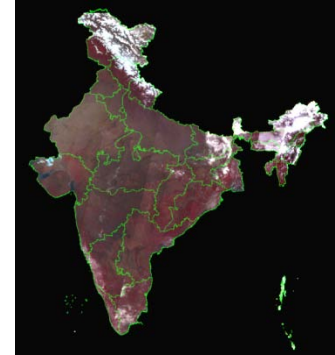


# Status report on the current and future Indian EO satellite systems



Dr. R. Ramakrishnan ,SAC/ISRO  
Dr.A.Senthil Kumar, NRSC/ISRO  
Dr. Virendra Singh, IMD

Presented to CGMS-[42] [Plenary] session, agenda item [D.1]

# Indian Earth Observation Satellites

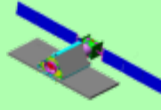
**2009**

RISAT-2  
X-SAR



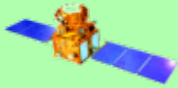
**2012**

RISAT-1  
C-SAR



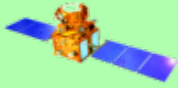
**2011**

RESOURCESAT-2  
LISS 3; LISS 4; AWiFS



**2003**

RESOURCESAT-1  
LISS 3; LISS 4; AWiFS



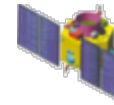
**2008**

IMS-1  
MX-T; HySI



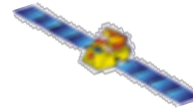
**2007/ 2008/ 2010**

CARTOSAT-2/2A/2B  
PAN



**2005**

CARTOSAT-1  
Stereo PAN, F/A



**2001**

Step  
& Stare PAN



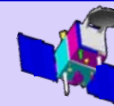
**2013**

INSAT-3D  
IMAGER, SOUNDER



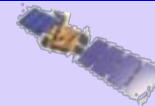
**2013**

SARAL  
ALTIKA, ARGOS



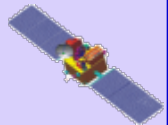
**2011**

Megha-Tropiques  
MADRAS, SAPHIR, SCaRaB



**2009**

OCEANSAT-2  
OCM , SCAT  
ROSA



**2003**

INSAT- 3A  
VHRR, CCD



**2002**

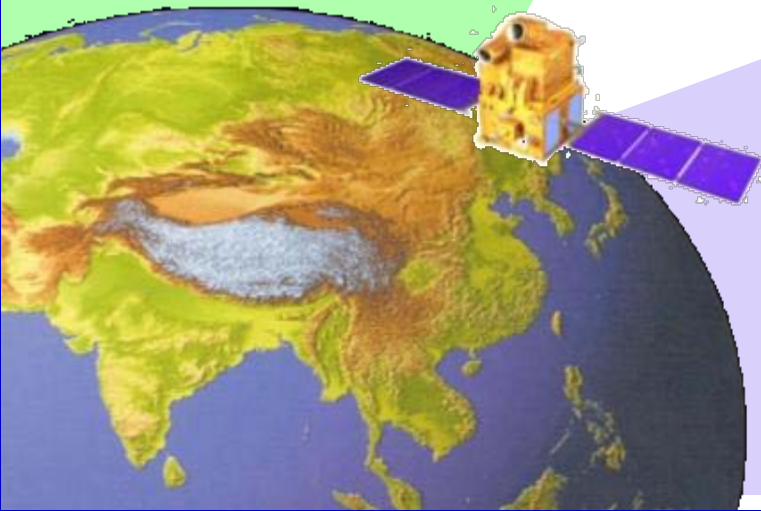
KALPANA-1  
VHRR



- One of the largest constellations
- Provides remote sensing data in a variety of spatial, spectral and temporal resolutions
- Both Optical and Microwave

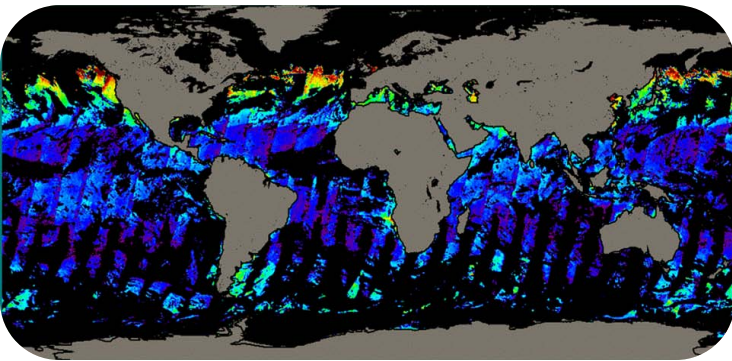
Land & Water

Ocean & Atmosphere



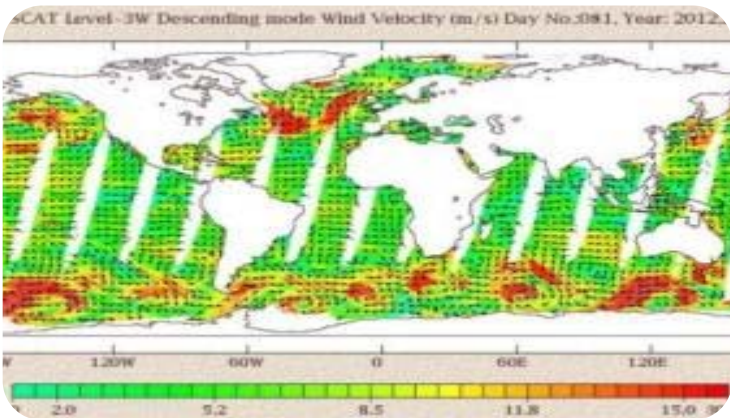
# Oceansat-2 (2009)

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



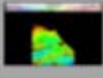

## Global data acquisition of Ocean colour

- High Resolution Data - NRSC and INCOIS
- 1km resolution global products through NRSC Website
- Global Chlorophyll, Aerosol Optical Depth through NRSC Website
- Regional/Global NDVI, VF, Albedo products



## Scatterometer Wind Products

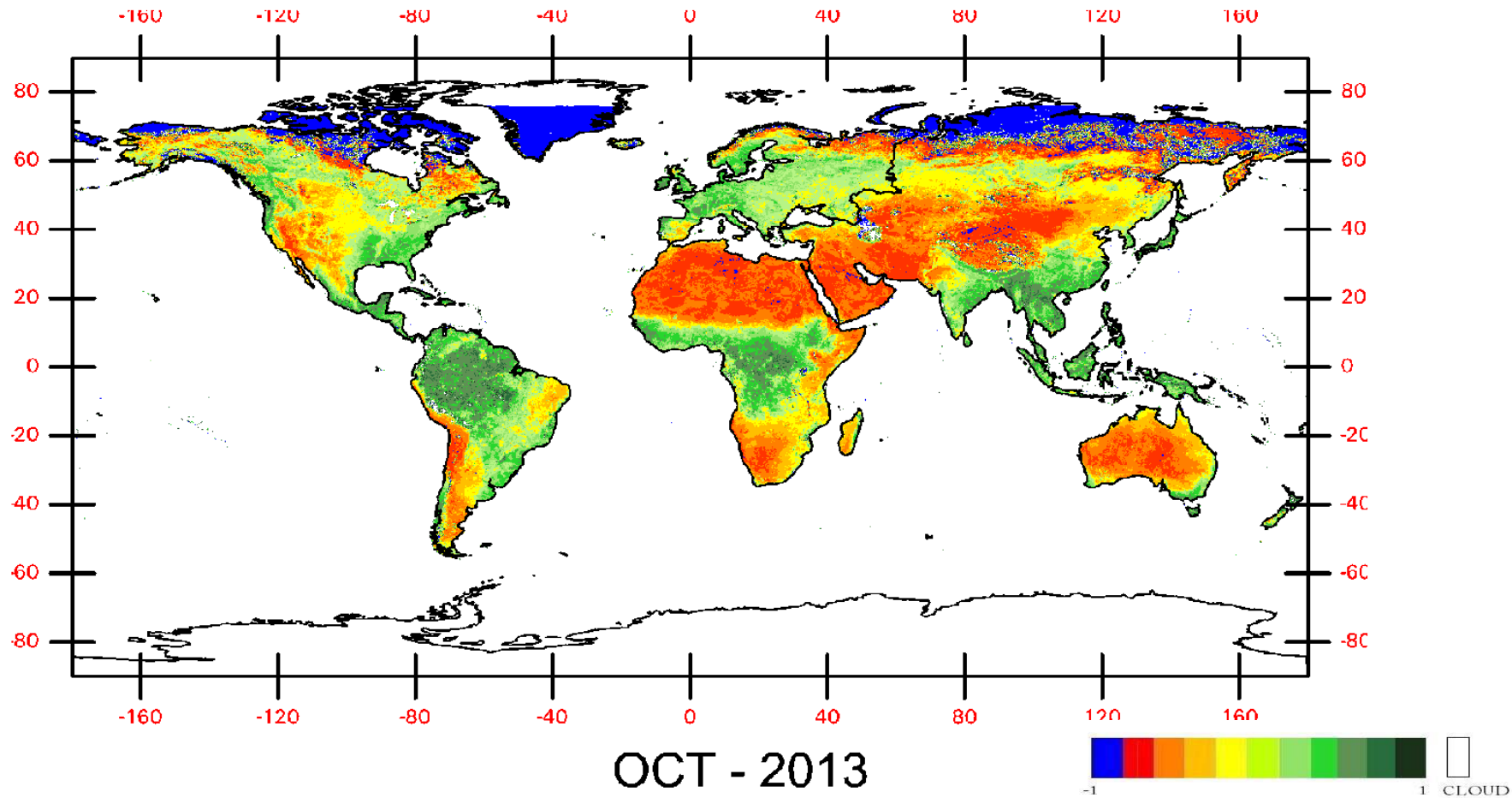
- Reception Station at Svalbard
- Real time transfer and processing
- Uploading to Web within 3 hrs through EUMETCAST
- 1.72 Lakhs data are downloaded from NRSC Website

OCM GAC Products		SCATTEROMETER Products	
	Radiance Products <a href="#">Read more</a>		Scatterometer Wind Products <a href="#">Read more</a>
	Geo-physical Parameter Products <a href="#">Read more</a>		Scatterometer Global Sigma-0 Products <a href="#">Read more</a>
	Binned Products <a href="#">Read more</a>		Scatterometer Global Wind Vector Products <a href="#">Read more</a>

## Data Dissemination Mechanism

- Established Ground station at INCOIS
- Ground station at Bharti, Antarctica is commissioned.
- EUMETCAST, NRSC Website for data and products

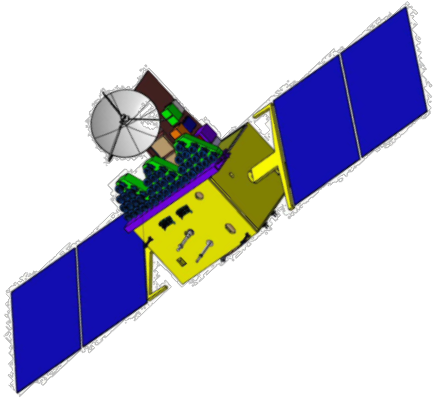
# Global Vegetation Index Products from OCM sensor



Pixel Size: 8 km; Cycle: Monthly; Method: Max. Value Composite (to reduce cloud cover)  
CC>80% with MODIS NDVI

# OCEANSAT-3 Mission

**LAUNCH: 2016-17**



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.

