

Indian Space Programme & Country Report to 9th GEOSS-AP



Dr. PVN Rao
ISRO, INDIA

January 2017

Vision: Harness Space Technology for National Development

Space Transportation

- Polar Satellite Launch Vehicle (PSLV)
- Geosynchronous Satellite Launch Vehicle (GSLV)
- Advanced Launch Vehicle
 - Modular LV
 - Reusable LV
 - Human spaceflight

Space Infrastructure

- Earth Observation: Land, Water, Cartography, Oceanography, Atmosphere & Weather
- Communication
- Navigation
- Space Science: Exploration, Solar Physics, Astronomy, Astrophysics, Space Probes
- Ground Segment



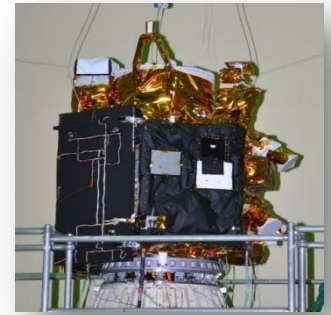
Space Applications

- Socio Economic Security: Food, water, Energy, Health, Shelter, Infrastructure & Information
- Sustainable Development: Agriculture, Urban, Coastal ecosystem, Climate change...
- Disaster Risk Reduction
- Governance: Planning, Monitoring & Decision support

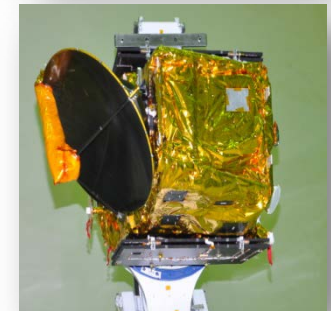
Capacity Building

- Human Resources
- Technical Infrastructure
- Enhanced Output (Outsourcing & TT)
- New Technologies Academia, Industries
- Indigenization
- International cooperation
- Outreach

ISRO Missions in the Last One Year



1. Nov 12: **GSAT-15**
2. Jan 20: **PSLV C31/IRNSS 1E**
3. Mar 11: **PSLV C32/IRNSS 1F**
4. Apr 28: **PSLV C33/IRNSS 1G**
5. Jun 22: **PSLV C34/ Cartosat 2 Series+..**
6. Sep 08: **GSLV F05/INSAT 3DR**
7. Sep 26: **PSLV C35/ SCATSat-1 +..**
8. Oct 02: **GSAT-18**
9. Dec 07: **Resourcesat-2A**



Additionally ...

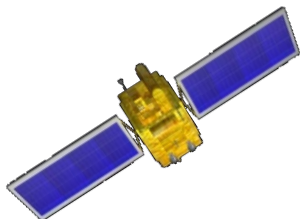
4 Student satellites

22 Satellites of 5 Nations

Earth Observation Satellites

LAND & WATER

RESOURCESAT-2, 2A

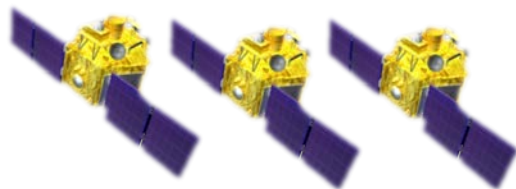


RISAT-1

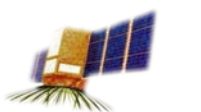


HIGH RESOLUTION

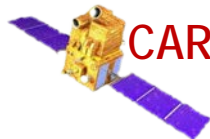
CARTOSAT-2; 2A; 2B; 2S



RISAT-2



CARTOSAT-1



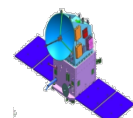
OCEAN

OCEANSAT-2



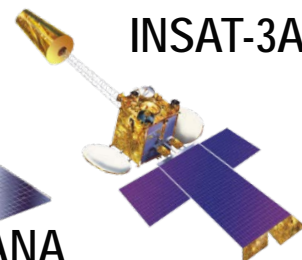
SARAL

SCATSAT-1

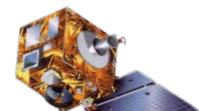


WEATHER; CLIMATE

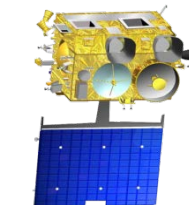
INSAT-3A



KALPANA



MEGHA-TROPIQUES



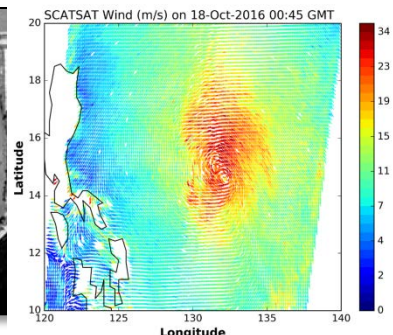
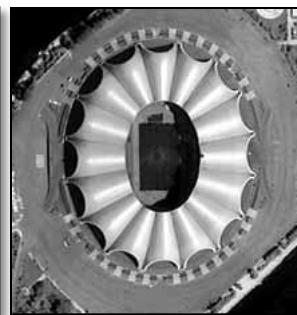
INSAT-3D,
3DR

Cartosat-3, Oceansat-3, Resourcesat-3, RISAT, GISAT in 2017-18 for continuity of services and new capabilities.

