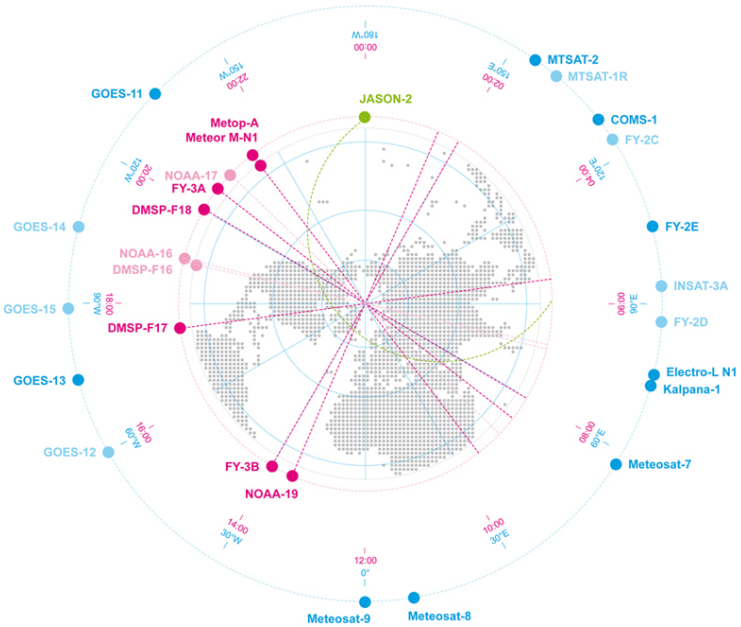


Report on the Status of Current and future satellites by ISRO

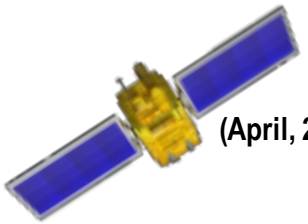
Presented to CGMS-45 Plenary, agenda item D.7

Coordination Group for Meteorological Satellites

Current Satellites

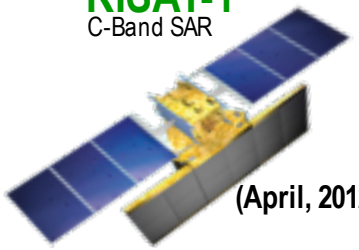
LAND & WATER

RESOURCESAT-2
LISS-3, LISS-4, AWiFS



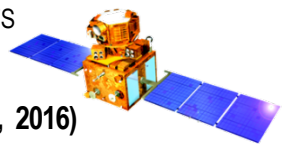
(April, 2011)

RISAT-1
C-Band SAR



(April, 2012)

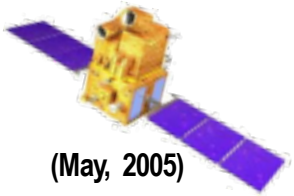
RESOURCESAT-2A
LISS-3, LISS-4, AWiFS



(Dec., 2016)

HIGH RESOLUTION

CARTOSAT-1
2.5m PAN stereo



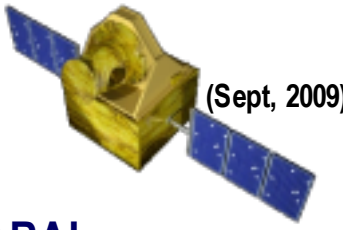
(May, 2005)

CARTOSAT-2
PAN,MS

(Jan 2007)

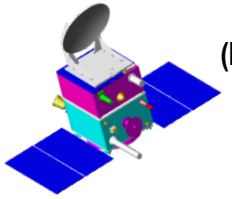
OCEAN

OCEANSAT-2
OCM, Scat, Rosa



(Sept, 2009)

SARAL
Ka-Altimeter



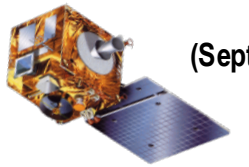
(Feb, 2013)

SCATSAT-1
Ku Scat

Sept, 2016

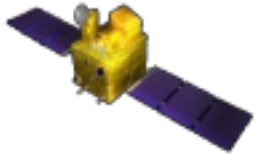
WEATHER; CLIMATE

KALPANA
VHRR



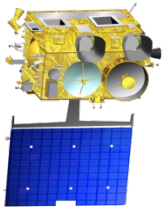
(Sept, 2002)

MEGHA-TROPIQUES
MADRAS, SCARAB, SAPHIR, ROSA



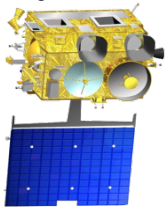
(Oct, 2011)

INSAT-3D
Imager, Sounder



(July, 2013)

INSAT-3DR
Imager, Sounder



(Sept, 2016)

Coordination Group for Meteorological Satellites

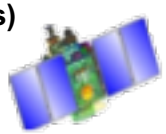
Future Satellites

June 23, 2017

CARTOSAT- 2E

VHR Panchromatic and Multispectral Imaging

- PAN (0.65 m, 10 km swath)
- Mx (2m , 10 km swath, 4 Xs)



Orbit : 505 km

Local time: 0930 hrs

April 2018

CARTOSAT-3

VHR Panchromatic, Multispectral Imaging

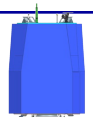
- PAN (0.25 m, 16 km swath)
- Mx (1m , 5 km swath)

Orbit : 450 km

Local time: 1030 hrs

Feb, 2019

HRSAT



Constellation of 3 satellites

- PAN (1 m, 15 km swath)
- Mx (1.9/3.84 m , 15 km swath)

Orbit : 660 km

Local time: 0930 hrs

Dec, 2018

GISAT - 1

Geosynchronous Orbit

- HR Mx VNIR : 50m; SWIR: 1.5 Km
- HYSI VNIR: 320m; WIR : 192m

Orbit : 36000 km

Every 30 min

Oct, 2018 & Feb, 2020

Oceansat-3 & 3A

Continuity for OS-2 with Improvements

- 13 band OCM, IR-SST
- Ku-band Scatterometer ,

Orbit : 720 km

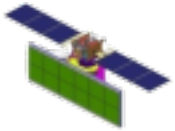
Local time: 1200 hrs

Oct, 2018

RISAT-1A

Continuity for RISAT-1

- C-Band SAR



Orbit : 536 km

Local time: 0600 hrs

Dec, 2019 & 2020

RESOURCESAT- 3 & 3A

Continuity for Resourcesat-2A

- ALISS-3:10m & 12m, 925 km, 5 Bands, ATCOR: 240m, 0.4-1μm, , 10 bit)

Orbit : 795 km

Local time: 1030 hrs

July, 2019 & 2020

RS SAMPLER- 3S & 3SA

High Res. Stereo imaging

PAN Fore & AFT
APAN: 1.25m, 60Km
Mx: 2.5m, 60Km, 4 Bands

Orbit : 630 km

Local time: 1030 hrs

2020

NISAR

Joint Mission with JPL/NASA

Payloads

- L & S Band SAR

Orbit : 747 km

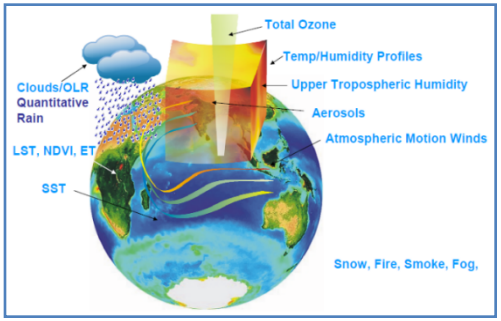
Local time: 0600 hrs

Coordination Group for Meteorological Satellites

Indian Satellite System for weather parameters

Satellite	Major Variables
Oceansat-1/ MSMR	Rain rate, Column Integrated Water Vapour, Cloud Liquid Water Content
INSAT 3A	Cloud, AMVs
Oceansat-2	Aerosols
KALPANA-1	Cloud, Radiation, Upper Tropospheric Humidity
Megha-Tropiques	Radiation Budget, Water Vapor Profile, Integrated Water Content, Temperature and Humidity Profiles
INSAT-3D/ INSAT-3DR/ 3DS	Temperature & Humidity Profiles, Ozone, Clouds, AMVs, Rainfall, SST, OLR, UTH and derived parameters

INSAT-3D Sounder Product	Resolution
Temperature profile	50 km x 50 km (5 x 5 pixels) 40-vertical pressure levels
Water vapour profile	50 km x 50 km (5 x 5 pixels) 21-vertical pressure levels up to 100 hPa
Ozone profile	50 km x 50 km (5 x 5 pixels) 40-vertical pressure levels
Total Column Ozone	50 km x 50 km (5 x 5 pixels)
Surface skin temp.	50 km x 50 km (5 x 5 pixels)

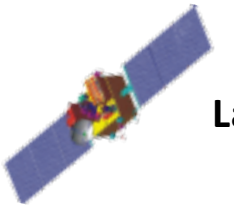


INSAT-3D Geophysical Products

Outgoing long wave radiation (OLR), Quantitative Precipitation Est. (QPE), Sea Surface Temperature (SST), Snow cover, Snow depth, Fire, Smoke, Aerosol, Cloud Motion Vector, Upper Tropospheric Humidity (UTH), Temperature & Humidity profiles, Total Ozone, Value added products from Sounder payload…

CURRENT LEO SATELLITES: Oceansat-2

A global mission, providing continuity of ocean colour data and wind vector in addition characterization of lower atmosphere and ionosphere from ROSA payload.



Launch: Sep 23, 2009

- An 8-band Ocean Colour Monitor (OCM) with 360 m spatial resolution; Swath -1420 km
- A Ku-Band Pencil beam SCATTEROMETER (OSCAT) with a ground resolution of 50 km x 50 km; Swath – 1400 km
- Radio Occultation Sounder for Atmospheric studies (ROSA) - Developed by the Italian Space Agency – ASI

- Due to problems in the payload Scatterometer operations are terminated from March 2014.
- The OCM and ROSA are functioning nominally.

