Joint IMD/ISRO updates since CGMS-50 and report on the medium to long-term future plans

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Presented to CGMS-51 plenary

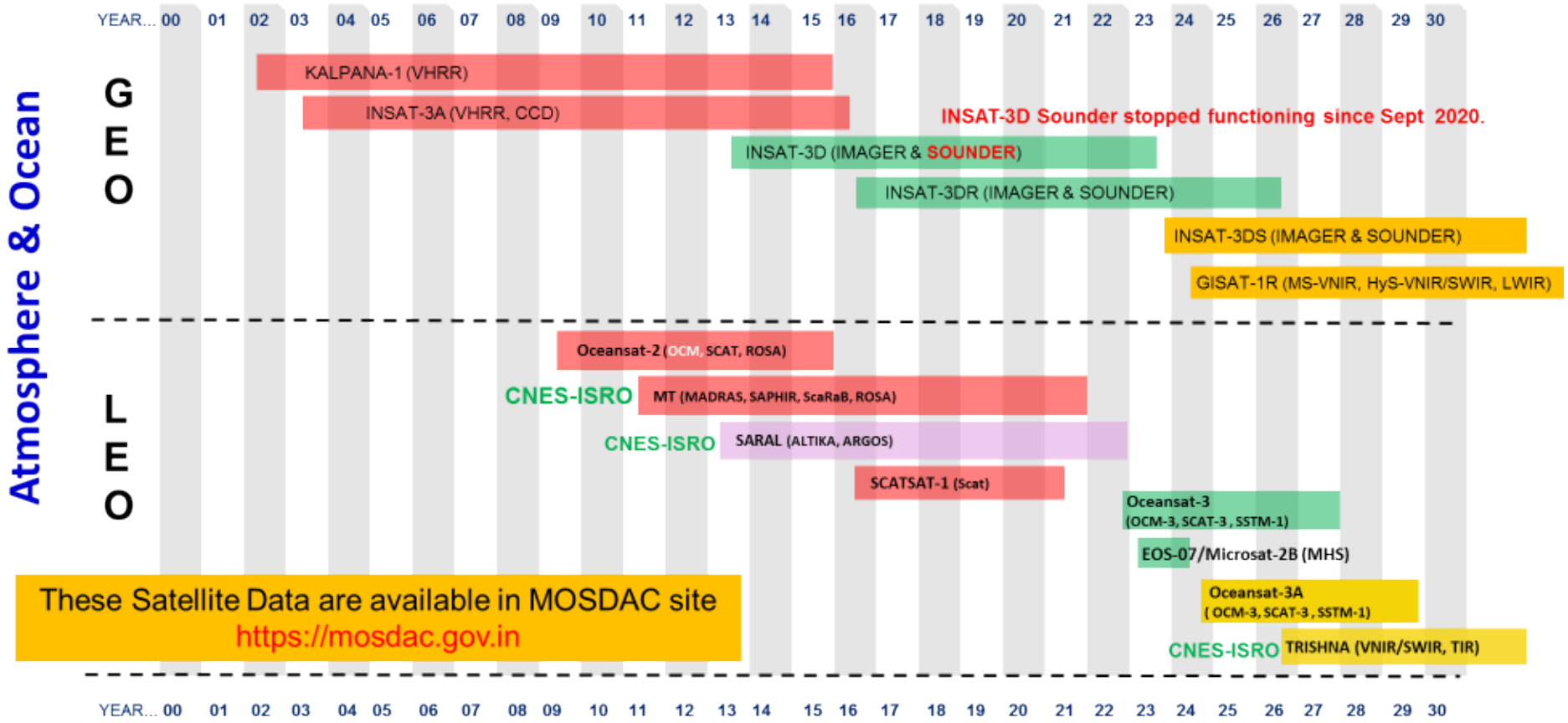
Recent Developments (Policy Point of view)

- Govt. of India unleashed reforms in space domain in 2020, opening the doors for enhanced participation of Non-Governmental Entities (NGEs) in carrying out end-to-end activities in the space domain.
- The “Indian Space Policy-2023” released in April 2023 gives the framework to implement the reform vision approved by the Cabinet.
- As per the Indian Space Policy -2023:
  - Indian national Space Promotion & Authorization Centre (IN-SPACe) an autonomous Organisation under DOS will act as the single window agency for the authorization of space activities by Government entities as well as NGEs.
  - ISRO will focus primarily on research and development of new space technologies and applications.
  - Remote sensing data of GSD of 5 m and higher, including the archived data shall be made accessible ‘free and open’ basis to all.
  - Remote sensing data of lesser than 5m GSD will be available free of charge to all Government agencies of India and at fair and transparent pricing to all.
  - DOS will ensure the availability of continuous &improved earth observation capability and data to fulfill the national requirements.
- The detailed guidelines are being worked out and the policy will be implemented very soon.