## Payloads:

- An 13-band Ocean Colour Monitor (**OCM**) in VNIR (400-1010 nm range) with 360 m spatial resolution and 1400 km swath for ocean Colour monitoring
- 2-band Long Wave Infra Red (**LWIR**) around 11 and 12  $\mu\text{m}$  for Sea Surface Temperature (thermal channels) at 1080 m resolution.
- A Ku-Band Pencil beam **SCATTEROMETER** with a ground resolution of 50 km x 50 km for Continuity of wind vector data for cyclone forecasting and numerical weather modelling

## 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, is envisaged in this mission.
- 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.

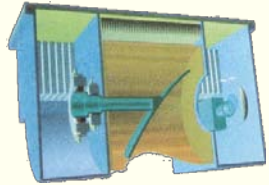


# Megha-Tropiques (Indo-French Mission: 2011)



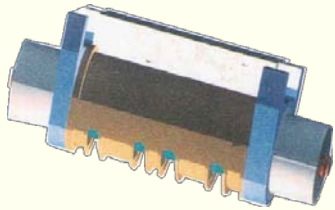
For studying water cycle and energy exchanges to better understand the life cycles of the tropical convective system. The satellite is contributing to Global Precipitation Mission (GPM)

## SAPHIR



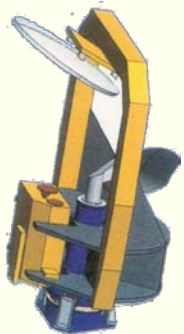
- Water vapour profile
- Six atmospheric layers upto 12 km height
- 10 km Horizontal Resolution

## SCARAB



- Outgoing fluxes at TOA
- 40 km Horizontal Resolution

## MADRAS

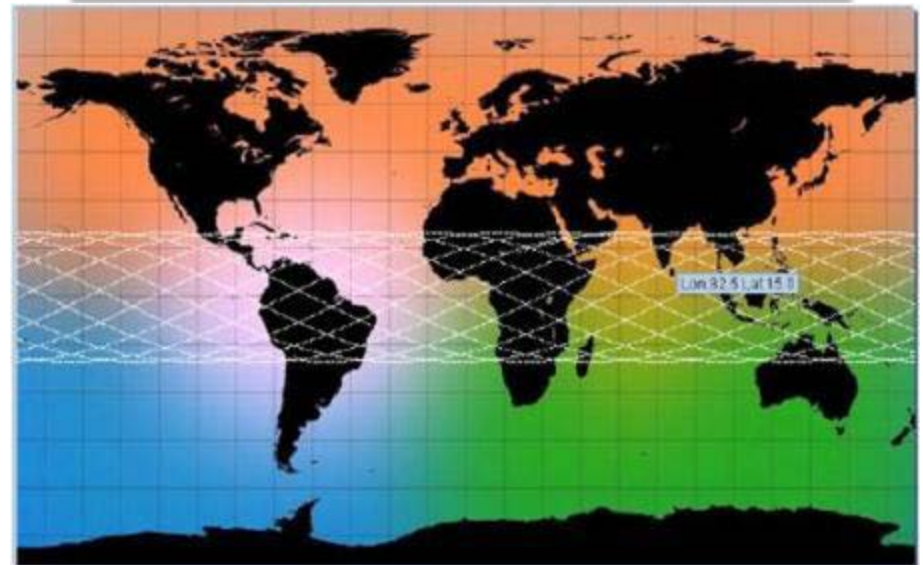


- Precipitation and Cloud properties
- 89 & 157 GHz: Ice particles in cloud top
- 18 & 37 GHz: Cloud Liquid Water and precipitation; Sea Surface Wind speed
- 24 GHz : Integrated water vapour

## Applications:

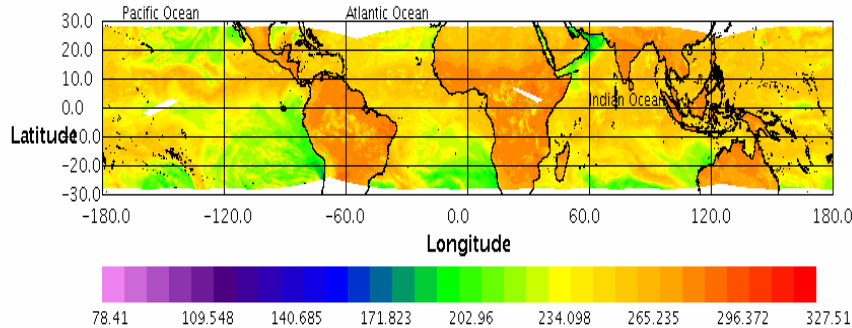
### Observations of tropics for

- Water vapour
- Clouds
- Cloud condensed water
- Precipitation
- Evaporation

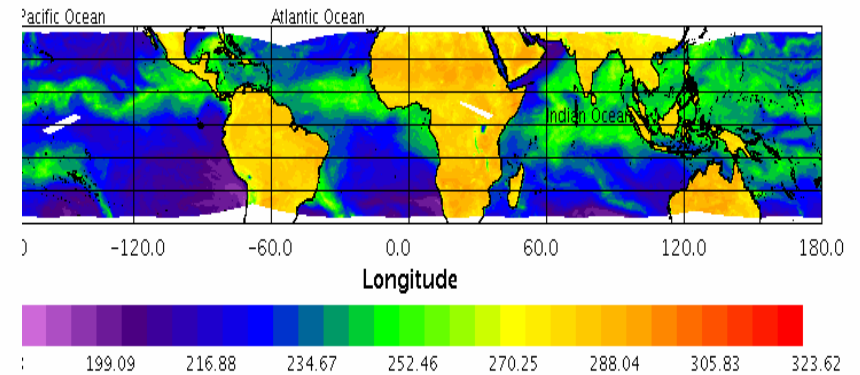


# MADRAS Brightness Temperature

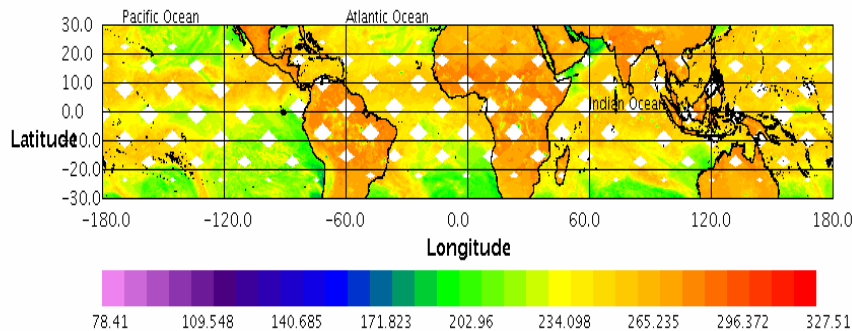
MADRAS\_CH-M4-H(89.0GHz)\_Brightness\_Temperature(17\_Oct\_2011)



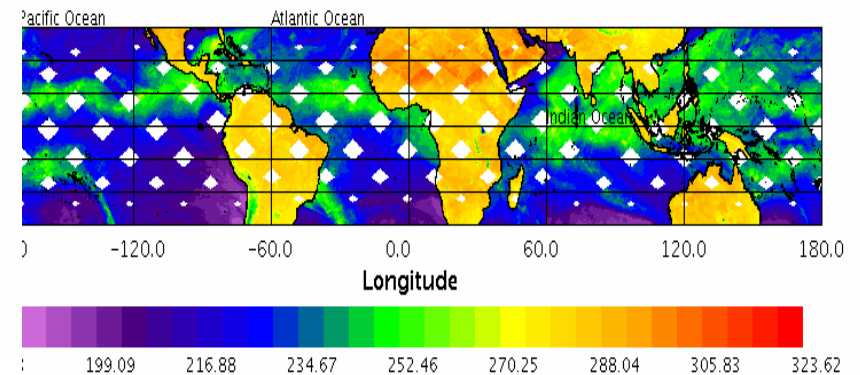
MADRAS\_CH-M2-V(23.8GHz)\_Brightness\_Temperature(17\_Oct\_2011)



