Missions:

INSAT-3DR

INSAT-3DR is identical to INSAT-3D in terms of Sensors and products.

INSAT or the Indian National Satellite System is a series of multipurpose Geo-stationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, and search and rescue needs of India. Commissioned in 1983, INSAT is the largest domestic communication system in the Asia Pacific Region. The satellite is monitored and controlled by Master Control Facilities that exist in Hassan and Bhopal. INSAT-3DR is a multipurpose geosynchronous spacecraft with main meteorological payloads (imager and sounder). The main objectives for this mission are to provide an operational, environmental and storm warning system to protect life and property. INSAT3DR is monitoring the earth's surface, oceanic observations and also provide data dissemination capabilities. It provides Broadcast Satellite Services (BSS) through two S-band transponders. The data acquisition and processing system is established at Space Applications Centre, Bopal Campus, Ahmedabad, India. The processing of INSAT-3DR data is taken place broadly in four steps.

1. Ground receiving system to receive data
2. Data Reception (DR) system to generate raw data (L0) files
3. Data Processing (DP) system to process L0 data and produce L1B data files (Calibrated and Geo located)
4. Product generation and Dissemination system

It is positioned at 74^0 East Longitude.

INSAT-3DR Introduction

INSAT-3DR is a dedicated meteorological spacecraft designed for enhanced meteorological observations and monitoring of land and ocean surfaces for weather forecasting and disaster warning. INSAT-3DR is configured on I-2K bus with Sounder, Imager and Data Relay Transponder (DRT) and Satellite Aided Search & Rescue (SAS&R) Payloads. INSAT-3DR with a lift of mass of about 2211 kg was flown on September 08, 2016 by GSLV-F05. Communication Payload sub systems are configured to support INSAT system for DRT SAS&R and Meteorological Payload services.

The mission goal is stated as "to provide an operational, environmental & storm warning system to protect life & property and also to monitor earth's surface and carryout oceanic observations and also provide data dissemination capabilities"

The satellite has 3 payloads

- Meteorological (MET) - IMAGER and SOUNDER
- Data Relay Transponder (DRT)
- Satellite Aided Search and Rescue (SAS&R)

The geophysical parameters that will be extracted from INSAT-3DR are Outgoing Longwave Radiation (OLR), Quantitative Precipitation Estimation (QPE), Sea Surface Temperature (SST), Snow Cover, Snow Depth, Fire, Smoke, Aerosol, Cloud Motion Vectors (CMV), Water Vapour Winds (WVW), Upper Tropospheric Humidity (UTH), Temperature, Humidity Profile and Total Ozone, Fog, Visible Wind Vectors and other value added parameters from Imager and Sounder.

INSAT-3DR Objectives

INSAT or the Indian National Satellite System is a series of multipurpose Geo-stationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, and search and rescue needs of India. Commissioned in 1983, INSAT is the largest domestic communication system in the Asia Pacific Region. The satellites also incorporate transponder(s) for receiving distress alert signals for search and rescue missions in the South Asian and Indian Ocean Region, as ISRO is a member of the COSPAR-Sarsat programme.

The main objectives for this mission are to provide an operational, environmental and storm warning system to protect life and property. INSAT-3DR will

- Monitor earth's surface and carryout oceanic observations and also provide data dissemination capabilities,
- Provide Broadcast Satellite Services (BSS) through two S-band transponders.,

INSAT-3DR SpaceCraft

The INSAT-3DR is a momentum-biased 3-axis stabilized spacecraft using star trackers for precise pointing control. The spacecraft has a launch mass of 2211 kg with a dry mass of 907 kg. It is in Geostationary orbit, altitude of ~35, 786 km, location at 74° East. The three-axis stabilized geostationary satellite carries two meteorological instruments: a six channel Imager and an IR Sounder. Along with the channels in Visible, Middle Infrared, Water Vapor and Thermal Infrared bands, the Imager includes a SWIR channel for wider applications. The Sounder will have eighteen narrow spectral channels in three IR bands in addition to a channel in visible band. It also has a Data Relay Transponder and Satellite based Search & Rescue Payload. Several innovative technologies like on-the-fly correction of scan mirror pointing errors, biannual yaw rotation of the spacecraft, micro-stepping SADA, star sensors and integrated bus management unit have been incorporated to meet the stringent payload requirements like pointing accuracies, thermal management of IR detectors and concurrent operation of both instruments.

A passive radiant cooler is used to cool the infrared detectors of imager and sounder instruments. The temperature of the detectors is maintained at 95 K (BOL) and 100 K (EOL). The passive cooler also maintains the sounder filter wheel temperature at 213 K.

INSAT-3DR Payloads

The satellite has 3 payloads:

- Meteorological (MET) - IMAGER and SOUNDER
- Data Relay Transponder (DRT)
- Satellite Aided Search and Rescue (SAS&R)

Meteorological Payload

The INSAT-3DR spacecraft incorporates advanced Imager and Sounder instruments.

IMAGER

The INSAT-3DR imager provides imaging capability of the earth disc from geostationary altitude in one visible (0.52 - 0.72 micrometers) and five infrared; 1.55 - 1.70(SWIR), 3.80 - 4.00(MIR), 6.50 - 7.00 (water vapour), 10.2 - 11.2 (TIR-1) and 11.5 - 12.5 (TIR-2) bands. The ground resolution at the sub-satellite point is nominally 1km x 1km for visible and SWIR bands, 4km x 4km for one MIR and both TIR bands and 8km x 8km for WV band.

The Imager is an improved design of VHRR-2 (Very High Resolution Radiometer) heritage instrument flown on the Kalpana-1 resolution in the visible band for the monitoring of meso scale phenomena and severe local storms. The two new SWIR and MWIR bands with a resolution of 1 km and 4 km, respectively, will enable better land-cloud discrimination and detection of surface features like snow. One more significant improvement is the split-band TIR channel with two separate windows in 10.2-11.2 and 11.5-12.5 Micrometer regions with a 4 km resolution.

This new element enables the extraction of sea surface temperature over the Indian region with a far greater accuracy since the dual-window algorithm can be applied to eliminate the atmospheric attenuation effects. The 1 km resolution of the visible channel and 4 km resolution of the thermal IR channels indirectly improve the accuracy of the derived products like outgoing longwave radiation and cloud motion vectors. The INSAT-3DR Imager payload is a replica of INSAT-3D Imager.

Key Parameters of the Imager

Telescope aperture	310 mm diameter
Number of bands (6)	0.52 - 0.72 µm, VIS (Visible) 1.55 - 1.70 µm, SWIR (Short Wave Infrared) 3.80 - 4.00 µm, MWIR (Mid Wave Infrared) 6.50 - 7.00 µm, WV (Water Vapor) 10.2 - 11.2 µm, TIR-1 (Thermal Infrared) 11.5 - 12.5 µm, TIR-2 (Thermal Infrared)
Spatial resolution	1 km for VIS and SWIR 4 km for MWIR 8 km for WV 4 km for TIR-1 and TIR-2
Band separation, band definition	Beam splitter, interference filters
IFOV (Instantaneous Field of View)	28 µrad for VIS and SWIR (1 km) 112 µrad for MWIR, TIR-1, & TIR-2 (4 km) 224 µrad for WV (8 km)
Sampling interval	1.75 samples / IFOV for VIS, SWIR,MIR & TIR-1 / -2 3.5 samples / IFOV for WV
Scan step angle	Linear in E-W direction (8 µR step size) Line step 224 µrad in N-S direction
Scan rate Scan linearity Inflight calibration	200º/s +0.2 s turnaround time 56 µR (peak to peak) Full aperture blackbody and spaceview
Scan modes	Full, normal and programmable sector for quick repetivity

Frame time	25 minutes for normal mode
Signal quantization	10 bit/sample
Downlink data rate	4.0 Mbit/s

SOUNDER

The INSAT-3DR sounder has 18 infrared channels distributed over longwave and shortwave bands alongwith one visible band. A visible channel provides synoptic view of the clouds and the earth to aid in generating three dimensional maps of temperature and moisture structure of the atmosphere.

The Sounder is a first time instrument of the geostationary INSAT series designed and developed at ISRO. The overall objective is to measure the temperature and humidity profiles (vertical distributions) to obtain a three-dimensional representation of the atmosphere. The instrument requirements call for soundings at 10 km ground resolution every 3 hours for a full frame scan. This enables the derivation of vertical profiles of temperature and humidity. These vertical profiles can then be used to derive various atmospheric stability indices and other parameters such as atmospheric water vapor content and total column ozone amount. The INSAT-3DR Sounder payload is a replica of INSAT-3D Sounder.

Key Parameters of the sounder

Telescope aperture	310 mm diameter
Number of bands (6)	18 Infrared + 1 Visible
Band definition	Filter wheel with interference filters
IFOV (Instantaneous Field of View)	280 µrad x 280 rad, corresponding to 10 km x 10 km on the surface
Sampling interval	280 µrad E-W / N-S
No of simultaneous soundings	4 per band
Scan step angle	10 km E-W, every 0.1 s, and 40 km N-S after completion of E-W scan, 150 µR rms
Step and dwell time	0.1, 0.2 and 0.4 s
Turnaround time	0.1 s per scan
In-flight calibration	Full aperture blackbody and space view
Scan modes	Options provided to cater to quick dynamic environmental phenomena
Frame time	160 minutes for 6000 km x 6000 km area sounding

Signal quantization	13 bit/sample
Downlink data rate	40 kbit/s
Frame time	90 kg, (without cooler), 100 W

Spectral parameters and sensitivity of the sounder

1	14.71 (680)	0.281 (13)	1.5
2	14.37 (696)	0.268 (13)	1
3	14.06 (711)	0.256 (13)	0.5
4	13.96 (733)	0.298 (16)	0.5
5	13.37 (749)	0.286 (16)	0.5
6	12.66 (790)	0.481 (30)	0.3
7	12.02 (832)	0.723 (50)	0.15
8	11.03 (907)	0.608 (50)	0.15
9	9.71 (1030)	0.235 (25)	0.2
10	7.43 (1425)	0.304 (55)	0.2
11	7.02 (1425)	0.394 (80)	0.2

12	6.51 (1535)	0.255 (60)	0.2
13	4.57 (2188)	0.048 (23)	0.2
14	4.52 (2210)	0.047 (23)	0.15
15	4.45 (2245)	0.045 (23)	0.15
16	4.13 (2420)	0.0683 (40)	0.15
17	3.98 (2513)	0.0683 (40)	0.15
18	3.74 (2671)	0.140 (100)	0.15
19	0.695 (14367) 0.05 (1000) (0.67-0.72)		0.1% albedo

Communication Payload

Communication transponders are required to be configured to provide continuity of some of the INSAT services. A total satellite mass of 2211kg is considered for the launch compatibility, and 70 kg (approximately) of mass apportionment is done for the communication payload components. The communication payload components are - Meteorological Transmitter, Data Relay Transponder, Satellite Aided Search and Rescue (SAS&R) Transponder & S-band Broadcast Satellite Services Transponder.

INSAT-3D

INSAT or the Indian National Satellite System is a series of multipurpose Geo-stationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, and search and rescue needs of India. Commissioned in 1983, INSAT is the largest domestic communication system in the Asia Pacific Region. The satellite is monitored and controlled by Master Control Facilities that exist in Hassan and Bhopal. INSAT-3D is a multipurpose geosynchronous spacecraft with main meteorological payloads (imager and sounder). The main objectives for this mission are to provide an operational, environmental and storm warning system to protect life and property. INSAT3D is monitoring the earth’s surface, oceanic observations and also provide data dissemination capabilities. It provides Broadcast Satellite Services (BSS) through two S-band transponders. The data acquisition and processing system is established at Space Applications Centre, Bopal Campus, Ahmedabad, India. The processing of INSAT-3D data is taken place broadly in four steps.

1. Ground receiving system to receive data
2. Data Reception (DR) system to generate raw data (L0) files
3. Data Processing (DP) system to process L0 data and produce L1B data files (Calibrated and Geo located)
4. Product generation and Dissemination system

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INSAT-3D Introduction

INSAT-3D is a dedicated meteorological spacecraft designed for enhanced meteorological observation and monitoring of land and ocean surfaces of weather forecasting and disaster warning. INSAT-3D is configured on I-2K bus with Sounder, Imager and Data Relay Transponder (DRT) and Satellite Aided Search & Rescue (SAS&R) Payloads. INSAT-3D was flown on July 26, 2013 with a lift of mass of about 2100 kg by ARIANE-5/GSLV-MK II /Soyuz launcher and expected minimum mission life is seven years. Communication Payload sub systems are configured to support INSAT system for DRT SAS&R and Meteorological Payload services.

The mission goal is stated as "to provide an operational, environmental & storm warning system to protect life & property and also to monitor earth's surface and carryout oceanic observations and also provide data dissemination capabilities"

The satellite has 3 payloads

- Meteorological (MET) - IMAGER and SOUNDER
- Data Relay Transponder (DRT)
- Satellite Aided Search and Rescue (SAS&R)

The geophysical parameters that will be extracted from INSAT3D are Outgoing Longwave Radiation (OLR), Quantitative Precipitation Estimation (QPE), Sea Surface Temperature (SST), Snow Cover, Snow Depth, Fire, Smoke, Aerosol, Cloud Motion Vector (CMV), Water Vapour Wind (WVW), Upper Tropospheric Humidity (UTH), Temperature, Humidity Profile and Total Ozone, Fog, Visible Wind Vector and other value added parameters from Imager and Sounder.

INSAT-3D Objectives

INSAT or the Indian National Satellite System is a series of multipurpose Geo-stationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, and search and rescue needs of India. Commissioned in 1983, INSAT is the largest domestic communication system in the Asia Pacific Region. The satellites also incorporate transponder(s) for receiving distress alert signals for search and rescue missions in the South Asian and Indian Ocean Region, as ISRO is a member of the Cospas-Sarsat programme.

The main objectives for this mission are to provide an operational, environmental and storm warning system to protect life and property. INSAT3D will

- Monitor earth's surface and carryout oceanic observations and also provide data dissemination capabilities,
- Provide Broadcast Satellite Services (BSS) through two S-band transponders.,

INSAT-3D SpaceCraft

The INSAT-3D is a momentum-biased 3-axis stabilized spacecraft using star trackers for precise pointing control. The spacecraft has a launch mass of 2000 kg with a dry mass of 907 kg. The nominal design life is 7.7 years. It is in Geostationary orbit, altitude of ~35, 786 km, location at 82° East. The three-axis stabilized geostationary satellite carries two meteorological instruments: a six channel Imager and an IR Sounder. Along with the channels in Visible, Middle Infrared, Water Vapor and Thermal Infrared bands, the Imager includes a SWIR channel for wider applications. The Sounder will have eighteen narrow spectral channels in three IR bands in addition to a channel in visible band. It also has a Data Relay Transponder and Satellite based Search & Rescue Payload. Several innovative technologies like on-the-fly correction of scan mirror pointing errors, biannual yaw rotation of the spacecraft, micro-stepping SADA, star sensors and integrated bus management unit have been incorporated to meet the stringent payload requirements like pointing accuracies, thermal management of IR detectors and concurrent operation of both instruments.

A passive radiant cooler is used to cool the infrared detectors of imager and sounder instruments. The detectors temperature is maintained at 95 K (BOL) and 100 K (EOL). The passive cooler is also to maintain the sounder filter wheel temperature at 213 K.

INSAT-3D Payloads

The satellite has 3 payloads:

- Meteorological (MET) - IMAGER and SOUNDER
- Data Relay Transponder (DRT)
- Satellite Aided Search and Rescue (SAS&R)

Meteorological Payload

The INSAT-3D spacecraft incorporates advanced Imager and Sounder instruments.

IMAGER

The INSAT-3D imager provides imaging capability of the earth disc from geostationary altitude in one visible (0.52 - 0.72 micrometers) and five infrared; 1.55 - 1.70(SWIR), 3.80 - 4.00(MIR), 6.50 - 7.00 (water vapour), 10.2 - 11.2 (TIR-1) and 11.5 - 12.5 (TIR-2) bands. The ground resolution at the sub-satellite point is nominally 1km x 1km for visible and SWIR bands, 4km x 4km for one MIR and both TIR bands and 8km x 8km for WV band.

The Imager is an improved design of VHRR/2 (Very High Resolution Radiometer) heritage instrument flown on the Kalpana-1 and INSAT-3A missions. The instrument features 6 spectral bands (against the 3 bands in previous versions) offering an improved 1 km resolution in the visible band for the monitoring of meso scale phenomena and severe local storms. The two new SWIR and MWIR bands with a resolution of 1 km and 4 km, respectively, will enable better land-cloud discrimination and detection of surface features like snow. One more significant improvement is the split-band TIR channel with two separate windows in 10.2-11.2 and 11.5-12.5 Micrometer regions with a 4 km resolution.

This new element enables the extraction of sea surface temperature over the Indian region with a far greater accuracy since the dual-window algorithm can be applied to eliminate the atmospheric attenuation effects. The 1 km resolution of the visible channel and 4 km resolution of the thermal IR channels indirectly improve the accuracy of the derived products like outgoing longwave radiation and cloud motion vectors.