Programmatic Developments

- Presently, 2 satellites INSAT-3D and INSAT-3DR are operational in GEO. Sounder onboard INSAT-3D is not functioning since Sep 2020.
- EOS-06 (Oceansat-3) was successfully launched on 26 Nov 2022 with Ku-band scatterometer, Dual-Band Sea Surface Temperature Monitor (SSTM), and 13-band Ocean Color Monitor (OCM-3).
- In-Orbit Test (IOT) have recently completed and CALVAL phase is going on. Data from Scatterometer and OCM-3 released to the users. SSTM operations have been stopped due to in-orbit anomaly in its scan mechanism.
- EOS-07 (Microsat-2B) was launched on 10-Feb-2023 in low-inclination orbit with a 6-channel Microwave Humidity Sounder (MHS) onboard.
- ISRO-CNES joint mission SARAL/AltiKa is functioning in mispointing mode and the mission is extended till December 2024 provided the health of the satellite is satisfactory.
- INSAT-3DS is planned to be launched later this year, 2023, with many improvements to mitigate the issues related to the blackbody calibration and mid-night sun-intrusion.
- GISAT-1R is scheduled for launch in the first half of 2024.
- Under GSICS, inter-calibration of IR channels are in demo phase with IASI-B/C and shortly extended to CrIS. Ray-Matching method has been developed for inter-calibration of Vis/SWIR channels using MODIS and 6 years (2016-2021) data has been processed for INSAT-3D/3DR VIS/SWIR channels.

Overview - Planning of ISRO satellite systems



Past | Present | Present (limited) | Future

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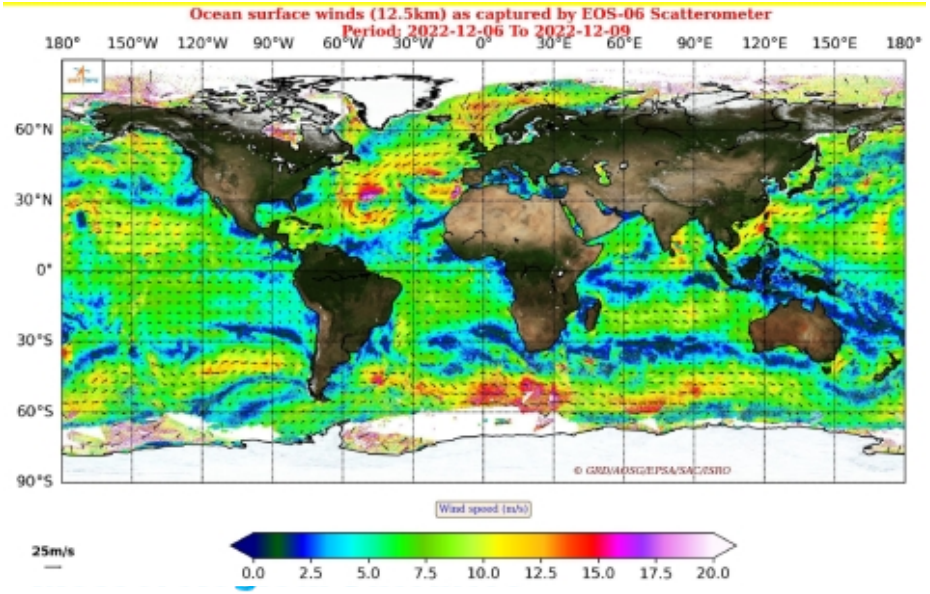
Oceansat-3 (EOS-6)

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

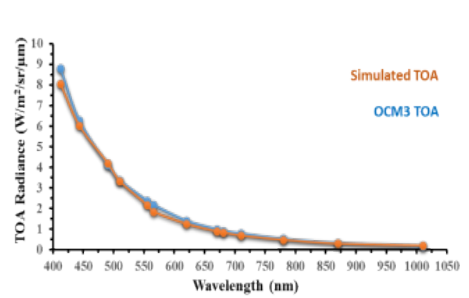
Scatterometer

- Ku-band, HH/VV (Swath 1400km), VV (1400-1800km)
- High-resolution mode for ocean surface wind vectors at 12.5 km for the first time in addition to 25 km (Antenna size increased to 1.4m).
- Experimental mode of high resolution wind @5km

