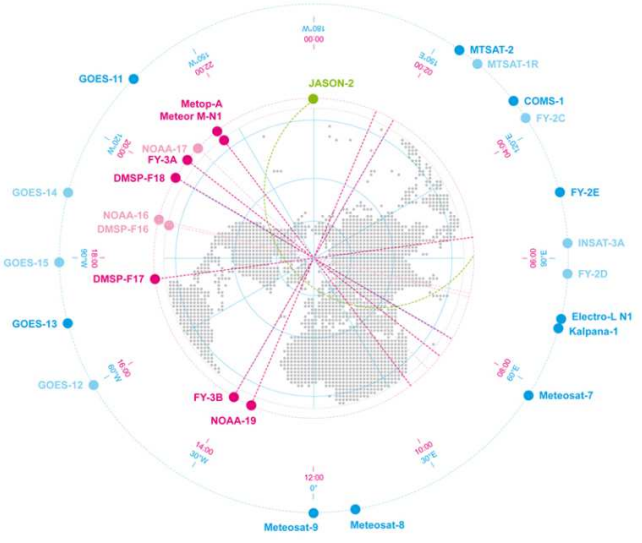
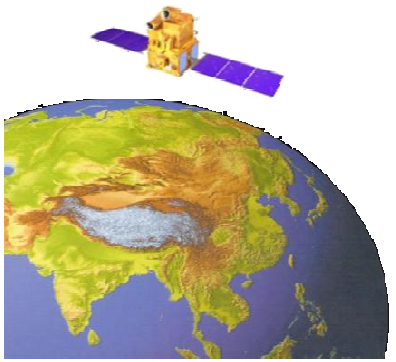


ISRO Report on the Status of Current and future satellites



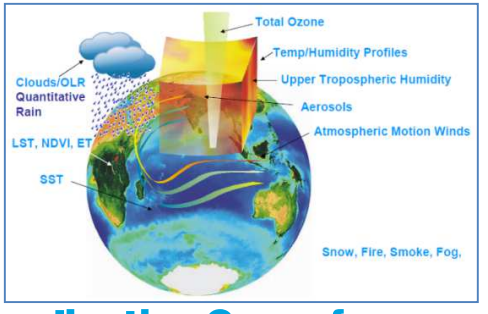
Presented to CGMS-44 WP-01 Plenary Session

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, Wind Speed over ocean
INSAT 3A	Cloud, NDVI
Oceansat-2	Aerosols, Ocean Surface Winds
KALPANA-1	Cloud, Radiation, Upper Tropospheric Humidity, Rain rate, SST, LST, AMVs
Megha-Tropiques	Radiation Budget, Water Vapor Profile, Integrated Water Content, rain rate, wind speed and cloud liquid water
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…

