ISROs Earth Observation Missions for Societal Benefits

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Land Use/Cover Changes, Environment and Emissions in South/Southeast Asia – An International Regional Science Meeting,
Johar Bahru, Malaysia, July 22-24, 2019

Indian Space Programme: Dimensions

Vision: Harness space technology for national development, while pursuing space science research and planetary exploration

Space Transportation

- PSLV
- GSLV
- Reusable LV
- Modular LV

Capacity building

- Human Resource Development
- Indigenization
- Technical Infrastructure
- International Cooperation
- Industry, Academia,
- Outreach

Space Infrastructure

- Earth Observation
- Communication
- Navigation
- Space Science & Planetary Missions

Space Applications

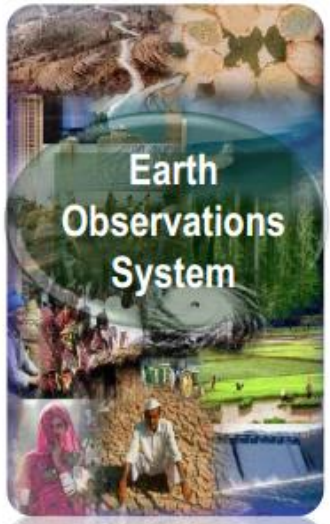
- Socio economic Security, Sustainable Development, DRR & Governance
- Synergistic Applications (EO, SatCom & Navigation)

Indian Earth Observation Programme

Space Segment

Constellation of Satellites

- Land & Water
- Cartography
- Ocean, Weather & Climate



Ground Segment

- Data Acquisition & Processing
- Data Products Generation
- In-situ Observation Network
- Information Dissemination

Institutional Linkages

- Ministries / Departments
- State Remote Sensing Centres
- Industry & Academia
- International Cooperation

Space Applications

- National Imperatives / tech. develop.
- NR Management & Disaster Mgmt.
- Land-Ocean-Atm. Interactions
- Enabling Geospatial data & Applns.

- **Ensuring Data Continuity for Operational Applications**
- **Augment space & ground segment with enhanced capabilities**
- **Periodic inventory of natural resources to enable SDI**
- **Advanced models to meet evolving needs of stakeholders.**
- **Information systems with decision tools & citizen centric services.**
- **Maximize outreach of space applications**

Current Operational Remote Sensing Capabilities

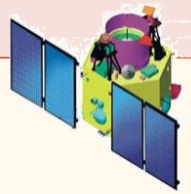
Natural Resources Inventory & Disaster Management

RESOURCESAT- 2 & 2A, HYSIS

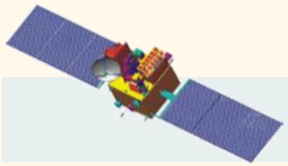
- Three tier imaging : 56 m / 23 m / 5.8 m
- Revisit Capability : 03 / 11 / 03 days

Large Scale Mapping, Infrastru. Planning & Cartography

CARTOSAT-1, CARTOSAT-2 (3) & 2S (4)



- 2.5 m Stereo imaging
- Sub-meter PAN and 1.5 m Multi-spectral



Oceanography

OCEANSAT-2 ; SARAL ; SCATSAT-1

- Ocean color 360 m with 2 days revisit
- PFZ, Ocean State Forecast
- Ocean Altimetry, Surface Wind Vector

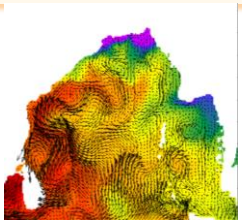
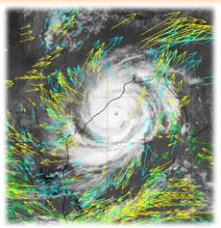
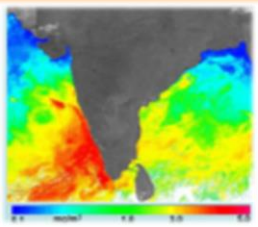
Weather & Climate

INSAT 3D & 3DR ; MEGHA-TROPIQUES

- 6 channel Imager – 48 images per day
- 19 Channel Sounder – Atm. Profiles
- Radio Occultation – humidity profiles

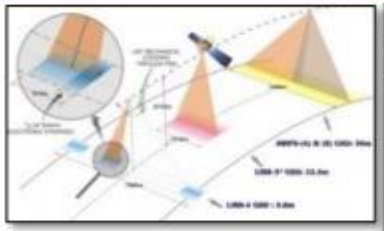




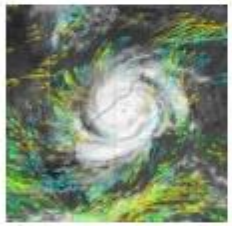




Remote Sensing Capabilities

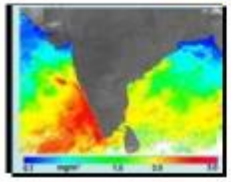
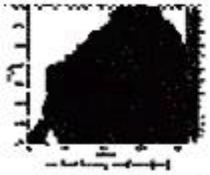
Land & Water Resources, Cartography

RESOURCESAT-2/2A	CARTOSAT- 1	CARTOSAT-2S
		
56 / 23 / 5.8 Meters	2.5 Meter - Stereo	Sub- meter

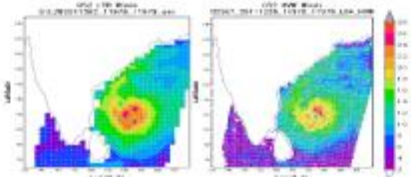
Weather & Climate

INSAT-3D & 3DR	MEGHA-TROPIQUES
	
6 Bands IMAGER 19 Channel Sounder 48 images per day Imager - 1 / 4 km	Radiation Budget Atm. Profiles Radio Occultation

Oceanography

OCEANSAT-2	SARAL
	
Ocean Color 360 m / 2 days	Ocean Altimetry Ka BAND ALTIMETER

SCATSAT-1



Wind Vector
Ku BAND
SCATTEROMETER

In-situ

- 3 Tier imaging
- High resolution imaging
- Stereo imaging
- Ocean color
- Ocean altimetry
- Ocean surface wind
- Profiles of atmosphere
- Sea surface temperature
- Rain above the oceans
- Vertical humidity profile
- All weather imaging
- Hyper-spectral imaging
- Earth's radiation budget

Recent launch

NovaSAR–1 of SSTL, UK
S–band Radar imaging

Automatic Weather Station

Micro Rain Radar

Sun Sky Photometer

Met and Ocean Buoy

Agro-met Station

Doppler Weather Radar

Flux Tower

GPS Sonde

Major Earth Observation Applications

Food Security

- Crop Acreage and Production Estimation
- Crop condition assessment & yield modeling
- Agricultural drought assessment
- Horticulture development
- Soil salinity and alkalinity mapping

Water Security

- Water Resources Information System
- Ground water prospects & recharge
- Irrigation and command area studies
- Reservoir Capacity Evaluation
- Watershed Development




Infrastructure Development

- Urban & Infrastructure development
- Rural road Connectivity
- Town / cities development plans
- Urban sprawl studies
- Growth Centre analysis

Societal Empowerment

- Space Based Information Support for Decentralized Planning
- Land Resource mapping
- Sujala - Participatory Watershed Project

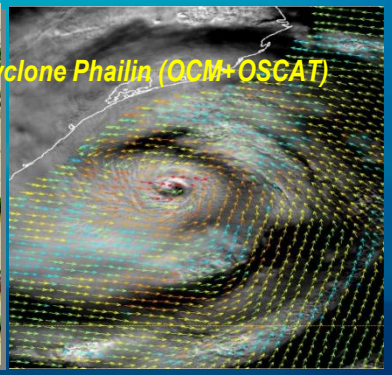
Major Earth Observation Applications

Environment & Ecosystem

- Forest cover mapping & Biodiversity
- Snow & Glacier studies
- Desertification & Land degradation
- Natural Resources Census
- Grassland Productivity

Disaster Management

- Near real time monitoring of Flood
- National database for Emergency Management
- Support to International Charter
- Landslide Hazard Zonation
- Forest Fire Damage Assessment



Ocean & Marine Resources

- Potential fishing zone mapping
- Coastal zone mapping
- Coral reef mapping
- Monitoring of navigational channels
- Ocean Primary Productivity
- Ocean State Forecast (OSF)

Weather & Climate

- Space and Ground observations
- Essential Climate Variables
- Weather Forecasting & Cyclone
- Storm Surge Modeling
- Extended Range Monsoon Prediction
- Climate modelling

Governance Applications - Many Ministries

Continuous & Demand based Activities for Planning, Monitoring & Evaluation and Decision Support

- **Support to Flagship Programmes**
  - **SHC** : Soil Health Card Scheme
  - **PMFBY** : Improved Crop Insurance Services
  - **PMGSY** : Better Utilization of Irrigation Potential
  - **AMRUT** : Citizen friendly sustainable cities
  - Swatch Bharat & Ganga Rejuvenation
    - Clean India Mission
    - National Mission for Clean Ganga
  - Monitoring of Public Benefit & Rural Development Schemes

    (**MGNREGA, PMAY, IWMP, …..**)
  - De-centralized Planning: Participatory planning
  - Education and Health: Universal Access and Quality
- **Institutionalization / Internalization** (20 Implemented)

Integrated Geospatial portal

bhuvan.nrsc.gov.in

Geospatial Technology for Development

National level Institutionalisation

Agriculture - Mahalanobis National Crop Forecast Center, MOA
Water - India Water Resources Info. System ; MOWR
Forest - State of Forests in India : Biennial reports; MOEF CC
Ocean - INCOIS provides PFZ, Ocean State forecast, Tsunami warning and many more …… MOES

National level Geospatial data usage

Rural Development - Wastelands, Land use & Land Cover Ground Water, Rural Roads……
Urban Development: NUIS, AMRUT, and Infrastructure Devt.
Land Resources - Watershed Development, National Landuse
Disaster Management - Floods, Cyclone, Landslides, Forest fire, Earth Quake, Drought……

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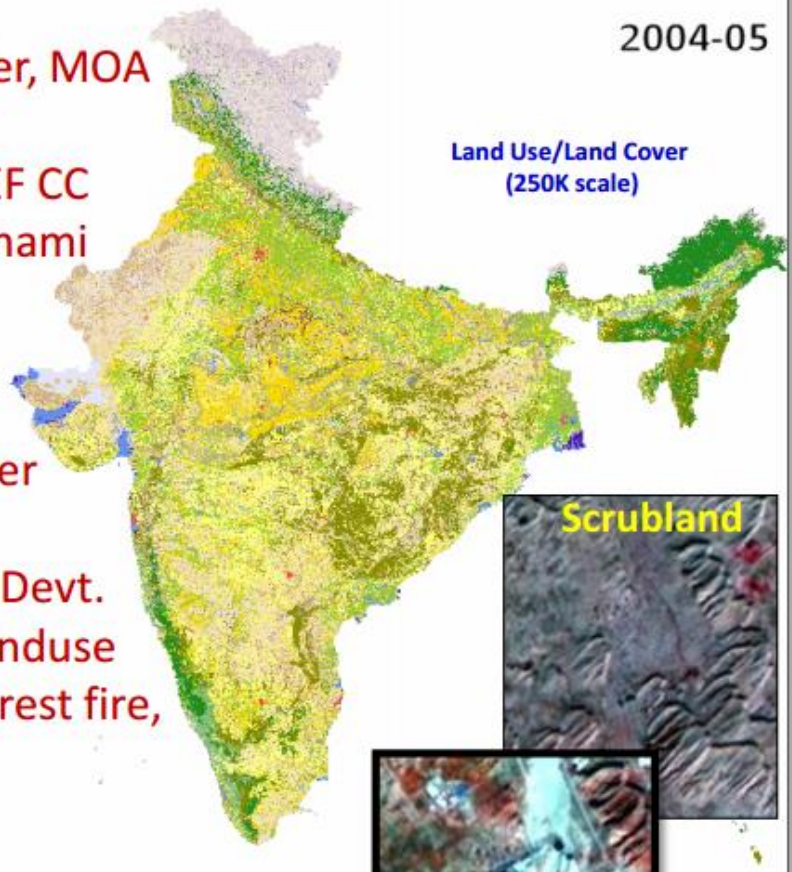
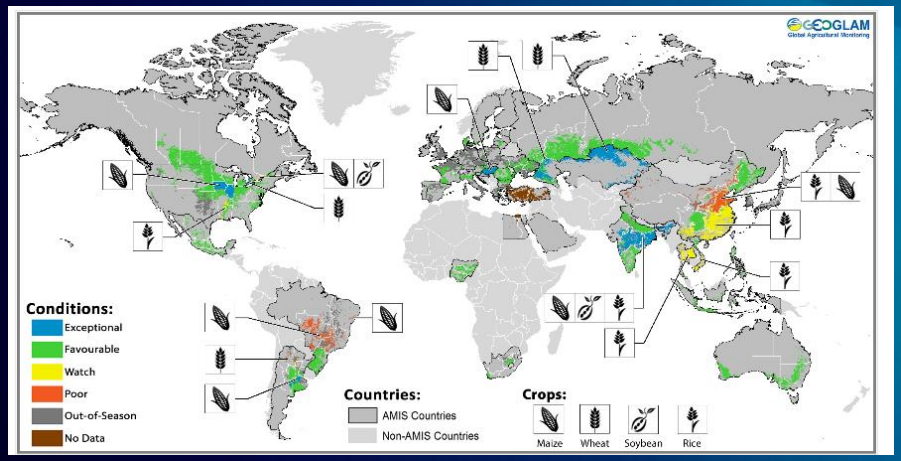


Diversity of Indian Agriculture



Net Sown Area : 141 Mha (44 %)

Food Grain Production : 275.68 Mt

Horticulture Production : 295 Mt

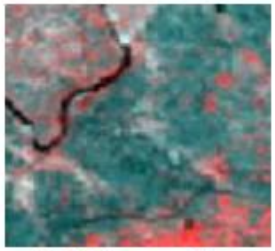
Net Irrigated Area : 66 Mha

GDP contribution ~ 13.7 %

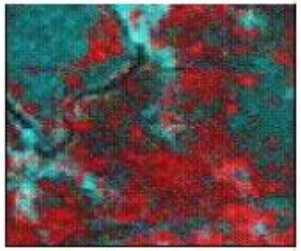
Employment Opportunity : 55%

Agriculture Applications (Operational @ MNCFC)

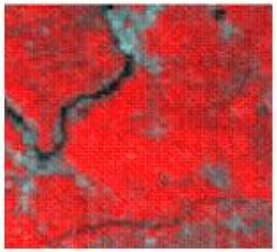
Crop Production Forecast- 8 Crops & Rabi Pulses



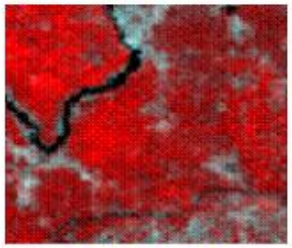
Mid November



Early January



Mid February



Mid March

Food-grain availability & policy decisions on procurement & stock management.

