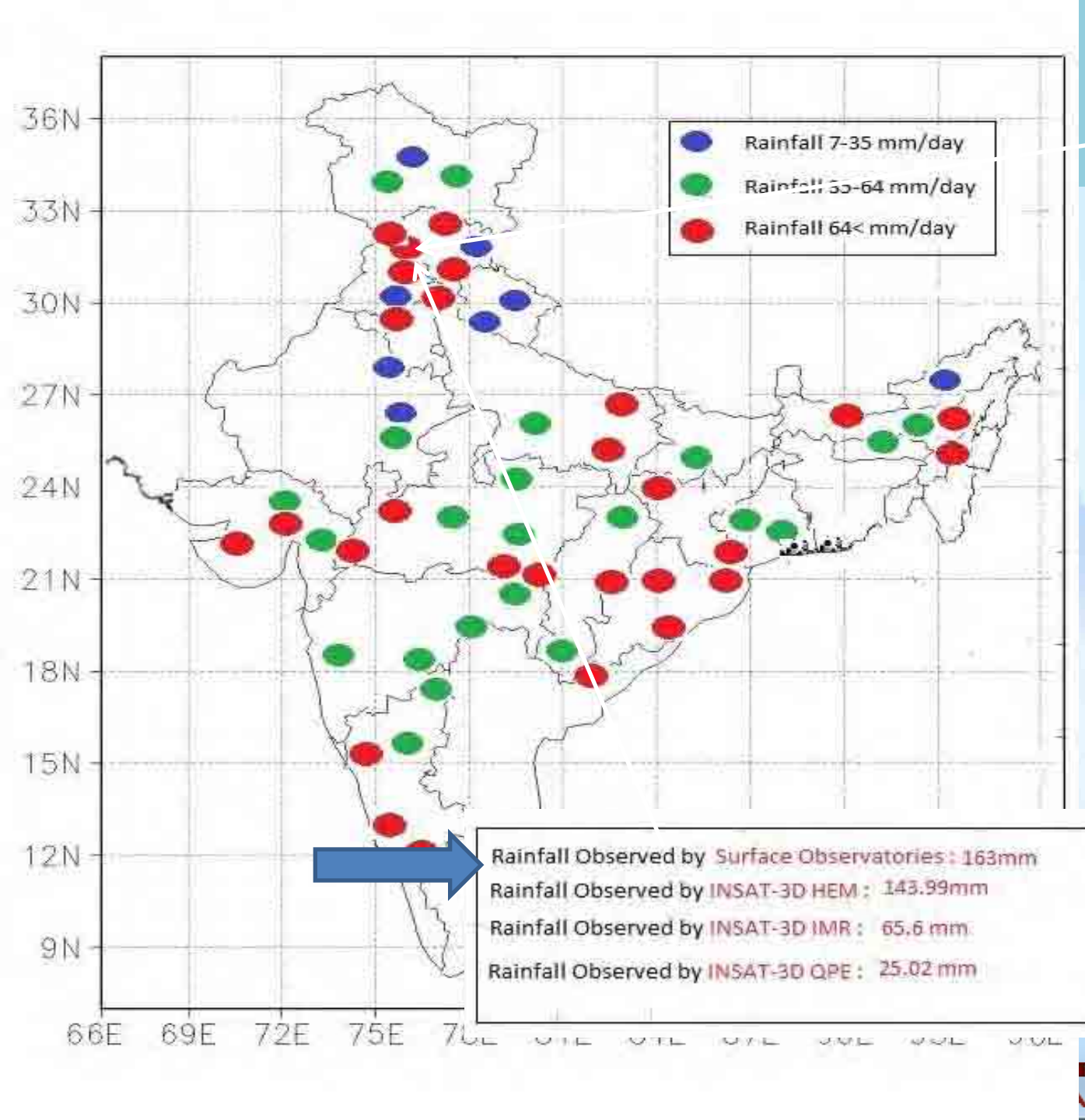


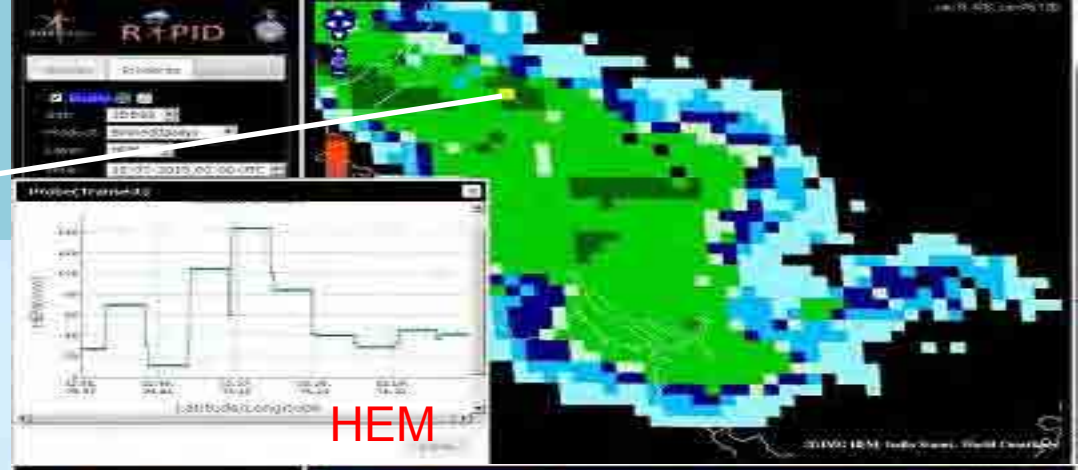

36N
33N
30N
27N
24N
21N
18N
15N
12N
9N
66E
69E
72E
Rainfall 7-35 mm/day
Rainfall 35-64 mm/day
Rainfall 64< mm/day
Rainfall Observed by Surface Observatories : 96mm
Rainfall Observed by INSAT-3D HEM : 73.11 mm
Rainfall Observed by INSAT-3D IMR : 32.00 mm
Rainfall Observed by INSAT-3D QPE : 50.14mm

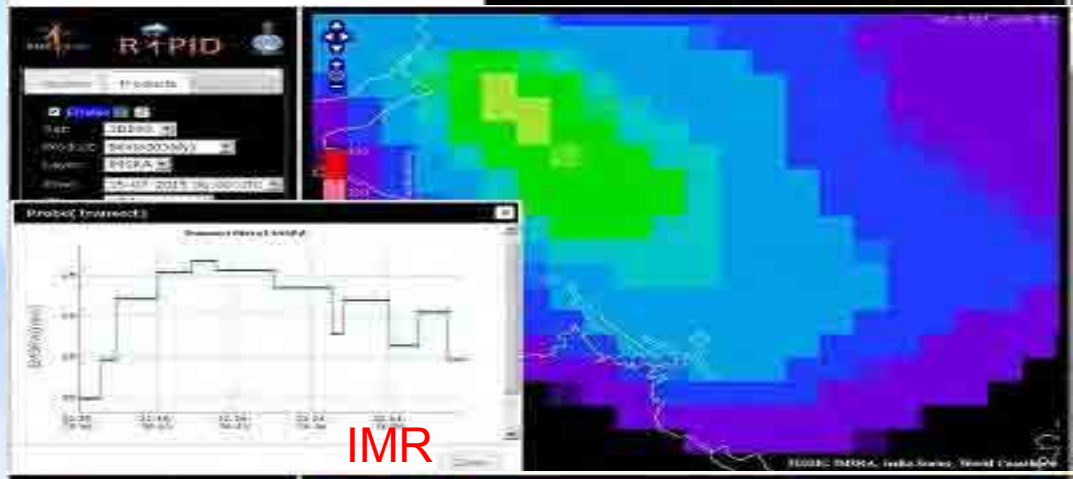

RAPID
HEM

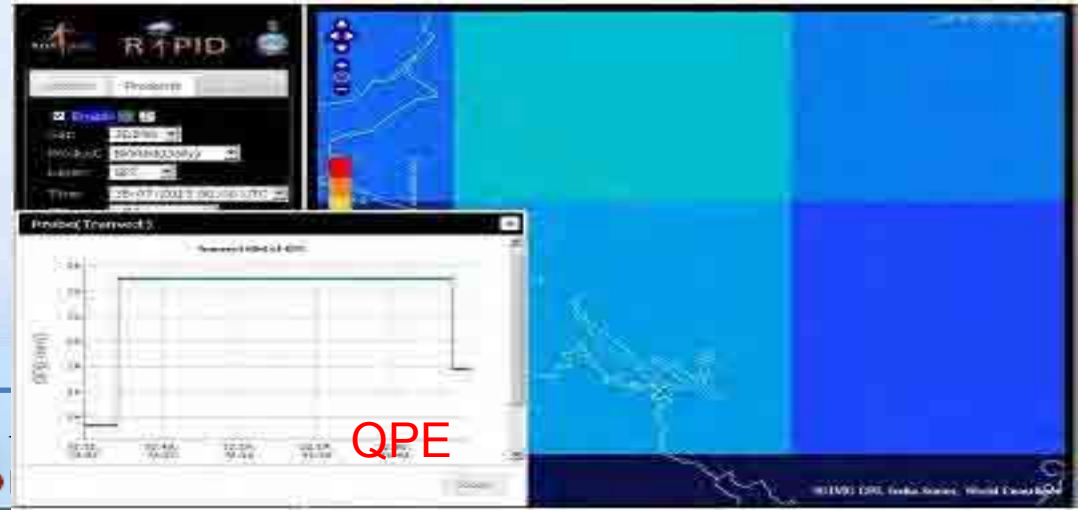

RAPID
IMR

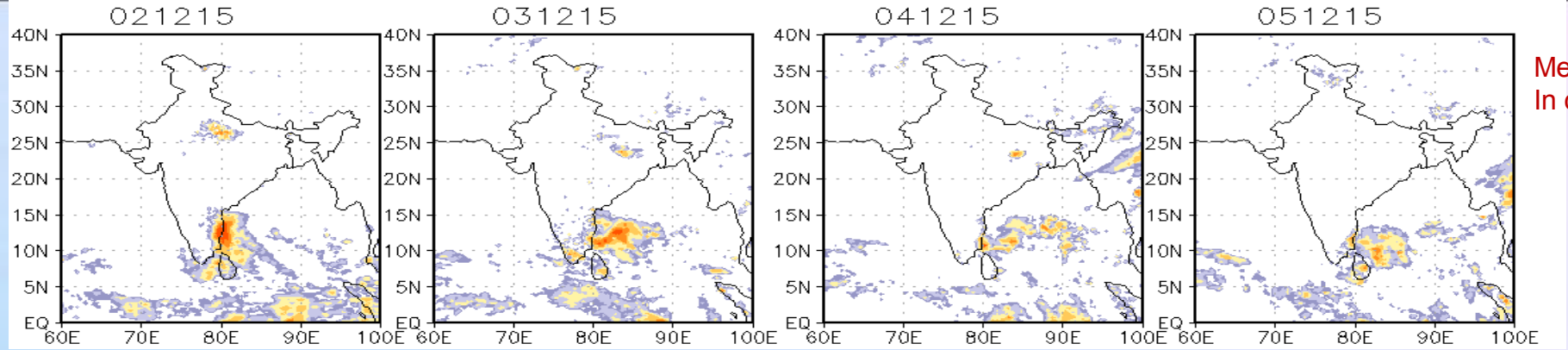

RAPID
QPE


Rainfall 7-35 mm/day
Rainfall 35-64 mm/day
Rainfall 64< mm/day
36N
33N
30N
27N
24N
21N
18N
15N
12N
9N
66E
69E
72E
75E
Rainfall Observed by Surface Observatories : 163mm
Rainfall Observed by INSAT-3D HEM : 143.99mm
Rainfall Observed by INSAT-3D IMR : 65.6 mm
Rainfall Observed by INSAT-3D QPE : 25.02 mm