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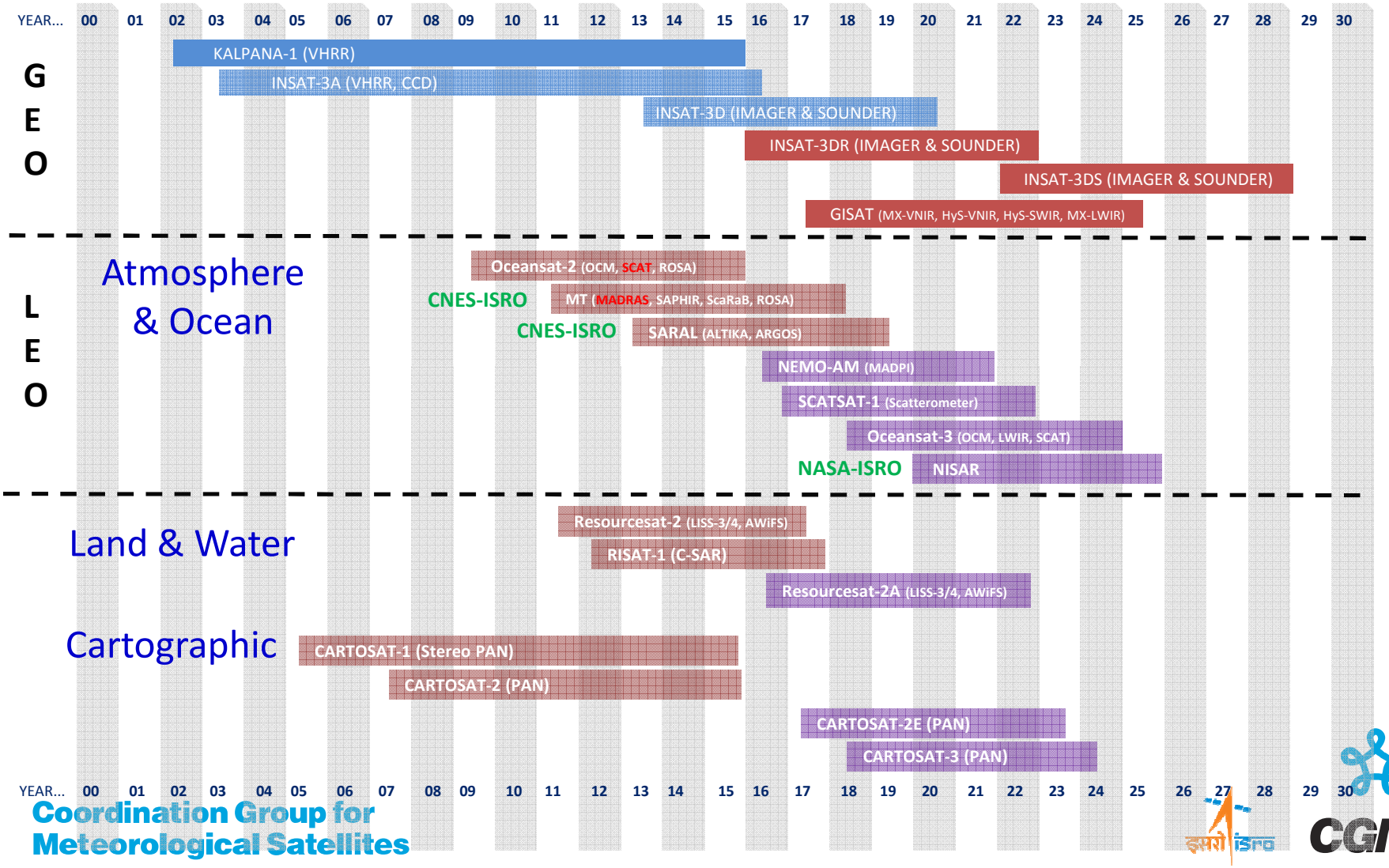
ISRO Current satellites for Earth Observations



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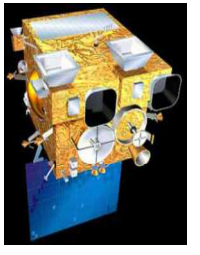
CURRENT GEO SATELLITES (INSAT-3D, Kalpana-1, INSAT-3A)

- INSAT-3D products have been extensively validated since its launch in 2013.
- IMSAT-3D AMV quality improved significantly after improvement in height assignment, radiance bias correction and image registration. These products are now routinely evaluated by ECMWF, NCMRWF and UKMO. NCMRWF and IMD have started assimilating AMV in operational model.
- RT model dependent radiance bias correction applied in INSAT-3D Sounder retrieval based on 6 months (Jan-Jun 2014) collocated data of Sounder and RAOB. This has improved quality of humidity sounding. Data prior to Dec 2014 is being reprocessed
- Clear-sky Tb product generated for INSAT-3D sounder and CSBT products are available in Sounder L2B products.
- CSBT are now operationally assimilated in NCMRWF model.
- INSAT-3D Imager data is extensively used for Tropical Cyclone analysis.