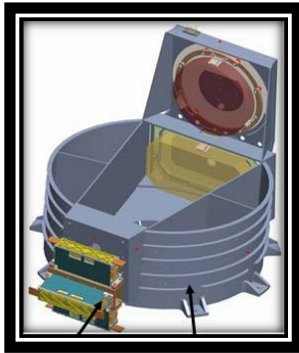
IMAGING CAPABILITY

1 KM

0.65 M



Resourcesat-2A



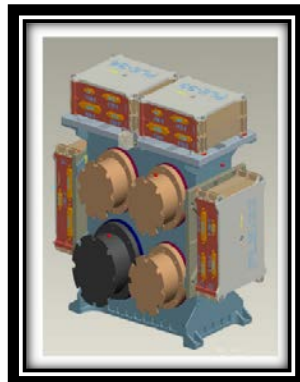
LISS-4

Bands: Green, Red, NIR
Quantization: 10 bits
GSD at Nadir: 5.8m
Swath: 70 km
Scene Size: 70 km x 70 km



LISS-3

Bands: Green, Red, NIR, SWIR
Quantization: 10 bits
GSD at Nadir: Across 23.5m/Along 22m
Swath: 141 km
Scene Size: 141 km x 141 km



AWiFS

Two Instruments: AWiFS-A & AWiFS-B
Bands: Green, Red, NIR, SWIR
Quantization: 12 bits (G,R,NIR), 14 bits (SWIR)
GSD at Nadir: 56m (at Nadir)
Swath: 320 km (Individual), 740 km (Combined)
Scene Size: 320 km x 320 km (SubScene)
Scene Size: 740 km x 740 km (Combined, Full Scene)

PSLV C36

Dec 07, 2016

20 Satellites

2 orbits

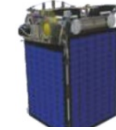
One mission



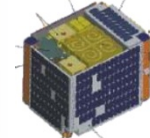
Cartosat-2 Series
Sub-metre Pan & 2m MX
June 22, 2016



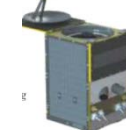
LAPAN-A3 Indonesia
(Earth Observation)



BIROS Germany
(RS of High Temperature events)



M3MSAT Canada
(Study AIS signals from LEO)



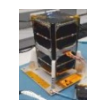
SKYSAT-Gen2-1 USA
(Sub-metre resolution EO)



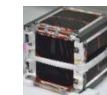
GHGSAT-D Canada
(Atm. GHG measurement)



DOVE (12 Sats.) USA
(Earth Observation)



SATYABAMASAT
Satyabama Uni.
(GHG data collection)

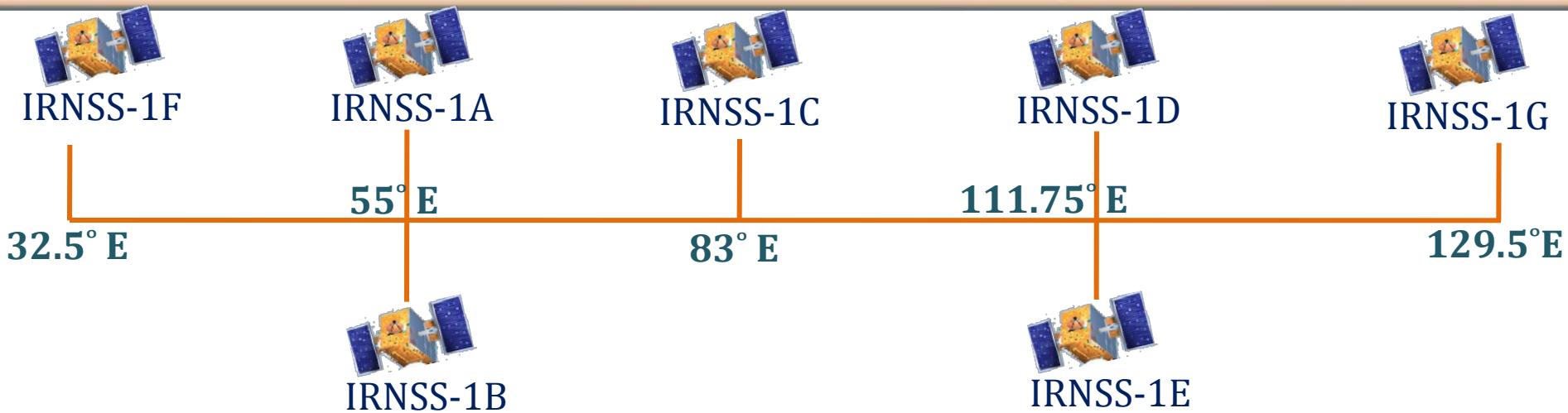


SWAYAM
College of Engineering ,Pune
(point to point messaging for HAM)

Vatican and Qatar in Cartosat-2 Series



Navigation – Indian Constellation (NavIC)



Application Sectors

- Vehicle Tracking and Fleet Management
- Maritime Services & Port Operations
- Railway operations
- Disaster Management Support
- Geo-tagging/Geo fencing
- Location based services
- Aid to hikers and travellers
- Survey Applications
- Infrastructure Planning
- Power Grid Synchronization
- Forest and Mining
- Precise Timing
- Mapping and Geodetic data capture
- Earth and Atmospheric Studies
- Search & Rescue
- ...

