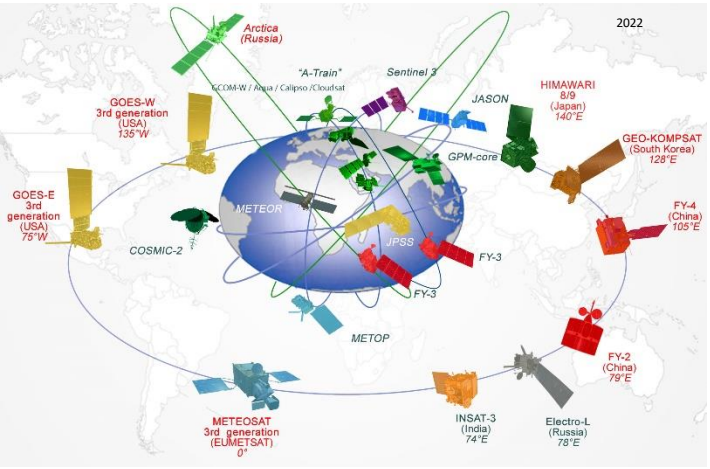

Status report on the current and future satellite systems by IMD

Presenter: Virendra Singh

Report Prepared By: Amit Kumar, R.K. Giri Virendra Singh

Presented to CGMS-47 Working Group II session, agenda item WG-II

Coordination Group for Meteorological Satellites

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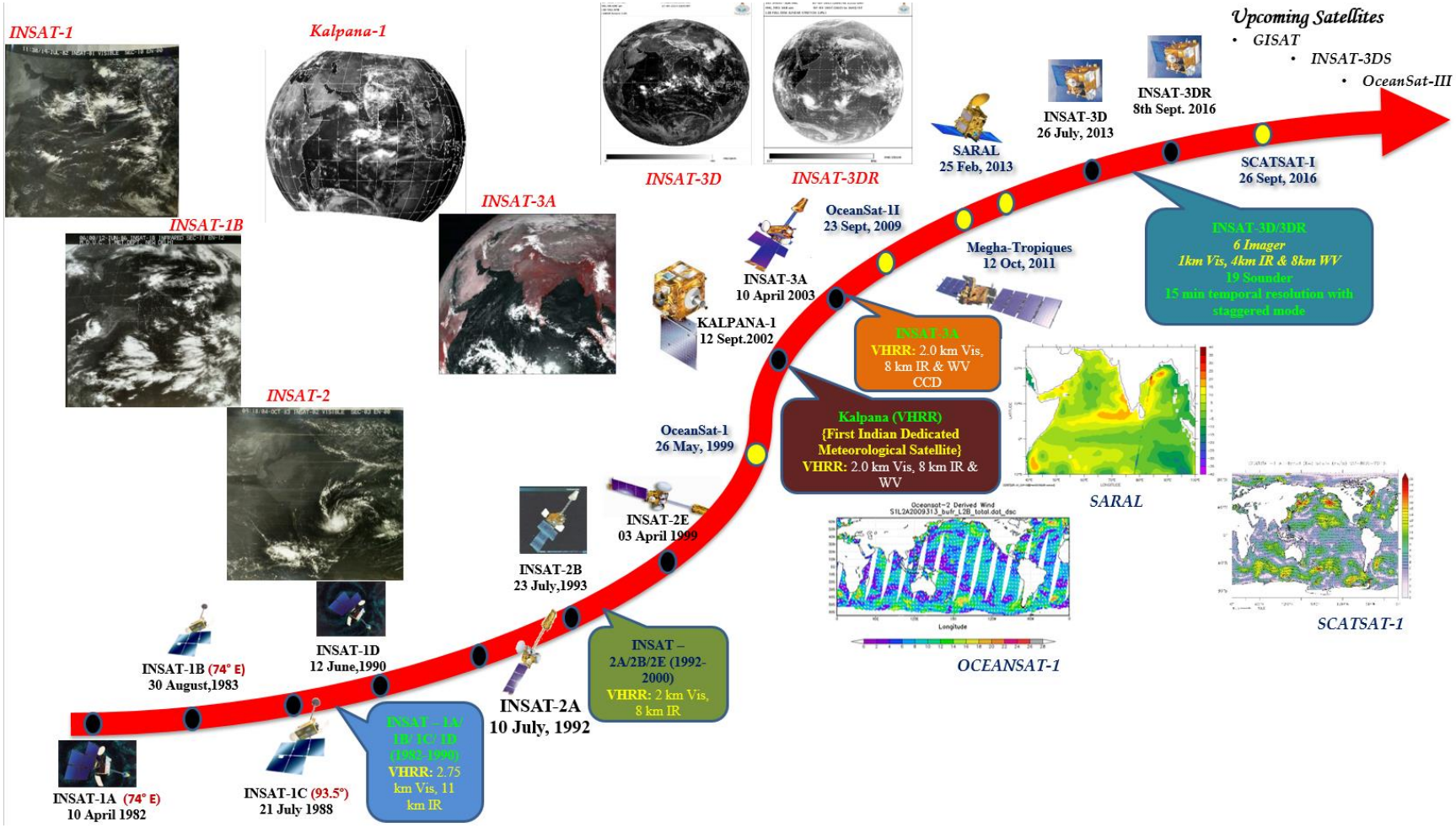
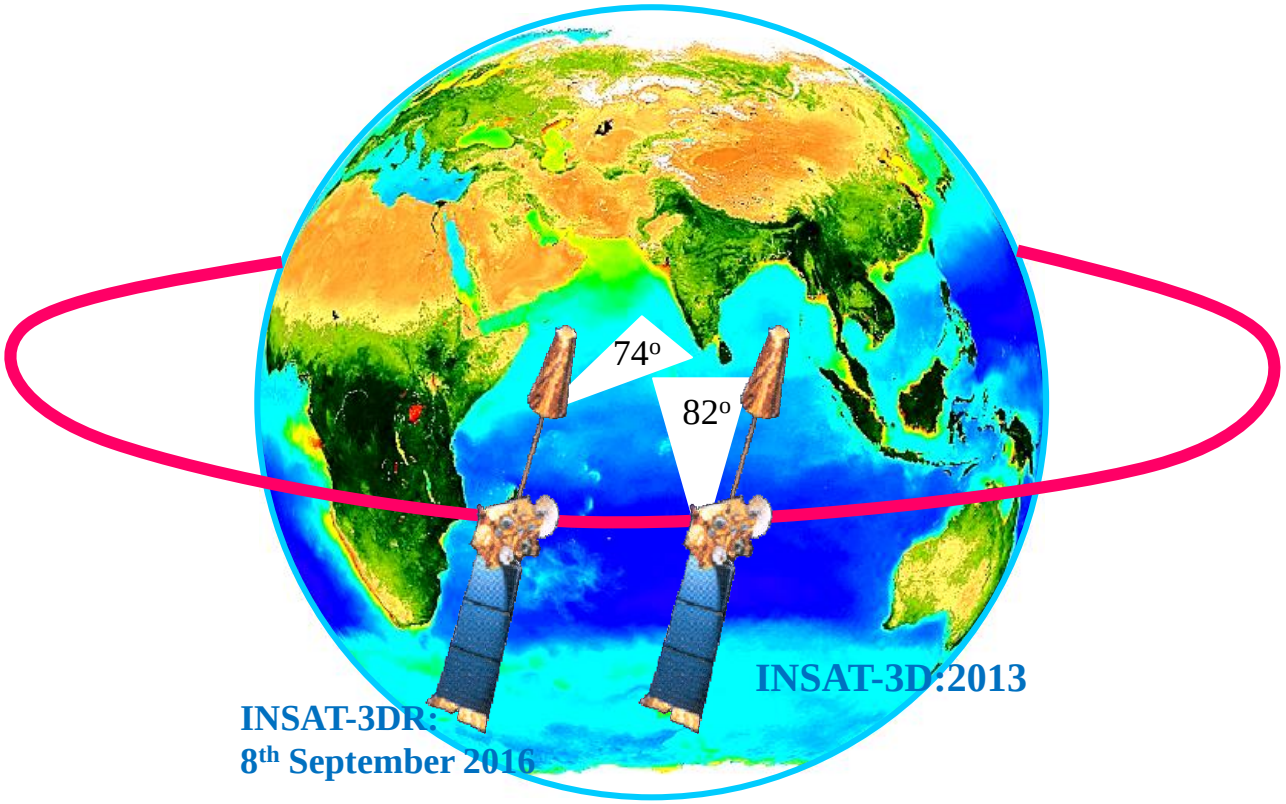
Overview - Planning of Indian satellite systems



Overview - Planning of Indian satellite systems

Satellite	Sensor	1980-1990	1990-2000	2000-2010	2010-2020
INSAT-1A (1982)	VHRR (VIS,TIR)	OLR, CMV, Rain, Cloud Image			
INSAT-1B (1983)	VHRR (VIS,TIR)	OLR, CMV, Rain, Cloud Image			
INSAT-1C (1988)	VHRR (VIS,TIR)	OLR, CMV, Rain, Cloud Image			
INSAT-1D (1990)	VHRR (VIS,TIR)		OLR, CMV, Rain, Cloud Image		
INSAT-2A (1992)	VHRR (VIS,TIR)		OLR, CMV, Rain, Cloud Image		
INSAT-2B (1993)	VHRR (VIS,TIR)		OLR, CMV, Rain, Cloud Image		
INSAT-2E (1999)	VHRR (VIS,WV,TIR) CCD (VIS,NIR,SWIR		OLR, AMV, UTH, Rain, Cloud Image		
Kalpana-1 (2002)	VHRR (VIS,WV,TIR)		OLR, AMV, UTH, Rain, Cloud Image		
INSAT-3A (2003)	VHRR (VIS,WV,TIR) CCD (VIS,NIR,SWIR		OLR, AMV, UTH, Rain, Cloud Image		
INSAT-3D (2013)	Imager (VIS, SWIR, MIR, WV, TIR1, TIR2) Sounder (18 IR + VIS)			OLR, AMV, UTH, Rain, Cloud Image Temperature, humidity profiles, Ozone	
INSAT-3DR (2016)	Similar to INSAT-3D			OLR, AMV, UTH, Rain, Cloud Image Temperature, humidity profiles, Ozone	
INSAT-3DS (2022)	Similar to INSAT-3D				OLR, AMV, UTH, Rain, Cloud Image Temperature, humidity profiles, Ozone

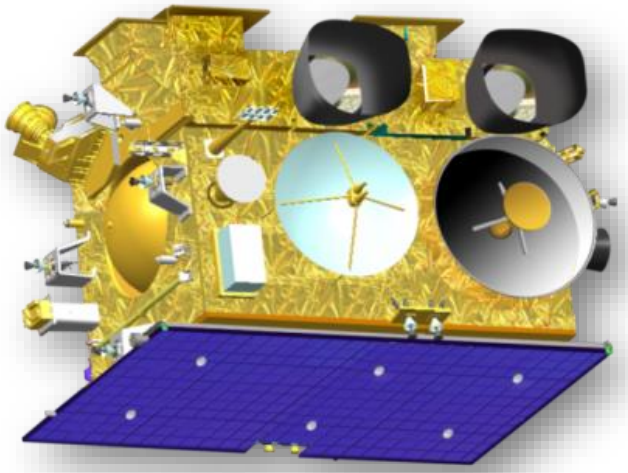
Current Indian Geostationary Meteorological Satellites



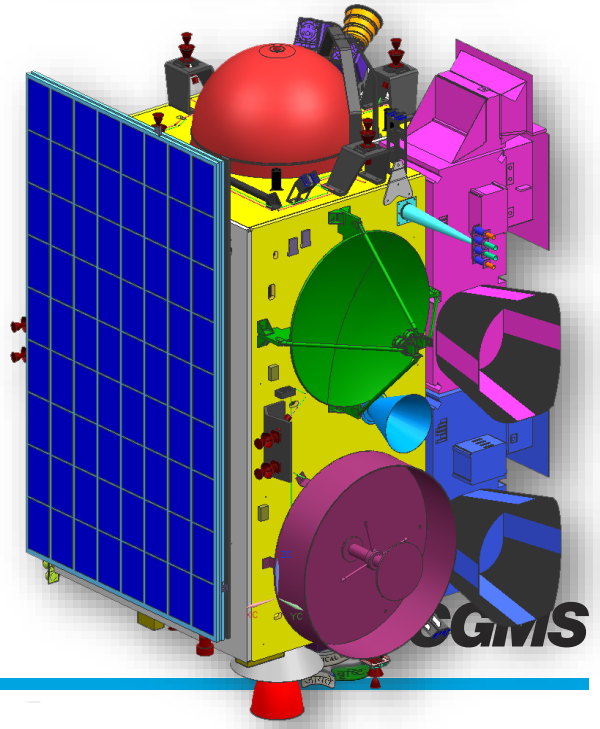
Current Indian Geo stationary Meteorological satellites

At present the following three INSAT satellites are in operation

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 is being used in staggered mode with INSAT-3D in order to reduce temporal resolution to 15 minutes.