Global data acquisition of Ocean colour

- High Resolution Data - NRSC and INCOIS
- 1km resolution global products through NRSC Website
- Global Chlorophyll, Aerosol Optical Depth through NRSC Website
- 3531 OCM data are downloaded from NRSC Website

Scatterometer Wind Products

- Reception Station at Svalbard
- Real time transfer and processing
- Uploading to Web within 3 hrs through EUMETCAST
- 1.72 Lakhs data are downloaded from NRSC Website

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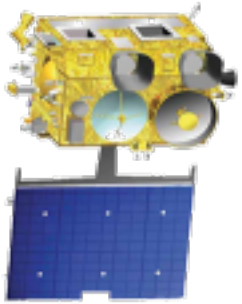
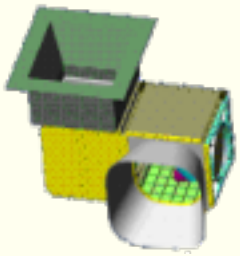
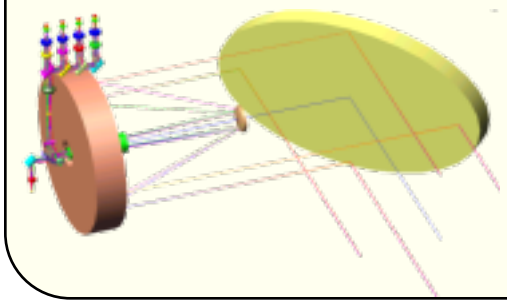
CURRENT GEO SATELLITES: INSAT – 3D/3DR



LAUNCH: Sep 8, 2016

6 Channel IMAGER



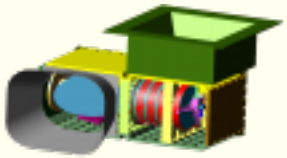


- Spectral Bands (µm)

Visible	: 0.55	- 0.75
Short Wave Infra Red	: 1.55	- 1.70
Mid Wave Infra Red	: 3.70	- 3.95
Water Vapour	: 6.50	- 7.10
Thermal Infra Red – 1	: 10.30	- 11.30
Thermal Infra Red – 2	: 11.30	- 12.50

- Resolution : 1 km for Vis & SWIR
  4 km for MIR & TIR
  8 km for WV

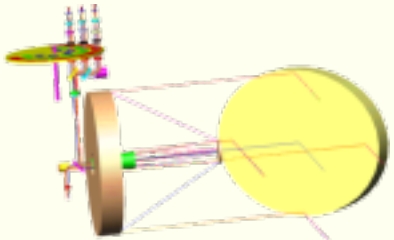
19 Channel SOUNDER



- Spectral Bands (µm)

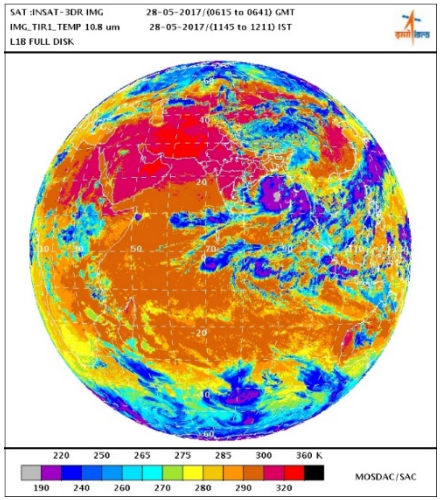
Short Wave Infra Red	:	Six bands
Mid Wave Infra Red	:	Five Bands
Long Wave Infra Red	:	Seven Bands
Visible	:	One Band

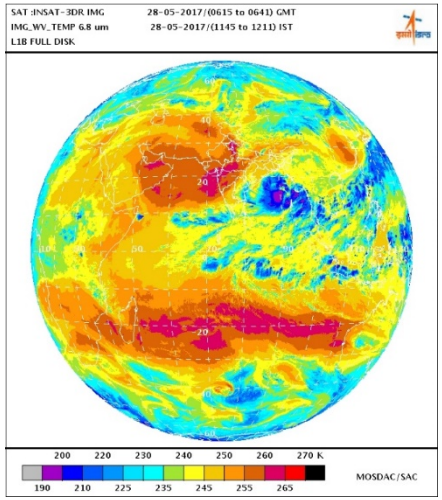
- Resolution (km) : 10 X 10 for all bands
- No of simultaneous : 4 sounding per band

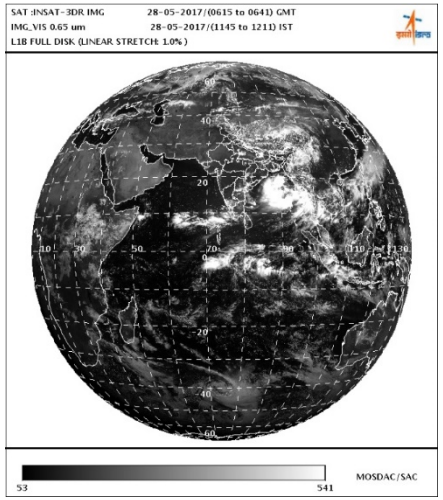


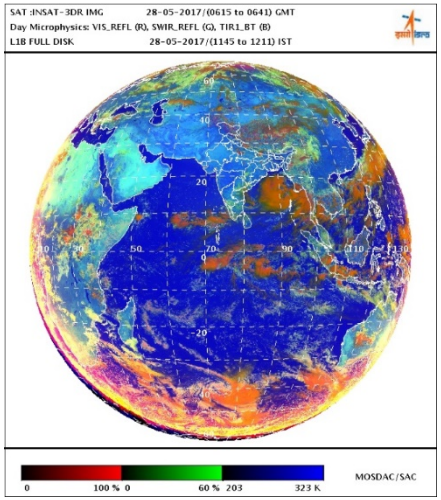
Coordination G
Meteorological

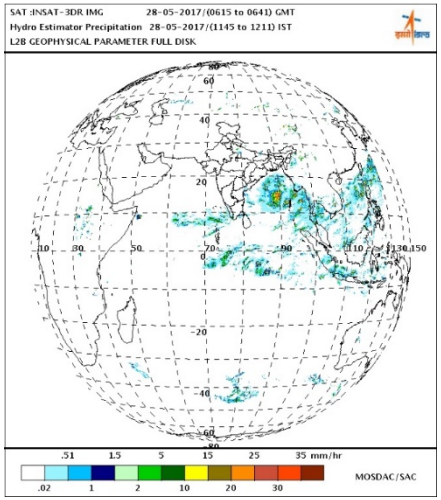
CGMS

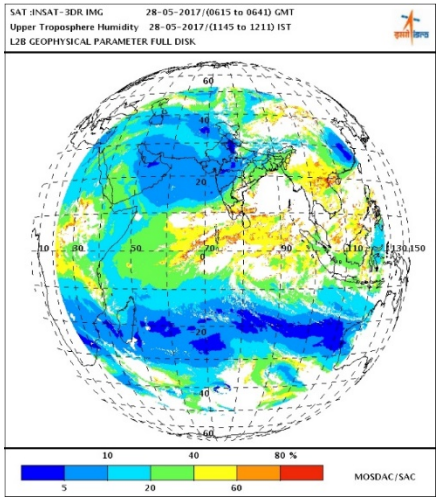


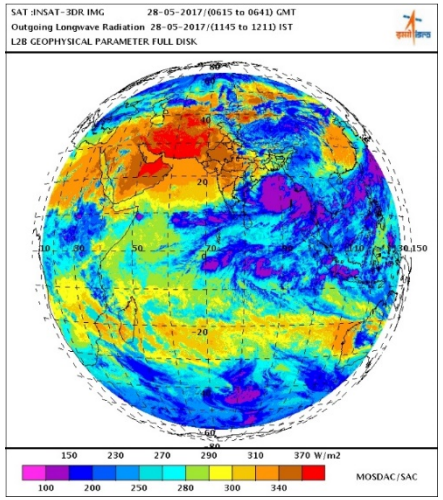


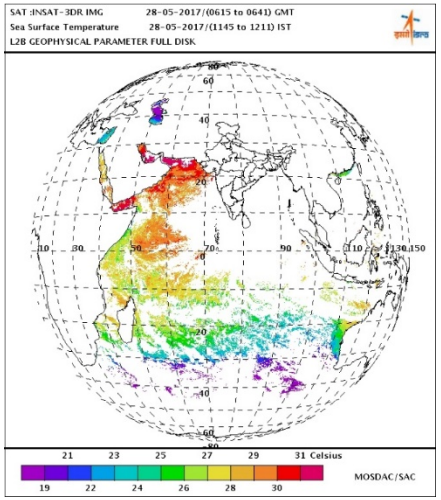




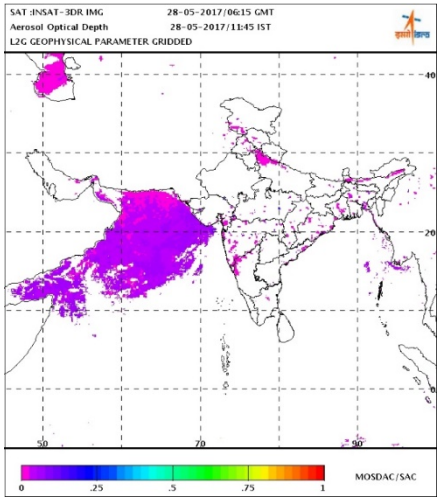


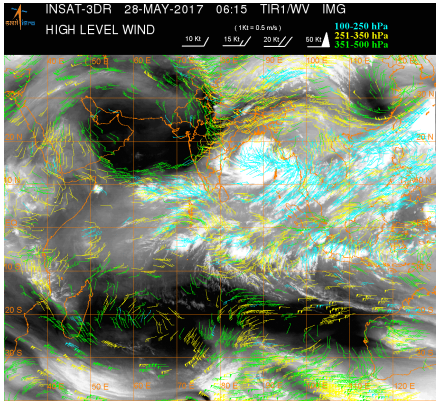


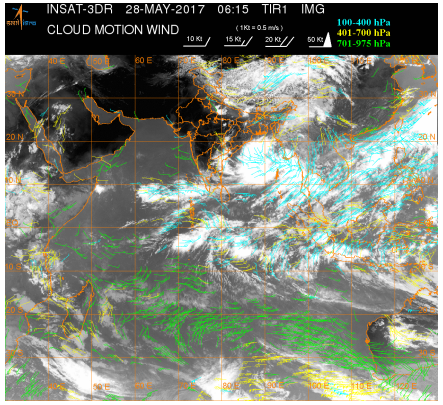


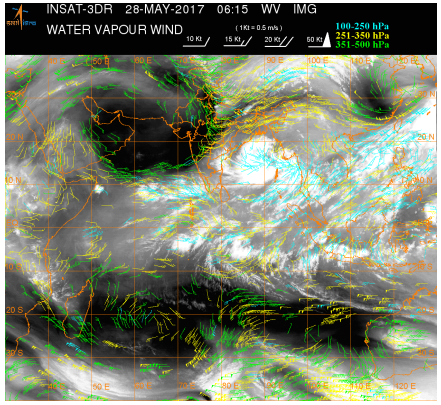


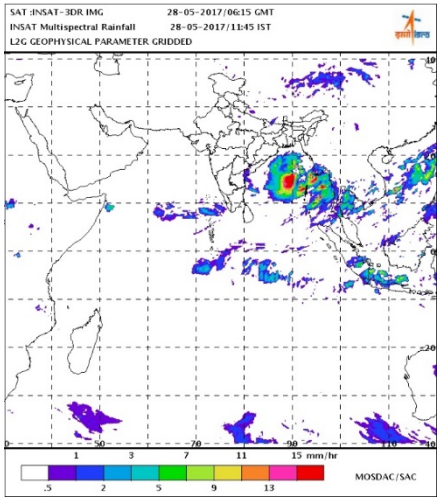
Coordination Group for Meteorological Satellites