Aviation



Railways



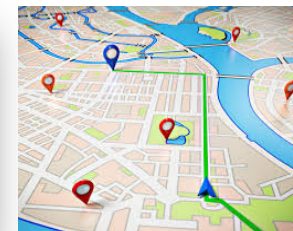
Roadways



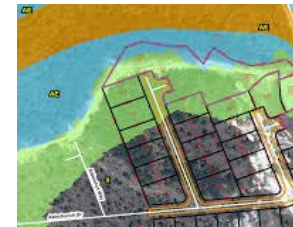
Maritime



Navigation



Survey

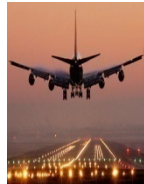


GAGAN (GPS Aided Geo Augmented Navigation) SYSTEM

- Jointly implemented by ISRO & Airports Authority of India
- Certified for en-route and landing aviation services

APPLICATIONS

Aviation - Safety of Life, Increased efficiency
Civilian - Precision Agriculture, Mining
Monitoring, Transport fleet
management, Maritime
Navigation, Strategic Applications,
Surveying,



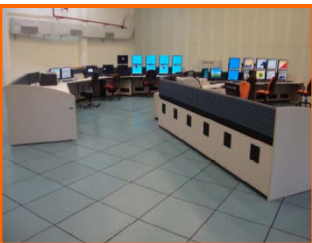
3 GEO Satellites



3 Uplink stations



2 Control Centres



15 Reference Stations



2 Data communication networks



Data Reception, Processing & Archival

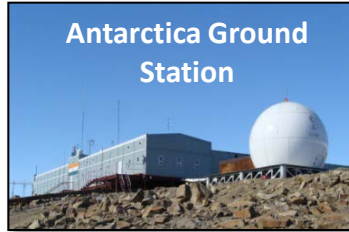
1980's



2016

Data Reception

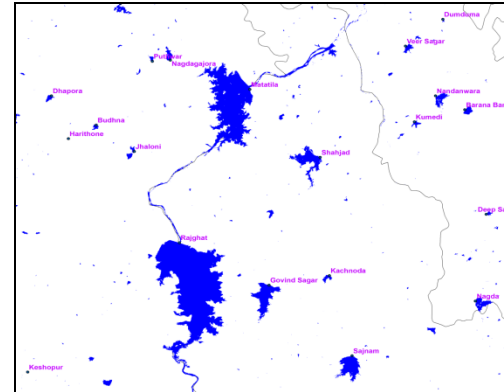
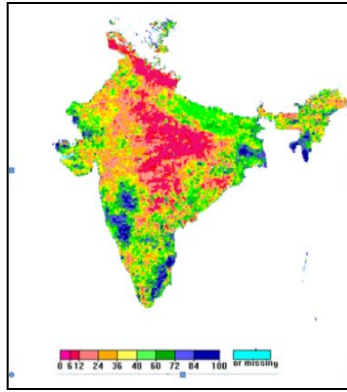
10 m Antenna
L,S Bands
Single Mission