INSAT-3D/3DR Imager Channel Specification

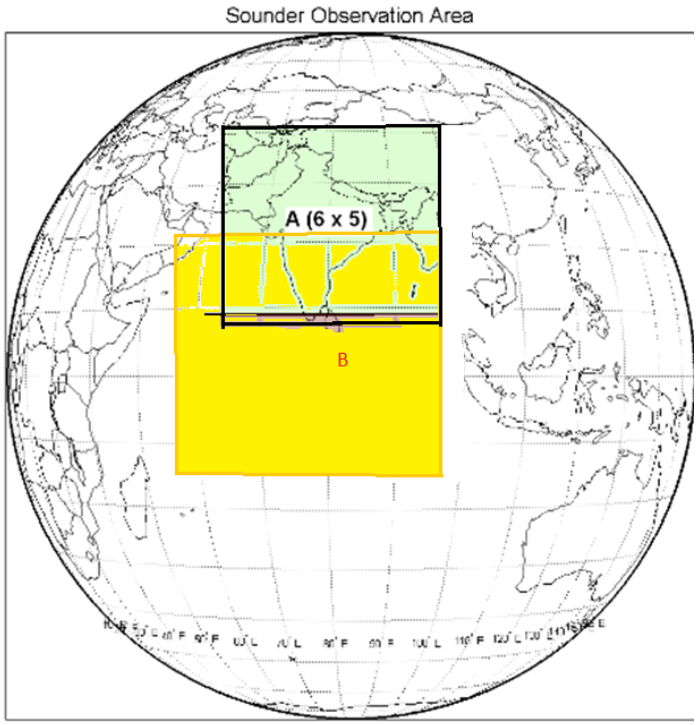
Channels Number	Channel ID	Channel name	Spectral range (µm)	Resolution (Km)
1.	VIS	visible	0.55 – 0.75	1.0
2.	SWIR	short wave infrared	1.55 – 1.70	1.0
3.	MIR	medium wave infrared	3.7 – 3.9	4.0
4.	WV	water vapour	6.5 – 7.1	8.0
5.	TIR1	long wave infrared	10.3 – 11.3	4.0
6.	TIR2	split	11.5 - 12.5	4.0

INSAT-3D Sounder Channels Characteristics

Detector	Ch. No.	λ_c (μm)	ν_c (cm^{-1})	NEΔT @300K	Principal absorbing gas	Purpose
Long wave	1	**14.67**	682	0.17	CO_2	***Stratosphere temperature***
	2	**14.32**	699	0.16	CO_2	***Tropopause temperature***
	3	**14.04**	712	0.15	CO_2	***Upper-level temperature***
	4	**13.64**	733	0.12	CO_2	***Mid-level temperature***
	5	**13.32**	751	0.12	CO_2	***Low-level temperature***
	6	**12.62**	793	0.07	water vapor	***Total precipitable water***
	7	**11.99**	834	0.05	water vapor	***Surface temp., moisture***
Mid wave	8	**11.04**	906	0.05	window	***Surface temperature***
	9	**9.72**	1029	0.10	ozone	***Total ozone***
	10	**7.44**	1344	0.05	water vapor	***Low-level moisture***
	11	**7.03**	1422	0.05	water vapor	***Mid-level moisture***
	12	**6.53**	1531	0.10	water vapor	***Upper-level moisture***
Short wave	13	**4.58**	2184	0.05	N_2O	***Low-level temperature***
	14	**4.53**	2209	0.05	N_2O	***Mid-level temperature***
	15	**4.46**	2241	0.05	CO_2	***Upper-level temperature***
	16	**4.13**	2420	0.05	CO_2	***Boundary-level temp.***
	17	**3.98**	2510	0.05	window	***Surface temperature***
	18	**3.76**	2658	0.05	window	***Surface temp., moisture***
Visible	19	**0.695**	14367	-	visible	***Cloud***

Operational scenario of INSAT-3D/3DR

INSAT Series	Temporal Resolution
3D -Imager (6 Channel)	½ hourly (xx00 & xx30 UTC)
3D -Sounder (19 Channel)	1 ½ hourly (two times region-B) and hourly (Three times Region-A)
3DR -Imager (6 Channel)	½ hourly (xx15 & xx45 UTC)
3DR -Sounder (19 Channel)	Hourly (Three times Region-A) and 1 ½ hourly (two times region-B)



Sector-A	Sector-B
0000UTC-INSAT-3D	0000UTC-INSAT-3DR
0100UTC-INSAT-3D	0130UTC-INSAT-3DR
0200UTC-INSAT-3D	
0300UTC-INSAT-3DR	0300UTC-INSAT-3D
0400UTC-INSAT-3DR	0430UTC-INSAT-3D
0500UTC-INSAT-3DR	

Then this cycle will be repeated on six hourly basis.

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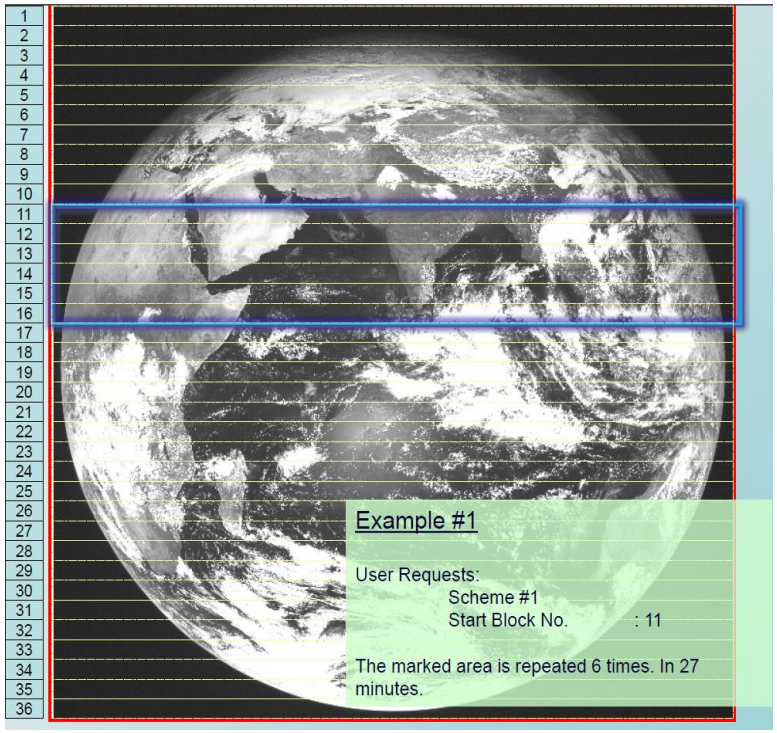
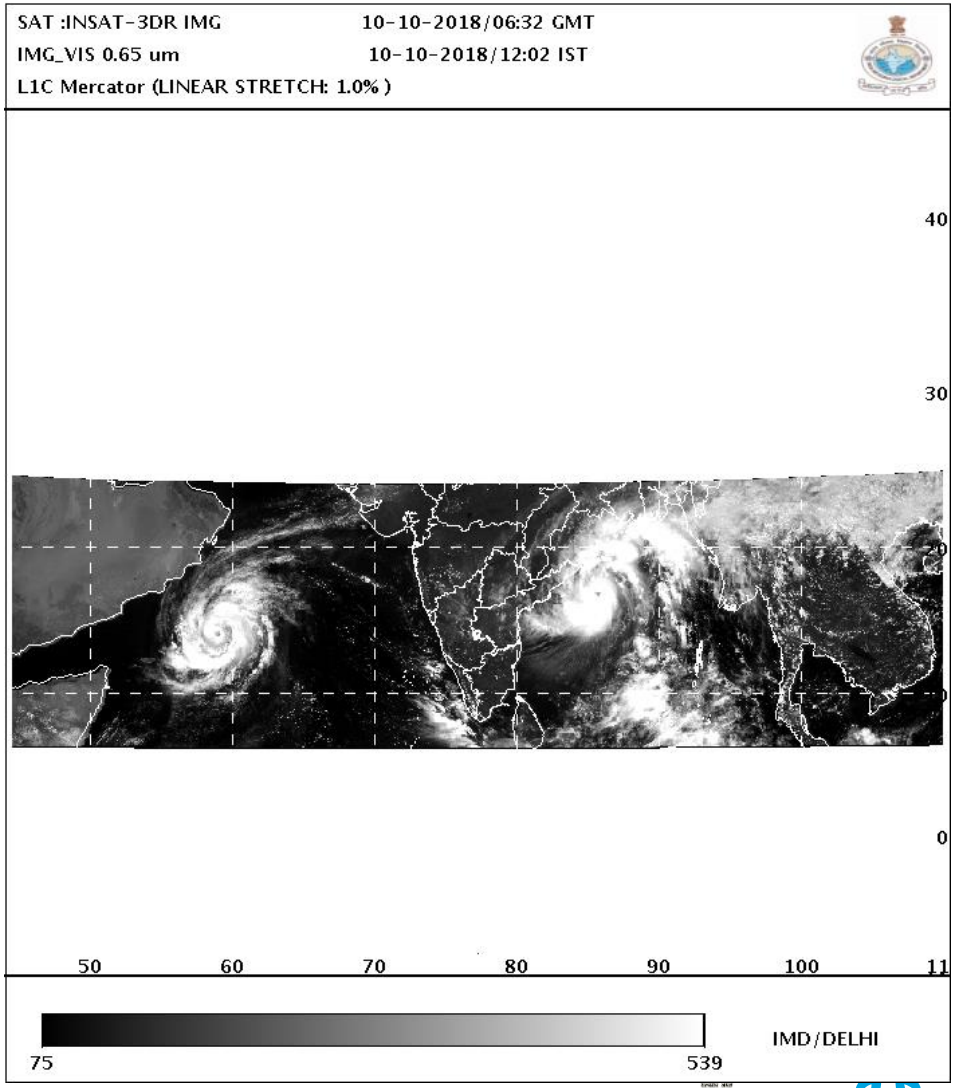
SOP of Rapid Scan Strategy of Imager of INSAT-3DR has been finalised for conducting it during Cyclone/ specific weather event. It has been successfully carried out for four cyclones i.e. VSCS LUBAN, TITLI, GAJA & ESCS FANI.