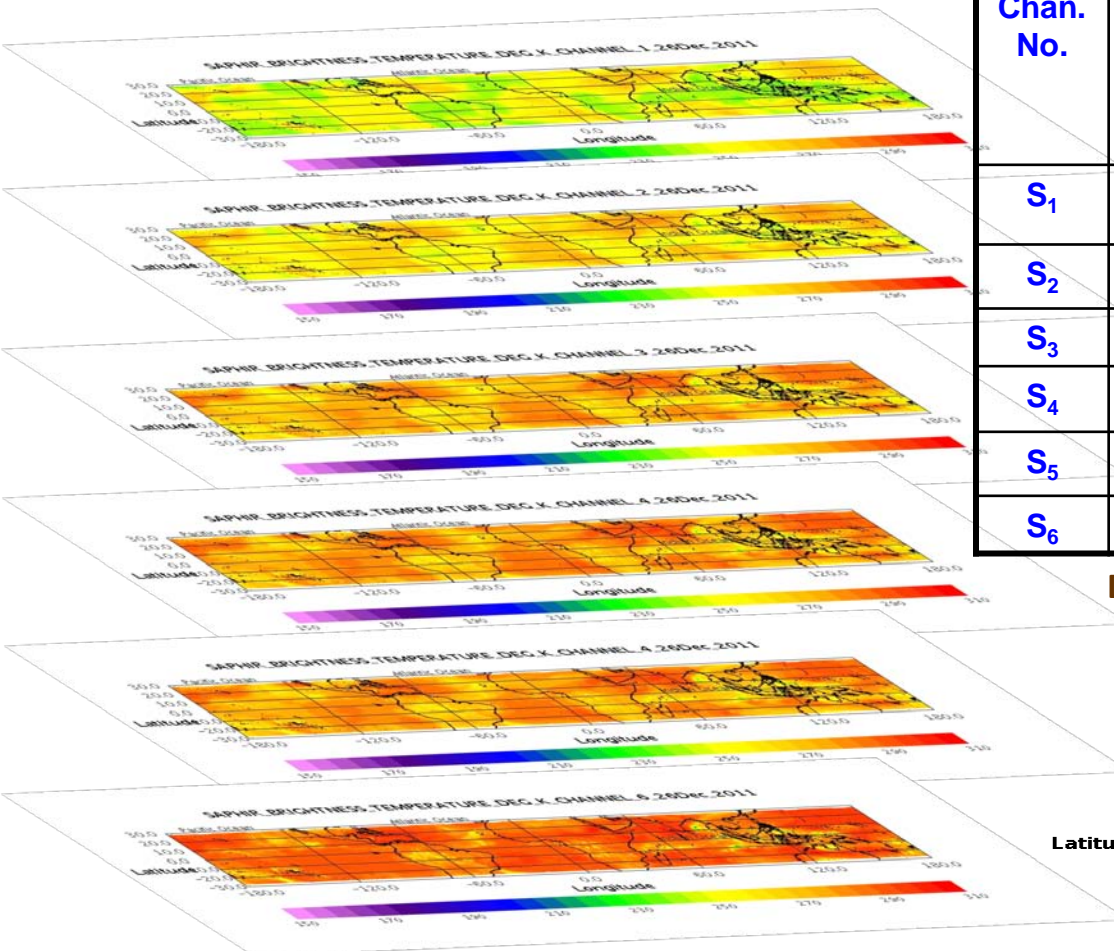
TRMM-TMI\_CH9(85.5GHz,H)\_Brightness\_Temperature(17\_Oct\_2011)



TRMM-TMI\_CH5(21.0GHz,V)\_Brightness\_Temperature(17\_Oct\_2011)



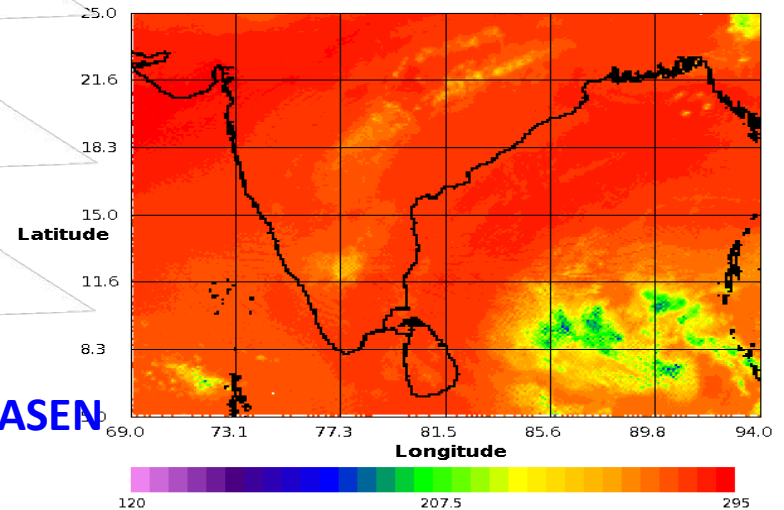
# SAPHIR Brightness Temperature Specifications



SAPHIR Six Channels

Chan. No.	Central frequency (GHz)	BW (MHz)	$\Delta T(K)$ sensitivity Requirement (goal) at 300K	Absolute Calibration (K) over 180-300K
S <sub>1</sub>	183.31±0.2	200	2(1)	±1
S <sub>2</sub>	183.31±1.1	350	1.5(0.7)	±1
S <sub>3</sub>	183.31±2.7	500	1.5(0.7)	±1
S <sub>4</sub>	183.31±4.2	700	1.3(0.6)	±1
S <sub>5</sub>	183.31±6.6	1200	1.3(0.6)	±1
S <sub>6</sub>	183.31±11	2000	1.0(0.5)	±1

Dynamic Temperature Range: ( 4K - 310K)

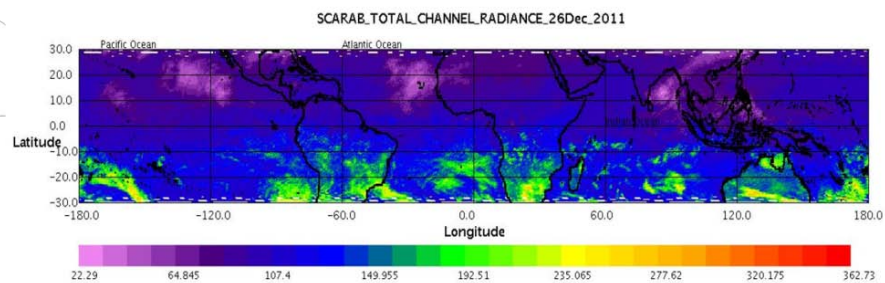
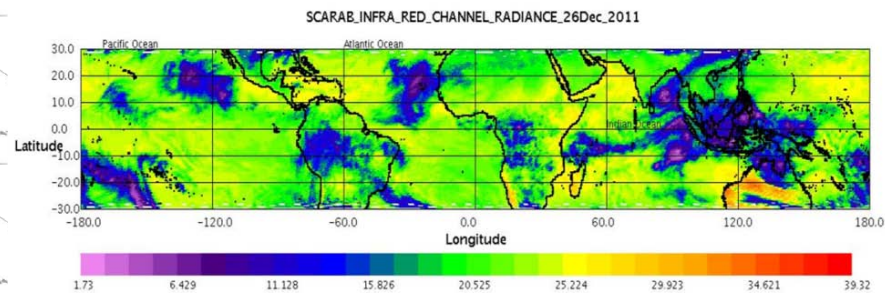
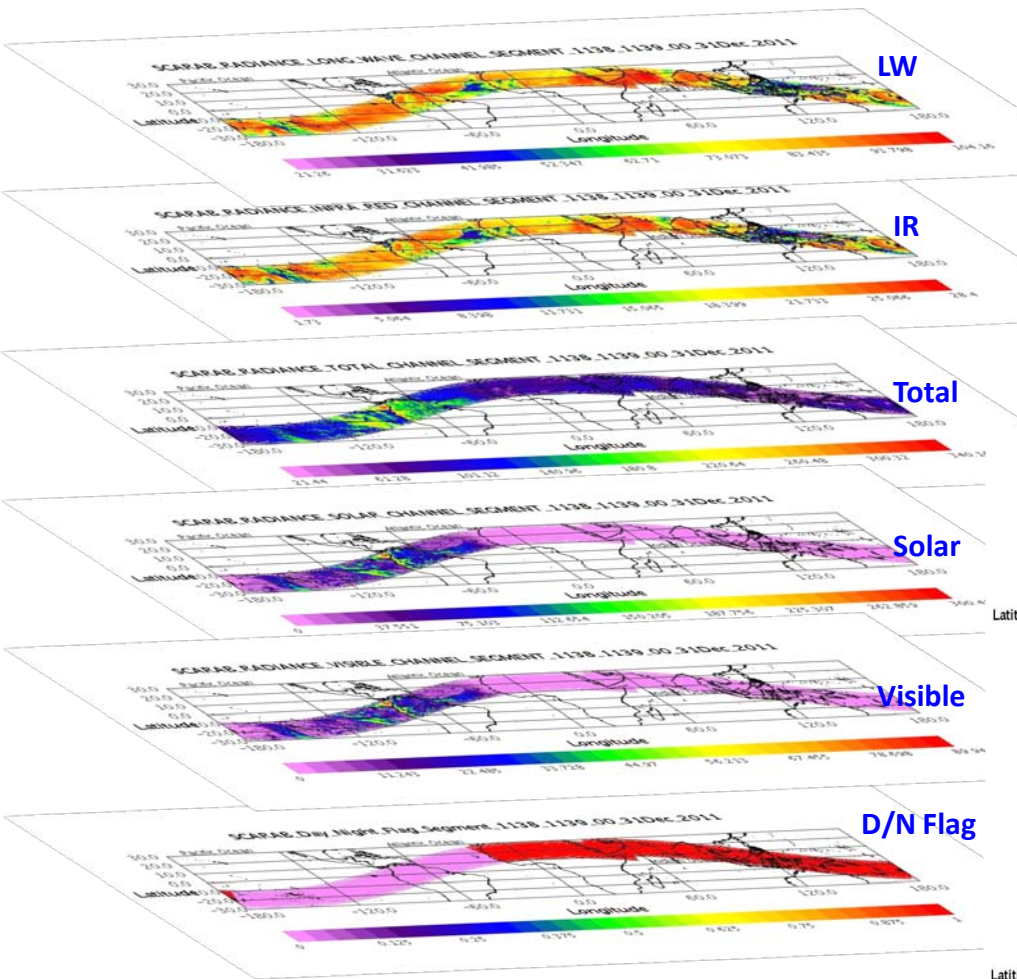


Cyclone - MAHASEN  
From Megha-Tropiques Eyes



# SCARAB Radiance Specifications

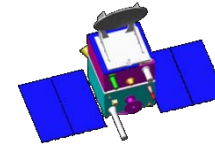
Channel	Wavelength (mm)	Signal Dynamics $W.m^{-2}.sr^{-1}$	Noise (Crest) $W.m^{-2}.sr^{-1}$
Sc <sub>1</sub> -Visible	0.55-0.65	120	<1
Sc <sub>2</sub> -Solar	0.2-4.0	425	<0.5
Sc <sub>3</sub> -Total	0.2-200.0	500	<0.5
Sc <sub>4</sub> -IR Window	10.5-12.5	30	<0.5