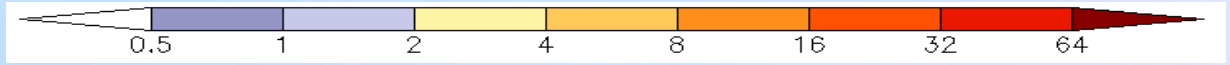

RAPID
HEM


RAPID
IMR

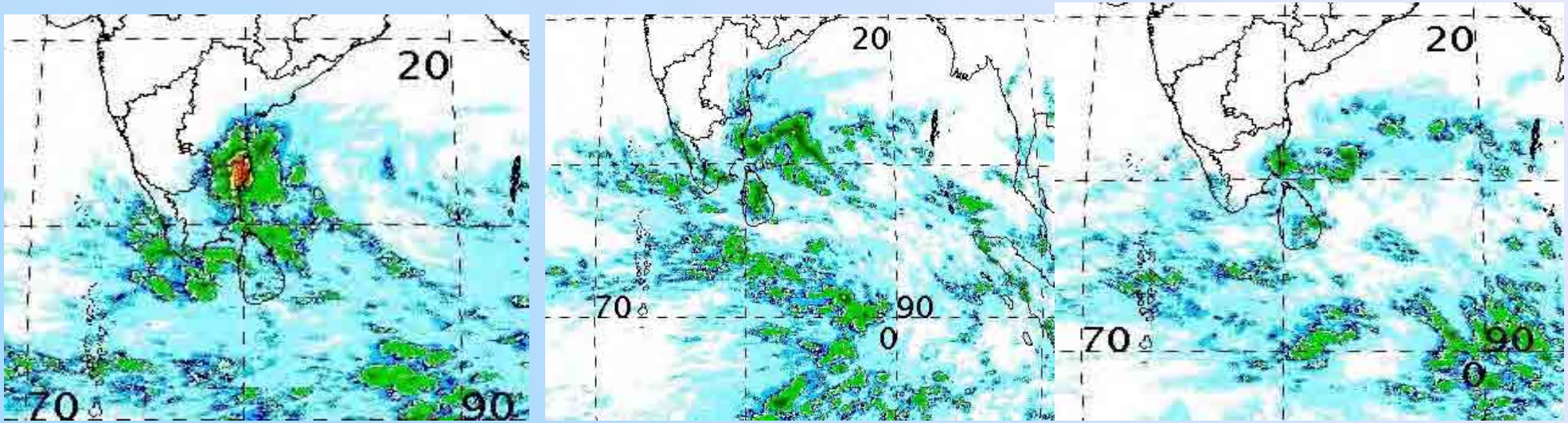

RAPID
QPE



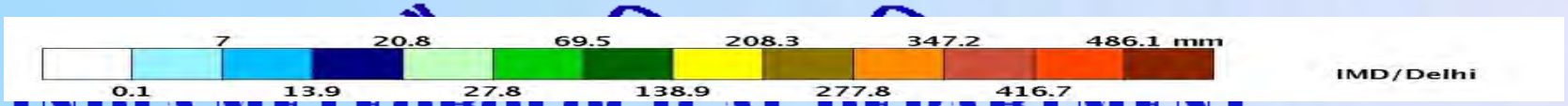
Merged Rainfall (GPM)
In cm



INSAT Hydro Estimator Rainfall



01/12/15 02/12/15 03/12/15



INDIA METEOROLOGICAL DEPARTMENT

Identification of SNOW in RGB Imagery and RAPID

In day time micro physics RGB imagery **Snow** look like this

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Snow pixels** value lies in the following range,

VIS Albedo	>35 %
SWIR Albedo	<20 %
TIR1	260°K to 280 °K

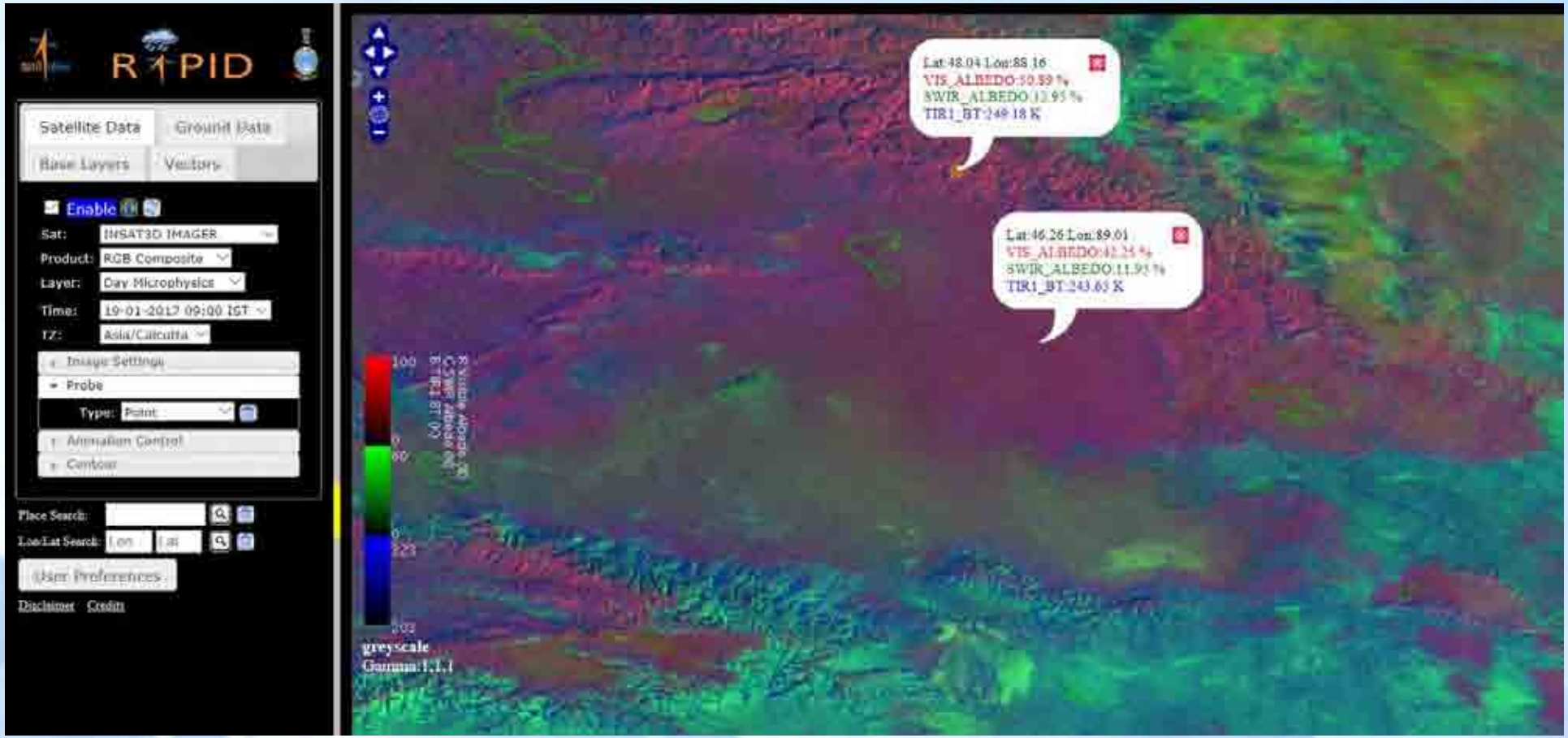
In night time microphysics RGB imagery, **Snow** look like this.

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Snow pixel** value lies in the following range,

TIR2BT – TIR1BT	Negative
TIR1BT - MIRBT	Negative
TIR1BT	260°K to 290°K

Note: However these ranges may change from place to place and over time, user may work out the values of their areas.

Identification of SNOW in RGB Imagery and RAPID



Identification of SAND/DUST in RGB Imagery and RAPID

In day time micro physics RGB imagery **Sand / Dust** look like this

If Day-time Microphysics RGB is viewed and analyzed through RAPID, the **Sand / Dust pixels** value lies in the following range,

	Sand	**Dust**
VIS Albedo	20% to 30%	20% to 30%
SWIR Albedo	40% to 70%	30% to 40%
TIR1	290°K to 320 °K	275°K to 295 °K

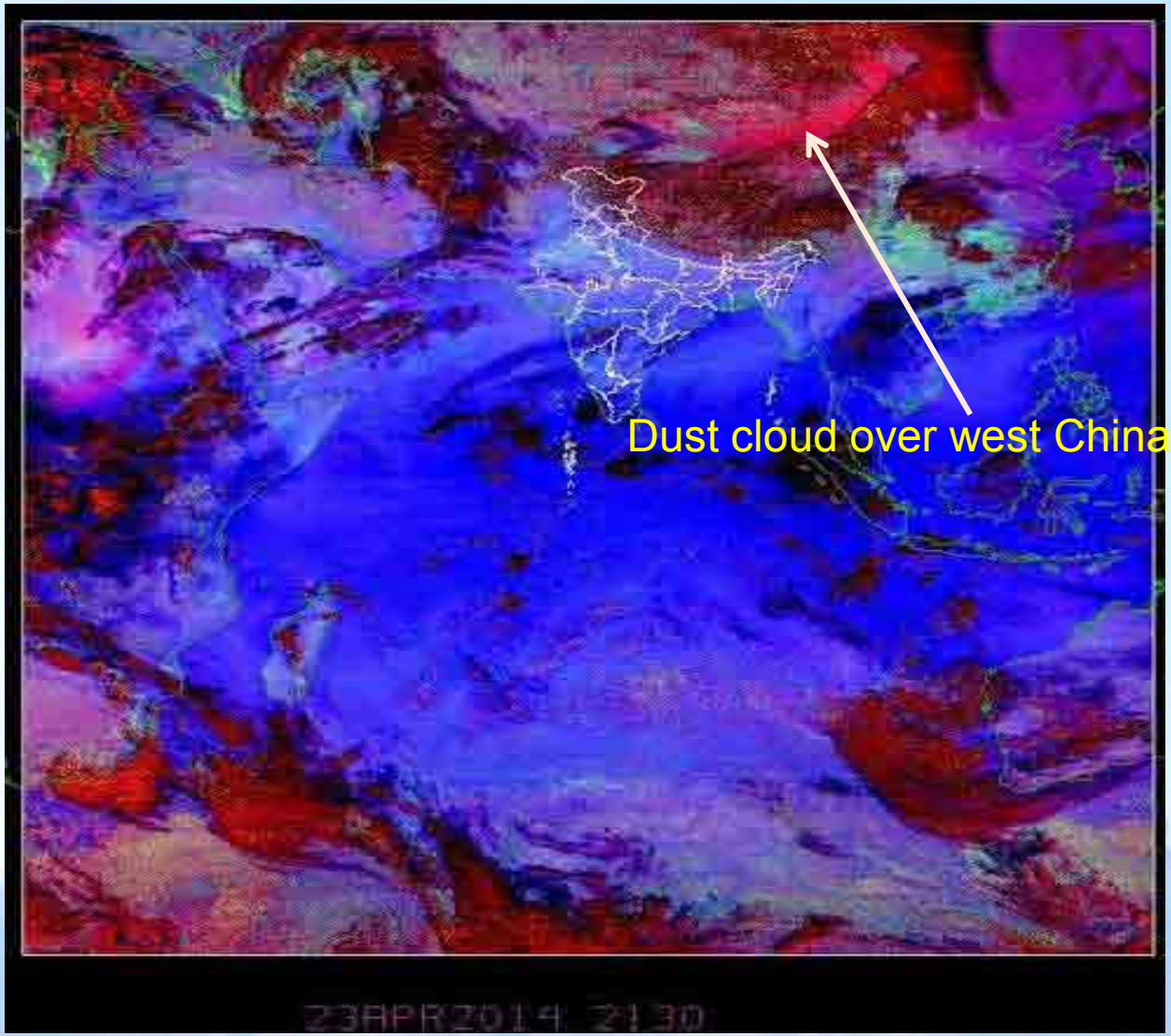
In night time microphysics RGB imagery, **Sand / Dust** look like this.