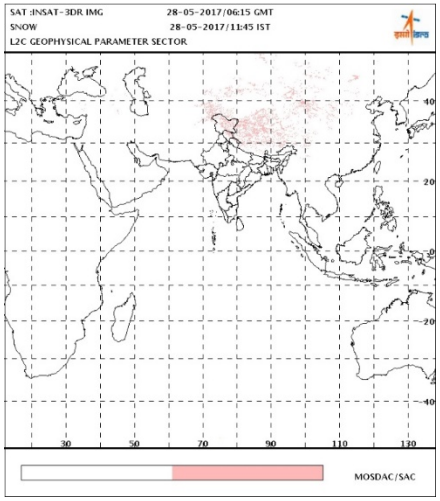

SAT :INSAT-3DR IMG 28-05-2017/06:15 GMT
Aerosol Optical Depth 28-05-2017/11:45 IST
L2G GEOPHYSICAL PARAMETER GRIDDED
MOSDAC/SAC

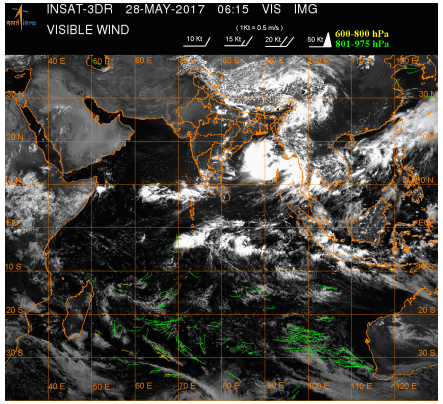

INSAT-3DR 28-MAY-2017 06:15 TIR1/WV IMG
HIGH LEVEL WIND
100-250 hPa
251-350 hPa
351-500 hPa


INSAT-3DR 28-MAY-2017 06:15 TIR1 IMG
CLOUD MOTION WIND
100-400 hPa
401-700 hPa
701-975 hPa


INSAT-3DR 28-MAY-2017 06:15 WV IMG
WATER VAPOUR WIND
100-250 hPa
251-350 hPa
351-500 hPa


SAT :INSAT-3DR IMG 28-05-2017/06:15 GMT
INSAT Multispectral Rainfall 28-05-2017/11:45 IST
L2G GEOPHYSICAL PARAMETER GRIDDED
15 mm/hr
MOSDAC/SAC


SAT :INSAT-3DR IMG 28-05-2017/06:15 GMT
SNOW 28-05-2017/11:45 IST
L2C GEOPHYSICAL PARAMETER SECTOR
MOSDAC/SAC

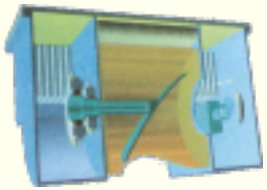

INSAT-3DR 28-MAY-2017 06:15 VIS IMG
VISIBLE WIND
600-800 hPa
801-975 hPa

CURRENT LEO SATELLITES: Megha-Tropiques

For studying water cycle and energy exchanges to better understand the life cycles of the tropical convective system. The satellite is contributing to Global Precipitation Mission (GPM)

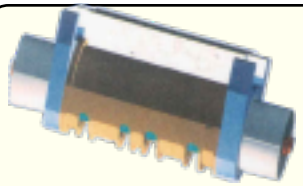
Launch: 2011

SAPHIR



- Water vapour profile
- Six atmospheric layers upto 12 km height
- 10 km Horizontal Resolution

SCARAB

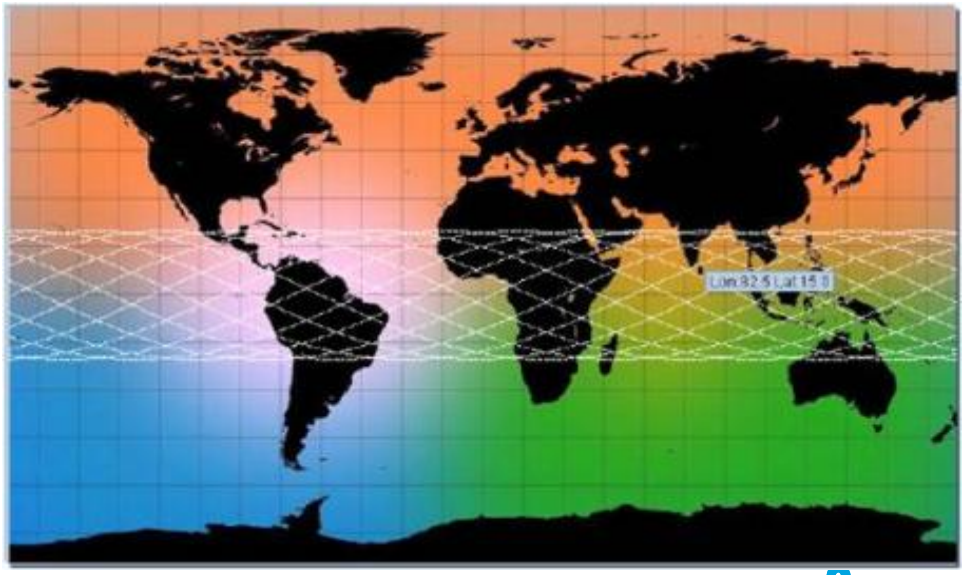


- Outgoing fluxes at TOA
- 40 km Horizontal Resolution

MADRAS

- Precipitation and Cloud properties
- 89 &157 GHz: Ice particles in cloud top
- 18 &37 GHz: Cloud Liquid Water and precipitation; Sea Surface Wind speed
- 24 GHz : Integrated water vapour

- SAPHIR and SCARAB data products are available operationally.
- MADRAS payload functioned for 18 months and the data is available.



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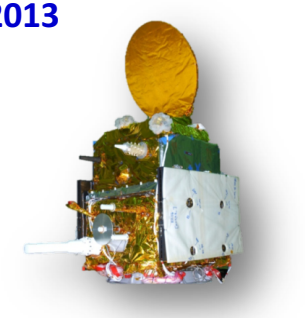
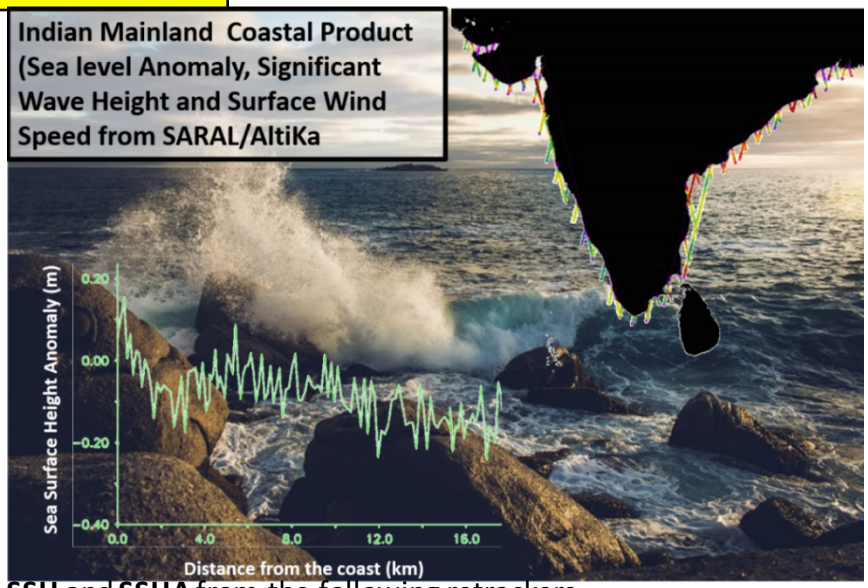
CURRENT LEO SATELLITES: SARAL: Satellite with Argos and Altimeter

-Joint Indo-French satellite mission for oceanographic studies

Hosted on MOSDAC FTP Site

Launch: Feb 25, 2013





Altika Payload:

- **Ka-band** (35.75 GHz, BW 500 MHz) radar altimeter
- Dual-frequency microwave radiometer (23.8 & 37 GHz)
- DORIS & Laser Retro-reflector Array
- Repeat Cycle: 35 days

ARGOS Data Collection System:

- Contributes to development and operational implementation of global ARGOS DCS.
- Collect a variety of data from ocean buoys to transmit the same to the ARGOS Ground Segment for subsequent processing and distribution.

