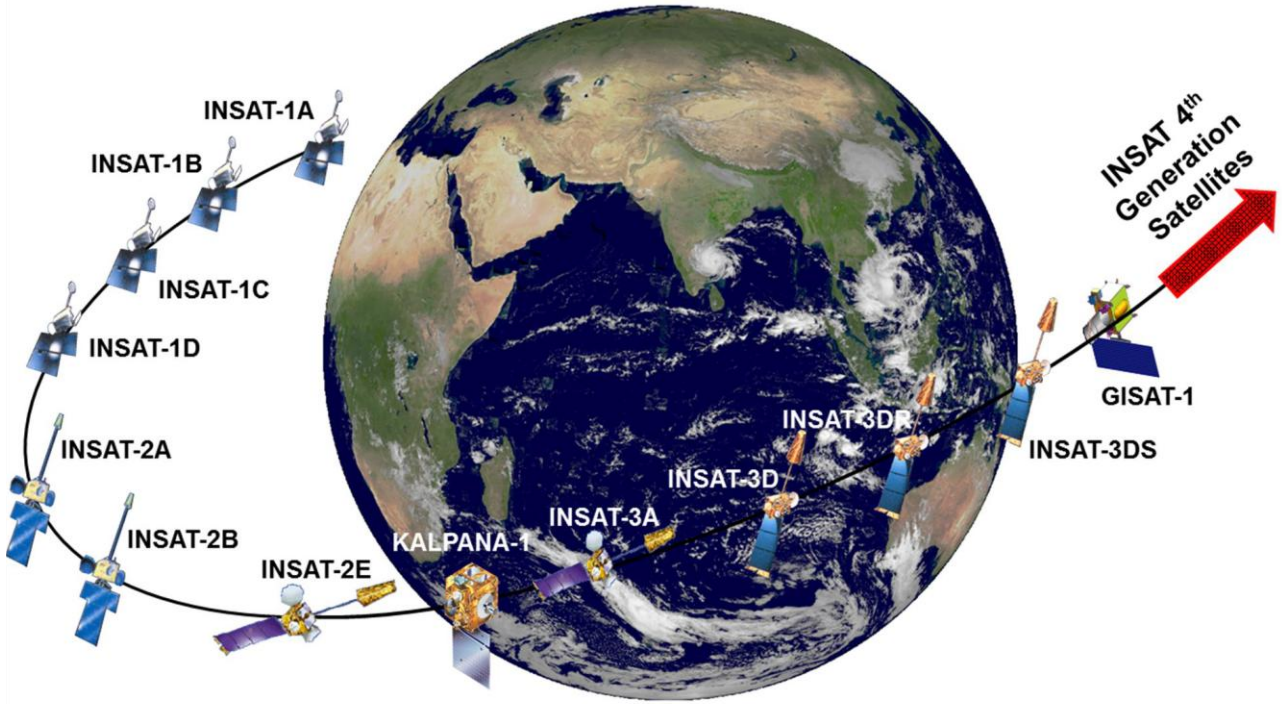
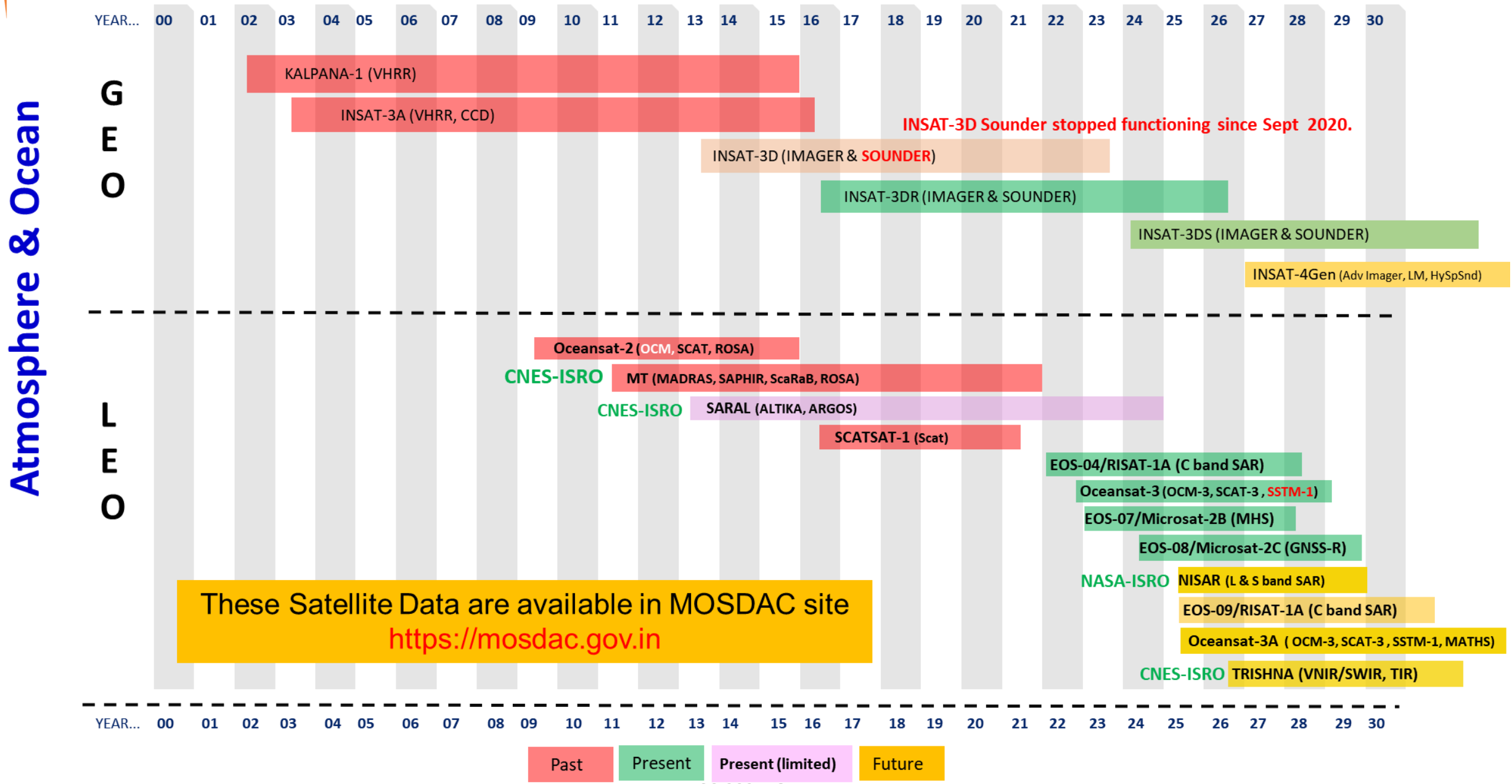
ISRO Agency Report:

Present and future satellite instruments in support of Met-Ocean applications

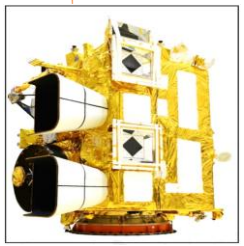


Pradeep Thapliyal
Space Applications Centre (ISRO)
pkthapliyal@sac.isro.gov.in

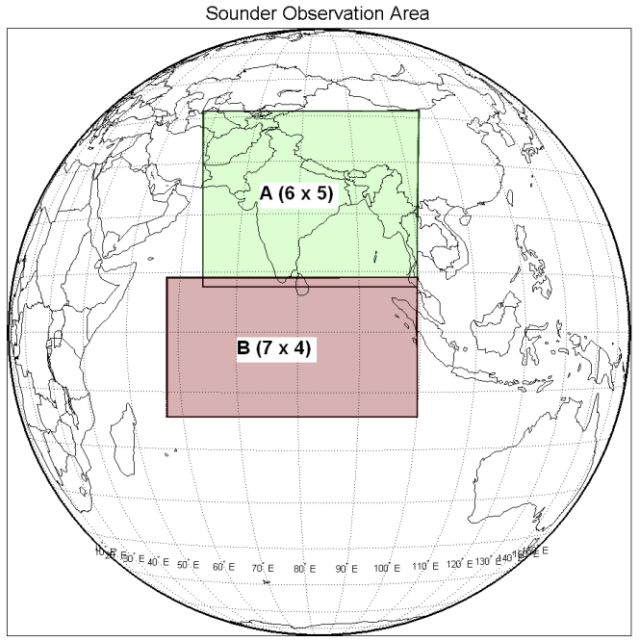
Overview - ISRO satellite systems



INSAT-3DS

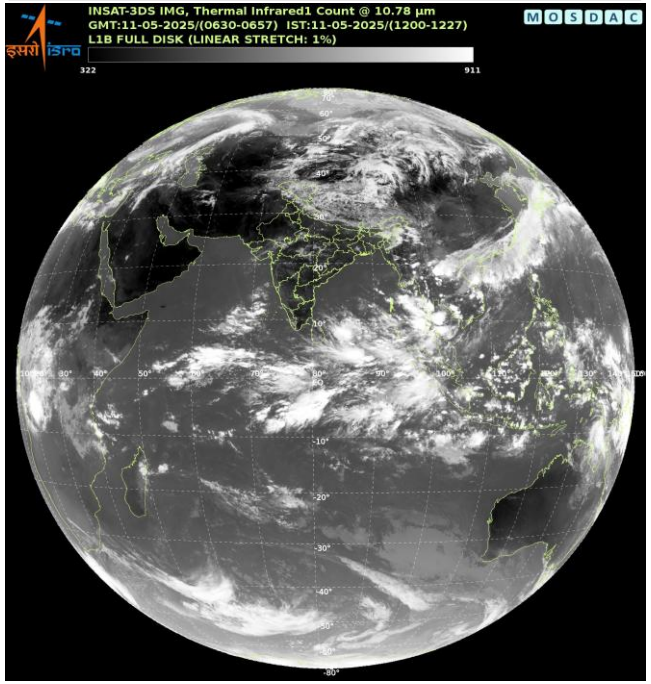


- Launched on 17-Feb-2024 from Satish Dhawan Space Centre (SDSC/ISRO)
- Improvements to mitigate the issues related to the BBCAL/mid-night sun
- **INSAT-3DS replaced INSAT-3D at 82E**



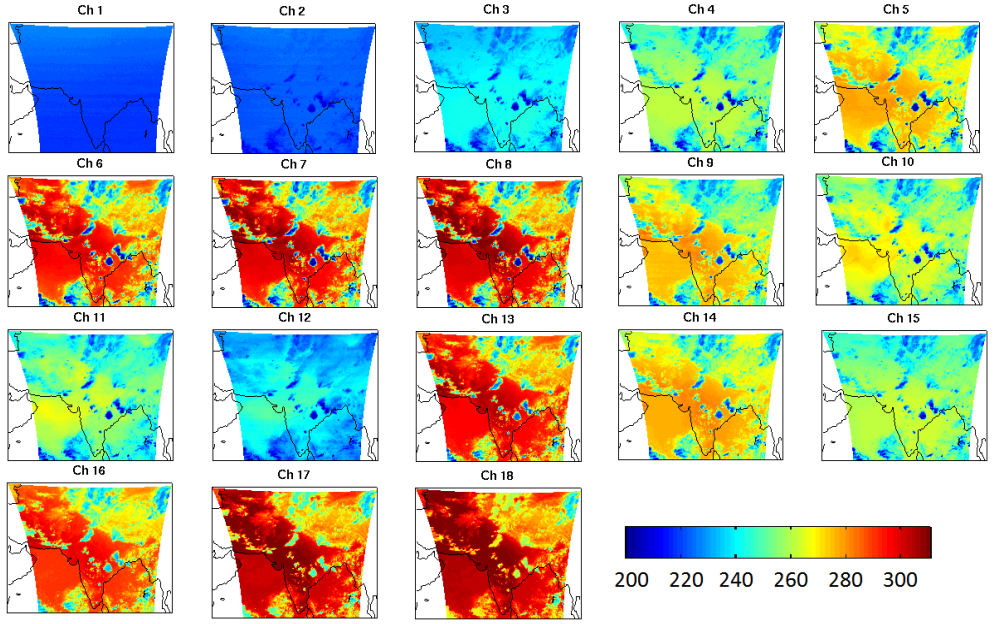
6-Channel Imager

Channel	Spectral Band (μm)	Spatial Resolution at Nadir (km)	SNR @ 100% or NEΔT@300K
VIS	0.55-0.75	1 km	SNR>150
SWIR	1.55-1.68	1 km	SNR>150
MIR	3.80-4.00	4 km	1.4K
WV	6.5-7.1	8 km	1.0K@230K
TIR-1	10.3-11.3	4 km	0.35K
TIR-2	11.5-12.5	4 km	0.35K