If Night-time Microphysics RGB is viewed and analyzed through RAPID, the **Sand / Dust pixel** value lies in the following range,

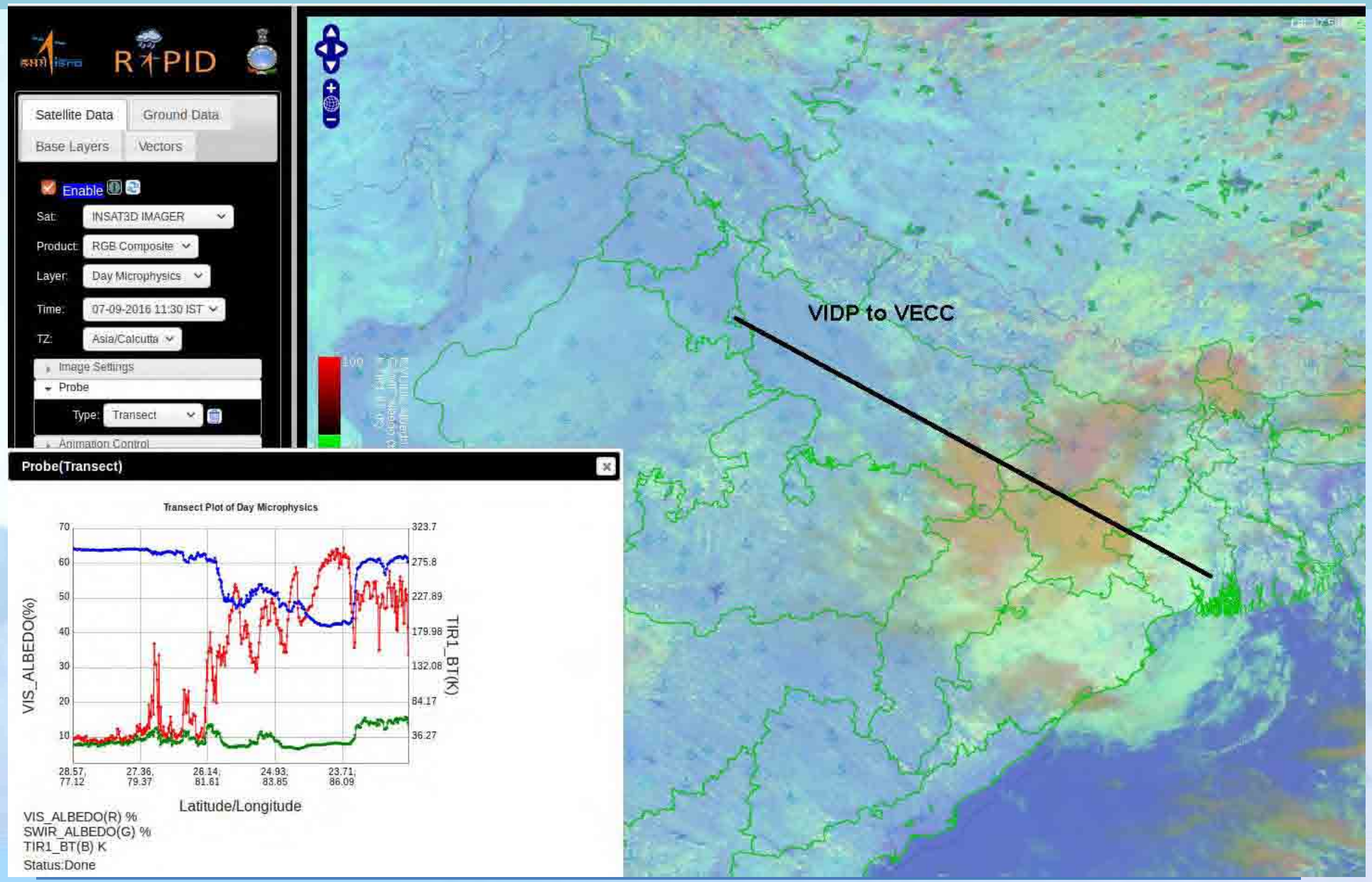
	Sand	**Dust**
TIR2BT – TIR1BT	Negative	Negative
TIR1BT - MIRBT	Negative	Negative
TIR1BT	280°K to 290°K	275°K to 285°K

Note: However these ranges may change from place to place and over time, user may work out the values of their areas.

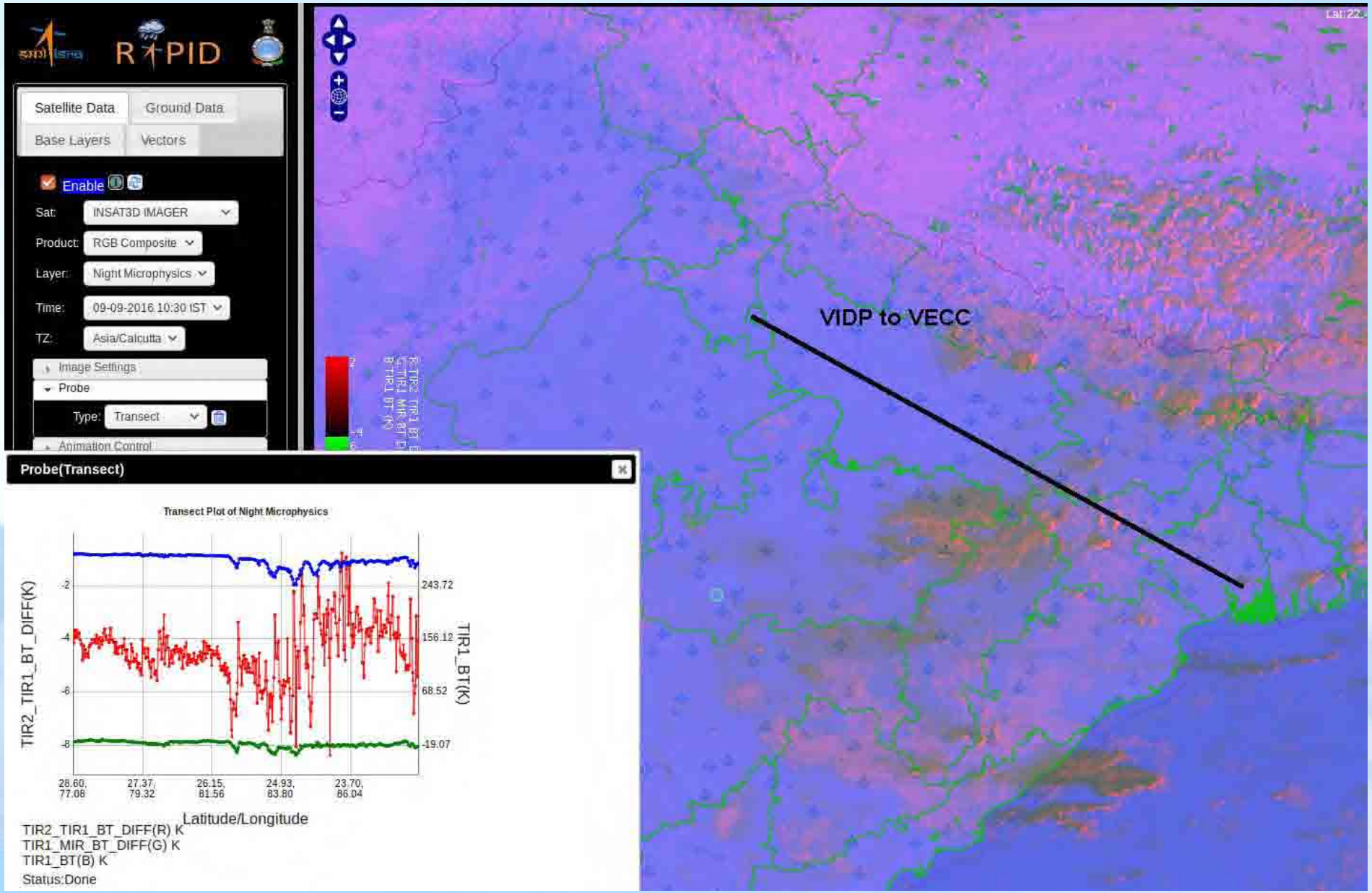
DUST in RGB Imagery



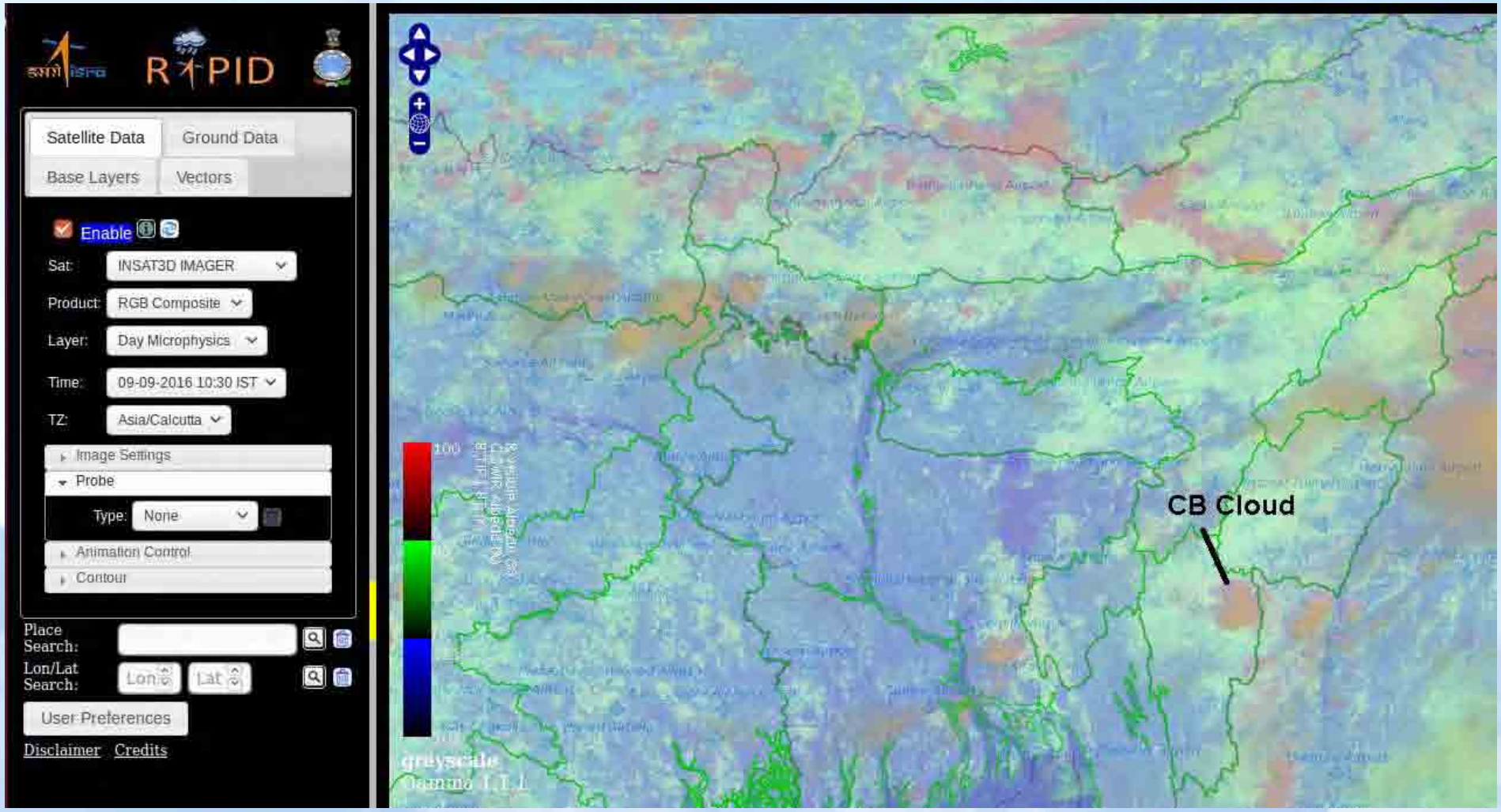
Route Transect view Day Microphysics(Aviation Purpose)