Key Parameters of the Imager

Telescope aperture	310 mm diameter
Number of bands (6)	0.52 - 0.72 µm, VIS (Visible) 1.55 - 1.70 µm, SWIR (Short Wave Infrared) 3.80 - 4.00 µm, MWIR (Mid Wave Infrared) 6.50 - 7.00 µm, WV (Water Vapor) 10.2 - 11.2 µm, TIR-1 (Thermal Infrared) 11.5 - 12.5 µm, TIR-2 (Thermal Infrared)
Spatial resolution	1 km for VIS and SWIR 4 km for MWIR 8 km for WV 4 km for TIR-1 and TIR-2
Band separation, band definition	Beam splitter, interference filters
IFOV (Instantaneous Field of View)	28 µrad for VIS and SWIR (1 km) 112 µrad for MWIR, TIR-1, & TIR-2 (4 km) 224 µrad for WV (8 km)
Sampling interval	1.75 samples / IFOV for VIS, SWIR,MIR & TIR-1 / -2 3.5 samples / IFOV for WV
Scan step angle	Linear in E-W direction (8 µR step size)

	Line step 224 µrad in N-S direction
Scan rate Scan linearity Inflight calibration	200º/s +0.2 s turnaround time 56 µR (peak to peak) Full aperture blackbody and spaceview
Scan modes	Full, normal and programmable sector for quick repetivity
Frame time	25 minutes for normal mode
Signal quantization	10 bit/sample
Downlink data rate	4.0 Mbit/s

SOUNDER

The INSAT-3D sounder has 18 infrared channels distributed over longwave and shortwave bands. A visible channel provides synoptic view of the clouds and the earth to aid in generating three dimensional map of temperature and moisture structure of the atmosphere.

The Sounder is a first time instrument of the geostationary INSAT series designed and developed at ISRO. The overall objective is to measure the temperature and humidity profiles (vertical distributions) to obtain a three-dimensional representation of the atmosphere. The instrument requirements call for soundings at 10 km ground resolution every 3 hours for a full frame scan. This enables the derivation of vertical profiles of temperature and humidity. These vertical profiles can then be used to derive various atmospheric stability indices and other parameters such as atmospheric water vapor content and total column ozone amount.

Key Parameters of the sounder

Telescope aperture	310 mm diameter
Number of bands (6)	18 Infrared + 1 Visible
Band definition	Filter wheel with interference filters
IFOV (Instantaneous Field of View)	280 µrad x 280 rad, corresponding to 10 km x 10 km on the surface
Sampling interval	280 µrad E-W / N-S
No of simultaneous soundings	4 per band
Scan step angle	10 km E-W, every 0.1 s, and 40 km N-S after completion of E-W scan, 150 µR rms
Step and dwell time	0.1, 0.2 and 0.4 s
Turnaround time	0.1 s per scan
In-flight calibration	Full aperture blackbody and space view
Scan modes	Options provided to cater to quick dynamic environmental phenomena
Frame time	160 minutes for 6000 km x 6000 km area sounding

Signal quantization	13 bit/sample
Downlink data rate	40 kbit/s
Frame time	90 kg, (without cooler), 100 W

Spectral parameters and sensitivity of the sounder

1	14.71 (680)	0.281 (13)	1.5
2	14.37 (696)	0.268 (13)	1
3	14.06 (711)	0.256 (13)	0.5
4	13.96 (733)	0.298 (16)	0.5
5	13.37 (749)	0.286 (16)	0.5
6	12.66 (790)	0.481 (30)	0.3
7	12.02 (832)	0.723 (50)	0.15
8	11.03 (907)	0.608 (50)	0.15
9	9.71 (1030)	0.235 (25)	0.2
10	7.43 (1425)	0.304 (55)	0.2
11	7.02 (1425)	0.394 (80)	0.2

12	6.51 (1535)	0.255 (60)	0.2
13	4.57 (2188)	0.048 (23)	0.2
14	4.52 (2210)	0.047 (23)	0.15
15	4.45 (2245)	0.045 (23)	0.15
16	4.13 (2420)	0.0683 (40)	0.15
17	3.98 (2513)	0.0683 (40)	0.15
18	3.74 (2671)	0.140 (100)	0.15
19	0.695 (14367) 0.05 (1000) (0.67-0.72)		0.1% albedo

Communication Payload

Communication transponders are required to be configured to provide continuity of some of the INSAT services. A total satellite mass of 2000kg is considered for the launch compatibility, and 70 kg (approximately) of mass apportionment is done for the communication payload components. The communication payload components are - Meteorological Transmitter, Data Relay Transponder, Satellite Aided Search and Rescue (SAS&R) Transponder & S-band Broadcast Satellite Services Transponder.

INSAT-3D Payloads

The satellite has 3 payloads:

- Meteorological (MET) - IMAGER and SOUNDER
- Data Relay Transponder (DRT)
- Satellite Aided Search and Rescue (SAS&R)

Meteorological Payload

The INSAT-3D spacecraft incorporates advanced Imager and Sounder instruments.

IMAGER

The INSAT-3D imager provides imaging capability of the earth disc from geostationary altitude in one visible (0.52 - 0.72 micrometers) and five infrared; 1.55 - 1.70(SWIR), 3.80 - 4.00(MIR), 6.50 - 7.00 (water vapour), 10.2 - 11.2 (TIR-1) and 11.5 - 12.5 (TIR-2) bands. The ground resolution at the sub-satellite point is nominally 1km x 1km for visible and SWIR bands, 4km x 4km for one MIR and both TIR bands and 8km x 8km for WV band.

The Imager is an improved design of VHRR/2 (Very High Resolution Radiometer) heritage instrument flown on the Kalpana-1 and INSAT-3A missions. The instrument features 6 spectral bands (against the 3 bands in previous versions) offering an improved 1 km resolution in the visible band for the monitoring of meso scale phenomena and severe local storms. The two new SWIR and MWIR bands with a resolution of 1 km and 4 km, respectively, will enable better land-cloud discrimination and detection of surface features like snow. One more significant improvement is the split-band TIR channel with two separate windows in 10.2-11.2 and 11.5-12.5 Micrometer regions with a 4 km resolution.

This new element enables the extraction of sea surface temperature over the Indian region with a far greater accuracy since the dual-window algorithm can be applied to eliminate the atmospheric attenuation effects. The 1 km resolution of the visible channel and 4 km resolution of the thermal IR channels indirectly improve the accuracy of the derived products like outgoing longwave radiation and cloud motion vectors.

Key Parameters of the Imager

Telescope aperture	310 mm diameter
Number of bands (6)	0.52 - 0.72 µm, VIS (Visible) 1.55 - 1.70 µm, SWIR (Short Wave Infrared) 3.80 - 4.00 µm, MWIR (Mid Wave Infrared) 6.50 - 7.00 µm, WV (Water Vapor) 10.2 - 11.2 µm, TIR-1 (Thermal Infrared) 11.5 - 12.5 µm, TIR-2 (Thermal Infrared)
Spatial resolution	1 km for VIS and SWIR 4 km for MWIR 8 km for WV 4 km for TIR-1 and TIR-2
Band separation, band definition	Beam splitter, interference filters

IFOV (Instantaneous Field of View)	28 µrad for VIS and SWIR (1 km) 112 µrad for MWIR, TIR-1, & TIR-2 (4 km) 224 µrad for WV (8 km)
Sampling interval	1.75 samples / IFOV for VIS, SWIR,MIR & TIR-1 / -2 3.5 samples / IFOV for WV
Scan step angle	Linear in E-W direction (8 µR step size) Line step 224 µrad in N-S direction
Scan rate Scan linearity Inflight calibration	200º/s +0.2 s turnaround time 56 µR (peak to peak) Full aperture blackbody and spaceview
Scan modes	Full, normal and programmable sector for quick repetivity
Frame time	25 minutes for normal mode
Signal quantization	10 bit/sample
Downlink data rate	4.0 Mbit/s

SOUNDER

The INSAT-3D sounder has 18 infrared channels distributed over longwave and shortwave bands. A visible channel provides synoptic view of the clouds and the earth to aid in generating three dimensional map of temperature and moisture structure of the atmosphere.

The Sounder is a first time instrument of the geostationary INSAT series designed and developed at ISRO. The overall objective is to measure the temperature and humidity profiles (vertical distributions) to obtain a three-dimensional representation of the atmosphere. The instrument requirements call for soundings at 10 km ground resolution every 3 hours for a full frame scan. This enables the derivation of vertical profiles of temperature and humidity. These vertical profiles can then be used to derive various atmospheric stability indices and other parameters such as atmospheric water vapor content and total column ozone amount.

Key Parameters of the sounder

Telescope aperture	310 mm diameter
Number of bands (6)	18 Infrared + 1 Visible
Band definition	Filter wheel with interference filters
IFOV (Instantaneous Field of View)	280 µrad x 280 rad, corresponding to 10 km x 10 km on the surface
Sampling interval	280 µrad E-W / N-S
No of simultaneous soundings	4 per band
Scan step angle	10 km E-W, every 0.1 s, and 40 km N-S after completion of E-W scan, 150 µR rms
Step and dwell time	0.1, 0.2 and 0.4 s
Turnaround time	0.1 s per scan
In-flight calibration	Full aperture blackbody and space view
Scan modes	Options provided to cater to quick dynamic environmental phenomena
Frame time	160 minutes for 6000 km x 6000 km area sounding

Signal quantization	13 bit/sample
Downlink data rate	40 kbit/s
Frame time	90 kg, (without cooler), 100 W

Spectral parameters and sensitivity of the sounder

1	14.71 (680)	0.281 (13)	1.5
2	14.37 (696)	0.268 (13)	1
3	14.06 (711)	0.256 (13)	0.5
4	13.96 (733)	0.298 (16)	0.5
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18	3.74 (2671)	0.140 (100)	0.15
19	0.695 (14367) 0.05 (1000) (0.67-0.72)		0.1% albedo

Communication Payload

Communication transponders are required to be configured to provide continuity of some of the INSAT services. A total satellite mass of 2000kg is considered for the launch compatibility, and 70 kg (approximately) of mass apportionment is done for the communication payload components. The communication payload components are - Meteorological Transmitter, Data Relay Transponder, Satellite Aided Search and Rescue (SAS&R) Transponder & S-band Broadcast Satellite Services Transponder.

KALPANA-1

Metsat is an exclusive meteorological satellite of ISRO in geo-synchronous orbit. This satellite is developed out of a small I-1000 bus made of carbon fibre re-enforced plastic light weight structure, a uni power bus employing an 18AH Ni-Cd battery and a single GaAs/Ge solar panel generating 640 watts of power. Metsat uses a 3-axis stabilized momentum biased attitude control system with suitable linearly controlled magnetic torquers for solar radiation pressure compensation. A unified propulsion system of bi-propellant apogee motor of 440 Newtons and the reaction control engines of 22 Newtons has been selected for efficient and versatile mission management.

Metsat carries on-board a Very High ResolutionRadiometer (VHRR) and a Data Relay Transponder (DRT) for weather data transmission. VHRR provides earth imageries in visible band with a resolution of2 km, in thermal infrared and water vapor bands with 8 km. DRT collects weather data from un-attended data collection platforms located throughout India and transmits the same to centrally located Meteorological Data Utilisation Centre. The satellite dry mass is about 495 kg. Metsat was launched on- board upgraded and modified satellite launch vehicle (PSLV) with a lift–off mass of 1060 kgs in September 2002. After successful launch and early orbit operations and in orbit characterization of the Payload, the satellite has been commissioned for routine usage of weather data and imageries.

KALPANA-1 Introduction

Kalpana-1 is the first dedicated meteorological satellite launched by Indian Space Research Organisation using Polar Satellite Launch Vehicle on 2002-09-12. This was the first satellite launched by the PSLV into the Geo-stationary orbit. The satellite was originally known as MetSat-1. On February 5, 2003 it was renamed to Kalpana-1 by the Indian Prime Minister Atal Bihari Vajpayee in memory of Kalpana Chawla?a NASA astronaut who perished in the Space Shuttle Columbia disaster.

The satellite features a Very High Resolution scanning Radiometer (VHRR), for three-band images and a Data Relay Transponder (DRT) payload.

So far, meteorological services had been combined with telecommunication and television services in the INSAT series. MetSat-1 is a precursor to the future INSAT system that will have separate satellites for meteorology and telecommunication & broadcasting services.

KALPANA-1 Objectives

Major Metsat/Kalpana mission objectives are:-

- To establish a small satellite I-1000 bus system which can meet the exclusive service requirements of a meteorological payload for earth imageries
- Collection of weather data from low cost unattended data collection platforms-to configure Metsat spacecraft within the lift-off mass constraints of upgraded existing polar satellite launch vehicle for deployment in geo-synchronous transfer orbit (GTO) mission.

KALPANA-1 SpaceCraft

The MetSat-1 spacecraft was developed by ISAC (ISRO Satellite Center), Bangalore. MetSat has been designed using a new spacecraft bus (I-1000 bus) employing lightweight structural elements like CFRP (Carbon Fibre Reinforced Plastic). A central structural thrust cylinder provides mounting interfaces propellant tanks, pressurant tank, equipment panels, payload, solar array assembly, and with the launch vehicle.

Structural brackets are provided to mount momentum wheels, reaction wheel, RCS (Reaction Control System) thrusters, earth sensors, sun sensors, LAM (Liquid Apogee Motor), and propulsion components.

MetSat-1 is three-axis stabilized (momentum biased control subsystem). However, unlike its INSAT predecessors, the MetSat-1 spacecraft does not feature a sail/boom design. The attitude is sensed by suite of sensors (gyros, Earth sensors, digital sun sensor, coarse analog sun sensors, and solar panel sun sensor). Magnetic torquers serve as actuators to unload the momentum of the wheels. In addition, active thrusters are used (one 440N LAM for orbit raising maneuvers and eight 22 N thrusters for orbit and attitude control).

The propulsion system employed is a unified bi-propellant with mono-methyl hydrazine (MMH) as fuel and mixed oxides of nitrogen (MON3) as oxidizer. The S/C employs passive thermal control system by utilizing multi-layer insulation blankets, optical solar reflectors, heat sinks, paints, thermal grease, thermal shields etc. The temperature of individual subsystems spread over the satellite is maintained by a bank of 112 heaters.

EPS (Electrical Power Subsystem): Electrical power of 550 W is generated by a single panel solar array of 2.15 m x 1.85 m using GaAS solar cells. The solar panel features a drive mechanism to point it into the sun. A single NiCd battery (18 Ah capacity) provides power for eclipse phases. The SADA (Solar Array Driver Assembly) slip rings and drive mechanism are modified to meet the power transfer and drive requirements, it is mass-optimized.

The spacecraft has a launch mass of 1055 kg including 560 kg of propellant (495 kg S/C dry mass). MetSat-1 has a design life of 7 years with an operational goal of 10 years.

KALPANA-1 Payloads

VHRR

VHRR/2 is a modified version of the VHRR heritage imagers flown on INSAT-2A, -2B, and -2E. The VHRR observes in VIS, water vapor and TIR bands providing a spatial resolution of 2 km in VIS band and 8 km for the rest. VHRR was developed by SAC (Satellite Application Center), Ahmedabad, India. The instrument operates in three scanning modes:

- Full frame mode (20° North-South x 20° East-West), minimum in about 33 minutes covering the entire Earth disk
- Normal frame mode (14° N-S x 20° E-W), minimum in about 23 minutes

- Sector frame mode in which the sector can be positioned anywhere in steps of 0.5° in the N-S direction to cover 4.5° N-S x 20° E-W. This mode is particularly suited for rapid, repetitive coverage during severe weather conditions like a cyclone.

The nominal frame repetition rates are: 40, 30 and 20 minutes respectively. VHRR is an opto-mechanical system (whiskbroom type imager). The incoming solar radiation is reflected onto a Ritchey-Chretien telescope of 20 cm aperture by a beryllium scan mirror mounted at 45° to the optical axis. The optical system includes a gold-film dichoric beam-splitter that transmits visible light energy and reflects WV/TIR energy, so that the radiation from the Earth is channelized to the visible and IR focal planes simultaneously.

The visible band detector configuration consists of two staggered arrays of four silicon photodiodes each; while two sets of mercury-cadmium telluride (MCT) detector elements operating nominally at 100-110 K sense the WV/thermal radiation. The scan mirror is mounted on a two-axis, gimballed scan mechanism system to generate a 2-D image by sweeping the detector instantaneous field of view (FOV) across the Earth's surface in east to west (fast scan) and north to south (slow scan).