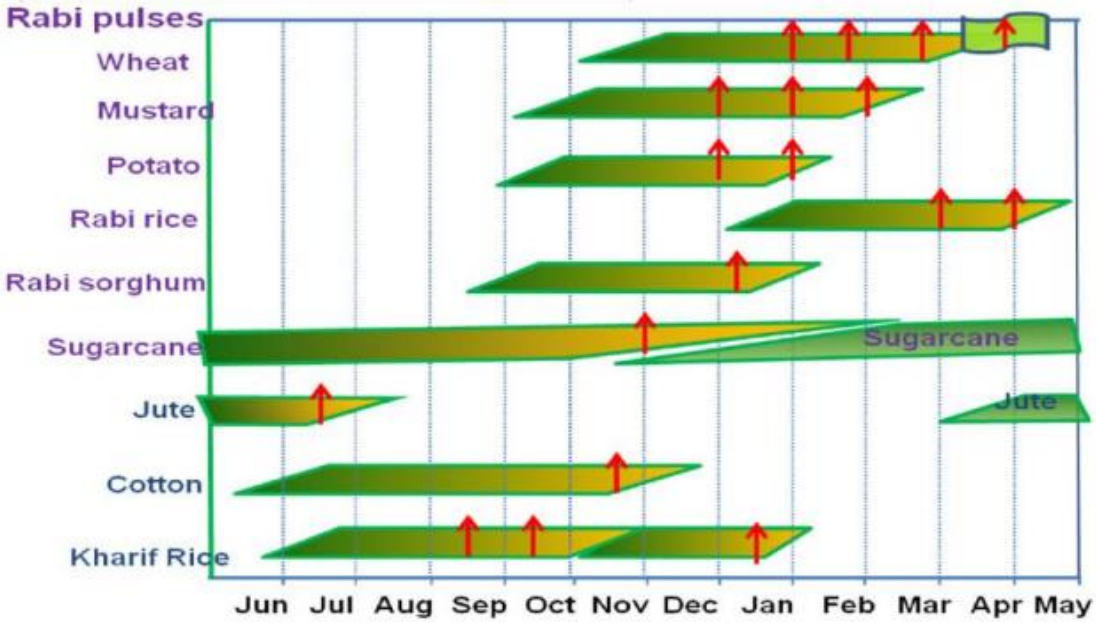
Pre-harvest Production Estimation Rice, Wheat, Mustard, Sugarcane, Potato, Cotton, Sorghum, Jute, Pulses

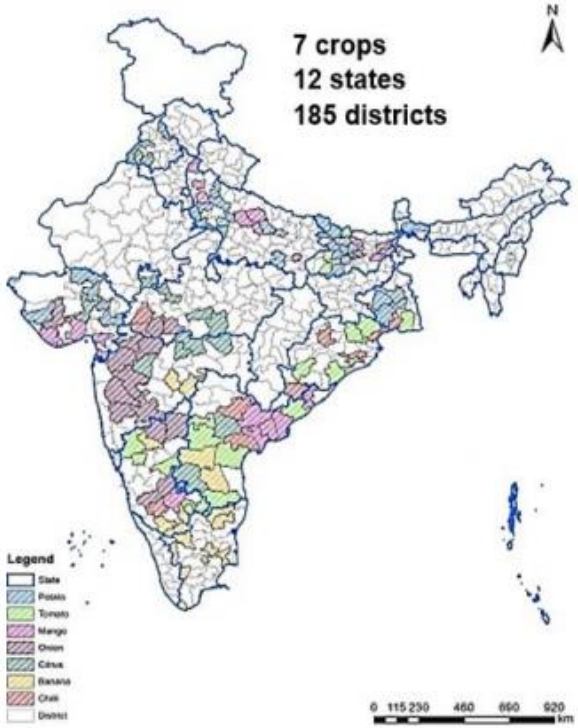
Working Towards 25 crops

New Challenges

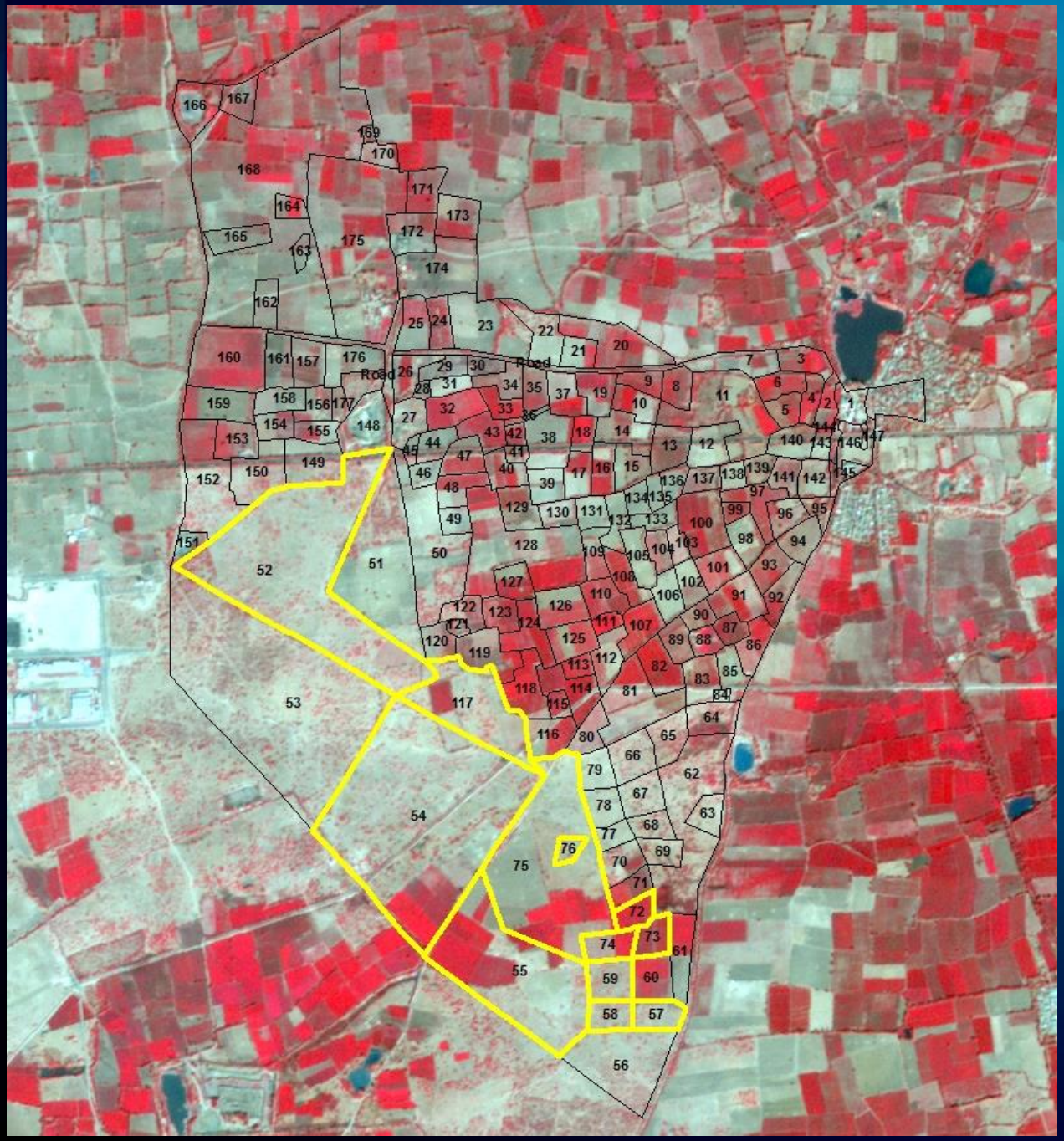
- Soil Health Card
- Crop Insurance
- Crop Intensifi-cation

Horticulture Mission (CHAMAN) Phase-1 is completed





Village level crop assessment



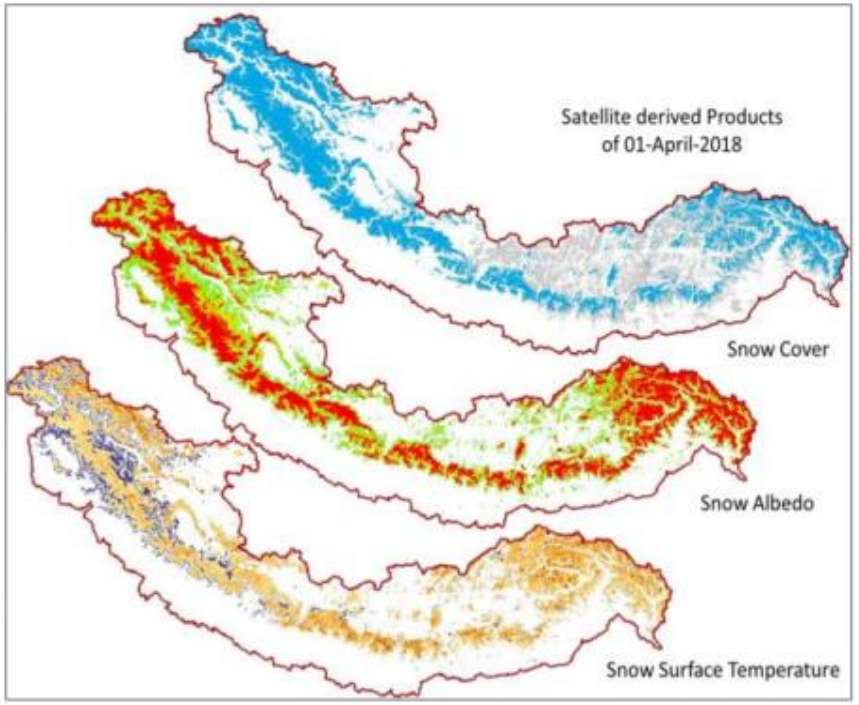
Village: Ughrojpura
Taluka: Mandal
Dist: Ahmedabad

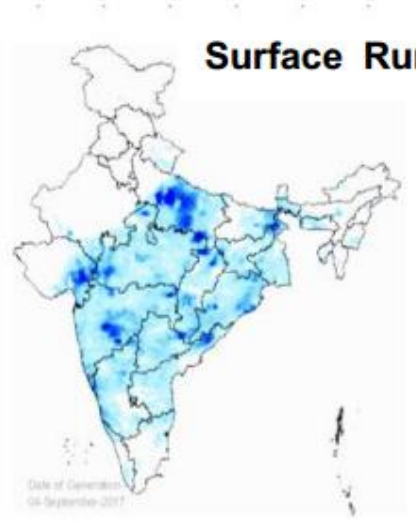
Imagery Date: 31 JAN 2016

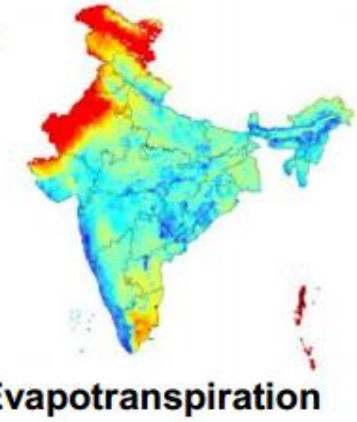
National Hydrology Project (with MOWR)

>> India-WRIS is being internalised to NWIC

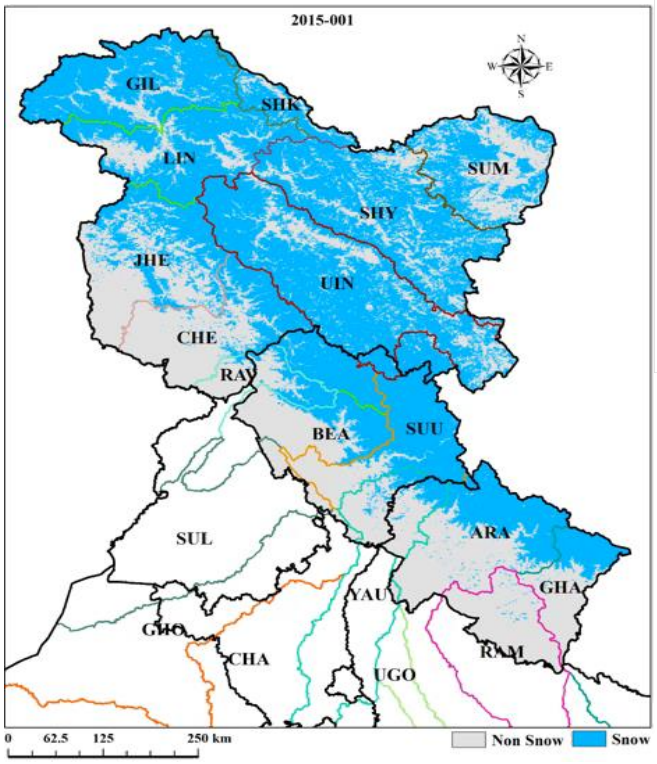
- Hydro-Informatics
  - *Snow melt, Soil Moisture, Evapotranspiration, Surface Runoff, Reservoir Inflows, Hydrological Drought*
- Development of Spatial Flood Early Warning for Godavari and Tapi
- GLOF Modelling for high risk lakes
- Real-time DSS for Irrigation Water Management
- Hydro-conditioned DTM (ALTM and Satellite) for Flood and GLOF modelling
- Capacity building for Central & State water resources departments personnel (4 Trainings & 100 Officials/year)
- Web services through NWIC & Bhuvan