- Normal mode scan area has been divided into 36 blocks in North-South directions such that:
  - Each block covers 0.50 in N-S direction.
  - No of Scan lines for Each block: 40
  - Time required to scan each block: 45 seconds

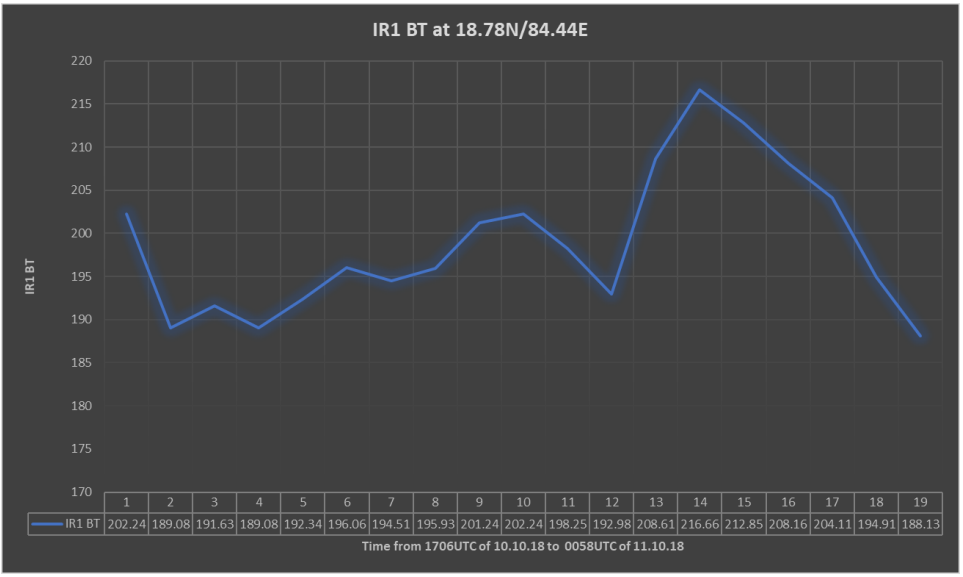


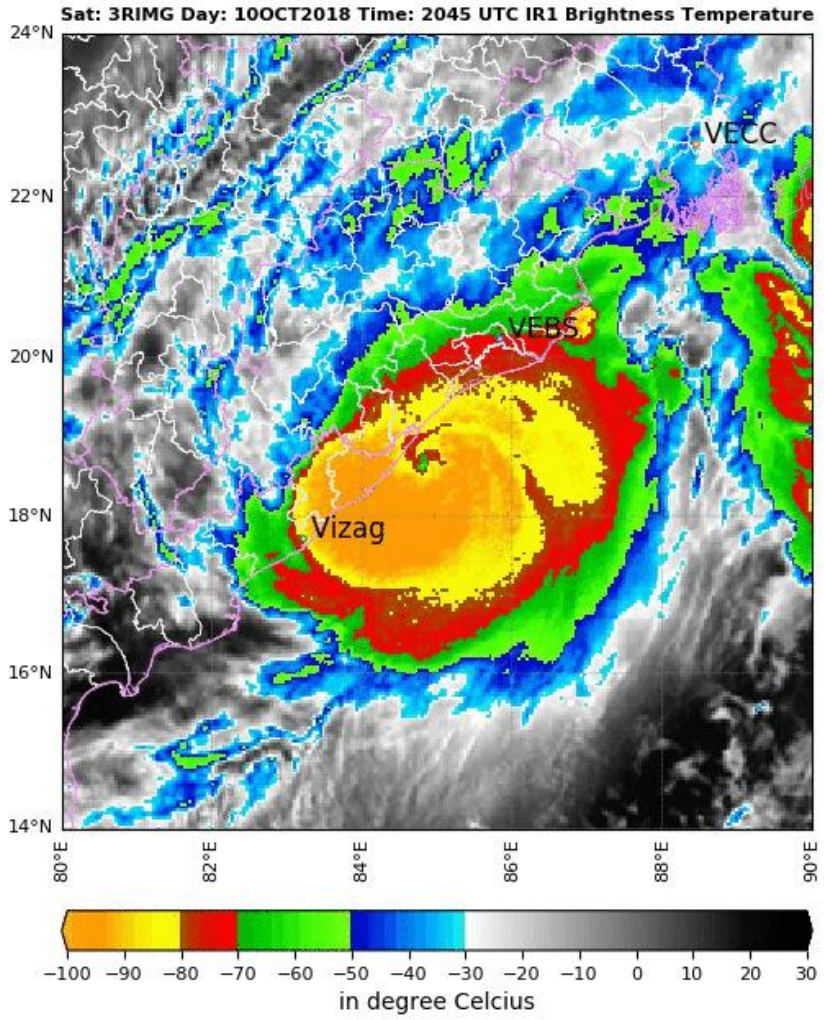
- Extent of coverage: 6 Blocks (3° coverage in 234 lines)
- No. of repetitions: 6
- Time required: 27 minutes
- (6 blocks with 6 repetitions)

Rapid Scan by INSAT-3DR conducted for Luban, Titli ,Gaja & FANI cyclones and Images were disseminated through INSAT-3DR webpage on real time basis.

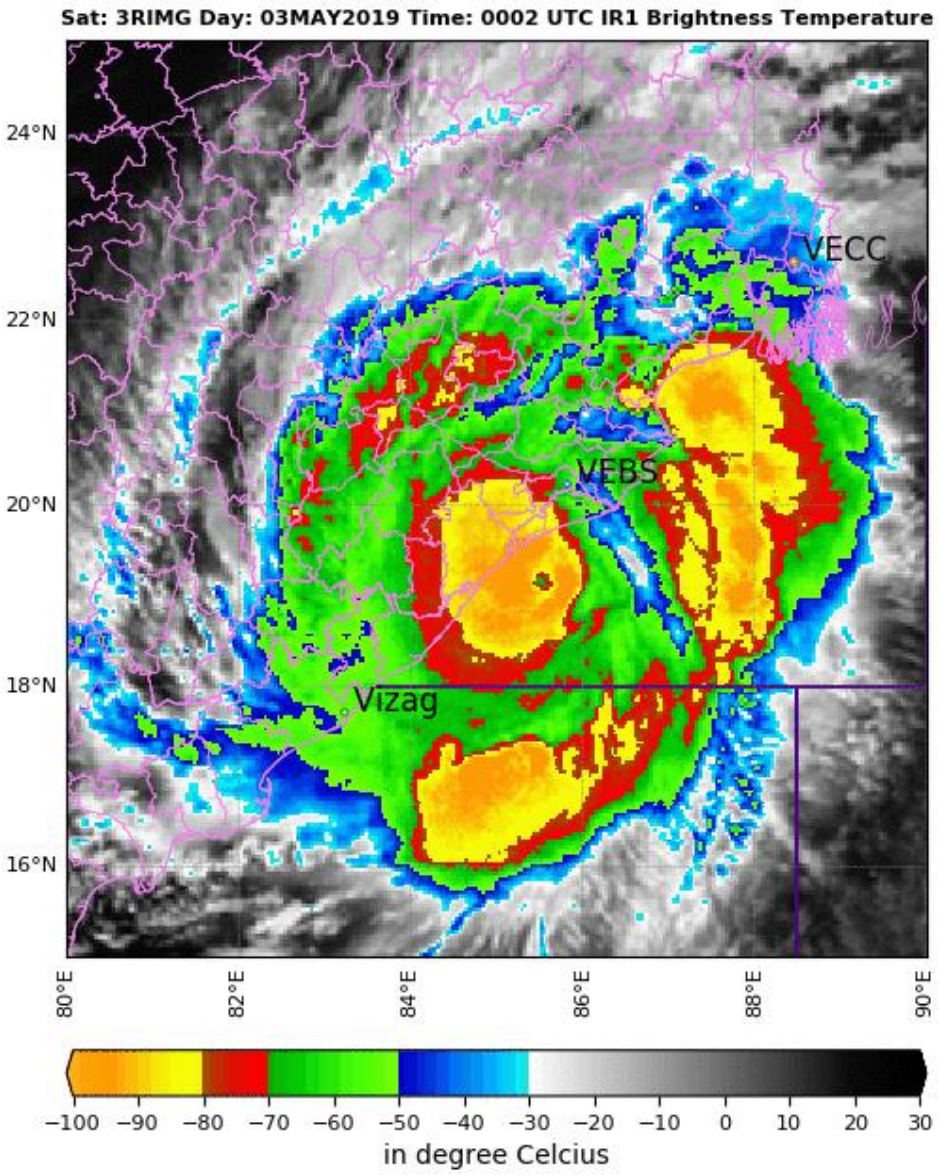


During Landfall of VSCS "TITLI" seen from "Rapid Scan"