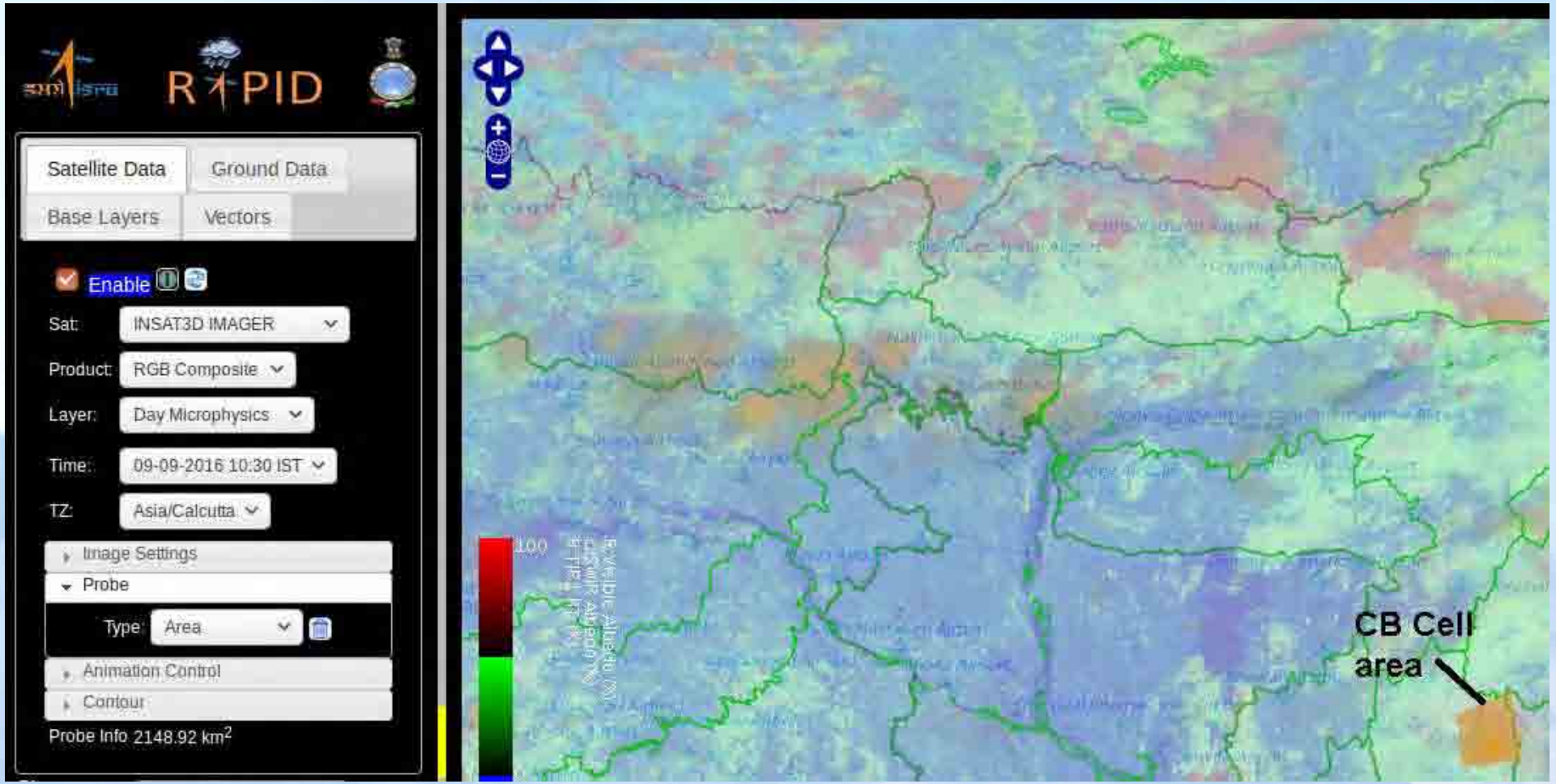
Route Transect view Night Microphysics(Aviation Purpose)



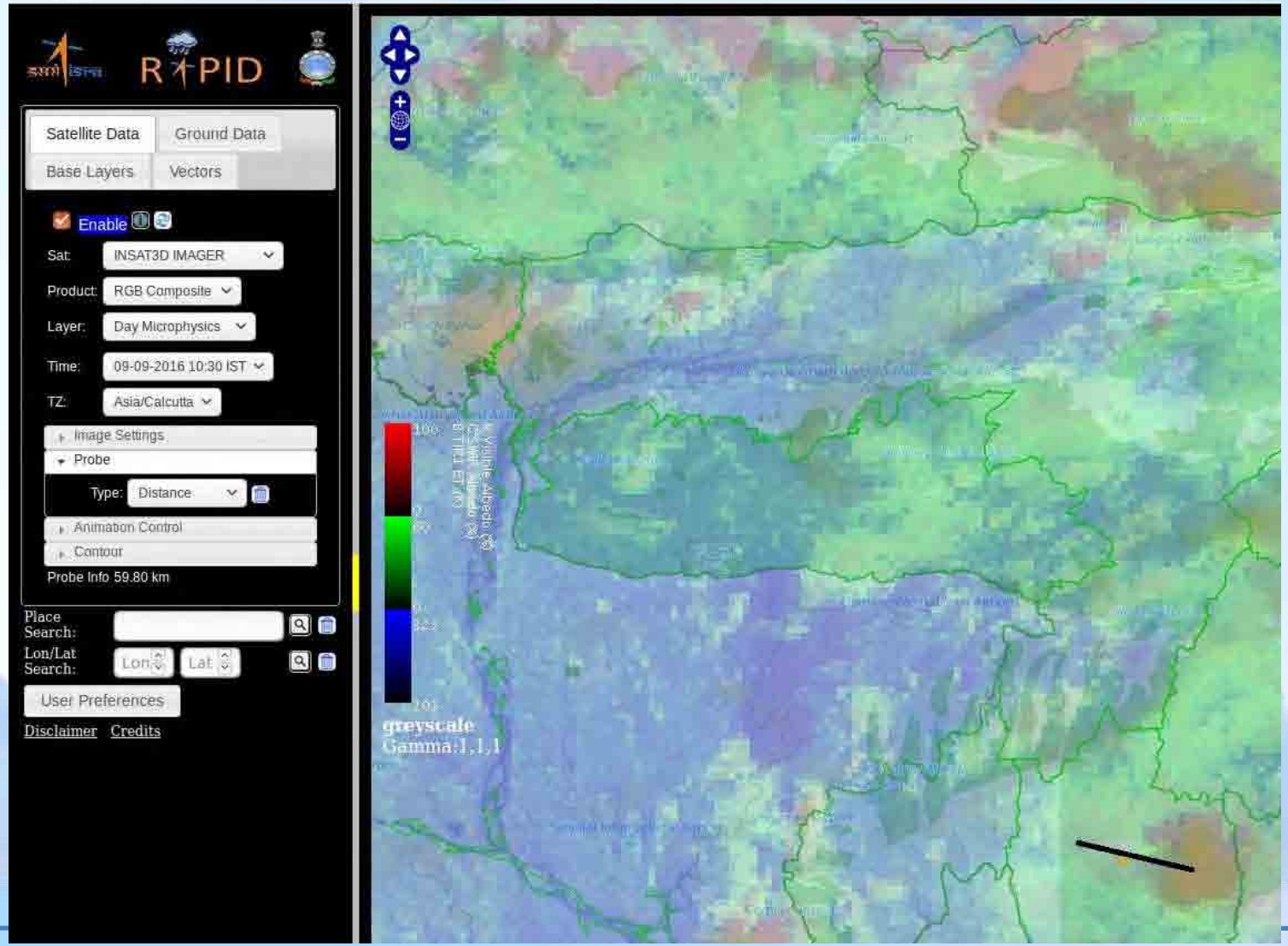
Area of CB Cloud to be calculate by selecting Aerodromes in Open Street Map base layer:



Area of CB Cloud Area of CB Cloud to be calculate by selecting Aerodromes in Open Street Map base layer:

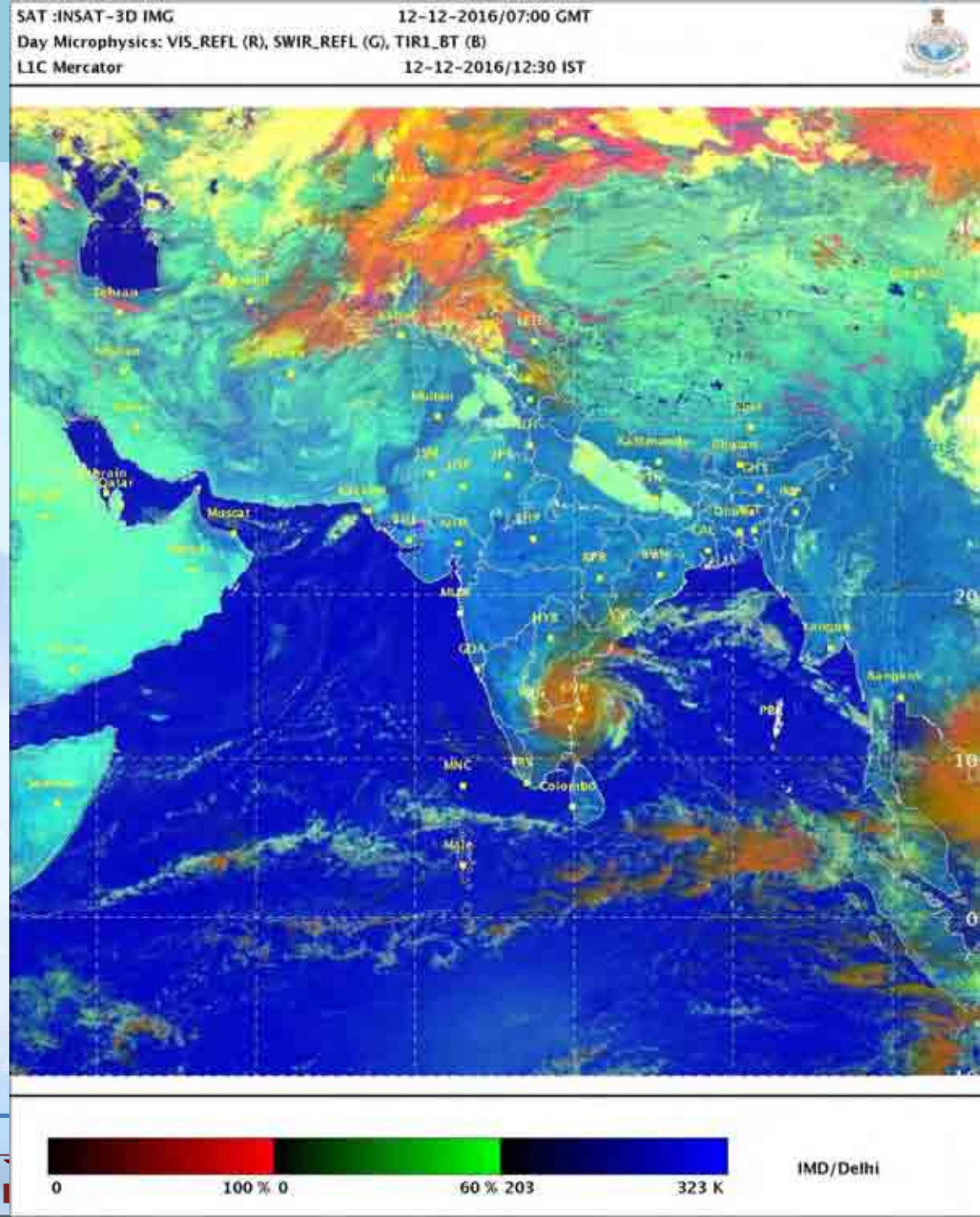


CB Cloud Distance from Aerodrome by selecting Aerodromes in Open Street Map base layer:

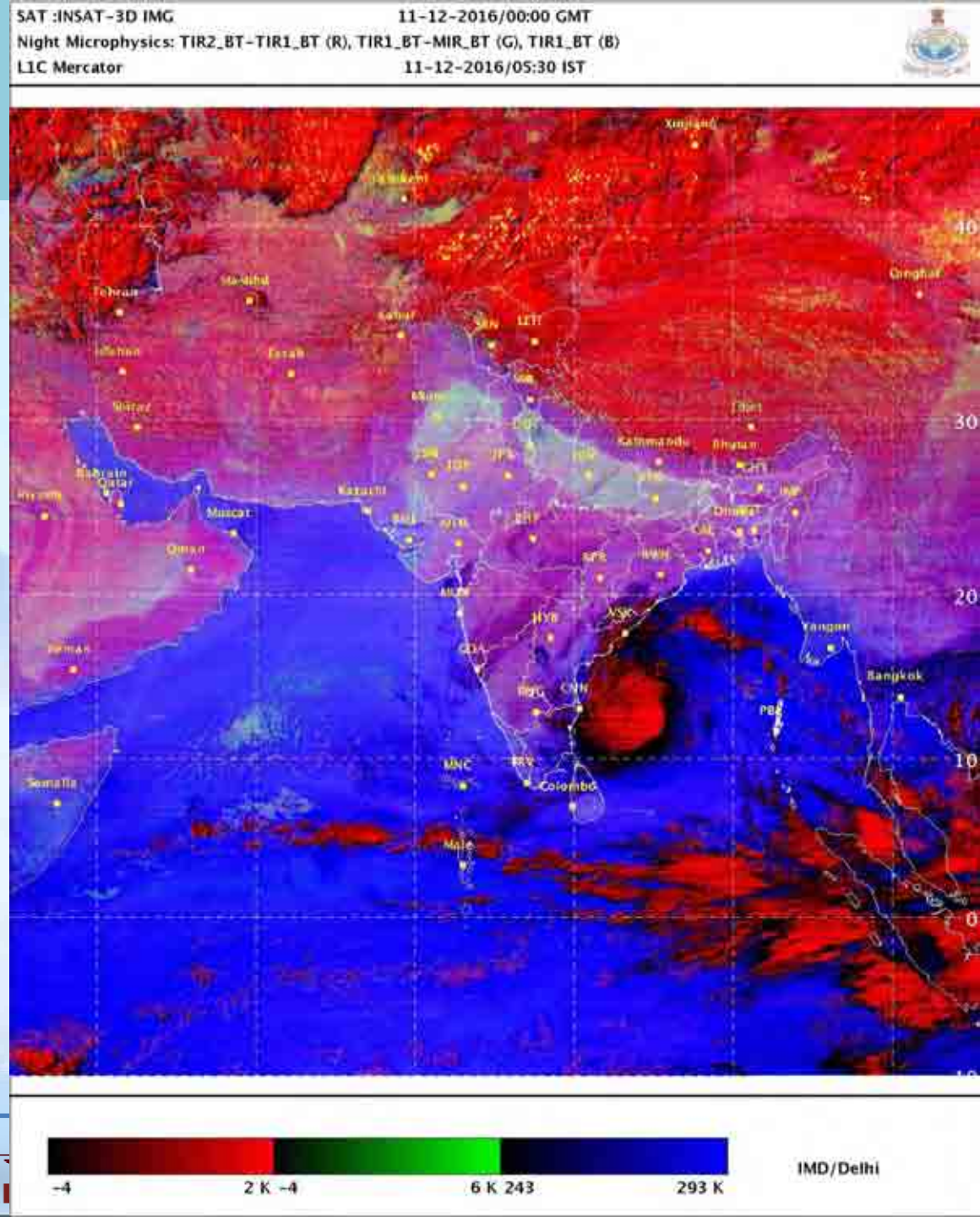


Fog & Vardah Cyclone

Fog over North India and Vardah Cyclone making landfall over South India



Vardah Cyclone & Fog Animation (11 – 13 Dec 2016)

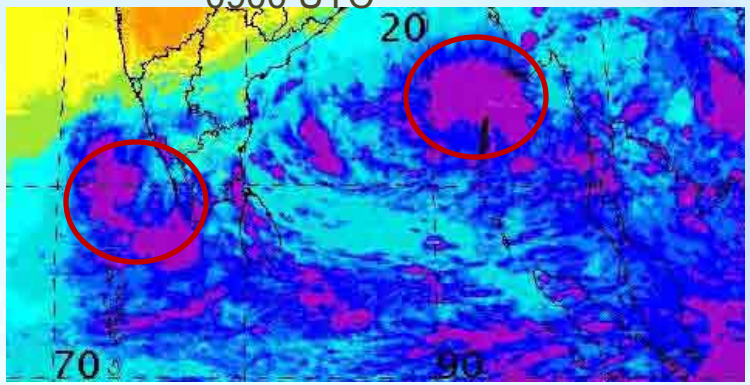


भारत मौसम विज्ञा
INDIA METEOROLOGICAL

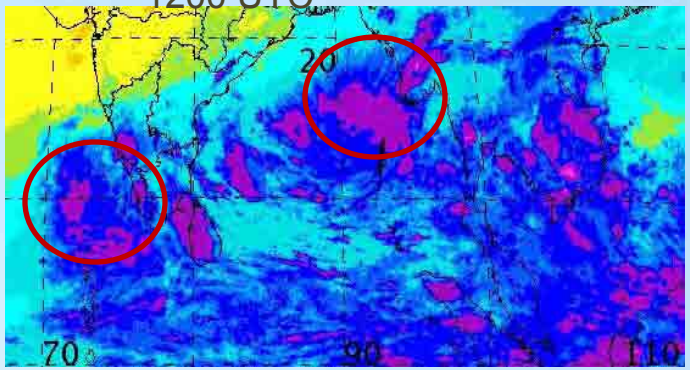
OLR and CTT Half hourly values for Weather Hazards

OLR Values (Half hourly/Hourly)

0900 UTC

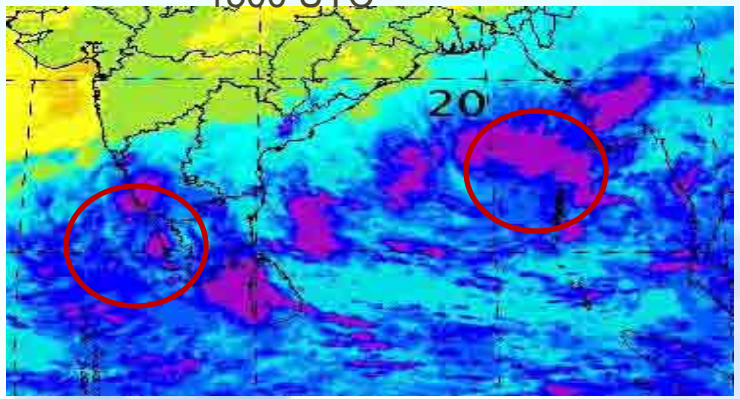


1200 UTC

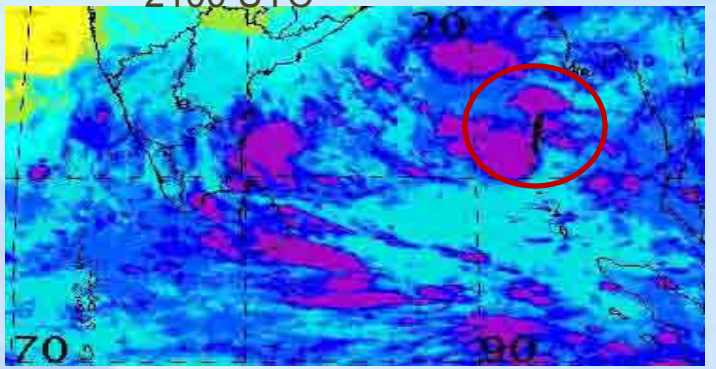


Deep convective clouds are usually identified by their cold cloud tops which emit low values of outgoing longwave radiation (OLR)

1500 UTC



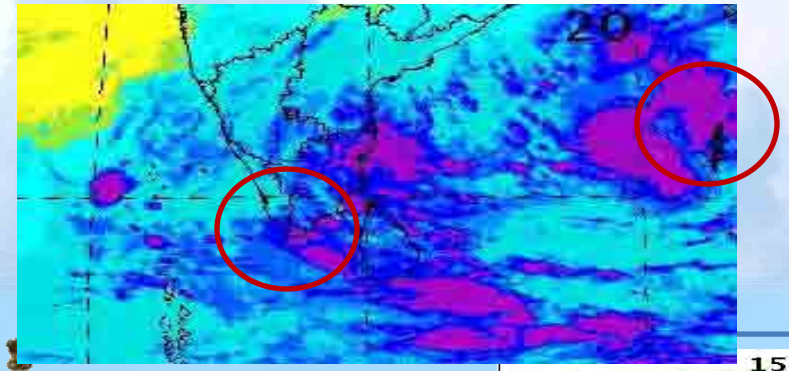
2100 UTC



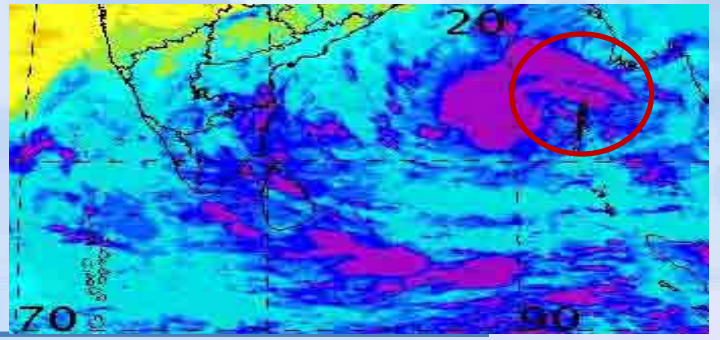
OLR Values
Less than

< 150-160

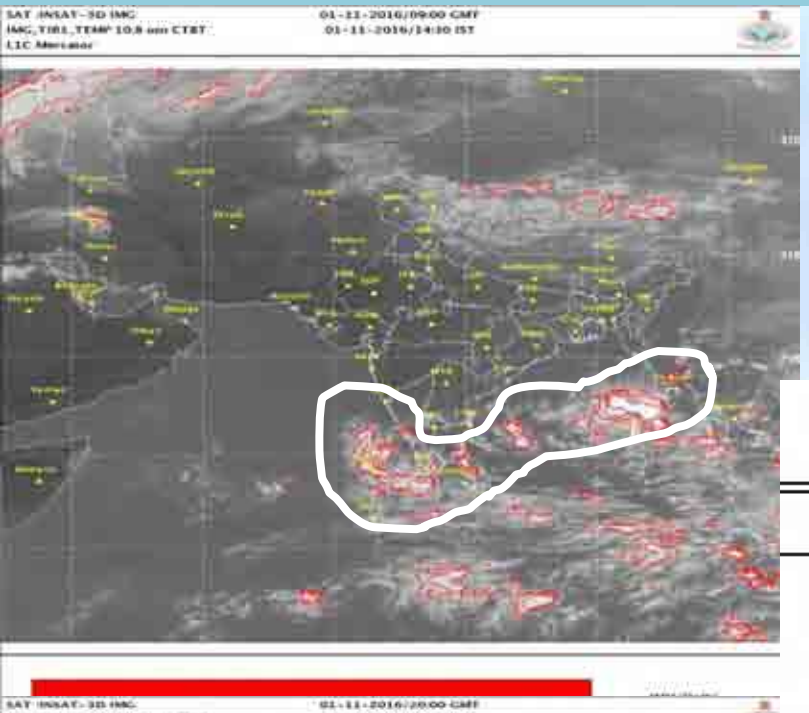
2 Nov, 0000 UTC



2 Nov, 0300 UTC



CTT Values (Half hourly/Hourly)



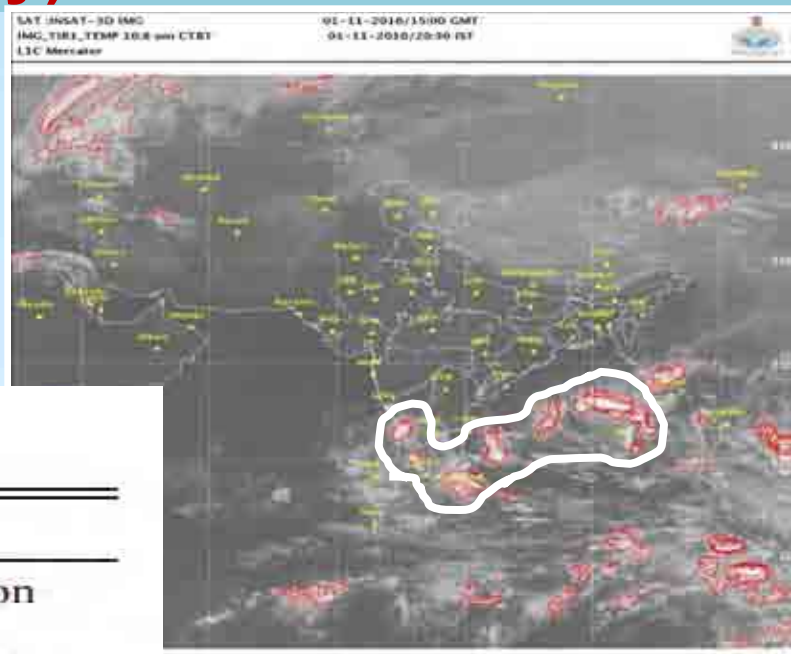
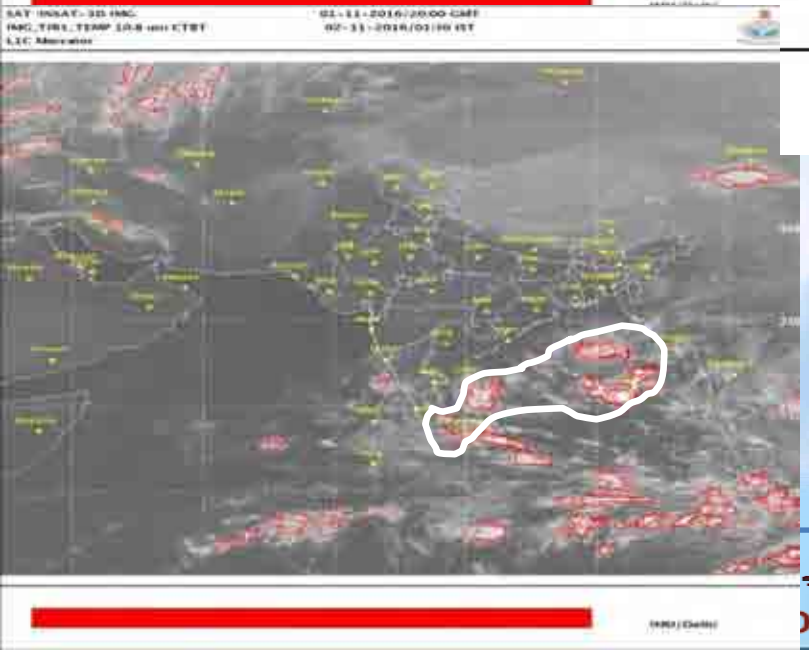