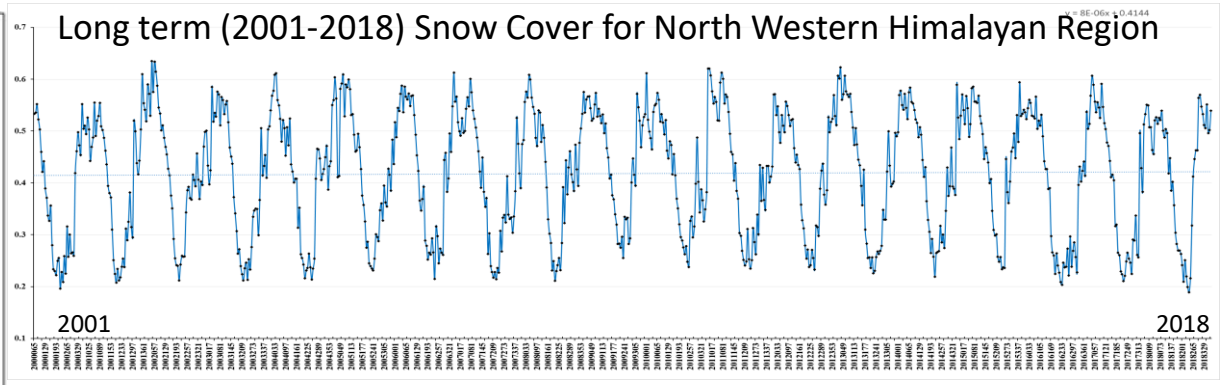


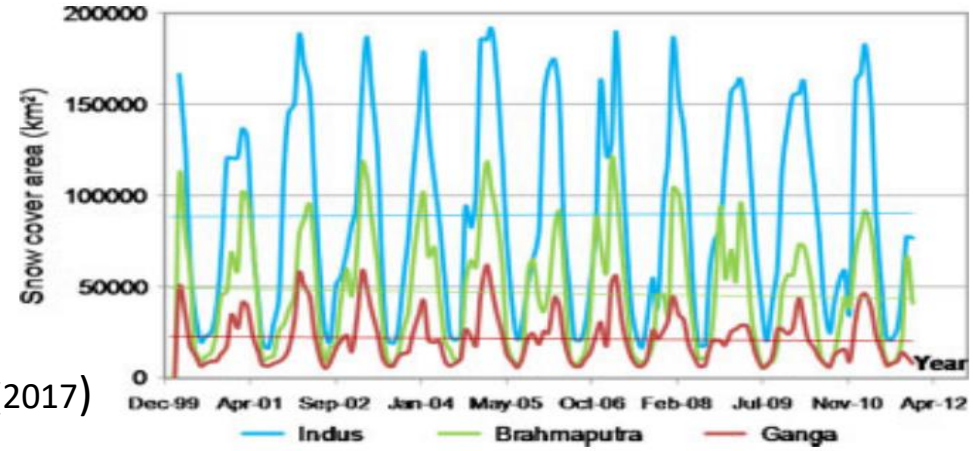




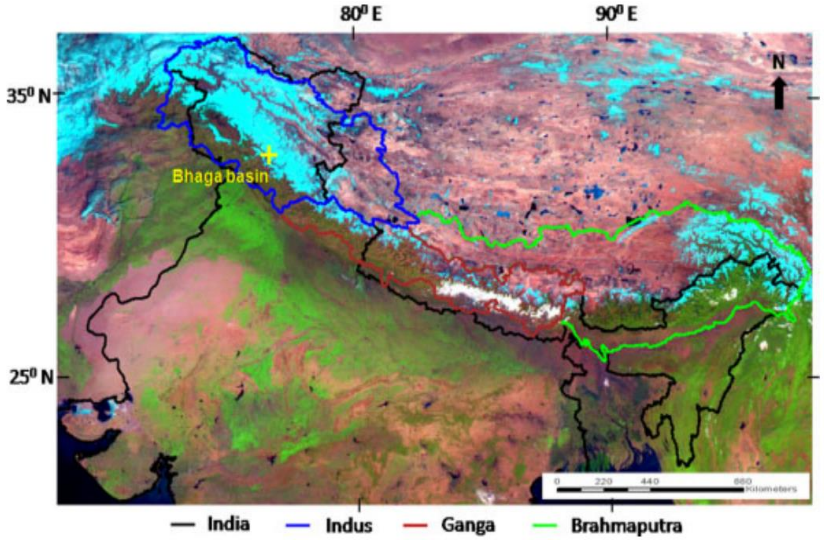
Himalayan Snow cover dynamics

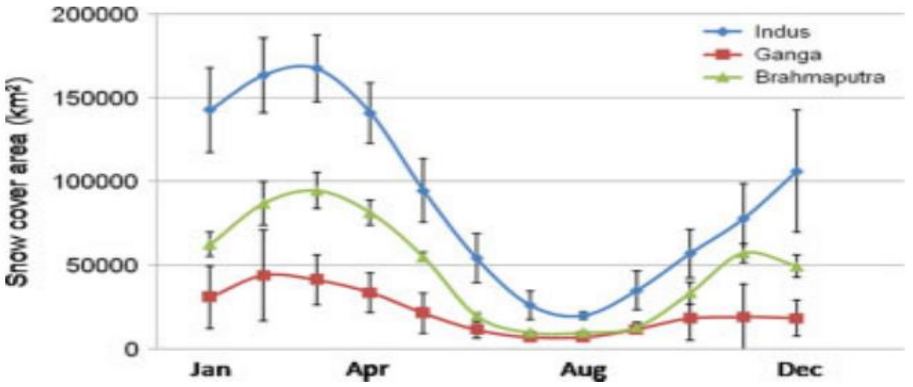






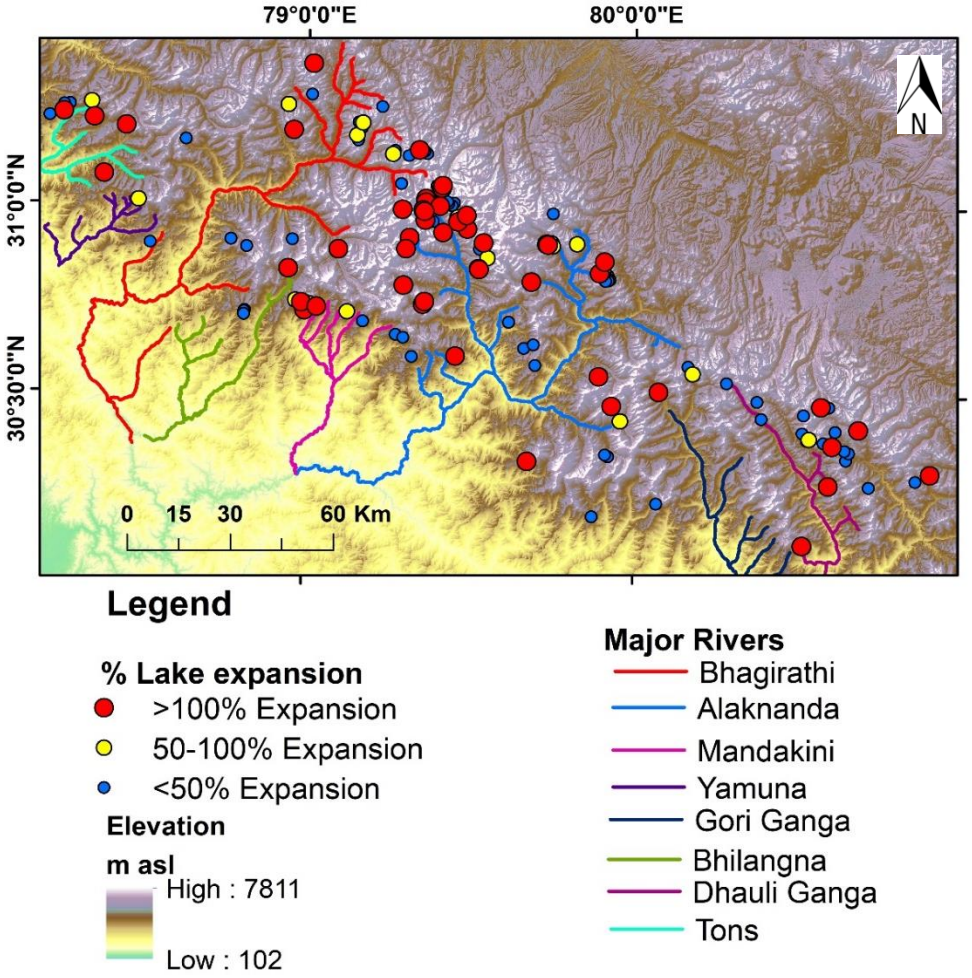
Nikam et al. (2017)

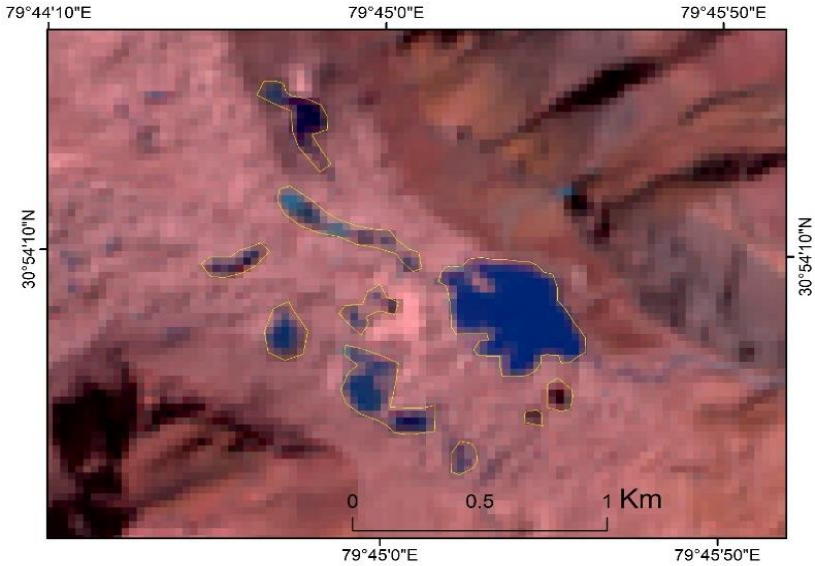


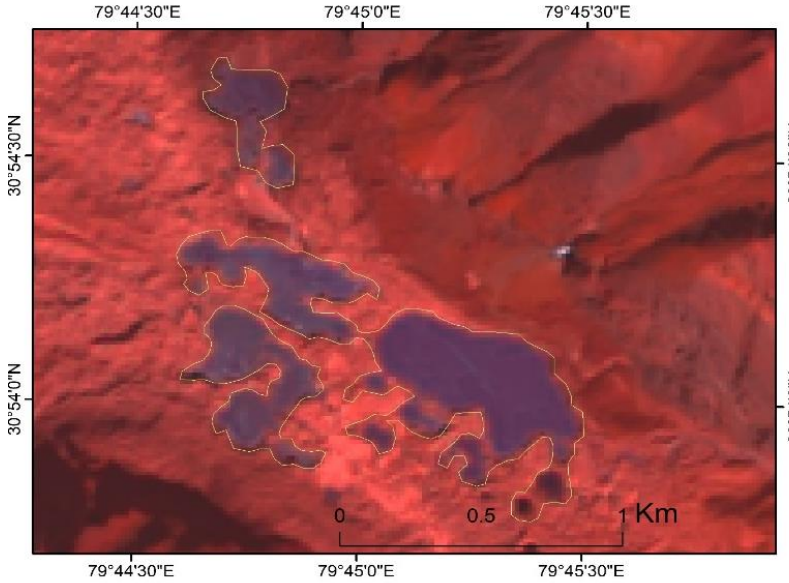


Singh et al. (2014), Int. J of Climatology

Spatial distribution of Glacial Lakes (larger than 0.01 sq. km) in Uttarakhand Himalaya





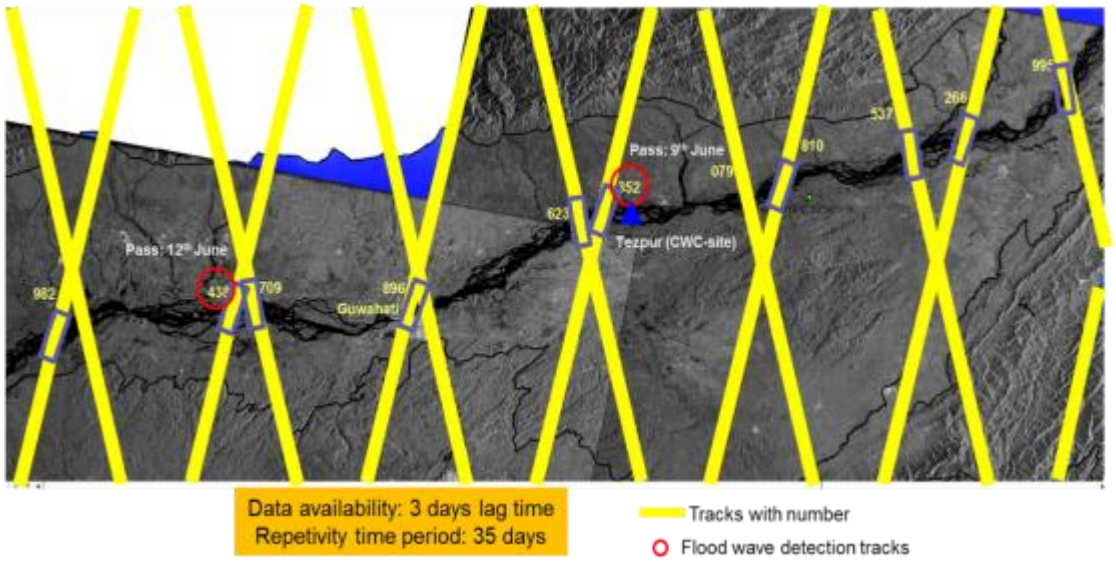


A total of 1392 glacial lakes (>500m^2) covering an area of 8.39 km^2 as per record of the year 2015 exist in Uttarakhand Himalaya.

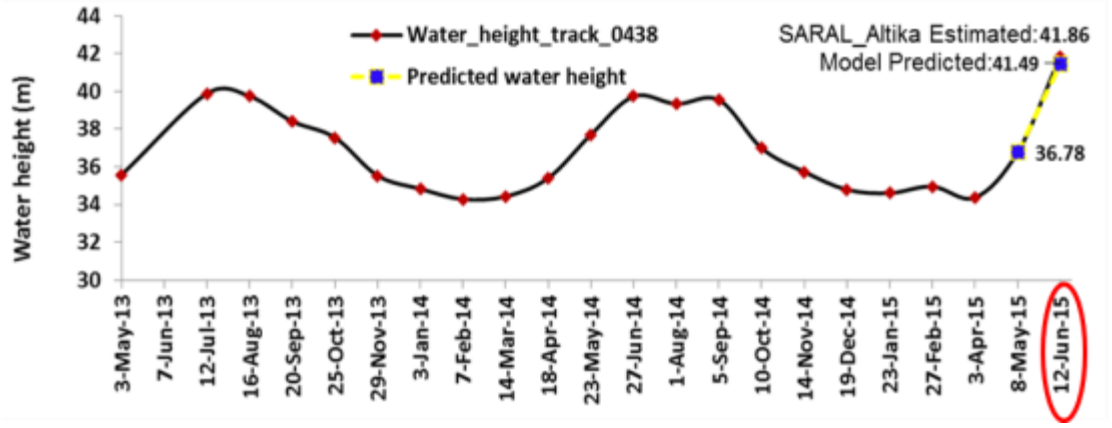
Analysis revealed that lakes have increased in areal extent (57%) at the mean rate of 1.8% per year between 1994 and 2017.

Altika Data for Inland Hydrology

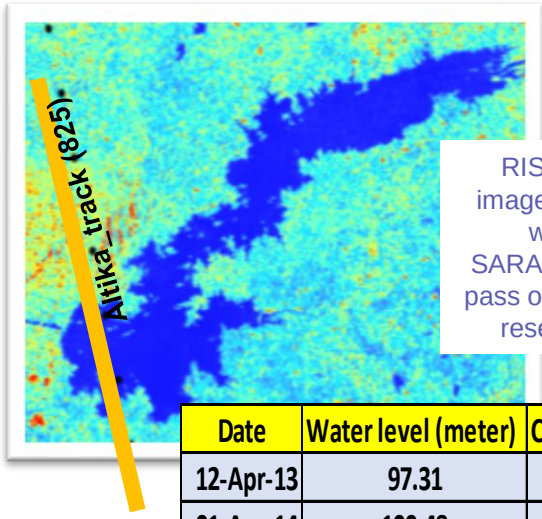
Indian region of the Brahmaputra river along with SARAL-Altika tracks overlaid on RISAT-1 radar image.



Brahmaputra river water (during April 2013 to June 2015) including model predicted water levels for 12th June 2015.



Assessment of water levels for Ukai

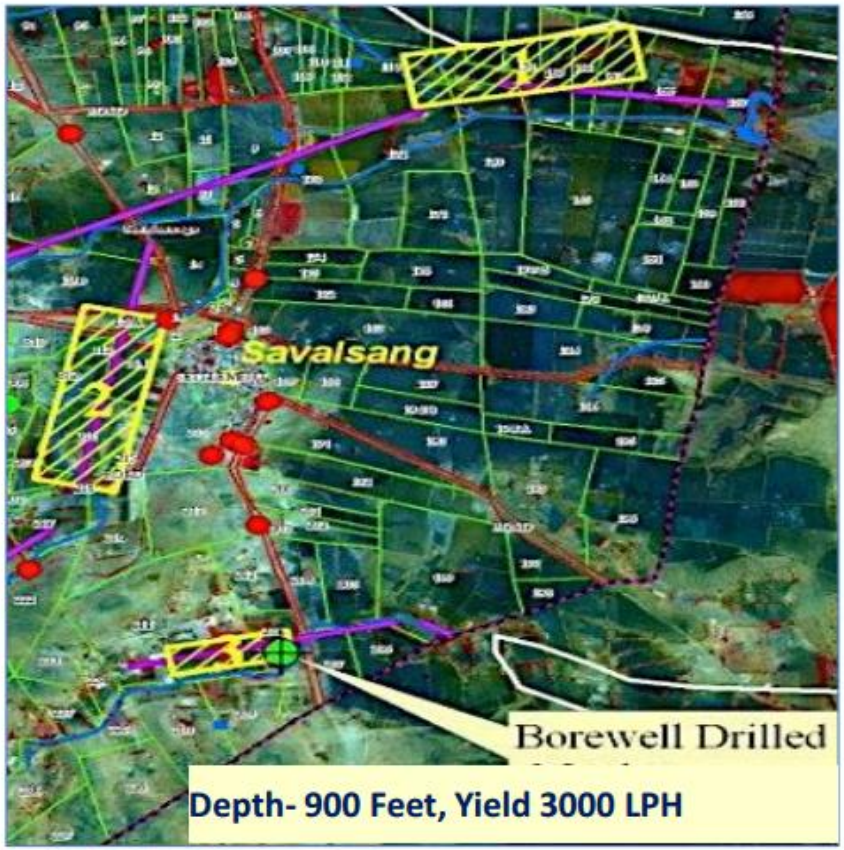


RISAT-1 image, along with SARAL/AltiKa pass over Ukai reservoir

Date	Water level (meter)	Capacity (MCM)
12-Apr-13	97.31	3347.75
01-Apr-14	100.48	4570.81
01-Apr-15	95.89	2905.15
01-Apr-16	94.12	2424.73
01-Apr-17	98.5	3819.261

- The water level over the inland water bodies is retrieved using altimeter waveforms data.
- Range is corrected for tropospheric, ionospheric coand tidal correction.
- Retracking algorithms are developed.