# SARAL: Satellite with Argos and Altimeter (2013)

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

French (CNES)- Indian (ISRO) Collaboration

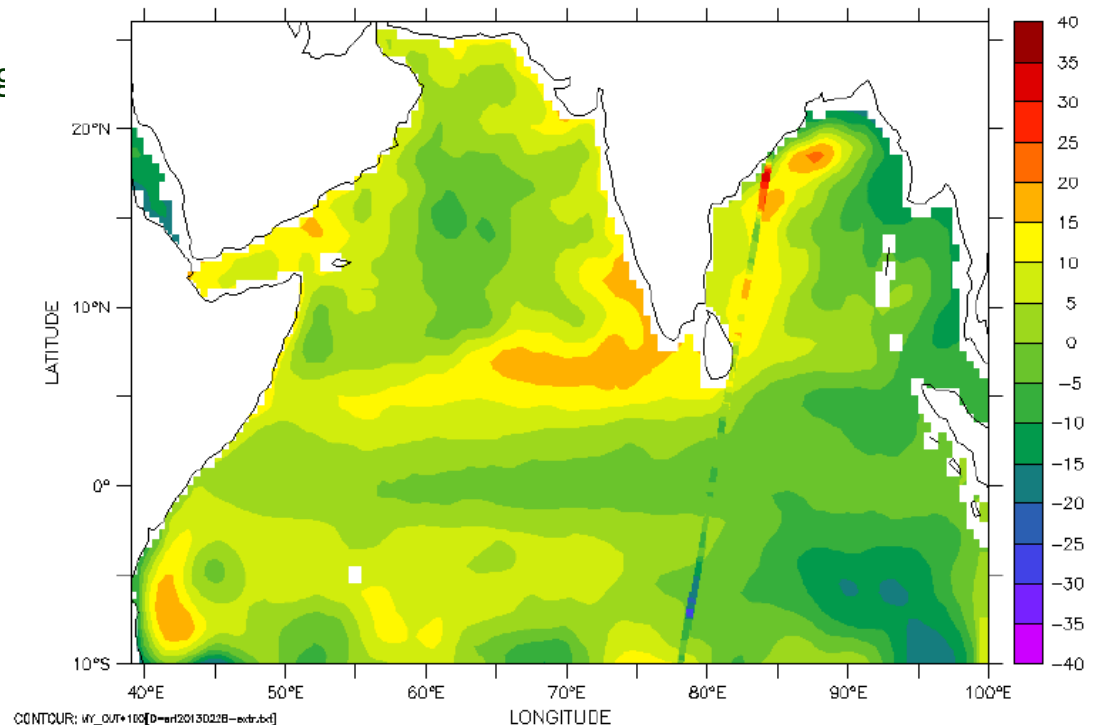


## Mission:

- Sun-synchronous, polar orbiting satellite
- Inclination: 98.38 Deg.
- Altitude: ~800 km
- Repeat cycle: 35 days

## 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



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

# Operational Weather monitoring satellites in GEO

INSAT-3A

VHRR,

CCD

Launch:

**2003**



KALPANA

VHRR

Launch:

**2002**

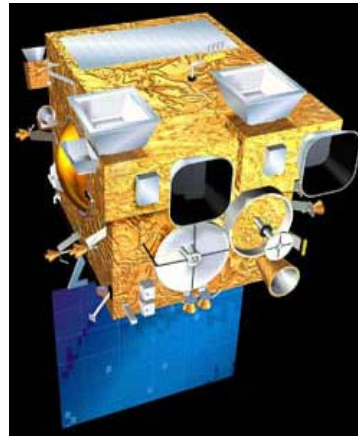
INSAT 3D

Imager

Sounder

Launch:

**2013**

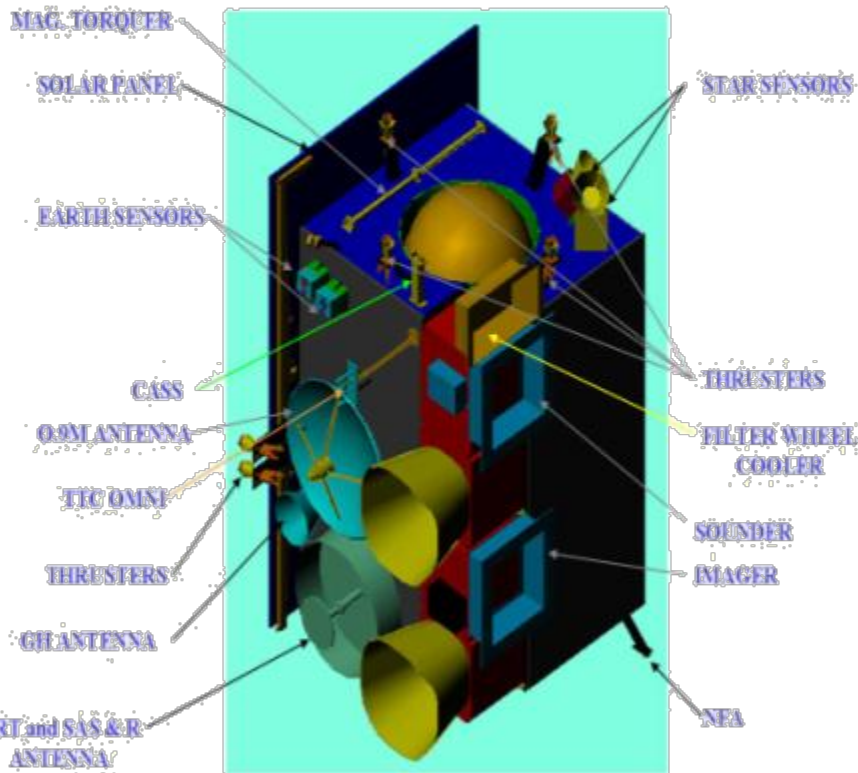


# INSAT-3D (2013)

## Follow Mission to Kalpana



### INSAT 3D S/C (STOWED VIEW)



### Payloads:

#### IMAGER

- Spectral Bands (6): VIS, SWIR, MWIR, WV, TIR- 1 & 2
- Spatial Resolution: 1 km for VIS & SWIR  
4 km for MIR & TIR  
8 km for WV

#### SOUNDER – Water Vapour & Temperature profiles

- Spectral Bands (19): SWIR (6), MWIR (5), LWIR (7), Vis (1)
- Resolution (km): 10 X 10 for all bands
- No of simultaneous sounding : 4 per band

Data relay Transponder; Search & Rescue Payloads

### Potential Applications

Quantitative precipitation estimation, vertical temperature and moisture profile of the atmosphere, surface and cloud top temperatures, ozone distribution, Sea Surface Temperature (SST), fire, smoke, fog detection, etc.



## Advanced weather satellite of India configured with improved Imaging System and Atmospheric Sounder



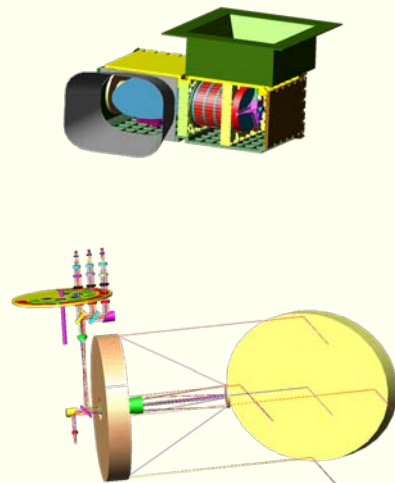
### 6 Channel IMAGER



<ul style="list-style-type: none"> <li>• Spectral Bands (<math>\mu\text{m}</math>)</li> </ul>	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">Visible</td> <td style="padding: 2px;">: 0.55</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">0.75</td> </tr> <tr> <td style="padding: 2px;">Short Wave Infra Red</td> <td style="padding: 2px;">: 1.55</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">1.70</td> </tr> <tr> <td style="padding: 2px;">Mid Wave Infra Red</td> <td style="padding: 2px;">: 3.70</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">3.95</td> </tr> <tr> <td style="padding: 2px;">Water Vapour</td> <td style="padding: 2px;">: 6.50</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">7.10</td> </tr> <tr> <td style="padding: 2px;">Thermal Infra Red – 1</td> <td style="padding: 2px;">: 10.30</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">11.30</td> </tr> <tr> <td style="padding: 2px;">Thermal Infra Red – 2</td> <td style="padding: 2px;">: 11.30</td> <td style="padding: 2px;">-</td> <td style="padding: 2px;">12.50</td> </tr> </table>	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
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																						
<ul style="list-style-type: none"> <li>• Resolution</li> </ul>	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">: 1 km for Vis &amp; SWIR</td> </tr> <tr> <td style="padding: 2px;">4 km for MIR &amp; TIR</td> </tr> <tr> <td style="padding: 2px;">8 km for WV</td> </tr> </table>	: 1 km for Vis & SWIR	4 km for MIR & TIR	8 km for WV																					
: 1 km for Vis & SWIR																									
4 km for MIR & TIR																									
8 km for WV																									

### 19 Channel SOUNDER

- Spectral Bands ( $\mu\text{m}$ )
- 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



# Geo Imaging Satellite (GISAT)

**LAUNCH: 2016-17**



**LAUNCH: 2016-17**

- **Multiple acquisition capability from a Geosynchronous Orbit**
- **Geostationary orbit of 36,000 km**
- **Every 30 minutes observation over India**



**High resolution multi-spectral VNIR (HRMX-VNIR): 50m Resolution**

**Hyper spectral VNIR: 320m Resolution**

**Hyper spectral SWIR (HySI-SWIR): 192m Resolution**

**High resolution Multi-spectral (HRMX-TIR): 1.5km Resolution**

# GISAT-1

## Payloads:

### 1. High resolution multi-spectral VNIR (HRMX-VNIR):

Bands:	B1 (0.45 mm – 0.52 mm)	} 50m Res.
	B2 (0.52 mm – 0.59 mm)	
	B3 (0.62 mm – 0.68 mm)	
	B4 (0.71 mm – 0.74 mm)	
	B5 (0.77 mm – 0.86 mm)	
	B6 (0.845 mm – 0.875 mm)	

### 2. Hyper spectral VNIR:

No. of Bands : 60 bands in range 0.4 mm to 0.87 mm  
 Resolution : 320 m

### 3. Hyper spectral SWIR (HyS-SWIR):

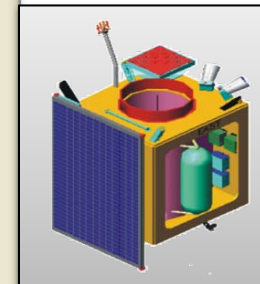
No. of Bands : 150 bands in range 0.9 mm to 2.5 mm  
 Resolution : 192m