7.5m antenna
S, X Bands
Multi-Mission

Data Processing

Rad. / Geo
Corrected,
Scene Product



Terrain corrected,
Value added,
Global Geophysical
Products

No. of
Products

30
products /day

1000 +
products /day

Turn Around
Time

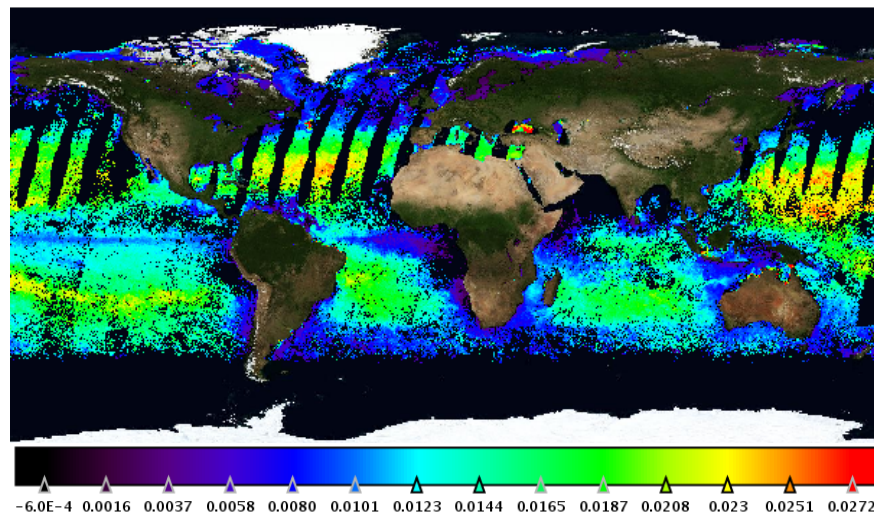
10
days

1
hour

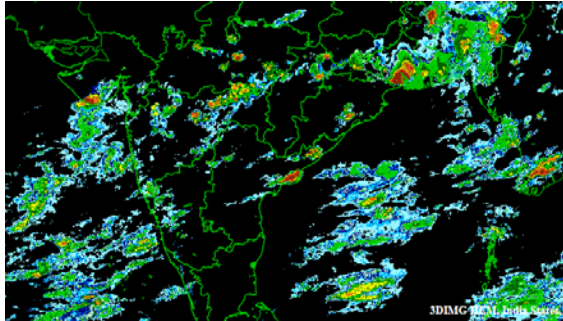
Products
Utilization

2000
products/year

1.5 lakhs
products/year



INSAT 3DR Products

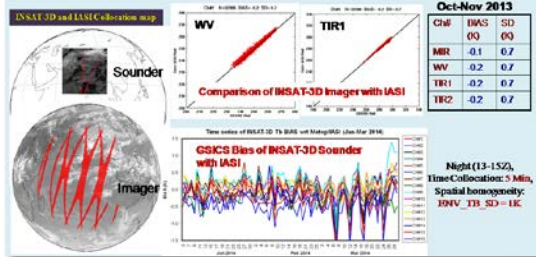


Monitoring of extreme rain events

GSICS Intercalibration of INSAT-3D Imager and Sounder

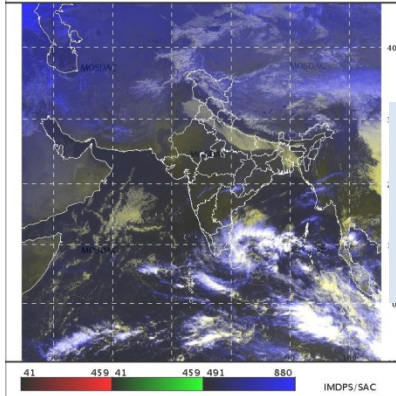
INSAT-3D Counts (Imager/Sounder) → Calibrated Radiances → Re-Calibrated Radiance (GSICS)

Reference instruments: Hyperspectral sounder IASI/MetOp (EUMETCAST at SAC Bopal camp)
 Procedure: Collocation in space, time, observation zenith angle over homogenous scene condition
 Convolve hyperspectral radiance over INSAT-3D using SRFs as weight
 Validation of the procedure for GOES-13 Imager and Sounder



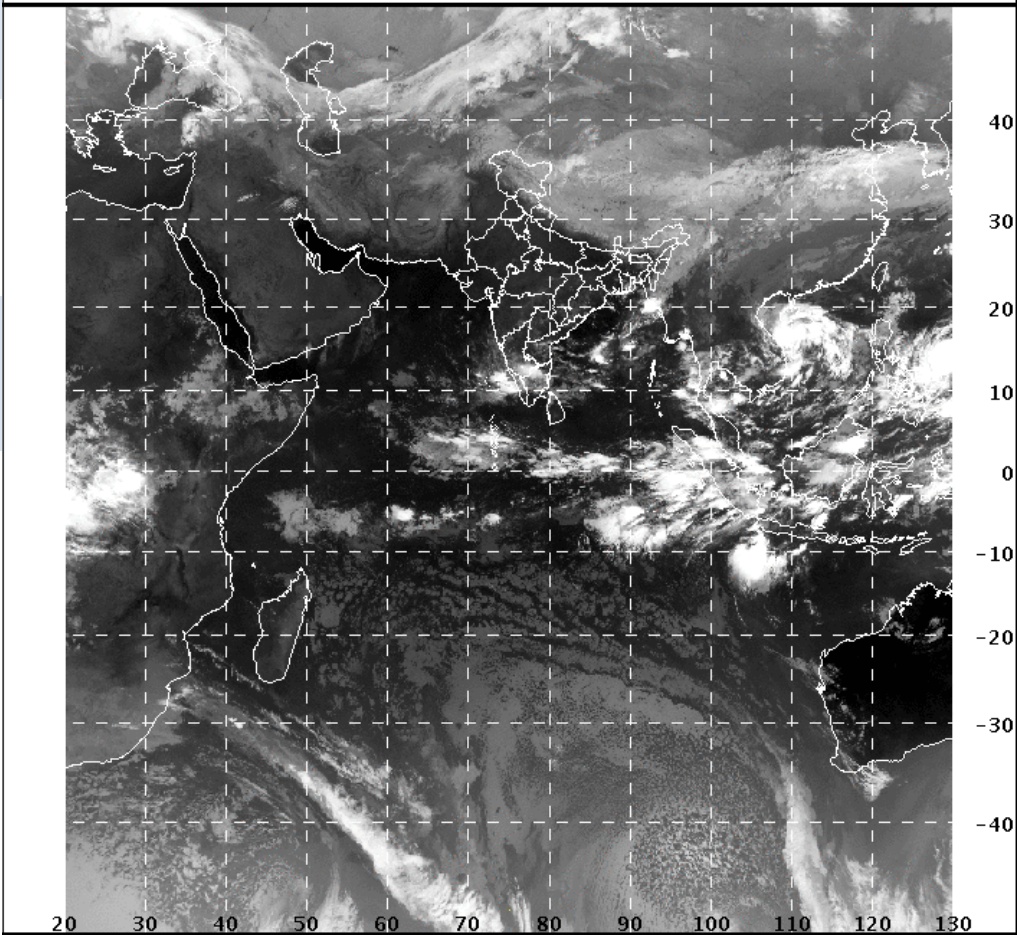
Inter-satellite Calibration GSICS

SAT: INSAT-3D IMG 27-12-2014/05:00 GMT
 IMG_VIS 0.65 um (R), IMG_VIS 0.65 um (G), IMG_TIR1 10.8 um (B)
 LIC Mercator 27-12-2014/10:30 IST



Tropical Cyclone monitoring & prediction

SAT: INSAT-3DR IMG 13-10-2016/00:14 GMT
 IMG_TIR1 10.8 um 13-10-2016/05:44 IST
 LIC Mercator (LINEAR STRETCH: 1.0%)