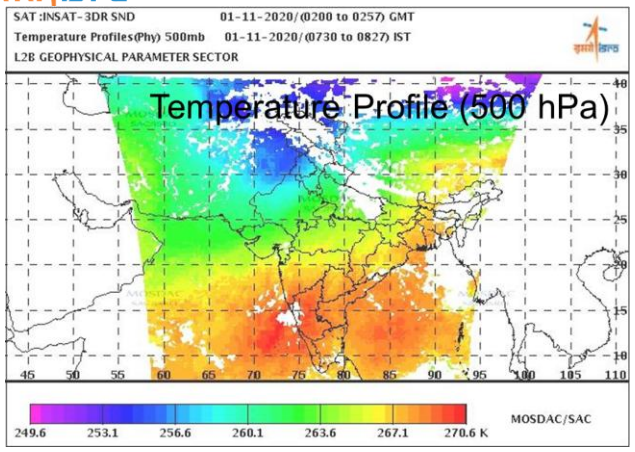


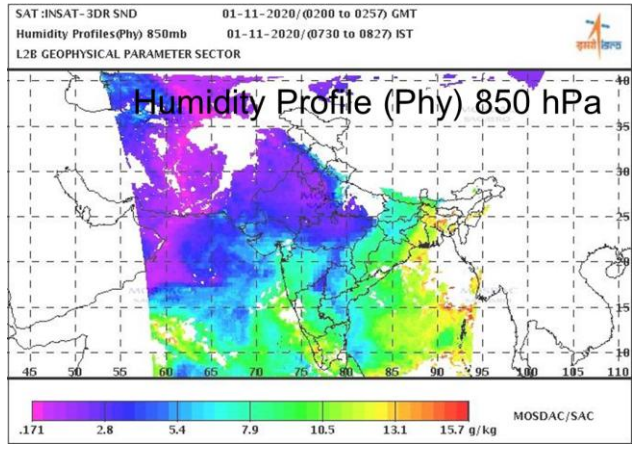
19 - Channel Sounder (18 IR + 1 VIS)

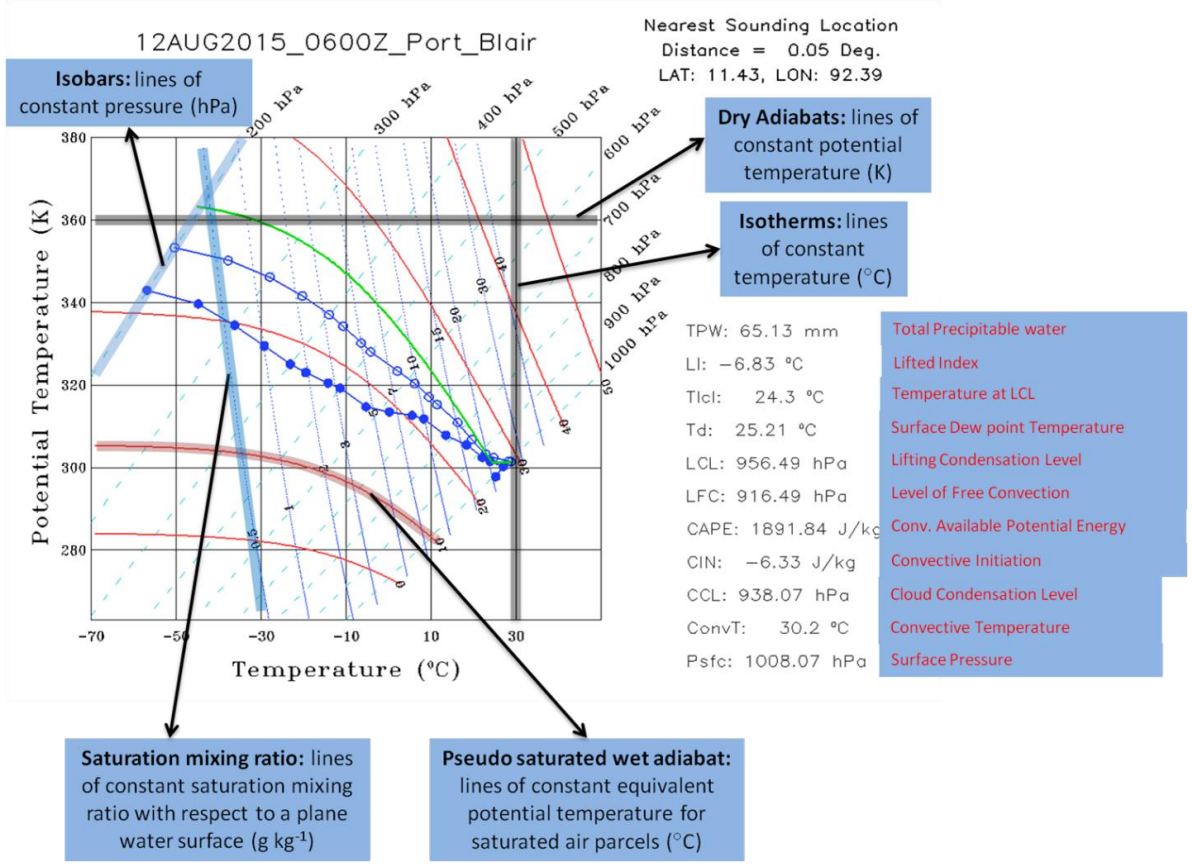
Detector	Ch. No.	λ_c (μm)	ν_c (cm^{-1})	Principal absorbing gas	Purpose
Long wave	1	14.68	681	CO_2	Stratosphere temperature
	2	14.36	696	CO_2	Tropopause temperature
	3	14.06	711	CO_2	Upper-level temperature
	4	13.69	731	CO_2	Mid-level temperature
	5	13.35	749	CO_2	Low-level temperature
	6	12.63	792	H_2O	Total precipitable water
	7	12.01	833	H_2O	Surface temp., moisture
Mid wave	8	11.00	909	Window	Surface temperature
	9	9.72	1029	O_3	Total ozone
	10	7.43	1347	H_2O	Low-level moisture
	11	7.03	1422	H_2O	Mid-level moisture
	12	6.51	1537	H_2O	Upper-level moisture
Short wave	13	4.60	2174	N_2O	Low-level temperature
	14	4.55	2200	N_2O	Mid-level temperature
	15	4.48	2235	CO_2	Upper-level temperature
	16	4.16	2404	CO_2	Boundary-level temperature
	17	4.01	2493	window	Surface temperature
	18	3.76	2659	window	Surface temperature, moisture
Visible	19	0.695	14367	visible	Cloud detection during daytime

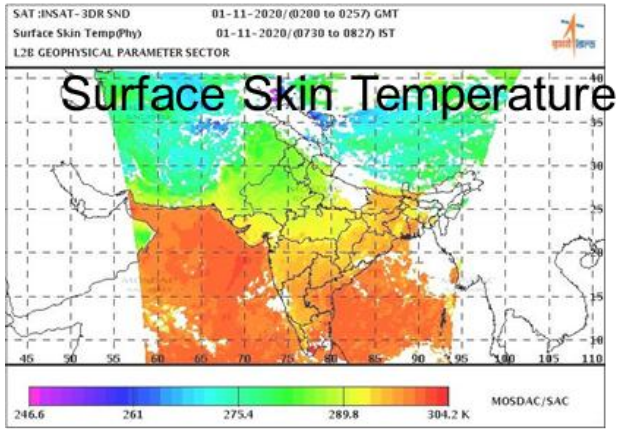


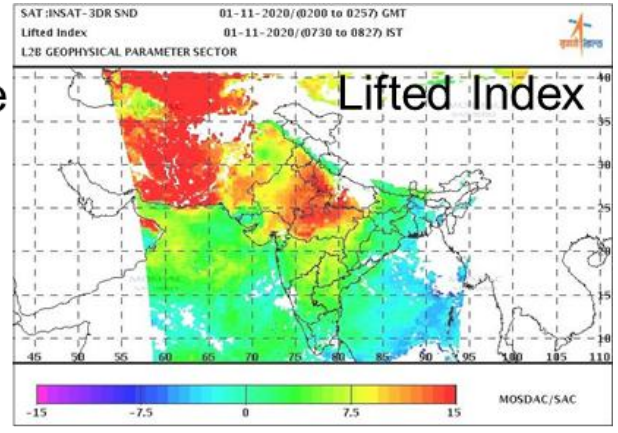
Sounder Derived Products (01-Nov-2020, 2GMT)