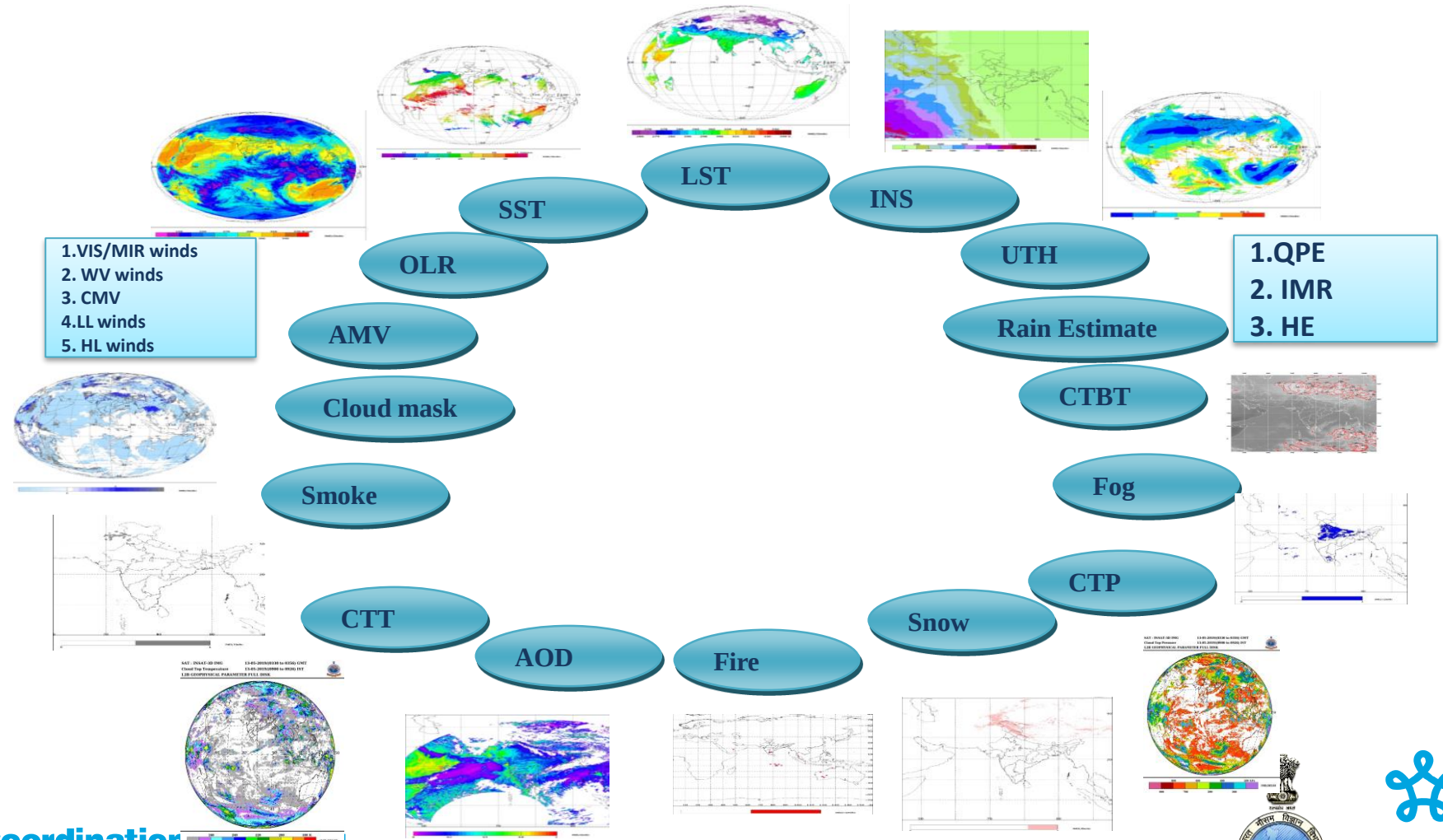




During Landfall of ESCS "FANI" seen from "Rapid Scan"



Geophysical parameters/products of INSAT-3D/3DR Imager



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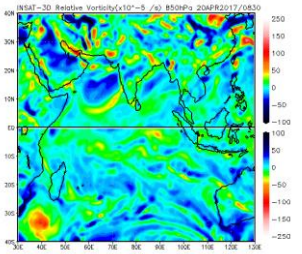
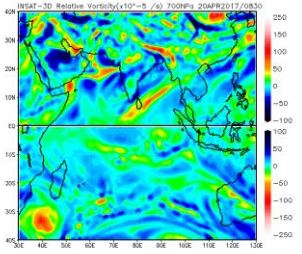
Wind Derived Products from INSAT-3D/3DR Imager Winds

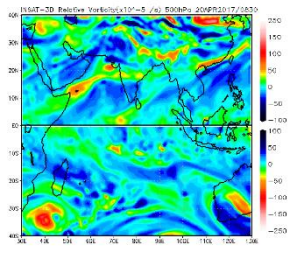
Vorticity



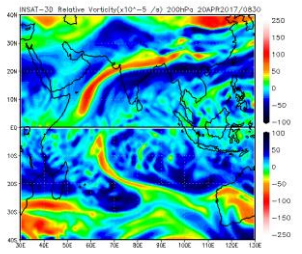
850 hPa



700 hPa

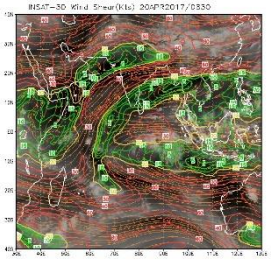


500 hPa

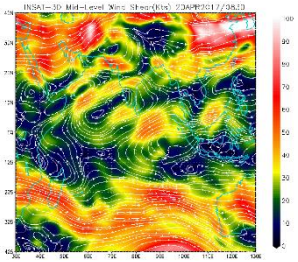


200 hPa

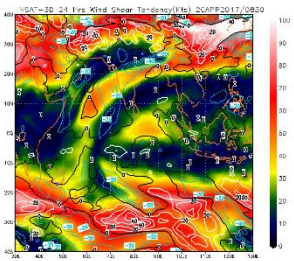
Wind Shear



Wind Shear

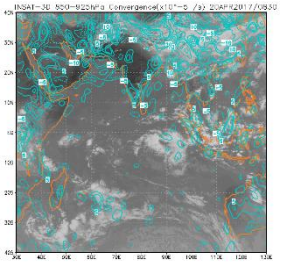


Mid Level Wind Shear

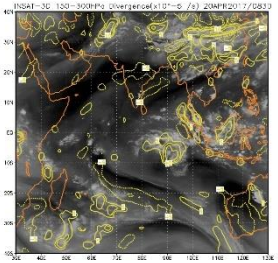


Wind Shear Tendency

Convergence & Divergence

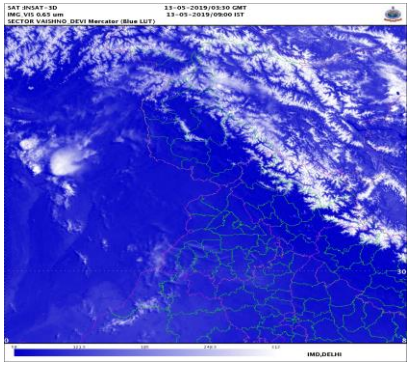


Low Level Convergence

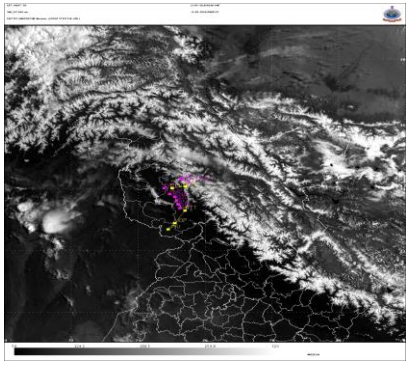


Upper level Divergence

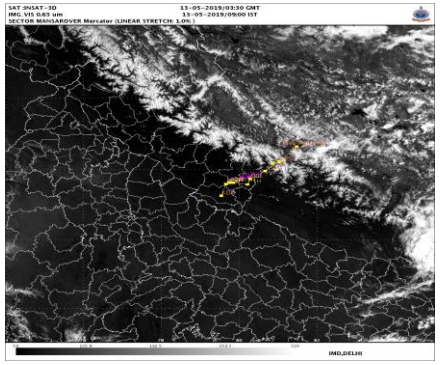
Images Generated from INSAT-3D/3DR Imager as per Stakeholder's Requirements



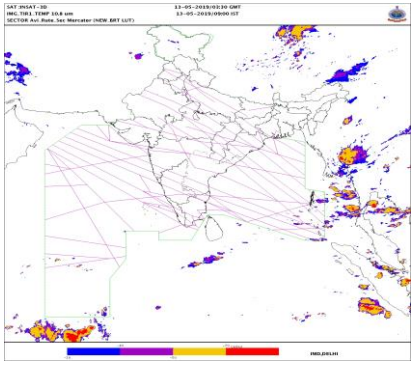
Mata Vaisno Devi



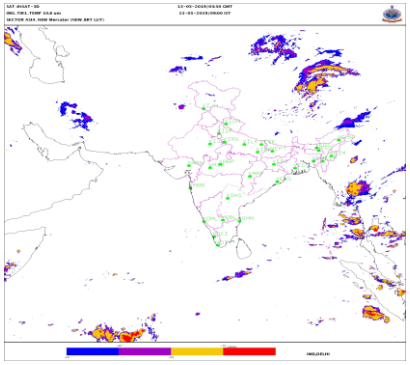
Amarnath Yatra



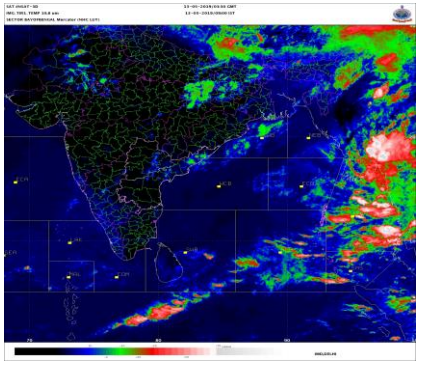
Chaar Dham Yatra



Aviation Sector



Aviation Sector



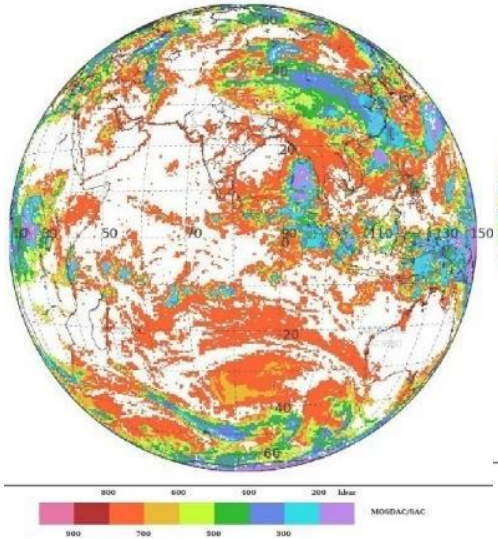
BD/NHC Curve

New Products from INSAT-3D/3DR

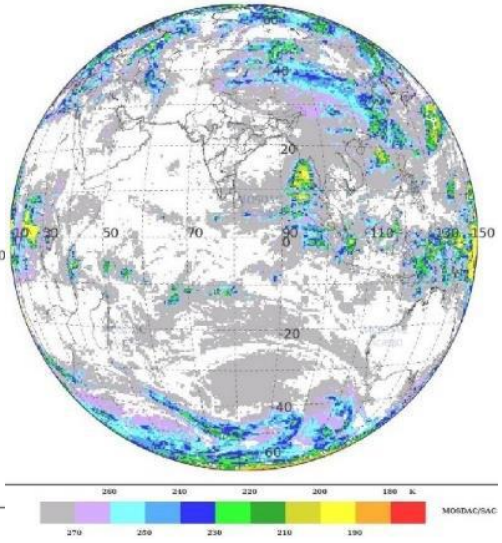
Cloud Top properties and CSBT products from INSAT-3D/3DR imager

- IR window and IR-WV intercept methods are applied to generate cloud top temperature, pressure and effective cloud amount from INSAT-3D/3DR observations.
- CSBT products are generated for NPW data assimilation

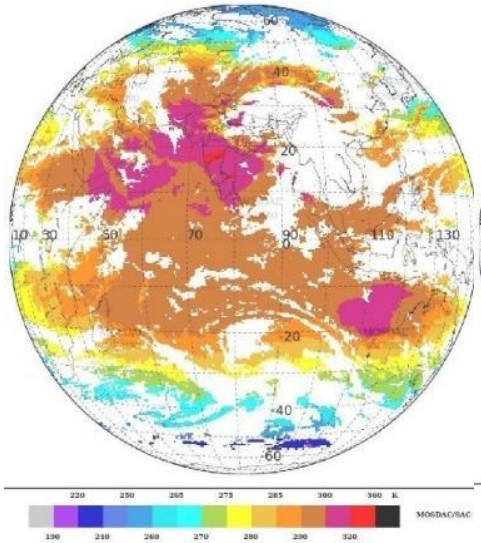
CTP (hPa)