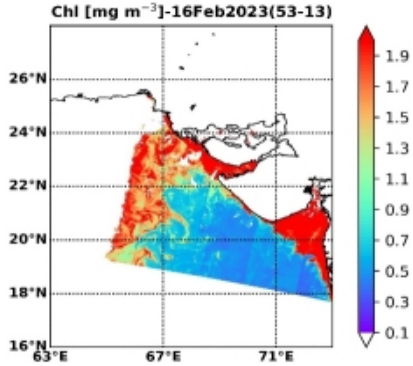


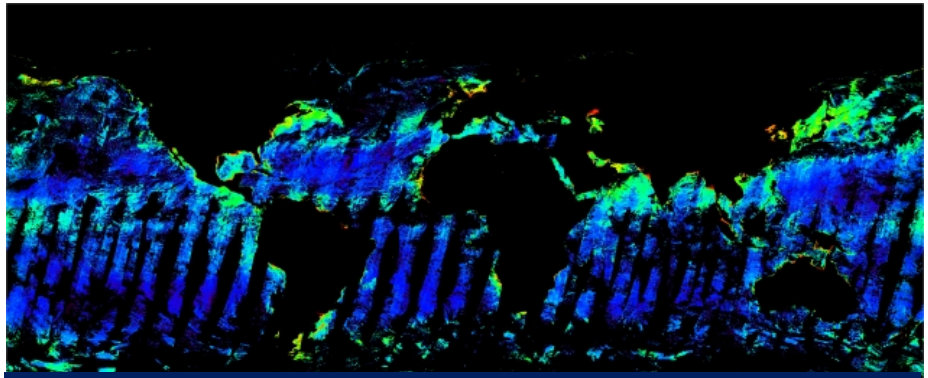
OCM-3

- 13-bands @ 412, 443, 490, 510, 555, 566, 620, 670, 681, 710, 780, 870, 1010 nm
- Narrow Spectral Bandwidth (10-20 nm)
- Improved SNR > 1000, Swath: 1440 km
- LAC/GAC mode: 366 m / 1.1 km



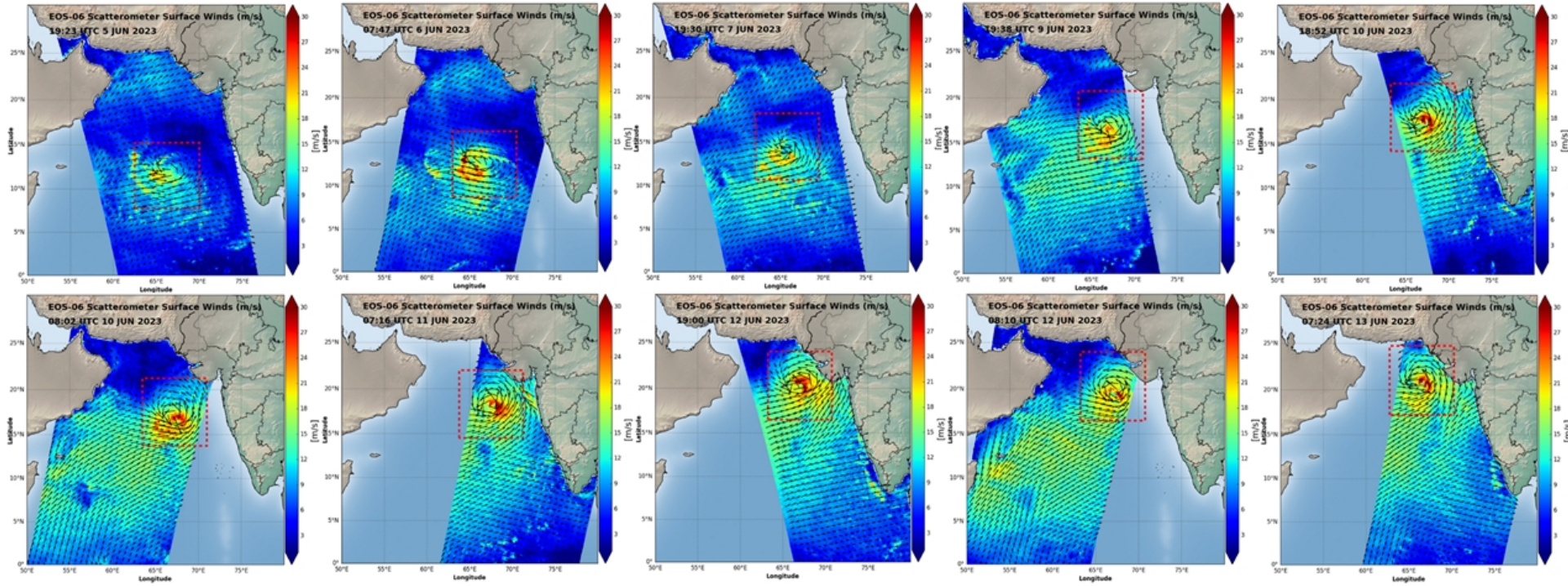
OCM3 vicarious calibration over Marine Optical Buoy (MOBY) site using 6SV2.1 RT model using 14 matchups (Dec 2022 – Apr 2023)





Global mosaic of OCM-3 Chl-a (20-29 March 2023)

EOS-06 SCAT passes over Tropical Cyclone BIPARJOY during 05-13 June 2023



Monitoring of track and intensity of Tropical Cyclone **BIPARJOY** in the Arabian Sea by EOS-06 SCAT observed ocean surface winds. The cyclogenesis, intensification and surface wind structure of TC Biparjoy is well captured and explained by the SCAT winds. (https://www.mosdac.gov.in/scorpio)