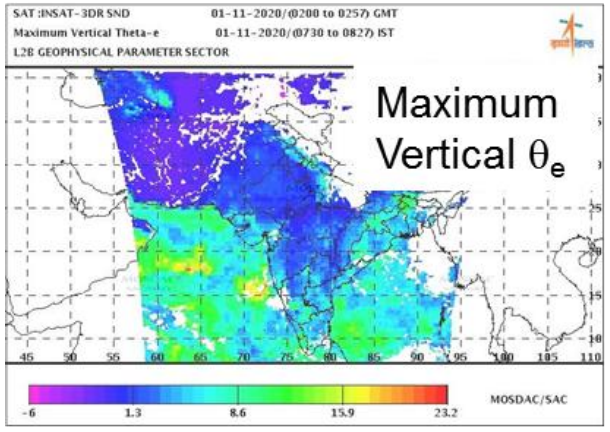


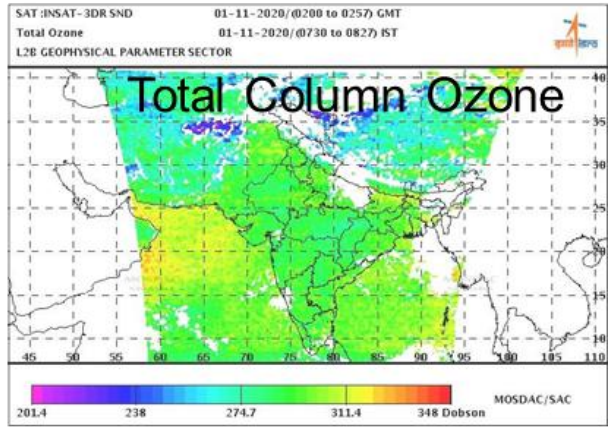


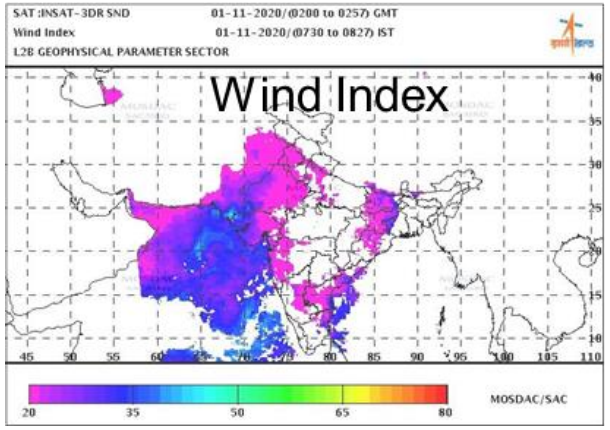


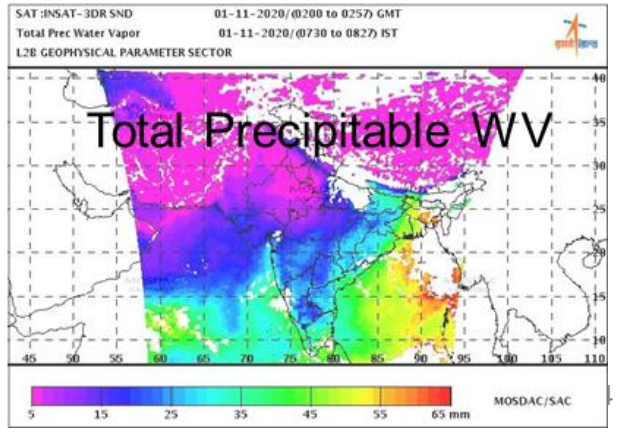






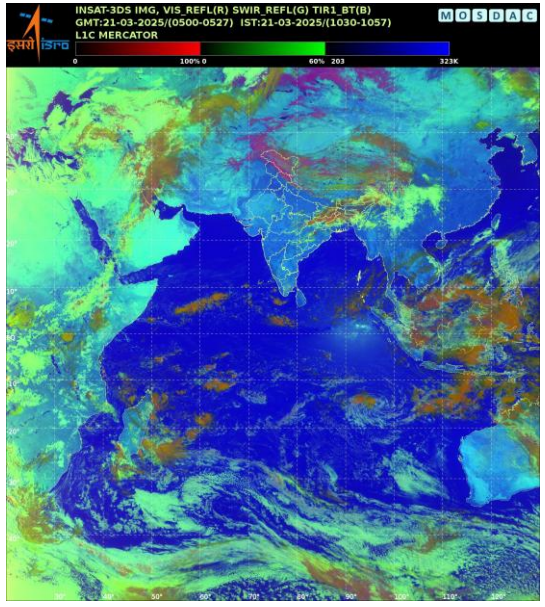




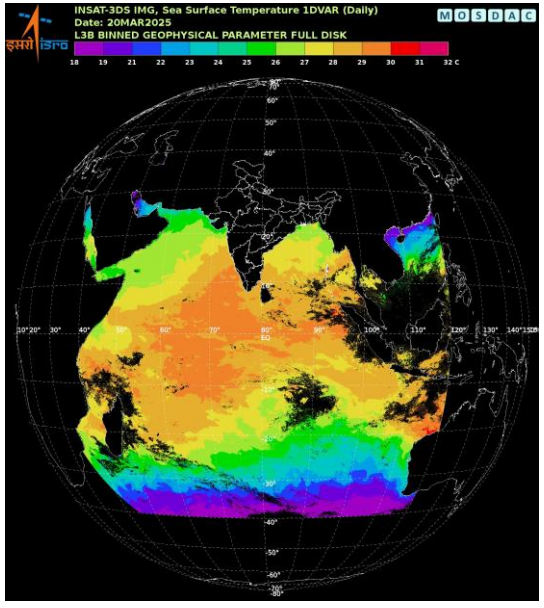


Sample Imager Derived Products

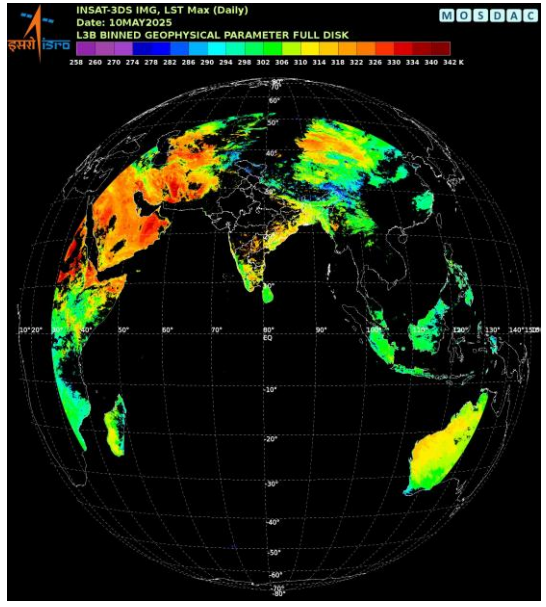
Day Microphysics



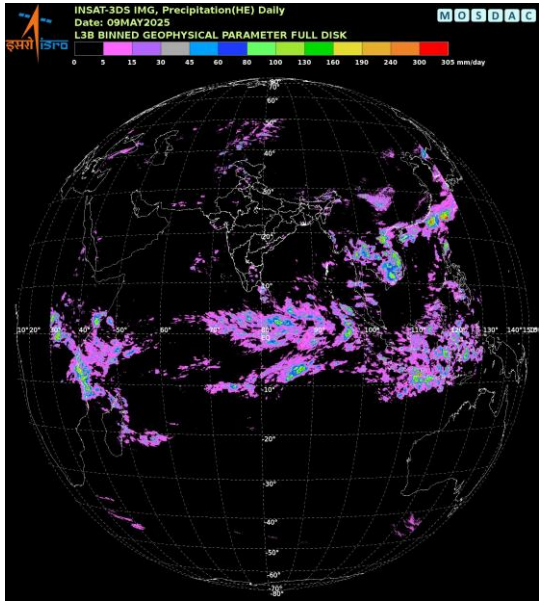
Daily SST



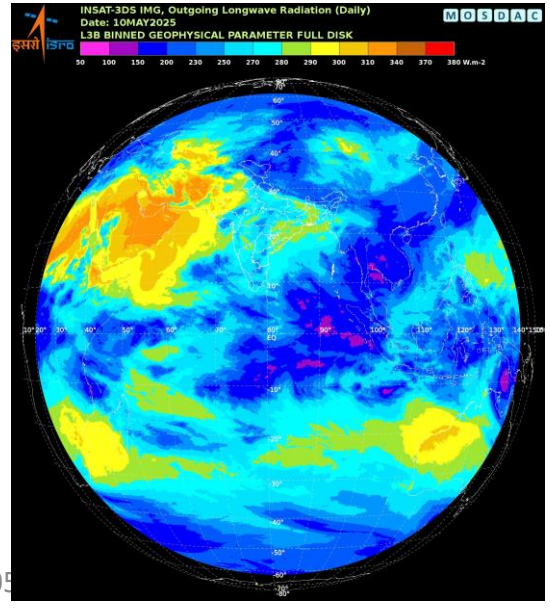
Daily Max LST



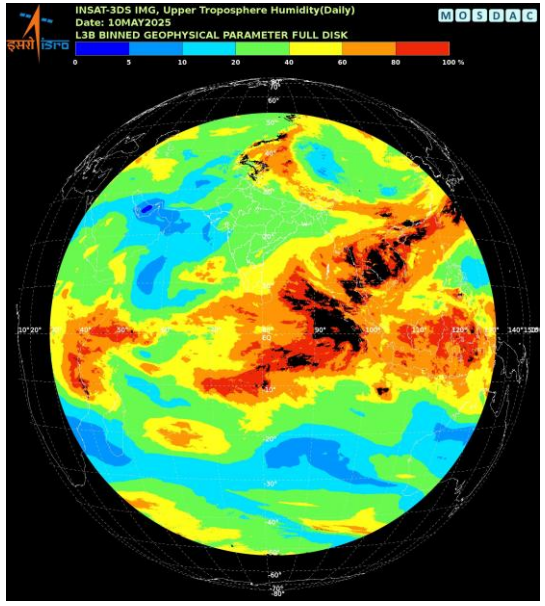
HE - Rain



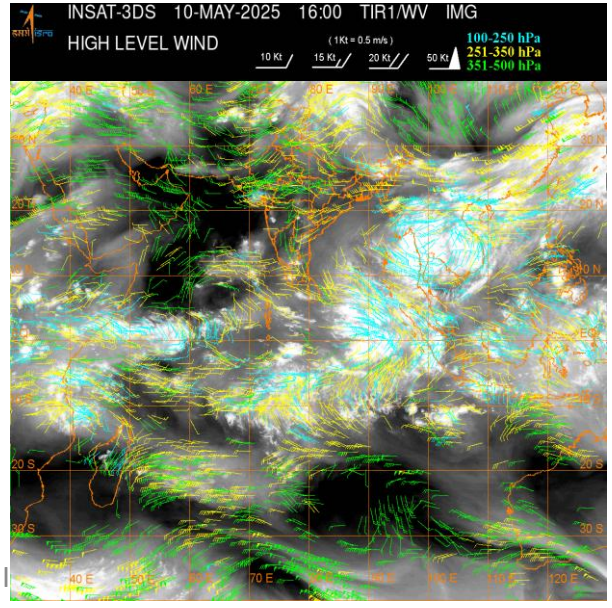
Daily OLR



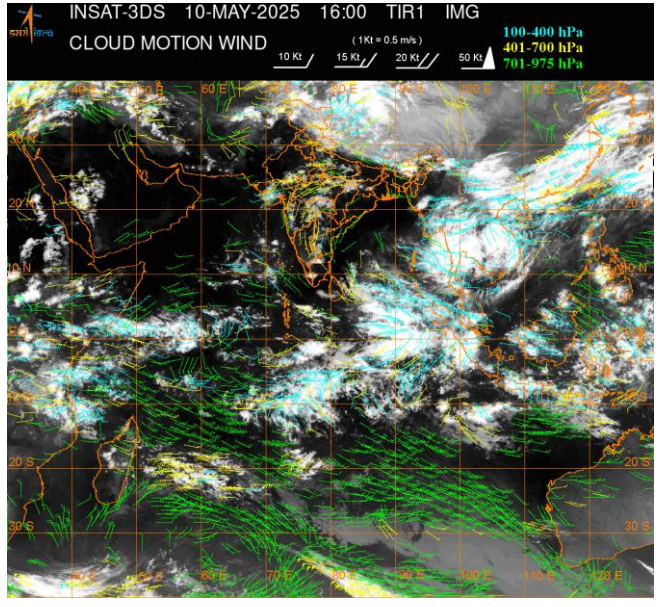
Daily UTH



High Level Wind (WVWV)

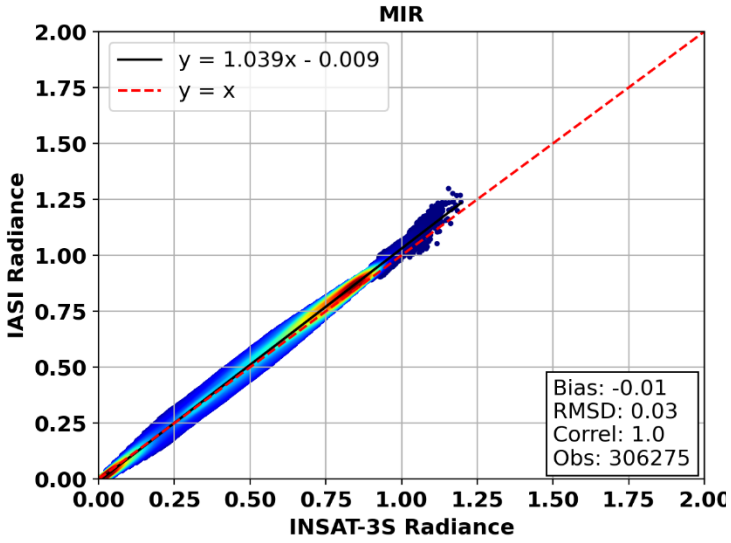


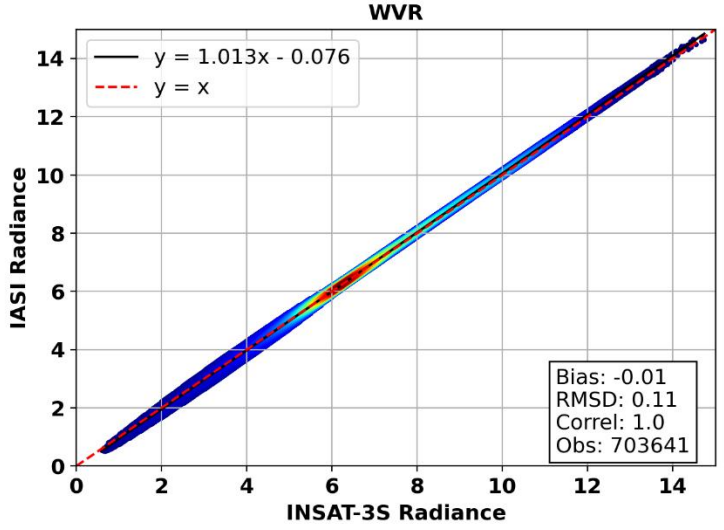
Cloud Motion Vector (CMV)