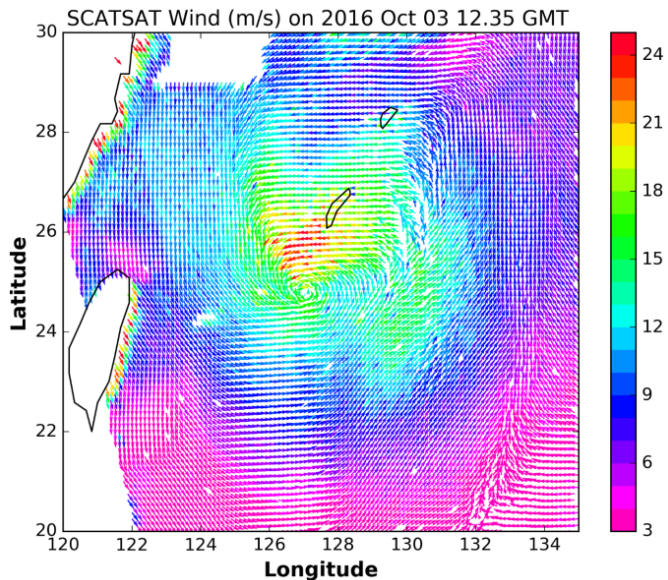
461

890

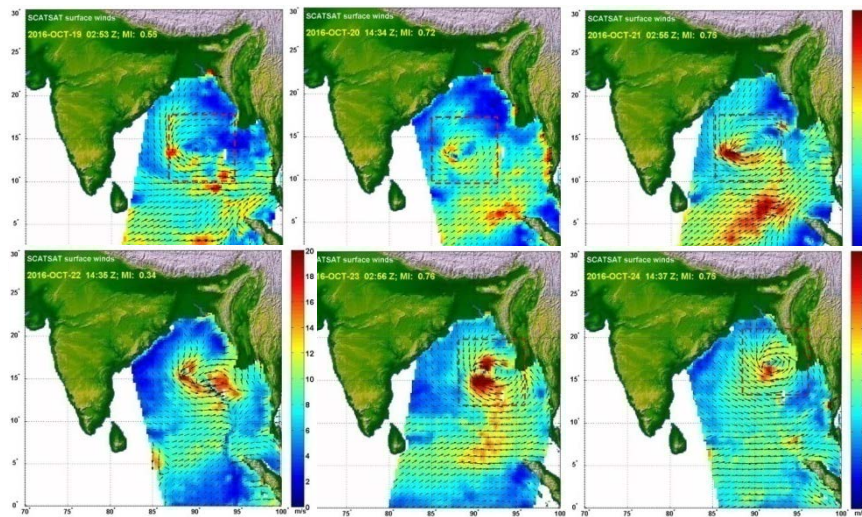
IMDPS/SAC

Scatsat-1 Products

Hurricane Chaba, Near South Korea Coast (Scatsat-1: October 03, 2016)



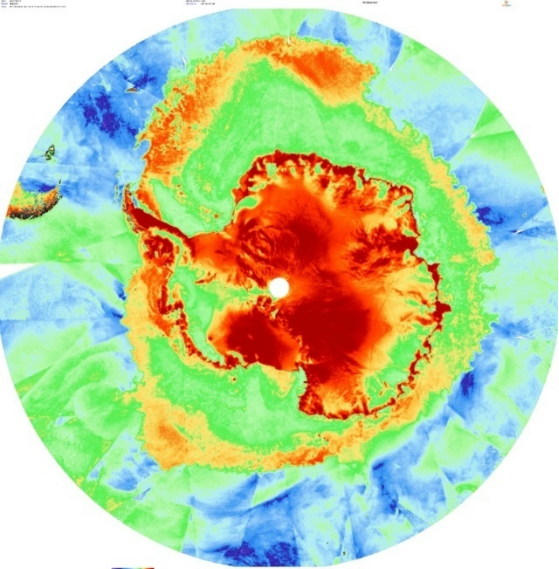
Tropical Cyclogenesis (Cyclone KYANT, BoB)



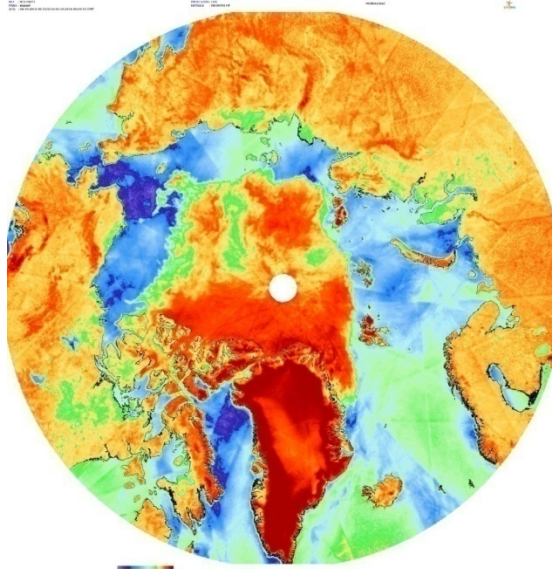
TC Formation: 25 OCT 00 Z

Cyclogenesis Prediction: 19 OCT 03 Z

Lead Prediction time: 140 Hrs

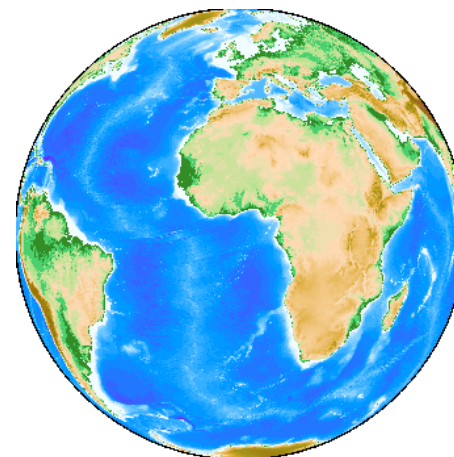


Antarctic



HH Pol

Arctic



Support to International Organisations for Disaster Management

Sentinel Asia

- Satellite Data Support (16 supports)
- Capacity Building

International Charter 'Space and Major Disasters'