- 40 Hz **SSH** and **SSHA** from the following retrackers
  - **BETA5 (exp) retracker**
  - **BETA9 (exp)**
  - **BAGP4 (least square)**
  - **BAGP4 (nelder mead)**
  - MLE4 calculated to 40 Hz
- 40 Hz SWH from all above algorithms
- 40 Hz SIGMA (0) from all above algorithms
- 40 Hz wind speed from all above algorithms
- 40 Hz flags for these algorithms
- 40 Hz Waveform class
- 40 Hz land flag
- distance from coast
- quality parameter for retracker fitting
- waveforms from data itself

Coordination Group for Meteorological Satellites

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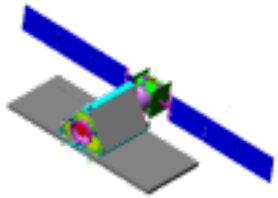
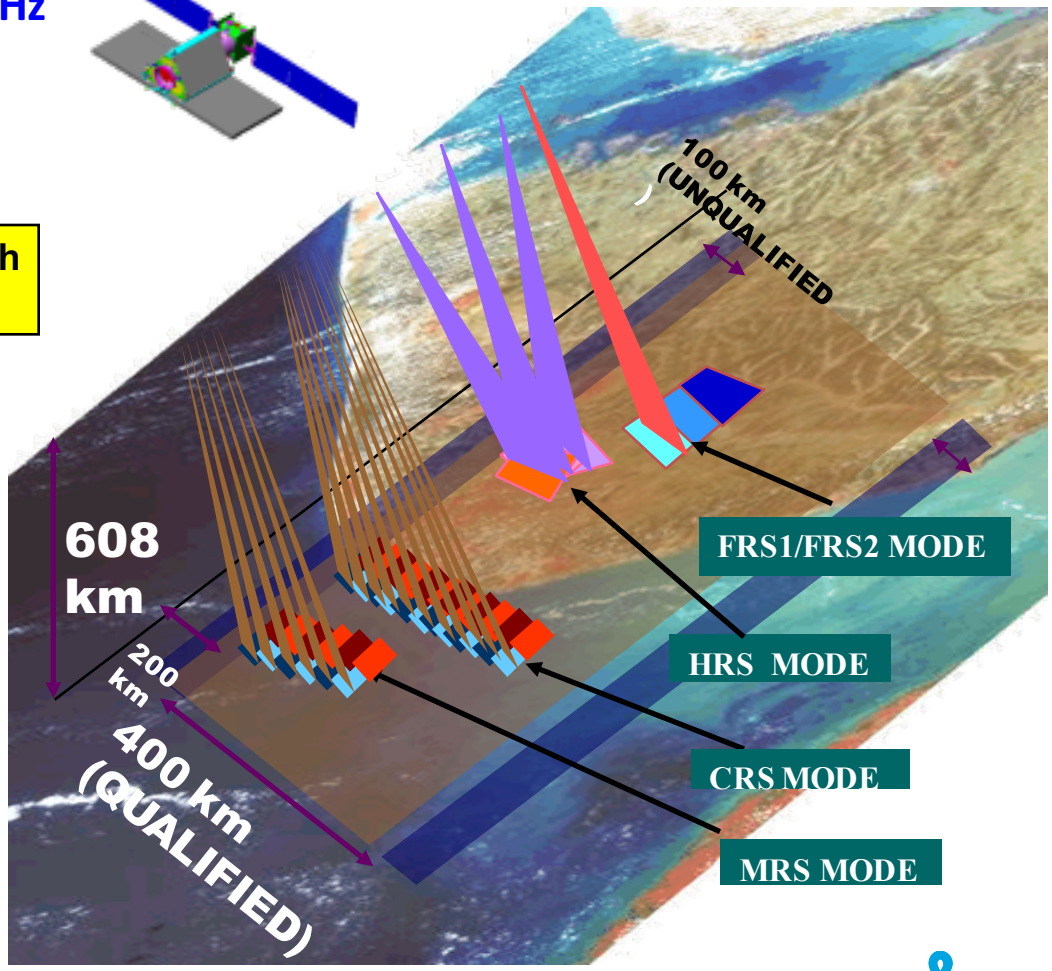
CURRENT LEO SATELLITES: Radar Imaging Satellite (RISAT-1)

Space borne SAR in C-band at 5.35 GHz

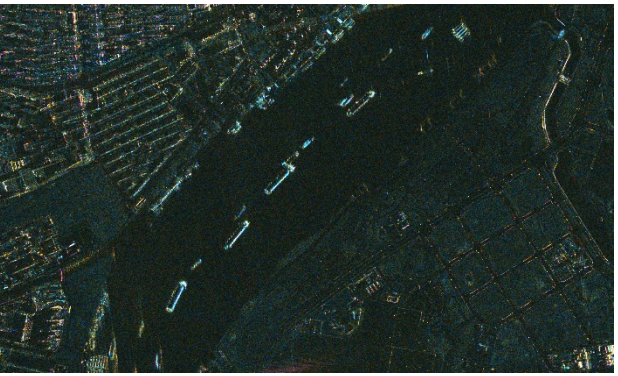
Launch: April 2012

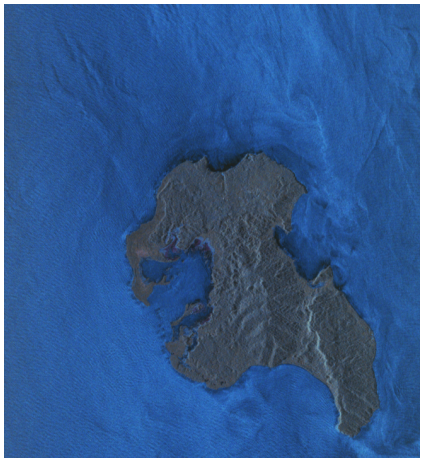
Single/ Dual / Quad Polarisation imaging with 3 - 50 m Resolution & 10 - 240 km Swath

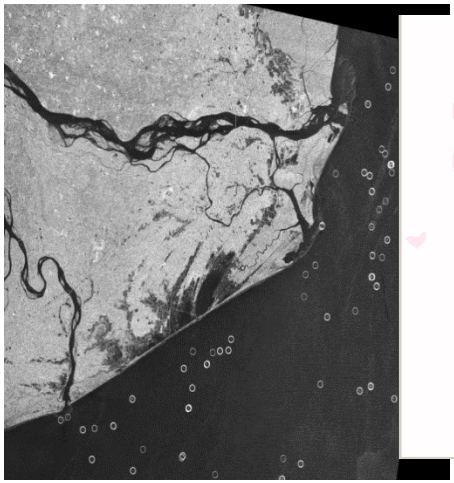


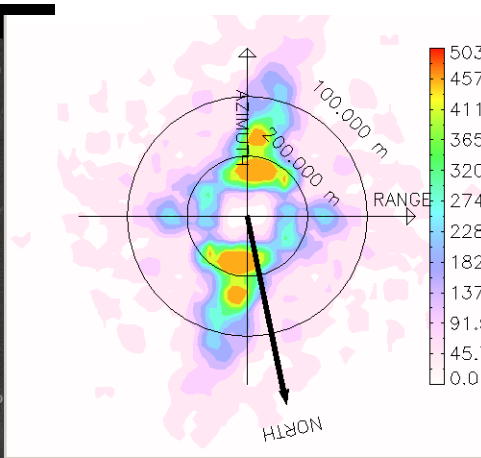


RISAT-1 has all-weather/ day-night SAR observation capability for applications such as agriculture, forestry, soil moisture, geology, sea ice, coastal monitoring, object identification, and flood monitoring.

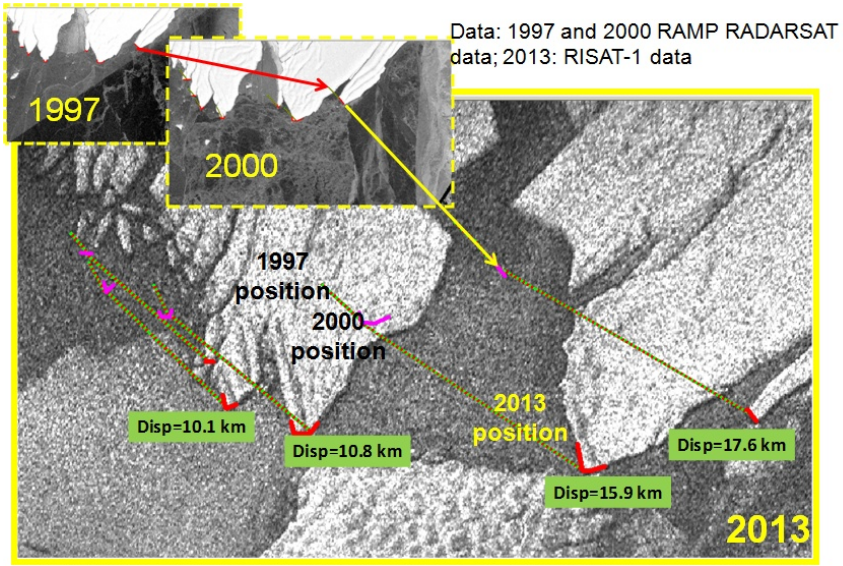




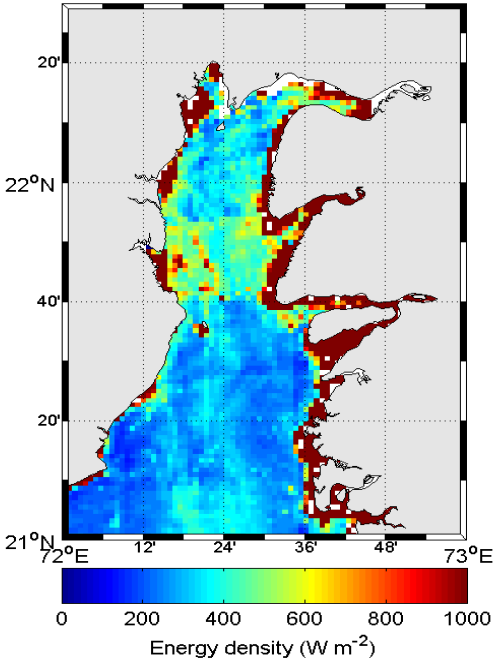


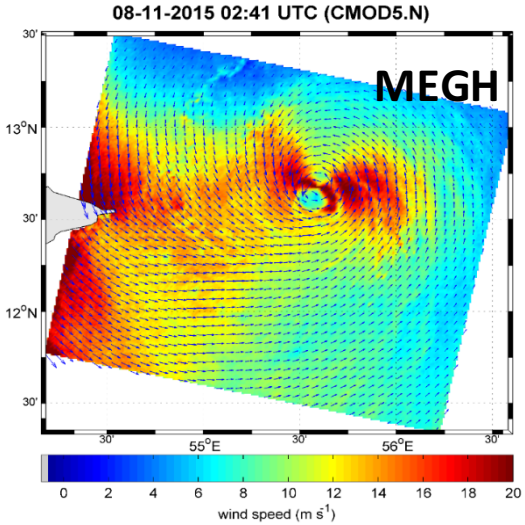


Monitoring of ice shelf advancement (Amery Ice Shel



SAR





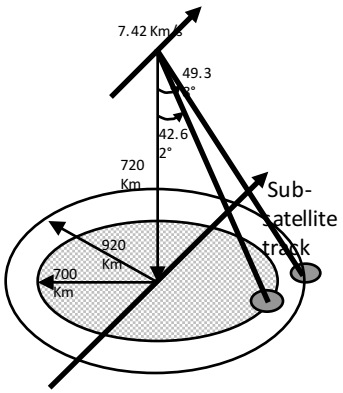
Meteorological Satellites

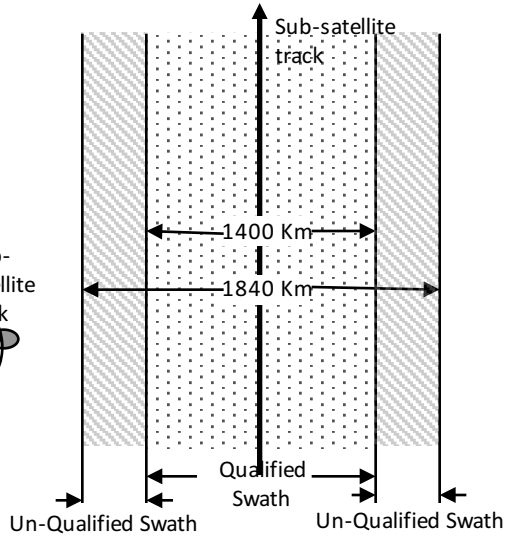
CURRENT LEO SATELLITES: (SCATSAT-1)

SCATSAT-1 is planned as an in-orbit replacement for the Scatterometer carried onboard Oceansat-2, which is non-functional after 4 ½ years of service.