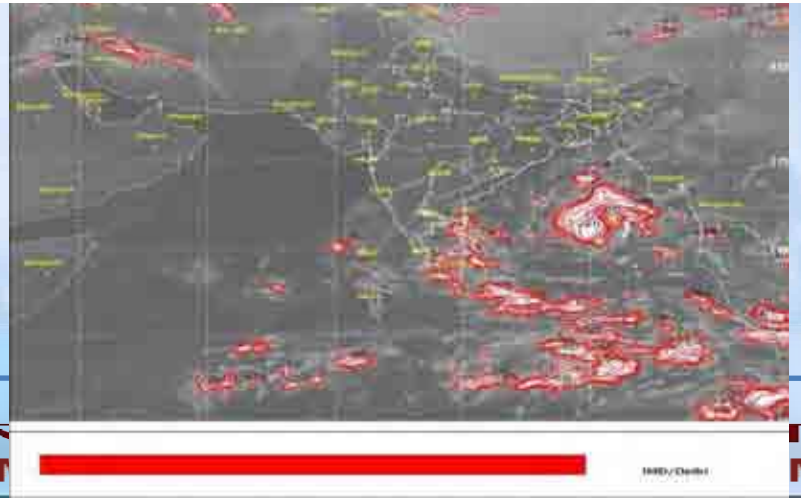
TABLE 1. Cloud classification

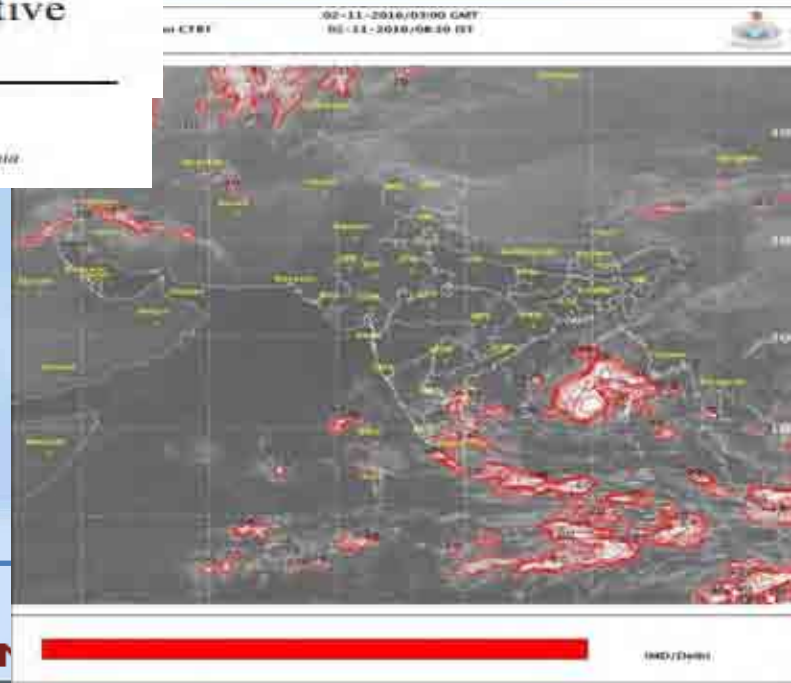
Cloud-top temperature	Comments
$T_{top} \leq 220$ K	Very deep convection
220 K $< T_{top} \leq 235$ K	Deep convection
235 K $< T_{top} \leq 255$ K	Background convective Cloudiness

RÉMY ROCA+ AND V. RAMANATHAN

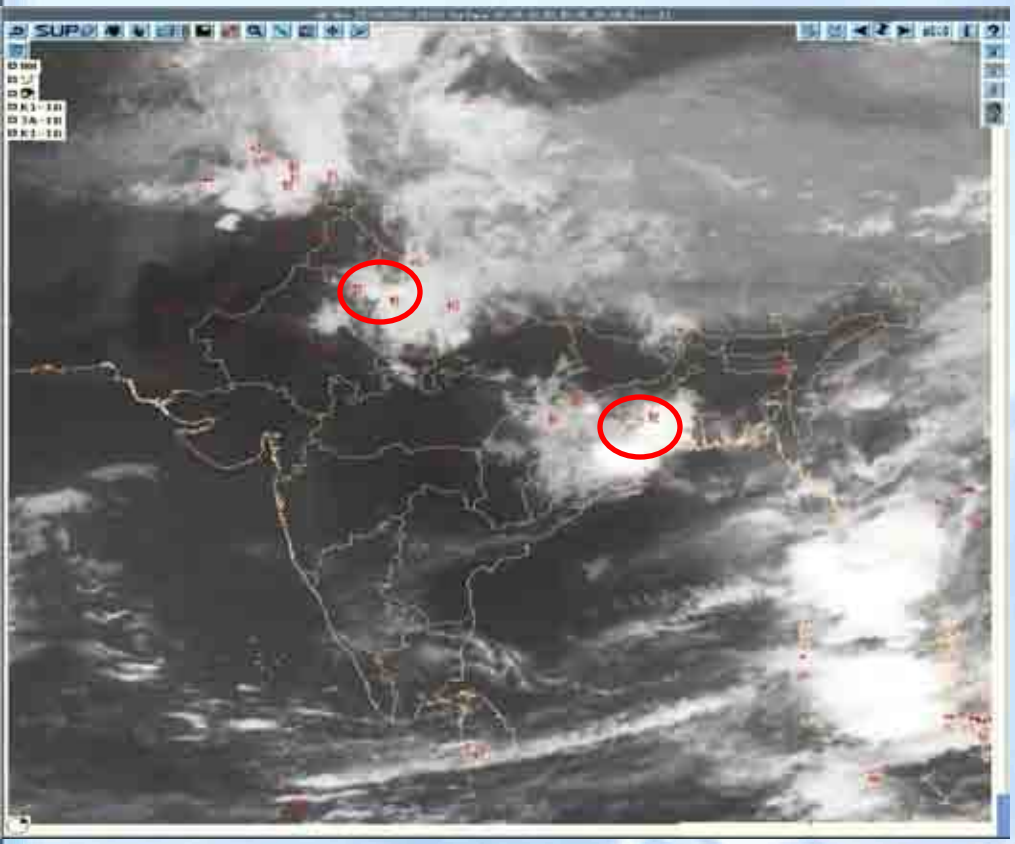
Center for Cloud Chemistry and Climate, Scripps Institution of Oceanography, La Jolla, California

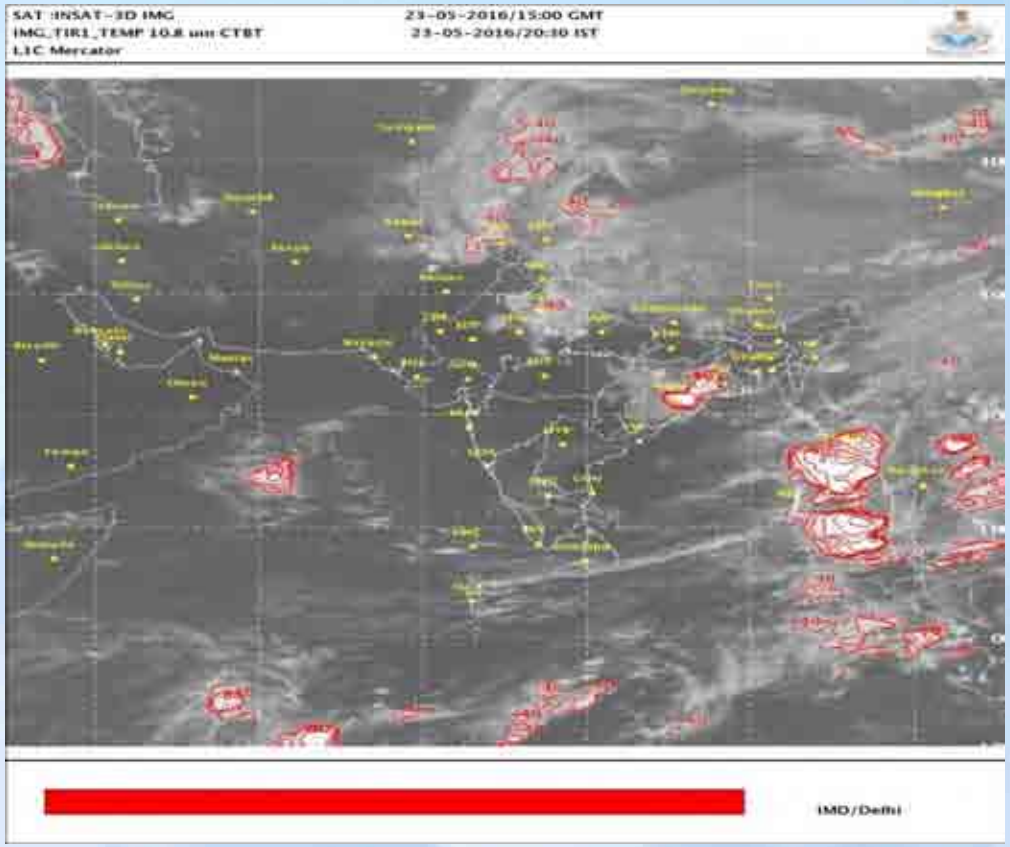






Thunderstorm reported on 23rd may 2016 at 1500 UTC

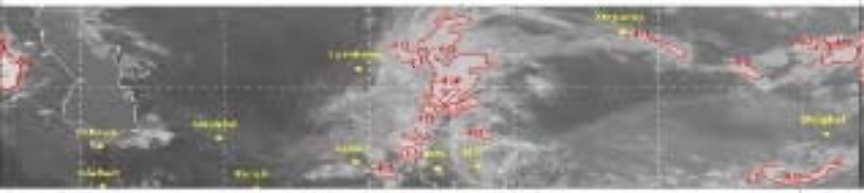


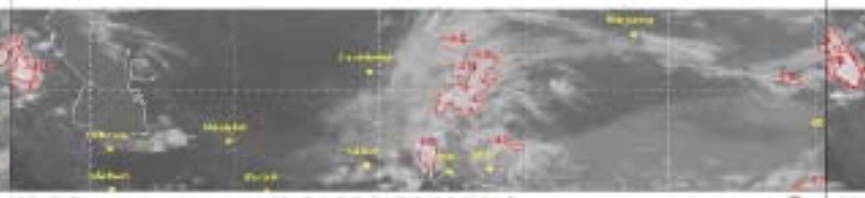


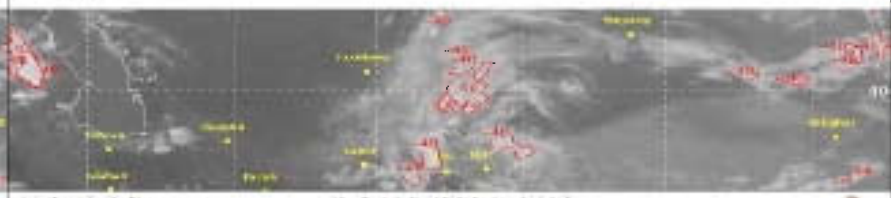
SAT :INSAT-3D IMG 23-05-2016/12:00 GMT
IMG_TIR1_TEMP 10.8 um CT&T 23-05-2016/17:30 IST
L1C Mercator