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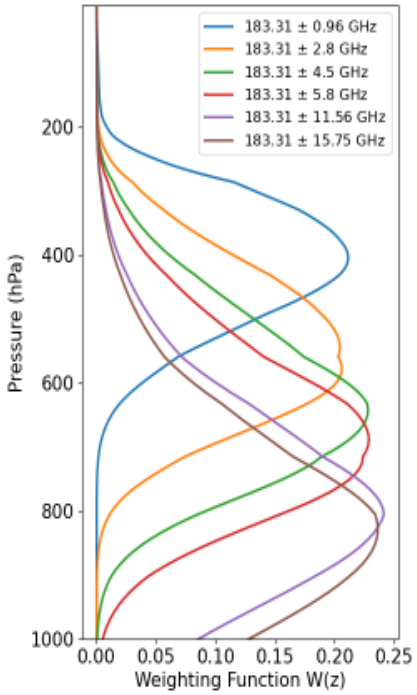
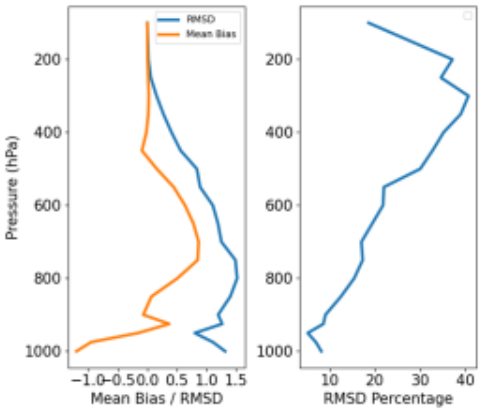
EOS-07 Microwave Humidity Sounder (MHS)

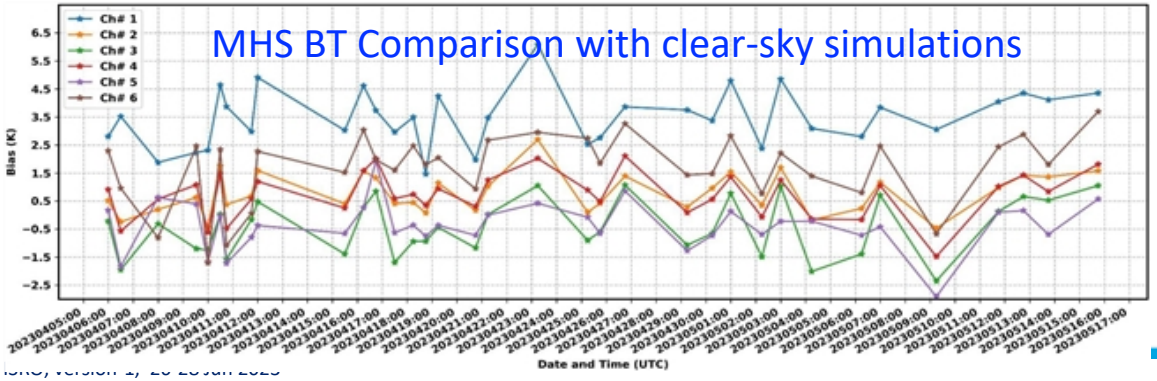
Launch: 10-Feb-2023, SDSC/ISRO, SSLV-D2

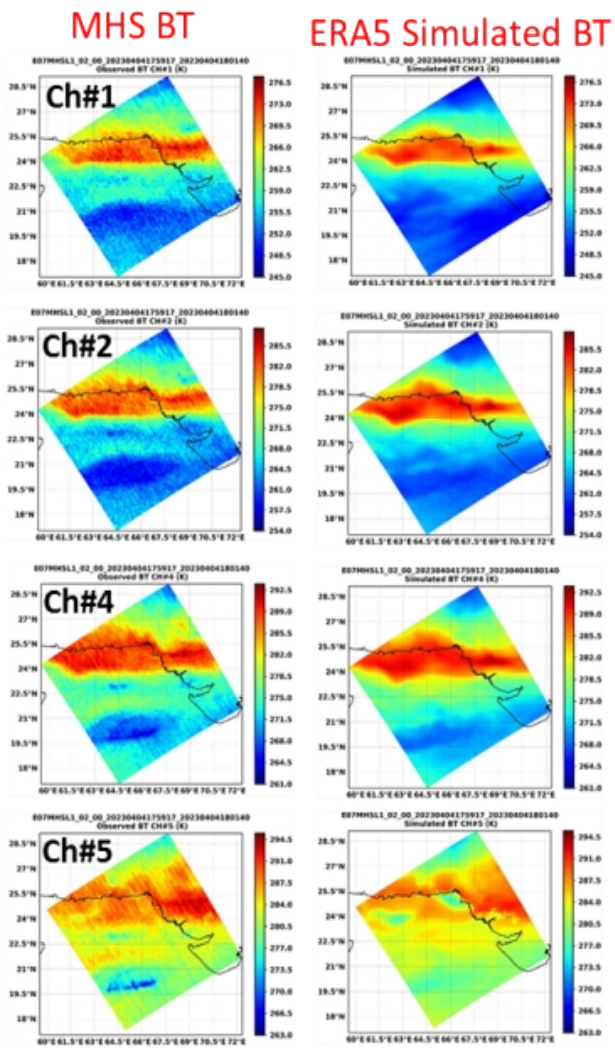
- MHS is a demonstration of in-house developed mm-wave technology
- 450 km altitude, 37 deg inclined orbit
- Swath: ~1000 km
- Experimental: 15 minutes of orbit coverage
- 6-channel cross-track scanning Radiometer operating at 183.31±15.75 GHz band
- Spatial resolution of 10 km @Nadir





