Multi Meteorological Data Receiving and Processing System(MMDRPS)

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Multi-Mission Meteorological Data Receiving & Processing System (MMDRPS)-IMD has established an advanced stage MMDRPS for INSAT-3D, INSAT-3DR and INSAT-3DS satellites and system made operational since 1st October 2019.

MMDRPS have the following capabilities:

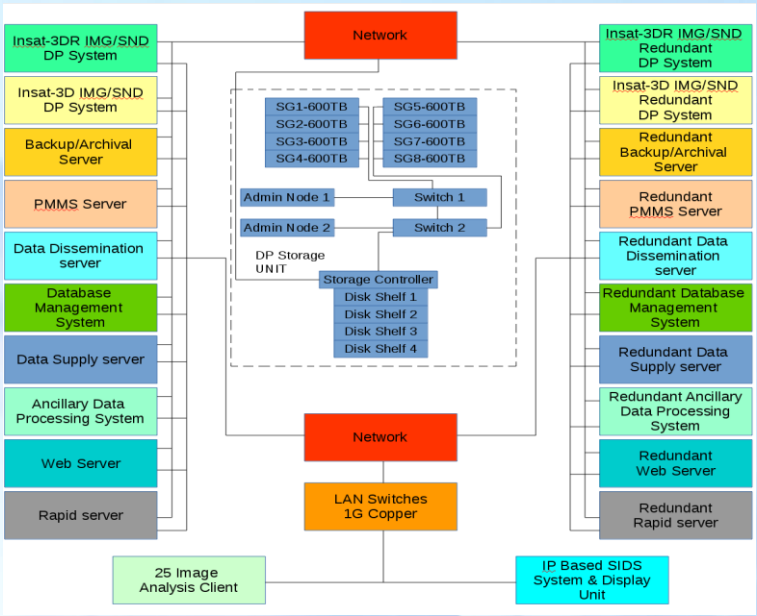
Image processing software for INSAT-3D/3DR and upcoming INSAT-3DS satellite data and convert them to the various standard formats like ASCII, binary, NetCDF, Hierarchical Data Format (HDF5).

- MMDRPS have very high end processing system which cut down the processing time from 15 minutes to 7 minutes.
- Cal/ Val site data / GISCS calibration coefficient to be used in operational chain.
- System is capable to process RAPID scan data of INSAT-3DR Imager payload conducted during Extreme weather events.
- MMDRPS have storage capacity of the order of 2.0/2.0PB(Main/ Mirror) & 324TB SSD which will facilitate online sharing of processed data for all Indian meteorological satellites to the registered users as per IMD data policy.
- All available past satellite datasets starting from 1983 will be kept in online mode in due course of time.

Data Processing System at MMDRPS

The raw data from DR System is transferred to the Data Processing System via TCP/IP network. The main function of DP System is to process the data received from DRS and give the desired products. The DP System consists of main & redundant severs having 8 Dell Power Edge R940 servers (INSAT- 3D& 3DR Imager and INSAT-3D & 3DR Sounder servers) and 2 Dell Power Edge T640 servers (Ancillary Data Processing System server). All the raw data from DRS is processed in these servers and the desired products are obtained. After processing, the data is transferred to dedicated system for storage

Block Diagram of Data Processing, Product Generation and Storage system of MMDRPS



1.1 Meteorological satellite system:

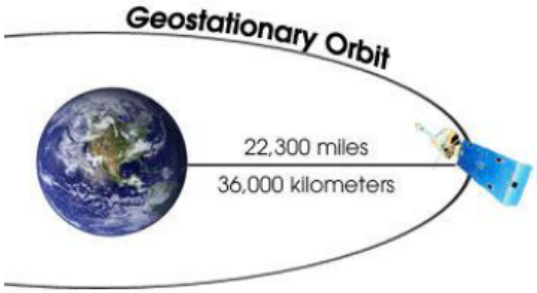
There are two types of satellites viz., Geostationary Satellite and Polar orbiting Satellite observing the earth for meteorological purposes.

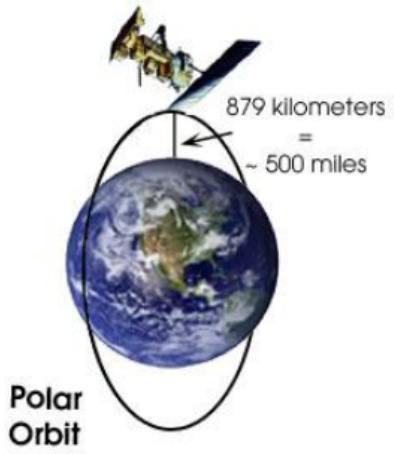
(a) Geostationary Satellites:

Geostationary satellites orbit around the earth over the equator at a height 35800 km. They complete one orbit in every 24 hours so that their period is synchronized with that of the Earth's rotation about its own axis. They remain over same location on the equator. Geostationary satellite images are built up by scanning with a mirror that is tilted in steps from pole to pole at such a rate that on each rotation of the satellite an adjacent strip of the Earth is scanned.