Orbit : 720 km in sun-synchronous

LAUNCH: Sep 26, 2016





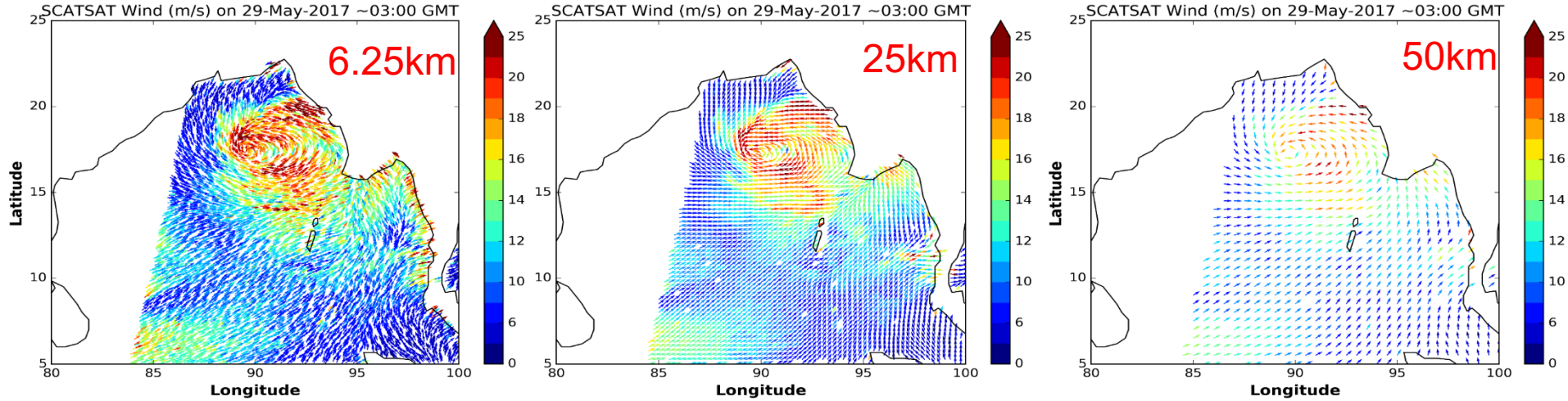
- IMS-2 Bus
- Ku-Band (13.515 GHz) Pencil beam Scatterometer
- Ground resolution: 50 km x 50 km
- Swath: 1440 Km
- Polarization: HH and VV
- Wind Direction: O to 360 deg with accuracy of 20 deg
- Wind Speed: 4 to 24 m/s with accuracy of 10% or 2m/s

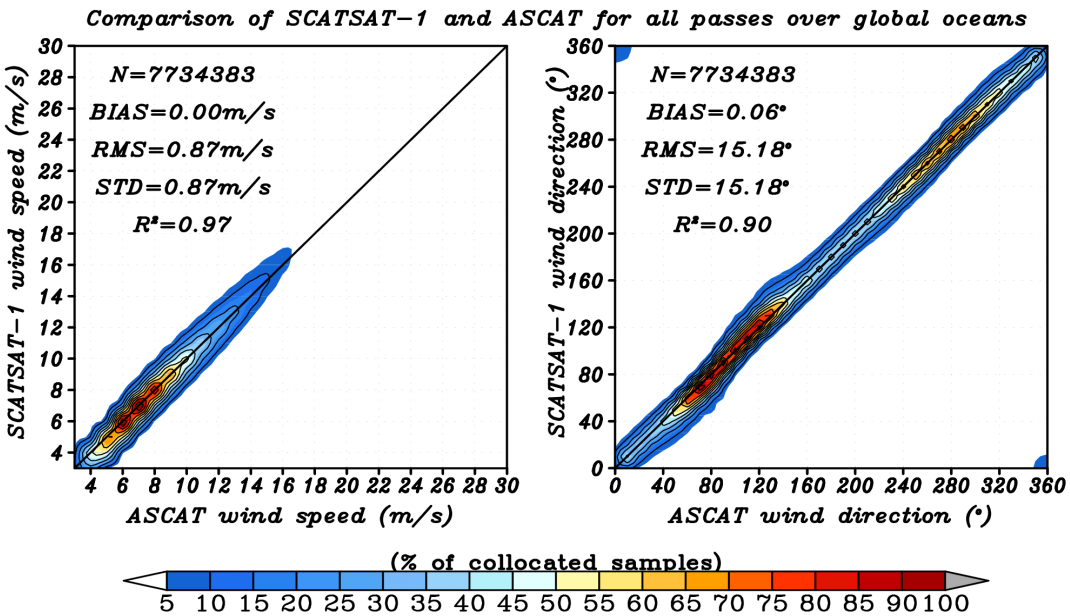
Objectives:

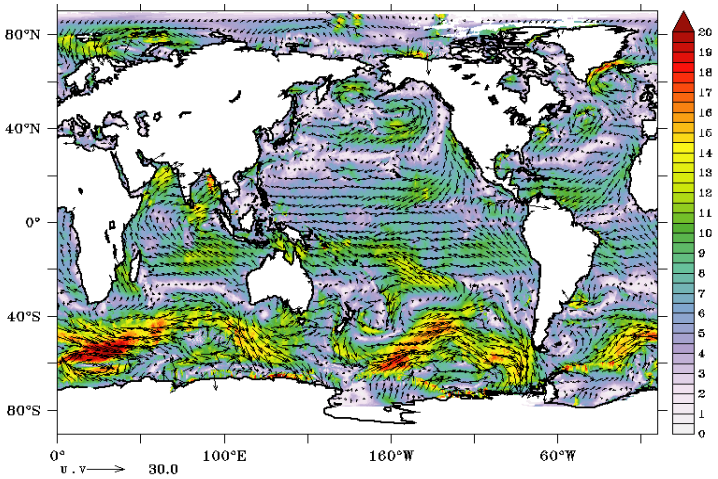
- To provide global wind vector data for national and international user Community.
- To provide continuity of weather forecasting services to the user communities.
- To generate wind vector products for weather forecasting, cyclone detection and tracking.

Coordination Group for Meteorological Satellites

Cyclone Mora as Captured by SCATSAT-1 Winds (m/s)







Government of India

MOSDAC

Select Date: Go

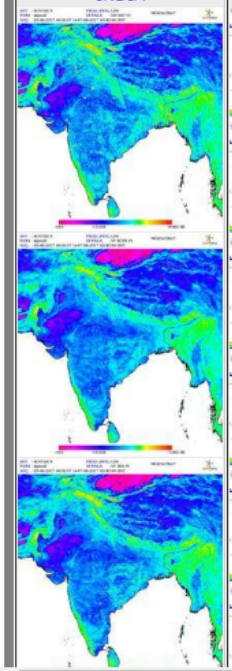
SCATSAT-1 DATA PRODUCTS PICTURE GALLERY

Meteorological and Oceanographic Satellite Data Archival Centre(SAC, ISRO)

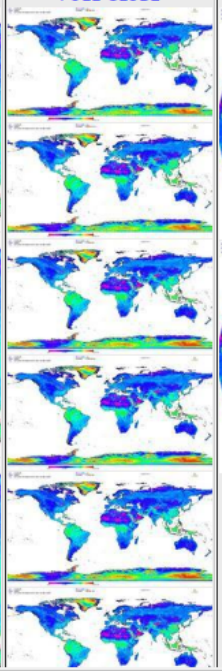
VIEW GAMMA-0

INDIA		FULLGLOBE		NPOLAR24		NPOLAR72		ICE COVER		SPOLAR24		SPOLAR72		ANALYZED WIND VECTORS	
Product Type	Expected Count	Product Type	Expected Count	Product Type	Expected Count	Product Type	Expected Count	Product Type	Expected Count(min,max)	Product Type	Expected Count	Product Type	Expected Count	Product Type	Expected Count
HH-ASC	1	HH-ASC	1	HH-BOTH	1	HH-DES	1	ICE COVER	1	HH-BOTH	1	HH-ASC	1	AWV	1
HH-DES	1	HH-DES	1	VV-BOTH	1	VV-DES	1			VV-BOTH	1	VV-ASC	1		
HH-BOTH	1	HH-BOTH	1												
VV-ASC	1	VV-ASC	1												
VV-DES	1	VV-DES	1												
VV-BOTH	1	VV-BOTH	1												
INDIA(Sigmanaught) Total Count : 6 DATE: 05Jun2017 to 06Jun2017		**FULL GLOBE(Sigmanaught)** Total Count : 6 DATE: 04Jun2017 to 05Jun2017		**NPOLAR24(Sigmanaught)** Total Count : 2 DATE: 06Jun2017		**NPOLAR72(Sigmanaught)** Total Count : 2 DATE: 04Jun2017 to 06Jun2017		**ICE COVER** Total Count : 1 DATE: 07Jun2017		**SPOLAR24(Sigmanaught)** Total Count : 2 DATE: 05Jun2017		**SPOLAR72(Sigmanaught)** Total Count : 2 DATE: 04Jun2017 to 06Jun2017		**AWV** Total Count : 1 DATE: 05Jun2017	