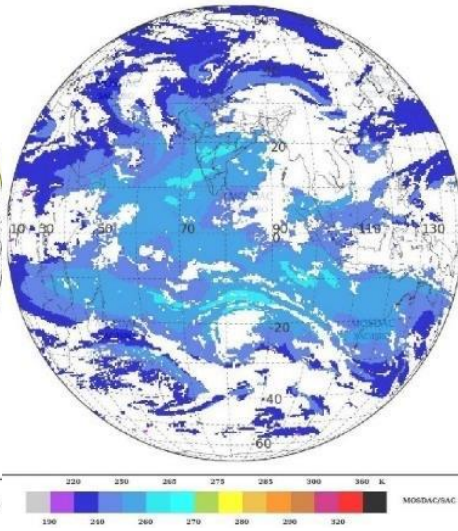
CTT (K)



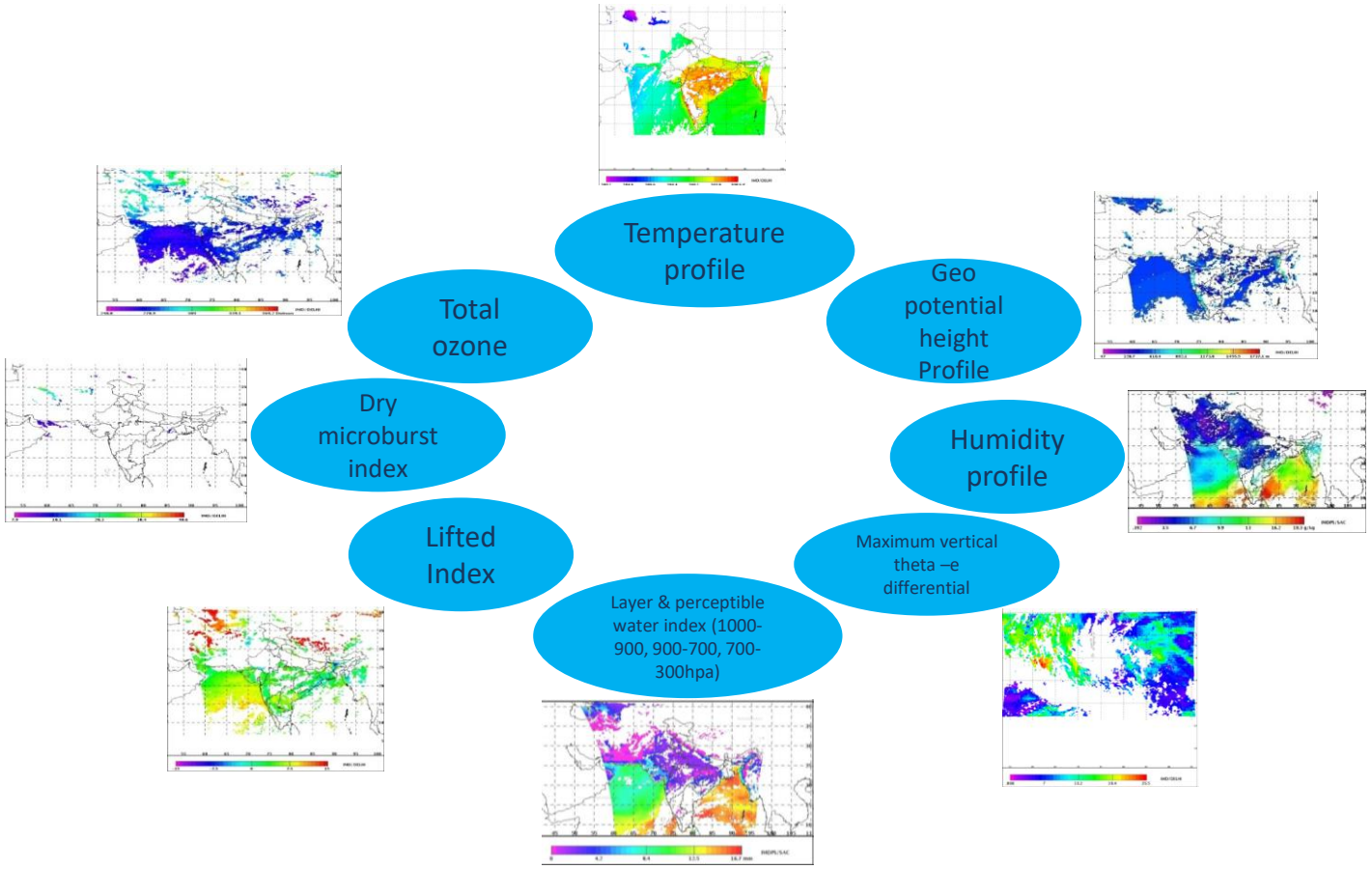
CSBT-TIR-1 (K)



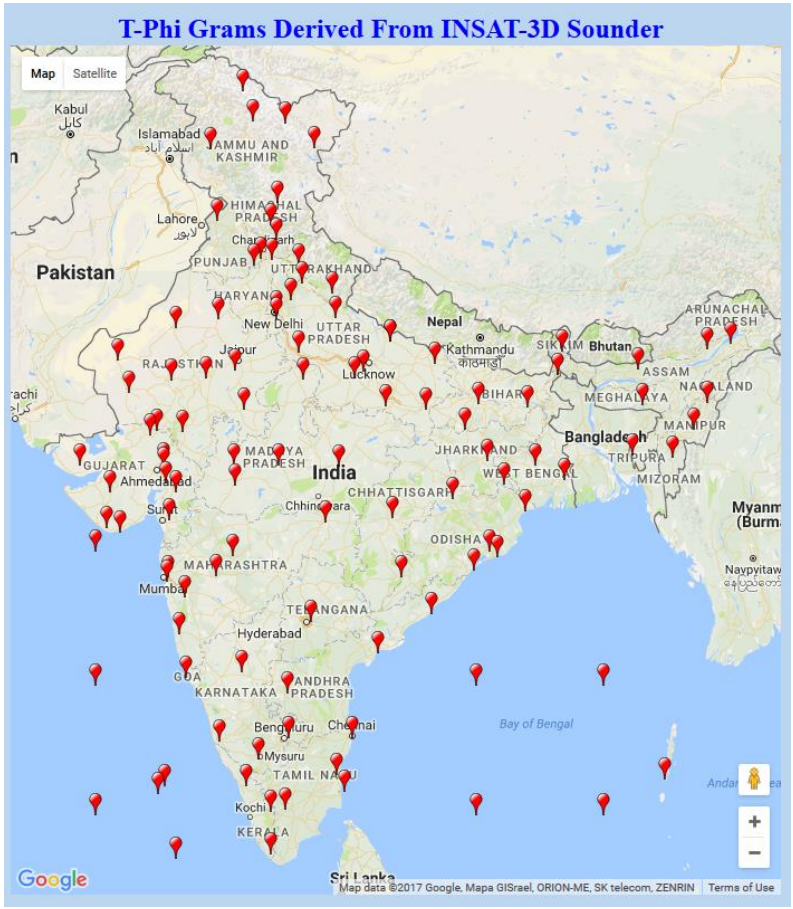
CSBT-WV (K)

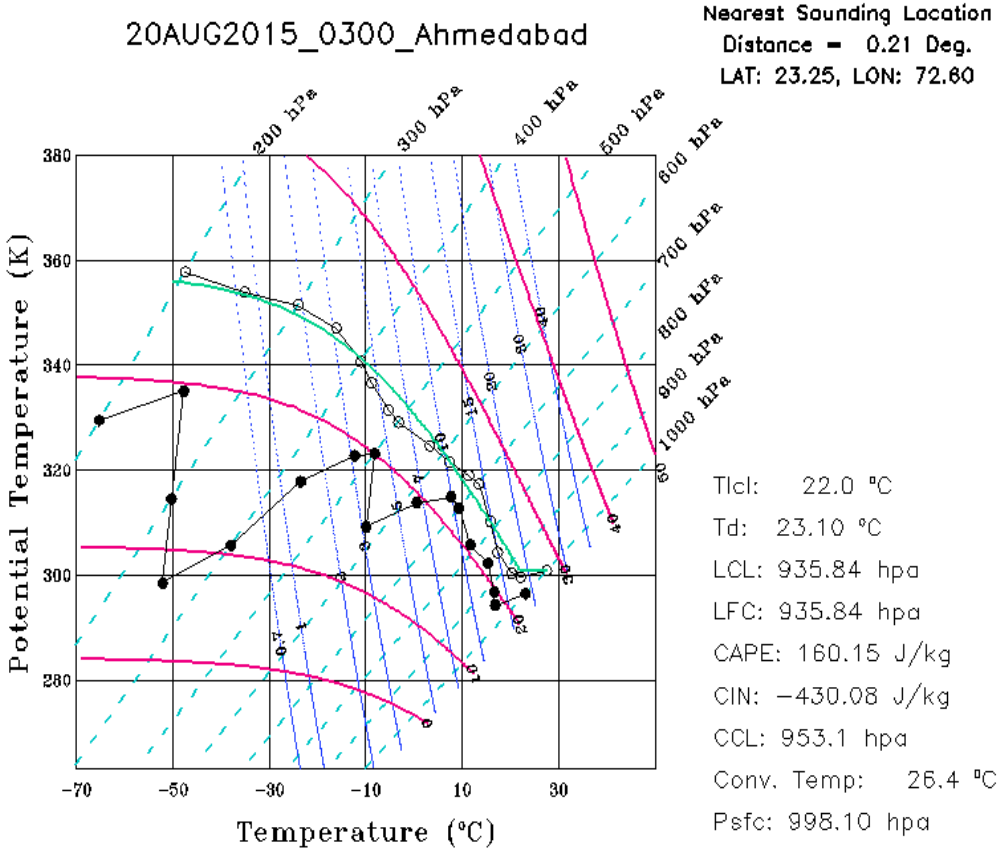


Geophysical parameters OF INSAT-3D/3DR Sounder



Provision of generation of T-phi gram for 709 locations.





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Calibration & Validation Activities

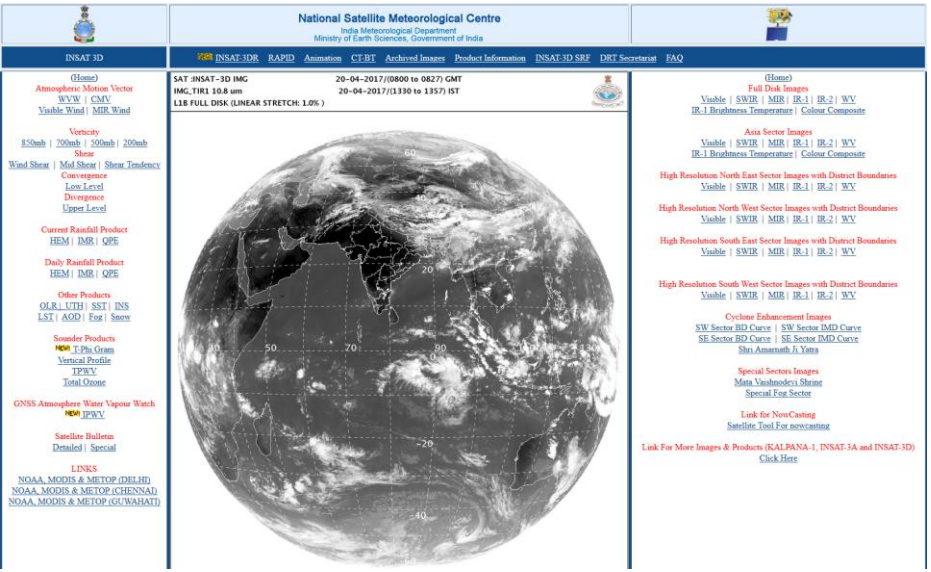
Calibration Coefficients are being updated on monthly basis in IMDPS system by using GSICS corrections of last 30 days dynamically carried out by SAC Ahmedabad.