(b) Polar orbiting satellite:

Polar orbiting satellites orbits pass approximately over the poles usually at a height of about 850 km. The whole surface of the Earth can be observed by these satellites which follow orbits nearly fixed in space while the Earth rotates beneath them. The areas scanned on each pass called swath are nearly adjacent at the equator on consecutive passes but it overlaps on polewards.

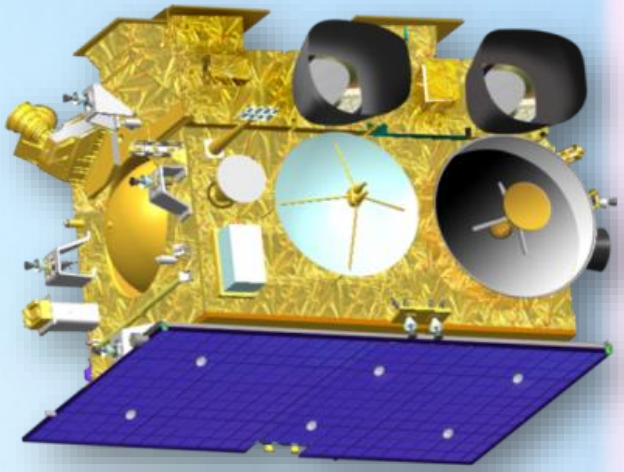




Current Indian Geo stationary Meteorological satellites

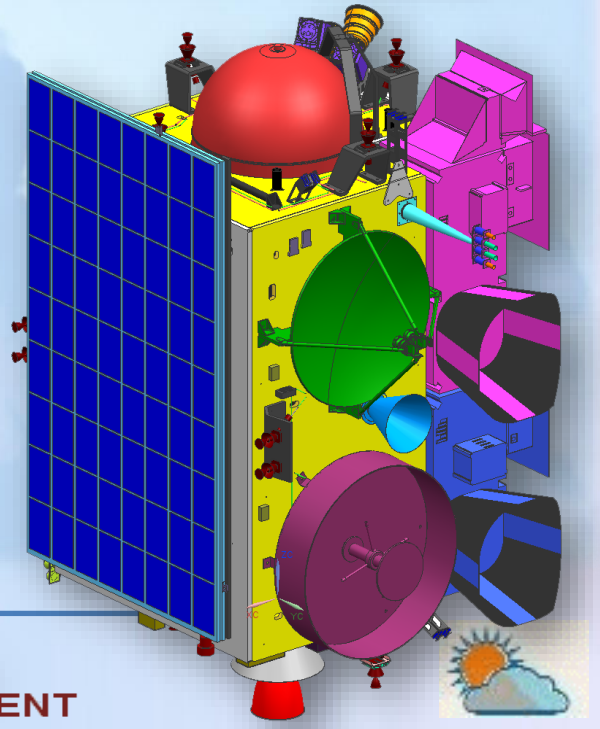
At present the following three INSAT satellites are in operation

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



INSAT-3D-*INDIA's Advanced Weather Satellite*

INSAT-3D: India launched an exclusive meteorological satellite on 26th July, 2013 from French , Guyana using ARIANE rocket. It is located at 82 Degrees East.

Mission objectives:

•To monitor earth's surface, carryout oceanic observations and its environment in various spectral channels of meteorological importance.