- Day-to-day Charter Activities
- Satellite Data Support for 22 activations in 2016

UN ESCAP

- Drought Monitoring
- Satellite Data Support

SAARC STORM

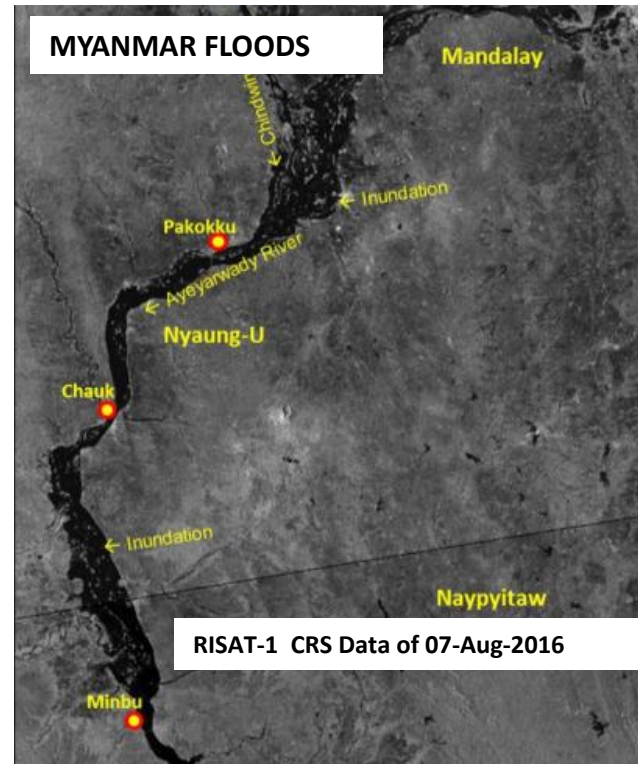
India, Bangladesh, Nepal and Bhutan

CEOS – WG Disasters

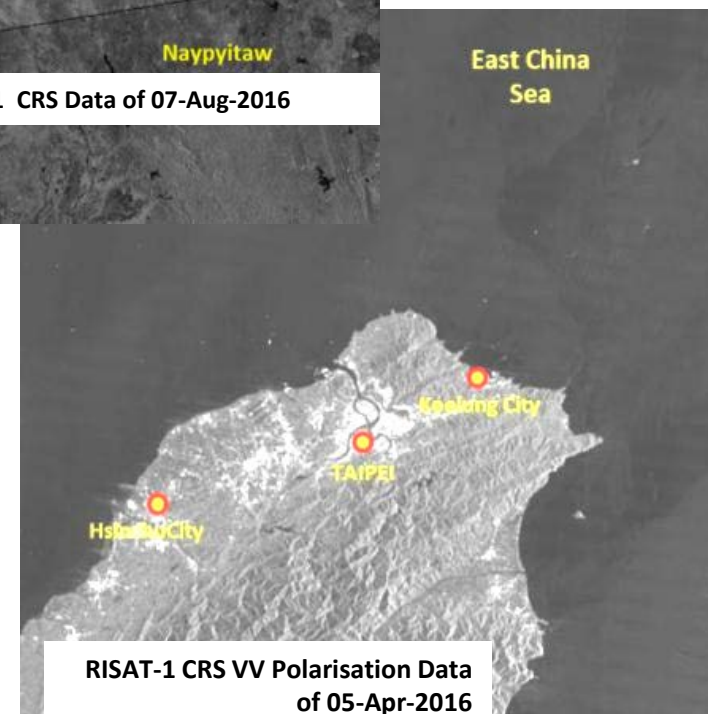
- Disaster Pilots

Workshop/Events

Asia Pacific Space Leaders Forum
on Nov 2, 2016



TAIWAN OIL SPILL



Ground Observation Network Infrastructure

Agro Metrological Stations (AMS)



- Vegetation Response to Climate and CO₂ Uptake
- Network of Micrometeorological (Canopy scale) Measurements
- Sensors for Radiation balance, Energy Balance, Water balance

Carbon Flux Tower



- Size of current pool of carbon in vegetation & soils
- Quantitative estimates of C flux viz., GPP, NPP & respiration
- Fluxes controlled by environmental variables & vegetation types

Automatic Weather Station (AWS)



Continuous Recording of:

- Temperature, atm. pressure
- wind speed and direction
- rainfall
- relative humidity
- solar radiation

Doppler Weather Radar (DWR)



- Continuous monitoring of extreme weather events
- Radar network for entire coastal areas, NE region, major cities.