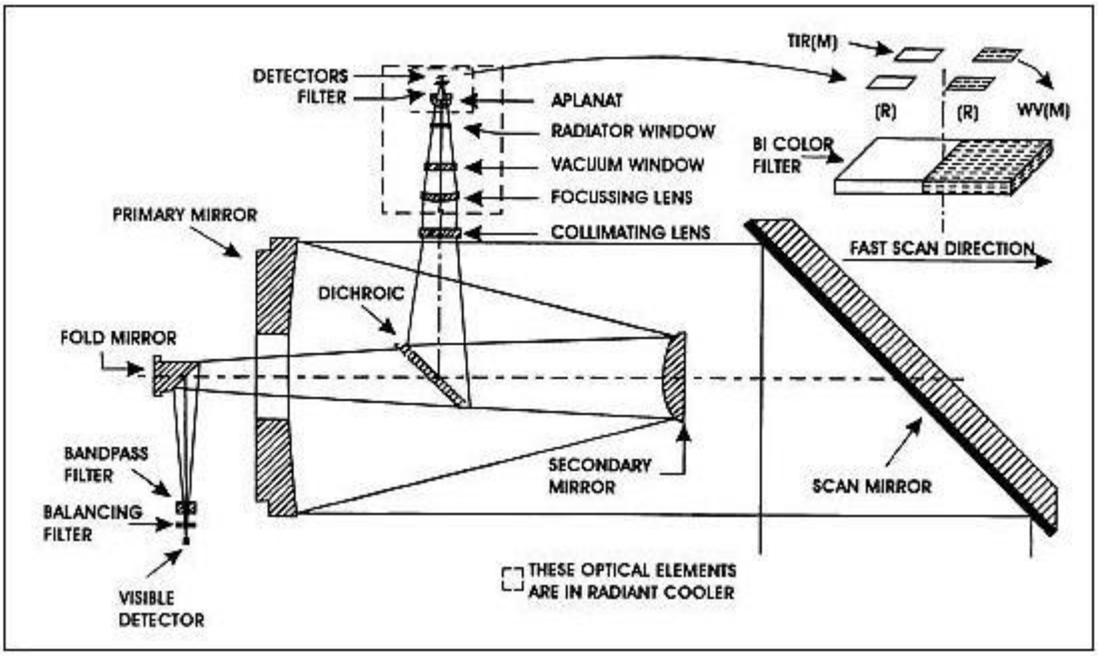
Imaging modes of the VHRR instrument

Full scan	20° N-S and 20° E-W	33 min
Normal scan	14° N-S and 20° E-W	23 min
Sector scan	4.5° N-S and 20° E-W	23 (3 times)

Imaging modes of the VHRR instruments

VIS	4 +4 redundant	> 0.23 approx.	0-100% albedo	6 : 1 min at 2.5% albedo
Water Vapor (WV)	1 + 1 redundant	> 0.21 approx.	4-340 K	0.25 K at 300 K
TIR	1 + 1 redundant	> 0.21 approx.	4-320 K	0.5 K at 300 K

Schematic illustration of the VHRR instrument



VHRR Instrument

Spectral band: VIS	0.55 - 0.75 µm; Integrated out-of-band response <3%
Spectral band: TIR	Inter detector mismatch < 5% 10.5 - 12.5 µm; Integrated out-of-band response <3%
Spectral band: MWIR (Water vapor)	Out-of-band response peak < 0.1% 5.7 - 7.1 µm
Spatial resolution VIS	56 µrad (or 2 km x 2 km)
Spatial resolution TIR and MWIR	224 µrad (or 8 km x 8 km)
Radiometric performance: SNR	> 6 for VIS at 2.5% albedo
Radiometric performance: NEDT	< 0.25 K at 300 K for IR channel
Dynamic range of TIR/MWIR channels	4-340 K
Dynamic range of VIS channel	0-100%
Misregistration between VIS and IR	<56 µrad

Modulation Transfer Function (MTF)	> 21% for IR and TIR; >23% for VIS channel

DRT (Data Relay Transponder)

The DRT (Data Relay Transponder) is part of a DCS (Data Collection System) of ISRO. The objective is to collect data from unattended meteorological platforms in the ground segment. DRT receives receives signals from unattended weather data collection platforms and retransmits them to the central station. The data from these payloads are being used for comprehensive weather status and forecasting.

RF communication of DRT: Uplink frequency = 402.75 MHz; downlink frequency = 4506.05 MHz; bandwidth =± 100 kHz; EIRP = 21 dBW (min).

Note: MetSat-1 does not carry SAS&R (Satellite Aided Search and Rescue) system. In the INSAT-2 series, the INSAT-2A and -2B satellites carried SAS&R transponders as well as DRTs (Data Relay Transponders). According to ISRO information, INSAT-3A (launch April 9, 2003) and INSAT-3D (to be launched subsequently), will carry SAS&R and DRT payloads.

INSAT-3A

INSAT-3A is a multipurpose satellite for providing telecommunications, television broadcasting, meteorological and search & rescue services. It carries twenty four transponders - twelve operating in the normal C-band frequency, six in Extended C-band and six in Ku-band. Nine of the twelve normal C-band transponders provide expanded coverage and the remaining three have India coverage beam. All the extended C-band as well as the Ku-band transponders has India coverage beams. INSAT-3A also carries a Ku-band beacon. For meteorological observation, INSAT-3A carries a three channel Very High Resolution Radiometer (VHRR) with 2 km resolution in the visible band and 8 km resolution in thermal infrared and water vapour bands. In addition, INSAT-3A carries a Charge Coupled Device (CCD) camera which operates in the visible and short wave infrared bands providing a spatial resolution of 1 km. A Data Relay Transponder (DRT) operating in UHF band is incorporated for realtime hydro-meteorological data collection from unattended platforms located on land and river basins. The data is then relayed in extended C-band to a central location. INSAT-3A also carries another transponder for Satellite Aided Search and Rescue (SAS & R) as part of India's contribution to the international Satellite Aided Search and Rescue programme. INSAT-3A was launched by European Ariane-5G Launch Vehicle into a Geosynchronous Transfer Orbit (GTO) with a perigee of 200 km and an apogee of 35,980 km. The satellite is maneuvered to its final orbit by firing the satellite's apogee motor. Subsequently, the deployment of solar array, antennae and the solar sail is carried out and the satellite is commissioned after in-orbit checkout.

INSAT-3A Introduction

INSAT-3A, a multipurpose satellite built by ISRO was launched by Ariane in April 2003. It is located at 93.5 degree East longitude. It is third satellite in INSAT-3 series after INSAT-3B & INSAT-3C. It provides communication, weather and search & rescue services.

INSAT-3A Objectives

To provide

- Telecommunications
- Television broadcasting
- Meteorological
- Search and Rescue services

INSAT-3A SpaceCraft

Satellite details

Acronym	INSAT-3A		
Full name	Indian National Satellite - 3A		
Satellite Description	• 4th flight unit of the INSAT-3 series. • Missions: operational meteorology and telecommunication		
Mass at launch	2950 kg	Dry mass/td>	1348 kg
Power	3100 W		
Orbit	Geostationary orbit	Altitude	35786 km
Longitude	93.5° E		

Status	Operational		
Details on Status (as available)	• Nominal operations.		
Launch	2003-04-10	EOL	>2015

INSAT-3A Payloads

Communication Payload

12 Normal C-band transponders (9 channels provide expanded coverage from Middle East to South East Asia with an EIRP of 38 dBW, 3 channels provide India coverage with an EIRP of 36 dBW and 6 Extended C-band transponders provide India coverage with an EIRP of 36 dBW).

6 upper extended C-band transponders having India beam coverage providing an EoC-EIRP of 37 dBW.

6 Ku-band transponders provide India coverage with EIRP of 48 dBW.

Meteorological Payload

A Very High Resolution Radiometer (VHRR) with imaging capacity in the visible (0.55-0.75 µm), thermal infrared (10.5-12.5 µm) and Water Vapour (5.7-7.1 µm) channels, provide 2x2 km, 8x8 km and 8x8 km ground resolutions respectively.

A CCD camera provides 1x1 km ground resolution, in the visible (0.63-0.69 µm), near infrared (0.77-0.86 µm) and shortwave infrared (1.55-1.70 µm) bands.

A Data Relay Transponder (DRT) having global receive coverage with a 400 MHz uplink and 4500 MHz downlink for relay of meteorological, hydrological and oceanographic data from unattended land and ocean-based automatic data collection-cum-transmission platforms.

A Satellite Aided Search and Rescue (SAS&R) SARP payload having global receive coverage with 406 MHz uplink and 4500 MHz downlink with India coverage, for relay of signals from distress beacons in sea, air or land.

Megha Tropiques

Megha-Tropiques is an Indo-French Joint Satellite Mission for studying the water cycle and energy exchanges in the tropics. The main objective of this mission is to understand the life cycle of convective systems that influence the tropical weather and climate and their role in associated energy and moisture budget of the atmosphere in tropical regions. Megha-Tropiques provides scientific data on the contribution of the water cycle to the tropical atmosphere, with information on condensed water in clouds, water vapour in the atmosphere, precipitation, and evaporation. With its circular orbit inclined 20 deg to the equator, the Megha-Tropiques is a unique satellite for climate research that should also aid scientists seeking to refine prediction models. The Megha-Tropiques has day, night and all-weather viewing capabilities; it passes over India almost a dozen times every day, giving scientists an almost real- time assessment of the evolution of clouds.

Megha Tropiques Introduction

The tropical belt receives more energy from Sun than it radiates back into space. The excess energy is transported to temperate regions by the motion of atmosphere and oceans. Any variation in the energy budget of the tropics will therefore effect the whole planet. The energy exchanges are strongly linked to the water cycle and particularly to the tropical connective systems: huge amount of latent heat are released in the tropical rains, while high humidity and thick clouds strongly affect the radiation budget. Many interactions between radiation, water vapour, clouds, precipitation and atmospheric motion determine the life cycle of convective cloud systems, and the occurrence of extreme events like tropical cyclones, monsoons, flood and droughts. Due to dynamic nature of above parameters, the frequency of observation from low orbiting sun-synchronous orbits is inadequate. Only geo-stationary satellites allow continuous monitoring of the Tropics, but their Vis-IR sensors give limited information on the cloud surface properties or horizontal distribution of water vapour.

Low orbiting (~800 km) satellites with low inclinations provide high repetitivity. An inclination at 20 degrees provides 6 observations of each point on the Inter-Tropical Convergence Zone (ITCZ). The most energetic tropical systems, such as the cloud clusters of ITCZ, the Monsoon systems and the Tropical cyclones, extend over hundreds of kilometers. Hence, a ground resolution of about 10 km is adequate for these observations.

In order to meet most of the above requirements, Megha Tropiques has been envisaged which is low earth orbit (LEO) mission. Megha in Sanskrit is ‘cloud’ and Tropiques in French is ‘tropics’. Megha-tropiques Mission is an ISRO-CNES (Indo-French) collaborative programme intended for studying the water cycle and energy exchanges in the tropics using a satellite platform.

Megha-Tropiques is a one-tonne satellite which will be operated as part of a joint programme between the Indian Space Research Organisation (ISRO) and France′s Centre National d′Etudes Spaciales (CNES). The spacecraft was constructed by ISRO, based around the IRS bus developed for earlier Indian satellites, and carries four instruments which will be used to study the Earth′s atmosphere.

ISRO is responsible of the system and the satellite. ISRO provides the launcher, the paltform, part of the MADRAS instrument, the GPS receiver and the mission operation center, which will process all the products until level 1. ISRO also performs the integration and test of the MADRAS instrument, of the complete payload and of the satellite.

CNES provides a support for the system activities, the hyperfrequency part of the MADRAS instrument (MARFEQ) developped under contract by ASTRIUM, and the SAPHIR and SCARAB instruments developped by CNES with a support of the LMD, LERMA and CETP laboratories. CNES also provides the data processing algorithms for the SAPHIR and SCARAB instruments and participates to the development of the MADRAS data processing algorithms. A data and instruments performances expertise center will be created in France.

For the French part, the level 2 and upper data processing will be realised in the thematic center Icare.

Megha Tropiques Ground Segment

The ground segment is divided into:

1. A satellite operation ground segment providedby India:

   an S-band telemetry and command station

   a satellite monitoring and control center

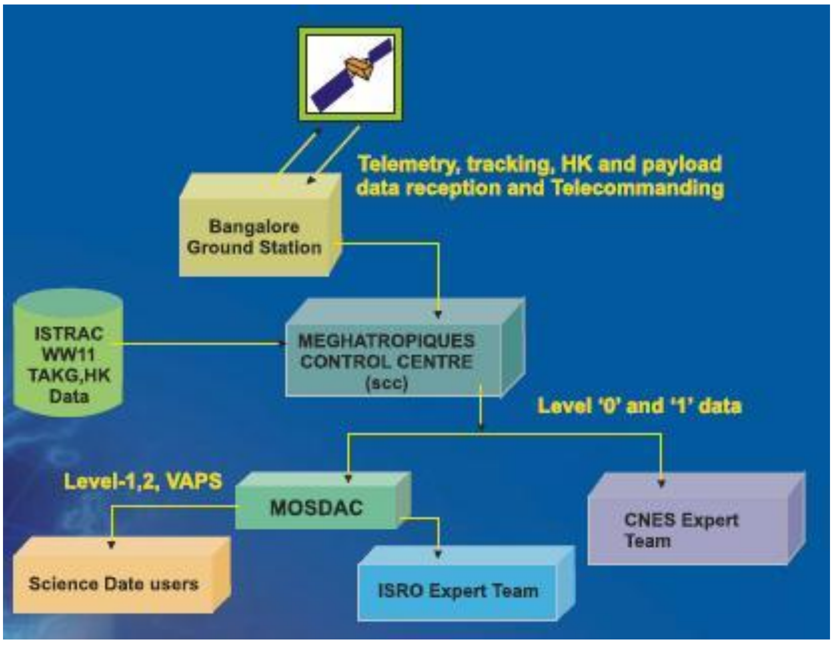
2. A science ground segment including Indian and French parts:

   an S-band mission station for payload telemetry located in India

   a mission operation center located in India

   a level-2 processing center in India such as MOSDAC

   a level-2 processing center named ICARE in France



The Megha-Tropiques satellite is launched by an Indian PSLV launcher in 2011, on a 867 km orbit with an inclination of 20°.

Megha Tropiques Objectives

The main objective of the Megha-Tropiques mission is to study the convective systems that influence the tropical weather and climate. The Megha-Tropiques mission goals are as follows:

- To provide, simultaneous measurements of several elements of the atmospheric water cycle (water vapour, clouds, condensed water in clouds, precipitation and evaporation),
- To measure the corresponding radiative budget at the top of the atmosphere,
- To ensure high temporal sampling in order to characterize the life cycle of the convective systems and to obtain significant statistics.

The payloads have swaths of around 1700-200km. It is necessary to measure the above parameters for a minimum duration of 3 years in order to observe the inter-annual variability and getting an opportunity to observe El Nino-type events in the tropics.

The satellite is launched into a non-sun synchronous orbit, unlike other IRS spacecraft. This Megha-Tropiques satellite carries four payloads namely, MADRAS-a microwave imager, SAPHIR-scanning radiometer instrument, SCARAB-scanner for radiative budget and GPS occultation receiver for atmospheric studies. The major orbit parameters are:

Altitude:	867 km, circular
Inclination:	20°
Period:	102.16 minutes
Repetitivity:	97 orbits in 7 days
No. of Orbits Per day:	14 (approx.)

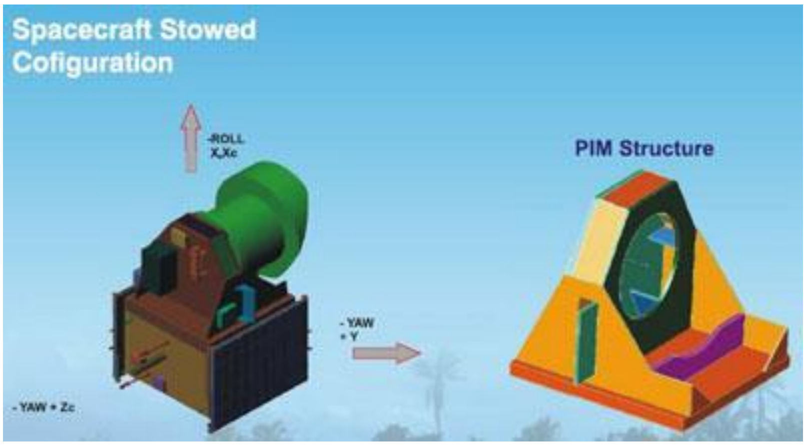
Megha Tropiques SpaceCraft

The Megha-Tropiques system is composed of a mini-satellite developed jointly by France and India, which includes:

- a platform derived from the Indian IRS platform
- a set of four payloads
  - MADRAS, developed jointly by CNES and ISRO
  - SAPHIR, provided by CNES
  - SCARAB, provided by CNES
  - a radio-occulation receiver GPS, provided by ISRO

MADRAS is a conical scanning microwave imager: the incidence has to be constant to take advantage of the polarization information. The spot size is always the same but the scan track follows a circle arc. SAPHIR and SCARAB are cross track scanning radiometers: the scan track is perpendicular to the satellite track and the spots enlarge with the scan angle.

Megha-Tropiques Spacecraft consists of two major modules: a cuboid spacecraft bus derived from the IRS heritage; and the Payload Instrument Module (PIM), housing the payloads and associated elements. The spacecraft deployment mechanism consists of solar array deployment after separation from the launcher; a MADRAS hold-down release mechanism; and the MADRAS scan mechanism. Thermal control system with Optical Solar Reflectors and the Multi-Layer Insulation (MLI) blankets.



A centralised Bus Management Unit (BMU) supports all the functions of the Attitude Orientation Control System (AOCS), sensor processing, TT&C handling, thermal management, onboard data storage logistics, and the Ampere Hour Meter processing.

Megha Tropiques Payloads

Megha-Tropiques carries the following four payloads:

- Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS), an Imaging Radiometer developed jointly by CNES and ISRO
- Sounder for Probing Vertical Profiles of Humidity (SAPHIR), from CNES
- Scanner for Radiation Budget (ScaRaB), from CNES
- Radio Occultation Sensor for Vertical Profiling of Temperature and Humidity (ROSA), procured from Italy

MADRAS (Microwave Analysis and Detection of Rain and Atmospheric Structures)

MADRAS system is a five channel, self calibrating, microwave radiometer system. The radiometer is designed to estimate atmospheric water parameters and wind speed in the equatorial belt. The choice of the channels has been driven by their potential contribution to the measurement of the parameters defined above.

Geophysical Parameters

- Rainfall
- Cloud Ice Content
- Wind Speed
- Total Precipitable Water
- Cloud Liquid Water

M1	18.7 GHz	H+V	0.5 K	40km
M2	23.8 GHz	V	0.5 K	40km
M3	36.5 GHz	H+V	0.5 K	40km
M4	89 GHz	H+V	1.0 K	10km
M5	157 GHz	H+V	1.0 K	6km

SAPHIR microwave humidity sounder and radiometer

The mission specifications call for determination of humidity with an accuracy of 10 to 20 percent in 5 to 7 layers of the troposphere, over 10 km pixels. For realizing that performance, it is necessary to choose channels for which the atmospheric contribution to the radiance comes from different levels of the troposphere. This can be obtained by sampling an absorption line of water vapour by channels more or less close to the centre of the line. A candidate line, already chosen for other instruments, is the line at 183.3 GHz. It is possible to get contribution functions peaking from heights of 2 km.up to 10 to 12 km in tropical redundant to use more than 5 channels. A sixth complimentary channel in a window regions has to be used to correct for the surface effects in the lowest channels; the 150 channel of MADRAS can be used for that. This is the principle of SAPHIR instrument, which has been studied in the frame of micro satellites.