Comparison statistics of MHS L2 vs GFS (02 Apr 2023, 06:00 UTC)

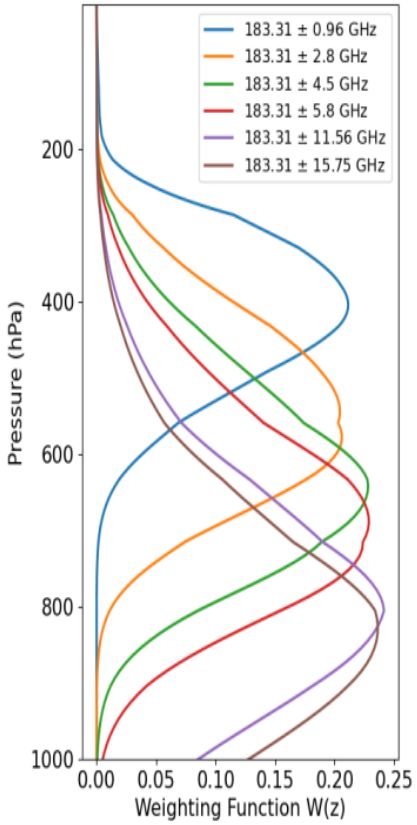




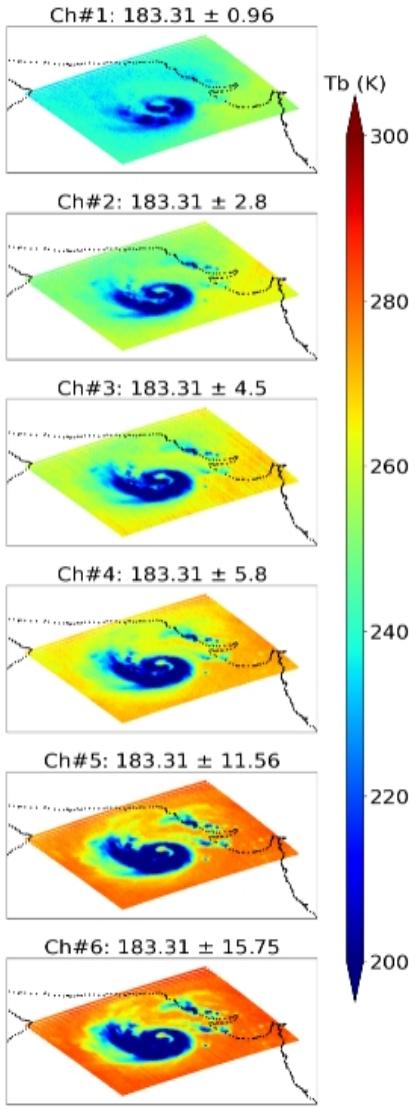
04-April-2023 1800Z

EOS-07 MHS passes over Tropical Cyclone BIPARJOY (13 June 2023, 07:55 UTC)

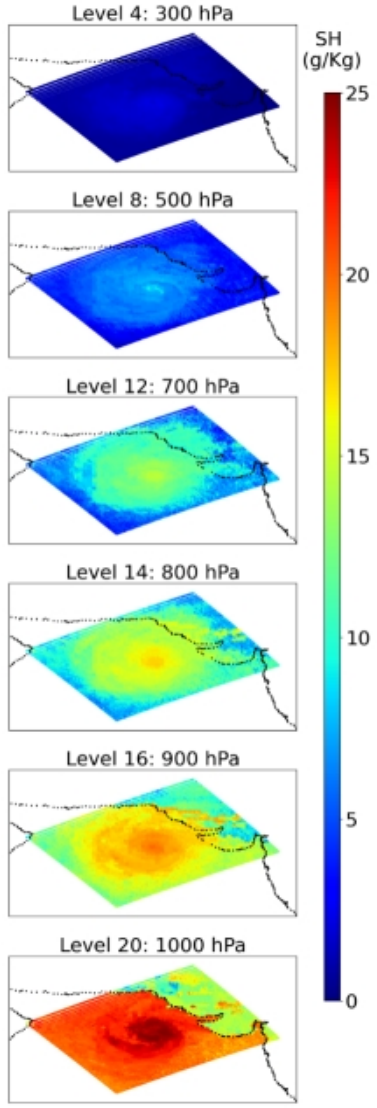
MHS Weighting Functions (Standard Tropical Atmosphere)