SAT :INSAT-3D IMG 23-05-2016/13:00 GMT
IMG_TIR1_TEMP 10.8 um CT&T 23-05-2016/18:30 IST
L1C Mercator

SAT :INSAT-3D IMG 23-05-2016/14:00 GMT
IMG_TIR1_TEMP 10.8 um CT&T 23-05-2016/19:30 IST
L1C Mercator



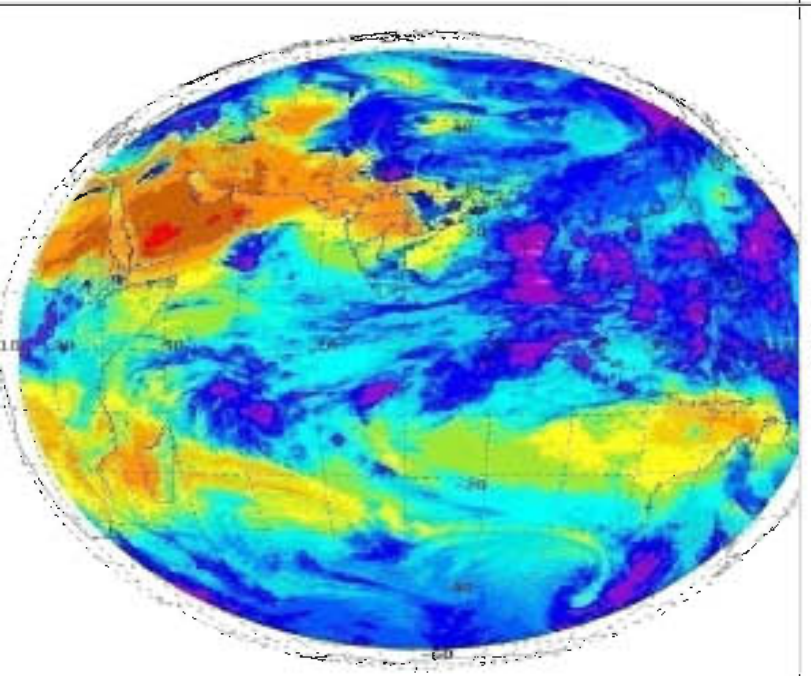


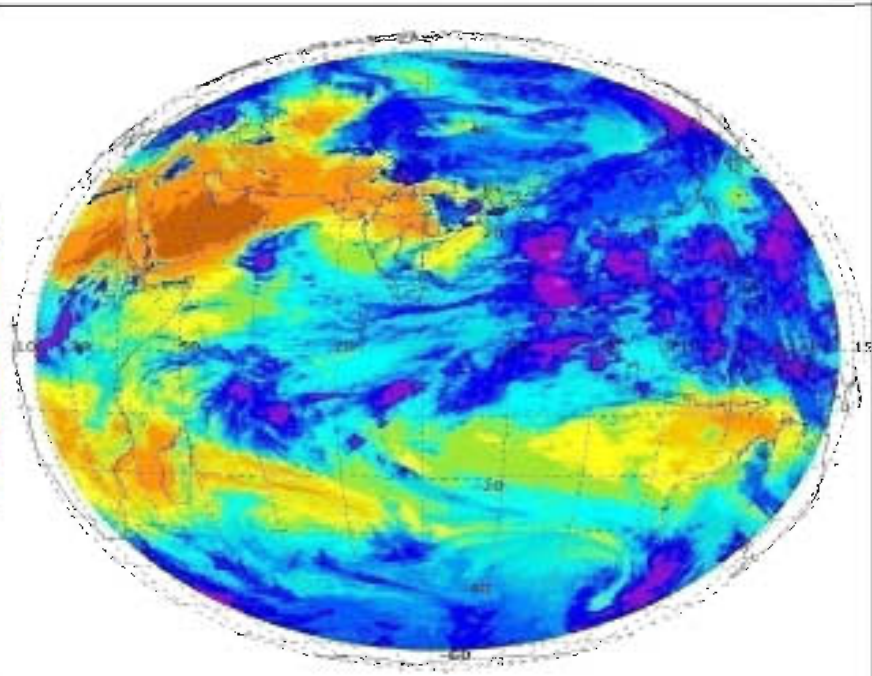


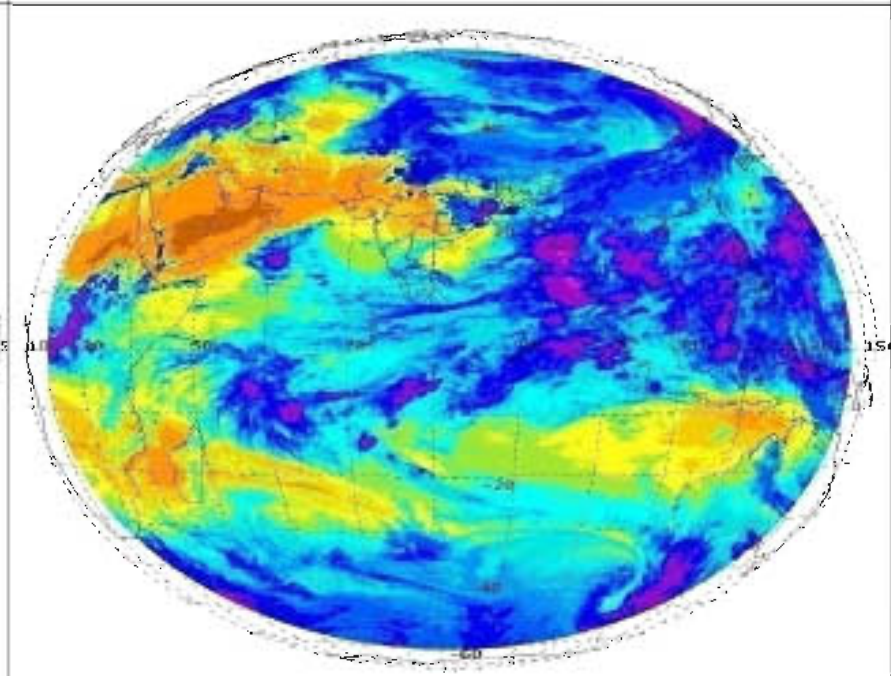
AT :INSAT-3D IMG 23-05-2016/(1200 to 1226) GMT
Outgoing Longwave Radiation 23-05-2016/(1730 to 1756) IST
L2B GEOPHYSICAL PARAMETER FULL DISK

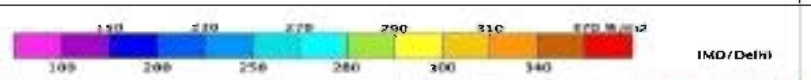
SAT :INSAT-3D IMG 23-05-2016/(1300 to 1326) GMT
Outgoing Longwave Radiation 23-05-2016/(1830 to 1856) IST
L2B GEOPHYSICAL PARAMETER FULL DISK

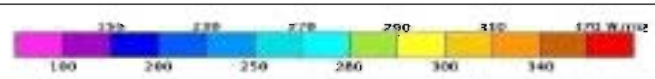
SAT :INSAT-3D IMG 23-05-2016/(1400 to 1426) GMT
Outgoing Longwave Radiation 23-05-2016/(1930 to 1956) IST
L2B GEOPHYSICAL PARAMETER FULL DISK