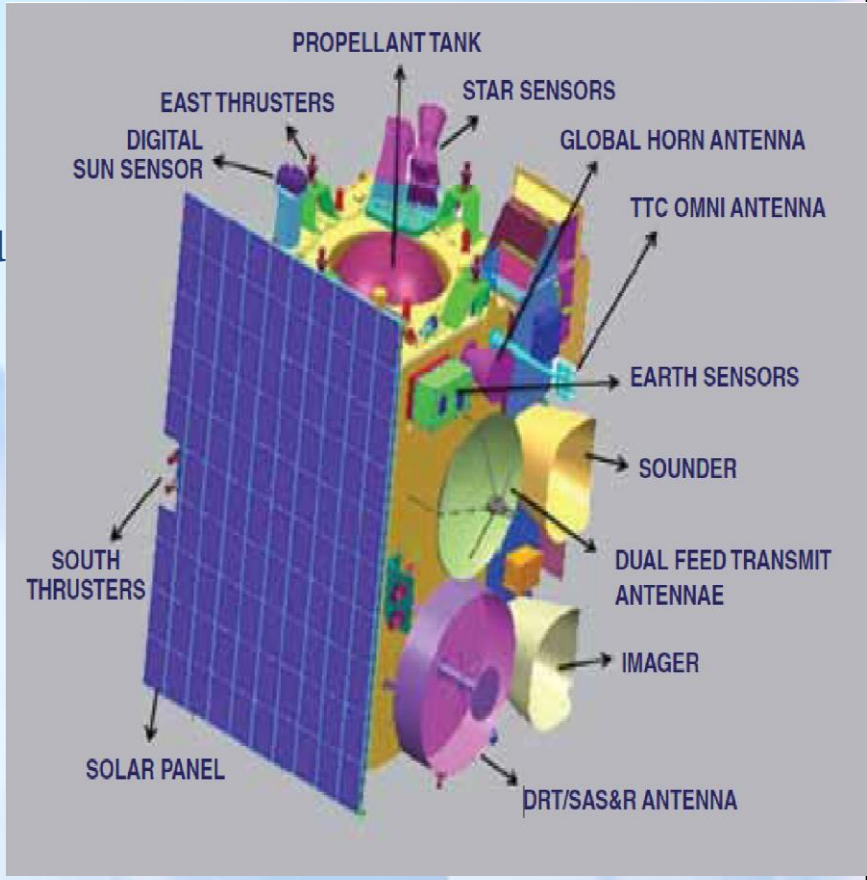
•To provide the vertical profile of temperature and humidity parameters of the atmosphere.

•To provide the data collection and data dissemination capabilities from the Data Collection platforms (DCPs

•To provide the satellite aided search and rescue services.

Payloads

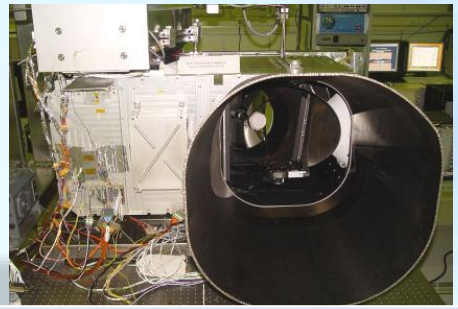
- Six channel imager
- Nineteen channel sounder
- Data Relay Transponder(DRT)
- Satellite aided Search and Rescue(S&SR) System.



Meteorological payloads are state-of-art and have significant technological improvement in sensor capabilities and higher resolution compared to earlier INSAT missions

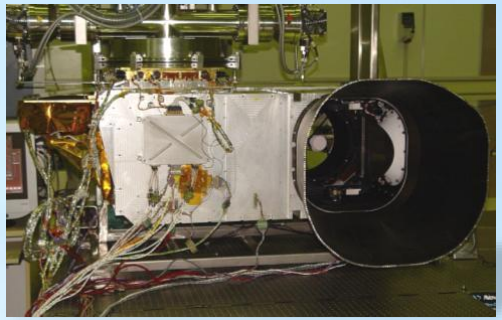
INSAT 3D Met. Payloads

Six channel Imager



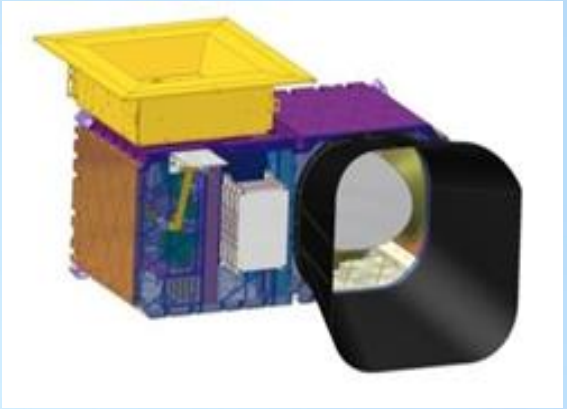
- Visible to Thermal IR
- 1KM to 8KM IGFOV
- Half hourly earth coverage
- Flexible scanning modes
  - Programmable number of lines and frame repeats
- Improved Blackbody calibration scheme
- Image motion & Mirror motion compensation

Nineteen channel Sounder



- Visible to Long Wave IR
- Fully programmable East-West and North –South Scan pattern
- Programmable dwell time for East-West scan step motion
- Automatic space view every 2 min and Blackbody view every 30min.
- 10KM IGFOV, 14bits digitization
- Image motion & Mirror motion compensation

Overview – INSAT-3D payloads-IMAGER



It is multi-spectral (optical radiometer) capable of generating the images of the earth in six wavelength bands significant for meteorological observations, namely, visible, shortwave infrared, middle infrared, water vapor and two bands in thermal infrared regions. The Imager generates images of the earth disk from geostationary altitude of 36,000 km every 26 minutes and provide information on various parameters, namely, outgoing long-wave radiation, quantitative precipitation estimation, sea surface temperature, snow cover, cloud motion winds, etc

The Imaging System of INSAT-3D has the following significant improvements over that of KALPANA and INSAT-3A:

- Improved 1 km resolution in the visible band for the monitoring of mesoscale phenomena and severe local storms
- Imaging in Middle Infrared band to provide night time pictures of low clouds and fog.
- Imaging in two Thermal Infrared bands for estimation of Sea Surface Temperature (SST) with better accuracy.
- Higher Spatial Resolution in the Thermal Infrared band.