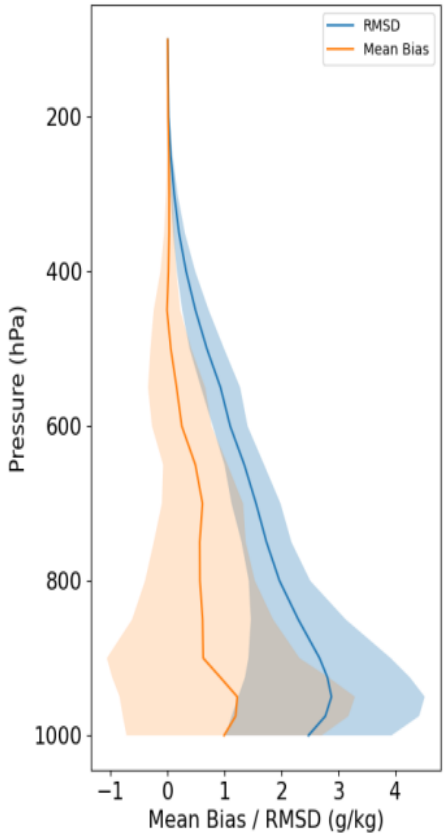
MHS BT Observations



MHS Retrieved WV Profile



Accuracy of MHS WV Profiles w.r.t. GFS Analysis



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SARAL/AltiKa: ISRO-CNES Joint Altimeter Mission

(An assessment of geophysical parameters for various phases of operations)

SARAL/AltiKa : Launched Feb, 2013 (First Ka-band Space-borne Altimeter)

10-years of operation and still going strong!

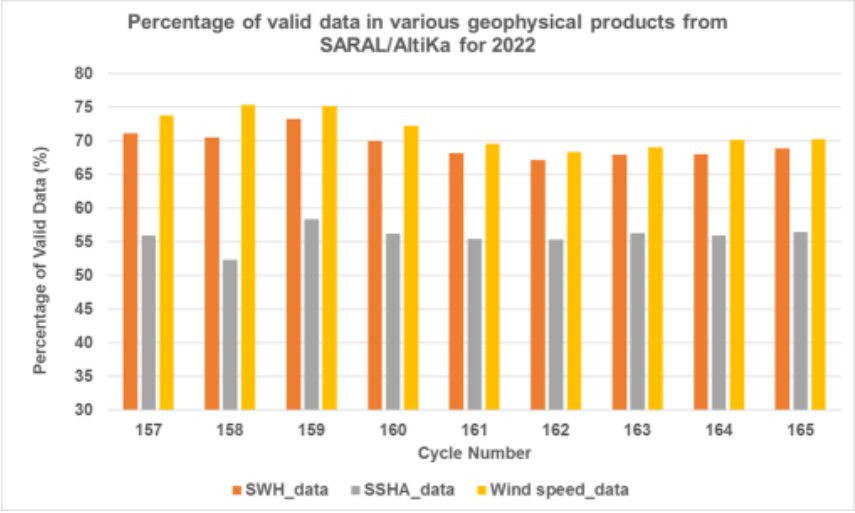
Important component of operational oceanography

Three phases of operations

- Exact Repeat Mode (ERM) – Mar,13 – Jul,16
- Geodetic Mode (GM)- Jul, 16-Jan,19
- Star Sensor anomaly phase (large mis-pointing) Feb, 19 onwards