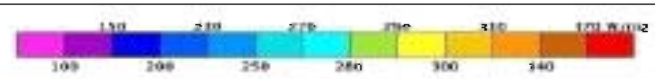


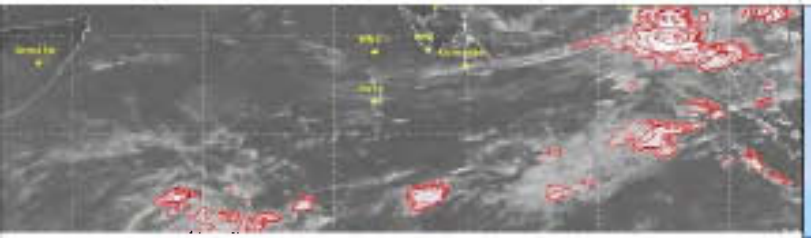


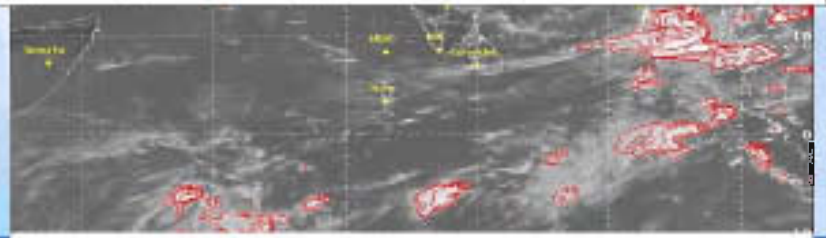


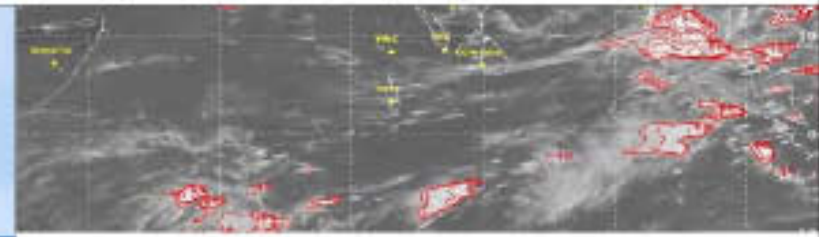




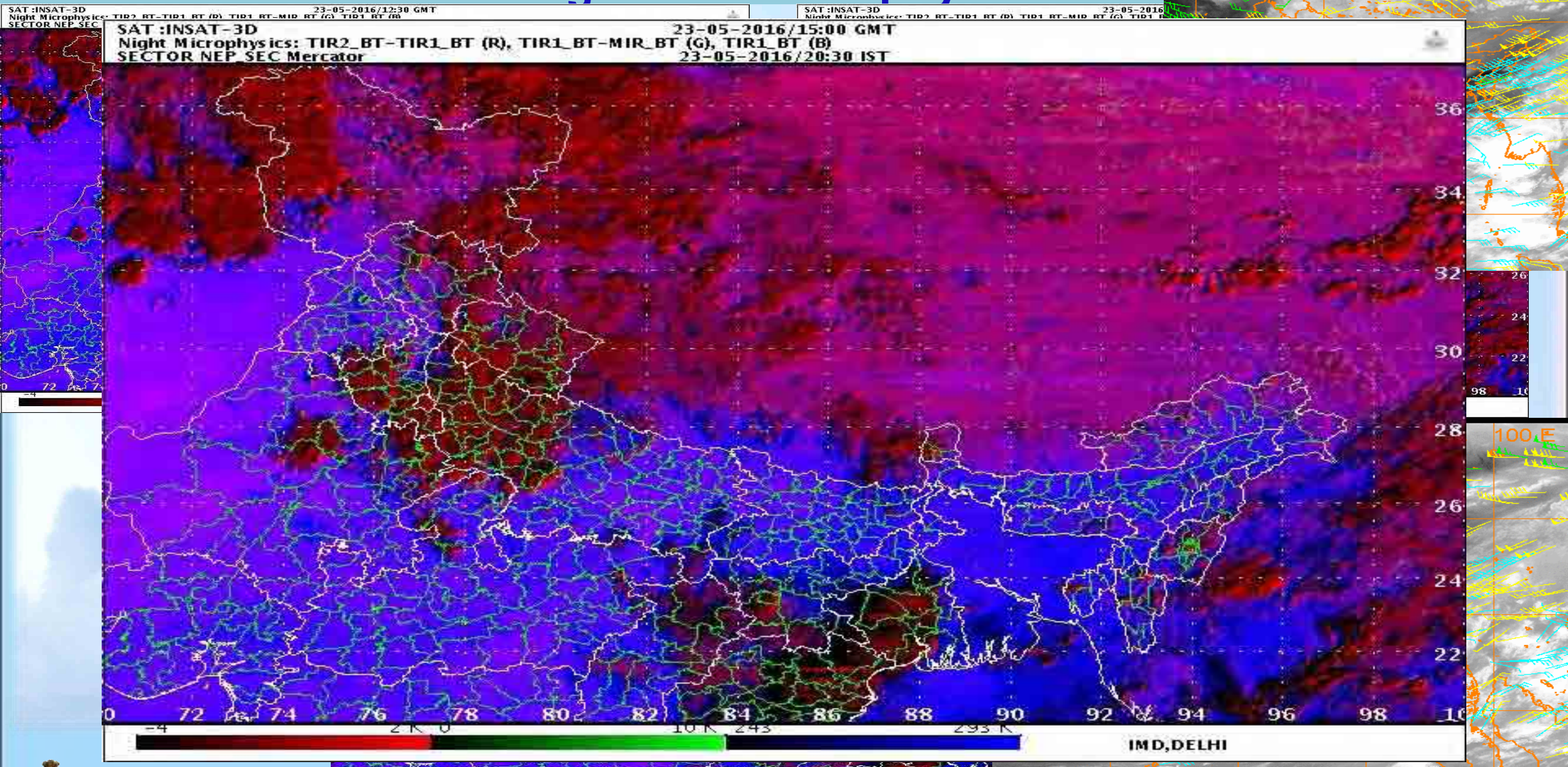


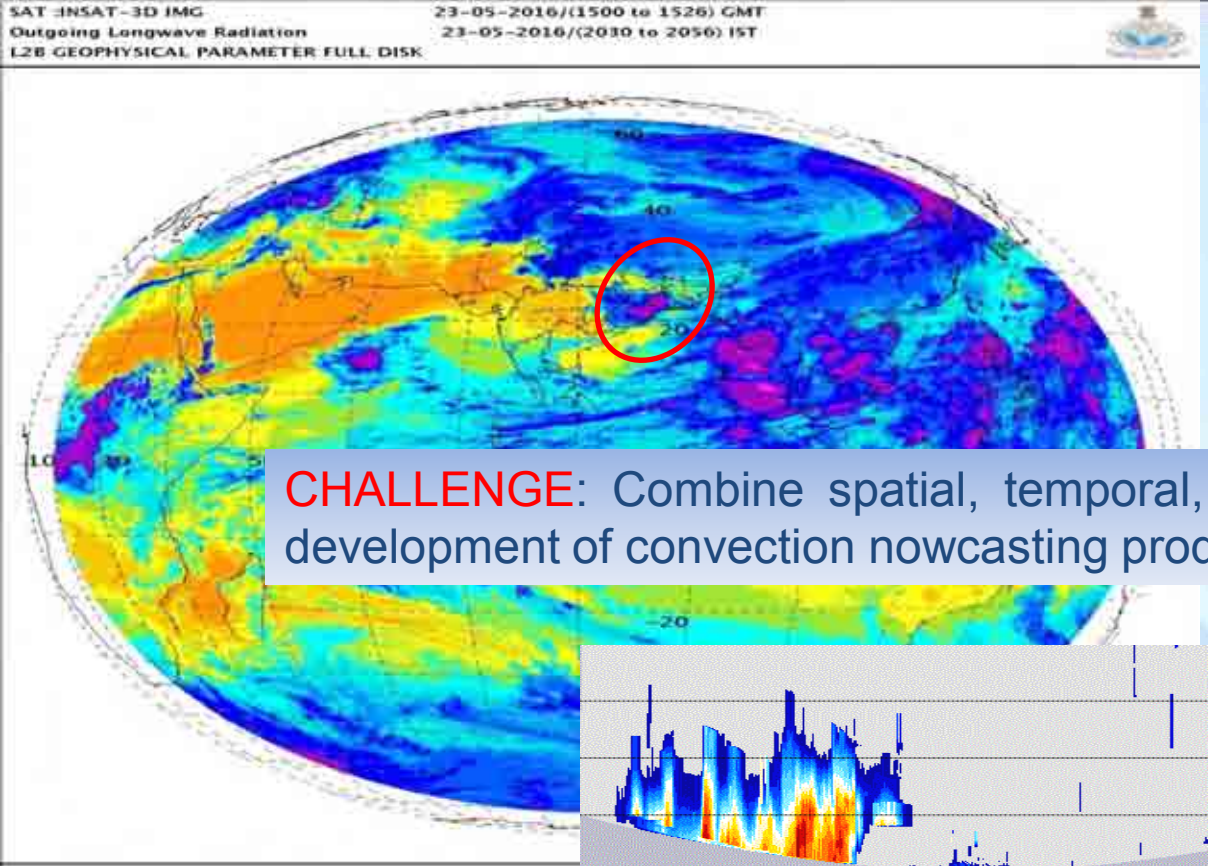


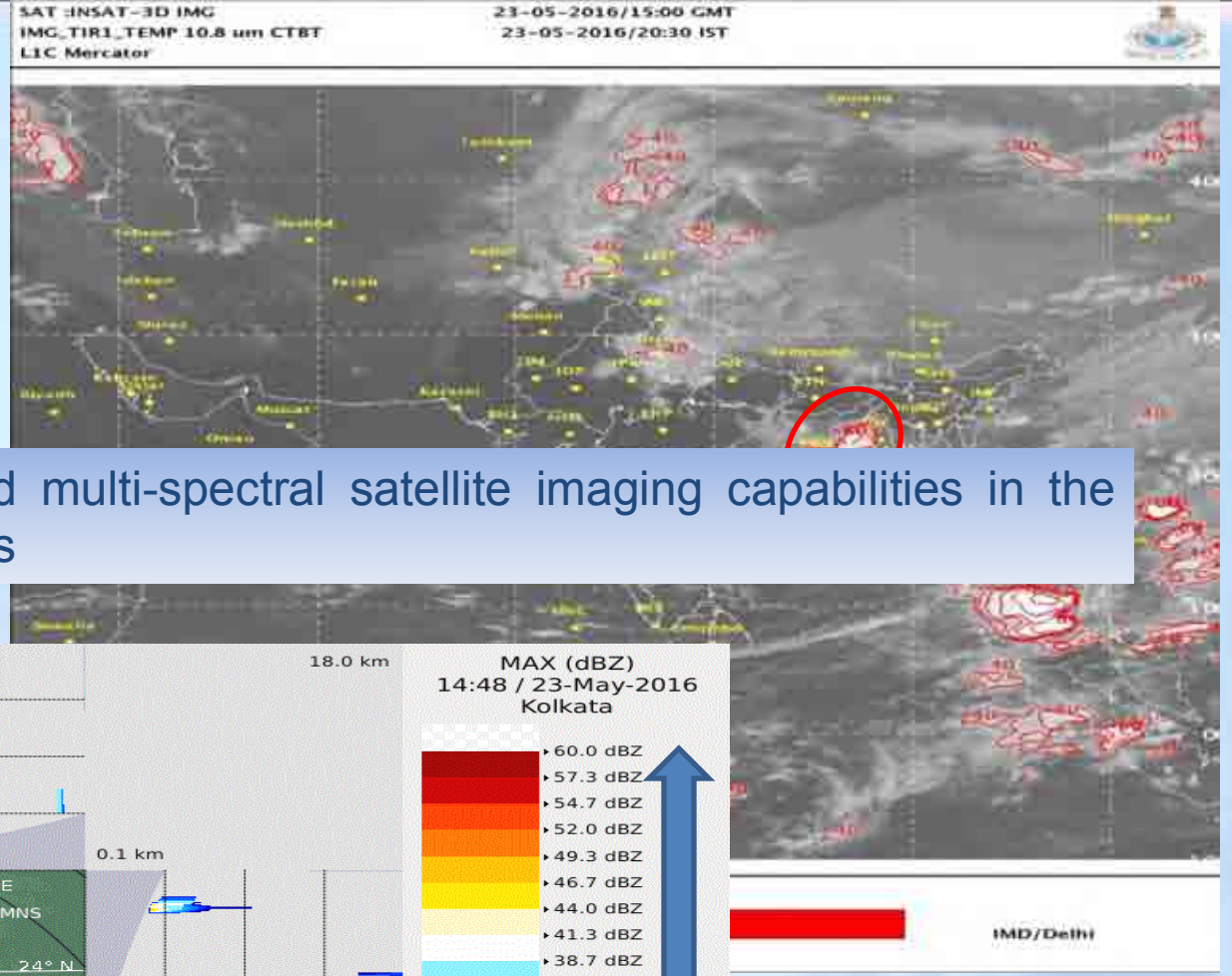




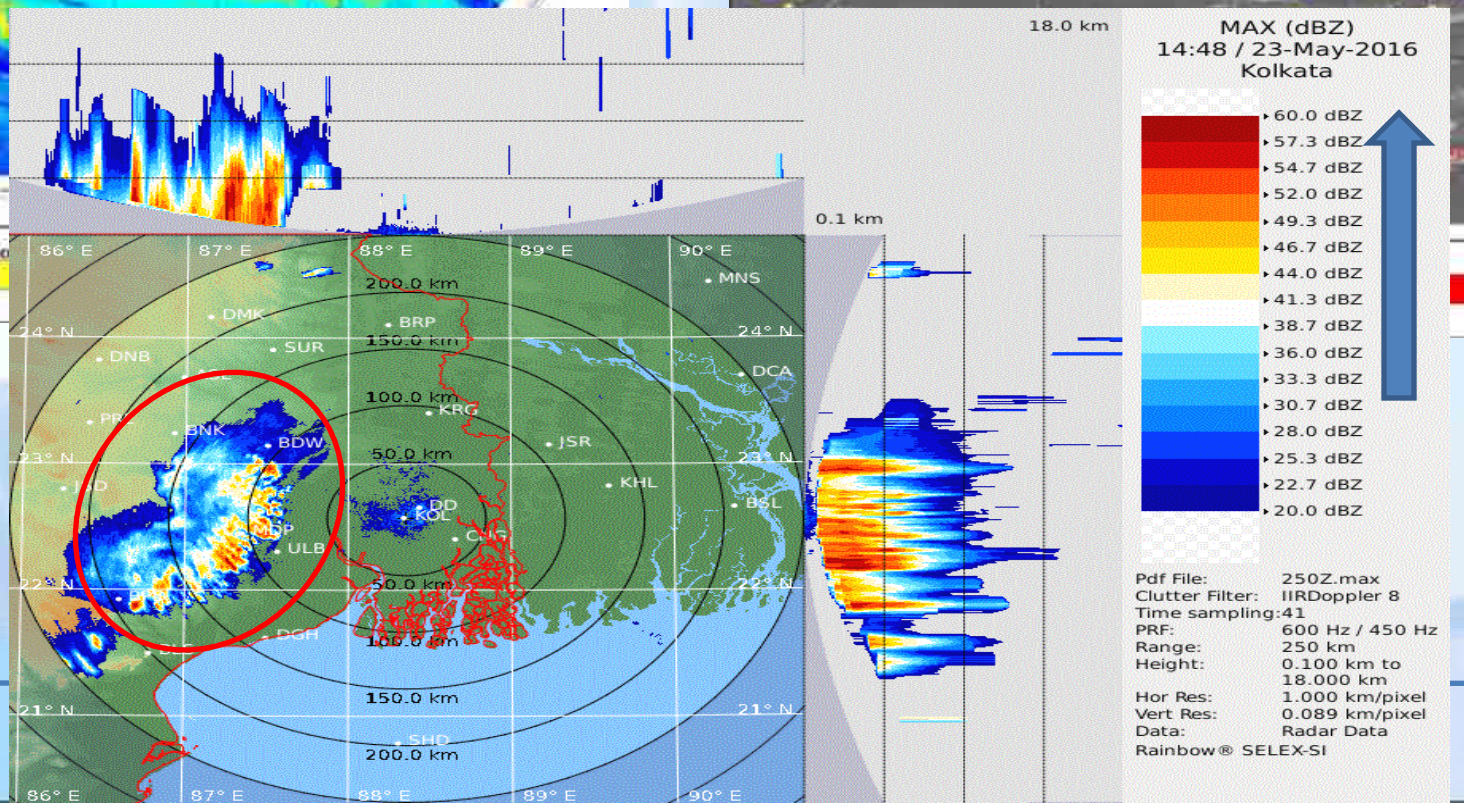
Night time Microphysics







CHALLENGE: Combine spatial, temporal, and multi-spectral satellite imaging capabilities in the development of convection nowcasting products



Thank You