Ground Water Prospects and Sustainability



Bhuvan Bhujal on Geoportal

Ground Water Prospects

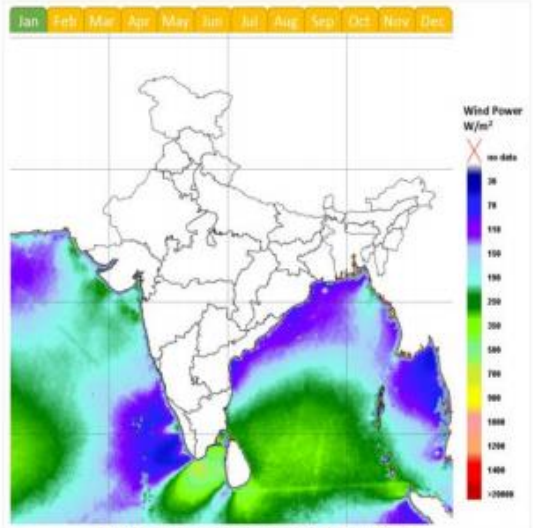
Locations for recharge structures

Hydro-geomorphological mapping at village level , 3D aquifer mapping

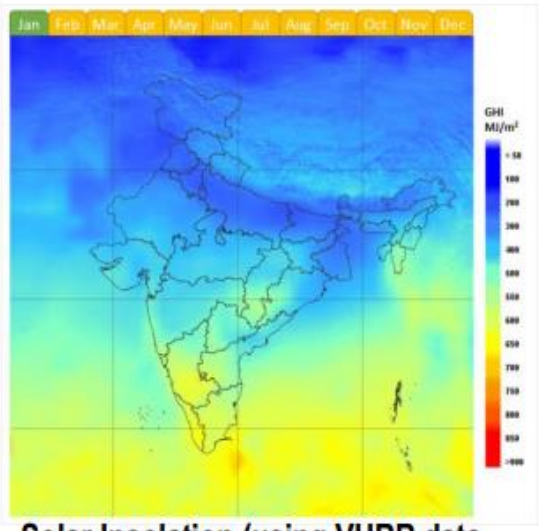
During the 2016 **Drought season in Karnataka**, Village Level Satellite Data Derived inputs were used for siting Bore wells (About 100 wells drilled @ ~85% Success rate)

Energy Management Information System - with NITI Aayog

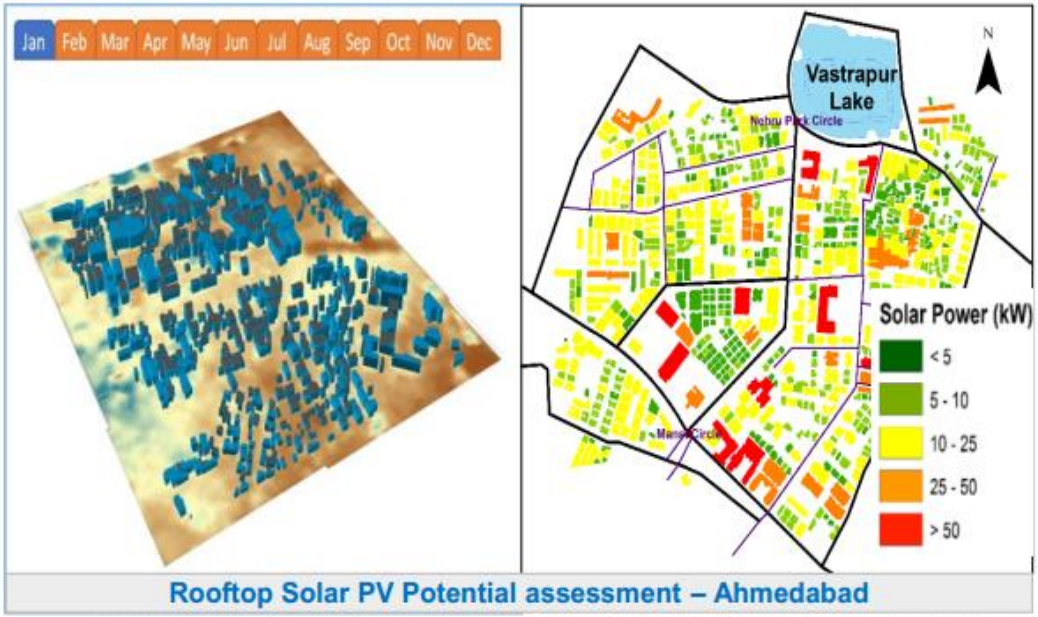
- Atlases of solar, offshore wind & wave energy potential
- 72-Hour solar power forecast developed 6Hrly interval
- Roof-top SE potential
- MobileApp for assessing location-specific Solar & Wind Energy potential



Wind Energy potential (using Scattero meter data)



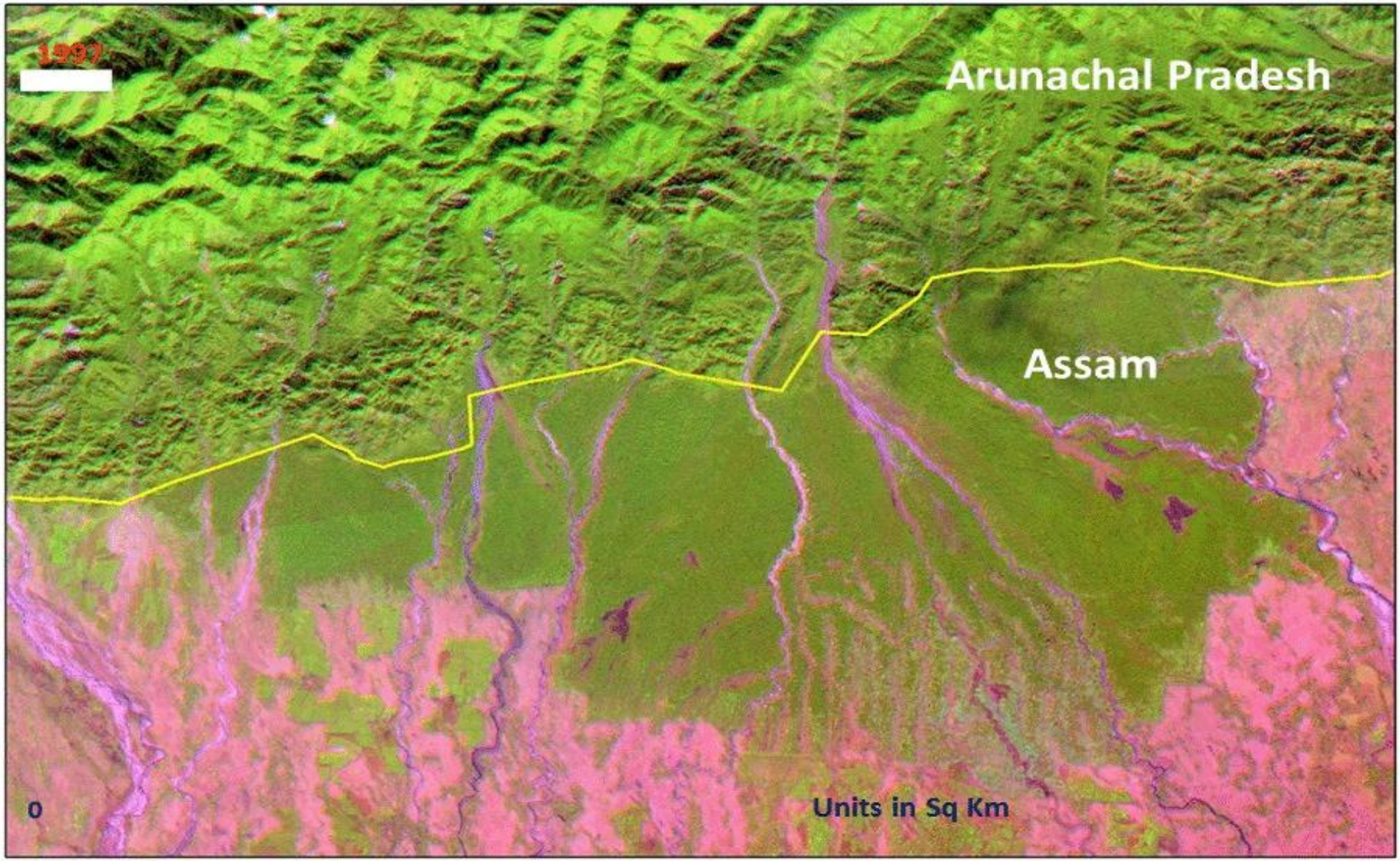
Solar Insolation (using VHRR data of INSAT-3D/3DR)



Rooftop Solar PV Potential assessment – Ahmedabad

" Solar Calculator " Android App

Time Lapsed Data Cube for
Large Scale Deforestation in Assam

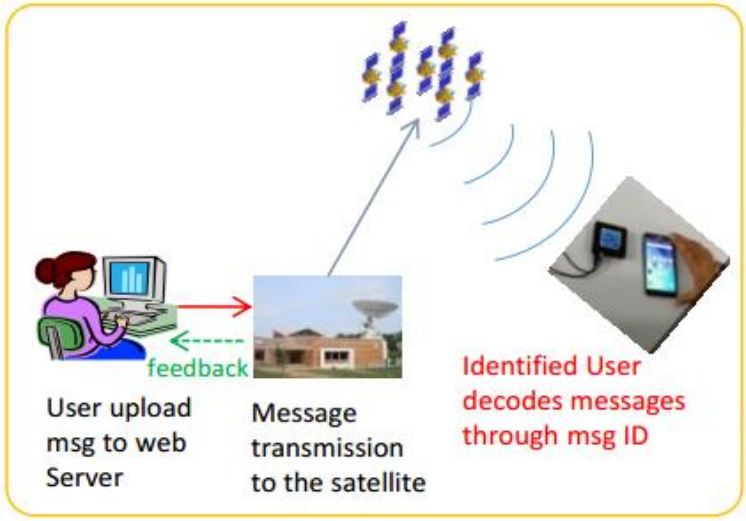


Sonitpur District of Assam

NavIC for Fishermen Community

NavIC based Mobile App Features

- **Location based information**
- **Maritime Intl. boundaries**
- **Online potential Fishing Zones**
- **Weather & Sea State Alerts**
- **Multi-language support**



INSAT - 3D & 3DR

(July 2013 / Sep. 2016)

Observations at 15-minute interval : 48 images/ day

- Provide opportunity to capture short-lived cloud processes.
- More no. of AMVs (20-30%) & 10% improvement in accuracy.
- Structural changes within cyclone during rapid intensification stages are well captured
- Better estimation of cloud growth/decay and improvement in rainfall estimation

6 Channel IMAGER	
Bands (μm)	Resolution
VIS (0.55-0.75)	1km
SWIR (1.55-1.70)	1 km
MIR (3.8-4.0)	4km
WV (6.5-7.1)	8km
TIR-1 (10.2-11.3)	4km
TIR-2 (11.5-12.5)	

19 Channel SOUNDER

Central WL : 0.695 – 14.71 um

Visible : One Band

SWIR : Six bands

MWIR : Five Bands

LWIR : Seven Bands

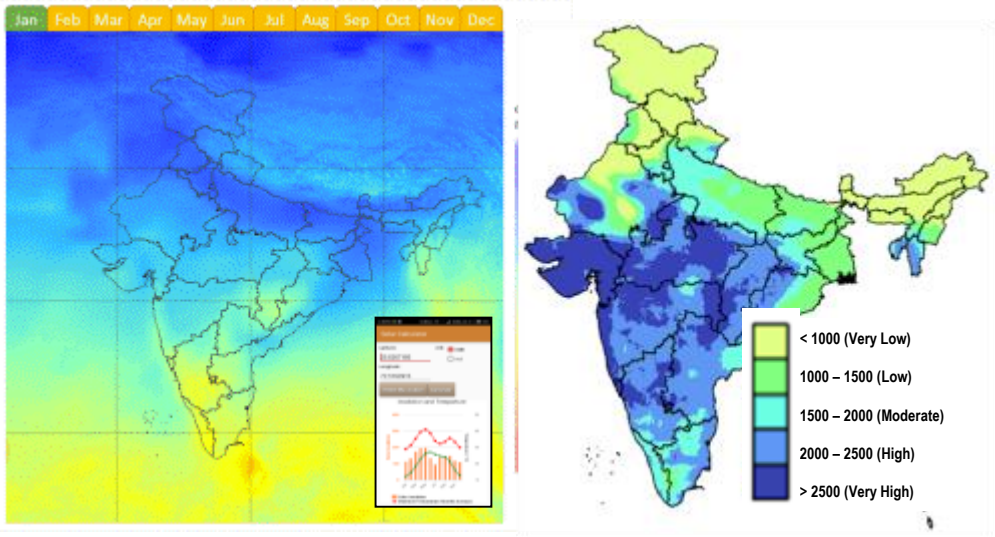
Resolution (km): 10 X 10

40 profiles of Temp. (surface to 70 km)

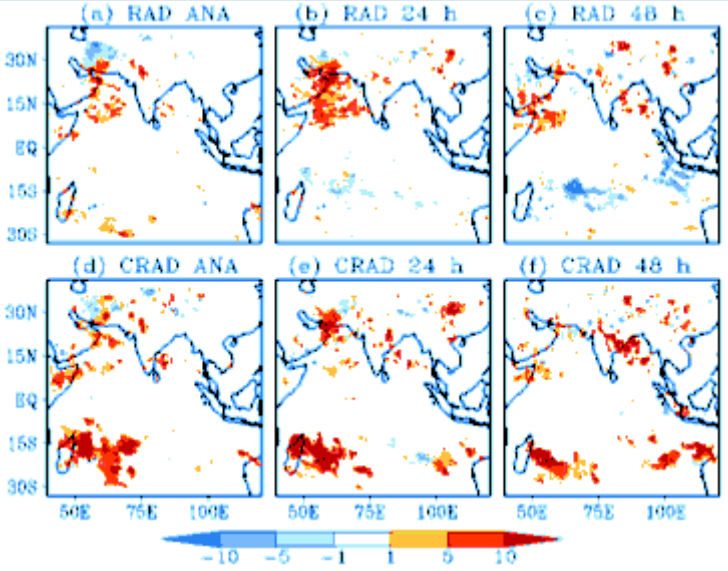
21 Profiles of Humid. (surface to 15 km)

Integrated Ozone (Surface to ~ 12 km)