### 4. High resolution Multi-spectral (HRMX-TIR):

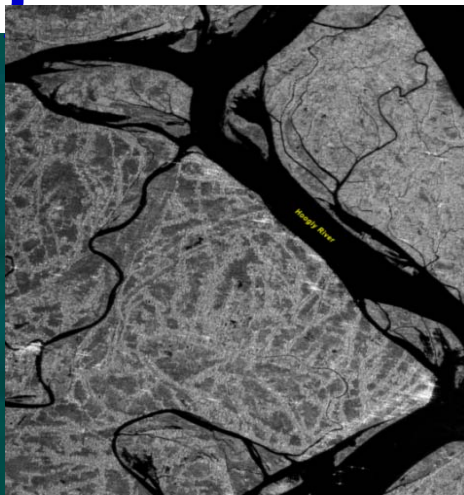
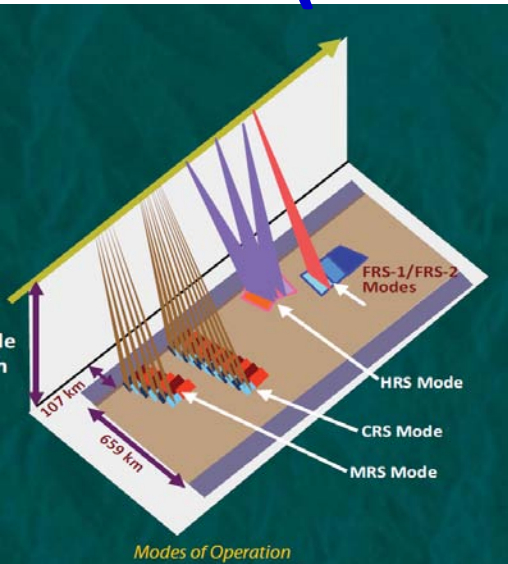
Bands:	TIR1 (7.1 mm – 7.6 mm)	} 1.5 km Res.
	TIR2 (8.3 mm – 8.7 mm)	
	TIR3 (9.4 mm – 9.8 mm)	
	TIR4 (10.3 mm – 11.3 mm)	
	TIR5 (11.5 mm – 12.5 mm)	
	TIR6 (13 mm – 13.5 mm)	

- *Multi-spectral, multi-resolution imager*
- *Full or part of the earth disk from Geosynchronous orbit.*

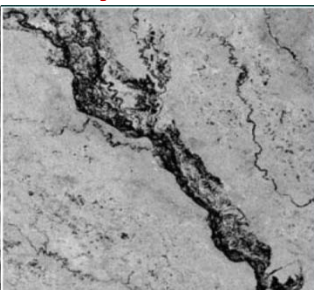
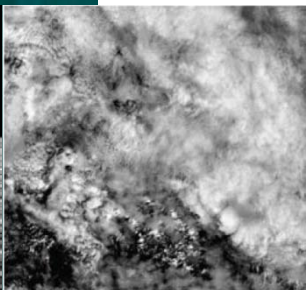
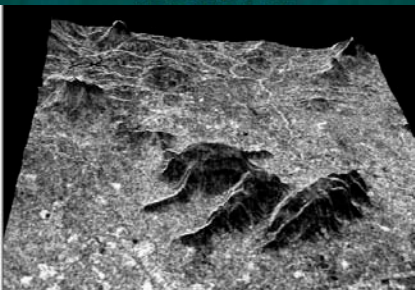
**Frequent Monitoring of Coastal & Ocean Parameters**



## RISAT1(2012)



**Sunderban (West Bengal)  
as viewed by RISAT-1**



**Terrain Visualization  
of RISAT-1**

**Cloudy Area seen  
from optical sensor**

**Cloudy Area seen  
from RISAT-1**

- **C band SAR 5.35 GHz frequency**
- **Land, water, Ocean studies & Disaster Applications**
- **Data is operationally available from NRSC.**

**Coordination Group for  
Meteorological Satellites**

## IMAGING MODES

P/L Modes	Swath in Km	Resolution in m
Coarse Resolution ScanSAR ( <b>CRS</b> )	220	50
Medium Resolution ScanSAR ( <b>MRS</b> )	115	25
Fine Resolution Stripmap Mode ( <b>FRS-1</b> )	25	3
Fine Resolution Stripmap Mode ( <b>FRS-2</b> )	25	9
High Resolution ScanSAR Mode ( <b>HRS</b> )	10 x 100	1

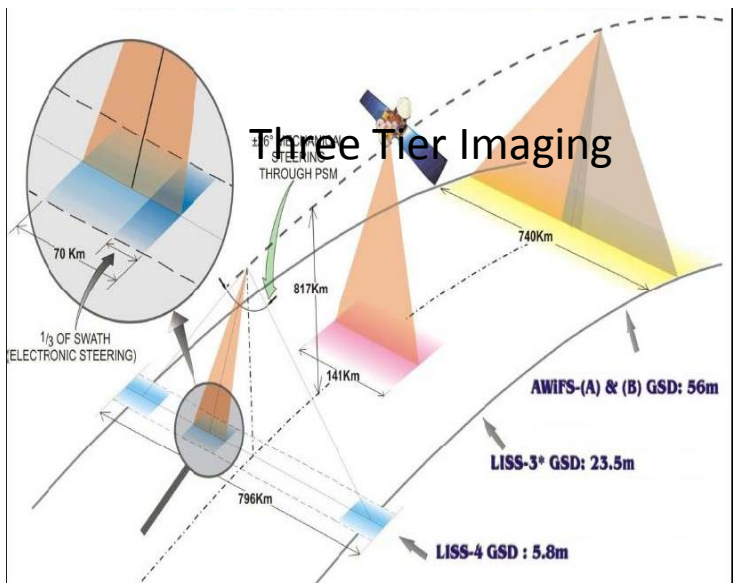
## MISSION

Particular	Value
Orbit	Circular Polar Sun Synchronous
Orbit Altitude	536 km
Orbit Inclination	97.552 degrees
Orbit Period	95.49 min
Number of Orbits per day	14
Repeativity	25 days
Local Time of Equator Crossing	6:00 am/6:00 pm



# RESOURCESAT-2 (2011)

## Payload Specifications



<b>Spatial Resolution</b>	5.8m (LISS-4MX) , 23.5m (LISS-3), 56 m (AWIFS)
<b>Swath</b>	70Km (LISS-4MX) , 141 Km (LISS-3), 740 Km (AWIFS)
<b>Spectral Band</b>	0.5-0.85 microns
<b>Quantization</b>	10 / 12 bits
<b>ROLL tilt</b>	+/- 26 deg ( only for LISS -4MX)
<b>OBSSR Capacity</b>	300 GB

## MISSION

<b>Semi-major axis</b>	<b>7195.12 Km</b>
<b>Altitude</b>	817 Km
<b>Inclination</b>	98.69 deg
<b>No of orbits per day</b>	14 5/24
<b>Orbit period</b>	101.35 min
<b>Eccentricity</b>	0.0001
<b>Receptivity (LISS-III)</b>	24 days
<b>Revisit (LISS-IV)</b>	5 days
<b>Receptivity (AWIFS)</b>	5 days
<b>Ground Track Velocity</b>	6.65 Km/sec
<b>Equatorial Crossing</b>	10:30 AM ( descending )



SHARJAH, UAE



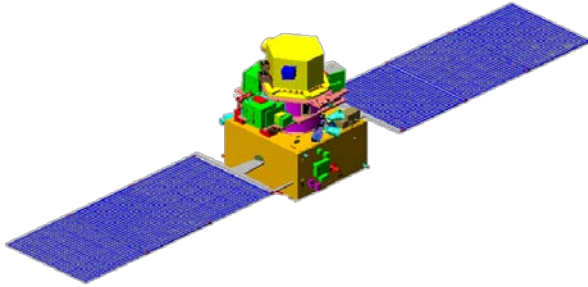
LISS-3 DUBAI



LISS-4 MX



AWIFS



### Major Objectives

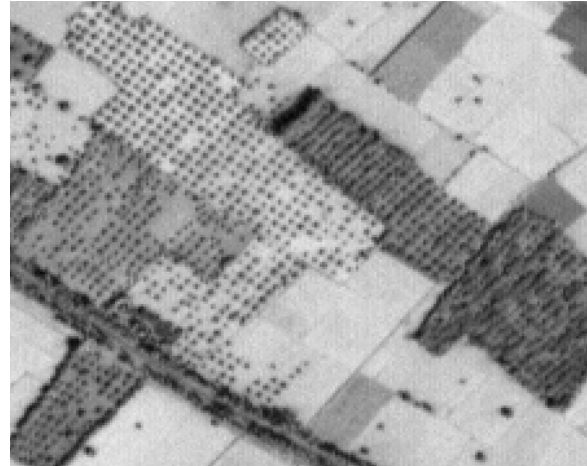
- To provide continuity of on-going services of Resourcesat-2 and ensure in-orbit redundancy of the satellite
- Increased frequency of observations in tandem with Resourcesat-2 during overlap period
- To explore newer application areas in Land and Water Resources monitoring & management

<b>SENSORS</b>	<b>SPECTRAL BANDS</b>	<b>Ground Resolution (meters)</b>	<b>Swath (km)</b>	<b>Radiometric Resolution (bits)</b>	<b>Revisit Cycle (days)</b>
LISS III VNIR/SWIR	B2 B3 B4 B5	23.5	141	10	24
LISS-IV MX VNIR	B2 B3 B4	5.8	70	10	24
AWiFS VNIR/SWIR	B2 B3 B4 B5	56	740	12	5

# Cartosat-1 and 2 (2005, 2007)

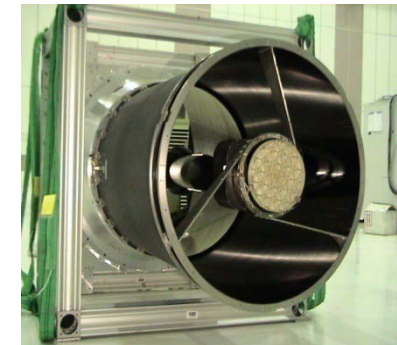
## Cartosat-1

- 2.5 m resolution, 30 km Swath
- Stereo mission;  $+26^\circ$  /  $-5^\circ$  forward/ Aft view
- Revisit : 5 days
- Along Track Stereo viewing - first of its kind in the world



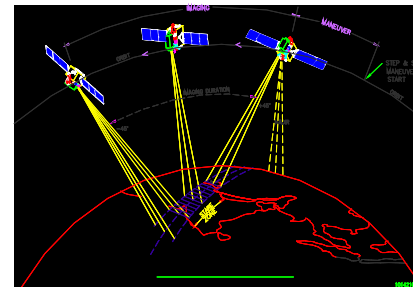
## Cartosat-2

- Swath (km) : 10
- SNR :  $\geq 180$
- IGFOV (m) : 0.8
- SWR (%) :  $\geq 10$



### Cartosat-2 Data Products - Handling of unique imaging modes

- *paint brush*
- *multi-view in step and stare*
- *spot scenes*







### MOSDAC OBJECTIVES

Application of Space Technology for the benefit of the common man.  
Weather forecasting, cyclone prediction & continuous weather & ocean data availability.