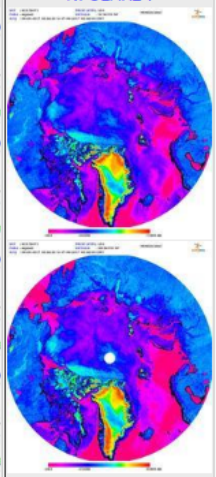
INDIA



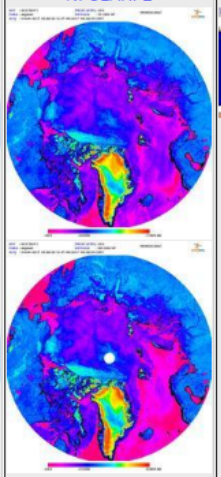
FULL GLOBE



NPOLAR24

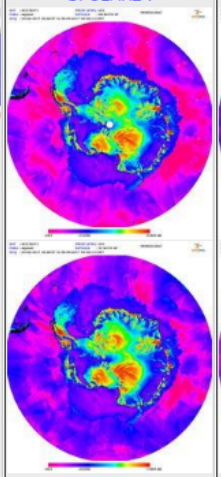


NPOLAR72

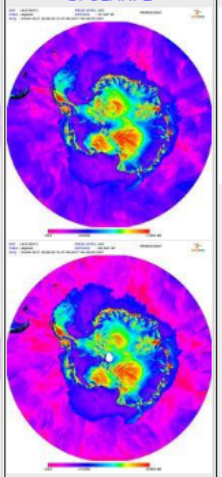


ICE COVER

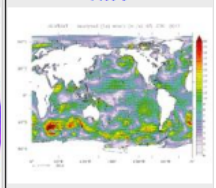
SPOLAR24



SPOLAR72



AWV



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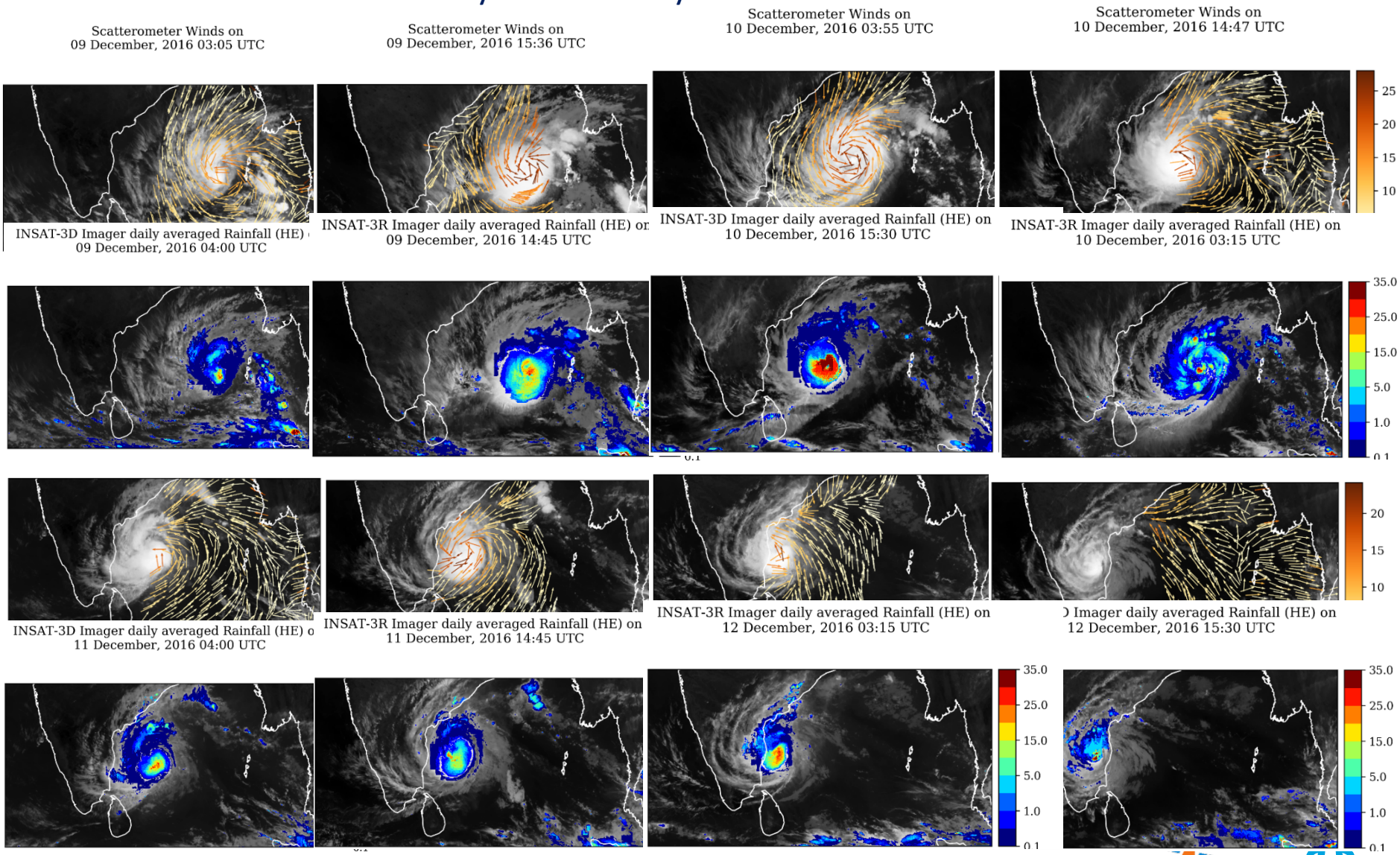
VARDHA Cyclone seen by INSAT & SCATSAT-1



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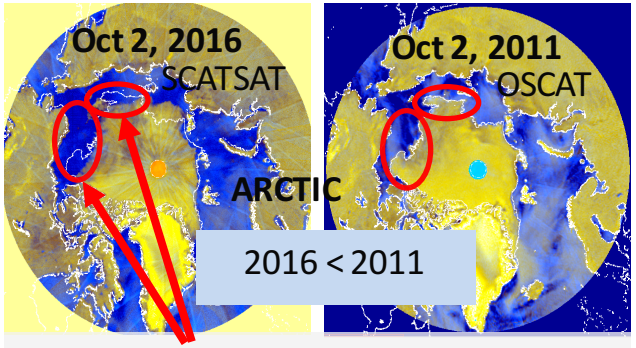
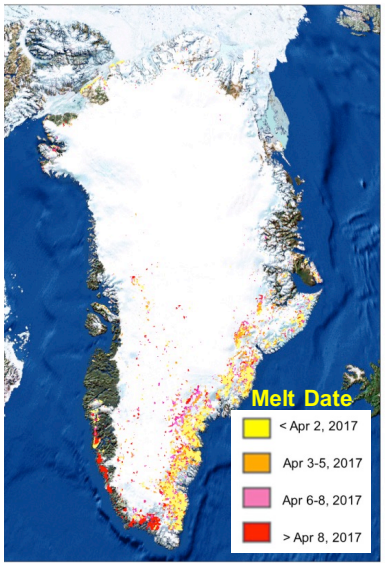
MONITORING OF POLAR CRYOSPHERE (OSCAT, SCATSAT, RISAT, AltiKa & LISS-4)

Sea Ice Status- OSCAT & SCATSAT

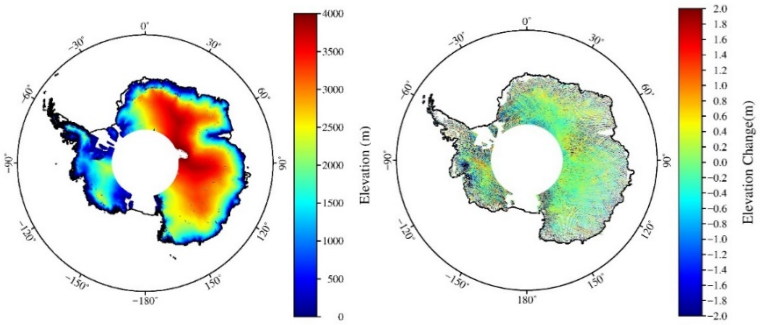


The area without sea ice, which was under sea ice cover in 2011 (H-V-APR RGB)

Greenland Melting – Status April 2017 (SCATSAT)

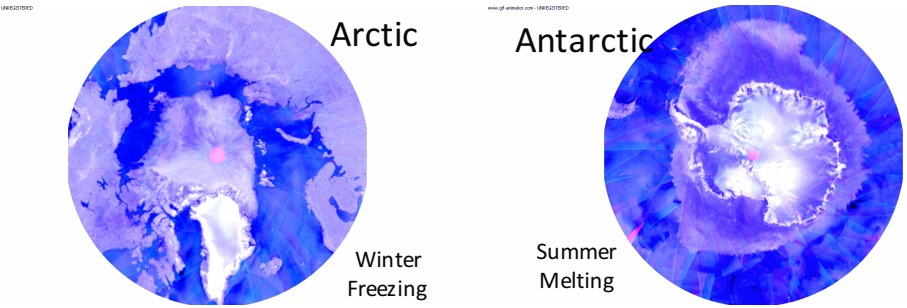


SARAL AltiKa for Antarctic Elevation studies



Elevation (Oct-Nov 2015)

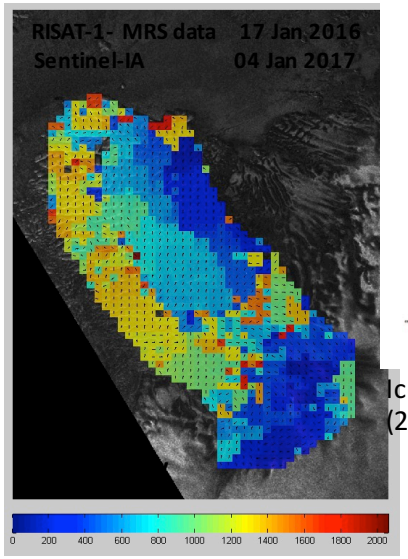
Elevation Change (2013 & 2015)

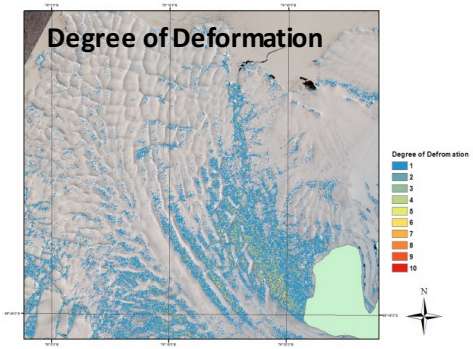


Summer surface melt condition– 2017 with 2010 & 2013

SCATSAT (2017) compared with OSCAT (2010 & 2013); Red to Violet indicates Warm to cool condition compared to 2017 (**2010 < 2017 < 2013**)