Atmospheric Boundary Level Network

Mixed Layer Heights obtained from indigenously developed
GPS Sondes

Wind Profiler

Doppler Lidars

EO - Information Services

Bhuvan



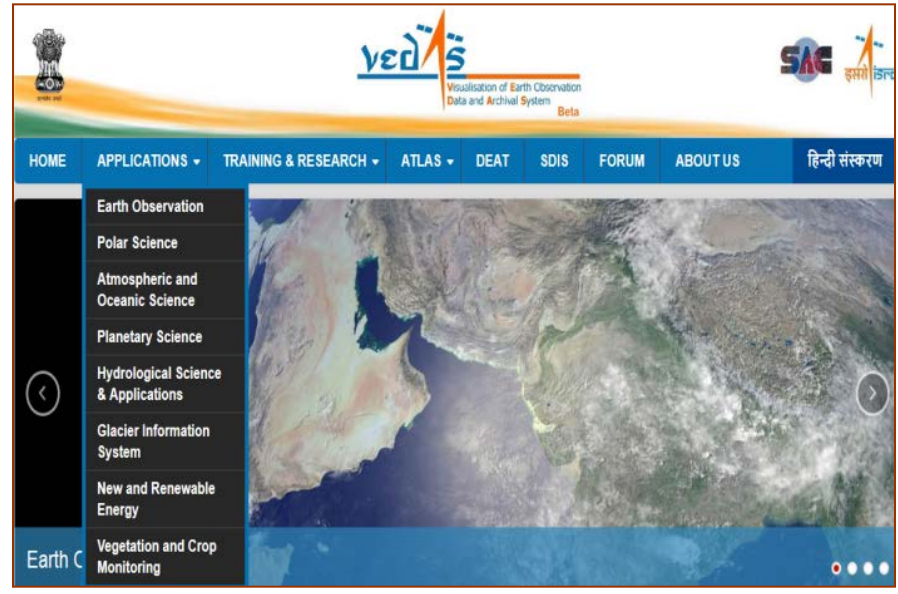
MOSDAC



India-Water Resources Info. System



Vedas



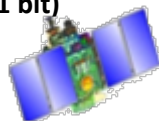
EO Missions - Near Future

2017

CARTOSAT- 2D & 2E VHR Panchromatic and Multispectral Imaging

- PAN (0.60 m, 10 km swath, 11 bit)
- Mx (2m , 10 km swath, 4 Xs, 11 bit)

Orbit : 500 km
Local time: 0930 hrs



2018

GISAT - 1 Geosynchronous Orbit

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

Orbit : 36000 km
Every 30 min

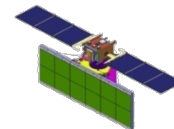


2018

RISAT-1A Continuity for RISAT-1

- C-Band SAR

Orbit : 536 km
Local time: 0600 hrs

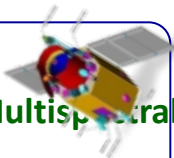


2018

CARTOSAT-3 VHR Panchromatic, Multispectral Imaging

- PAN (0.25 m, 16 km swath, 11 bit)
- Mx (1m , 16 km swath, 11 bit)