Overview – INSAT-3D payloads-IMAGER cont.

The salient features of INAST-3D Imager are as follows:

- Blackbody calibration sequence is modified as compared to VHRR of earlier satellites.
- Three flexible mode of operation
- High Resolution mode: in the Fast Scan direction IFOVs are over sampled by 1.75 times.
- A biannual rotation of yaw by 180 degree has been introduced to reduce the cooler patch temperature. This is to be taken care during processing

Spectral Band	Wave length μm	Ground Resolution	Quantization bits	IGFOV μ□rad
VIS	0.55 – 0.75	1 Km	10	28
SWIR	1.55-1.70	1 Km	10	28
MIR	3.80-4.00	4 Km	10	112
WVP	6.50-7.10	8 Km	10	224
TIR 1	10.3-11.3	4 Km	10	112
TIR 2	11.5 – 12.5	4 KM	10	112

Mode of Operation	Time of coverage	Coverage Area
Full frame mode	26 minutes	18x18 degrees
Programmed Normal scan mode	23 minutes	14x18degrees
Programmed Sector scan mode	6 minutes	4 degrees in NS & 18 degrees in EW

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

Spatial Resolution of INSAT 3D/3DR Imager Channel

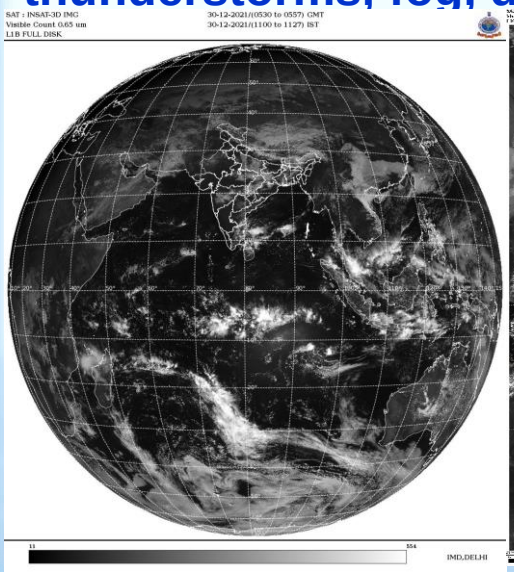
Channel no.	Spectral Band	Spectrum (μm)	Ground Resolution (km)	Purpose
1	Visible	0.55 – 0.75	1 × 1	Clouds, Surface features
2	SWIR	1.55 – 1.70	1 × 1	Snow, Ice and water phase in clouds
3	MIR	3.80 – 4.00	4 × 4	Clouds, Fog, Fire
4	WV	6.50 – 7.10	8 × 8	Upper-Troposphere Moisture
5	TIR1	10.2 – 11.3	4 × 4	Cloud top and surface temperature
6	TIR2	11.5 – 12.5	4 × 4	Lower-Troposphere Moisture

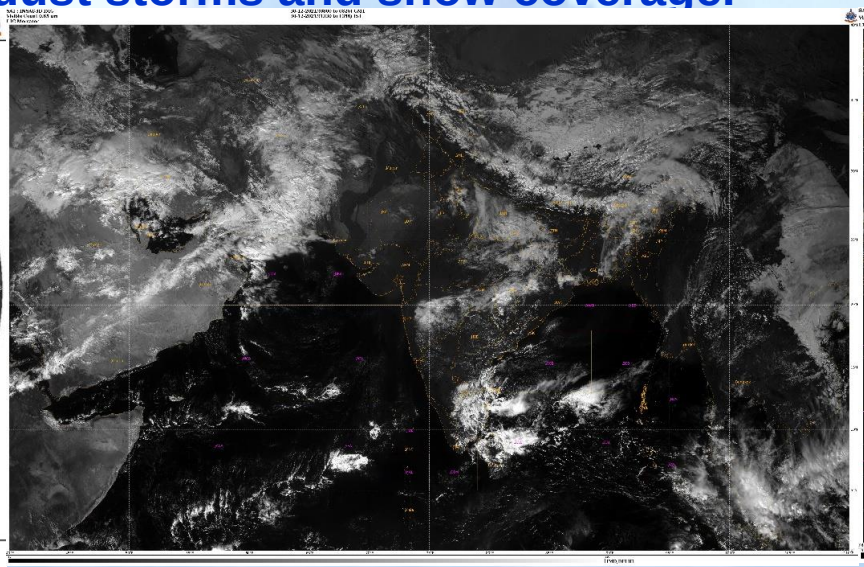
Visible Band (0.55 – 0.75µm)