### FTP SITES

[MOSDAC](#) | [MEGHATROPIQUES](#) | [CALVAL](#) | [PRWONAM](#) | [SARAL](#)

### ALERTS FROM EXPERIMENTAL FORECAST

Uttarakhand Heavy Rain/Cloudburst Image

### EVENTS

Archives

[EVENTS OF NOVEMBER 2013](#)  
[MARS COLOR CAMERA CAPTURES CYCLONE HELEN on NOV. 19, 2013](#)

### MISSIONS

[KALPANA](#)  
[INSAT3A](#)  
[OCEANSAT2](#)  
[MEGHATROPIQUES\(MT\)](#)  
[SARAL](#)  
[INSAT-3D](#)


### SERVICES

[PRODUCT CATALOGUE](#)  
[METADATA](#)  
[SATELLITE DATA](#)  
[IN-SITU DATA](#)  
[WEATHER FORECAST](#)  
[SEA STATE FORECAST](#)  
[CYCLONE No Cyclone in Ind](#)  
[CALVAL](#)  
[AWS-MP](#)

### TODAY'S FORECAST OF AHMEDABAD

Temperature(°C):42.9(14:30 Hrs)  
 Rain (mm): No Rain  
 Humidity(%):65.5(17:30 Hrs) [more](#)

### ANNOUNCEMENTS

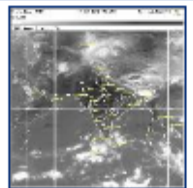
 APR 9, 2014: With deep regret, SAC announces the discontinuation of VALUE ADDED OSCAT WIND PRODUCTS on MOSDAC web site from Feb 21, 2014 onwards, due to payload problem.

### APPLICATIONS

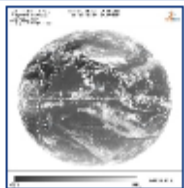
[SARAL - World Sea State Atlas](#)  
[MEGHA-TROPIQUES & SARAL Satellites](#)

- ◊ [Current Position](#)
- ◊ [Orbit Viewer](#)

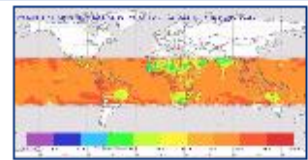
### KALPANA-1



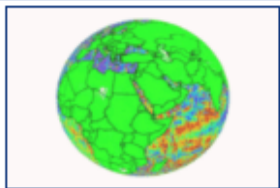
### INSAT-3D



### MEGHA TROPIQUES



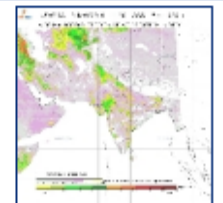
### SARAL-SSHA



### HEAVY RAIN



### OTHER PRODUCTS



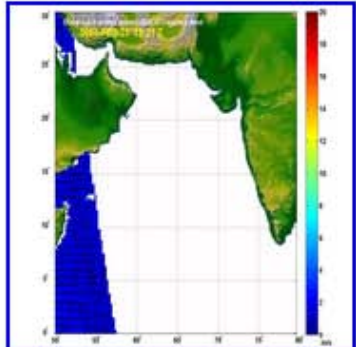


# SCORPIO

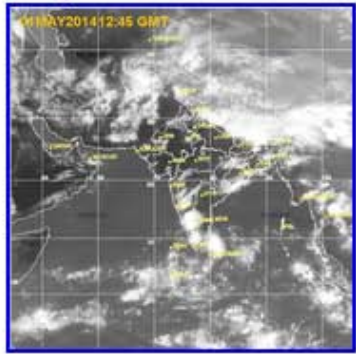
Satellite based Cyclone Observations and Real-time Prediction over the Indian Ocean



Current Date : Thu 01 - May - 2014 Time : 07 : 09 IST



No Cyclone in Indian Ocean



Kalpana IR Image



Longitude  Latitude



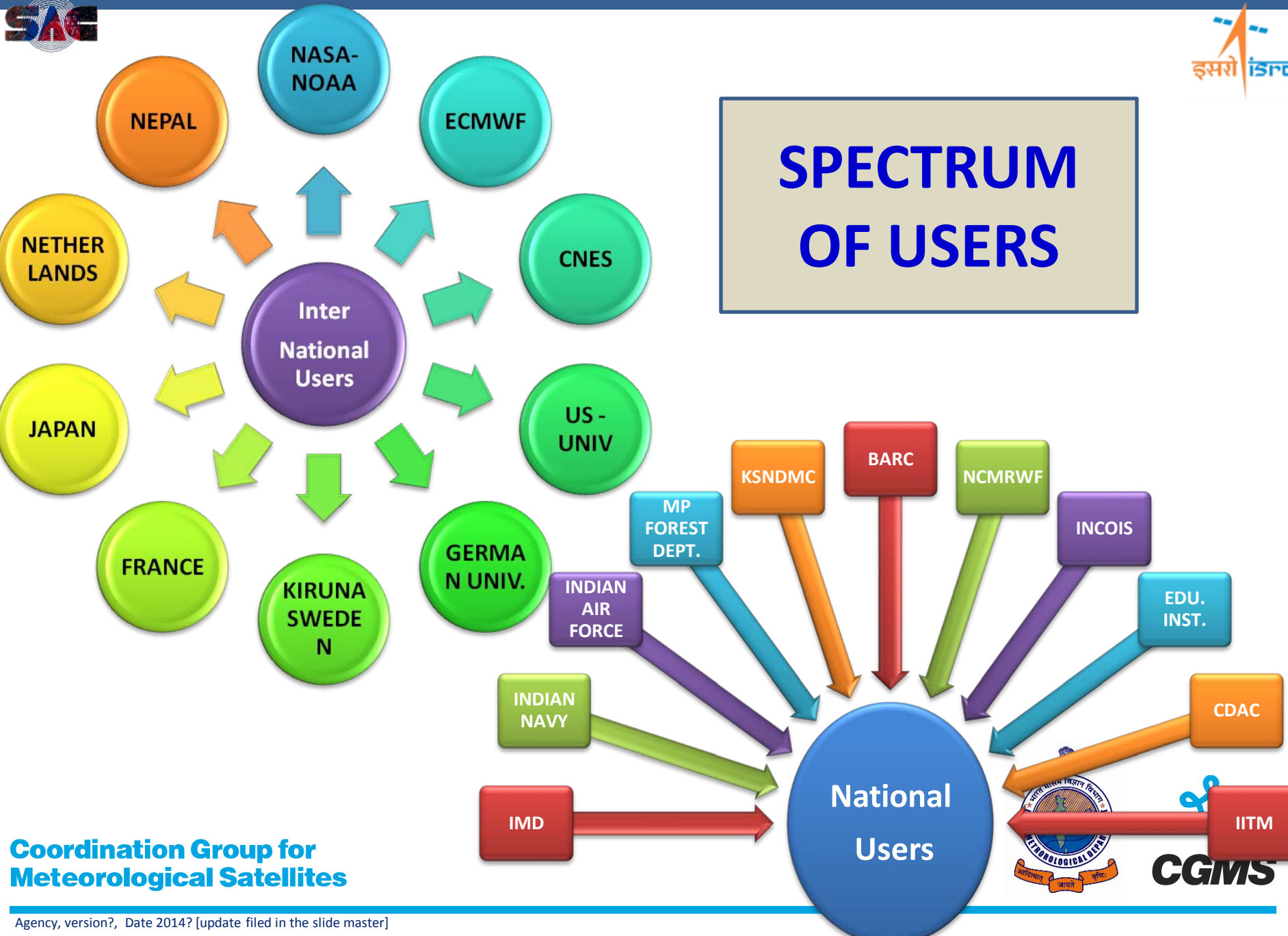
Global Cyclogenesis

Disclaimer:

This is an experimental run. Cyclone position , Intensity and Forecast shown may be subject to large errors. Information must be used with caution.



## SPECTRUM OF USERS



**Bhuvan** is a Geo-portal of ISRO (<http://bhuvan.nrsc.gov.in>), allowing host of services covering visualization, free data download, thematic map display and analysis, timely information on disaster and project specific GIS applications since August 2009.

Name	Description	Data Availability
<b>Bhuvan 2D / 3D</b>	Allows <b>visualization</b> with pan, zoom, place name search, overlays and online editing	Resourcesat-1– AWiFS, LISS III & LISS IV, Cartosat 1 & 2 – PAN (merged with LISS IV), Oceansat – 1&2 - OCM
<b>NRSC Open EO Data Archive (NEODA)</b>	Allows <b>download</b> of free satellite data and products of specified period and resolution	Resourcesat-1: AWiFS Ortho and LISS III Ortho, IMS-1: HySI, CartoDEM, Oceansat-2:OCM2: NDVI(LAC, GAC), VF and Albedo, Tropical Cyclone Heat Potential, Ocean Heat Content, D 26, Wind Products.
<b>Thematic Services</b>	To display or <b>analyze</b> using WMS / WMTS (OGC web Services)	Thematic Maps of 1:10,000, 1:50,000, 1:250,000 – Landuse/Landcover, Wasteland, Geomorphology, Lineament, Urban Landuse, Urban Sprawl, Erosion, Salt Affected and Water Logged Area, Water bodies.
<b>Disaster Services</b>	To provide <b>timely information</b> on various disasters for better decision making	Drought, Earthquake, Flood, Forest Fire, Landslide and Cyclone.  Data Support for International Disasters.
<b>Projects</b>	To provide <b>platform</b> to create, visualize, share, analyze Geospatial data products and services towards Spatial Mashups	Municipal GIS, Tourism GIS, Forestry, Irrigation, Agriculture, Urban etc