Kalpana-1
VHRR
(2002)
74E

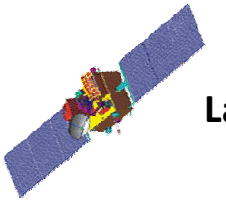
INSAT-3A
VHRR,
CCD
(2003)
93.5E



INSAT-3D
Imager,
Sounder
(2013)
82E

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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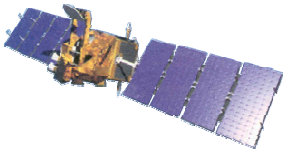
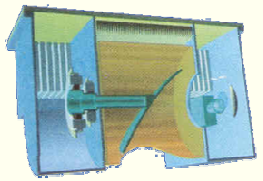
CURRENT LEO SATELLITES: Megha-Tropiques



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)

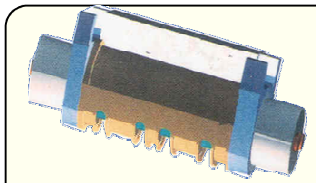
Launch: 2011

SAPHIR



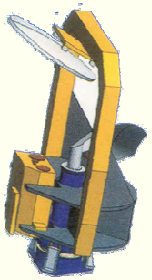
- Water vapour profile, rain rate
- Six atmospheric layers upto 12 km height
- 10 km Horizontal Resolution

SCARAB



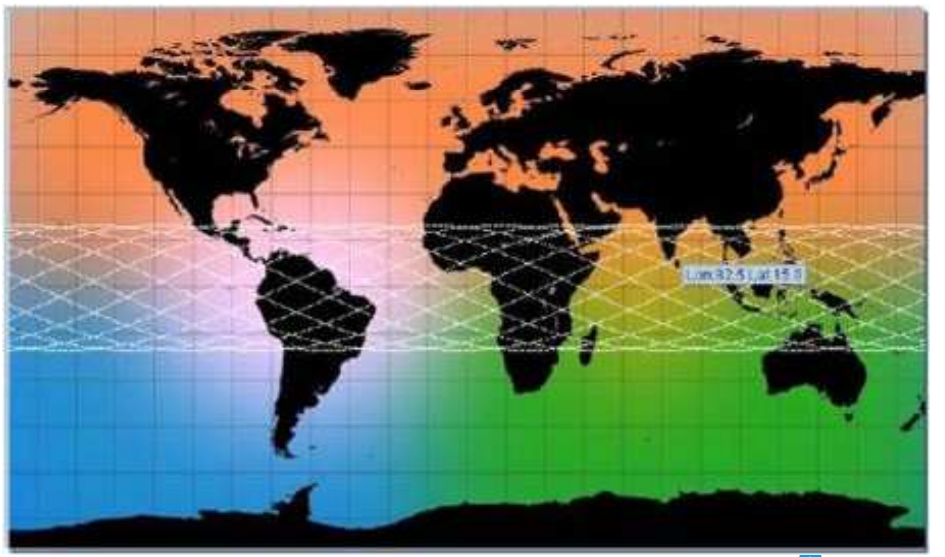
- Outgoing fluxes at TOA
- 40 km Horizontal Resolution

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



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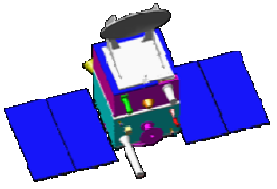
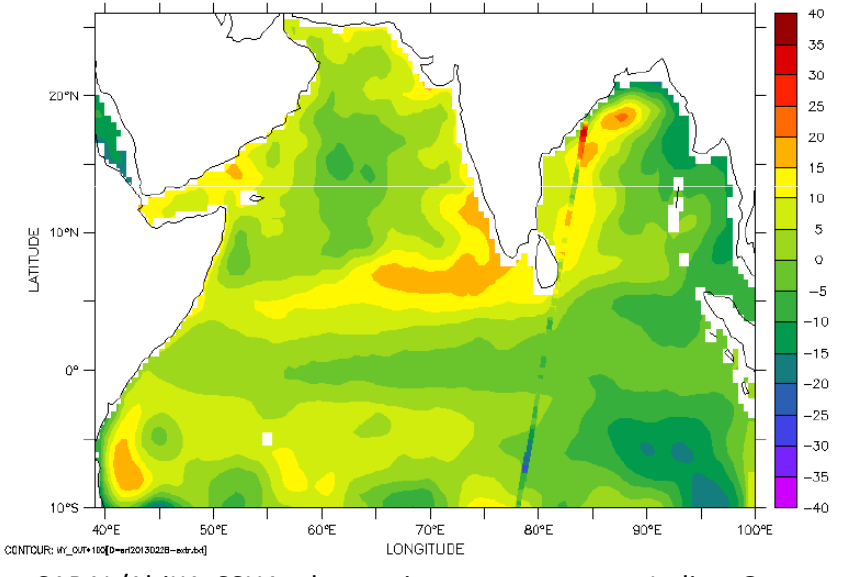
CURRENT LEO SATELLITES: SARAL: Satellite with Argos and Altimeter