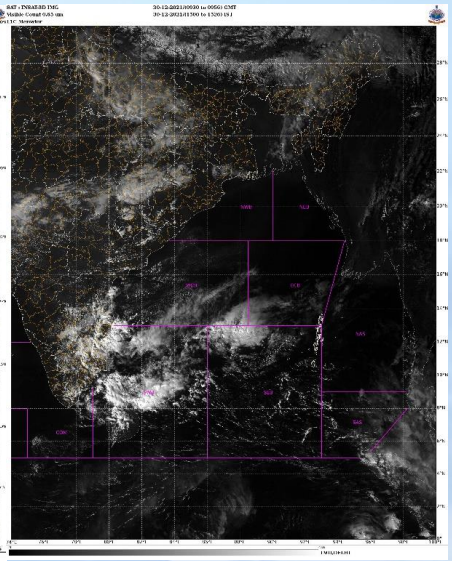
The Visible Band is reflective type of band limited to day time.

Visible images obtained during day time depend on albedo of the target surface. Thus cloud appear brighter due to high albedo and Land appears dark

These Images are used for monitoring mesoscale weather features such as cloud cover, air mass boundaries, convergence zones, cyclone movement, thunderstorms, fog, dust storms and snow coverage.





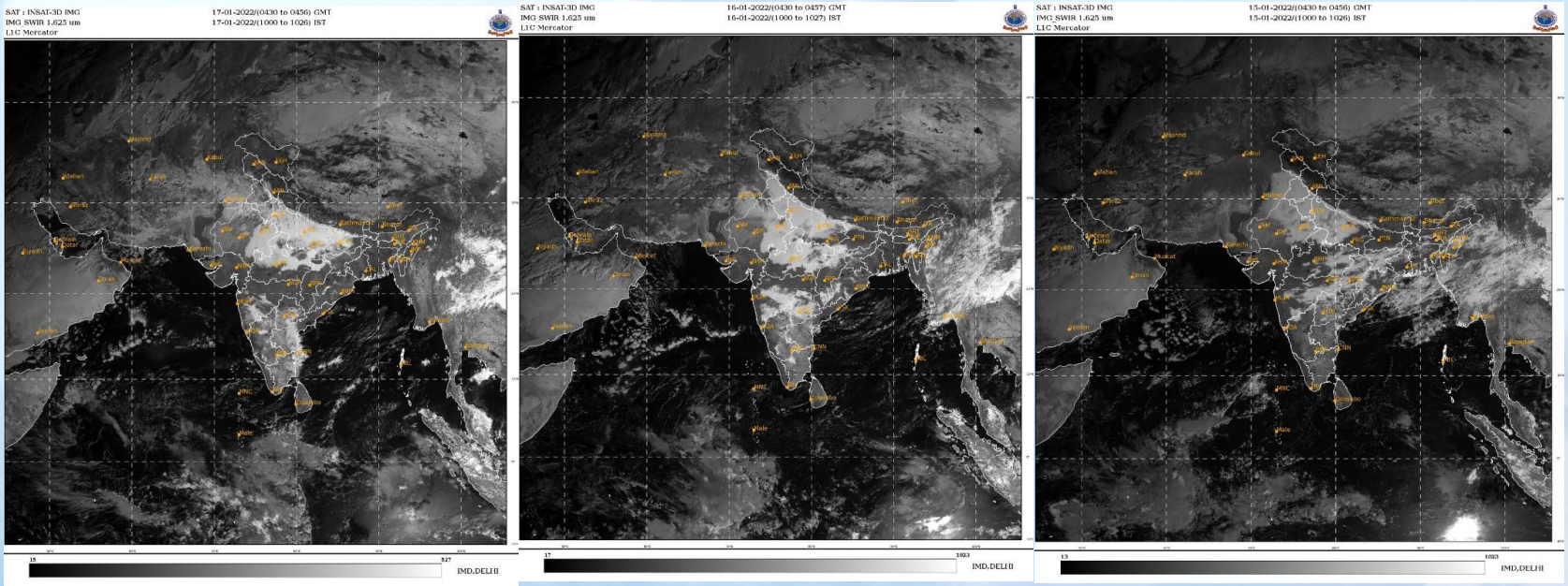


Shortwave Infrared (1.55 – 1.70µm)

The SWIR Band is also a reflective type of band limited to day time.