Geophysical Parameters

- Humidity Profile

S1	183.31 ± 0.2	200	<2 (TBC)	± 1	H
S2	183.31 ± 1.1	350	<2 (TBC)	± 1	H
S3	183.31 ± 2.8	500	<2 (TBC)	± 1	H
S4	183.31 ± 4.2	700	<2 (TBC)	± 1	H
S5	183.31 ± 6.8	1200	<2 (TBC)	± 1	H
S6	183.31 ± 11.0	2000	<2 (TBC)	± 1	H

ScaRaB- Broadband radiation measurement instrument

SCARAB is a four channel instrument mainly measuring in Visible (Sc1), InfraRed (Sc4) along with Solar Radiation (Sc2) and Total Radiation (Sc3). The long-wave irradiance is deduced from the difference between Sc3 and Sc2 measurements. Channels in Visible and IR window, Sc1 and Sc4 are used for scene identification (surface, clouds, partially covered) and for assuring compatibility and comparisons with the images from operational satellites.

Geophysical Parameters

- Radiation Fluxes

Sc1-Visible	0.5 to 0.7 µm	120 $W.m^2.sr.^{-1}$	< 1 $W.m^2.sr.^{-1}$
Sc2-Solar	0.2 to 4.0 µm	425 $W.m^2.sr.^{-1}$	< 0.5 $W.m^2.sr.^{-1}$
Sc3-Total	0.2 to 100 µm	500 $W.m^2.sr.^{-1}$	< 0.5 $W.m^2.sr.^{-1}$
Sc4-IR Window	10.5 to 12.5 µm	30 $W.m^2.sr.^{-1}$	< 0.5 $W.m^2.sr.^{-1}$

ROSA Radio Occultation Sensor

GPS Radio Occultation sensor enables measurement of water vapour and temperature profiles in the tropics. GPS ROS payload is there to supplement / complement the mission for the atmospheric studies. A GPS ROS payload, ROSA (GPS-ROS) provided by the Italian Space Agency (ASI), is configured as the fourth payload.

Frequency	L1 1.56 to 1.59 GHz; L2 1.212 to 1.242 GHz
GPS code used	C/A and P Code
GPS code used	<300 km
Hor Res	0.3 km (Low Troposphere); 1-3 km (High Troposphere)
Vert Res	<1 K Temperature; 10% or 0.2g/Kg Humidity

SARAL-AltiKa

SARAL mission results from the common interest of both CNES and ISRO in studying ocean from space using altimetry system and in promoting maximum use of the ARGOS Data Collecting System. Radar altimetry by satellite is a technique used in oceanography to measure, globally over the oceans, the sea level needed to understand ocean circulation and its variability. The importance of altimetry data to better understand the ocean circulation and its impact on the climate of the Earth led to the TOPEX/Poseidon and Jason series of satellites complemented by ERS1-2, GFO and ENVISAT. With the launch of these missions began a data collection that must continue well into the century in order to monitor the inter-annual evolution and separate transient phenomena from secular variations. SARAL/AltiKa mission belongs to the global altimetry system and then participates to the precise and accurate observations of ocean circulation and sea surface elevation for its life time. Thus it is the aim of AltiKa part of the SARAL mission to provide altimetric measurements designed to study ocean circulation and sea surface elevation with the same accuracy as the one provided by ENVISAT mission and complementary to Jasons mission. The AltiKa project developed by CNES is based on a large Ka-band altimeter (35.75 GHz, 500MHz), 1st oceanographic altimeter using such a high frequency. The use of the Ka-band frequency will supply more accurate measurements (improvement of the spatial and vertical resolution) enabling a better observation of ices, coastal areas, continental water bodies as well as the waves height. The drawback of this Ka-band frequency is its sensitivity to rain that can lead to signal attenuation. The SARAL/AltiKa mission is part of the operational satellite altimetry system, jointly with Jason-2, and enables to ensure the service continuity which is nowadays provided by ENVISAT altimeter jointly with Jason-2 and Jason-1. By ensuring the observations continuity and widening the observation areas, CNES answers the wish of the oceanography community by bringing a description: For the meso-scale in open ocean,, In coastal areas, For the seasonal forecast, For the hydrology, For the climate studies. AltiKa data will thus contribute, along with data from others altimetry missions, to the development of operational oceanography, to our climate understanding and to the development of forecasting capabilities through data assimilation methods improvement in coupled oceanatmosphere coupling models, bio-chemistry models, etc

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SARAL-AltiKa Objectives

SARAL/AltiKa main scientific objective is to provide data products to oceanographic research user community in studies leading to improve our knowledge of the ocean meso-scale variability, thanks to the improvement in spatial and vertical resolution brought by SARAL/AltiKa.

Ocean meso-scale variability is defined as a class of high-energy processes, with wave lengths within a 50km to 500km range, and with periods of a few days to one year. Kinetic energy of mesoscale variability is one order of magnitude more than mean circulation's one. Description of mesoscale is thus essential for understanding ocean dynamics, including mean circulation and its climatic effects (through interactions of meso-scale turbulence with the mean flow).

SARAL/AltiKa main scientific objective is divided in sub-themes including:

- Intrinsic scientific studies of ocean at meso-scale dynamics: observations, theoretical analyses, modelling, data assimilation, parameterization, ...
- Improvement of our understanding of the oceanic component in the climate system: investigation of local processes at small or medium scale poorly known and understood at present, but which have an impact on the modelling of climate variability at large spatial and temporal scales.
- Contribution to the study of coastal dynamic processes, especially small or medium scale phenomena, whose retrieval will enable to anticipate many downstream applications.
- Contribution to operational oceanography which is seeking large amounts of in situ and space observation data.

SARAL/AltiKa secondary objectives are notably the monitoring of the main continental waters level (lakes, rivers, closed seas), the monitoring of mean sea level variations, the observation of polar oceans, the analysis and forecast of wave and wind fields, the study of continental ices (thanks to improved performances of Ka-band) and sea ices, the access to low rains climatology (enabled in counterpart to the sensitivity of Ka-band to clouds and low rains) and the marine biogeochemistry (notably through the role of the meso and sub-meso-scale physics).

SARAL-AltiKa SpaceCraft

The 450 kg satellite consists of a SSB/ IMS-2 platform and a SARAL/AltiKa specific payload module. The platform provides all housekeeping functions including propulsion, electrical power, command and data handling, telecommunications, and attitude control. The payload module provides mechanical, electrical, thermal, and dynamical support to the SARAL/AltiKa instruments.

The SARAL satellite is mainly composed of:

- A spacecraft bus IMS-2 (Small Satellite Bus). This platform, developed by ISRO, is designed for satellites in the range of about 500 kg at launch.
- a payload developed by CNES.

The SARAL payload includes the following components:

- An Altimeter, provided by CNES - the main mission instrument and a dual frequency microwave radiometer, provided by CNES - to correct the altimeter measurement for atmospheric range delays induced by water vapor.
- The radio positioning DORIS system, provided by CNES - for precision orbit determination using dedicated ground stations

The AltiKa instrument consists of a Ka-band altimeter and an embedded dual frequency radiometer.

- A Laser Reflector Array (LRA), provided by CNES - to calibrate the orbit determination system.

And the ARGOS-3 instrument (and associated components) that has its own mission on-board the SARAL satellite as part of the ARGOS system.

SARAL-AltiKa Payloads

SARAL carries the following four payloads:

- Ka-band altimeter with enhanced bandwidth
  - Ionospheric effects are negligible
  - Better vertical resolution (0.3m)
  - Ka-band (35 GHz) authorizes a compact, lightweight instrument easier to accommodate on a wide range of satellite buses.
- Dual-frequency radiometer (24/37 GHz)
  - Required for tropospheric correction
  - Derived from Madras (Megha-Tropiques) developments.
- Laser Retro-reflector Array
  - Useful for orbitography and system calibration.
- DORIS
  - For adequate orbitography performances in low earth orbit
  - Enable to have similar performance as reference missions like T/P, JASON, ENVISAT
  - Required for mean sea level analysis and coastal/inland application.

Oceansat-2

Oceansat-2 satellite mainframe systems derive their heritage from previous IRS missions. Oceansat-2 was launched by PSLV-C14 from Satish Dhawan Space Centre, Sriharikota on Sept. 23, 2009. It carries three payloads: Ocean Colour Monitor (OCM) Ku-band Pencil Beam scatterometer (SCAT) developed by ISRO Radio Occultation Sounder for Atmosphere

(ROSA) developed by the Italian Space Agency. Oceansat-2 is envisaged to provide continuity of operational services of Oceansat-1(IRS-P4) with enhanced application potential.

OCEANSAT-2 Introduction

India's Polar Satellite Launch Vehicle, PSLV-C14, in its 16th Mission launched 958 kg Oceansat-2 and six nano-satellites into a 720 km. intended Sun Synchronous Polar Orbit (SSPO) on September 23, 2009.

OCEANSAT-2 mission is an evolution of the OCEANSAT-1. IRS-P4 (OCEANSAT-I), launched in 1999, is a dedicated satellite for Ocean applications and carries two Payloads: Ocean Color Monitor (OCM) and Multi-frequency Scanning Microwave Radiometer (MSMR). Out of these two, OCM is providing valuable data which is used for various applications both within India and by International users. The most significant application areas are identification of Potential Fishery Zones (PFZ) using OCM data & prediction of Monsoon arrival using MSMR data. Experience from OCM data consisted into algorithms developed for atmospheric correction of the data and retrieval of parameters like Chlorophyll concentration, total suspended matter (TSM), estimation of primary productivity, detection of algal blooms.

OCEANSAT-2 provides same operational services as OCEANSAT-1 while adding new ones like atmospheric vertical profiles of temperature, pressure and humidity, wind fields over ocean surface, sea state, Ocean dynamics , and bio-physical parameters.

OCEANSAT-2 is equipped with three payloads: OCM, Scatterometer and ROSA. OCM was also present on OCEANSAT-I, Scatterometer and ROSA are new instruments. The OCEANSAT-2 data is received at the ISRO Ground Segment, located in Hyderabad, and also at the ASI Multimission National Centre (CNM) , located in Matera.

Oceansat-2 Objectives

The Indian satellite Oceansat-2 is designed to provide service continuity for operational users of the Ocean Colour Monitor (OCM)instrument on Oceansat-1. It will also enhance the potential of applications in other areas. The main objectives of OceanSat-2 are to study surface winds and ocean surface strata, observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and suspended sediments in the water.

The primary mission objectives of Oceansat-2 are:

- To design, develop, launch and operate a three axis stabilized spacecraft carrying an Ocean Colour Monitor and Ku-band Scatterometer,
- To develop / implement algorithms for retrieval of geophysical parameters like wind vector on an operational basis.
- To promote new applications in the areas of ocean studies including prediction of cyclone trajectory, fisheries, coastal zone mapping etc.

Oceansat-2 gathers systematic data for oceanographic, coastal and atmospheric applications. The main objectives of OceanSat-2 are to study surface winds and ocean surface strata, observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and suspended sediments in the water.

Oceansat-2 carries two payloads for ocean related studies, namely, Ocean Colour Monitor (OCM) and Ku-band Pencil Beam Scatterometer. An additional piggy-back payload called ROSA (Radio Occultation Sounder for Atmospheric studies) developed by the Italian Space Agency (ASI) is also included. The major applications of data from Oceansat-2 are identification of potential fishing zones, sea state forecasting, coastal zone studies and inputs for weather forecasting and climatic studies.

Oceansat-2 SpaceCraft

Oceansat-2 is envisaged to provide continuity of operational services of Oceansat-1(IRS-P4) with enhanced application potential.

Launch date:	Sept 23, 2009
Launch site:	SHAR, Sriharikota
Launch vehicle;	PSLV - C14
Orbit:	Polar Sun Synchronous
Altitude:	720 km
Inclination:	98.28°
Period:	99.31 minutes
Repetitivity:	2 days
Payloads:	OCM, SCAT and ROSA

Local time of Eq. crossing:	12 noon ± 10 minutes
Mass at lift off:	960 Kg
Power:	15 Sq.m Solar panels generating 1360W, Two 24 Ah Ni-Cd Battries
Mission Life:	5 years

Oceansat-2 Payloads

The scientific payload contains three instruments. Two are Indian and one is from the Italian Space Agency.

- Ocean Colour Monitor (OCM)
- Scanning Scatterometer (SCAT)
- Radio Occultation Sounder for Atmospheric Studies (ROSA)

Ocean Colour Monitor (OCM)

OCM is an 8-band multi-spectral camera operating in the Visible and Near IR spectral range. This camera provides an instantaneous geometric field of view of 360 meter and a swath of 1420 km. OCM can be tilted up to + 20 degree along track.

Scanning Scatterometer (SCAT)

SCAT is an active microwave device designed and developed at ISRO/SAC, Ahmedabad. It is used to determine ocean surface level wind vectors through estimation of radar backscatter. The scatterometer system has a 1-m parabolic dish antenna and a dual feed assembly to generate two pencil beams and is scanned at a rate of 20.5 rpm to cover the entire swath. The Ku-band pencil beam scatterometer is an active microwave radar operating at 13.515 GHz providing a ground resolution cell of size 50 x 50 km. It consists of a parabolic dish antenna of 1 meter diameter which is offset mounted with a cant angle of about 46 degree with respect to earth viewing axis. This antenna is continuously rotated at 20.5 rpm using a scan mechanism with the scan axis along the +ve Yaw axis. By using two offset feeds at the focal plane of the antenna, two beams are generated which will conically scan the ground surface. The back scattered power in each beam from the ocean surface is measured to derive wind vector. It is an improved version of the one on Oceansat-1. The inner beam makes an incidence angle of 48.90^0 and the outer beam makes an incidence angle of 57.60^0 on the ground. It covers a continuous swath of 1400 km for inner beam and 1840 km for outer beam respectively. The inner and outer beams are configured in horizontal and vertical polarization respectively for both transmit and receive modes. The aim is to provide global ocean coverage and wind vector retrieval with a revisit time of 2 days.

Radio Occultation Sounder for Atmospheric Studies (ROSA)

ROSA is a new GPS occultation receiver provided by ASI (Italian Space Agency). The objective is to characterize the lower atmosphere and the ionosphere, opening the possibilities for the development of several scientific activities exploiting these new radio occultation data sets.

OCEANSAT-3

EOS-06(Oceansat-3) also known as Earth Observing Satellite EOS-06(Oceansat-3), was launched by PSLV-C54 from Satish Dhawan Space Centre, Sriharikota on 26 November 2022. EOS-06(Oceansat-3) is developed to provide a unique opportunity for simultaneously measuring the physical, biological and atmospheric parameters for the first time from three instruments, (i) 13-band advanced Ocean Colour Monitor (OCM-3), (ii) Ku-band Scatterometer (SCAT-3) and (ii) a 2-channel Sea Surface Temperature Monitor (SSTM). ARGOS is the fourth payload provided by French Space Agency (CNES) and serves as a data collection platform from various ocean based platform. EOS-06(Oceansat-3) is envisaged to provide continuity of operational services of Oceansat-1, 2 and SCATSAT-1 Mission with enhanced application potential.

Oceansat-3 Introduction

ISRO has launched the EOS-06(Oceansat-3) satellite on 26 Nov 2022 in a polar sun-synchronous orbit at 740km altitude. EOS-06(Oceansat-3) is the third-generation satellite in the Oceansat series. This is to provide continuity services of Oceansat-2 spacecraft with enhanced payload specifications as well as application areas.

EOS-06(Oceansat-3) has three main instruments, 13-band advanced Ocean Colour Monitor, Ku-band Scatterometer and a 2-channel Sea Surface Temperature Monitor. ARGOS is the fourth provided by French Space Agency (CNES). Unfortunately, the SSTM developed a technical problem in scan mechanism and therefore, not in operation at present.

Payloads on EOS-06(Oceansat-3) are :

• Ku-band Scatterometer (SCAT-3)

• 13-band Ocean Colour Monitor (OCM-3)

• 2-band Sea Surface Temperature Monitor (SSTM)

• ARGOS by CNES French Space Agency

Applications planned using EOS-06(Oceansat-3) datasets are as follows :

- Marine Resource Management
- Carbon & Nitrogen Cycling in Ocean
- Phytoplankton biodiversity
- Zooplankton & secondary pro

- Algal bloom detection and monitoring
- Climate change studies
- Phytoplankton physiology
- Atmosphere-Ocean processes and biological productivity
- Sediment dynamics & fluvial fluxes in coastal ocean
- Submarine applications
- Biogeochemical modelling
- Air quality dynamics from Oceansat -3
- Coral reef ecosystem studies
- Land surface NDVI/LST
- Cryospheric Science
- Assimilation of ocean surface winds in NWP models
- Monsoon onset
- Cyclogenesis, track prediction, intensification
- Studies of ocean surface waves
- Modeling surface currents
- Assimilation of winds in coupled ocean circulations models,
- Winds and its effect on oceanic mixed layer
- Air-sea interactions
- Large-scale soil moisture estimation
- Vegetation classifications and their growth assessment.