# NOEDA Products in Bhuvan Store

## A. Satellite/Sensor Basic Data

No.	Product	Resolution	Availability	Coverage: Tile Extent/Spatial Extent	Tiles/ Files
1	<b>IMS-1:Hyper spectral Imager</b>	Spectrally deconvolved 17 bands	2008-12	India: Scene Based	306
2	<b>RS-1: AWiFS Ortho</b>	56 m	2008, 2009 (2 seasons), 2010 (2 seasons)	India: 1° X 1°	1648
3	<b>RS-1:LISS III Ortho</b>	24 m	2008-09, 2011	India: 15' X 15'	9636
4	<b>Cartosat-1: DEM</b>	30 m	2006-08	India: 1° X 1°	375

## B. Thematic Products – Land Geophysical

No.	Product	Resolution	Availability	Coverage: Tile Extent/Spatial Extent	Tiles/ Files
1	<b>OS-2:OCM: NDVI</b>	1 Km	2011(Monthly), 2012 and 2013 (Fortnight)	India	44
2	<b>OS-2:OCM: Vegetation Fraction</b>	1 Km	2011(Monthly), 2012 and 2013 (Fortnight)	India	44
3	<b>OS-2:OCM: NDVI - Global Coverage</b>	8 Km	2013	Global Coverage	5
4	<b>OS-2:OCM: Albedo</b>	1 Km	2013 (Fortnight)	India	7



# NOEDA Climate Products in Bhuvan Store

## C. Ocean – geophysical

No.	Product	Resolution	Availability	Coverage: Tile Extent/Spatial Extent	Tiles/ Files
1	<b>Tropical Cyclone Heat Potential</b>	0.25°	Jan 1998 – till date	North Indian Ocean (30S – 30N; 30-120E )	~6000
2	<b>Ocean Heat Content</b>	0.25°	Jan 2002 – till date	North Indian Ocean (30S – 30N; 30-120E )	~4400
3	<b>Depth of 26°C Isotherm</b>	0.5° x 0.5°	July 2013 – till date	30° S - 30° N; 30° E - 120° E	~200

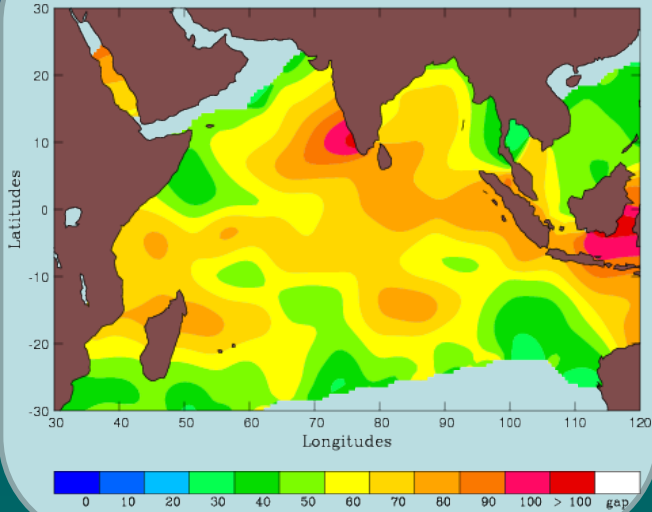
## D. Ocean – wind

No.	Product	Resolution	Availability	Coverage: Tile Extent/Spatial Extent	Tiles/ Files
1	<b>Ocean Wind Stress</b>	0.5° x 0.5°	Jan. 2012 – Mar'14	30° S- 30° N; 30° E- 120° E	~800
2	<b>Ocean Wind Stress Curl</b>	0.5° x 0.5°	Jan. 2012 – Mar'14	30° S- 30° N; 30° E- 120° E	~800
3	<b>Ocean Wind Velocity</b>	0.5° x 0.5°	Jan. 2012 – Mar'14	30° S - 30° N; 30° E- 120° E	~800

# Oceanic Heat Content Products

TCHP (kJ/cm<sup>2</sup>)

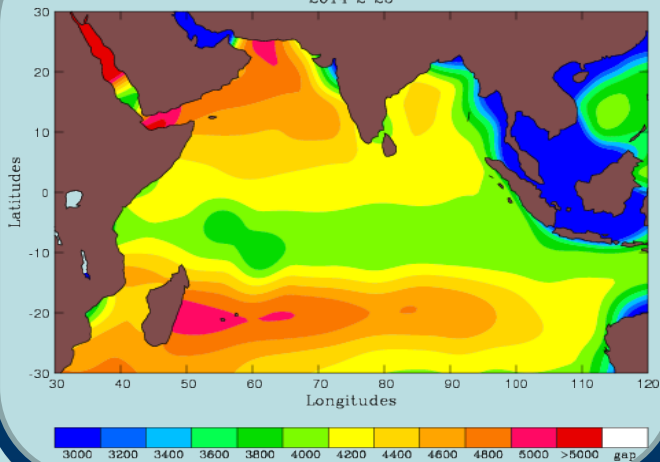
2014 2 25



- ❑ Tropical cyclone heat potential (TCHP) – a measure of energy available for cyclones by summing the heat content in ocean water where SST is above 26 deg.
- ❑ It is predicted with input parameters (a) sea surface height anomaly (SSHA) from Aviso altimeters, b) sea surface temperature (SST) from TRMM Microwave Imager (TMI) & (c) the climatological values of the depth of the 26°C isotherm (D26) derived from temperature profiles of World Ocean Atlas 2009.
- ❑ Daily **0.25 degree TCHP** and **0.5 deg. D26** available since January 1998 to present (one week delay) in png format

OHC<sub>700</sub> (kJ/cm<sup>2</sup>)

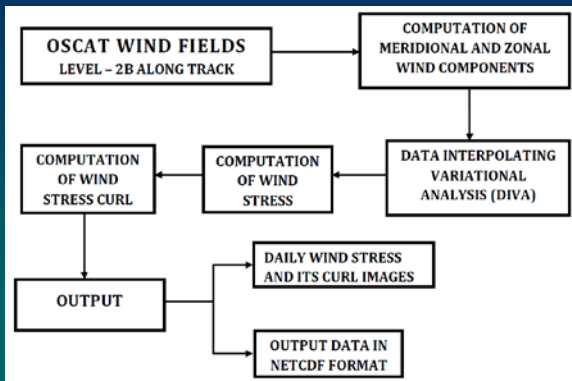
2014 2 25



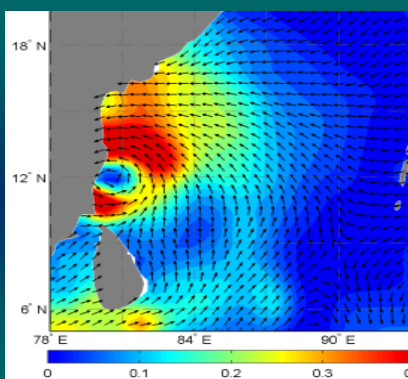
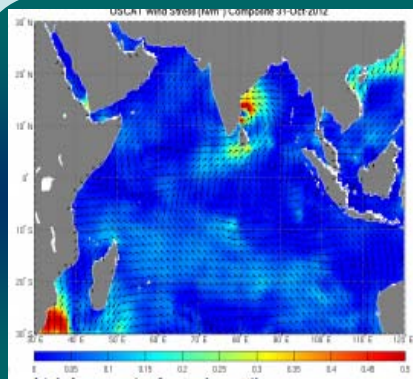
- ❑ Ocean Heat Content at 700m Layer (OHC<sub>700</sub>) – important climatic parameter required for atmospheric and oceanic studies like cyclone and monsoon prediction and ocean heat transport estimations.
- ❑ It is predicted (a) SSHA from altimeters, b) SST from TRMM-TMI, and (c) the climatological values of OHC<sub>700</sub> derived from temperature profiles of World Ocean Atlas 2009.
- ❑ The prediction model is similar one of ANN
- ❑ Daily **0.25 degree OHC<sub>700</sub>** available since January 2002 to present (one week delay) in png image format

# Oceanic Wind Products

## Wind Products

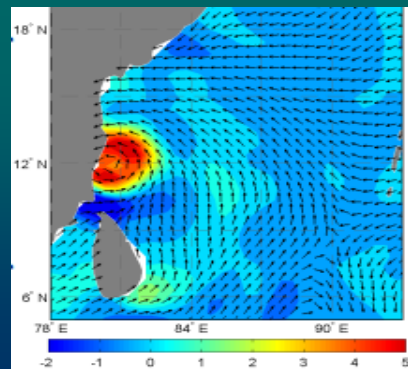
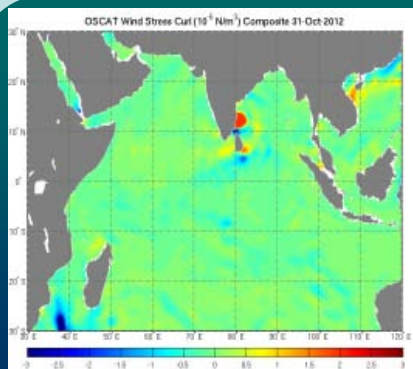


- Daily and Two days wind composites generated from OSCAT over Indian Ocean using Data Interpolation Variational Analysis (DIVA) Methodology developed in collaboration with INCOIS and RC-E.
- Validated with in-situ buoys ( $r=0.81$ ) and ASCAT Winds
- **Wind velocity, stress and curl products** are provided in a 0.5 deg x 0.5 deg grid and made available in 'png' and netcdf formats. **Reprocessing of these products @25km in progress**



### Wind stress

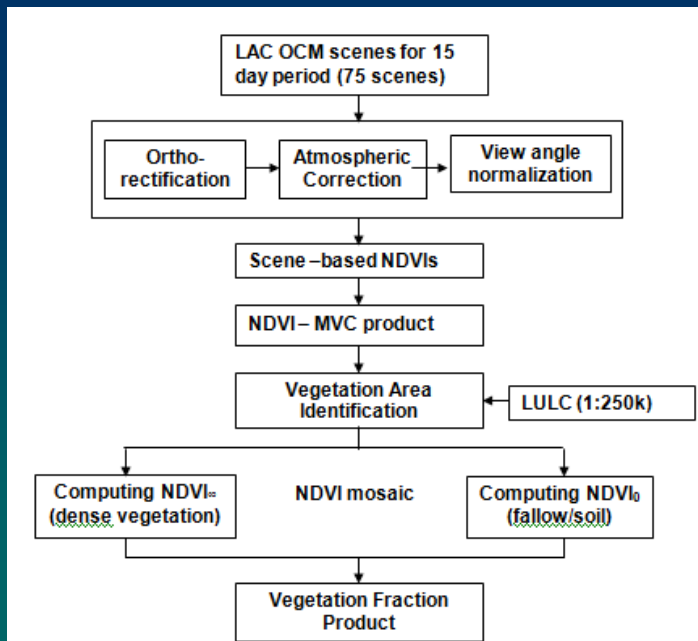
- Horizontal force of the wind or wind stress is calculated from OSCAT wind speed and non-linear drag coefficient .
- Zonal (E-W) /Meridional (N-S) stress products are estimated with angular components of wind vector and combined to release the total wind stress



### Stress Curl:

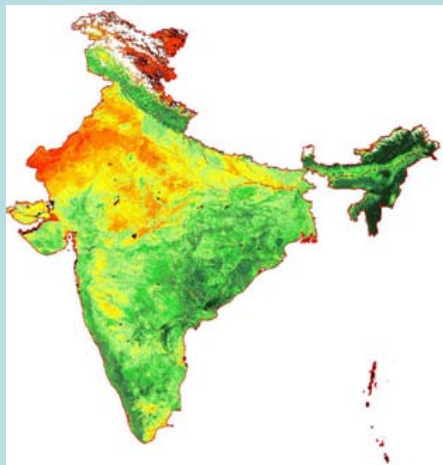
- Curl - a measure of rotation of ocean surface circulation and computed from the zonal and meridional components with numerical differentiation method.