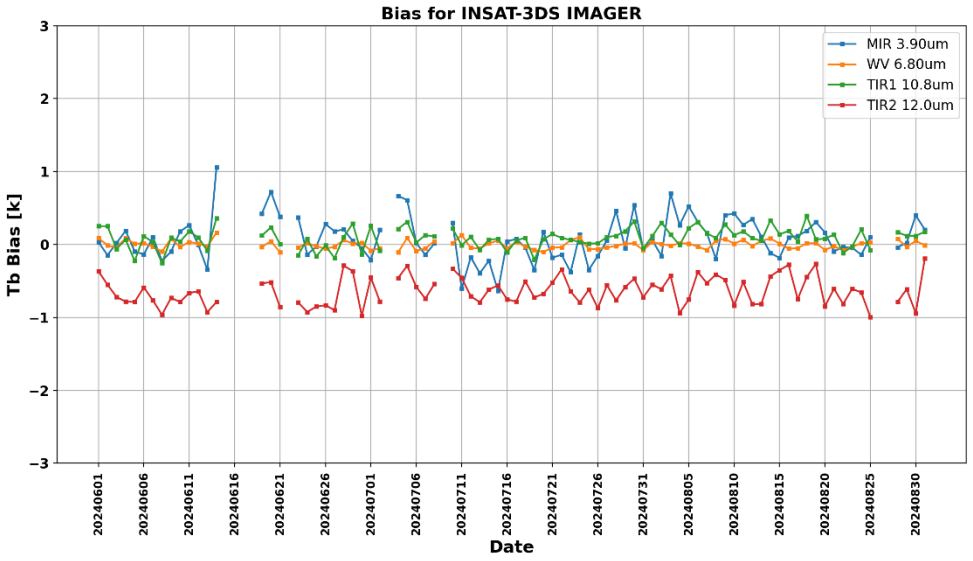


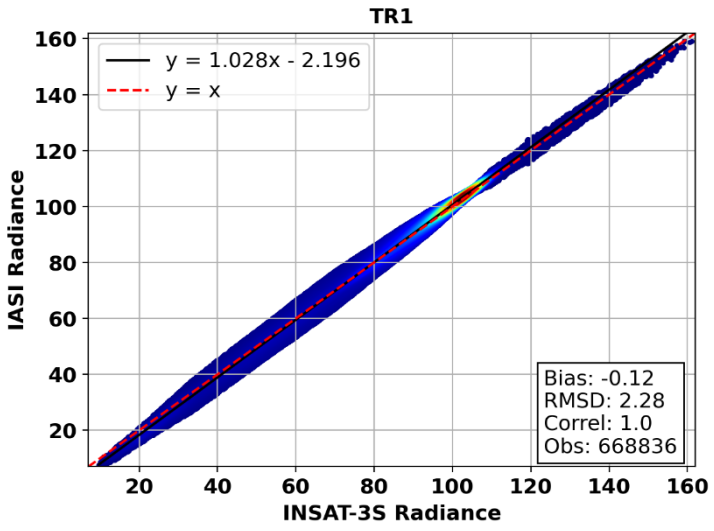
Inter-Calibration Outcomes: INSAT-3DS IMAGER (Jun-Aug, 2024)

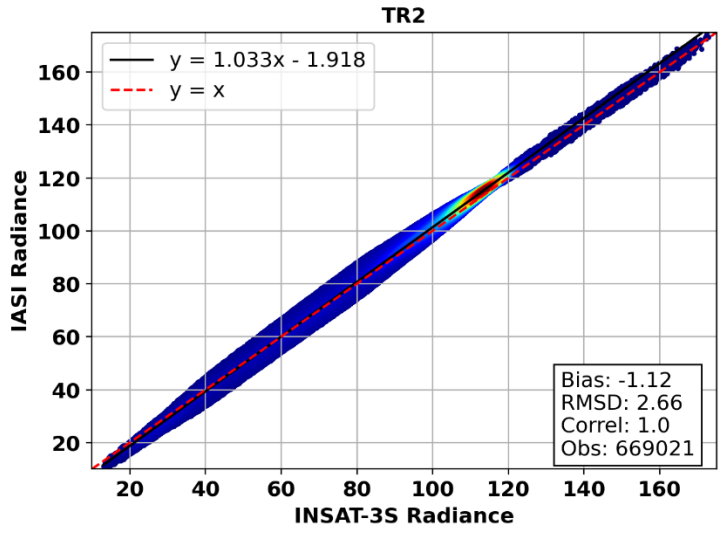
- **Brightness Temperature observed in different Imager Channels match very well with the reference instrument, MetOp-IASI, as per GSICS procedure**
- **There is diurnal and seasonal consistency in the L1B products due to improved BBCAL**
- **This improvement is reflected in the SST, which is highly sensitive to BT errors**



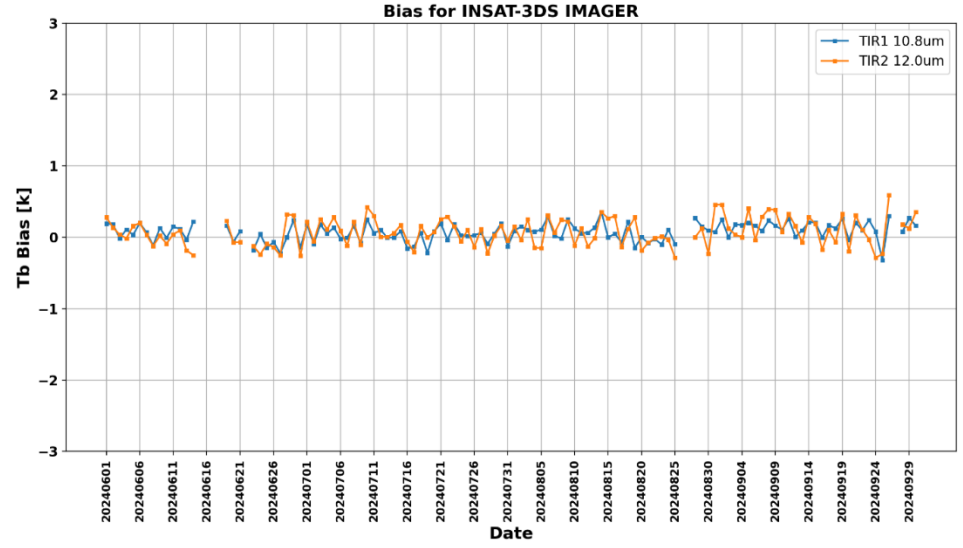








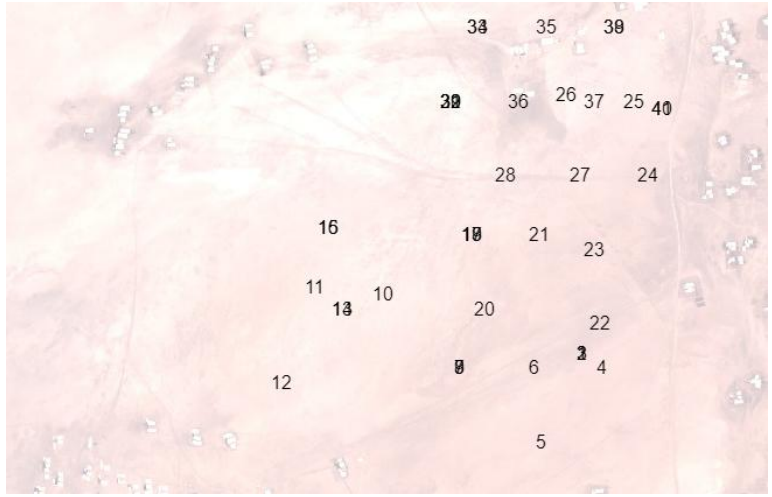
After GSICS Correction



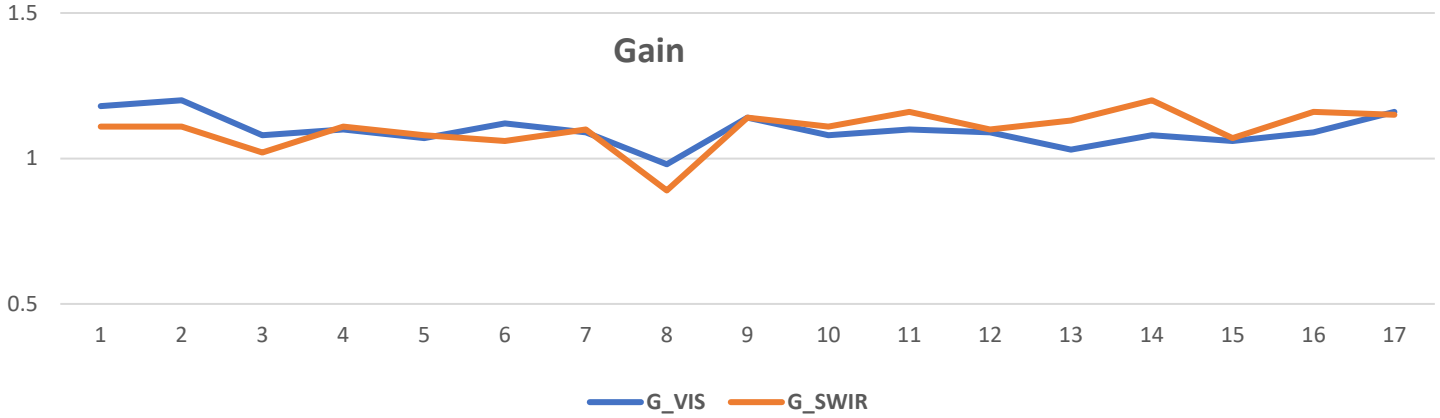
*Bias and RMSD are derived from x - y

INSAT-3DS Imager VIS/SWIR Channel Calibration

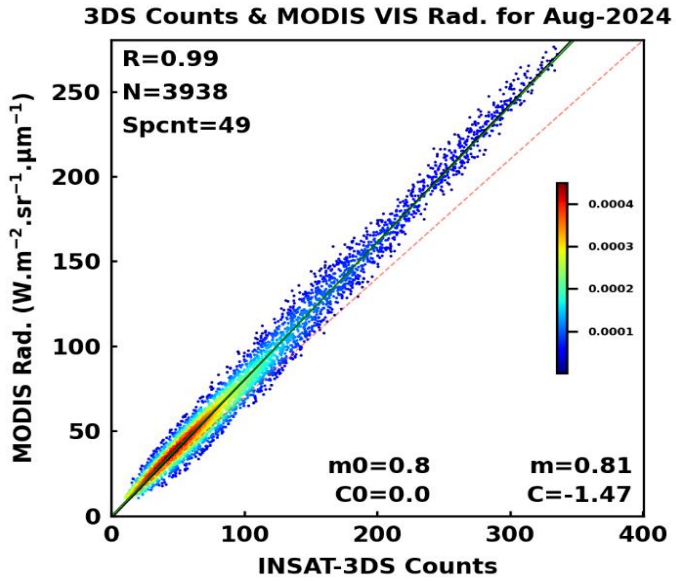
Gain derived from reflectance measurements over Little Rann of Kutch on 20 Mar2024

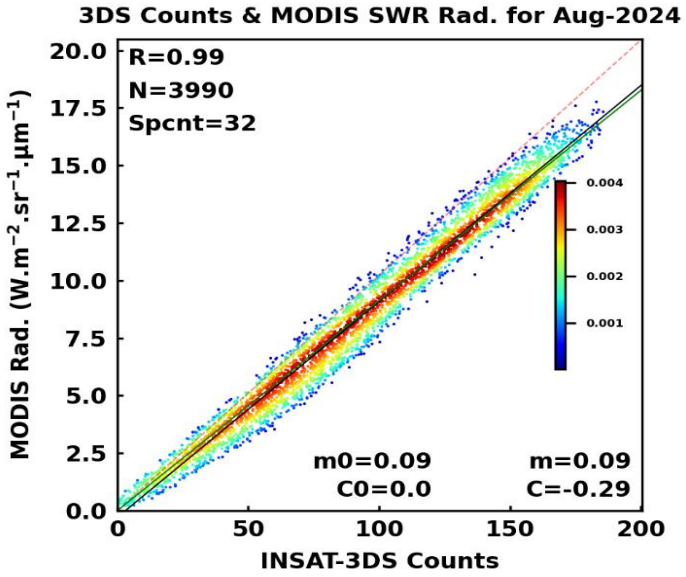


Gain for VIS and SWIR bands derived from Imager TOA radiance and simulated (6S TOA radiance)