Solar energy potential & 48-Hour forecast

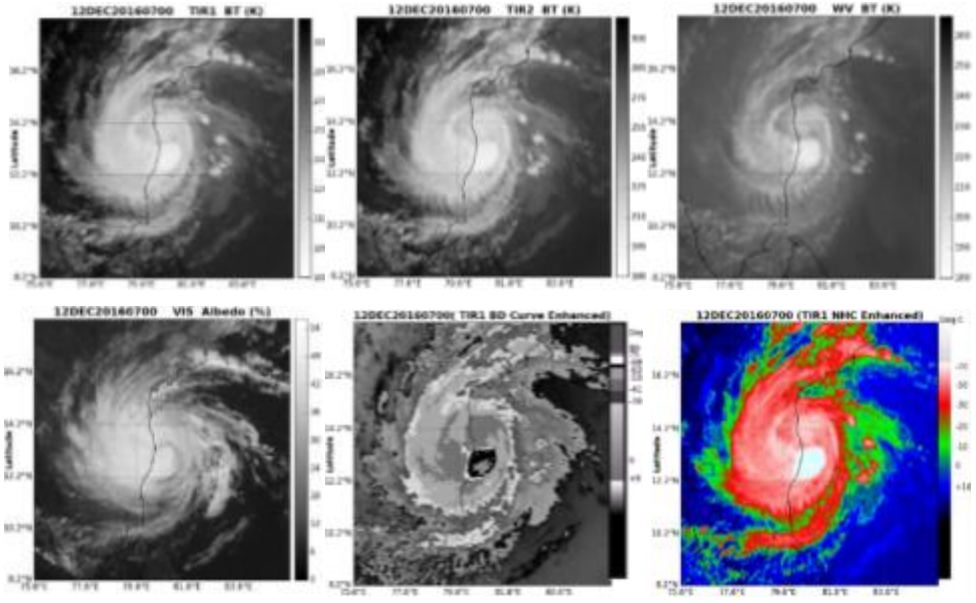


Assimilation of Clear-Sky Brightness Temperature

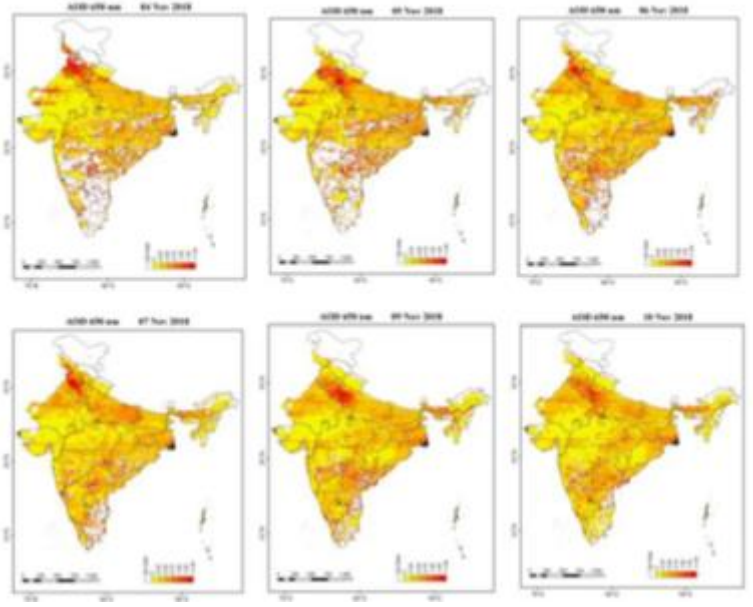


Improved Rainfall prediction

Continuous monitoring of Tropical Cyclones



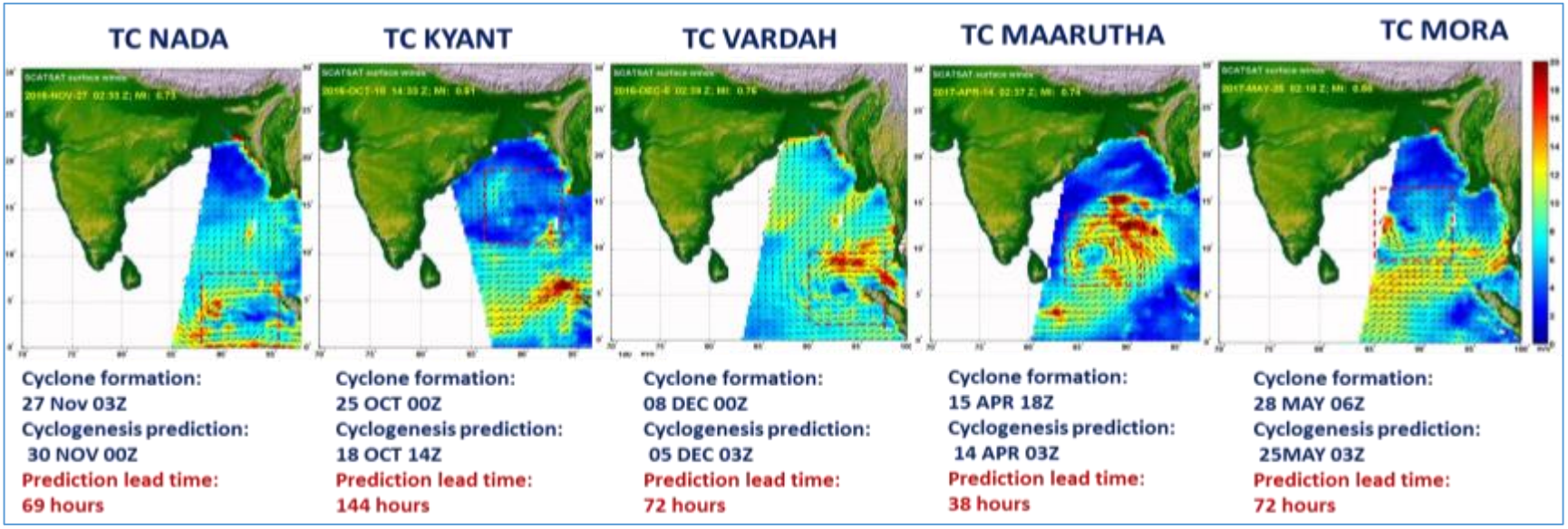
Spatial distribution of INSAT-3D AOD



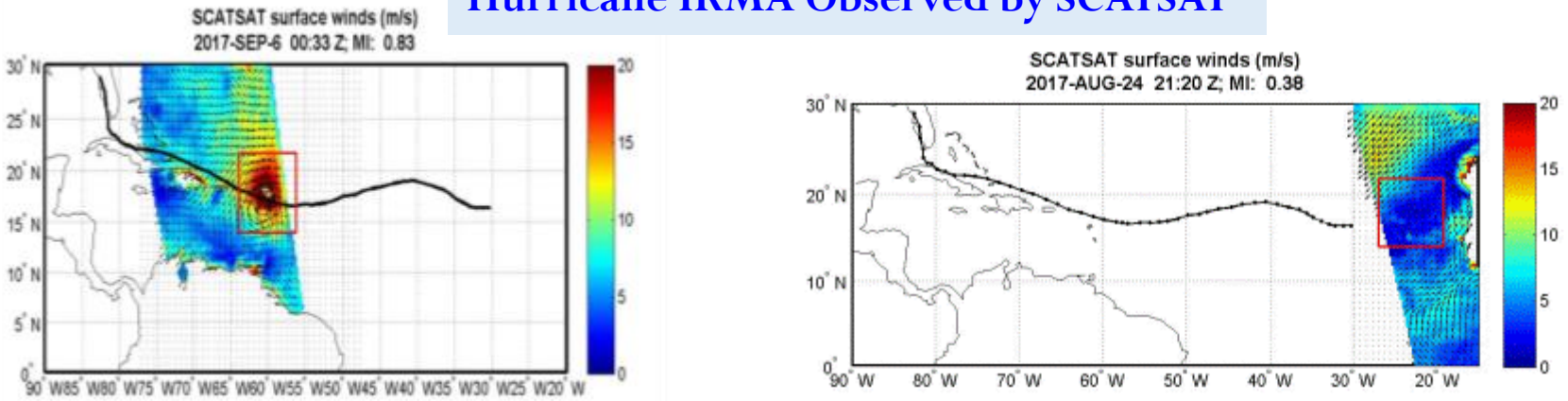
Tropical Cyclogenesis Prediction using SCATSAT-1

Scatsat-1 showing earliest detection of tropical cyclogenesis.

Mean Prediction Lead Time: 79 hours (~3 days in advance)

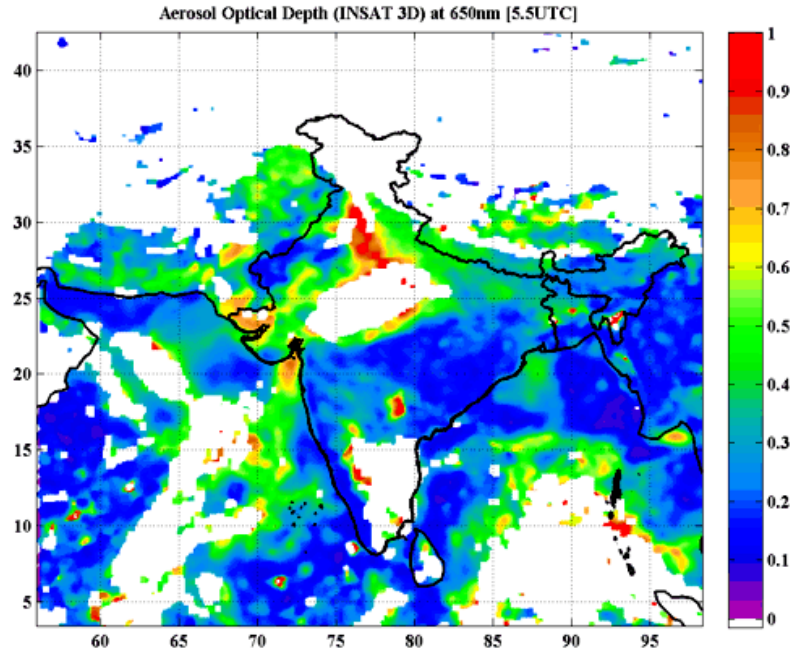


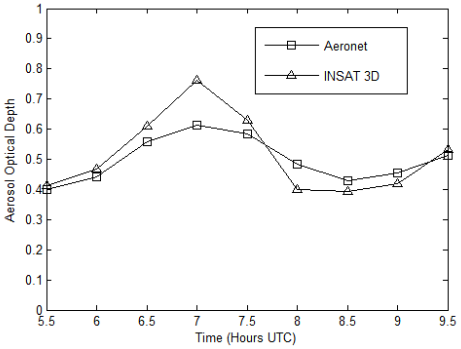
Hurricane IRMA Observed by SCATSAT



Life cycle of winds captured by SCATSAT during Aug 24 to Sept. 11, 2017

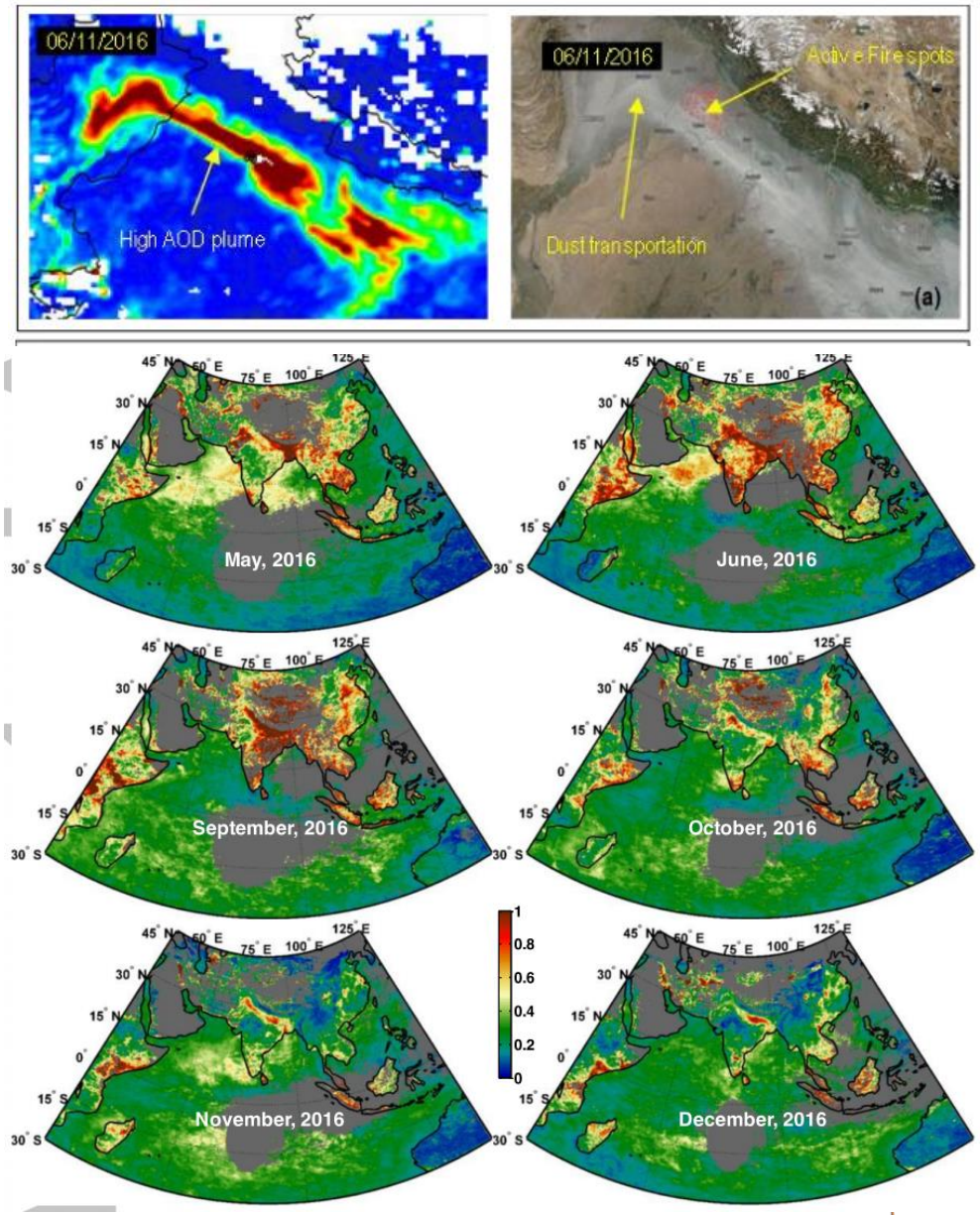
Aerosol Products from INSAT-3D Imager





Animation of INSAT 3D derived AOD from 05:30 hrs to 09:30 hrs (UTC) on 1 January 2014.