-Joint Indo-French satellite mission for oceanographic studies

Launch: Feb 25, 2013



Altika/SARAL mission belongs to global altimetry system for precise and accurate observations of ocean topography, circulation & sea surface monitoring



SARAL/AltiKA SSHA observation overpass over Indian Ocean on Feb 28, 2013 and SLA from POM model at 0.5 degree resolution.

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.

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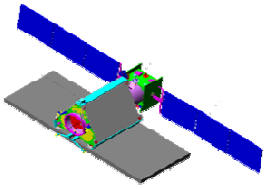
CURRENT LEO SATELLITES: Radar Imaging Satellite (RISAT-1)

Space borne SAR in C-band at 5.35 GHz

Launch: April 2012

Single/ Dual / and hybrid 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.

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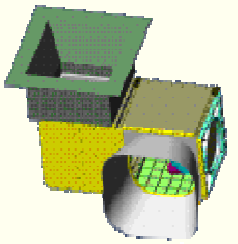
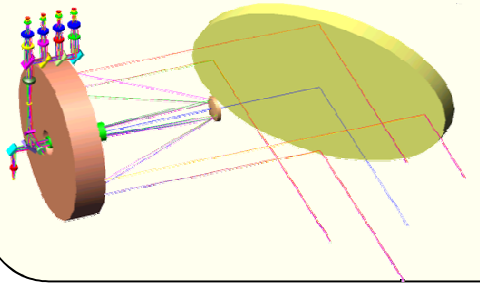
FUTURE GEO SATELLITES: INSAT - 3DR/3DS

LAUNCH: 2016





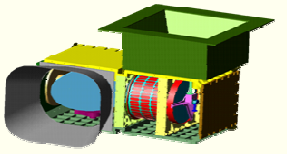
6 Channel IMAGER

- 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

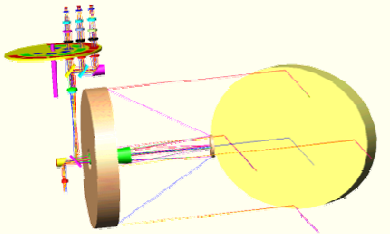
19 Channel SOUNDER



- 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



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FUTURE GEO SATELLITES: (GISAT)