INSAT-3DS Imager Counts and MODIS Radiance for VIS & SWIR



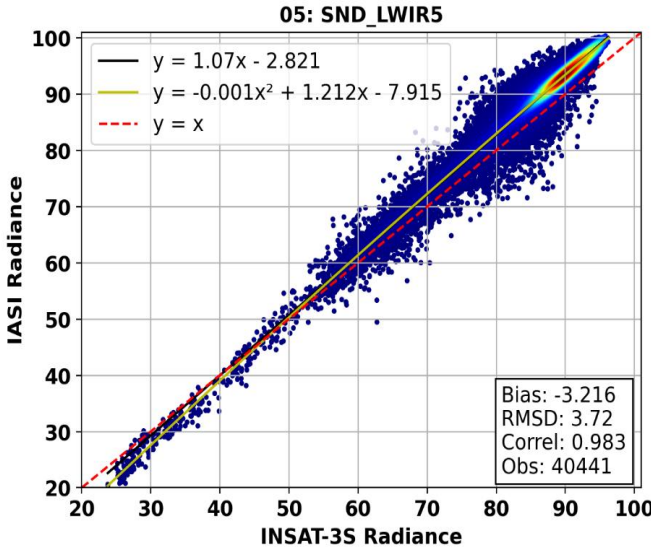


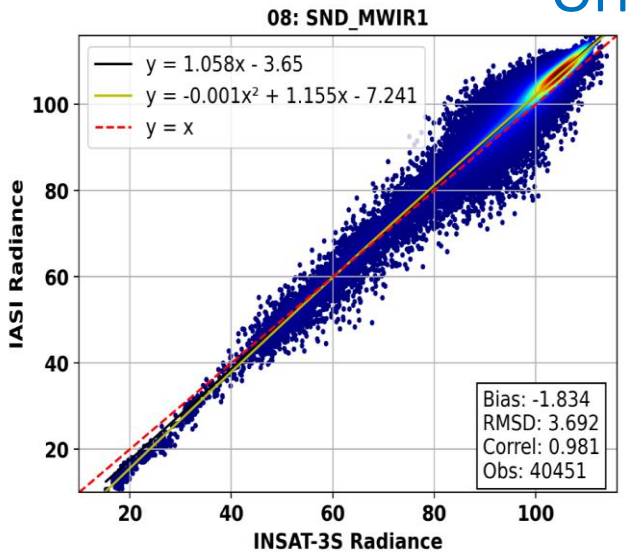
INSAT-3DS Sounder BIAS Time Series (May2024 to Apr2025)

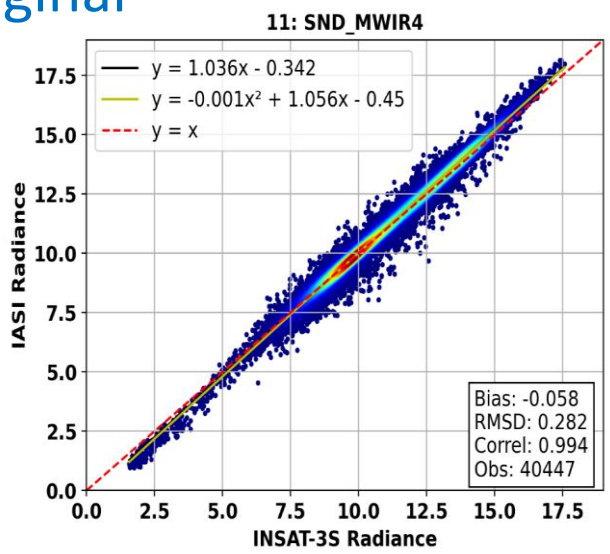
GSICS Intercalibration of INSAT-3DS Sounder using Metop-B/C IASI as reference

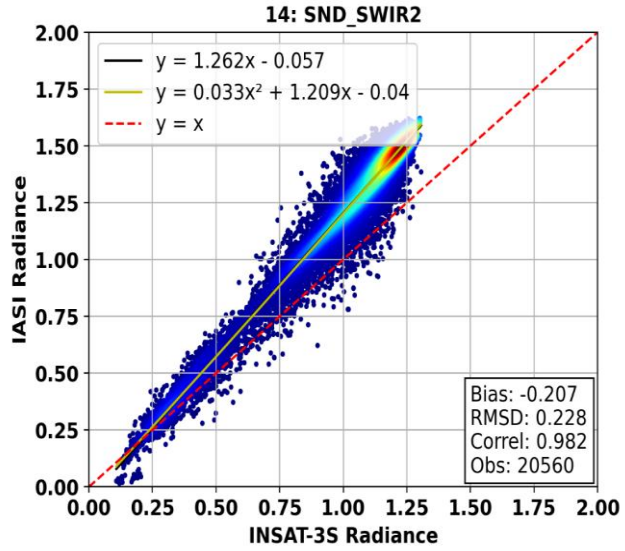
GSICS Inter-Calibration Outcomes: INSAT-3DS Sounder (Jan, 2025)