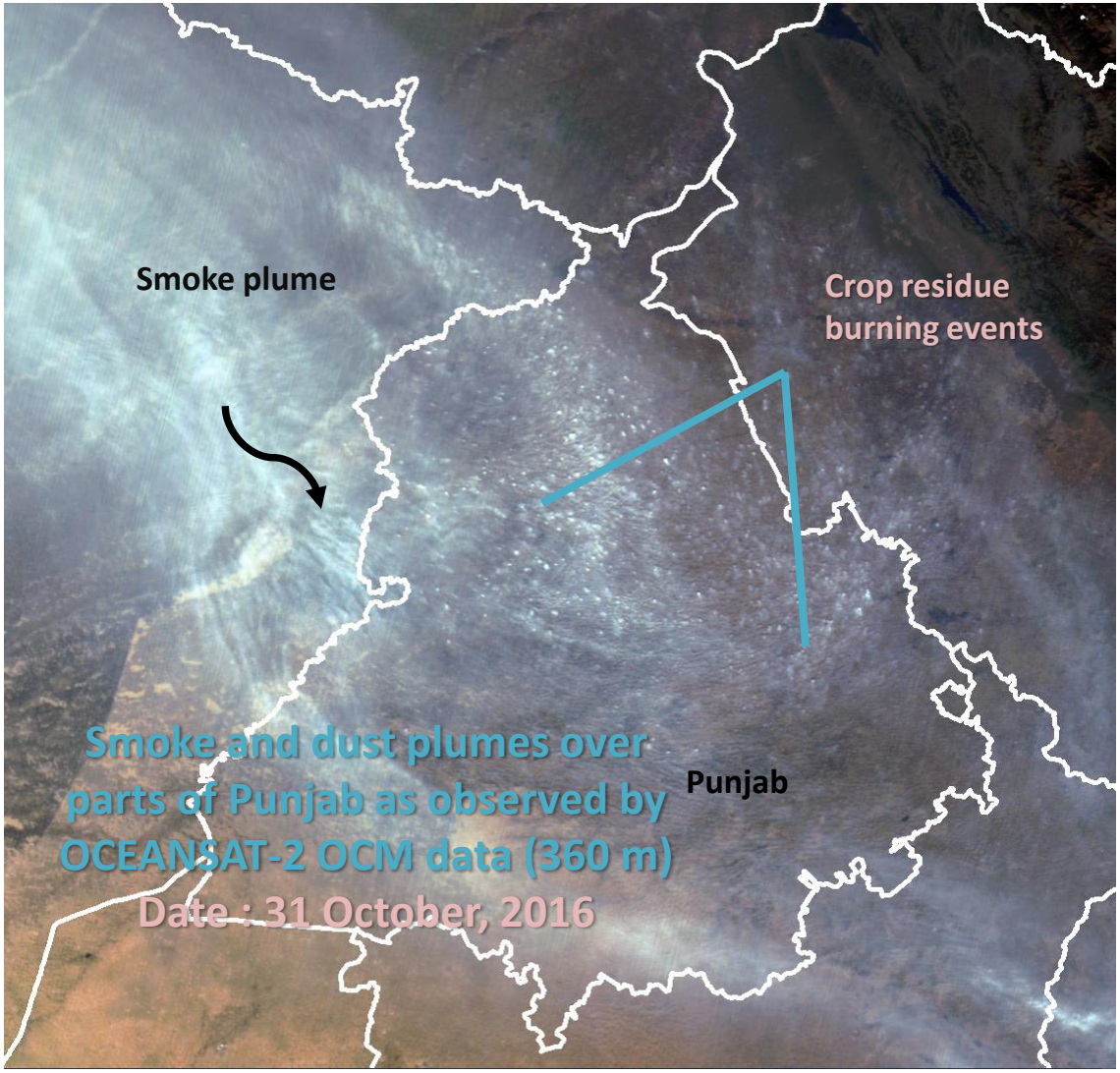
Comparison of AOD retrieved from INSAT 3D and AERONET with respect to time at Jaipur on 1 January 2014



Mishra (2018), JGR Atmosphere

iirs

Crop Residue/Stubble Burning



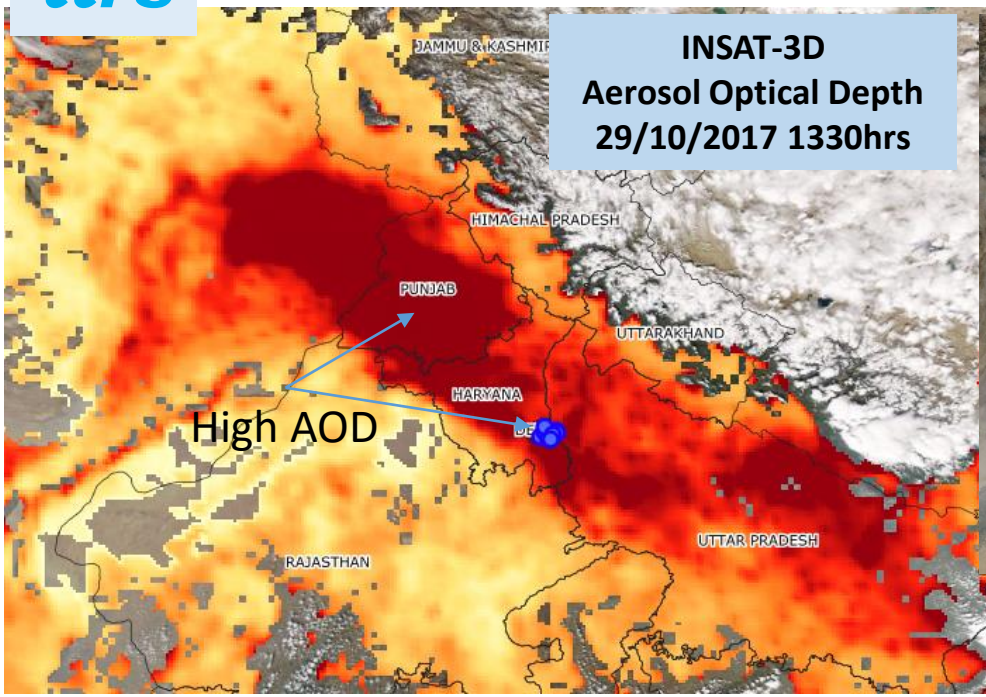
Smoke and dust plumes over parts of Punjab as observed by OCEANSAT-2 OCM data (360 m)
Date : 31 October, 2016

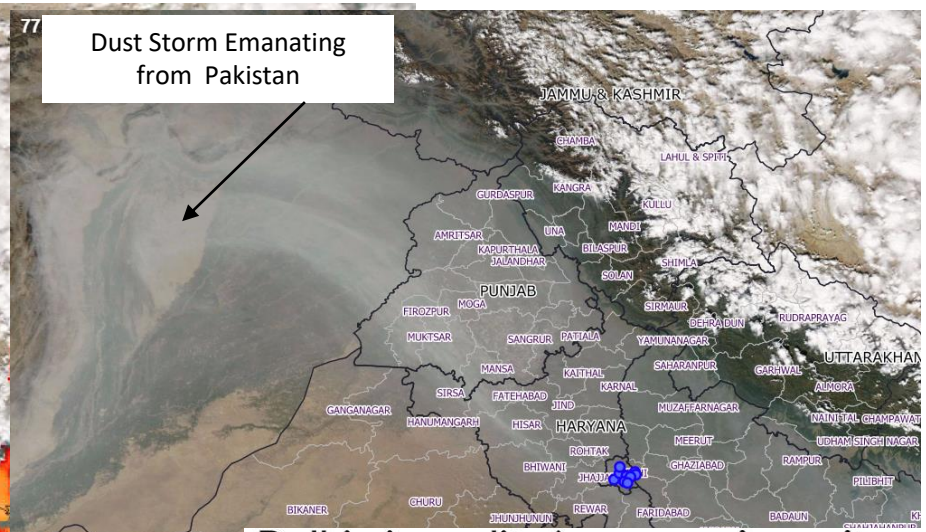
1. What Is Stubble Burning?

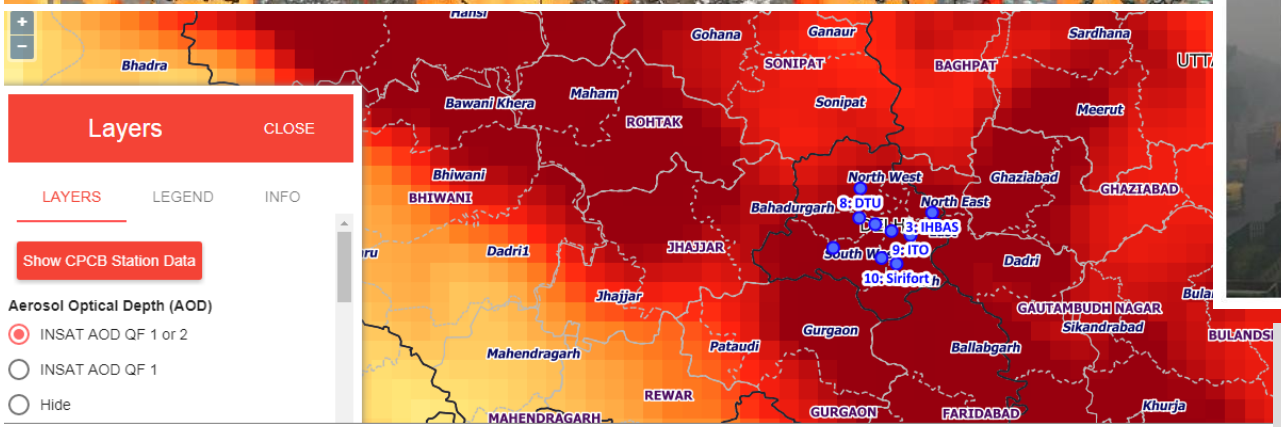
Stubble burning is, quite simply, the act of removing paddy crop residue from the field to sow wheat. It's usually required in areas that use the 'combine harvesting' method which leaves crop residue behind. Now, what is combine harvesting?

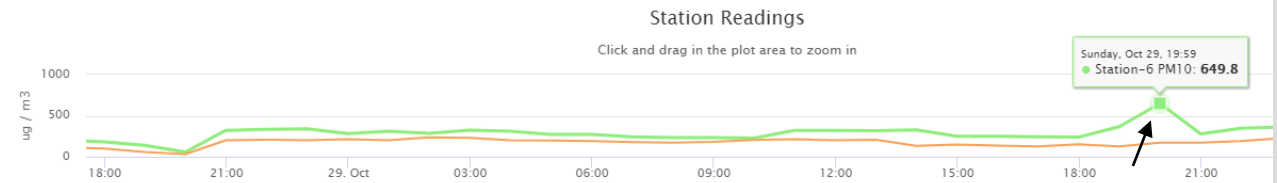
Combines are machines that harvest, thresh i.e separate the grain, and also clean the separated grain, all at once. The problem, however, is that the machine doesn't cut close enough to the ground, leaving stubble behind that the farmer has no use for. There is pressure on the farmer to sow the next crop in time for it to achieve a full yield. The quickest and cheapest solution, therefore, is to clear the field by burning the stubble.

Dust Storm Over North India causing very poor Air Quality on October 29, 2017









High PM 10.0 picked by CPCB station data, New Delhi

Delhi air quality 'very poor', won't improve very soon

TNN | Updated: Oct 29, 2017, 11:02 IST

A- A+

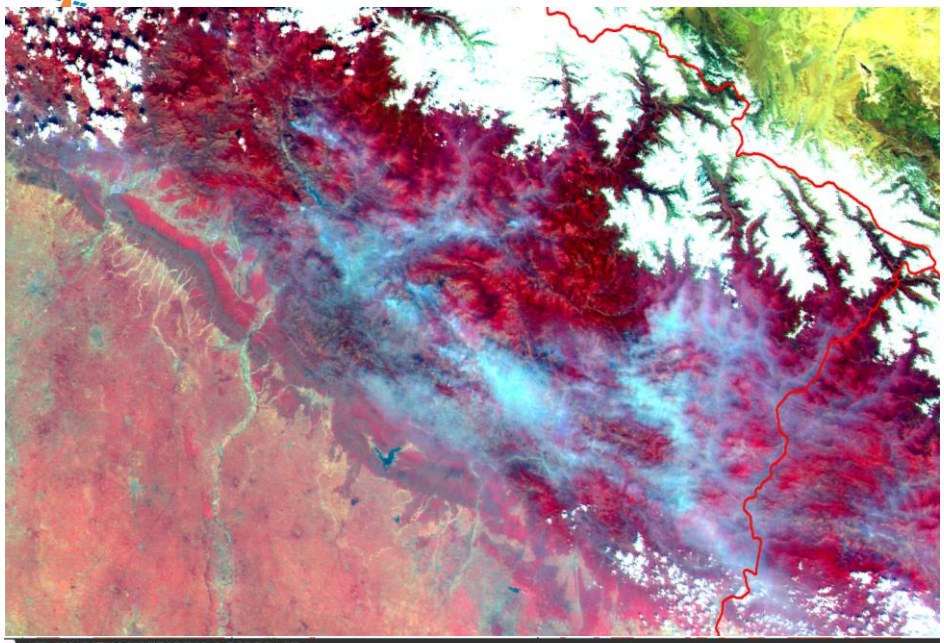
HIGHLIGHTS

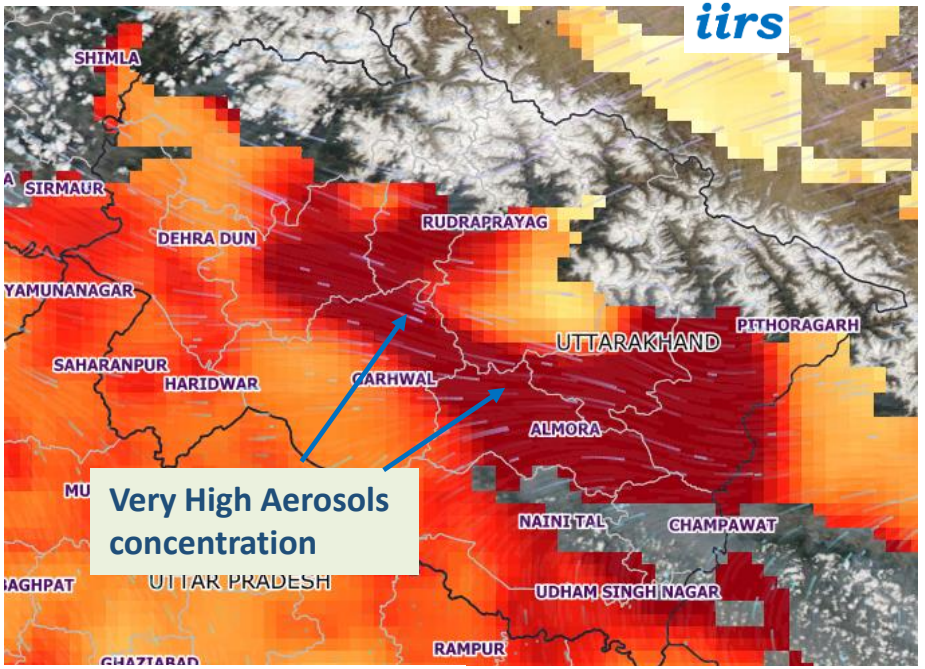
- Delhi's air quality has so far remained unaffected by stubble burning in Punjab with the region instead getting easterly winds from UP which have high moisture content
- Experts say the current meteorological conditions are likely to stay similar for the next few days which will see misty conditions in the morning

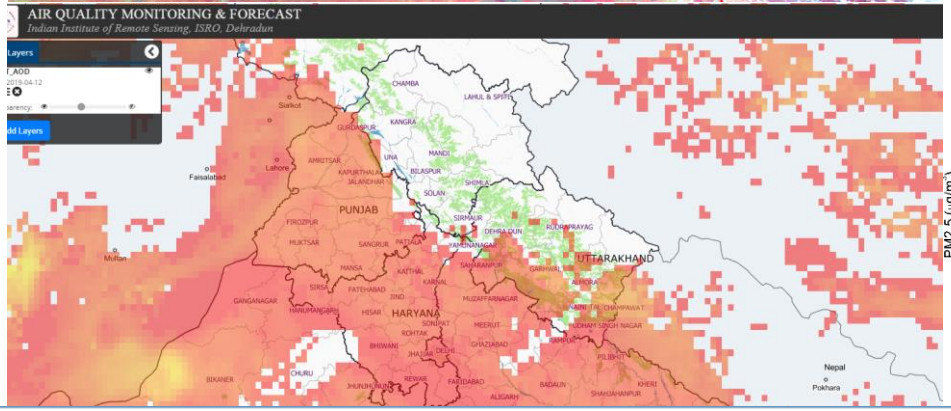
A dust storm was seen in satellite images of INSAT-3D imager and MODIS-Aqua over north India, causing worsening of air quality over Delhi and surrounding regions. High PM 10.0 values were reported by CPCB, New Delhi.