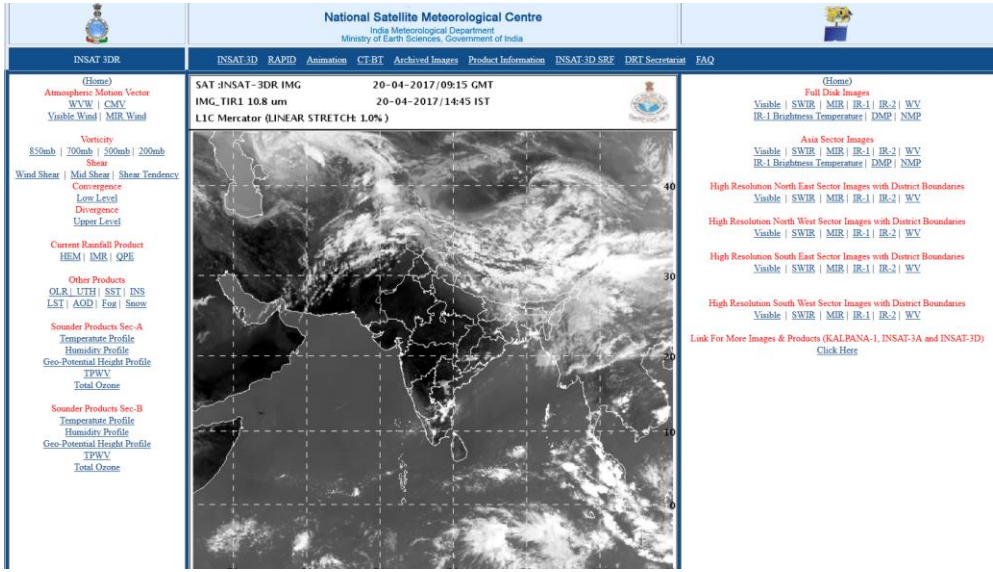
IMD has started three calibration and validation activities such as:

a) IN-SITU CAL VAL of INSAT-3D/3DR (Site Selected-Bhuj, Gujarat)[IMD-ISRO]
b) IOGEO Project with Kalpana-1/INSAT-3D[IMD-EUMetSat]
c) Lunar Calibration using INSAT-3D/3DR [IMD-EUMetSat]

Dissemination through a dedicated IMD web site Updated every fifteen Minutes

http://satellite.imd.gov.in/insat.htm





Coordination Group for Meteorological Satellites

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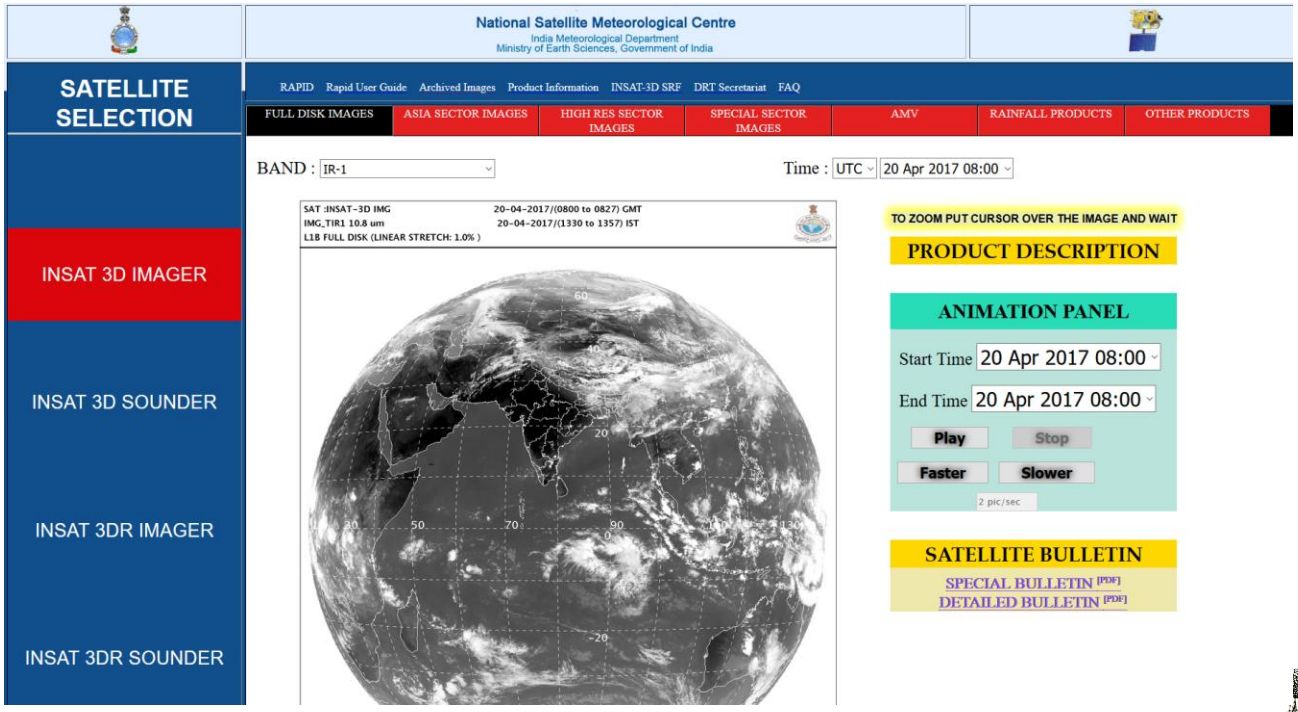
Dissemination through a dedicated IMD web site Updated every fifteen Minutes with Authentication feature

http://satmet.imd.gov.in

- Provision to view last 48 channel images/products images through drop down menu.
- Product description of all Imageries and Products are made available on webpage.
- Provision for running Animation for all channel images/products images for last 48 scans along with date and time selection.

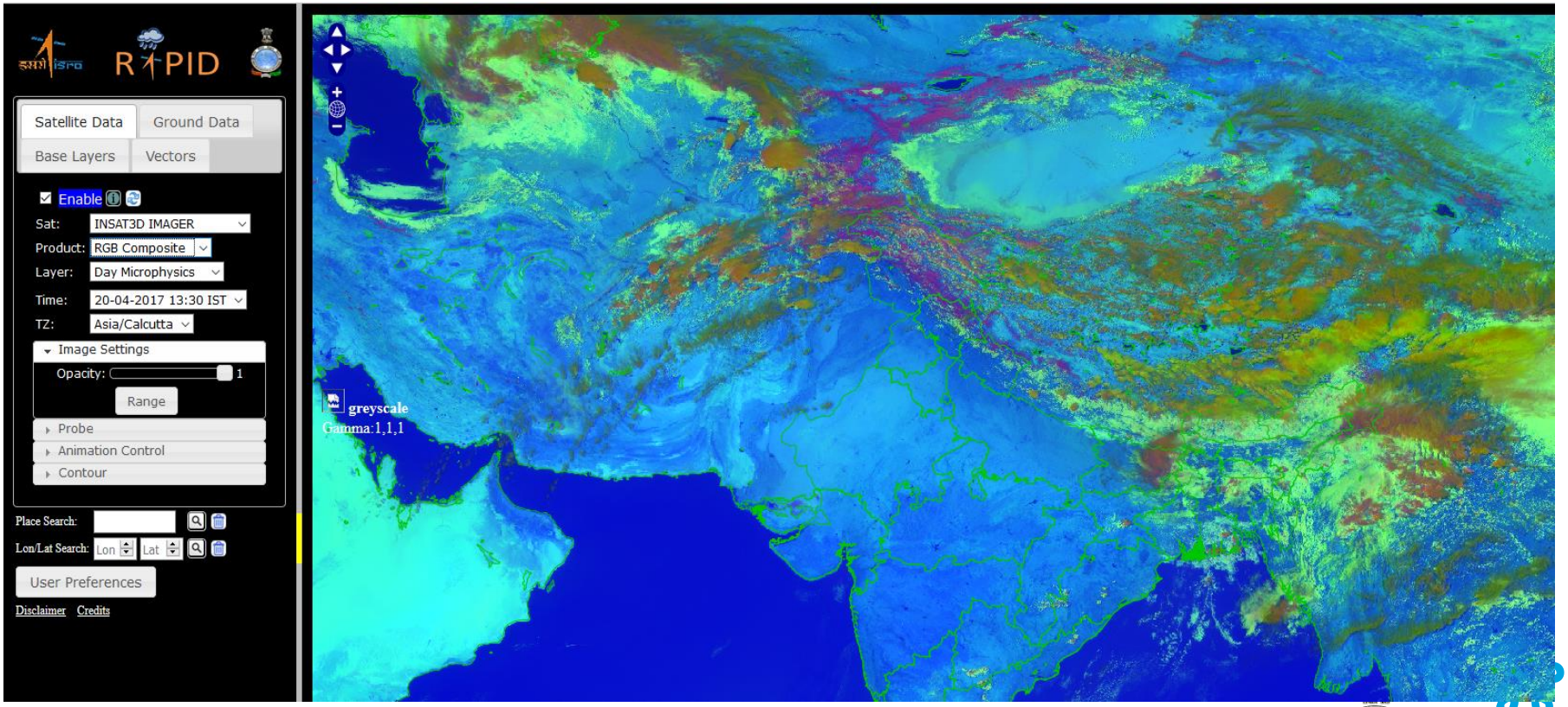


Online Archival of all channel images & products images are available of last six month