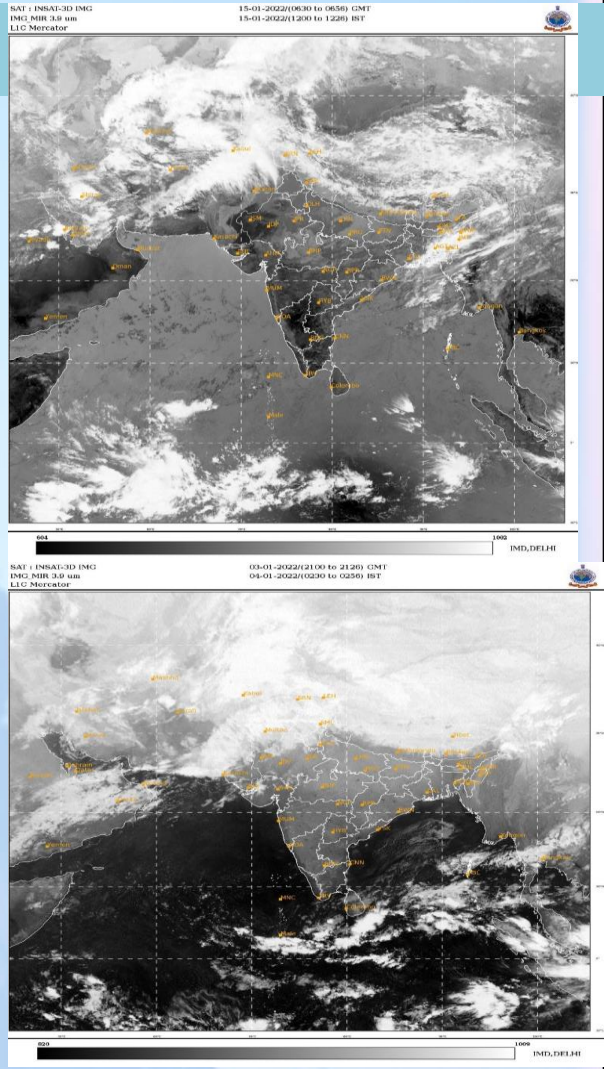
Incident radiation in SWIR, strongly absorbed by water, ice, snow and reflected by cloud, while in case of visible spectrum these objects essentially transparent. Therefore, melting snow patches or lake, ice is seen bright in the visible image while these appears dark in SWIR images and therefore SWIR images are used to differentiate the rain giving cloud and snow.

The SWIR band is also sensitive to the moisture content. Soils recently irrigated therefore appears in darker tones in SWIR images. These Images are used for monitoring local snow cover, day time Fog, Convective R/F estimation, Cloud radiative properties, NDSI.



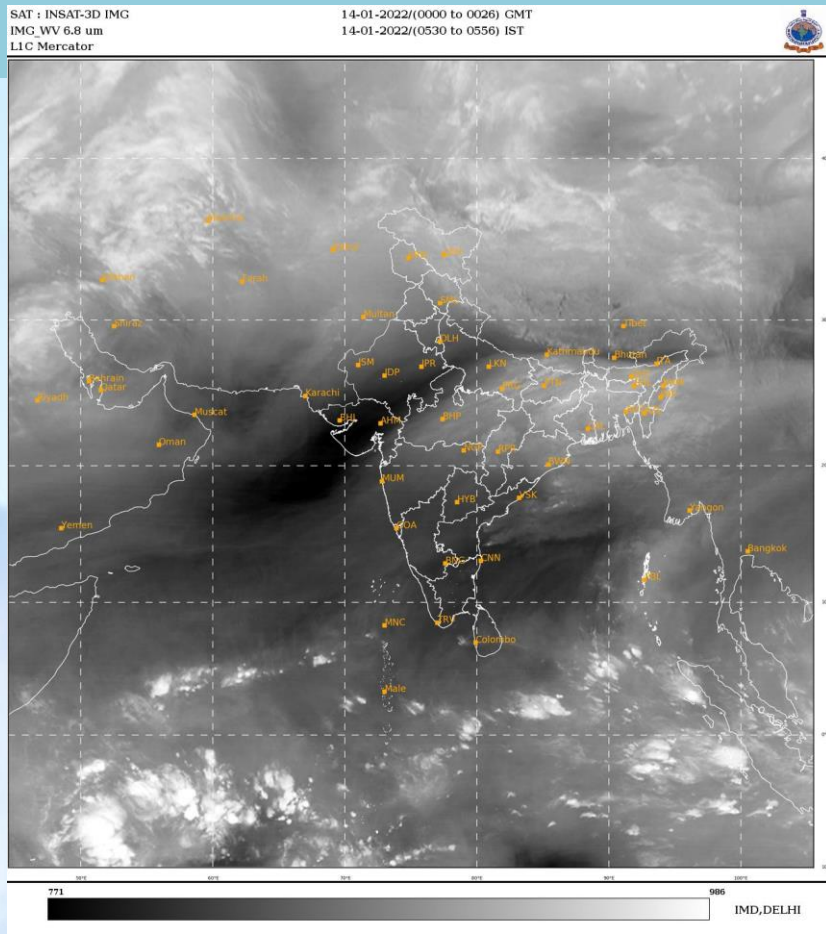
Midwave infra-red (MIR) (3.9um)