OCEANSAT-3 Objectives

- To ensure the data continuity of Ocean colour and wind vector data to sustain the operational applications.
- To improve the applications, some additional datasets such as Sea Surface Temperature and more number of bands in Optical region for florescence and in Infrared region for atmospheric corrections are accommodated.
- To develop / improve related algorithms and data products to serve in well-established application areas and to enhance the mission utility.

OCEANSAT-3 SpaceCraft

Launch date:	26 November 2022
Launch site:	SHAR, Sriharikota
Launch vehicle;	PSLV – C54
Orbit:	Polar Sun Synchronous

Altitude:	740 km
Inclination:	
Repetitivity:	2 days
Payloads:	OCM, SCAT , SSTM and ARGOS
Local time of Eq. crossing:	12 noon
Mass at lift off:	

OCEANSAT-3 Payloads

The scientific payload contains three instruments.

• Ku-band Scatterometer (SCAT-3)

• 13-band Ocean Colour Monitor (OCM-3)

• 2-band Sea Surface Temperature Monitor (SSTM)

• ARGOS by CNES French Space Agency

Ocean Colour Monitor (OCM-3) :

OCM-3 is a 13-band multi-spectral camera operating in the Visible and Near IR spectral range. It has 13 *narrow (*10-20 nm) *spectral bands. T*his camera provides an instantaneous geometric field of view of 368 meter and a swath of ~ 15000 km. OCM can be tilted up to + 20 degree along track. OCM-3 is planned to be operated in two modes:

1. Local Area Coverage (LAC) mode at 366 m resolution

2. Global Area Coverage (GAC) mode at 1.1 km resolution

Scatterometer (SCAT-3) :

SCAT-3 is an active microwave device designed and developed at ISRO/SAC, Ahmedabad. It is used to determine ocean surface level wind vectors through estimation of radar

backscatter. Following are the sensor characteristics:

• 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.

• Experimental mode of high resolution wind @5km

• Accuracy (RMSE): Speed ~ 1.5 m/s, Direction: ~15 deg.

• Noise Equivalent s_0 improved by ~5dB to -39.5dB (-35dB) for H-beam, and -35dB (-31dB) for V-beam

Sea Surface Temperature Monitoring (SSTM) :

2-band Sea Surface Temperature Monitor (SSTM) is a new instrument on-board Oceansat-3.

INSAT-3DS

INSAT-3DS is identical to INSAT-3D in terms of Sensors and products.

INSAT or the Indian National Satellite System is a series of multipurpose Geo-stationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, and search and rescue needs of India. Commissioned in 1983, INSAT is the largest domestic communication system in the Asia Pacific Region. The satellite is monitored and controlled by Master Control Facilities that exist in Hassan and Bhopal. INSAT-3DS is a multipurpose geosynchronous spacecraft with main meteorological payloads (imager and sounder). The main objectives for this mission are to provide an operational, environmental and storm warning system to protect life and property. INSAT3S is monitoring the earth's surface, oceanic observations and also provide data dissemination capabilities. It provides Broadcast Satellite Services (BSS) through two S-band transponders. The data acquisition and processing system is established at Space Applications Centre, Bopal Campus, Ahmedabad, India. The processing of INSAT-3DS data is taken place broadly in four steps.

1. Ground receiving system to receive data
2. Data Reception (DR) system to generate raw data (L0) files
3. Data Processing (DP) system to process L0 data and produce L1B data files (Calibrated and Geo located)
4. Product generation and Dissemination system

INSAT-3DS Introduction

INSAT-3DS is a dedicated meteorological spacecraft designed for enhanced meteorological observation and monitoring of land and ocean surfaces of weather forecasting and disaster warning. INSAT-3DS is configured on I-2K bus with Sounder, Imager and Data Relay Transponder (DRT) and Satellite Aided Search & Rescue (SAS&R) Payloads. INSAT-3DS was flown on February 17, 2024 with a lift of mass of about 420 Tonnes by GSLV-F14 and expected minimum mission life is seven years. Communication Payload sub systems are configured to support INSAT system for DRT SAS&R and Meteorological Payload services.

The mission goal is stated as "to provide an operational, environmental & storm warning system to protect life & property and also to monitor earth's surface and carryout oceanic observations and also provide data dissemination capabilities"

The satellite has 3 payloads

- Meteorological (MET) - IMAGER and SOUNDER
- Data Relay Transponder (DRT)
- Satellite Aided Search and Rescue (SAS&R)

The geophysical parameters that will be extracted from INSAT3DS are Outgoing Longwave Radiation (OLR), Quantitative Precipitation Estimation (QPE), Sea Surface Temperature (SST), Snow Cover, Snow Depth, Fire, Smoke, Aerosol, Cloud Motion Vector (CMV), Water Vapour Wind (WVW), Upper Tropospheric Humidity (UTH), Temperature, Humidity Profile and Total Ozone, Fog, Visible Wind Vector and other value added parameters from Imager and Sounder.

INSAT-3DS Objectives

INSAT or the Indian National Satellite System is a series of multipurpose Geo-stationary satellites launched by ISRO to satisfy the telecommunications, broadcasting, meteorology, and search and rescue needs of India. Commissioned in 1983, INSAT is the largest domestic communication system in the Asia Pacific Region. The satellites also incorporate transponder(s) for receiving distress alert signals for search and rescue missions in the South Asian and Indian Ocean Region, as ISRO is a member of the Cospas-Sarsat programme.

The main objectives for this mission are to provide an operational, environmental and storm warning system to protect life and property. INSAT3DS will

- Monitor earth's surface and carryout oceanic observations and also provide data dissemination capabilities,
- Provide Broadcast Satellite Services (BSS) through two S-band transponders.,

INSAT-3DS SpaceCraft

The INSAT-3DS is a momentum-biased 3-axis stabilized spacecraft using star trackers for precise pointing control. The spacecraft has a launch mass of 420 Tonnes with Lift-Off Mass of 2275 kg . The nominal design life is 7.7 years. It is in Geostationary orbit, altitude of ~35, 786 km, location at 82° East. The three-axis stabilized geostationary satellite carries two meteorological instruments: a six channel Imager and an IR Sounder. Along with the channels in Visible, Middle Infrared, Water Vapor and Thermal Infrared bands, the Imager includes a SWIR channel for wider applications. The Sounder will have eighteen narrow spectral channels in three IR bands in addition to a channel in visible band. It also has a Data Relay Transponder and Satellite based Search & Rescue Payload. Several innovative technologies like on-the-fly correction of scan mirror pointing errors, biannual yaw rotation of the spacecraft, micro-stepping SADA, star sensors and integrated bus management unit have been incorporated to meet the stringent payload requirements like pointing accuracies, thermal management of IR detectors and concurrent operation of both instruments.

A passive radiant cooler is used to cool the infrared detectors of imager and sounder instruments. The detectors temperature is maintained at 95 K (BOL) and 100 K (EOL). The passive cooler is also to maintain the sounder filter wheel temperature at 213 K.

INSAT-3DS Payloads

The satellite has 3 payloads:

- Meteorological (MET) - IMAGER and SOUNDER
- Data Relay Transponder (DRT)
- Satellite Aided Search and Rescue (SAS&R)

Meteorological Payload

The INSAT-3DS spacecraft incorporates advanced Imager and Sounder instruments.

IMAGER

The INSAT-3DS imager provides imaging capability of the earth disc from geostationary altitude in one visible (0.52 - 0.72 micrometers) and five infrared; 1.55 - 1.70(SWIR), 3.80 - 4.00(MIR), 6.50 - 7.00 (water vapour), 10.2 - 11.2 (TIR-1) and 11.5 - 12.5 (TIR-2) bands. The ground resolution at the sub-satellite point is nominally 1km x 1km for visible and SWIR bands, 4km x 4km for one MIR and both TIR bands and 8km x 8km for WV band.

The Imager is an improved design of VHRR/2 (Very High Resolution Radiometer) heritage instrument flown on the Kalpana-1 and INSAT-3A missions. The instrument features 6 spectral bands (against the 3 bands in previous versions) offering an improved 1 km resolution in the visible band for the monitoring of meso scale phenomena and severe local storms. The two new SWIR and MWIR bands with a resolution of 1 km and 4 km, respectively, will enable better land-cloud discrimination and detection of surface features like snow. One more significant improvement is the split-band TIR channel with two separate windows in 10.2-11.2 and 11.5-12.5 Micrometer regions with a 4 km resolution.

This new element enables the extraction of sea surface temperature over the Indian region with a far greater accuracy since the dual-window algorithm can be applied to eliminate the atmospheric attenuation effects. The 1 km resolution of the visible channel and 4 km resolution of the thermal IR channels indirectly improve the accuracy of the derived products like outgoing longwave radiation and cloud motion vectors.

Key Parameters of the Imager

Telescope aperture	310 mm diameter
Number of bands (6)	0.52 - 0.72 µm, VIS (Visible) 1.55 - 1.70 µm, SWIR (Short Wave Infrared) 3.80 - 4.00 µm, MWIR (Mid Wave Infrared) 6.50 - 7.00 µm, WV (Water Vapor) 10.2 - 11.2 µm, TIR-1 (Thermal Infrared) 11.5 - 12.5 µm, TIR-2 (Thermal Infrared)
Spatial resolution	1 km for VIS and SWIR 4 km for MWIR 8 km for WV 4 km for TIR-1 and TIR-2
Band separation, band definition	Beam splitter, interference filters
IFOV (Instantaneous Field of View)	28 µrad for VIS and SWIR (1 km) 112 µrad for MWIR, TIR-1, & TIR-2 (4 km) 224 µrad for WV (8 km)
Sampling interval	1.75 samples / IFOV for VIS, SWIR,MIR & TIR-1 / -2 3.5 samples / IFOV for WV
Scan step angle	Linear in E-W direction (8 µR step size) Line step 224 µrad in N-S direction
Scan rate Scan linearity Inflight calibration	200º/s +0.2 s turnaround time 56 µR (peak to peak) Full aperture blackbody and spaceview
Scan modes	Full, normal and programmable sector for quick repetivity

Frame time	25 minutes for normal mode
Signal quantization	10 bit/sample
Downlink data rate	4.0 Mbit/s

SOUNDER

The INSAT-3DS sounder has 18 infrared channels distributed over longwave and shortwave bands. A visible channel provides synoptic view of the clouds and the earth to aid in generating three dimensional map of temperature and moisture structure of the atmosphere.

The Sounder is a first time instrument of the geostationary INSAT series designed and developed at ISRO. The overall objective is to measure the temperature and humidity profiles (vertical distributions) to obtain a three-dimensional representation of the atmosphere. The instrument requirements call for soundings at 10 km ground resolution every 3 hours for a full frame scan. This enables the derivation of vertical profiles of temperature and humidity. These vertical profiles can then be used to derive various atmospheric stability indices and other parameters such as atmospheric water vapor content and total column ozone amount.

Key Parameters of the sounder

Telescope aperture	310 mm diameter
Number of bands (6)	18 Infrared + 1 Visible
Band definition	Filter wheel with interference filters
IFOV (Instantaneous Field of View)	280 µrad x 280 rad, corresponding to 10 km x 10 km on the surface
Sampling interval	280 µrad E-W / N-S
No of simultaneous soundings	4 per band
Scan step angle	10 km E-W, every 0.1 s, and 40 km N-S after completion of E-W scan, 150 µR rms
Step and dwell time	0.1, 0.2 and 0.4 s
Turnaround time	0.1 s per scan
In-flight calibration	Full aperture blackbody and space view
Scan modes	Options provided to cater to quick dynamic environmental phenomena

Frame time	160 minutes for 6000 km x 6000 km area sounding
Signal quantization	13 bit/sample
Downlink data rate	40 kbit/s
Frame time	90 kg, (without cooler), 100 W

Spectral parameters and sensitivity of the sounder

1	14.71 (680)	0.281 (13)	1.5
2	14.37 (696)	0.268 (13)	1
3	14.06 (711)	0.256 (13)	0.5
4	13.96 (733)	0.298 (16)	0.5
5	13.37 (749)	0.286 (16)	0.5
6	12.66 (790)	0.481 (30)	0.3
7	12.02 (832)	0.723 (50)	0.15
8	11.03 (907)	0.608 (50)	0.15
9	9.71 (1030)	0.235 (25)	0.2
10	7.43 (1425)	0.304 (55)	0.2
11	7.02 (1425)	0.394 (80)	0.2

12	6.51 (1535)	0.255 (60)	0.2
13	4.57 (2188)	0.048 (23)	0.2
14	4.52 (2210)	0.047 (23)	0.15
15	4.45 (2245)	0.045 (23)	0.15
16	4.13 (2420)	0.0683 (40)	0.15
17	3.98 (2513)	0.0683 (40)	0.15
18	3.74 (2671)	0.140 (100)	0.15
19	0.695 (14367) 0.05 (1000) (0.67-0.72)		0.1% albedo

Communication Payload

Communication transponders are required to be configured to provide continuity of some of the INSAT services. A total satellite mass of 2000kg is considered for the launch compatibility, and 70 kg (approximately) of mass apportionment is done for the communication payload components. The communication payload components are - Meteorological Transmitter, Data Relay Transponder, Satellite Aided Search and Rescue (SAS&R) Transponder & S-band Broadcast Satellite Services Transponder.

SCATSAT-1

Scatsat-1 was launched by PSLV-C35 from Satish Dhawan Space Centre, Sriharikota on September 26, 2016. It carries the Ku-band Pencil Beam scatterometer (SCAT) payload developed by SAC-ISRO.

SCATSAT-1 Introduction

Indian Space Research Organisation launched SCATSAT-1 for ocean and weather related studies and seven co-passenger satellites into polar Sun Synchronous Orbit (SSO) on September 26, 2016. The Polar Satellite Launch Vehicle, in its 37th flight, (PSLV-C35) launched the satellites at 9:12 hours on September 26, 2016 from Satish Dhawan Space Centre in Sriharikota. The 377 kg SCATSAT-1 satellite have satellites from Algeria, Canada and USA, as well as two satellites from Indian Universities as its co-passengers. SCATSAT-1 is placed into a 720 km Polar Sun Synchronous Orbit, whereas the two Universities' satellites and the five foreign satellites are placed into a 670 km polar orbit. This PSLV mission is unique in itself as it is for the first time that its payloads are placed into two different orbits. PSLV-C35 launched from the First Launch Pad (FLP) of Satish Dhawan Space Centre and is the 15th flight of PSLV in 'XL' configuration (with the use of solid strap-on motors).

SCATSAT-1 Objectives

The Indian satellite SCATSAT-1 is a miniature satellite dedicated to ocean wind observation. It is preceded by Oceansat-2 which was also dedicated for the same objective. Major objectives of SCATSAT-1 is weather forecasting, cyclone prediction along with ocean state monitoring and prediction. It is currently catering towards weather and climate sector, naval and shipping operations, renewable energy sector along with tracking services to India as well as to the world.

SCATSAT-1 SpaceCraft

SCATSAT-1 is envisaged to provide continuity of operational services of OSCAT (IRS-P4) with enhanced application potential.

Launch date:	September 26, 2016
Launch site:	SDSC (Satish Dhawan Space Centre), Sriharikota.
Launch vehicle;	PSLV - C35
Orbit:	Sun Synchronous, dawn-dusk orbit

Altitude:	720 km
Inclination:	97.4°
Local Time on Ascending Node	6:00 hours
Repetitivity:	2 days
Payloads:	Scatterometer
Mass at lift off:	310 Kg
Power:	15 Sq.m Solar panels generating 1360W, Two 24 Ah Ni-Cd Battries
Mission Life:	5 years

SCATSAT-1 Payloads

Scanning Scatterometer (SCAT)

SCAT is an active microwave device designed and developed at SAC/ISRO, Ahmedabad. It is used to determine ocean surface level wind vectors through estimation of radar backscatter. The scatterometer system has a 1-m parabolic dish antenna and a dual feed assembly to generate two pencil beams and is scanned at a rate of 20.5 rpm to cover the entire swath. The Ku-band pencil beam scatterometer is an active microwave radar operating at 13.515 GHz providing a ground resolution cell of size 25 x 25 km. The parabolic dish antenna of 1 meter diameter is offset mounted with a cant angle of about 46 degree with respect to earth viewing axis. This antenna is continuously rotated at 20.5 rpm using a scan mechanism with the scan axis along the +ve Yaw axis. By using two offset feeds at the focal plane of the antenna, two beams are generated which will conically scan the ground surface. The back scattered power in each beam from the ocean surface is measured to derive wind vector. The inner beam makes an incidence angle of 48.90^0 and the outer beam makes an incidence angle of 57.60^0 on the ground. It covers a continuous swath of 1400 km for inner beam and 1840 km for outer beam respectively. The inner and outer beams are configured in horizontal and vertical polarization respectively for both transmit and receive modes. The aim is to provide global ocean coverage and wind vector retrieval with a revisit time of 2 days.

Parameter	Inner beam	Outer beam

Orbital altitude	720 km	
Instrument frequency	13.515 GHz (Ku-band)	
Wind speed range	3-30 m/s, accuracy of 1.8 m/s (rms) or 10%	
Wind direction	0^0 to 360^0, accuracy of 20^0 rms	
Wind vector cell size (resolution)	25 km x 25 km grid	
Polarization	HH	VV
Swath width	1400 km	1840 km
Scanning circle radius	700 km	920 km
Scanning rate	20.5 rpm	

Bayesian based MT-SAPHIR rainfall

Megha- Tropiques (MT) is a joint Indo-French collaborative satellite mission, which is launched on 12 October 2011. The main objective of MT is to get more understanding on convective system, energy exchange and water cycle in the tropical region. It is equipped with Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS) (not in operational), Scanner for Radiation Budget, Radio Occultation Sensor for Atmosphere and Sondeur Atmospherique du Profil d'Humidite Intertropical par Radiometrie (SAPHIR). SAPHIR provides clear sky atmospheric humidity profiles at 6-channels near 183.31GHz water vapour resonance. The observations of SAPHIR provides an opportunity to estimate rainfall using 183.31GHz channels. A Bayesian based rainfall retrieval technique is developed using SAPHIR channel-6 (183.31±11GHz) brightness temperature observations. Estimated rainfall has been validated with IMERG and DPR products during Jan-Dec 2017. The global distribution of rainfall patterns are captured well by the estimation.