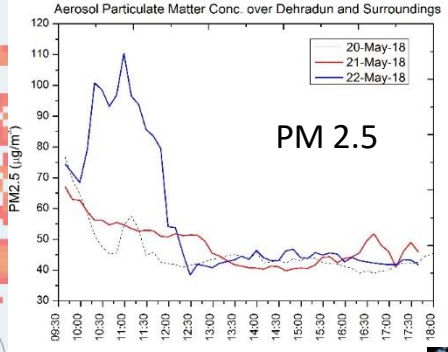
Data: Air Quality Portal VEDAS of SAC/ISRO

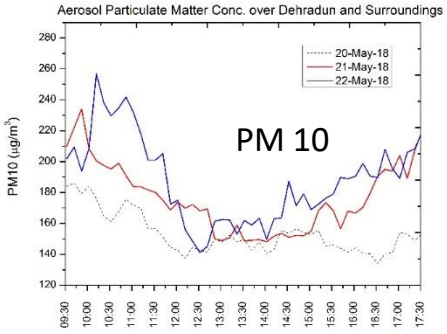
Impact of forest fires on the Air Quality in Uttarakhand State on May 20-30, 2018

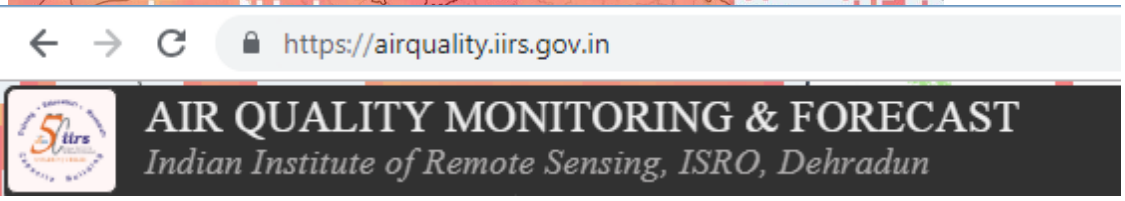




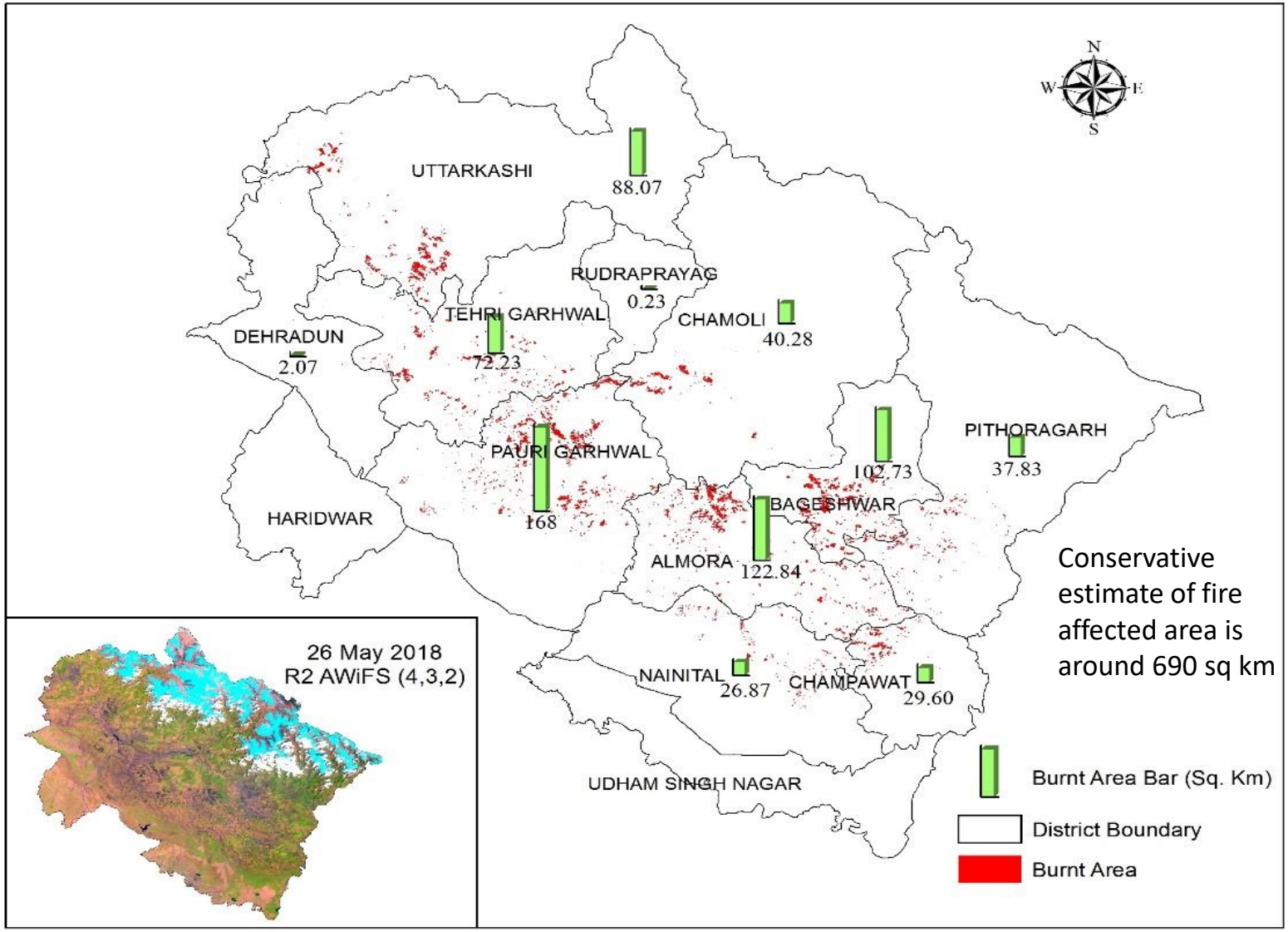








Forest Fire Affected area during May 19-30, 2018



Total fire affected area using AWiFS data as on 29 May 2018

AIR QUALITY MONITORING & FORECAST SYSTEM

(https://airquality.iirs.gov.in/)

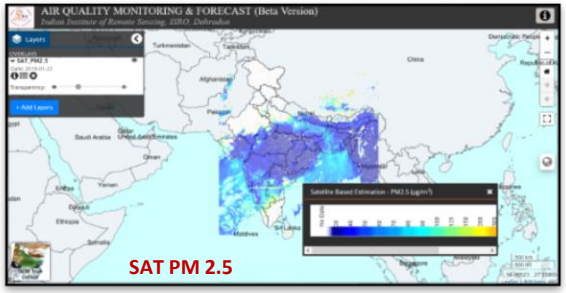
Web portal is being developed to disseminate model generated forecast fields and satellite based inputs for the monitoring and analysis of air quality

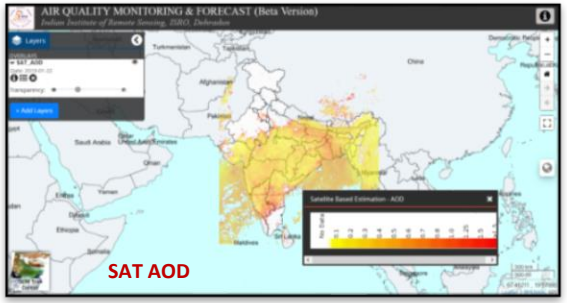
OVERLAY LAYERS	BASE MAPS
• **DUST (Current and archive for last two days**): PM10, PM2.5 and Dust load • **Pollutant Gases (Current and archive for last two days):** O3, CO, NO2, and SO2 • **Satellite Based Estimation (Last five observations):** AOD, PM2.5, and PM10 • Active fire data from FIRMS • **Wind details using Windy API (windy.com)** • **Vector Layers from Vedas (India State, District &Taluk and Continents)**	• OCM True Colour (Source:IIRS) • Bhuvan Map (Source: Bhuvan) • NASA Blue Marble (Source: NASA Blue Marble, image service by OpenGeo) • Aerosol Optical Depth (Source: RAPID-IMD) • MODIS Aqua Corrected Reflectance TrueColor (Source: NASA EOSDIS GIBS) • Aerosol Optical Depth - Terra/ MODIS & Aqua/MODIS (Source: NASA EOSDIS GIBS)

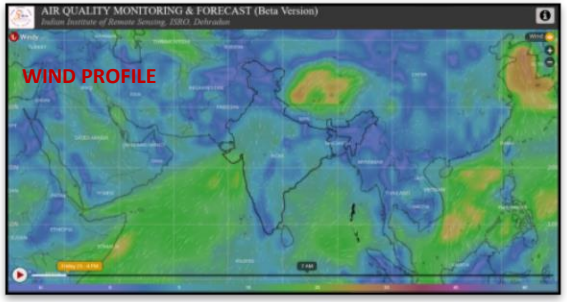
Dust Forecast	• 2 days forecast for dust burden and dust based particulate matter (PM 10 and PM 2.5) generated using numerical prediction model WRF fully coupled with Chemistry (WRF-Chem). Generated for every 6 hour interval at 25 km resolution.
Pollutant Gases	• WRF-Chem model is being used to simulate two days forecast of four gaseous air pollutants O3,CO, NO_2 and SO2 over the Indian Subcontinent daily. Generated for every 6 hour interval at 25 km
Satellite Based Estimation	• Satellite based estimation of surface level Aerosol Particulate Matter (PM2.5 and PM10) over Indian sub-continent at 12.5 km resolution on daily scale.. Geographically Weighted Regression (GWR) is used to estimate regional PM2.5 & PM10 by combination of INSAT-3D derived AOD, dispersion, source apportionment, meteorology and ground based measurements.

Web GIS Functions

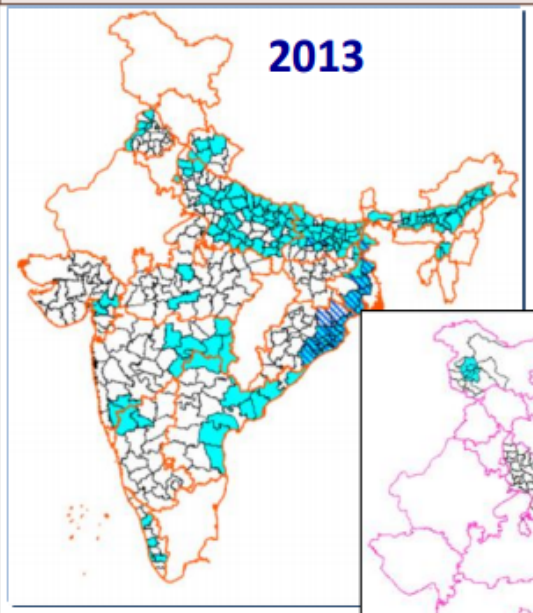
- Web mapping open-source leaflet library used with Geoserver as the GIS Server.
- GIS tools like zooming, panning, layers toggle control, transparency, identify etc.
- Python based ETL (Extract, Transform and Load) utility for automating the process of data loading and online publishing as OGC complaint WMS layers.

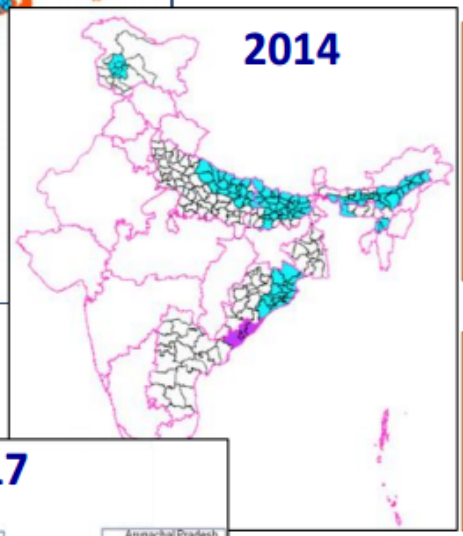


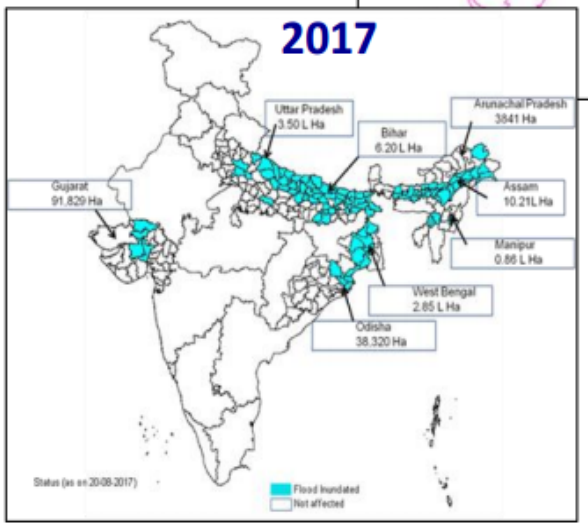




Disaster Management Support







FLOODS
- Inundation Mapping
- Hazard Zonation
- Early Warning

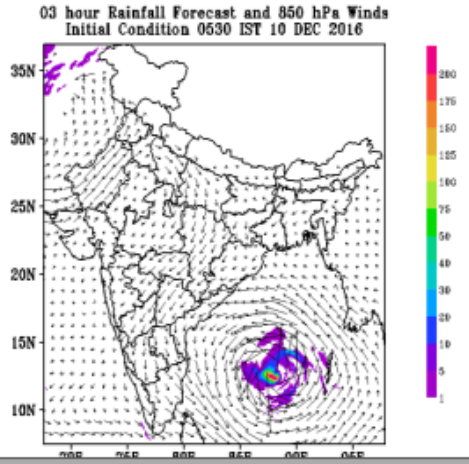
FOREST FIRE
- Fire Detection
- Fire Alert (within 30 min. of acquisition)