- The Mid IR window channel (3.9um) is more temperature sensitivity than TIR
- Used in conjunction with thermal infrared channels.
- It is almost impossible to detect fog or low cloud in conventional IR (10-12 μm) images in night if the fog top has a similar temperature to that of the adjacent ground.
- In this 3.9 μm channel, however the water droplets in fog can be differentiated from a land or sea surface at the same temperature because of emissivity difference. It is also used to identify night time fire/hotspot, volcanic eruption and ash detection in conjunction with thermal infrared window channel.
- During day time, this channel is modulated by reflected sunlight, the day time image is warmer than night time image. The sun glint by the sea surface produces glow in this channel and shows sea brighter than small cirrus cloud.



Water Vapour Channel (6.5 -7.1um)

- Water vapor channel is part of the IR spectrum where water vapour is dominant absorbing gas.
- In a normal moist atmosphere, most of the radiation received by the satellite originates between mid and upper part of the troposphere. Moist air or cloud in the lower half of the troposphere is not depicted well in WV imagery. But thick high clouds, such as cumulonimbus, anvils stand out prominently. Broad scale flow patterns of moisture, upper tropospheric cyclone, raising and subsidence of moisture appears bright and dark respectively.
- The jet streams are delineated by sharp gradients in moisture, with dry air on the pole ward side. The atmospheric motion vector derived from WV imagery is directly used in NWP models.



Visible vs IR Channel

Credit: NASA/JPL-Caltech/R. Hurt (SSC)

Satellite Data Handling at MMDRPS

SINGLE PASS			ONE DAY PASS		ONE M ONTH	TOTAL SIZE
3DIMG_RAW 3DIMG_H5 3DIMG_JPG	1006MB 961MB 303MB		47.2GB 45GB 14.2GB		1.4TB 1.3TB 426GB	3.1TB
3RIMG_RAW 3RIMG_H5 3RIMG_JPG	1006MB 961MB 303MB		47.2GB 45GB 14.2GB		1.4TB 1.3TB 426GB	3.1TB
	SA1	SA2	SA1	SA2		
3DSND_RAW 3DSND_H5 3DSND_JPG	15MB 76MB 25MB	19MB 91MB 25MB	360MB 1.8GB 600MB	304MB 1.4GB 400MB	19.5GB 96GB 30GB	145.5GB
3RSND_RAW 3RSND_H5 3RSND_JPG	15MB 76MB 25MB	19MB 91MB 25MB	360MB 1.8GB 600MB	304MB 1.4GB 400MB	19.5GB 96GB 30GB	145.5GB
DAILY PRODUCTS	….		180MB		5.3GB	6.7TB
TOTAL	5.1GB		222GB		6.7TB	

- The processed data volume of all scans of all channel of INSAT-3D & 3DR (Imager & sounder) is works out to be approx for one month would be around 6.7 TB.
- MMDRPS have storage capacity of the order of 2.0/2.0PB(Main/ Mirror) & 324TB SSD which will facilitate online sharing of processed data for all Indian meteorological satellites to the registered users as per IMD data policy through Web based secured satellite Data Supply System.

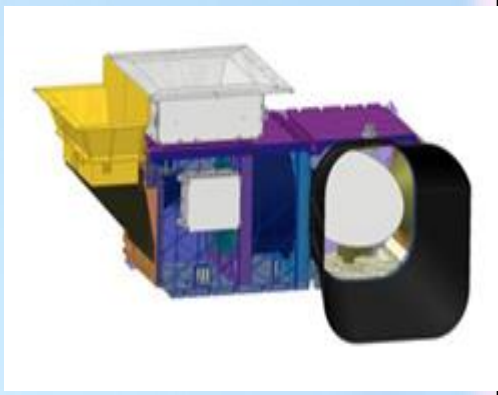
INSAT-3D Imager Products types and formats

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 (Point)					
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 (Gridded)					
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

INSAT-3D Imager Products types and formats

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
5	INSAT Multi-Spectral Rainfall Algorithm (IMSRA)	L3G	IMR	HDF	Daily, Weekly, Monthly and Yearly 0.1 deg x 0.1 deg
6	Quantitative Precipitation Index	L3G	QPI	HDF	Daily, Weekly, Monthly and Yearly (1 deg x 1 deg)