Data Access

Click Here to access the Science Products. Request to use MOSDAC Single Sign On user credentials to download the data.

Data Version

Version 1.1 (beta)

Data Sources

SAPHIR Level 1A TB data

Processing Steps

SAPHIR Level-1 brightness temperature of channel-6 (Tb6) and spatial variability of Tb6 (Std-tb6) within ±3 pixels (~30km at nadir and ~60km off nadir) is calculated. Bayesian algorithm is trained using GPM-IMERG half hourly rainfall Bayesian approach is applied to estimate rainfall from SAPHIR sounder observations.

References

Kummerow, C.D., W. S. Olson, and L. Giglio, A simplified scheme for obtaining precipitation and vertical hydrometeor profiles from passive microwave sensors, IEEE Trans. Geosci. Remote Sens., vol. 34, no. 5, pp. 1213–1232, Sep. 1996.

Pierdicca, N., F. S. Marzano, G. D'Auria, P. Basili, P. Ciotti, and A. Mugnai, Precipitation retrieval from spaceborne microwave radiometers using maximum a posteriori probability estimation, IEEE Trans. Geosci. Remote Sens., vol. 34, no. 4, pp. 831–846, Jul. 1996.

Olson, W.S., C. D. Kummerow, G. M. Heymsfield, and L. Giglio, A method for combined passive-active microwave retrievals of cloud and precipitation parameters, J. Appl. Meteorol., vol. 35, pp. 1763–1789, 1996.

Marzano, F.S., A. Mugnai, G. Panegrossi, N. Pierdicca, E. A. Smith, and J. Turk, Bayesian estimation of precipitating cloud parameters from combined measurements of spaceborne microwave radiometer and radar, IEEE Trans. Geosci. Remote Sens., vol. 37, no. 1, pp. 596–613, Jan. 1999.

Viltard, N., C. Burlaud, and C. D. Kummerow, Rain retrieval from TMI brightness temperature measurements using a TRMM PR–based database. J. Appl. Meteor. Climatol, 45, 455–466, doi:10.1175/JAM2346.1, 2006.

Gopalan, K., N.-Y. Wang, R. Ferraro, and C. Liu, Status of the TRMM 2A12 land precipitation algorithm. J. Atmos. Oceanic Technol., 27, 1343–1354, doi:10.1175/2010JTECHA1454.1, 2010.

Derivation Techniques and Algorithm

User should refer report "Rainfall Estimation from Megha-Tropiques Microwave Sounder-SAPHIR using Bayesian Approach" for complete reference to the algorithm.

Limitations

Rainfall estimates are not provided in the 3 outermost scan positions of the SAPHIR scan.

Known problems with data

No known issues at this time.

File Naming Convention

HDF5 file:

MTSAPS__VVV_*_YYYY_MM_DD_*.Bayesian_RR.h5

VVV is the Level 1 version number

YYYY is the year, MM is the month and DD is the date of the orbit.

MetaData

Core Metadata Elements	Definition
Metadata language	English
Metadata Contact	MOSDAC
Metadata date	June 2018
Data Lineage or Quality	Rain Rate
Title	Bayesian based MT-SAPHIR rainfall
Abstract	Megha- Tropiques (MT) is a joint Indo-French collaborative satellite mission, which is launched on 12 October 2011. The main objective of MT is to get more understanding on convective system, energy exchange and water cycle in the tropical region. It is equipped with Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS) (not in operational), Scanner for Radiation Budget and Radio Occultation Sensor for Atmosphere and Sondeur Atmospherique du Profil d'Humidite Intertropical par Radiometrie (SAPHIR). SAPHIR provides clear sky atmospheric humidity profiles at 6-channels near 183.31GHz water vapour resonance. The observations of SAPHIR provides an opportunity to estimate rainfall using 183.31GHz channels. A Bayesian based rainfall retrieval technique is developed using SAPHIR channel-6 (183.31±11GHz) brightness temperature observations.

Estimated rainfall has been validated with IMERG and DPR products during Jan-Dec 2017. The global distribution of rainfall patterns are captured well by the estimation.

Dataset Contact	Neerja Sharma and Kaushik Gopalan, GRD/AOSG/EPSA, Space Applications Centre (ISRO), Ahmedabad, 380015, kaushikg@sac.isro.gov.in
Update Frequency	January 2017 to May 2018 have been processed. Data will be updated daily with ~24 hours lag.
Access Rights or Restriction	Open Access
Spatial Resolution	Data is provided at native spatial resolution of the SAPHIR instrument.
Language	English
Topic Category	Rainfall
Keywords	Microwave sounder, Bayesian technique, rainfall
Date or period	From January 2017 onwards.
Responsible Party	Neerja Sharma and Kaushik Gopalan,GRD/AOGG/ EPSA, Space Applications Centre (ISRO), Ahmedabad-380015, India
Organization	Space Applications Centre (ISRO), Ahmedabad, India

Org. role	Rainfall retrieval from MT-SAPHIR observations
Individual name	Neerja Sharma, GRD/AOSG/EPSA, SAC(ISRO), Ahmedabad-380015, India. Ph:+91 79 26916115. Email:neerjasharma@sac.isro.gov.in Kaushik Gopalan, GRD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 6110. Email: kaushikg@sac.isro.gov.in
Position	Scientist/Engineer, GRD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015
Vertical Extent (minimumValue, maximumValue, unitOfMeasure, vertical datum)	NA
Geographic Extent	Tropical region (28S to 28N)
Geographic name, geographic Identifier	lat_min: 28S, lat_max: 28N, lon_min: 0, lon_max: 360
Bounding box	lat_min: 28S, lat_max: 28N, lon_min: 0, lon_max: 360
Temporal Extent	January 2017 onwards

Access Rights or Restrictions	Open Access
Distribution Information	Online download of data files in HDF5 format
Processing Level	Level 2 (Data product derived from MT SAPHIR)
Reference System	Datum: WGS84

GPS derived Integrated water vapour

This dataset contains Integrated Water Vapor (IWV) estimates derived from GPS receivers that comprise the GAGAN TEC network. These receivers have been installed at airports at various locations in India. The Zenith Tropospheric Delay was estimated from the GPS observations using the GAMIT software. Further, IWV was estimated from the ZTD values using surface temperature and pressure from ERA-I reanalysis as additional inputs. The GAGAN-IWV estimates for 1 year – March 2013 to February 2014 – have currently been made available.

Data Access

Click Here to access the Science Products . Request to use MOSDAC Single Sign On user credentials to download the data.

Data Version

Version 1.0 (beta)

Data Sources

GPS receivers from GAGAN TEC Network

Processing Steps

GAMIT software used to derive Zenith Tropspheric Delay (ZTD)
Integrated Water Vapor (IWV) derived using procedure described in Bevis et. al. (1992)

References

M. Bevis, S. Businger, T. A. Herring, C. Rocken, R. A. Anthes, and R. H. Ware, “GPS Meteorology: Remote sensing of atmospheric water vapor using global positioning system,” J. Geophys. Res., vol. 97, pp. 15, 787-15, 801, 1992.

Herring, T. A., R. W. King, and S. C. McClusky. "Introduction to Gamit/Globk." Massachusetts Institute of Technology, Cambridge (2008).

Acharya, R., M. R. Sivaraman, K. Bandyopadhyay, N. Nagori, S. Sunda, and S. Regar (2007), Ionospheric studies for the implementation of GAGAN, Ind. J. Radio Space Phys., 36 (5), 394–404.

Sunda, S., R. Sridharan, B. M. Vyas, P. V. Khekale, K. S. Parikh, A. S. Ganeshan, C. R. Sudhir, S. V. Satish, and M. S. Bagiya (2015), Satellite-based augmentation systems: A novel and cost-effective tool for ionospheric and space weather studies, Space Weather, 13, doi:10.1002/2014SW001103.

Derivation Techniques and Algorithm

Described in the report titled “Demonstration of GNSS-based short-range forecasting of rainfall”

Limitations

The IWV estimates constitute a conical average of variable shape and orientation depending on the location of available GPS satellites.

Known problems with data

No known issues at this time.

File Naming Convention

ASCII files:
Currently, the data for 1 year is provided in the file gagan_iwv_v1.txt

MetaData

Core Metadata Elements	Definition

Metadata language	English
Metadata Contact	MOSDAC
Metadata date	November, 2017
Data Lineage or Quality	GPS-derived Integrated Water Vapor.
Title	GPS-derived Integrated Water Vapor (Indian region)
Abstract	This dataset contains Integrated Water Vapor (IWV) estimates derived from GPS receivers that comprise the GAGAN TEC network. These receivers have been installed at airports at various locations in India. The Zenith Tropospheric Delay was estimated from the GPS observations using the GAMIT software. Further, IWV was estimated from the ZTD values using surface temperature and pressure from ERA-I reanalysis as additional inputs. The GAGAN-IWV estimates for 1 year – March 2013 to February 2014 – have currently been made available.
Dataset Contact	Kaushik Gopalan, GRD/AOSG/EPSA, Space Applications Centre (ISRO), Ahmedabad, 380015, kaushikg@sac.isro.gov.in
Update Frequency	1 year of GPS-derived IWV is now available. Further data will be added intermittently in caches of 1 year each.
Access Rights or Restriction	Open Access
Spatial Resolution	Point data
Language	English
Topic Category	GNSS meteorology

Keywords	GNSS meteorology, GPS meteorology, Integrated Water Vapor
Date or period	March 2013 to February 2014
Responsible Party	Kaushik Gopalan,GRD/AOGG/ EPSA, Space Applications Centre (ISRO), Ahmedabad-380015, India
Organization	Space Applications Centre (ISRO), Ahmedabad, India
Org. role	Geophysical parameters from satellite altimeter in the coastal region.
Individual name	Kaushik Gopalan, GRD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 6110. Email: kaushikg@sac.isro.gov.in
Position	Scientist/Engineer, GRD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015
Vertical Extent (minimumValue, maximumValue, unitOfMeasure, vertical datum)	NA
Geographic Extent	Indian Landmass
Geographic name, geographic Identifier	Indian Landmass
Bounding box	lat_min: 0N, lat_max: 30N, lon_min: 60E, lon_max: 100E

Temporal Extent	March 2013 to February 2014
Access Rights or Restrictions	Open Access
Distribution Information	Online download of data files in ASCII format
Processing Level	Level 2 (Data product derived from raw GPS data)
Reference System	Datum: WGS84

GSMap ISRO Rain

The GSMaP_ISRO is a precipitation product that was developed through the Indian Space Research Organisation (ISRO) - Japan Aerospace Exploration Agency (JAXA) Implementation of Agreement (IA) specifically for the Indian subcontinent. It is currently available from March 2000 Onwards and offers a horizontal resolution of 0.1°X 0.1° on a latitude/longitude grid with a temporal resolution of 1 hour. The dataset is based on the Global Satellite Mapping of Precipitation (GSMaP) algorithm (Kubota et al. 2020; Kumar et al. 2021, 2022) with Indian Meteorological Department (IMD) gauge correction, and is a specialized product that focuses on the Indian landmass. The GSMaP algorithm, designed by the JAXA, is instrumental in creating a comprehensive view of precipitation using microwave radiometers and cloud moving data from Geostationary Infrared (IR) technology. The algorithm is separated into three primary categories for effective measurement: the microwave imager, microwave sounder, and microwave-infrared (MVK) combined (Mega et al. 2019). A detailed verification of GSMaP_ISRO for the Indian summer monsoon periods of 2000-2020 against ground, satellite and various merge rainfall products is presented in Kumar et al. (2022).

Data Access

Science products are available to download with a Single Sign On on MOSDAC. Click Here to access the data

Data Version

Version 1.0 (beta)

Data Sources

GSMaP_MVK product, NOAA Climate Prediction Center (CPC) rainfall analysis, CPC Infrared brightness temperature, IMD gridded rain (0.25 degree), etc.

Processing Steps

-For gauge adjustment, the software used was JAXA MCD_V05.02, based upon Mega et al. (2019). -Merging NOAA CPC and Indian gauges was accomplished using Matlab software. -The algorithms pertaining to GSMaP_ISRO are provided in Kumar et al. (2022) in detail.

References

Kubota, T., Aonashi, K., Ushio, T., Shige, S., Takayabu, Y. N., Kachi, M., and Oki, R. (2020). Global Satellite Mapping of Precipitation (GSMaP) products in the GPM era. Satellite Precipitation Measurement: Volume 1, 355-373. Kumar, P., Gairola, R., Kubota, T., and Kishtawal, C. (2021). Hybrid assimilation of satellite rainfall product with high density gauge network to improve daily estimation: A case of Karnataka, India. Journal of the Meteorological Society of Japan. Ser. II, 99(3), 741-763. Kumar, P., Varma, A. K., Kubota, T., Yamaji, M., Tashima, T., Mega, T., and Ushio, T. (2022). Long-Term High-Resolution Gauge Adjusted Satellite Rainfall Product Over India. Earth and Space Science, 9(12), e2022EA002595. Mega, T., Ushio, T., Matsuda, T., Kubota, T., Kachi, M., and Oki, R. (2019) Gauge-Adjusted Global Satellite Mapping of Precipitation, IEEE Trans. Geosci. Remote Sens, 57, 4, 1928-1935.

Kumar, P., Srivastava, S.S., Jivani, N., Varma, A.K., Yokoyama, C. & Kubota, T. (2024) Long-term assessment of ERA5 reanalysis rainfall for lightning events over India observed by Tropical Rainfall Measurement Mission Lightning Imaging Sensor. Quarterly Journal of the Royal Meteorological Society, 150(761), 2472â€“2488. Available from: https://doi.org/10.1002/qj.4719 (link is external)

Derivation Techniques and Algorithm

The manuscript titled "Long-Term High-Resolution Gauge Adjusted Satellite Rainfall Product Over India" provides a description.

Limitations

The number of gauge stations within a NOAA CPC pixel of 0.5 degree impacts the accuracy of the gauge-adjusted rainfall.

Known problems with data

No known issues at this time.

MetaData

Sr. No	Core Metadata Elements	Definition
1	Metadata language	English
2	Metadata Contact	MOSDAC
3	Metadata date	November, 2023
4	Data Lineage or Quality	IMD gauge adjusted GSMaP_ISRO Rain
5	Title	GSMaP_ISRO Rain
6	Abstract	The GSMaP_ISRO rain data has been derived through the IMD gauge based gridded rain & NOAA CPC gauge analysis adjustment of the GSMaP_MVK rain product. It offers high-quality rainfall information with excellent spatiotemporal resolution, covering a range spanning from March 2000 Onwards. It has been developed through the ISRO-JAXA Implementation of Agreement (IA). This product provides a lat/long grid with a 0.1° X 0.1° horizontal resolution, along with hourly temporal resolution.
6a	Developer	Prashant Kumar, Atul K. Varma, Takuji Kubota, Moeka Yamaji, Tomoko Tashima, Tomoaki Mega, Tomoo Ushio
7	Dataset Contact	Dr. Prashant Kumar, ASD/AOSG/EPSA Space Applications Centre, ISRO Ahmedabad-380015 prashant22@sac.isro.gov.in
8	Update Frequency	23 years of global GSMaP_ISRO rain. Further data will be added intermittently.

9	Access Rights or Restriction	Open Access
10	Spatial Resolution	0.1 degree
11	Language	English
12	Topic Category	Gauge adjusted satellite rainfall
13	Keywords	GSMaP_MVK, NOAA CPC rainfall analysis, CPC Infrared brightness temperature, IMD gridded rain (0.25 degree).
14	Date or period	March 2000 Onwards
15	Responsible Party	Dr. Prashant Kumar, ASD/AOSG/EPSA, Space Applications Centre, ISRO Ahmedabad-380015, India
16	Organization	Space Applications Centre (ISRO), Ahmedabad, India
16a	Org. role	Development of high spatio-temporal resolution gauge adjusted satellite rainfall
16b	Individual name	Dr. Prashant Kumar, ASD/AOSG/EPSA, Space Applications Centre, ISRO Ahmedabad-380015, India Email: prashant22@sac.isro.gov.in
16c	Position	Scientist/Engineer - SF
17	Geographic Extent	Global
18	Geographic name, geographic Identifier	Global
19	Bounding box	lat_min: -90 , lat_max: 90, lon_min: 0, lon_max: 360
20	Temporal Extent	March 2000 Onwards
21	Access Rights or Restrictions	Open Access

22	Distribution Information	Online download of data files in HDF5 format
23	Processing Level	Level 3 (Gauge adjusted satellite rainfall product)
24	Reference System	Datum: WGS84

METEOSAT8 Cloud Properties

NASA LaRC is operationally generating global cloud properties products using different geostationary satellites. This Metosat-8 cloud properties products include Cloud Phase, Optical Depth, Effective Water Radius, Effective Ice Diameter, Liquid Water Path, Ice Water Path, Effective Cloud Temperature, Cloud Top Height, Effective Cloud Height, Cloud Base Height, Cloud Top Pressure, Effective Cloud Pressure, Cloud Base Pressure, Broadband Albedo, Broadband Longwave Flux, and Cloud Thickness.