Orbit : 450 km
Local time: 1030 hrs

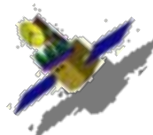


2018 & 2019

Oceansat-3 & 3A Continuity for OS-2 with Improvements

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

Orbit : 720 km
Local time: 1200 hrs



2020

NISAR Joint Mission with JPL/NASA Payloads

- L & S Band SAR

Orbit : 747 km
Local time: 0600 hrs



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

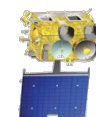


2019 & 2020

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



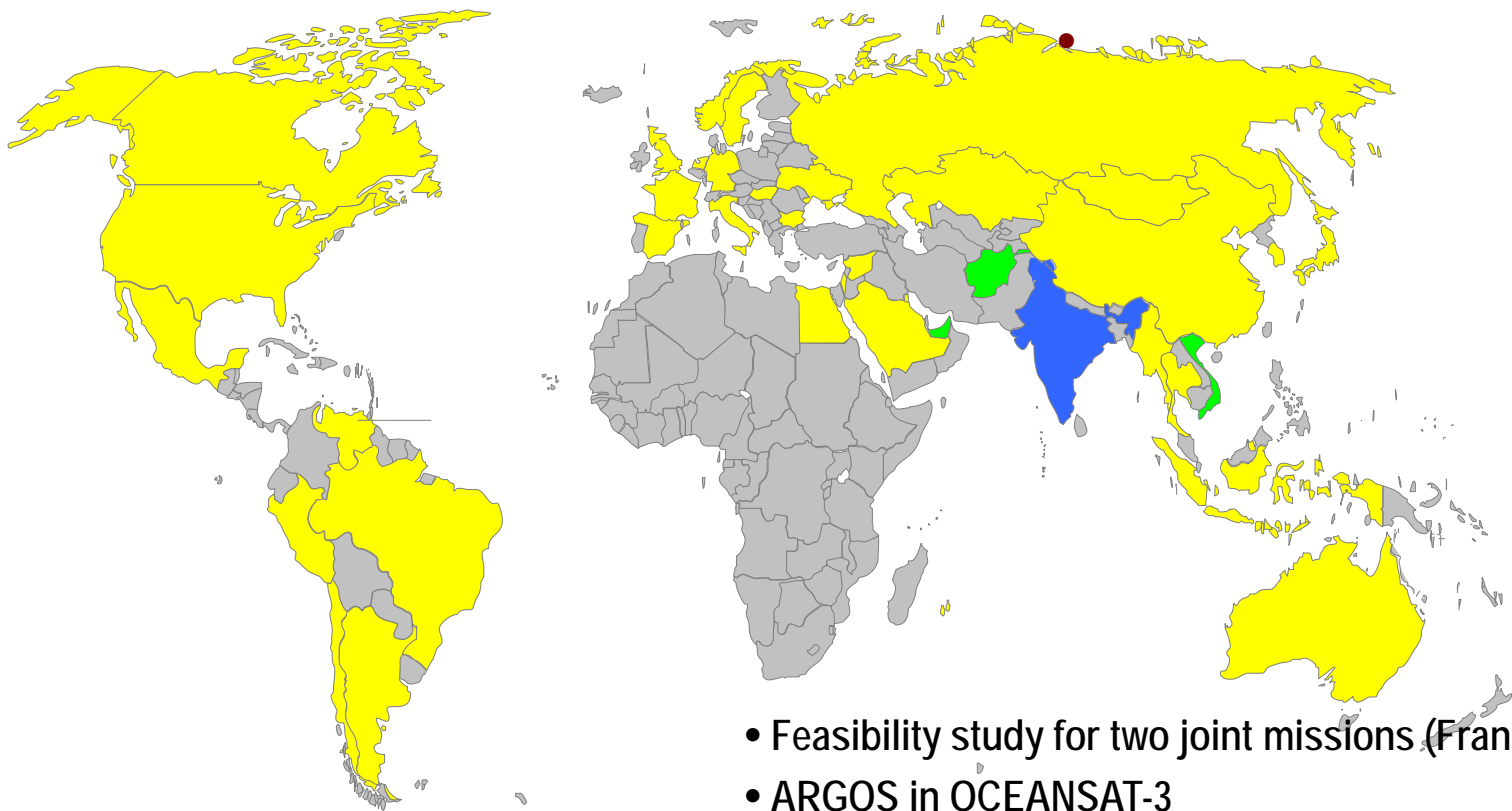
INSAT 3DS

Continuity for INSAT 3DR for
improved understanding of
weather systems

- 19 channel Sounder
- 6 Channel Imager

Orbit : 36000 km
Every 30 min

Expanding International Space Cooperation



- **Nine cooperative documents with 7 nations**

- **Afghanistan, France, Japan, Russia, USA, UAE & Viet Nam**

- Feasibility study for two joint missions (France & Japan)
- ARGOS in OCEANSAT-3
- Satellite navigation ground stations in India and Russia
- RESOURCESAT-2 and Landsat 7/8 data sharing
- ISRO–CNES Planetary Exploration JWG
- ISRO–NASA Heliophysics Working Group
- ISRO-AEM Workshop on DMS
- Data sharing & Training in ASEAN
- SAARC-STORM: Ground station network

National Meet

Promoting Space Technology Applications and Tools For Governance and Development

September 07, 2015
विज्ञान भवन, नई दिल्ली
Vigyan Bhawan, New Delhi



International Space Events in India



International Space Events in India in 2017

38th Asian Conference of Remote Sensing (38th ACRS)

“Space Applications: Touching Human Lives”

Oct 23-27, 2017
New Delhi, India

24th session of Asia-Pacific Regional Space Agency Forum (APRSAF-24)

“SPACE for Enhanced Governance and Development”

November 14-17, 2017
Bangalore, India

SAVE THESE DATES

Other Institutional Support Activities

Student Satellites

ANUSAT -2009

STUDSat - 2010

SRMSat - 2011

Jugnu (IITK) - 2011

SathyabamaSat -2016

SWAYAM (CoEP) - 2016

PRATHAM (IITM) -2016

PISAT (PES Univ.) - 2016

RESPOND

- **Sponsored Research for R&D activities in Academia**
- **Demonstration of feasibility & Indigenisation**
- **STCs in IITs and IISc**
- **JRP in Univ. of Pune**
- **In 2015-16: 84 projects; 62 institutes; 106 events; Rs. 24 Crores**

Space Science

- **PLANEX: Planetary Science & Exploration: 18 Projects**
- **Space Science Promotion Scheme: 8 Universities**
- **Solar Terrestrial Atmospheric Research Programme**
- **Indian Astronomy Olympiad Programme by Homi Bhabha Centre for Science Education**

Space Educational Institutions in India

Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP)

Affiliated to the United Nations
(www.cssteap.org)

1588 Professionals from 51 countries



Indian Institute of Remote Sensing, Dept. of Space, Govt. of India Dehradun

(www.iirs.isro.gov.in)

iirs

- Professionals trained: 10,512
- Foreign professionals: 983 from 95 Countries

Indian Institute of Space Science and Technology, Thiruvananthapuram

(www.iist.ac.in)



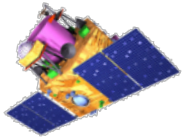
Enrolment (2016), Awarded (1003)

Space Centres and Units in India



Forthcoming Missions in near future of 2017

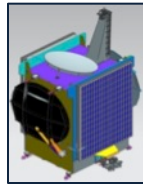
Cartosat-2 Series



PSLV - C37

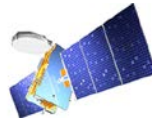
PAN with 0.63m
& MX with 2.0m

GSAT-19



GSLV MkIII-D1

Ku & Ka Band multi-
beam satellite



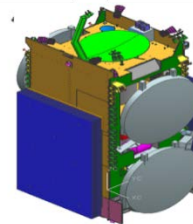
GSAT-9

12 Ku band
Communication services

SAARC Satellite



GSLV-F09



GSAT-11

High Throughput Satellite
- 12 Gbps capacity



GSAT-17

Communication satellite with 39
Transponders

Thank You