INSAT-3D-Sounder overview



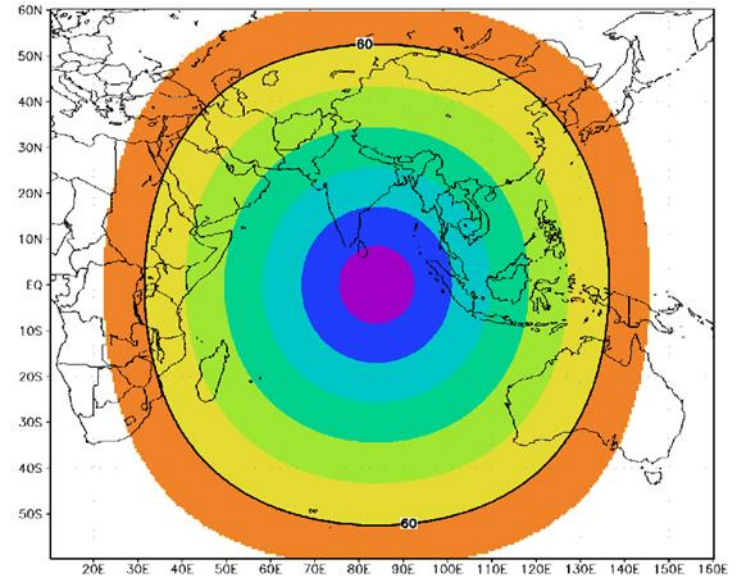
INSAT-3D carries a newly developed 19 channel sounder, which is the first such payload to be flown on an ISRO satellite mission. The Sounder has eighteen narrow spectral channels in shortwave infrared, middle infrared and long wave infrared regions and one channel in the visible region. The ground resolution at nadir is nominally 10x10km for all nineteen channels.

INSAT-3D adds a new dimension to weather monitoring through its Atmospheric Sounding System, with vertical profiles of temperature 40 levels (surface to 70 km) Humidity 21 levels (surface to 15 km) and integrated ozone from surface to top of the atmosphere These profiles are available for a selected region over Indian landmass every one hour and for the entire Indian Ocean Region every sixth hours

Channel	Spectral Range microns	Resolution
VISIBLE(1)	0.67 – 0.72	10X 10 kms.
SWIR(6)	3.67 – 4.59	10X 10 kms
MIR(5)	6.38 – 11.33	10X 10 kms
LWIR(7)	11.66 – 14.85	10X 10 kms

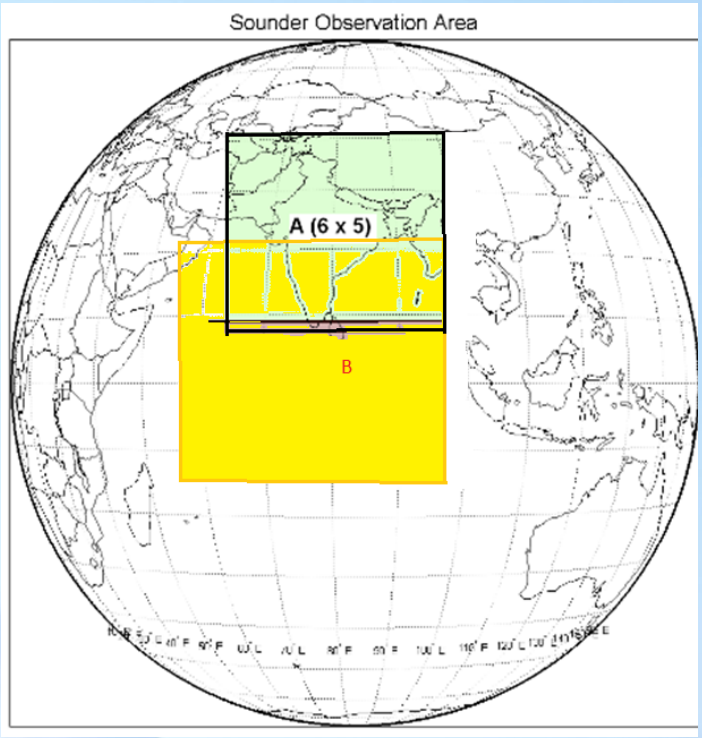
Operational scenario of INSAT-3D/3DR

Observation zenith angle INSAT-3D, S.S.P point at 82E)



6400 km x 6400 km scan takes 180 minutes

64 x 64 pixel scan takes 1.80 minutes



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

0000UTC-INSAT-3D
0100UTC-INSAT-3D
0200UTC-INSAT-3D
0300UTC-INSAT-3DR
0400UTC-INSAT-3DR
0500UTC-INSAT-3DR

Sector-B

0000UTC-INSAT-3DR
0130UTC-INSAT-3DR

0300UTC-INSAT-3D
0430UTC-INSAT-3D

Then this cycle will be repeated on six hourly basis.

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

Thank You