Data Sources

1. Cloud Properties Products, downloaded from LaRC, NASA

References

1. B. A. Wielicki, B. R. Barkstrom, B. A. Baum, T. P. Charlock, R. N. Green, D. P. Kratz, R. B. Lee, P. Minnis, G. L. Smith, T. Wong, D. F. Young, R. D. Cess, J. A. Coakley, D. A. H. Crommelynck, L. Donner, R. Kandel, M. D. King, A. J. Miller, V. Ramanathan, D. A. Randall, L. L. Stowe, R. M. Welch, "Clouds and the Earth's Radiant Energy System (CERES): Algorithm overview", IEEE Trans. Geosci. Remote Sens., vol. 36, no. 4, pp. 1127-1141, Jul. 1998.
2. C. Kummerow, W. Barnes, T. Kozu, J. Shine, J. Simpson, "The Tropical Rainfall Measuring Mission system (TRMM) sensor package", J. Atmos. Ocean. Technol., vol. 15, pp. 809-827, 1998

3. W. L. Barnes, T. S. Pagano, V. V. Salomonson, "Prelaunch characteristics of the moderate resolution imaging spectroradiometer (MODIS) on EOS-AM1", IEEE Trans. Geosci. Remote Sens., vol. 36, no. 4, pp. 1088-1100, Jul. 1998

Derivation Techniques and Algorithm

Minnis, Patrick & Sun-Mack, Szedung & F. Young, David & W. Heck, Patrick & Garber, Donald & Chen, Yan & A Spangenberg, Douglas & Arduini, Robert & Trepte, Qing & Smith Sr, William & Ayers, J & Gibson, Sharon & F. Miller, Walter & Hong, Gang & Chakrapani, Venkatesan & Takano, Yoshihide & Liou, Kuo-Nan & Xie, Yu & Yang, Ping. (2011). CERES edition-2 cloud property retrievals using TRMM VIRS and Terra and Aqua MODIS data-Part I: Algorithms. IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING. 49. 10.1109/TGRS.2011.2144601.

Limitations

Refer Paper

Known problems with data

Data will be available with delay

File Naming Convention

Following file naming convention are followed:

NetCDF File Name (NetCDFFileName):
M8SEV_DDMMMYYYY_HHMM_L2B_CP_IND_V04.0.nc
Parameter Chip File Name : NetCDFFilename_CloudParamName(4 Char).jpg

File Nomenclature Details:
SatIdSensorId_AcquisitionDateTime_ProcessingLevel_ProductName_ProductRegion_Version.nc
SatId (2 Char) = M8
SensorId (3 Char)= SEV (SEVIRI sensor)
AcquisitionDateTime (14 Char) = DDMMMYYYY_HHMM
ProcessingLevel (3 Char) = L2B
ProductName (2 Char) = CP (Cloud Properties)
ProductRegion (3 Char) = IND (Indian Region)
Version (5 Char) = V04.0 (Product Version Number)

MetaData

Sr. No	Core Metadata Elements	Definition
1	Metadata language	English

2	Metadata Contact	Sazid Mahammad, MRG/EPSA, Space Applications Centre (ISRO), Ahmedabad-380015, India. Email: sazid@sac.isro.gov.in
3	Metadata date	May 14, 2018
4	Data Lineage or Quality	Depends on Metosat 8 products, some times some data gaps may be observed
5	Title	Cloud Properties Products from Meteosat-8 over Indian Peninsula
6	Abstract	NASA LaRC is operationally generating global cloud properties products using different geostationary satellites. This Metosat-8 cloud properties products include Cloud Phase, Optical Depth, Effective Water Radius, Effective Ice Diameter, Liquid Water Path, Ice Water Path, Effective Cloud Temperature, Cloud Top Height, Effective Cloud Height, Cloud Base Height, Cloud Top Pressure, Effective Cloud Pressure, Cloud Base Pressure, Broadband Albedo, Broadband Longwave Flux, and Cloud Thickness.
7	Dataset Contact	Sazid Mahammad, MRG/EPSA, Space Applications Centre (ISRO), Ahmedabad-380015, India. Email: sazid@sac.isro.gov.in
8	Update frequency	1 hour
9	Access Rights or Restriction	Open Access
10	Spatial Resolution	6 Km (Nominal)
11	Language	English
12	Topic Category	Atmospheric Science
13	Keywords	Cloud Properties, Climate, cloud, cloud remote sensing, Clouds and the Earth's Radiant Energy System (CERES),
14	Date or period	From 01-May-2018 onwards
15	Responsible Party	EPSA/SAC, ISRO and LaRC, NASA
16	Organization	Space Applications Centre (ISRO), Ahmedabad, India and Langley Research Centre (NASA), Hampton, VA, USA

16a	Org. role	SAC: Extraction of Indian region and generation of chips LaRC: Generation of Cloud Properties product
16b	Individual name	Sazid Mahammad, MRG/EPSA, Space Applications Centre (ISRO), Ahmedabad-380015, India. Email: sazid@sac.isro.gov.in
16c	Position	Scientist/Engineer, MRG/EPSA, SAC (ISRO), Ahmedabad-380015, India. Email: sazid@sac.isro.gov.in
16d	Vertical Extent (minimumValue, maximumValue, unitOfMeasure, vertical datum)	Cloud top Properties
17	Geographic Extent	UL Coordinates: 38 N, 65 E. UR Coordinates: 38 S, 97.5 E. LL Coordinates: 5.5 N, 65 E. LR Coordinates: 5.5 S, 97.5 E
18	Geographic name, geographic Identifier	Indian Peninsula
19	Bounding box	UL Coordinates: 38 N, 65 E. UR Coordinates: 38 S, 97.5 E. LL Coordinates: 5.5 N, 65 E. LR Coordinates: 5.5 S, 97.5 E Number of Rows i.e. Image Height: 524 Number of Columns i.e. Image Width : 489
20	Temporal Extent	Hourly Product with Given date, time in GMT
21	Access Rights or Restrictions	Open Access
22	Distribution Information	Online download of data files in NetCDF format and images in jpg format
23	Processing Level	Level 2 (Data product derived from Metosat-8)
24	Reference System	Projection: Geographic Latitude,Longitude; Datum: WGS84

3D Volumetric TERLS DWRproduct

These products contain the 3D volumetric gridded de-cluttered radar reflectivity and de-aliased radial velocity generated from the C-Band Thumba Equatorial Rocket Launching Station (TERLS) DWR Volumetric PPI Scan data. The data grid has dimensions of (81x481x481) with a horizontal resolution of (1 km x 1 km) and vertical resolution of (250 m). The maximum altitude considered in while gridding is 20.0 km. This product can be used for various hydrological and numerical weather prediction applications.

Data Access

Click Here to access the Science Products . Request to use MOSDAC Single Sign On user credentials to download the data.

Data Version

Version 1.0 (beta)

Data Sources

TERLS C-Band Doppler Weather Radar (dprf mode)

Processing Steps

Following are the three major processing steps :
- The radar reflectivity data is corrected for clutter using a combination of spatial continuity filter and fuzzy-logic based echo classification algorithm.
- The radial velocity data is dealiased using a 2D multipass velocity dealiasing scheme based spatial continuity of velocity fields
- The corrected reflectivity and radial velocity from all elevations is then gridded into a 3D volumetric grid having resolution of 250 x 1 km x 1 km.

Derivation Techniques and Algorithm

Decluttering of Radar reflectivity and Dealiasing of radial velocity; 3D volumetric gridding of radar variables as explained in detail in the above mentioned reports.

Reference

(1) Sambit Kumar Panda, Bipasha Paul Shukla, and Prashant Kumar, Clutter Mitigation and 3D volumetric gridding of TERLS DWR Reflectivity Data (V1.0), SAC Report,

SAC/EPSA/AOSG/SR/19/2018

(2) Sambit Kumar Panda, Prashant Kumar and Bipasha Paul Shukla, 2D-Multipass velocity dealiasing of TERLS DWR Data for cyclone Okchi (V1.0), SAC Report,

SAC/EPSA/AOSG/SR/09/2018

(3) Bipasha Paul Shukla, Prashant Kumar Saxena and Sambit Kumar Panda, Study of Tropical cyclone Okchi using TERLS DWR, SAC Report, SAC/EPSA/TDP/SR/09/2018

(4) Gianfranco Vulpiani, and Coauthors, 2012: On the use of dual-polarized c-band radar for operational rainfall retrieval in mountainous areas. J. Appl. Meteor., 51(2):405–425.

(5) Marco Gabella and Riccardo Notarpietro, 2002: Ground clutter characterization and elimination in mountainous terrain. In Use of radar observations in hydrological and NWP models, Katlenburg-Lindau, Copernicus, 305–311. URL: http://porto.polito.it/1411995/

(6) Zhang et al. 2006, An Automated 2D Multipass Doppler Radar Velocity Dealiasing Scheme, J. of Atmos. and Ocean Tech, 23, 1239-1248, 2006

MetaData

Sr. No	Core Metadata Elements	Definition
1	Metadata language	English
2	Metadata Contact	MOSDAC
3	Metadata date	May, 2018
4	Data Lineage or Quality	3D volumetric gridded radar reflectivity and radial velocity from TERLS DWR
5	Title	Post processing of TERLS DWR data and Volumetric Gridding
6	Abstract	The TERLS DWR data has been processed to correct for clutter and velocity folding prior to their application in hydrological and numerical weather prediction models. The radar reflectivity has been corrected for clutter using a combination of a spatial continuity filter and a fuzzy-logic based echo classification algorithm. The velocity folded regions are dealiased using a 2D multipass velocity dealiasing algorithm. The corrected reflectivity and radial velocity are then gridded into 1 km x 1 km x 250 m 3D volumetric grid which can be used by scientists for further meteorological applications. This data was prepared under the TDP/R&D project “Storm Tracking and Prediction using Doppler Weather Radar
7	Dataset Contact	Sambit Kumar Panda, EPSA, Space Applications Centre (ISRO), Ahmedabad-380015
8	Update frequency	3 months

9	Access Rights or Restriction	Open Access
10	Spatial Resolution	Spatial resolution is 1 km, while vertical resolution is 250 m.
11	Language	English
12	Topic Category	Doppler Weather Radar Data application
13	Keywords	Doppler Weather Radar, Reflectivity, Radial Velocity, Decluttering, Dealiasing
14	Date or period	May 1-31, 2018.
15	Responsible Party	Sambit Kumar Panda, Bipasha Paul Shukla, ASD/AOSG/ EPSA, Space Applications Centre (ISRO), Ahmedabad-380015, India
16	Organization	Space Applications Centre (ISRO), Ahmedabad, India
16a	Org. role	Post processing of Doppler Weather Radar data and its application for Hydrological and Numerical Weather Prediction Models
16b	Individual name	Sambit Kumar Panda, ASD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 6117/6104. Email: sambit@sac.isro.gov.in
16c	Position	Scientist/Engineer-SC, ASD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015, India. Ph: +91 792691 6117/6104. Email: sambit@sac.isro.gov.in
17	Geographic Extent	lat_min: 06N lat_max: 11N lon_min: 74E lon_max: 79E
18	Geographic name, geographic Identifier	TERLS, Trivandrum.

19	Bounding box	lat_min: 06N lat_max: 11N lon_min: 74E lon_max: 79E
20	Temporal Extent	May1-31, 2018.
21	Access Rights or Restrictions	Open Access
22	Distribution Information	Online download in netcdf format and png files of daily archived data (".tar.gz" compressed files).
23	Processing Level	Level 2
24	Reference System	Datum: WGS84

Inland Water Height

It is crucial to know how the storage of inland water bodies change over time. Also, hydrological modelling studies face the challenge of decreasing availability of in-situ monitoring data. However, application of satellite radar altimetry over the inland water bodies becomes vital tool to estimate water levels through waveform retracking on satellite altimetry?s sensor data. SARAL-Altika was launched on 25 February 2013. It is a joint-mission of CNES France and ISRO to provide continuous monitoring of ocean and continental water surface. It was launched into a Sun synchronous polar orbit at an altitude of 790km with 35 days of orbit repetition and follows same ground track as ENVISAT satellite. It has 98.55 deg of inclination with 75 km of equatorial cross track separation. It has Ka-band (35.75 GHz) radar altimeter. Water level product for inland water bodies (presently for Brahmaputra river and Ukai Reservoir) has been generated using the SARAL-ALTIKA waveform data.

Data Access

Click Here to access the Science Products . Request to use MOSDAC Single Sign On user credentials to download the data.

Data Version

Version 1.0 (beta)

Data Sources

Altimeter Interim Geophysical Data Record (IGDR)
Geophysical Data Record (GDR)
ECMWF Pressure Fields
Global Ionosphere Maps (GIM) produced Total Electron Content (TEC) maps

Processing Steps

Firstly the waveforms are classified based on their signature, and then these waveforms are retracked with the suitable retracker.
Dedicated inland range correction algorithms are required to account for the atmospheric delays.Detailed information about the processing can be found in (S. Chanderet. al. 2014, A .Dubey et. al. 2014).

References

S. Chander, and P Chauhan (2013). Algorithm Theoretical BasisDocument for SARAL/AltiKa data processing for geophysical parametersretrieval, scientific report no. EPSA/MPSG/PMD/2013/01.
S Chander, D Ganguly, AK Dubey, PK Gupta, RP Singh and P Chauhan(2014).Inland water bodies monitoring using satellite altimetry overIndian region, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-8, 2014, ISPRS Technical Commission VIII Symposium, 09 ? 12 December 2014, Hyderabad, India.
A K Dubey, P K Gupta, S Dutta and R P Singh (2015). Water Level Retrieval using SARAL/AltiKa Observations in the Braided Brahmaputra River, Eastern India, Marine Geodesy, DOI: 10.1080/01490419.2015.1008156
D Ganguly, S Chander, S Deasi and P Chauhan. Optimal waveform retracker for inland water bodies: A case study over Ukai Dam/Reservoir, is under review in the journal of Marine Geodesy.
P K Gupta, A K Dubey, N Goswami, R P Singh and P Chauhan (2015): Use of SARAL/AltiKa Observations for Modeling River Flow. Marine Geodesy (accepted).

Derivation Techniques and Algorithm

The water level over the inland water bodies can be retrieved using altimeter waveforms data.
The range information is estimated based on the arrival time of the radar pulse. This range is then corrected for Dry tropospheric correction, wet tropospheric correction, ionospheric correction, and tidal correction, i.e. Load tide, solid earth tide. Detailed information about the range corrections can be found in the ATBD document (S. Chander and Prakash Chauhan, 2013) of the SARAL mission.

Limitations

Based on the availability of the Altimeter dataset over the study region (Data Gap, altimeter track loss, bad weather, etc.).

Known problems with data

Data problems due to bad weather (heavy rain)

Related data collections

GPS Field trip for water level measurement was conducted over Ukai reservoir on 9th November 2013, 17th January 2014 and 2nd January 2015.
Brahmaputra observed river water level data was collected for 6 locations from upstream to downstream from Inland Waterways Authority (IWAI) and Central Water Commission (CWC) along with the satellite pass synchronous field trips.

File Naming Convention

altimeter_derived_water_height_ukai_yyyymmdd_v1

MetaData

Sr. No	Core Metadata Elements	Definition
1	Metadata language	English
2	Metadata Contact	MOSDAC
3	Metadata date	March 05, 2015
4	Data Lineage or Quality	Water height estimation over inland water bodies using radar altimeters
5	Title	Inland Water Bodies Monitoring using Satellite Altimetry over Indian Region
6	Abstract	Inland water bodies? heightshave been estimated using SARAl-Altika and Jason-2 data over the two test sites, i.e. Ukai reservoir and Brahmaputra River (10 sites from upstream to downstream locations within the Indian region). The results were matched with the in-situ data collected from the GPS field trips and observed data collected from IWAI and CWC. In the first phase results of these two sites are presented herewith. Such 29 inland water bodies with (49 locations) are being done in the phase manner
7	Dataset Contact	Shard Chander and D Gangulay, PMD/BPSG/EPSA, Praveen Gupta and Amit Dubey, EHD/BPSG/EPSA SAC (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 4138. Email: pkgupta@sac.isro.gov.in; schander@sac.isro.gov.in
8	Update frequency	Near real time after the altimeter pass over the study area (35 days repetivity)

9	Access Rights or Restriction	Open Access
10	Spatial Resolution	NA
11	Language	English
12	Topic Category	Inland water bodies monitoring
13	Keywords	Rivers/reservoirs, Satellite altimetry, waveform retracking, geophysical range corrections, water levels
14	Date or period	Since launch of SARAL-Altika (February 2013)
15	Responsible Party	Dr.Prakash Chauhan, Biological and Planetary Sciences Group, EPSA, Space Applications Centre (ISRO), Ahmedabad-380015, India
16	Organization	Space Applications Centre (ISRO), Ahmedabad, India
16a	Org. role	Retrieval of water level using Remote sensing techniques
16b	Individual name	D. Ram Rajak, OSD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 6051. Email: rajakdr@sac.isro.gov.in
16c	Position	Scientist/Engineer, OSD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 6051. Email: rajakdr@sac.isro.gov.in
16d	Vertical Extent (minimumValue, maximumValue, unitOfMeasure, vertical datum)	Default value =NaN Unitofmeasurement= meter Datum: WGS84
17	Geographic Extent	UL Coordinates: 40N, 65E. UR Coordinates: 40N, 100E. LL Coordinates: 5, 65E. LR Coordinates: 5, 100E.
18	Geographic name,	Indian Region

	geographic Identifier	
19	Bounding box	UL Coordinates: 40N, 65E. UR Coordinates: 40N, 105E. LL Coordinates: 5, 65E. LR Coordinates: 5, 105E.
20	Temporal Extent	Historical time series plot of water heights over inland water body since the availability of altimeter measurement
21	Access Rights or Restrictions	Open Access
22	Distribution Information	Online download in text, and PNG formats
23	Processing Level	Level 3 (Data product derived from altimeter IGDR/GDR product)
24	Reference System	Datum: WGS84

River Discharge

River heights from satellite altimeters (ENVISAT, Jason-2 and SARAL AltiKa) have been derived at two cross-over points along Godavari River. Subsequently, river height discharge stage relationship between altimetry derived heights and In-situ river discharge has been established. Using this relationship, river discharge database for Godavari River for the period i.e. 2002 - 2015 has been generated..