Launch Schedule: 2017, Geostationary orbit, 83E

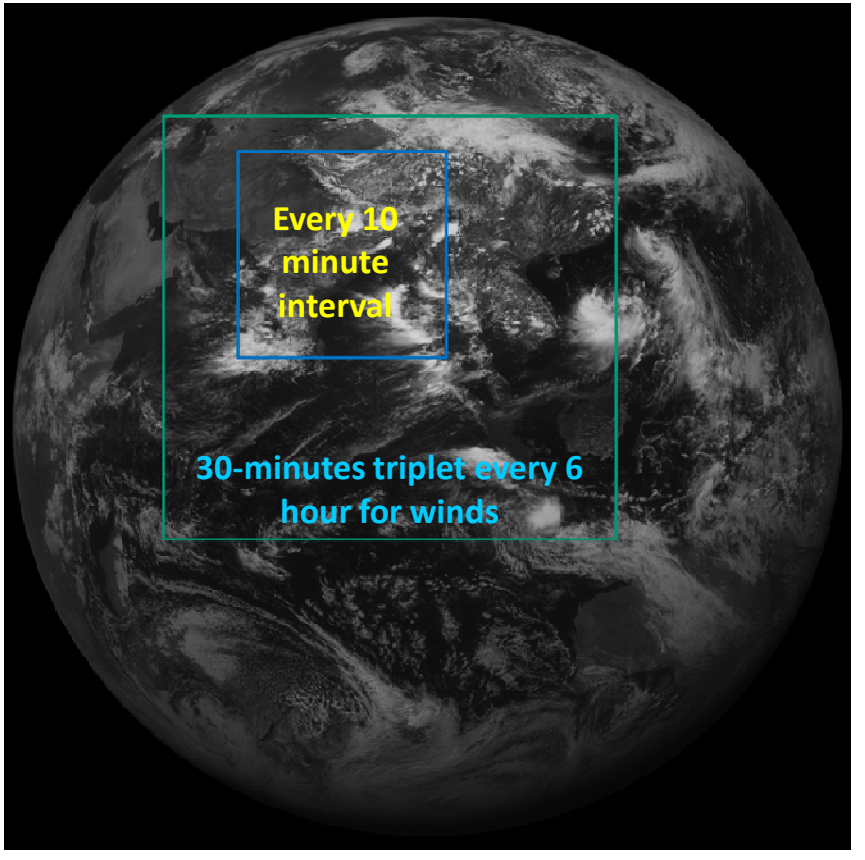
MX-VNIR: Multispectral - Visible Near Infrared, HySI-VNIR: Hyperspectral Imager - Visible Near Infrared, HySI-SWIR: Hyperspectral Imager - Short Wave Infrared, MX-LWIR: Multispectral - Long Wave Infrared.

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

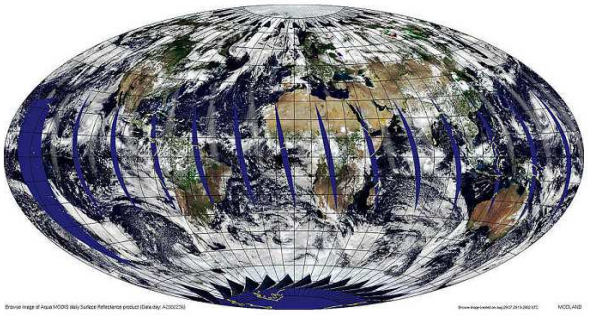
Coordination Group for Meteorological Satellites

GISAT Scan scenario

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

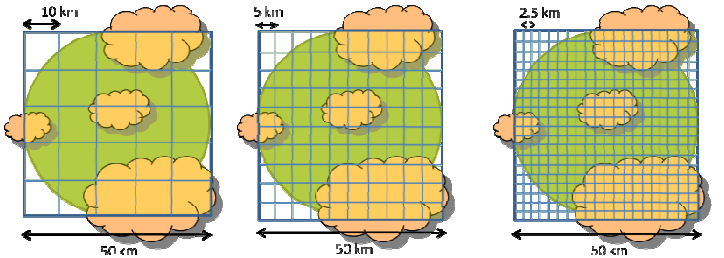


GISAT – Products



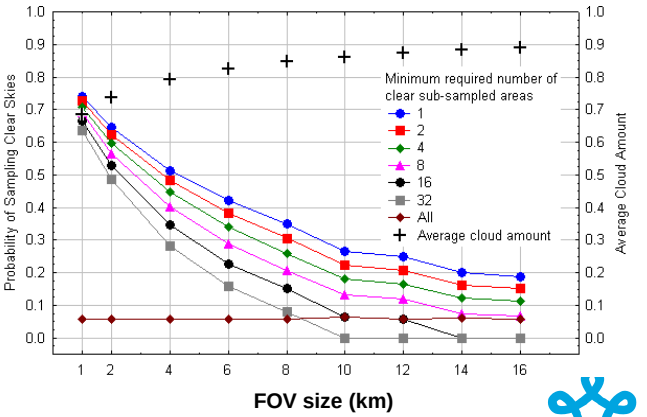
GISAT Strength

- High spatial (1.5 km) and temporal resolution (10 minutes) from LWIR
- High spatial and spectral resolution from VNIR and SWIR bands for cloud microphysics