# Terrestrial Vegetation Products

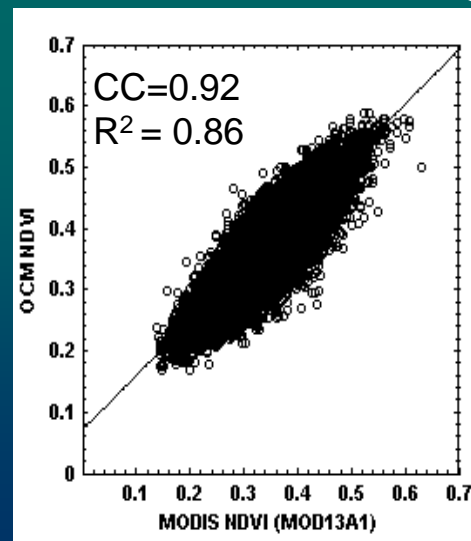
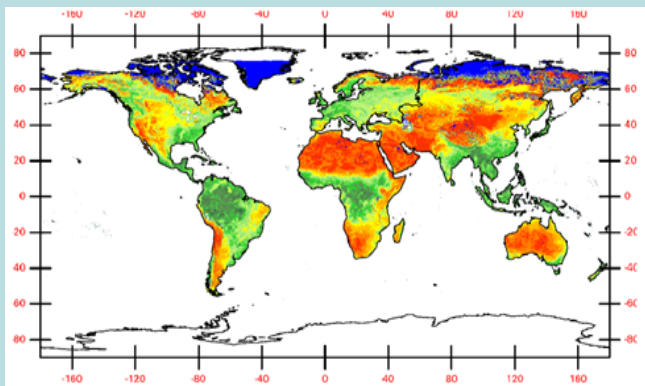


- ❑ **OCM LAC Vegetation products : Advantages of Wide swath of 1420 km, High revisit cycle of 2 days and high radiometric resolution (12 bits per pixel) prompted to attempt land geophysical products from OCM sensor.**
- ❑ Salient features: orthorectification, atmospheric and view angle correction, maximum value compositing (MVC) to minimize cloud masking the land cover
- ❑ 15-day or Fortnightly composite of NDVI and vegetation fraction products are generated and validated with MODIS vegetation products.
- ❑ The products are released at 1 km resolution in tiff from 2011 onwards.
- ❑ OCM GAC NDVI products are monthly (4-cycle MVC) at 8 km resolution

Vegetation Fraction - Nov'13



Global NDVI - Oct'13





# ISRO Cal Val Activities - Overview

- Establishing an Indian Cal-Val Program - by setting up instrumented CAL sites for theme-oriented ISRO missions.
- Collaborating with WGCV teams for Inter-Sensor Calibration with contemporary sensors over CEOS specified global calibration sites.

# Joint Calibration Exercise: RS2 AWIFS & MODIS Cross Calibration over Libya-4 CEOS Site

Collaboration with MODIS (NASA) – FP: Jack Xiong

- Cross calibration was based on 14 AWIFS acquired during June 2011 – Dec. 2012 and corresponding day data of MODIS
- BRDF, Spectral Mismatch, Water Vapor effects are compensated to obtain Radiometric Bias\* between two sensors

$$* Bias = \frac{\rho_{MODIS}^{TOA}}{\rho_{AWIFS}^{TOA}}$$

Bands	TERRA -	Bias	CE-95 Limits	Std. Dev. (%)
AWIFS B2	MODIS B4	1.014	0.967 – 1.06	8.552
AWIFS B3	MODIS B1	1.027	0.994 – 1.06	6.095
AWIFS B4	MODIS B2	1.045	1.020 – 1.069	4.513
AWIFS B5	MODIS B6	1.096	1.061 – 1.130	6.302

Bands	AQUA -	Bias	CE-95 Limits	Std. Dev. (%)
AWIFS B2	MODIS B4	1.012	0.962 – 1.061	9.076
AWIFS B3	MODIS B1	1.024	0.992 – 1.056	5.871
AWIFS B4	MODIS B2	1.045	1.016 – 1.074	5.347
AWIFS B5	MODIS B6	-	-	-

### Results:

- 1) Biases for AWIFS B2, B3 within 2% while ~4.5% for B4
- 2) Bias is about 9.6% for AWIFS B5
- 3) Std. Dev. is higher; further acquisitions /long term analysis in progress.

# Joint Calibration Exercise:



## LISS4 Calibration Exercise over CEOS Geometric Sites (Sioux Falls, Pueblo)

Collaboration with USGS – FP: Greg Stensaas

- Statistics generated were from 560 and 670 control points.
- Control points from a high resolution, high accuracy (<60cm) aerial imagery.

### Band Misregistration Error (Specs: $\pm 0.3$ p RMSE)

Parameter	Red (B3) – Green (B2)	
	Line (AL)	Pixel (AX)
Min	-0.24	-0.32
Mean	0.00	0.00
Max	0.25	0.32
RMSE	0.12	0.16

Parameter	Near IR (B4) – Red (B3)	
	Line (AL)	Pixel (AX)
Min	-0.34	-0.28
Mean	-0.02	-0.03
Max	0.30	0.22
RMSE	0.17	0.13

### Location Inaccuracy Specs: < 200m RMSE

Parameter	Location Error pixels (in m)	
	Line (AL)	Pixel (AX)
Min	0.75	4.3
Mean	28	19.7
Max	55.4	35.1
Std.Dev.	14	7.9
RMSE	31.3	21.2

### In Progress:

- Radiometric Calibration with L7/L8 over CEOS sites
- Geometric calibration to be repeated for consistency

# RISAT-1 Calibration Exercise at Gunning (Canberra, Australia)

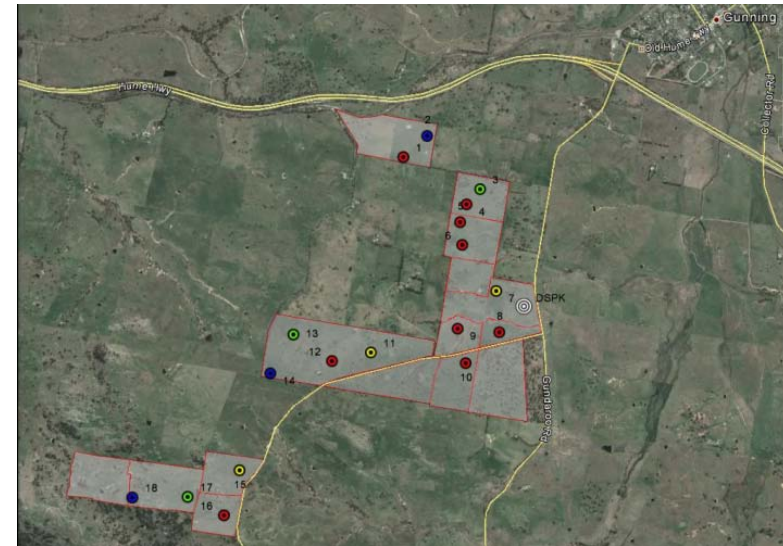
Collaboration with Geoscience, Australia – FP: Medhavy

**Joint Calibration Exercise - with Passive Corner Reflectors**  
**Image Acquisition planned between Dec13 and Mar14**

**18 Triangular Trihedrals installed at**  
**Location ~ (149.20 Lat/-34.8 Long)**

**CR Array Lay-out Map**

CR Type	CR No.	CR Size (m)
Mesh	1,6,10	1.5
Powder	4,9,12	1.5
Metal	(7,11,15)	1.0
	(5,8,16)	1.5
	(3,13,17)	2.0
	(2,14,18)	2.5



**Installation completed by 20DEC13**  
**RISAT-1 Imaging and Processing in progress**



2018



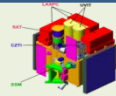
# INDIAN EO MISSION TIMELINE

Y  
E  
A  
R

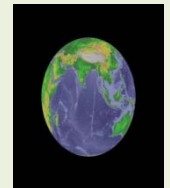
THANK  
YOU..

2002

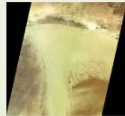
RISAT-1A



GISAT-1



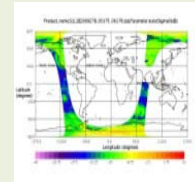
INSAT-3DR, S



Res-2A

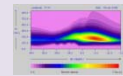


Carto-2C

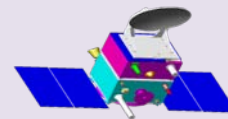


SCATSAT-1

FUTURE  
MISSIONS



SARAL(2012)



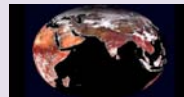
RISAT-1 (2012)



INSAT-3D (2013) CURRENT  
MISSIONS



Resourcesat-2(2011)



Oceansat-2(2009)



Mega Tropiques  
(2011)



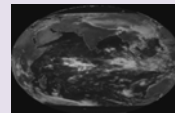
IMS-1(2008)



Carto-2 (2007)



Catro-1(2005)



Kalpana-1 (2002)



INSAT-3A (2003)

IRS-P6 (2003)

Coordination Group for  
Meteorological Satellites

EARTH OBSERVATION MISSIONS