Data Sources

1. GDR tracked data of ENVISAT and Jason-2 (PISTACH Hydrology) at Yanam (estuarine side) and Bhadrachalam (riverine side) for the entire period of respective missions were obtained from

a. ENVISAT website(http://earth.esa.int/

(link is external)

)
b.AVISO website(http://www.avisooceanobs.com

(link is external)

)(Jason-2)
2. SARAL/AltiKa data were obtained from MOSDAC website (http://www.mosdac.gov.in)

Processing Steps

1. The given range was corrected for
   - path delay in the atmosphere through which the radar pulse passes
   - the nature of the reflecting sea surface
2. All range corrections are added to the range
3. Rating curve methodology was developed between Altimeter river height and in-situ river discharge (Rantz et al. 1982).

References

1. Coastal and Hydrology Altimetry product (PISTACH), handbook 2010.
2. Frappart, F., S. Calmant, M. Cauhope, F. Seyler, and A. Cazenave (2006), Validation of ENVISAT RA-2 derived water levels over the Amazon Basin, Remote Sens. Environ., 100, 252 - 264, doi:10.1016/j.rse.2005.10.027.
3. Rantz, S. E., et al. (1982), Measurement and computation of streamflow: Volume 2. Computation of discharge, Water Supply Paper 2175, U.S. Geol. Surv., pp. 285 - 631.
4. Santos da Silva, J., S. Calmant, F. Seyler, O. C. R. Filho, G. Cochonneau, and W. J. Mansur (2010), Water levels in the Amazon basin derived from the ERS 2 and ENVISAT radar altimetry missions, Remote Sens. Environ., 114, 2160?2181, doi:10.1016/j.rse.2010.04.020.
5. SMMR and DMSP SSM/I-SSMIS Passive Microwave Data. [October 1978 to December 2012]. Boulder, Colorado USA: NASA National Snow and Ice Data CentreDistributed Active Archive Centre.

Derivation Techniques and Algorithm

The observed river height with respect to geoid is given by

$$\mathbf{Rh = H_{sat} - (R + C_w + C_d + C_i + C_{st} + C_p)} \qquad \mathbf{(1)}$$

Where

1. H_{sat} represents the satellite altitude with respect to reference ellipsoid
2. R represents the satellite range
3. C_w(w for wet tropospheric)and C_d (d for dry tropospheric) are corrections for delayed propagation in the atmosphere
4. C_i is the correction delayed propagation through the ionosphere
5. C_{st} and C_p represents the correction for solid and polar tides respectively.

Limitations

Based on the availability of the Altimeter dataset over the study region (data gap, altimeter track loss, loss of flooding events, etc.).

Known problems with data

Data problems due to bad weather (heavy rain)

Related data collections

1. Limited daily in-situ river discharge data (2007 - 2012) available along Godavari River were obtained from Dowlaiswaram Dam Authorities, Andhra Pradesh.
2. Hourly river heights/water levels were provided by Dr. Prakash Mehra, NIO Radar gauge at Yanam (Godavari Estuary) for the period 2008 - 2010.

File Naming Convention

Altimetername_derived_water_height_river_discharge_

Godavari_stationname_starting_date_ending_date

Envisat_derived_water_height_river_discharge_

Godavari_Bhadrachalam_Oct2002_Sep2010.txt

MetaData

Sr. No	Core Metadata Elements	Definition
1	Metadata language	English
2	Metadata Contact	MOSDAC
3	Metadata date	July 20, 2015
4	Data Lineage or Quality	Water height estimation and computation of river discharge over Godavari using radar altimeters
5	Title	Satellite Altimetry derived discharge over Godavari River during 2002-2015
6	Abstract	River heights and river discharge have been estimated using ENVISAT and SARAL/AltiKa over two sites and using Jason-2 over one site along Godavari River. The results arevalidated well with the in-situ data.
7	Dataset Contact	Dr. Rashmi Sharma OSD/AOSG/EPSA (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 6044. Email: rashmi@sac.isro.gov.in

8	Update frequency	SARAL/AltiKa and ENVISAT are in 35 day and Jason-2 10 day repetition period
9	Access Rights or Restriction	Open Access
10	Spatial Resolution	NA
11	Language	English
12	Topic Category	Water height estimation and estimation of river discharge
13	Keywords	River, Satellite altimeters, river height, range corrections, rating curve
14	Date or period	ENVISAT (June 2002 to September 2010), Jason-2 (July 2008 to December 2014) and SARAL/AltiKa (March 2013)
15	Responsible Party	Dr. Rashmi Sharma OSD/AOSG/EPSA (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 6044. Email: rashmi@sac.isro.gov.in
16	Organization	Space Applications Centre (ISRO), Ahmedabad, India
16a	Org. role	Estimation of river discharge using Remote sensing techniques
16b	Vertical Extent (minimumValue, maximumValue, unitOfMeasure, vertical datum)	Unit of measurement = meter for river height and m3/s for river discharge Datum: WGS84
17	Geographic Extent	

UL Coordinates: 19N, 80.5E

		UR Coordinates: 19N, 82.5E
		LL Coordinates: 16N, 80.5E
		LR Coordinates: 16N, 82.5E
18	Geographic Name, Geographic Identifier	Godavari river
19	Bounding box	
		UL Coordinates: 19N, 80.5E
		UR Coordinates: 19N, 82.5E
		LL Coordinates: 16N, 80.5E
		LR Coordinates: 16N, 82.5E
20	Temporal Extent	Time series plot of water heights and river discharge over Godavari river since 2002.
21	Access Rights or Restrictions	Open Access
22	Distribution Information	Online download in .txt format
23	Processing Level	Level 3 (Data product derived from altimeter GDR data)

24	Reference System	Datum: WGS84

High Resolution Sea Surface Salinity

The Bay of Bengal's high-resolution sea surface salinity has been reconstructed using a Lagrangian technique leveraging satellite data. The primary input datasets utilized are sea surface salinity data from the SMAP mission and sea surface currents derived from altimetry. These datasets are obtained at a spatial resolution of 25 km. The SMAP mission has been operational since 2015, whereas altimetry-derived sea surface currents have been available since 1993. Validation of this reconstructed product was conducted against in-situ datasets obtained from thermo-salinographs. Results indicate that the reconstructed product more accurately captures front formation compared to the original SMAP salinity fields.

Data Access

Science products are available to download with a Single Sign On on MOSDAC. Click Here to access the data

Data Version

Version 1.0 (beta).

Data Sources

SMAP Sea Surface Salinity
(https://podaac.jpl.nasa.gov/dataset/SMAP_JPL_L3_SSS_CAP_8DAY-RUNNINGMEAN_V5
(link is external)
) Altimetry-derived sea surface currents
(https://data.marine.copernicus.eu/product/SEALEVEL_GLO_PHY_L4_MY_008_047/
(link is external)
).

Processing Steps

i. Remap Sea Surface Currents with a spatial resolution of 5 km.
ii. Backward advection of particles from the final time {t} rsub {f} to the initial time {t} rsub {f} -14 , where 14 is the number of days the particles are advected using Runge-Kutta 4th order method.
iii. The SMAP Sea Surface Salinity observed at {t} rsub {f} -14 is interpolated onto the particle positions that day.
iv. With this, each particle has an SSS value on {t} rsub {f} day that corresponds to the observation at {t} rsub {f} -14 .

References

[1] Barbara, B., Drushka, K., & Gaube, P. (2021), â€œLagrangian reconstruction to extract small-scale salinity variability from SMAP obervationsâ€, JGR Oceans, 126(3), e2020JC016477.
[2] Dencausse, G., Morrow, R., RogÃ©, M., and Fleury, S. (2014). Lateral stirring of large-scale tracer fields by altimetry. Ocean Dynamics, 64(1), 61â€“78.
[3] DesprÃ¨s, A., Reverdin, G., and d'Ovidio, F. (2011). Mechanisms and spatial variability of mesoscale frontogenesis in the northwestern subpolar gyre. Ocean Modelling, 39(1), 97â€“113.
[4] Durack, P. J., Lee, T., Vinogradova, N. T., and Stammer, D. (2016). Keeping the lights on for global ocean salinity observation. Nature Climate Change, 6(3), 228â€“231.
[5] Lehahn, Y., d'Ovidio, F., and Koren, I. (2018). A satellite-based Lagrangian view on phytoplankton dynamics. Annual Review of Marine Science, 10(1), 99â€“119.
[6] RogÃ©, M., Morrow, R. A., and Dencausse, G. (2015). Altimetric Lagrangian advection to reconstruct Pacific Ocean fine-scale surface tracer fields. Ocean Dynamics, 65(9), 1249â€“1268.

Derivation Techniques and Algorithm

The algorithm is called Lagrangian Reconstruction Technique. User should refer [1].

Limitations

This algorithm is applicable only in the region with moderate to high eddy kinetic energy and where lateral advection dominates.
High resolution sea surface salinity product generated by Lagrangian technique can have error due to tracer bias (depends on accuracy of initial conditions) and advection bias (Passive stirring can introduce bias due to mixing physics (air-sea fluxes, mixing etc.)).

Known problems with data

Data sets have biases as well as inaccuracy.

File Naming Convention

Netcdf file: HRSSS_bck_YYYYMMDD_14D.nc

MetaData

Sr. No	Core Metadata Elements	Definition
1	Metadata language	English

2	Metadata Contact	MOSDAC
3	Metadata date	April, 2015
4	Data Lineage or Quality	High resolution sea surface salinity in Bay of Bengal using Lagrangian technique.
5	Title	Dynamic downscaling of Satellite Sea Surface Salinity for the Bay of Bengal
6	Abstract	Lagrangian technique is used for generating high-resolution sea surface salinity fields in the Bay of Bengal. This is achieved through the utilization of Sea Surface Salinity (SSS) data derived from the Soil Moisture Active Passive (SMAP) satellite, in conjunction with sea surface currents obtained from altimetry. By employing forward and backward schemes for the numerical advection of SMAP SSS fields using altimeter-derived geostrophic currents, a Lagrangian reconstruction is produced, capturing smaller-scale features. The reliability of our in-house developed algorithm is assessed by comparing it with an available reconstructed product in the Gulf Stream. Additionally, a preliminary validation is conducted against insitu data obtained from a thermo-salinograph. Further, the developed algorithm was modified to select the advection time dynamically.
7	Dataset Contact	Jai Kumar, POD/AOSG/EPSA, Space Applications Centre (ISRO), Ahmedabad, 380015, kumarj@sac.isro.gov.in
8	Update Frequency	Six months.
9	Access Rights or Restriction	Open Access
10	Spatial Resolution	Spatial resolution is 10 km
11	Language	English

12	Topic Category	High resolution sea surface salinity product (SAC-TDP) using satellite data.
13	Keywords	Sea surface salinity, sea surface currents, Lagrangian advection technique, high resolution
14	Date or period	April 2015 - June 2023
15	Responsible Party	Jai Kumar, POD/AOGG/ EPSA, Space Applications Centre (ISRO), Ahmedabad-380015, India
16	Organization	Space Applications Centre (ISRO), Ahmedabad, India
16a	Org. role	Geophysical parameters from satellite data in the Bay of Bengal region.
16b	Individual name	Jai Kumar, POD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015, India. Ph: +91 79 2691 6104. Email: kumarj@sac.isro.gov.in
16c	Position	Scientist/Engineer, POD/AOSG/EPSA, SAC (ISRO), Ahmedabad-380015
16d	Vertical Extent (minimum Value, maximum Value, unitOfMeasure, vertical datum)	Lat_min : 0N, Lat_max : 25N, Lon_min: 78E, Lon_max: 100 E
17	Geographic Extent	Indian Landmass
18	Geographic name, geographic Identifier	Bay of Bengal
19	Bounding box	Lat_min : 0N, Lat_max : 25 N, Lon_min: 78E, Lon_max: 100 E

20	Temporal Extent	April 2015-June 2023
21	Access Rights or Restrictions	Open Access
22	Distribution Information	Online download of data files in netCDF format
23	Processing Level	Level 4
4	Reference System	Datum: WGS84

About MOSDAC

Space Applications Centre (SAC) is an ISRO Centre located at Ahmedabad, dealing with a wide variety of themes from satellite payload development, operational data reception and processing to societal applications. SAC is responsible for the development, realization and qualification of communication, navigation, earth observation and planetary payloads and related data processing and ground systems in the areas of communications, broadcasting, remote sensing and disaster monitoring / mitigation. Meteorological and Oceanographic Satellite Data Archival Centre (MOSDAC) is a Data Centre of Space Applications Centre (SAC) and has facility for satellite data reception, processing, analysis and dissemination. MOSDAC is operationally supplying earth observation data from Indian meteorology and oceanography satellites, to cater to national and international research requirements.

Contact MOSDAC

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MOSDAC is operationally supplying earth observation data from Indian meteorology and oceanography satellites, to cater to national and international research requirements.

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Frequently Asked Questions

What is MOSDAC?

MOSDAC is the short form of Meteorological and Oceanographic Satellite Data Archival Center. It is a ISRO data portal which provides data through its web based service https://mosdac.gov.in

How to be a registered user of MOSDAC?

There is "SignUp" form available on MOSDAC portal. Pl fill up the form and submit. You will be intimated through e-mail about the approval

I have registered on MOSDAC . i have received an email for email verification. But when I click the link, I get error message.

Please copy the Email verification Hyperlink sent on your registered email id and paste it in a new browser window/tab and open the link to verify your email address.

I have received a 'reset password mail' But when I click the link, I get error message.

Please copy the 'Reset Password Hyperlink' sent on your registered email id and past it in a new browser window/tab and open the link to reset password.

I get error 'Invalid username or password' even though I provide correct credentials.

Your account is locked for one hour after 3 unsuccessful login attempts. Please try after one hour.

How to know forgot password?

Click Forgot Password link on MOSDAC Login Page. Enter username or email. If valid username/email is entered, user will get an email containing 'Reset Password Hyperlink'. please copy 'Reset Password Hyperlink' and paste it in new browser window/tab and open the link and follow the procedure to reset password.

How to change password?

Login with your user name and password. select 'Change Profile'. Your Profile page will be displayed. Select 'Password' from the left panel of Profile Page. Provide old and new password and click save. Your password will be changed.

I don't have username and password of MOSDAC. Can I download data?

Anonymous users (without username and password) can download only open data. In order to download all data from MOSDAC, you need to register on MOSDAC site. There is "SignUp" form available on MOSDAC portal. Pl fill up the form properly and submit. You will be intimated through e-mail about the approval

How can I get near real time data without data ordering?

If you want near real time data, you can place "standing order" from MOSDAC for Satellite data product/in-situ. Login to MOSDAC site and place standing order. A standing order can be placed for a maximum one month duration. After that you can again place the request. This functionality is available for privileged user only.

How in-situ data can be ordered/requested?

You are required to be a registered user for ordering the data. Be a registered user by filling up on-line form. Login to MOSDAC site. Select either "In-situ data order". Select the data of your interest. Place the order . Sign the agreement. A download link will be provided. After clicking here data will be downloaded on your desk through http.

How Ordered and download the satellite data ?

You are required to be a registered user for ordering the data. Be a registered user by filling up Sing Up form Available on the home page. Login to MOSDAC site with user credentials, Select "Satellite data order" . Select the data of your interest. Add to cart. submit the request. You will be given a request id no. You will be intimated through the mail about readiness of your data. You can also check status of your request from left menu under "My request tab"
Your requested data will be uploaded to your SFTP account at sftp://ftp.mosdac.gov.in. You can download data from sftp://ftp.mosdac.gov.in using your MOSDAC portal user credentials.

Which duration data can be obtained from MOSDAC?

To view availability of data Select "Catalog --> Satellite data" from top menu bar. All data products list of a satellite will be displayed, which contains details of the data products viz: abstract, start date, end date, frequency etc.

How many AWS are installed in each state of India?

Select "Catalog --> In-situ --> distribution" from top menu bar, AWS distribution map and no. of AWS installed in each state of India will be displayed.

Which duration data is available for AWS?

AWS data is available from Jan 2008 till present date.

How to get description about a data product?

Select "Catalog --> Satellite data" from top menu bar. All data products list of a satellite will be displayed, which contains details of the data products viz: abstract, start date, end date, frequency etc.

What datasets are available on MOSDAC?

Select "Catalog --> Satellite data" from top menu bar. All data products list of a satellite will be displayed. You can change the satellite to view data products of selected satellite.
Select "Catalog --> In-situ --> distribution" from top menu bar. All In-situ list will be displayed for which MOSDAC has datasets.

I am a registered user of MOSDAC. When I download L1 data I get the message "Your account is configured to download this data with latency of 3 days. Please select date accordingly." How should I download data?

There are two category of users in MOSDAC, NRT users and General users, NRT users have access to real time data. General users are provided access Level-2 and onwards data in NRT and Level-1 data with a latency of 3 days. This message implies that the data product requested by you can't be download in near real time. You can download 3 days old data or you can contact to MOSDAC admin if you want near real time data.