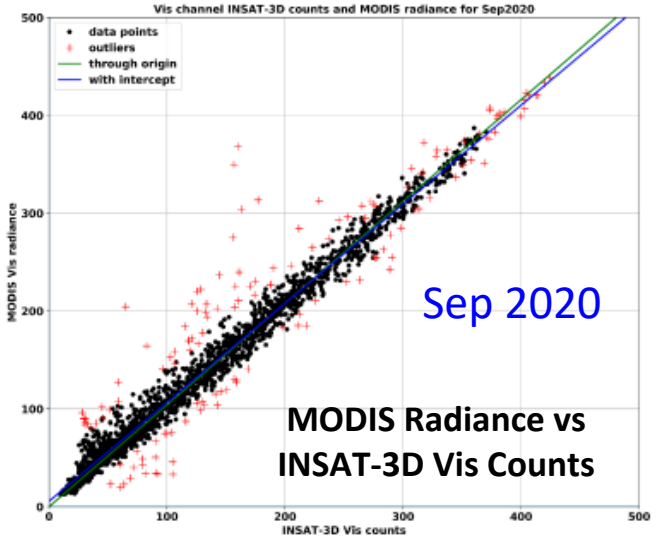
Assessment for the year 2022

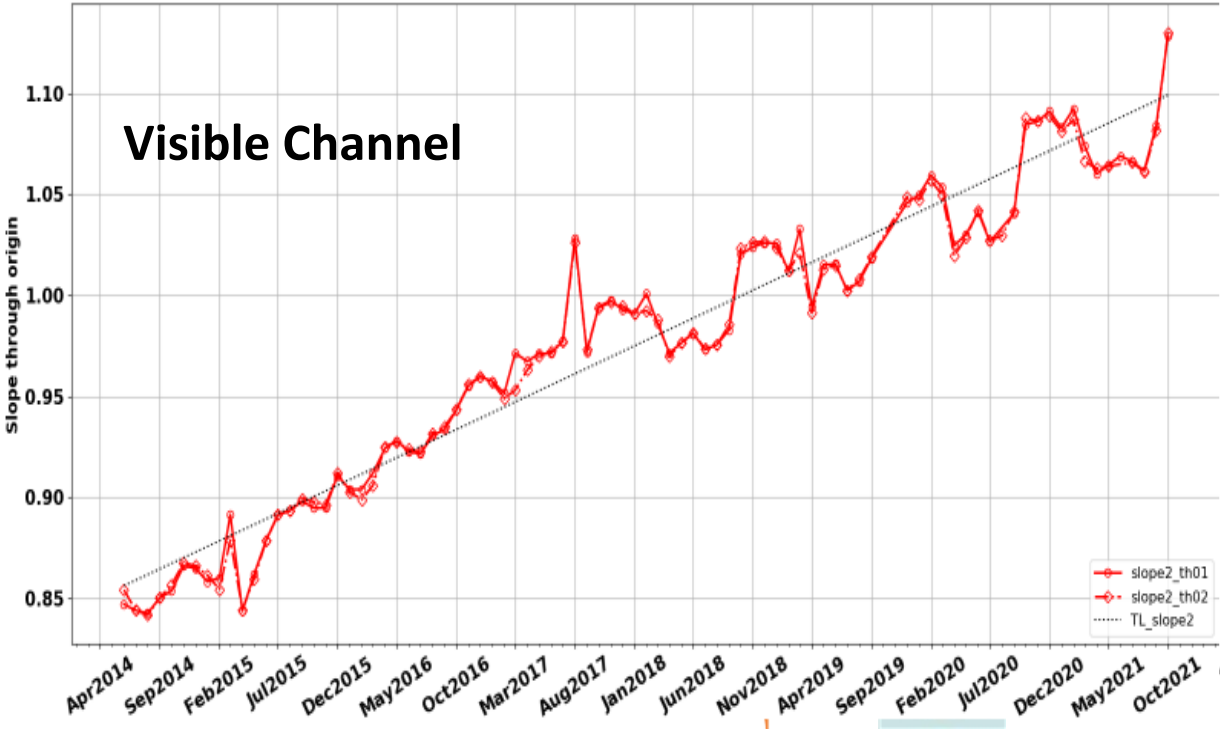
- Nearly 55% of SSHA data, 72% of Wind speed data and 68% of SWH data still remain usable for various ocean applications
- Significant Wave Height (SWH) data still being used in operational wave forecasting models.



ISRO's GSICS Activities, Action & Achievements Summary

- Regular monitoring of INSAT-3D/3DR imager IR channels wrt IASI (MetOp-A/B/C)
- Generated the gain coefficients for visible and SWIR channels of INSAT-3D using ray matching method with MODIS as reference instrument.
- Completed a case study to diagnose the calibration anomalies of INSAT-3D/3DR IR channels during pre and post flip period.
- Reprocessing of the INSAT-3D/3DR Imager data to fix the issues related to the Satellite Yaw-flip operation during eclipse period is undergoing.





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FUTURE GEO SATELLITES – GISAT-1R

GISAT Strengths: **(i)** High spatial (1.2 km) and temporal resolution (10 minutes) from LWIR

GISAT Geophysical Products/Applications

VNIR/SWIR Bands

- Cloud Microphysics (Nowcasting Applications)
- Aerosol Optical Depth over Ocean

LWIR Bands

- Nowcasting Applications
  - Cloud properties (type, amount, phase, height)
  - Atmospheric Stability Indices (Lifted Index)
  - Mid/Lower-Tropospheric Humidity
  - Total Precipitable Water (TPW)
  - Surface Skin Temperature (LST/SST)
- Aviation Applications
  - Thunderstorm Prediction
  - FOG Monitoring
  - Upper Air Turbulence
- High spatio-temporal resolution Rainfall
- Atmospheric motion vectors (AMV)
- Cyclone Monitoring