GISAT Products

- Cloud properties (type, amount, phase, height)
- Atmospheric stability
- Atmospheric motion vectors (AMV)
- Mid-Tropospheric Humidity
- Total Precipitable Water (TPW)
- High spatio-temporal resolution Rainfall
- Sea surface temperature (SST)
- Outgoing longwave radiation (OLR)
- Shortwave Radiation (SWR)
- Total column ozone
- Clear-sky Radiances
- SO_2 estimates



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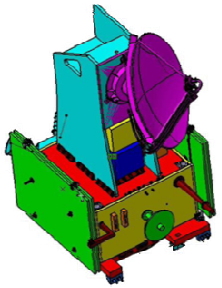
GISAT – Atmospheric Applications

- **Tropical Cyclone:** Detection and prediction of cyclone structural features within inner core with high spatio-temporal resolution and accuracy.
- **Nowcasting:** Prediction and monitoring of mesoscale convective systems
- **Cloud properties:** cloud type, height, cloud top pressure and temperature
- **Disaster Management:** High spatio-temporal resolution rainfall for flood forecasting
- **Radiance Assimilation:** Clear-sky radiances for prediction of rapidly changing weather systems (thunderstorm, cloud-burst etc.)
- **Aviation Applications:** Atmospheric turbulence, Fog prediction, thunderstorm
- **Ocean Applications:** High spatio-temporal resolution SST, Shortwave Radiation
- **Climate application:** Total column Ozone, OLR
- **SO_2 Monitoring:** In absence of cirrus clouds

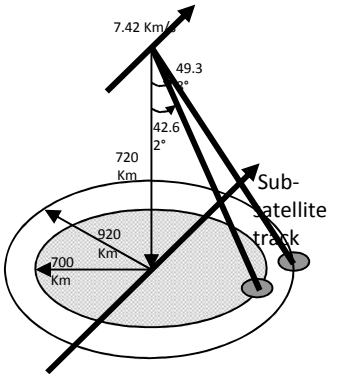
FUTURE LEO SATELLITES: (SCATSAT-1)

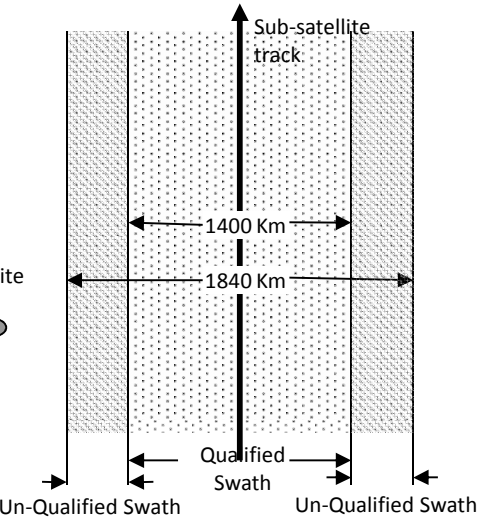
SCATSAT-1 is planned as an in-orbit replacement for the Scatterometer carried onboard Oceansat-2, which is non-functional after 4 ½ years of service.



Orbit : 720 km in sun-synchronous

LAUNCH: July 2016





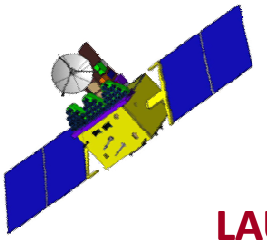
- IMS-2 Bus
- Ku-Band (13.515 GHz) Pencil beam Scatterometer
- Wind Products: 25 km x 25 km
- Swath: 1440 Km
- Polarization: HH and VV
- Wind Direction: O to 360 deg with accuracy of 20 deg
- Wind Speed: 4 to 24 m/s with accuracy of 10% or 2m/s

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.