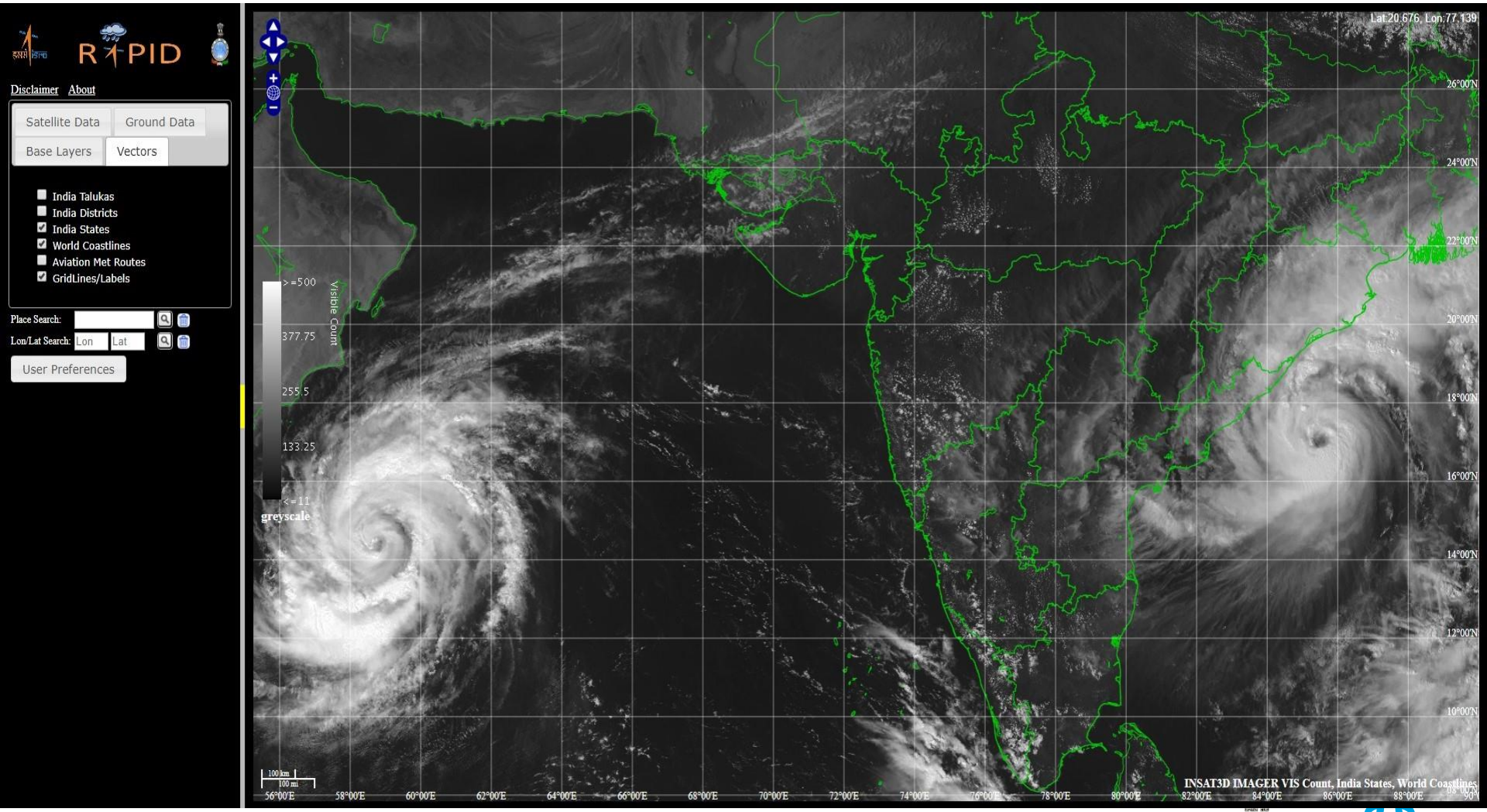
http://satmet.imd.gov.in/archive/

RAPID

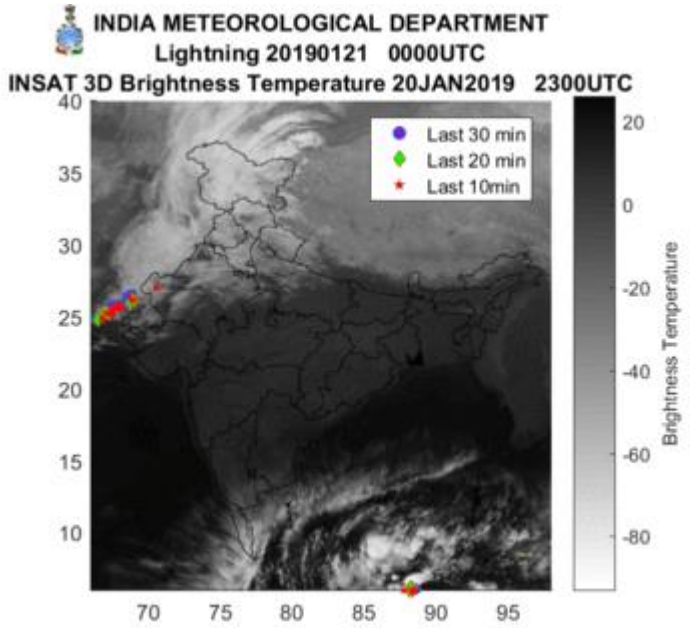
RAPID (Real time Analysis of Products & Information Dissemination) :- It is a web based quick visualization and analysis tool for satellite data on a real time basis. This introduces Next Generation Weather Data Access & Advanced Visualization.
http://www.rapid.imd.gov.in

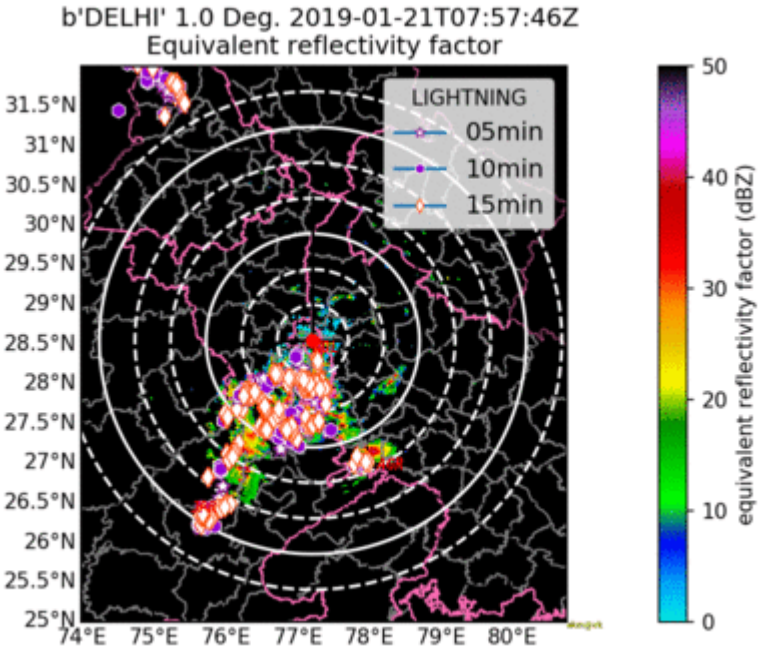


Eye of VSCS “LUBAN” and VSCS “TITLI” as seen by INSAT-3D through RAPID



- Lightning data (Updated every 15-minutes) divided into the 3 different time categories 10, 20 and 30 minutes in different colours.
- Prioritized to merge (all 3 types of instrument data) Satellite, RADAR and Lightning data for the weather forecast





Transmission of Satellite Data over GTS

1. Transmission of SCATSAT-1 data over GTS in BUFR format.
2. Transmission of Megha-Tropics ROSA payload over GTS in BUFR format.
3. INSAT-3D derived Winds (IR/WV/Vis) as in BUFR format is also being provided to UKMET Office through GTS.

Multi-Mission Meteorological Data Receiving & Processing System (MMDRPS)

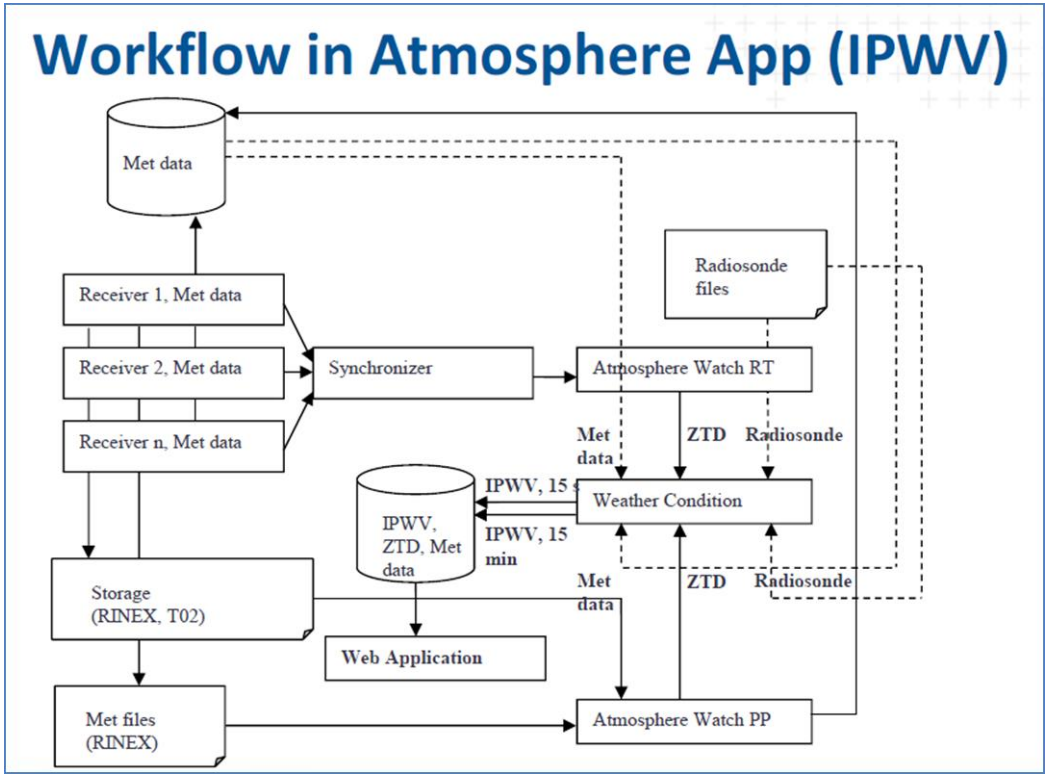
- Implementation of **Multi-Mission Meteorological Data Receiving & Processing System (MMDRPS) project** for reception, processing and dissemination of meteorological data of INSAT-3D/3DR/3DS is in process.
- MMDRPS will have very high end processing system which will cut down the processing time from currently 15 minutes to 5 minutes.
- MMDRPS will have storage capacity of the order of 2PB along with 330TB flash drive which will facilitate online sharing of processed data for all Indian meteorological satellites to the registered users as per IMD data policy.

New Proposed products in MMDRPS

S. No.	Geophysical Parameter
1	High Density Visible Cloud Drift Winds
2	Composite Wind Pattern of 15/30 Days
3	Sounder Cloud Properties (CTH, CTP, CTT, Isentropic Surface Analysis)
4	Surface Albedo
5	Actual Evo-Transpiration (AET)
6	Relative Evo-Transpiration (RET)
7	Biomass Burning Emission Product (BBEP)
8	MIR Reflectance
9	Himalaya Snow Cover
10	Net Radiation (Rnet)
11	Sounder Cloud Cleared Radiances/Tb
12	Imager Cloud Cleared Radiances/Tb
13	Imager Clear Sky Brightness Temperature (CSBT)
14	Cloud Microphysics
15	Potential Evapotranspiration
16	Short Wave Radiation Over Ocean
17	Merged Wind Products

IMD - GNSS Network – Present Status

25 GNSS + 5 GPS



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Dissemination through a dedicated IMD web site Updated every fifteen Minutes

http://gnss.imd.gov.in/TrimblePivotWeb/

GNSS ATMOSPHERE WATER VAPOUR WATCH

SATELLITE METEOROLOGY DIVISION

IMD ATMOSPHERE WATCH

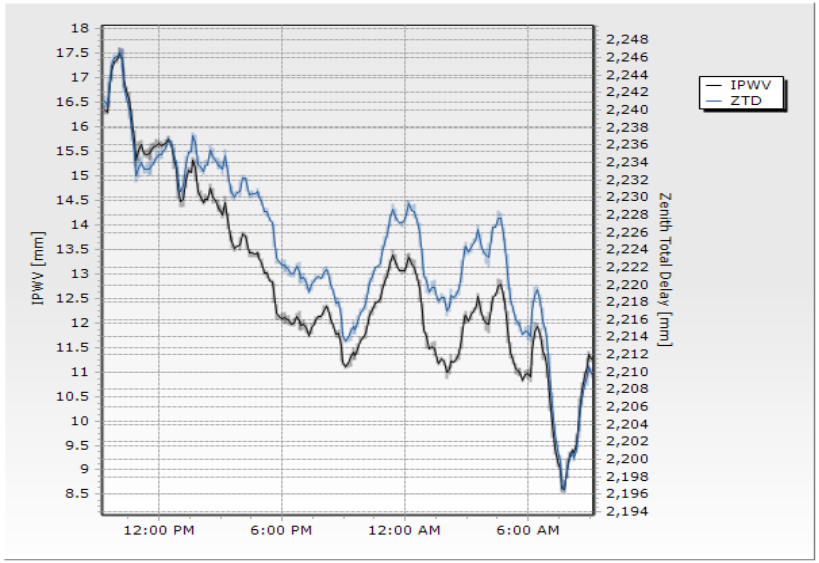
> Home > Atmospheric Conditions > Station Chart