Surface dynamics - Polar Record Glacier





Ice velocity using RISAT (2016) & Sentinel (2017); Deformation using LISS-4 (10-Jan-2016)

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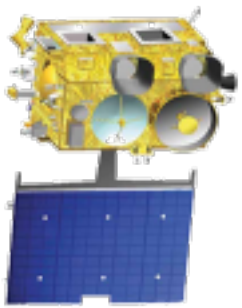
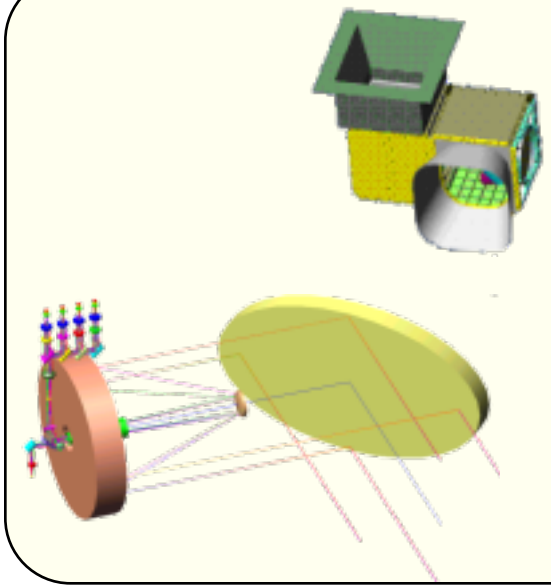
FUTURE GEO SATELLITES: INSAT - 3DS



LAUNCH:
spare ready in 2018

6 Channel IMAGER

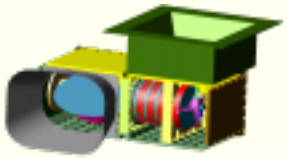


- Spectral Bands (µm)

Visible	: 0.55	- 0.75
Short Wave Infra Red	: 1.55	- 1.70
Mid Wave Infra Red	: 3.70	- 3.95
Water Vapour	: 6.50	- 7.10
Thermal Infra Red – 1	: 10.30	- 11.30
Thermal Infra Red – 2	: 11.30	- 12.50

- Resolution : 1 km for Vis & SWIR
  4 km for MIR & TIR
  8 km for WV

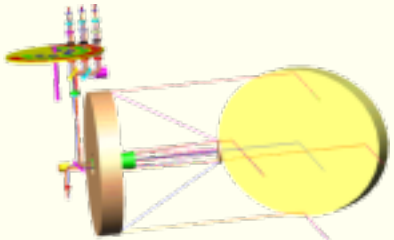
19 Channel SOUNDER



- Spectral Bands (µm)

Short Wave Infra Red	:	Six bands
Mid Wave Infra Red	:	Five Bands
Long Wave Infra Red	:	Seven Bands
Visible	:	One Band

- Resolution (km) : 10 X 10 for all bands
- No of simultaneous : 4 sounding per band



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FUTURE GEO SATELLITES: (GISAT)

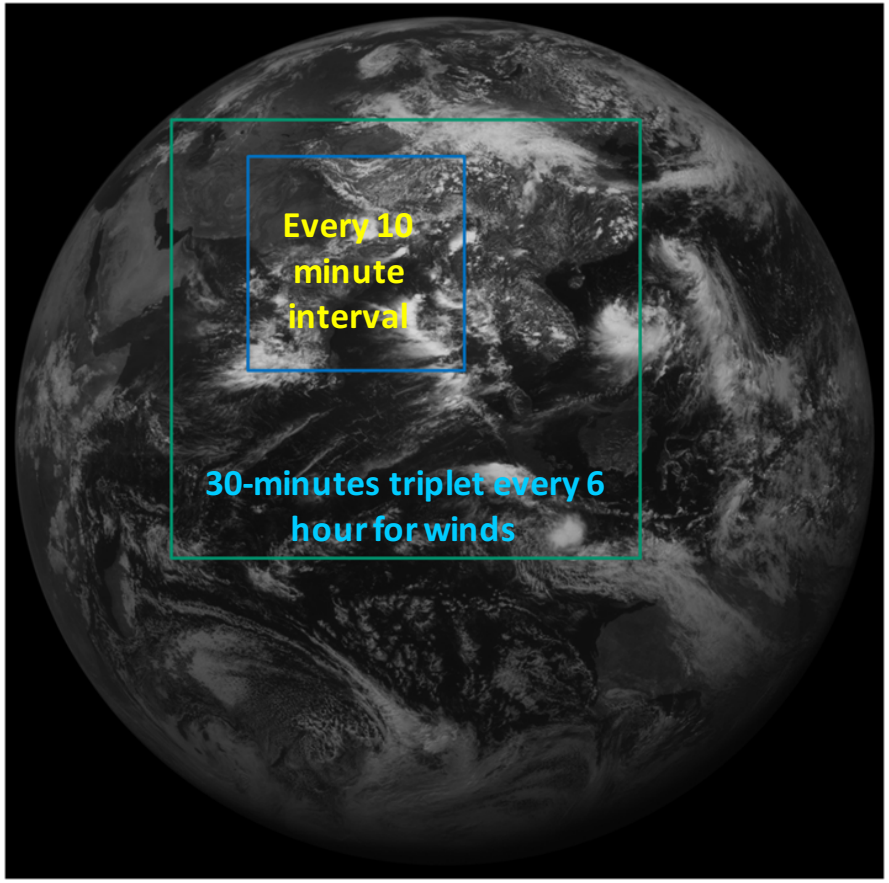
Launch Schedule: 2018, Geostationary orbit, 83E

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

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

GISAT Scan scenario

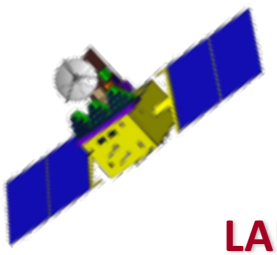
Scan area for two scan scenario (5° & 10 °)



Coordination Group for Meteorological Satellites

FUTURE LEO SATELLITES: (Oceansat-3)

OCEANSAT-3 is a global mission and is configured to cover global oceans and provide continuity of ocean colour data with global wind vector and characterization of lower atmosphere and ionosphere.



LAUNCH: 2018

Payloads:

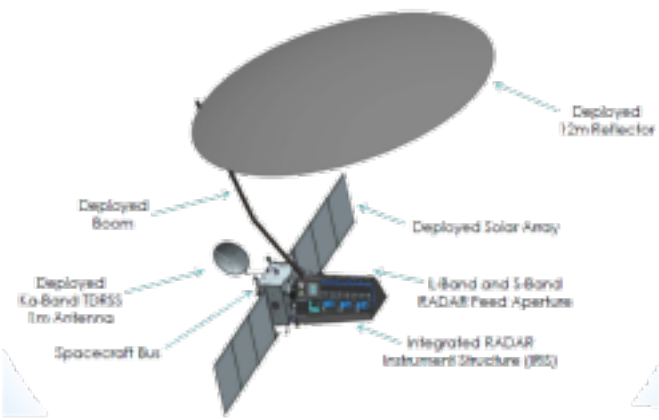
- **13-band Ocean Colour Monitor (OCM) - 400-1010 nm range; 360 m resolution; 1400 km swath**
- **2-band Long Wave Infra Red (LWIR) around 11 and 12 µm**
- **Ku-Band Pencil beam SCATTEROMETER**

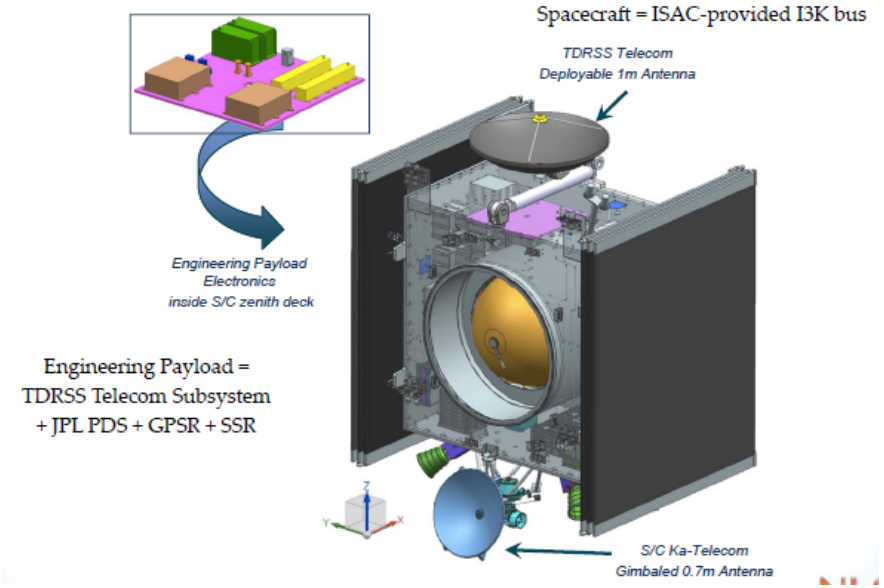
Objectives:

- Continuity of ocean colour data with improvements to continue and enhance operational services like potential fishery zone and primary productivity.
- To enhance the applications by way of simultaneous Sea Surface Temperature (SST) measurements, in addition to chlorophyll, using additional thermal channels.
- Continuity of wind vector data through repeat of Scatterometer for cyclone forecasting and numerical weather modelling.
- The mission, in tandem with Oceansat-2 (on availability), will improve the repetivity of ocean colour measurements to every 24 hour and wind vector measurements to every 12 hour.

FUTURE LEO SATELLITES: (NISAR) NASA-ISRO Synthetic Aperture Radar

LAUNCH: 2020





Major Objectives

- Design, develop and launch Dual frequency (L and S Band) Radar Imaging Satellite
- Explore newer application areas using L and S band microwave data, especially in surface deformation studies, terrestrial biomass structure, natural resources mapping & monitoring and studies related to dynamics of ice sheets, glaciers, forest fire, oil slick, etc.