Original

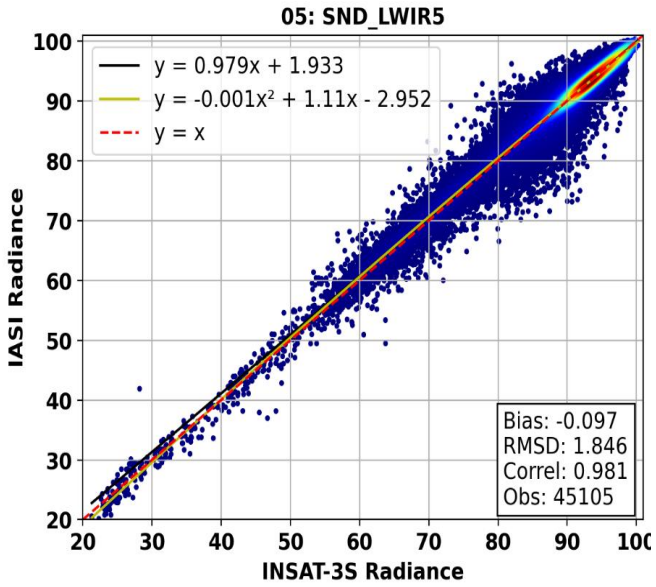


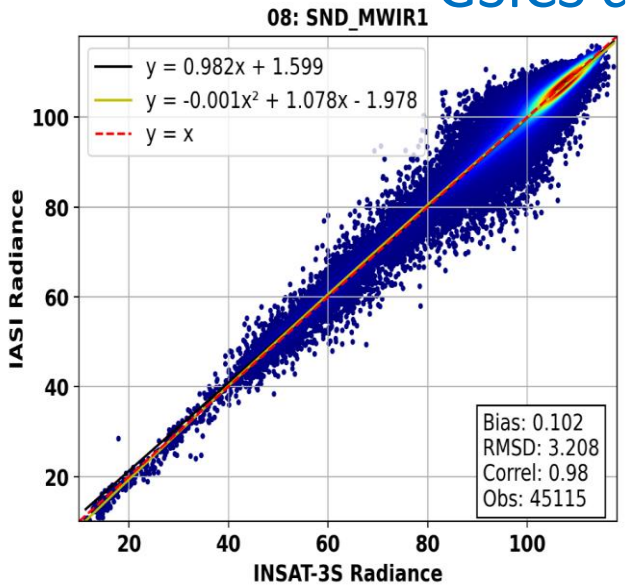


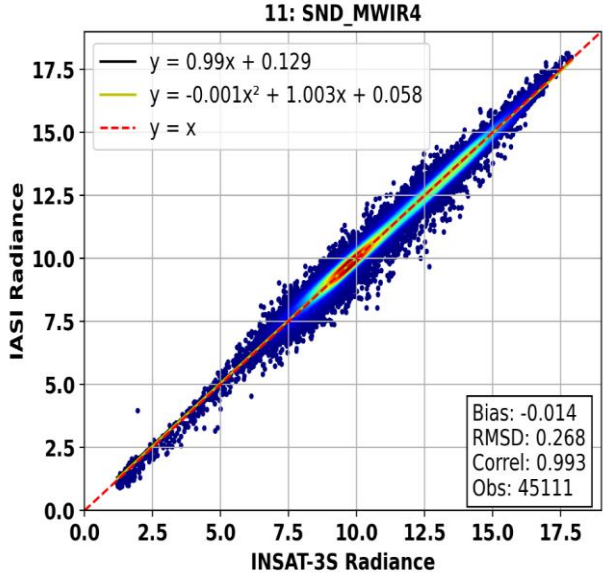


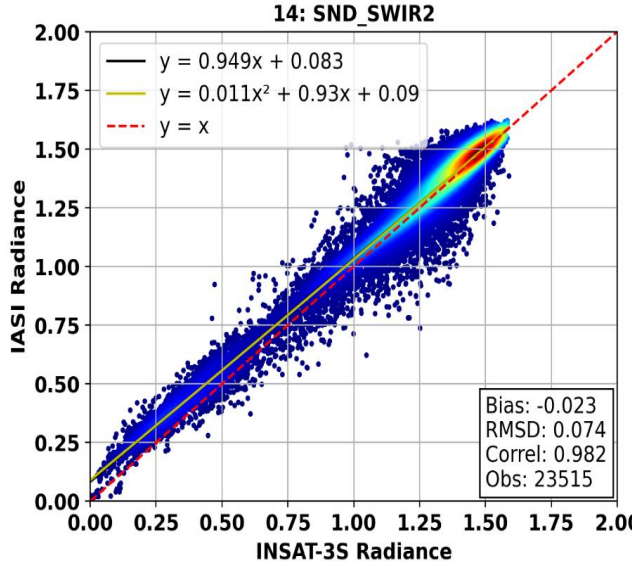


GSICS corrected



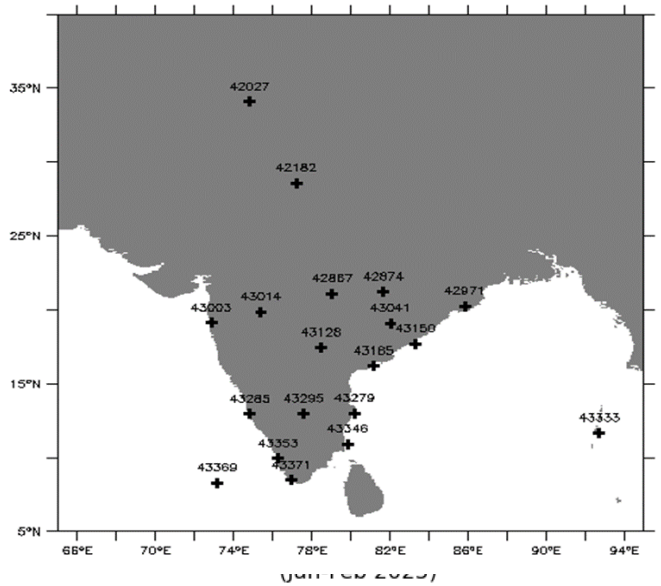


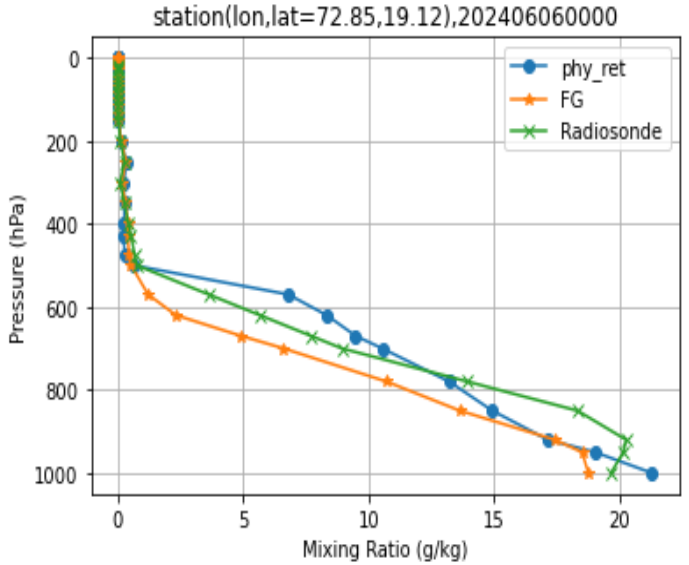


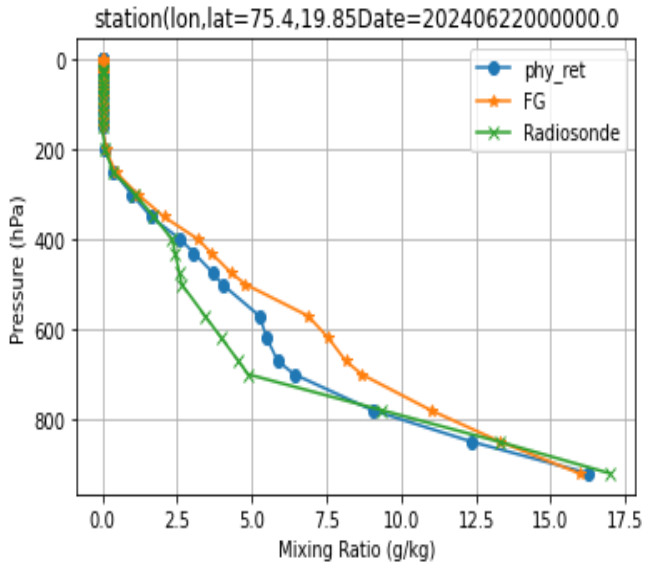


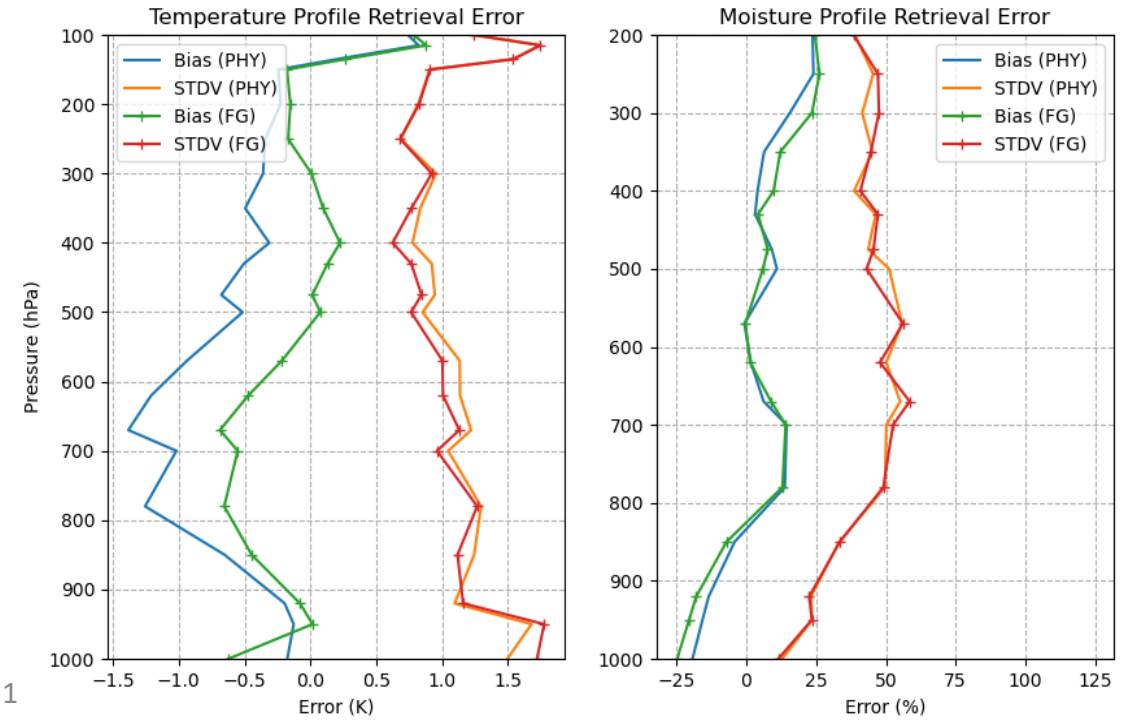
Radiance Unit: $mW/m^2/sr/cm^{-1}$

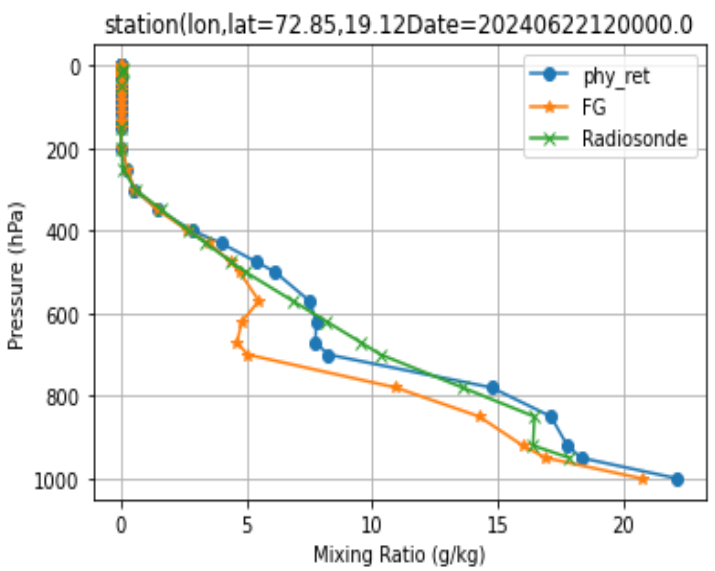
INSAT-3DS Sounder Validation with RAOB (Jan-Feb 2025)

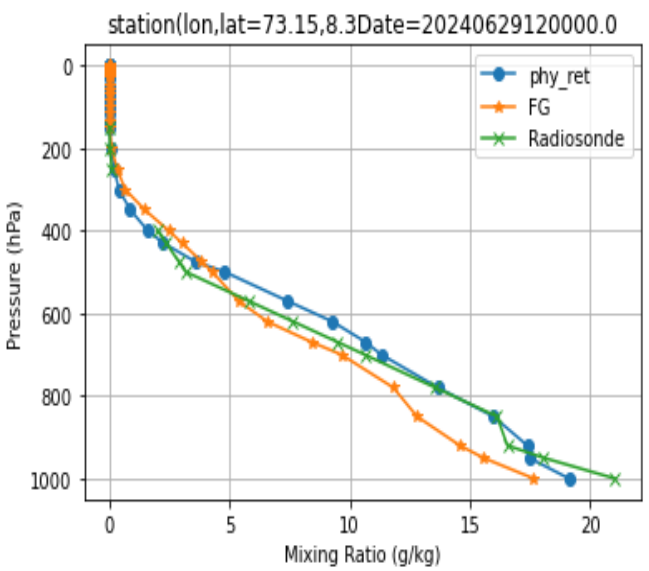










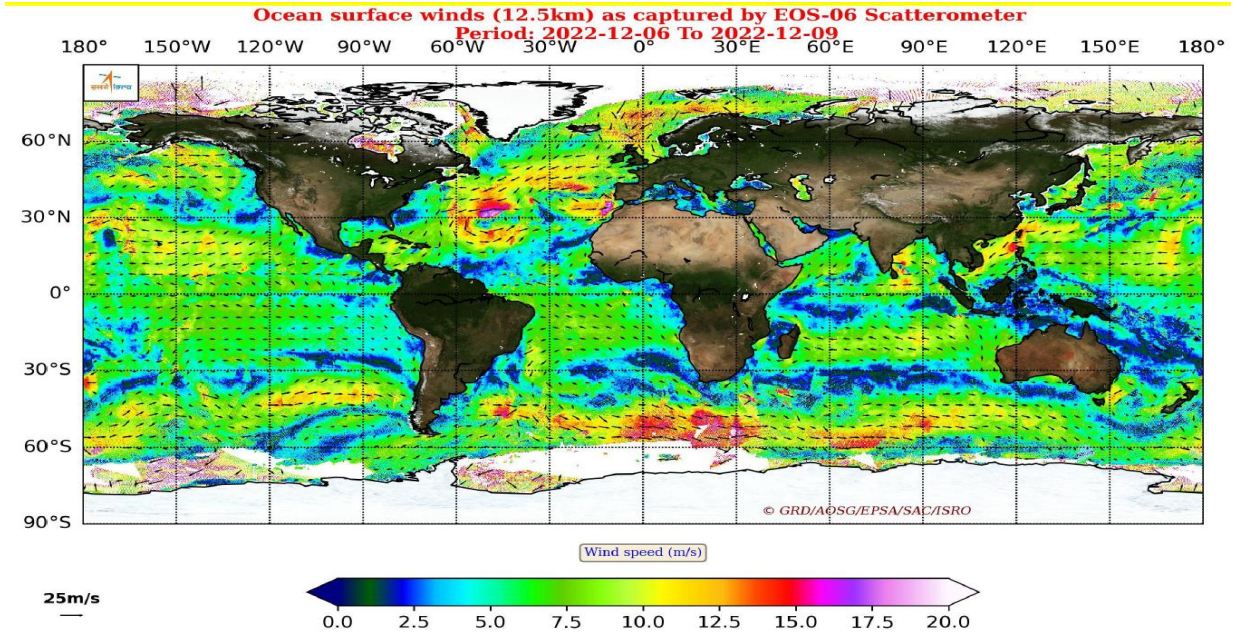


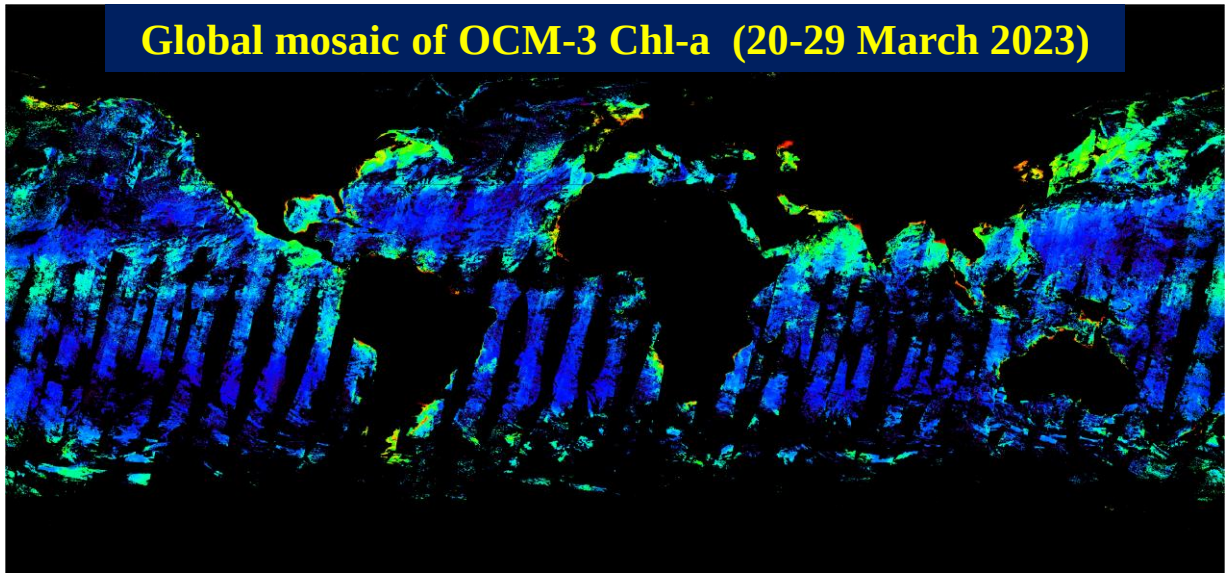
Sample individual Humidity Profile

EOS-06/Oceansat-3

Oceansat-3 Successfully launched on 26 Nov 2022

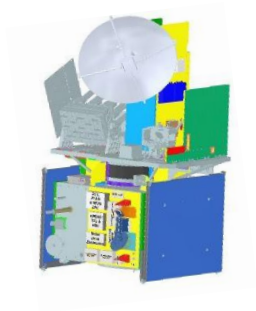
- Ku-band Scatterometer (SCAT-3) - *High Resolution winds (12.5 km)*
- 13-band Ocean Colour Monitor (OCM-3) - *Narrow bandwidth*
- 2-band Sea Surface Temperature Monitor (SSTM)
- ARGOS by CNES