- Home
  - Sensor Map
  - **Atmospheric Conditions**
    - IPWV Map
    - **Station Chart**
    - Condition Chart
    - IPWV Contour Map
    - IPWV Surface Map
    - IPWV Surface Map Animation
    - TEC Contour Map
    - TEC Surface Map
    - TEC Surface Map Animation
  - **Position Scatter Plot**
    - Position Scatter Plot
- Administrator Login

Station per Atmospheric Condition

ARGD | Timespan: Last 24 hours | Average Timespan: Raw | ☑ Display min and max values

Auto Refresh: Disabled



☑ IPWV
☑ Zenith Total Delay
☐ Temperature
☐ Pressure
☐ Humidity

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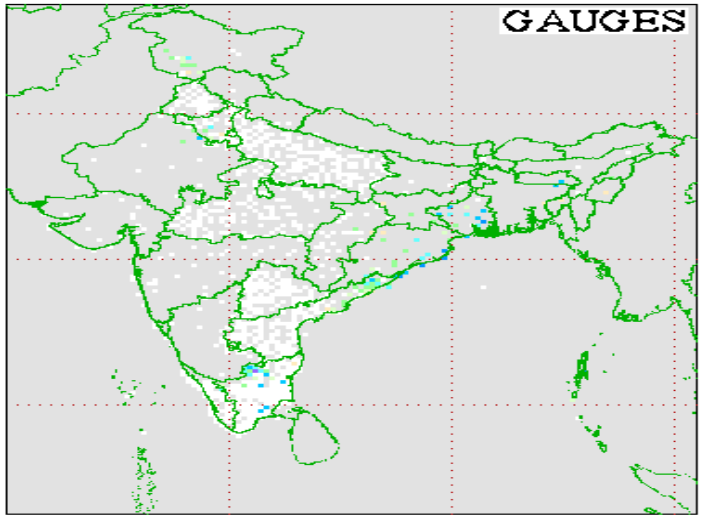
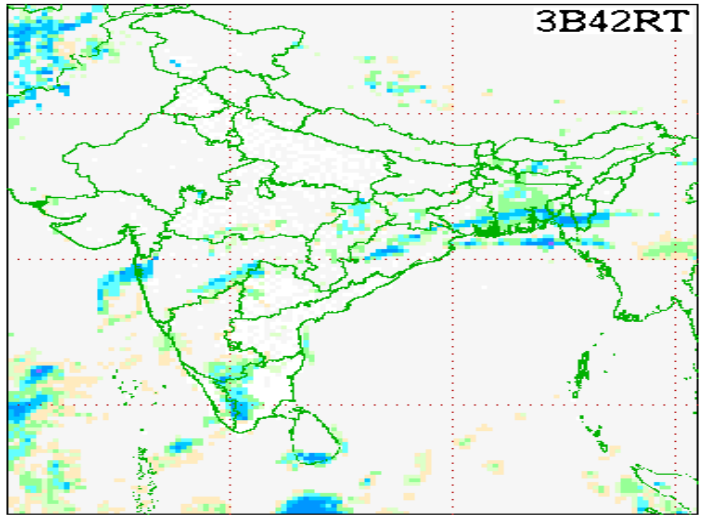
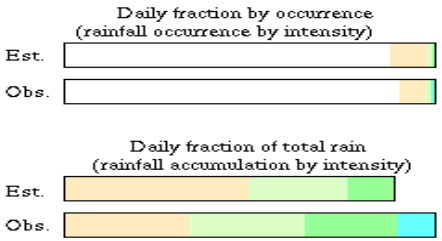
Development of IPWG inter-comparison site over India-in progress
Dr Chris Kidd and IMD team & completion by July 2019 (Action-CGMS-45)





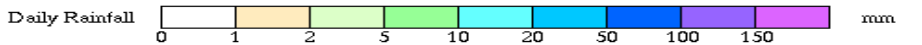


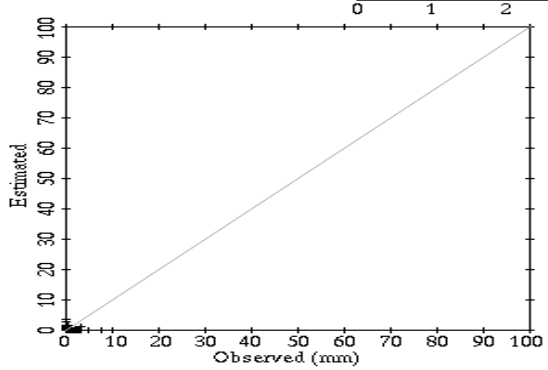
Estimated	zero	rain
Observed zero	792.	119.
Observed rain	86.	22.

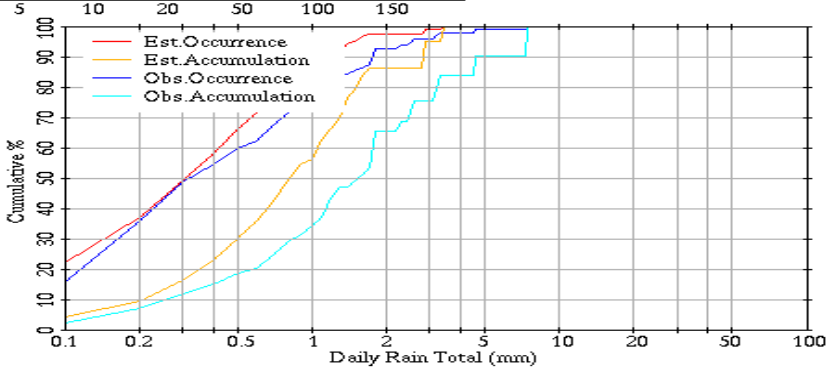
POD 0.204
FAR 0.844
HSS 0.040

Estimated	<1mm	>=1mm
Observed zero	822.	102.
Observed rain	75.	20.

POD 0.211
FAR 0.836
HSS 0.066







	Observed	Estimated
Number of points	1019.	1019.
Raining points	108.	141.
Raining points >1mm	92.	122.
Mean rain total	0.77	0.72
Conditional rain total	7.30	5.19
Maximum rain total	74.00	34.05

Bias	−0.05
Ratio	0.929
RMSE	4.7
Correlation	0.043
#samples	1019.

24h to 03Z
20180209

C.Kidd'18

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FUTURE GEO SATELLITES – GISAT-1

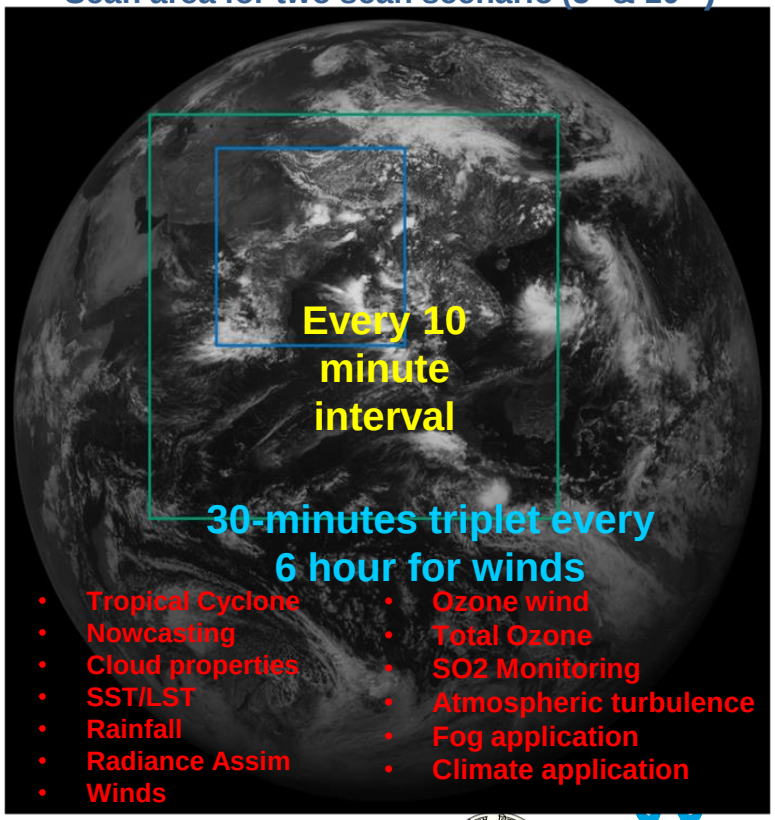
Launch Schedule: 2019, Geostationary orbit, 83E

MX-VNIR: Multispectral - Visible Near Infrared, HySI-VNIR: Hyperspectral Imager - Visible Near Infrared, HySI-SWIR: Hyperspectral Imager - Short Wave Infrared, MX-LWIR: Multispectral - Long Wave Infrared.

Band	Ch	SNR/N EdT	IFOV (m)	Range (μm)	Channels (μm)
MX-VNIR	4	> 200	50	0.45 - 0.875	B1: 0.45-0.52 B2: 0.52-0.59 B3: 0.62-0.68 B4: 0.77-0.86 B5N: 0.71-0.74 B6N: 0.845-0.875
HyS-VNIR	60	> 400	500	0.375 - 1.0	Δλ < 10 nm
HyS-SWIR	150	> 400	500	0.9 - 2.5	Δλ < 10 nm
MX-LWIR	6	NEdT < 0.15K	1500	7.0 – 13.5	CH1: 7.1-7.6 CH2: 8.3-8.7 CH3: 9.4-9.8 CH4: 10.3-11.3 CH5:11.5-12.5 CH6: 13.0-13.5

GISAT Scan scenario

Scan area for two scan scenario (5° & 10 °)



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FUTURE GEO SATELLITES – INSAT-3DS

INSAT-3DS: India will launch this exclusive third meteorological satellite of this series in 2022.

Payloads	Channel	Resolution	Data Rate/Bandwidth
Imager	visible (0.52-0.77 µm)	1x1 Km	3.92725 Mbps
	SWIR (1.55-1.70 µm)	1x1 Km	
	MIR (3.8-4.0 µm)	4x4 Km	
	WV (6.5-7.1 µm)	8x8 Km	
	TIR-1 (10.3-11.3 µm)	4x4 Km	
	TIR-2 (11.5-12.5 µm)	4x4Km	
Sounder	LWIR -7 channel (14.71-12.02 µm)	10x10 Km	40.00 Kbps
	MWIR-5 Channel (11.03-6.51 µm)		
	SWIR-6 Channel (4.57-3.74 µm)		
	VIS (0.695 µm)		
DRT	Up link 402.75MHz		
S&SR	Up link 406.05MHz		

THANK YOU