Band	Ch	SNR/ NEdT @300K	IFOV (m)	Range (µm)	Channels bandwidth (µm)
MX-VNIR	6	> 200	42	0.45 - 0.875	0.45-0.52 0.52-0.59 0.62-0.68 0.77-0.86 0.71-0.74 0.845-0.875
HyS-VNIR	158	> 400	320	0.375 - 1.0	Δλ : 4 nm
HyS-SWIR	256	> 400	190	0.9 - 2.5	Δλ : 7 nm
MX-LWIR	6	< 0.15K	1200	7.0 – 13.5	7.1-7.6 8.3-8.7 9.4-9.8 10.3-11.3 11.5-12.5 13.0-13.5

MX-VNIR: Multispectral Imager - Vis NIR,
HySI-VNIR: Hyperspectral Imager - Vis NIR
HySI-SWIR: Hyperspectral Imager - Short Wave Infrared,
MX-LWIR: Multispectral - Long Wave InfraRed.

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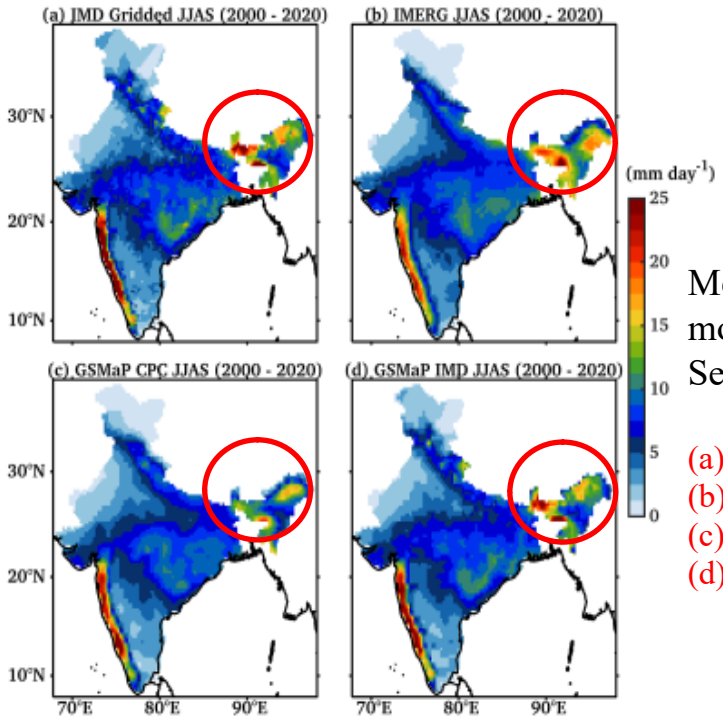
Other activities relevant to CGMS

GSMaP_INDIA Merged Rainfall (Under ISRO-JAXA IA):

- Long-term (23 years) high spatio-temporal resolution **(10 km and Hourly)**
  IMD Gridded rainfall

High Resolution Rapid Refresh (HRRR): Data Assimilation of DWR



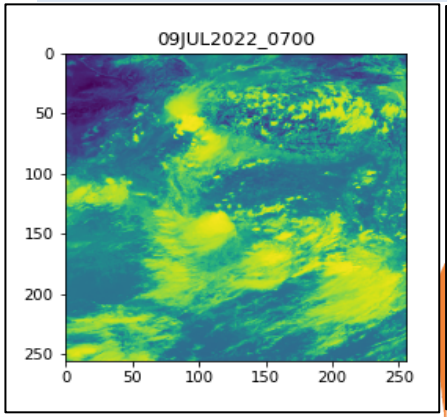
Mean daily summer monsoon rainfall (Jun-Sep, 2000-2020) from:

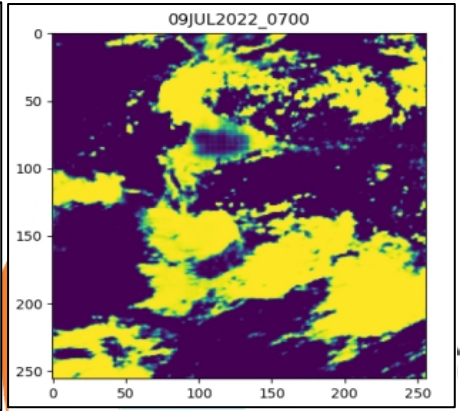
(a) IMD gridded rain,
(b) IMERG Final-run,
(c) GSMaP_CPC rain
(d) GSMaP_India (IMD rain)

Weather Nowcasting: Ongoing AI / ML based research and way ahead

- Research for improving Weather Nowcasting based on satellite data
- Focus on AI/ML techniques
- Utilization of INSAT-3DR, DWR & ground network
- Provides All-India Heavy Rainfall Alerts and Cloud-Burst Potential alerts

AI/ML based approaches for Nowcasting using INSAT-3D data






GOES-W
ENVISAT
"A-Train"
JASON
MTSAT
GOES-E
TRMM
FY-2
INSAT
GOES-9A
FY-3
METOP
METEOSAT
KALPANA
METEOSAT-IO

Thank You