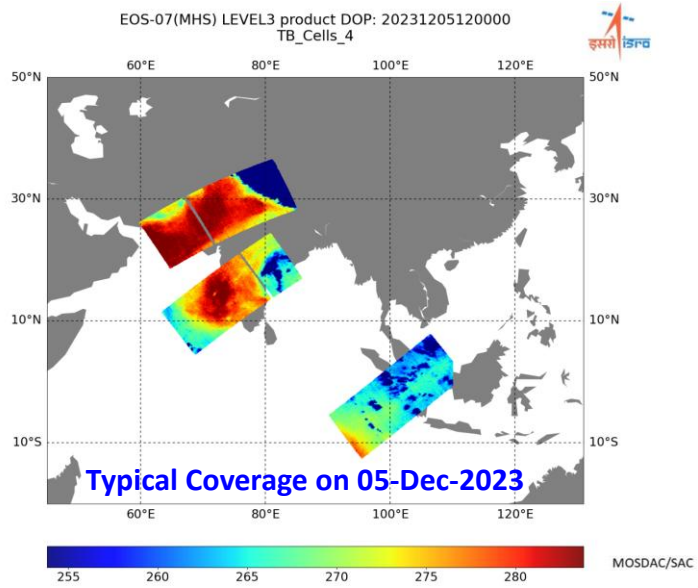
Microsat-2B (EOS-07) Millimeter-Wave Humidity Sounder (MHS)

Launch: 10-Feb-2023, SDSC/ISRO, SSLV-D2

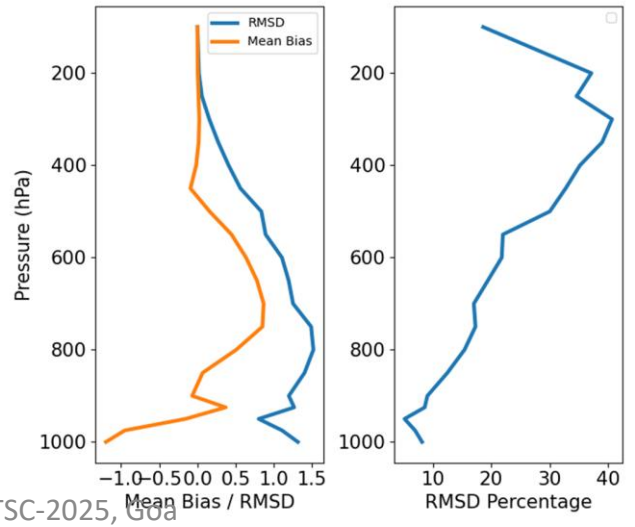


- Experimental: 15 minutes of orbit coverage
- Demonstration of in-house developed mm-wave technology
- 6-channel cross-track scanning Radiometer operating at 183.31±15.75 GHz band
- 450 km altitude, 37 deg inclined orbit
- Swath: ~1000 km,
- Spatial resolution of 10 km @Nadir

Evaluation of MHS data by NCMRWF in their Assimilation System showed positive impact in analysis and forecast

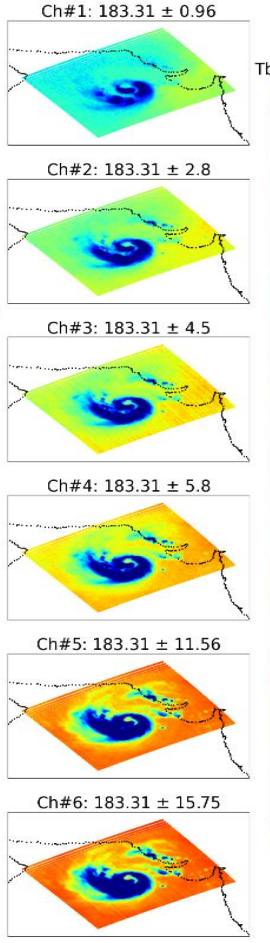


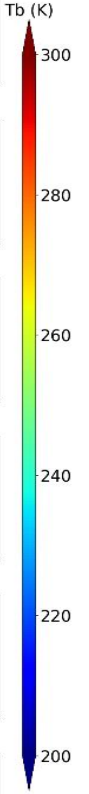
MHS Retrieved WV Profile Accuracy



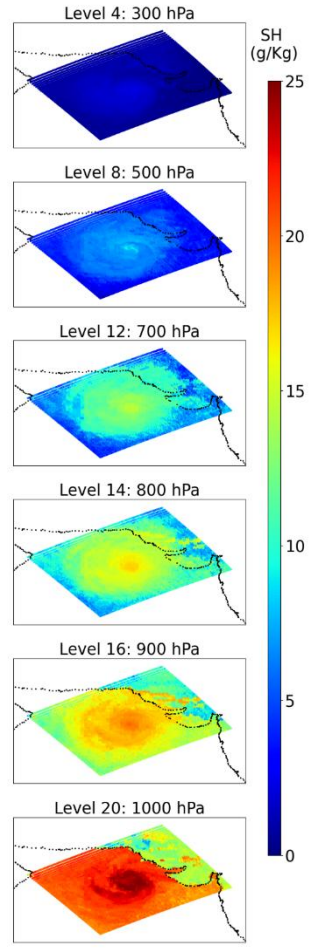
Tropical Cyclone BIPARJOY
(13 June 2023, 07:55 UTC)

MHS BT Observations





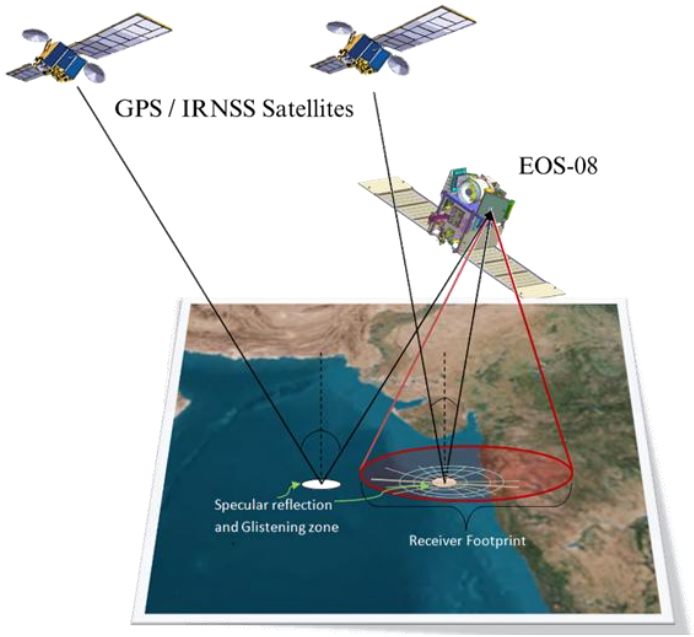
MHS Retrieved WV Profile



Microsat-2C (EOS-08): GNSS-R and EOIR (Launch: 16-Aug 2024, SSLV)

GNSS-R

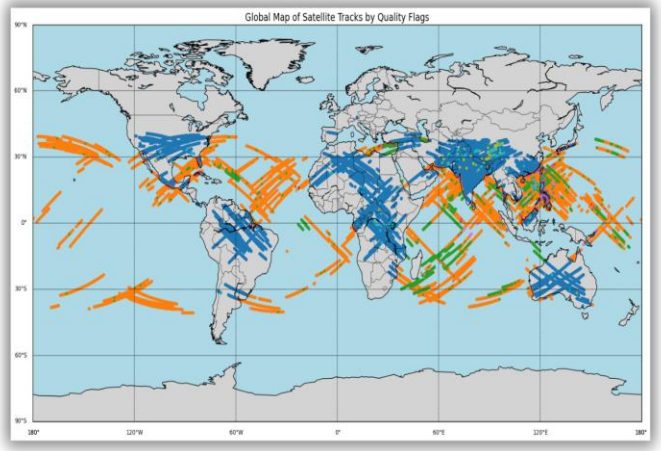
- Soil Moisture
- Sea surface wind speed
- SWH



EOIR

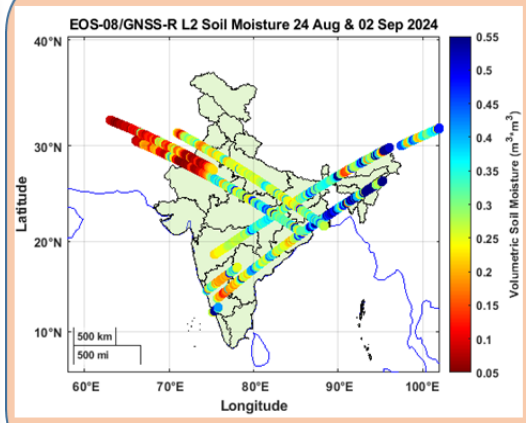
- High resolution **8m**, TIR and MIR
- Land surface temperature
- Forest/agriculture fire monitoring
- High resolution valley fog

SATELLITE TRACK PLOTS (EO8_GNSSR)

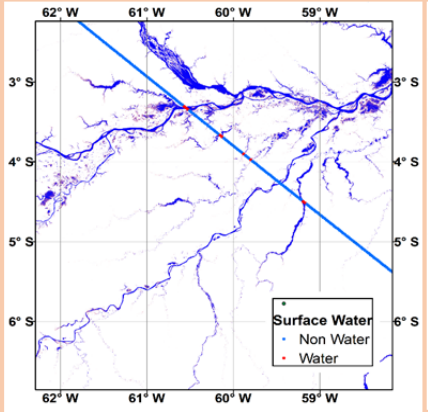


AUG 2024 - NOV 2024

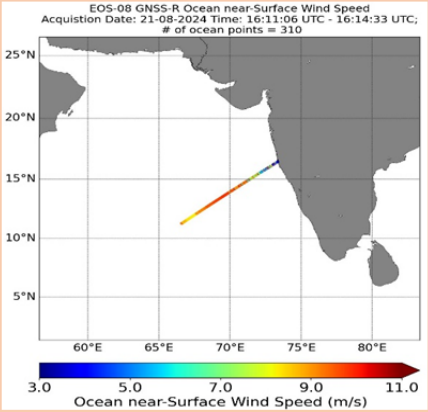
Application products demonstrated



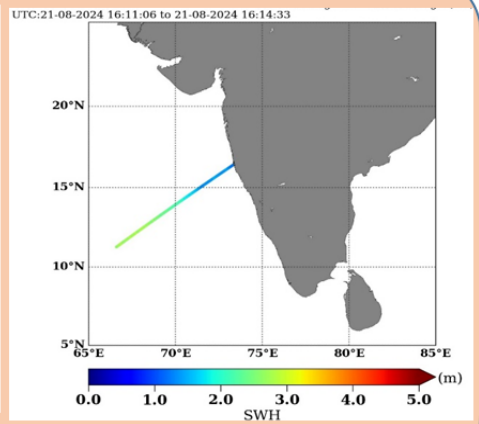
Soil moisture



Land inundation



Ocean wind speed



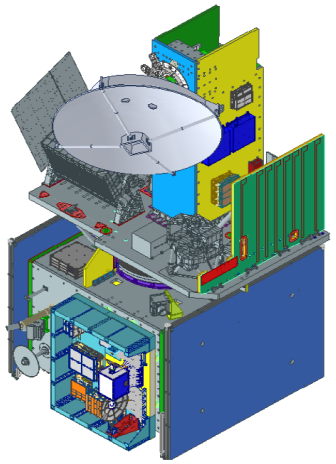
Significant wave height

Oceansat-3A (2025)