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:

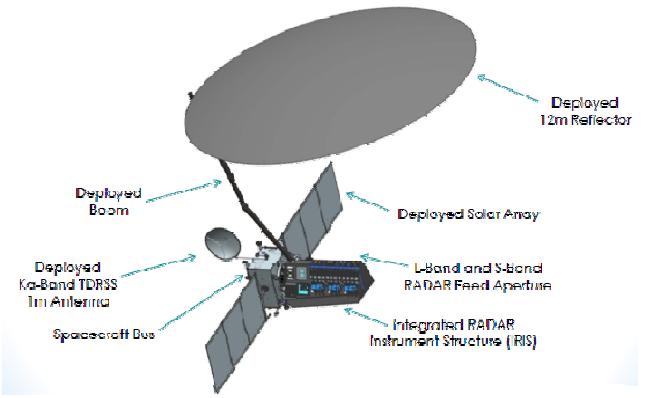
- **13-band Ocean Colour Monitor (OCM) - 400-1010 nm range; 360 m resolution; 1400 km swath**
- **2-band Long Wave Infra Red (LWIR) around 11 and 12 µm**
- **Ku-Band Pencil beam SCATTEROMETER**

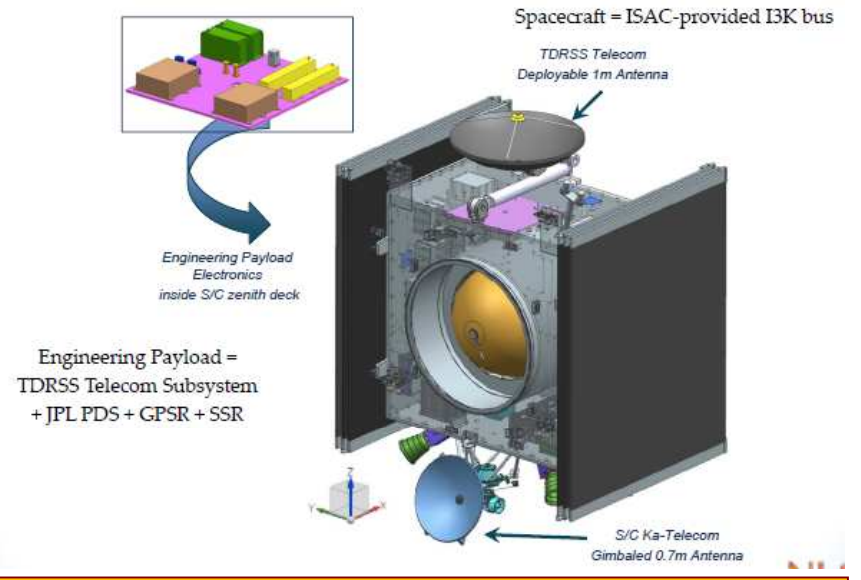
Objectives:

- 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.

FUTURE LEO SATELLITES: (NEMO-AM)

Nano satellite for Earth Monitoring and Observation- Aerosol Monitoring (NEMO)

- The MADPI sensor is capable of measuring multi-angle and polarised radiance at top of the atmosphere at high spatial resolution (30 m @ nadir) and radiometric resolution of 12 bits.
- The instrument is designed to observe reflected radiances in three spectral bands (480-500 nm, 660-680 nm and 860-880 nm).
- The unique capability of dual polarisation & multi–angle measurements through MADPI would open new areas of research in the field of aerosol monitoring.

Parameter	Value
IGFOV	30 m @500 km altitude
FOV	± 4.2deg X ± 1.5deg
Multi-angular view	7 view angles
Quantization	12 bits
Polarised channels	P-S polarised (0-90 deg)
Spectral Bands	480-500 nm, 660-680 nm and 860-880 nm
SNR @ saturation radiance	>90