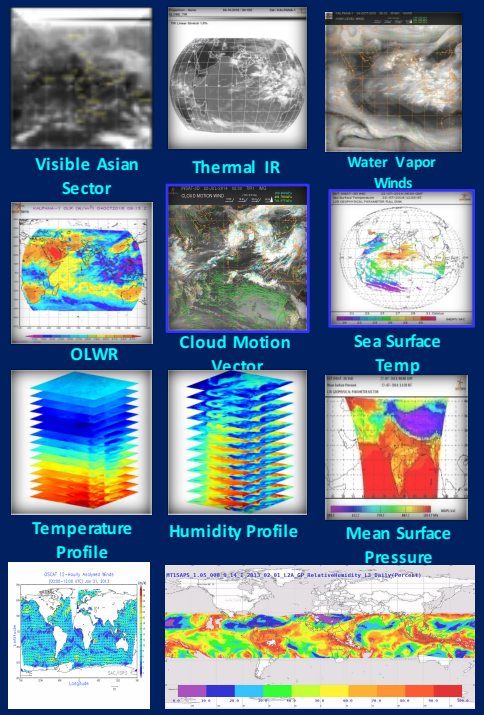
Coordination Group for Meteorological Satellites - CGMS

MOSDAC Meteorological and Oceanographic Satellite Data Archival Centre

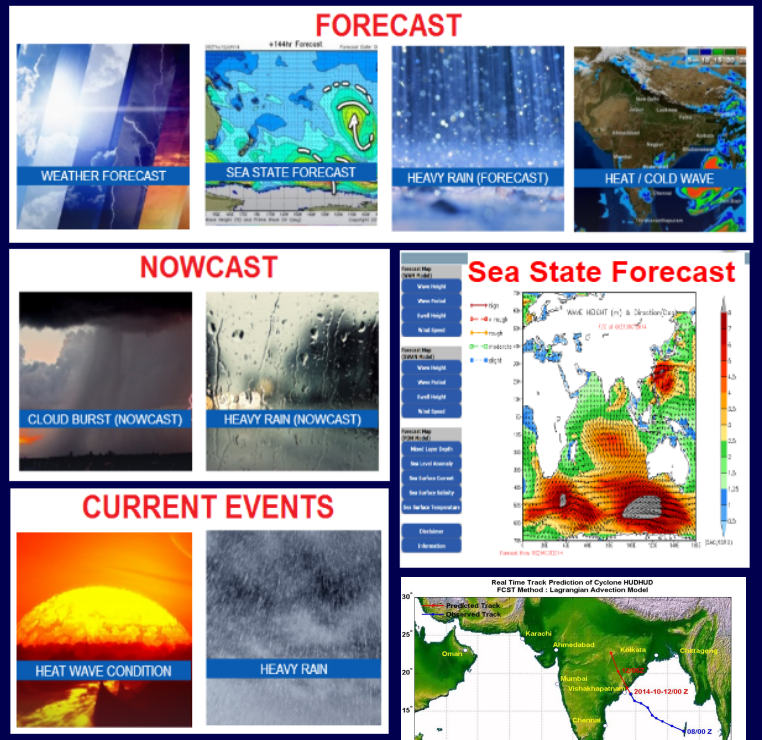
Multi Mission Satellite Data Repository Application of Space Technology for the benefit of the common man

Weather and Sea state forecasting, alerts, cyclone prediction and continuous weather and ocean data availability

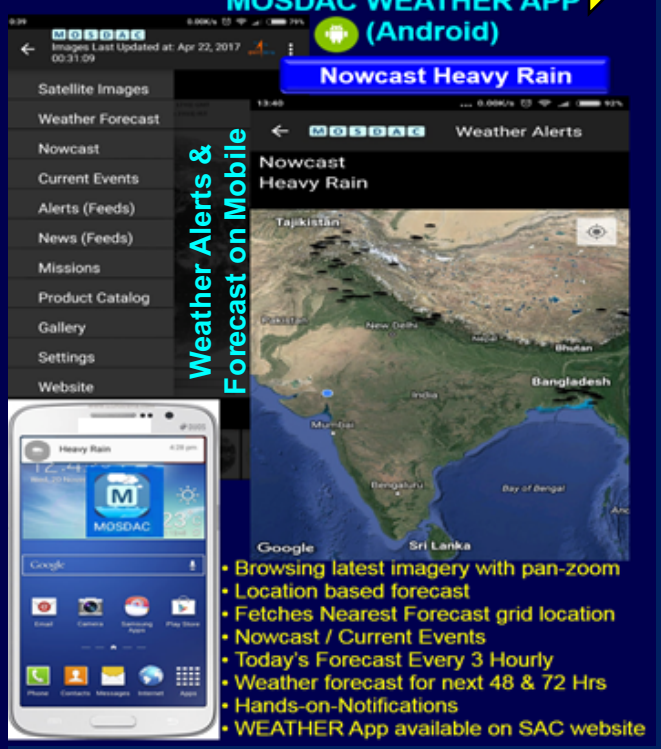
MET. & OCEAN DATA PRODUCTS



MOSDAC SERVICES



MOSDAC WEATHER APP (Android)



- Browsing latest imagery with pan-zoom
- Location based forecast
- Fetches Nearest Forecast grid location
- Nowcast / Current Events
- Today's Forecast Every 3 Hourly
- Weather forecast for next 48 & 72 Hrs
- Hands-on-Notifications
- WEATHER App available on SAC website

Major weather applications from ISRO'S Earth Observation System

Research Opportunities with INDIAN Satellite Data facilitated by MOSDAC Research Group (EPSA)

Email:admin@mosdac.gov.in

http://www.mosdac.gov.in

INDIAN Storehouse for Space based Weather Data

Research and Training

MOSDAC

http://mosdac.gov.in/smart

ISRO's initiative to promote research in Satellite Meteorology and Oceanography among students, academics and researchers using MOSDAC data.

How SMART will help the Students?

- SMART
  - Research Initiatives
    - Research Initiation Programme
    - Advanced Research Programme
    - Data Exploration Programme
  - Training Activities
    - Satellite Data Training Programme
    - Public Outreach Activities

Research Platform for Academia - VEDAS

Visualisation of Earth Observation Data and Archival System
Beta

- Research & training to Academia by providing data, domain knowledge and infrastructure
- Active participation of academia in development of newer techniques/ algorithms
- Mentors indigenous WebGIS server development

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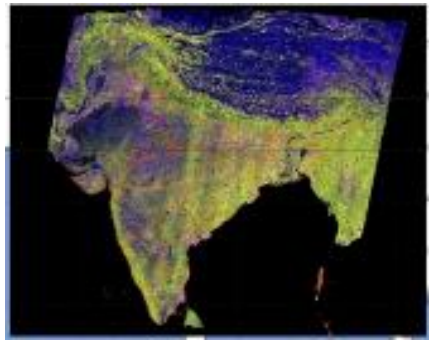
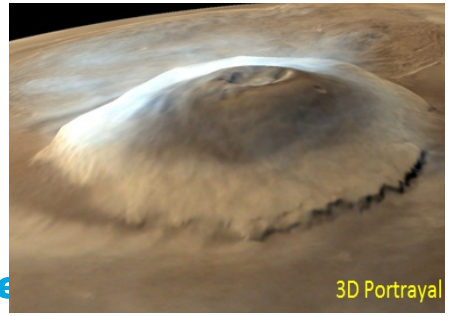
- Earth Observation
- Polar Science
- Atmospheric and Oceanic Science
- Planetary Science
- Hydrological Science & Applications
- Glacier Information System
- New and Renewable Energy
- Vegetation and Crop Monitoring
- Urban Sprawl Information System
- Special Products

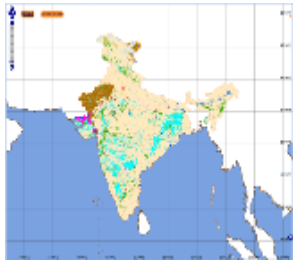
RISAT



3D visualization of Mars & Moon

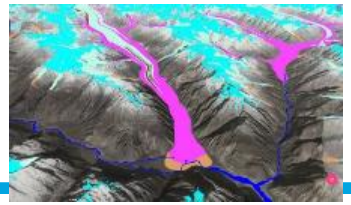


Desertification Status

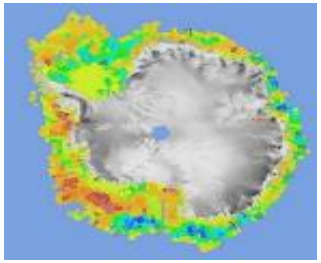


Urban Sprawl studies

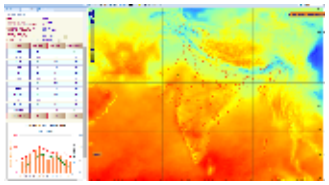
Glaciers in 3D using Carto DEM



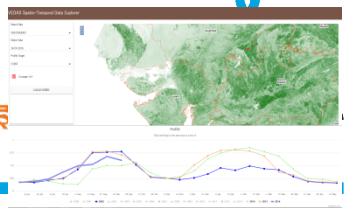
Antarctic Sea-Ice

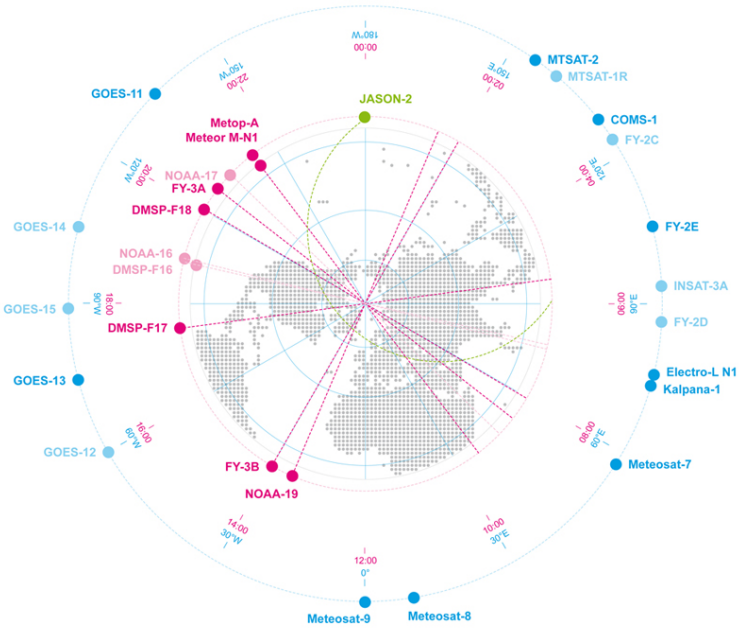


New & Renewable Energy



Vegetation Dynamics





Thanks

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Coordination Group for Meteorological Satellites