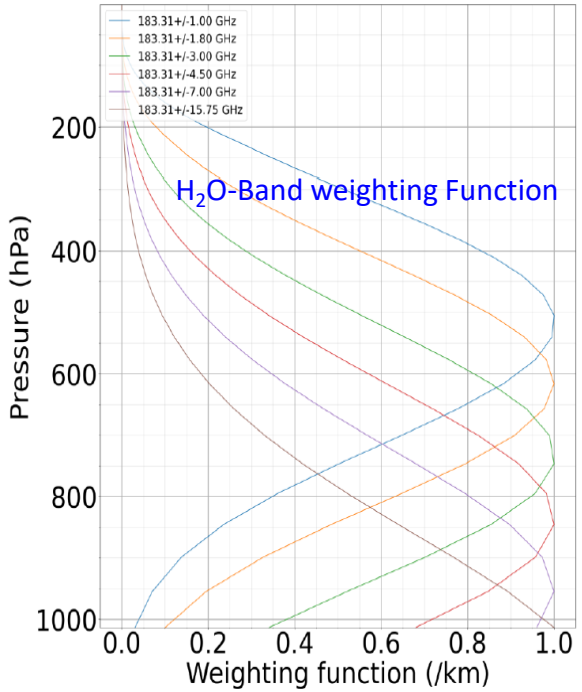
Payloads

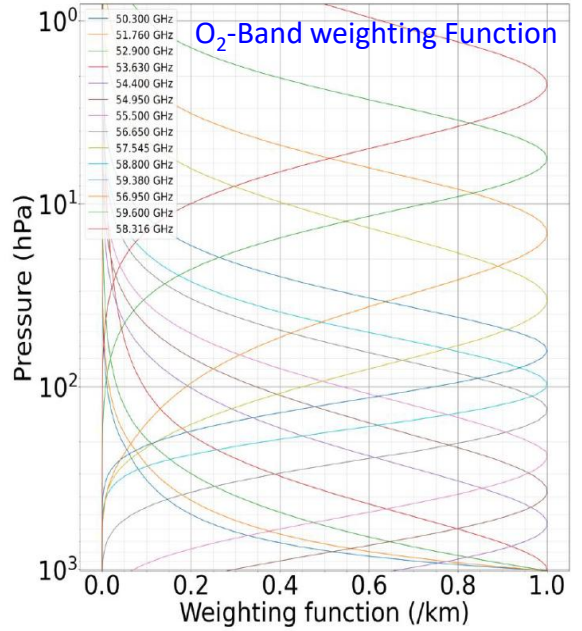
- 13-band OCM-3 (360m LAC, 1 km GAC)
- Ku-band Scatterometer
- 2-band Sea Surface Temperature Monitor (SSTM), 1 km Resolution
- Mm-wave Atmospheric Temperature and Humidity Sounder (MATHS)

- ARGOS in Oceansat-3 is replaced by Millimeter-wave Atmospheric Temperature and Humidity Sounder (MATHS) Payload
- A 20-channel cross-track scanning Radiometer operating at 50-60GHz and 183.31± 16.25GHz bands
- Spatial resolution of 25 km and 15 km, for O_2 and H_2O bands, respectively.



MATHS Payload





Other Satellites/instruments in consideration

Other Upcoming Missions in Discussion Mode

GEO: INSAT-4th Generation Satellite

a) Advanced Imager (legacy: GeoXO Imager)

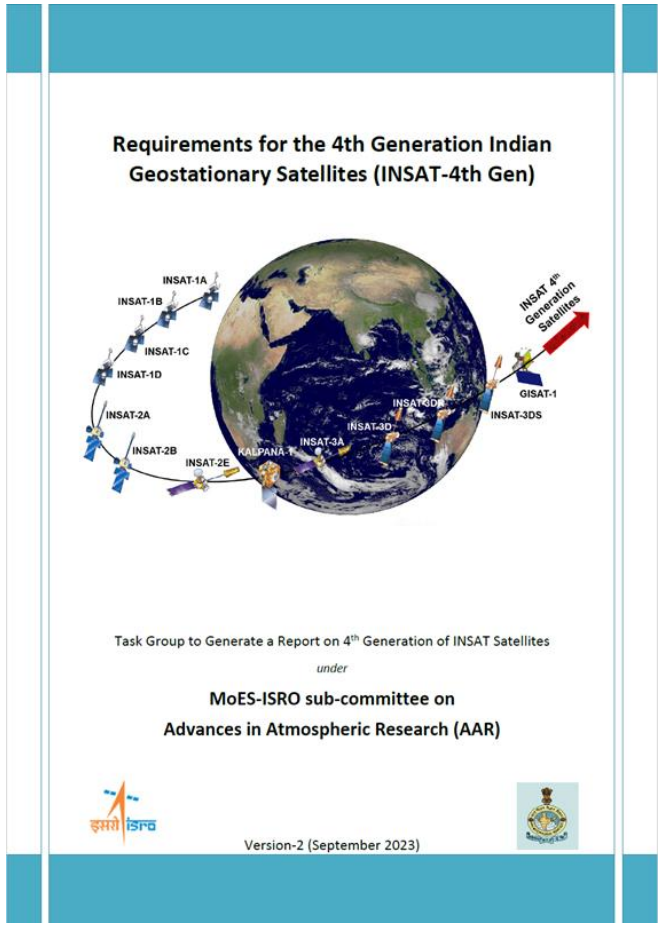
- 18 bands from 0.5 – 13.5 µm with spatial resolution 500m for VIS and 2 km for IR
- Faster scanning for nowcasting applications
- FD (Full Disk), India (3000 km x 3000 km) and Mesoscale (1000 km x 1000 km)
- Capability to provide FD image every 15 minute, Indian landmass every 5 minutes and Mesoscale images every 30 seconds.

b) Lightning mapper (Legacy: MTG-I/LI)

c) Hyperspectral Infrared Sounder (Legacy: MTG-S/IRS

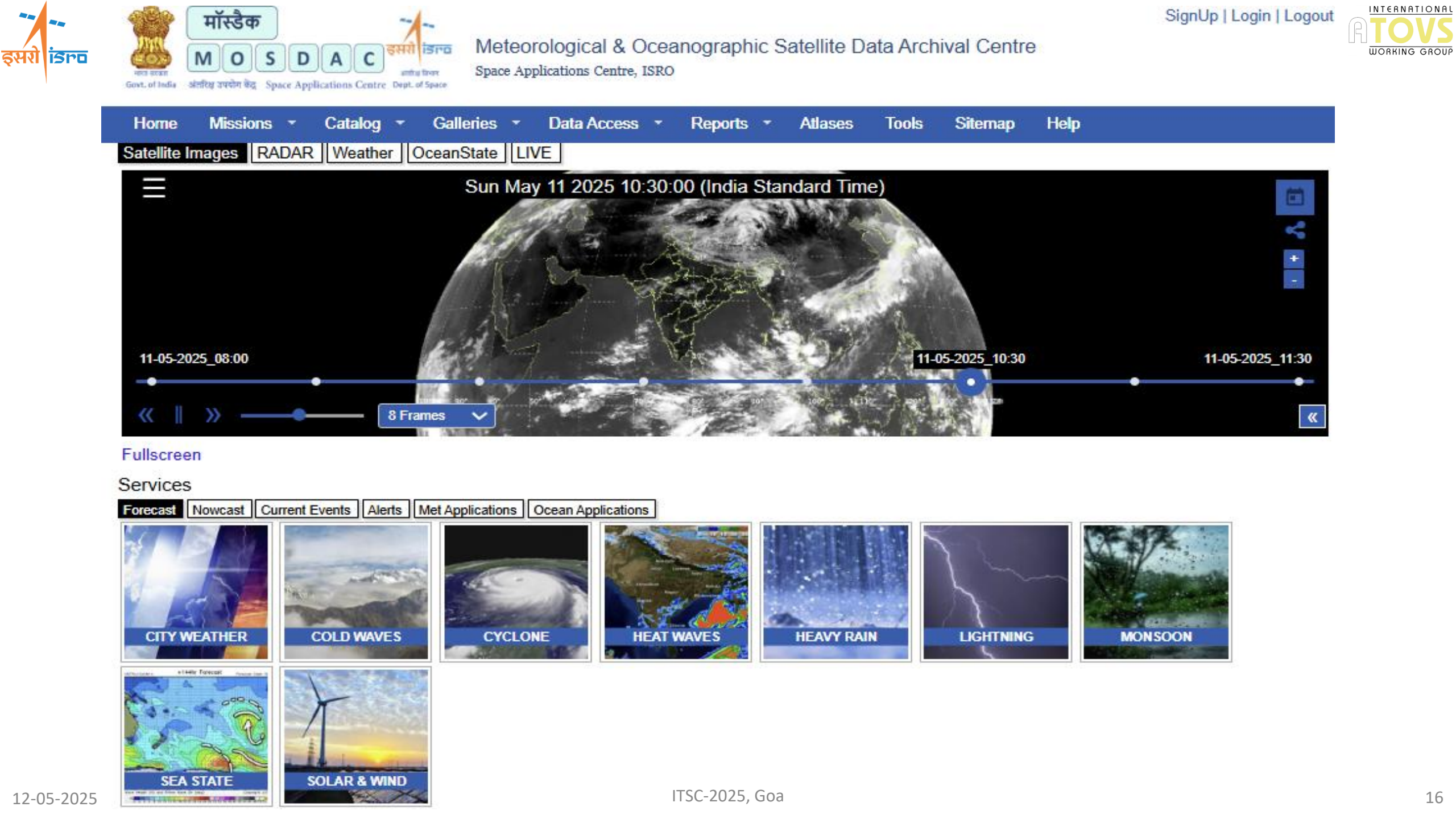
INSAT 4th Gen Application Potential

- Improve hurricane track and intensity forecasts
- Improved thunderstorm warning lead time
- Earlier warning of ground lightning strike hazard
- Detection of heavy rainfall and flash flood risk
- Improved aviation flight route planning
- Improved air quality monitoring and alerts
- Better fire detection and intensity estimation



Proposed Advanced Imager

No	Cen-WL (µm)	IGFOV (km)	Prime objectives and application potential
1	0.45	0.5	Aerosol over land, coastal water mapping
2	0.51	0.5	Clouds, fog, insolation, winds
3	0.65	0.5	Vegetation, aerosols over water, winds
4	0.86	0.5	Daytime Vegetation amount, aerosols
5	0.91	0.5	Daytime lower tropospheric water vapor
6	1.38	0.5	Daytime cirrus cloud
7	1.61	0.5	Cloud phase and particle size, snow
8	2.25	0.5	Cloud microphysics, vegetation, snow
9	3.80	2	Surface and cloud, fog at night, fire, winds
10	5.15	2	Lower tropospheric water vapour
11	6.20	2	High-level atmospheric WV, winds, rainfall
12	6.95	2	Mid-level atmospheric WV, winds, rainfall
13	7.40	2	Lower-level WV, winds and SO_2
14	8.50	2	TPW for stability, cloud phase, dust, SO_2
15	9.60	2	Total ozone, turbulence, winds
16	10.50	2	Imagery, SST, clouds, rainfall
17	11.50	2	Total water, ash, SST
18	13.30	2	Air temperature, cloud properties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Weather
OceanState
LIVE
Sun May 11 2025 10:30:00 (India Standard Time)
11-05-2025_08:00
11-05-2025_10:30
11-05-2025_11:30
8 Frames
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Services
Forecast
Nowcast
Current Events
Alerts
Met Applications
Ocean Applications
CITY WEATHER
COLD WAVES
CYCLONE
HEAT WAVES
HEAVY RAIN
LIGHTNING
MONSOON
SEA STATE
SOLAR & WIND

Summary

- Past/Present Indian satellite instruments for Met/Ocean applications
  - INSAT-3D series – Imager and Sounder
  - Oceansat series – Microwave Radiometer (MSMR), OCM, Scatterometer, *ROSA,* SSTM
  - MeghaTropiques – MADRAS, *ScaRaB, SAPHIR, ROSA*
  - Microsat-2B (Exp) – Microwave Humidity Sounder (MHS)
  - Microsat-2C (Exp) – GNSS-R, EOIR
- Future satellites –
  - Oceansat-3A – OCM3, SCAT, SSTM, MATHS (Microwave Atmospheric Temperature & Humidity Sounder)
  - INSAT-4th Generation – Advanced Imager, Lightning Mapper, Hyperspectral IR Sounder
- **New Space policy – strong justification/requirement from user agencies - Operational or Research/Academia**