CYCLONE
- Damage Assessment
- Landfall Prediction
- Early Warning

LANDSLIDE
- Inventory
- Early Warning

Agri. DROUGHT
- Monitoring & Assessment

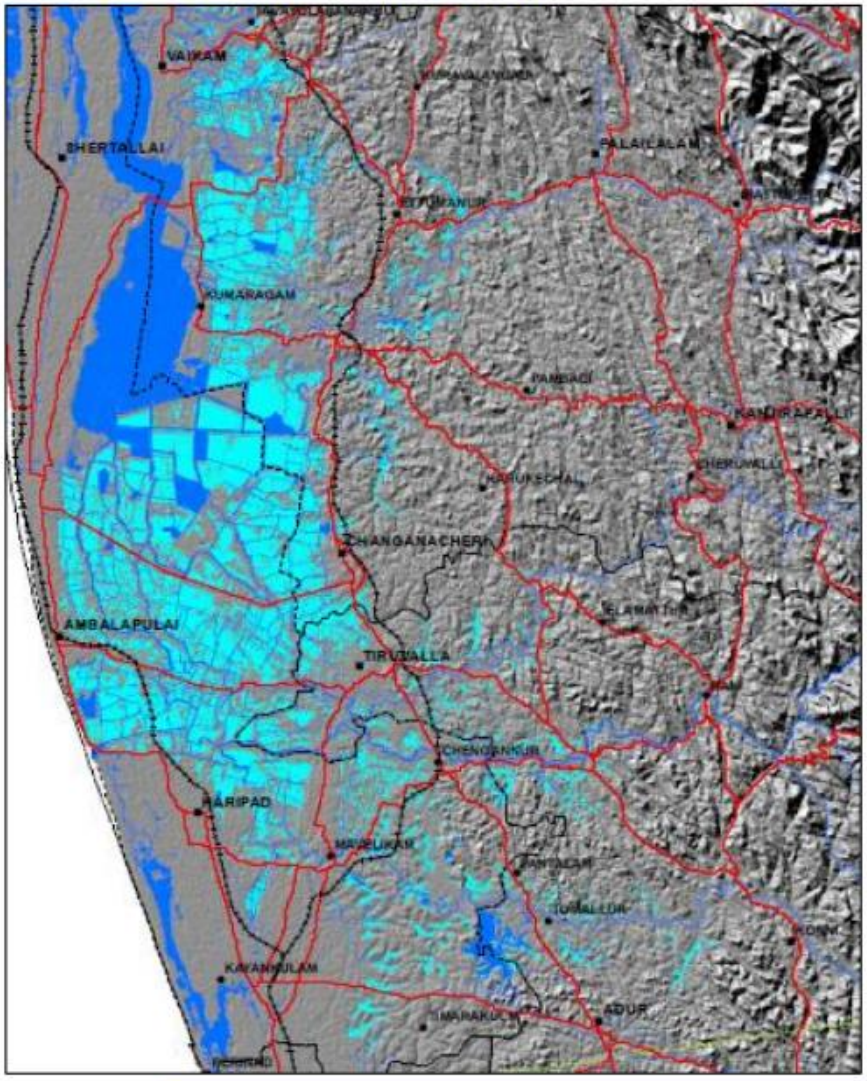
EARTHQUAKE
- Damage Assessment



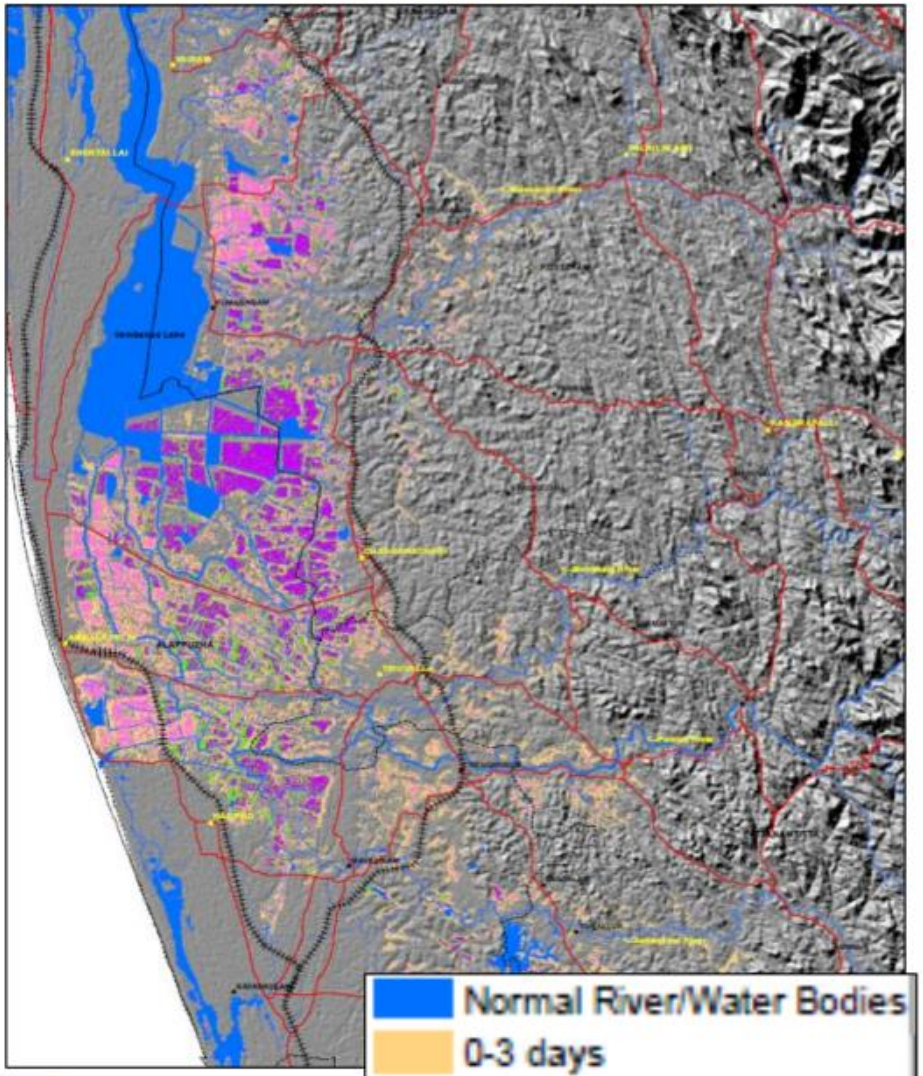
- Decision Support Centre
- National Database for Emergency Management
- North Eastern Regional Node for Disaster Risk Reduction
- ICR-ER implementation - MHA

Devastating Floods of Kerala - 2018

Flood Inundation Map



Flood Duration Map

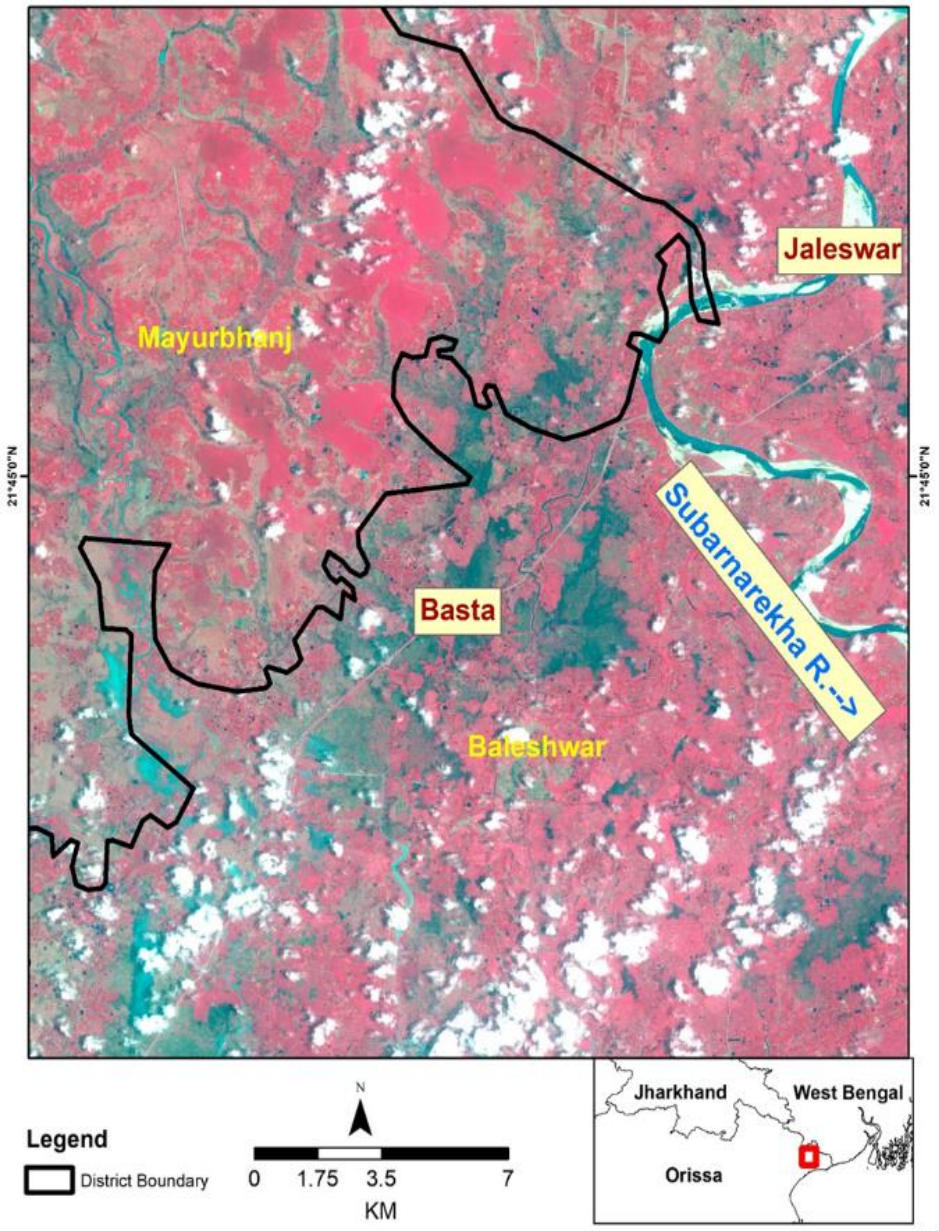


Flooded Area – 90,000 ha
Flooded Roads, Rail segments mapped
Duration of flooding mapped

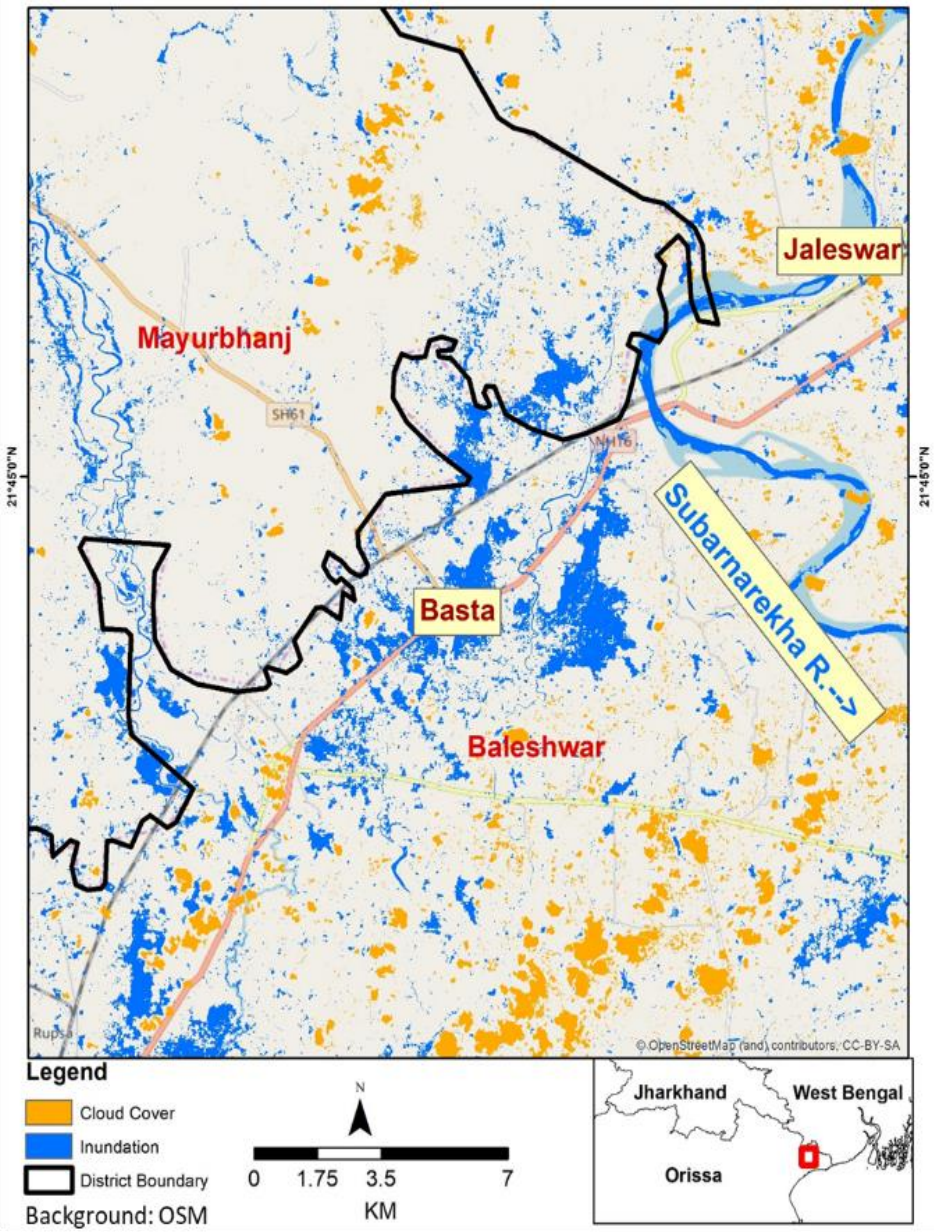
Cyclone Fani

Inundation Observed in Parts of Baleshwar and Mayurbhanj districts, Odisha

Satellite Data: Sentinel 2: 5-5-2019



Satellite Data: Sentinel 2: 5-5-2019

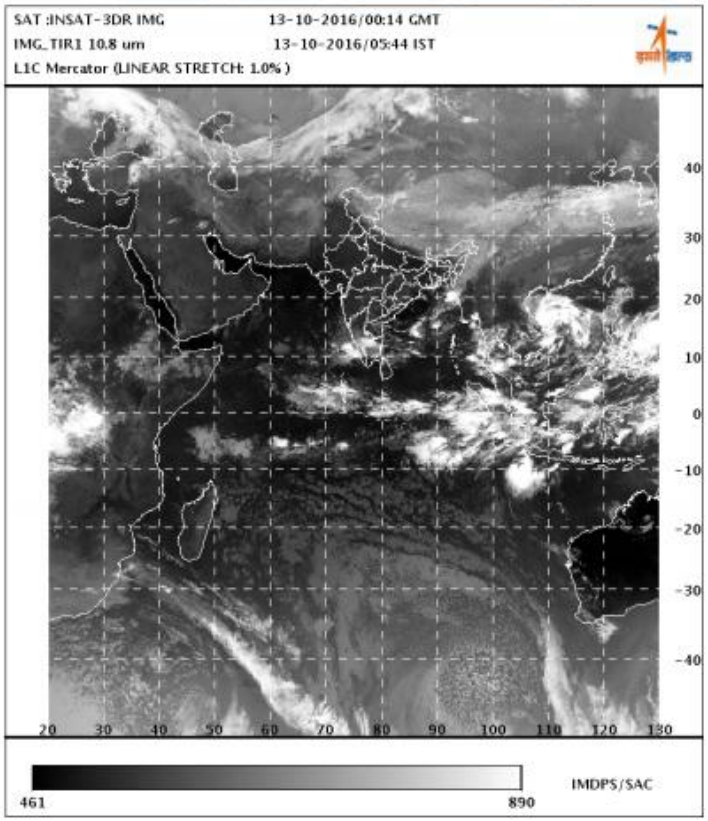


MOSDAC

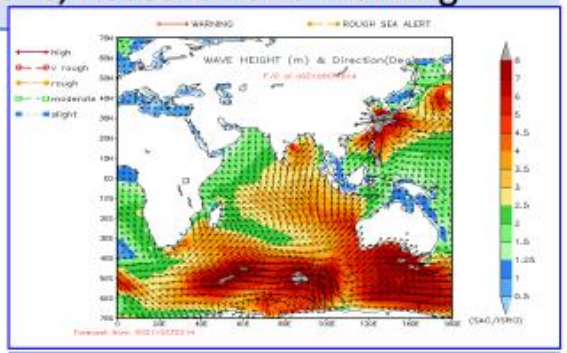
M O S D A C

Indian Storehouse for Space based Weather and Ocean Data

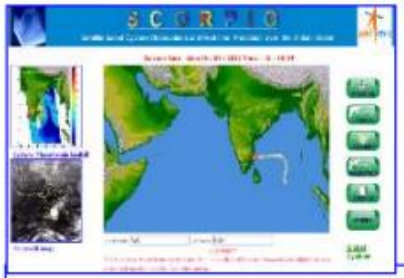
Multi Mission Met and Ocean Satellite Data Repository
CAL-VAL – In situ Data, Weather and Ocean State Forecast
Met and Ocean Applications, Research and Training

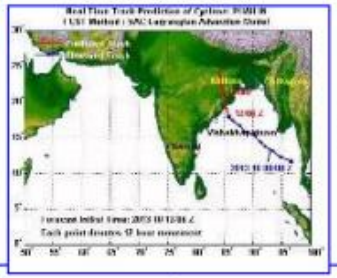


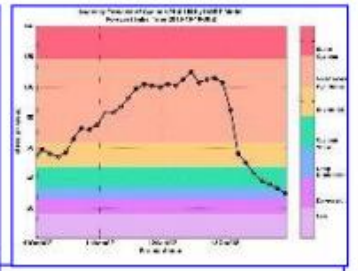
WEATHER FORECAST
24, 48 and 72 hrs. at 5 Km.



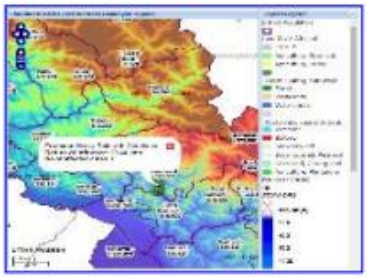
SEA STATE FORECAST
(6 hourly) for 5 days





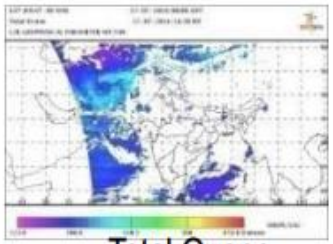


CYCLONE: Track and Intensity forecast over Indian Ocean

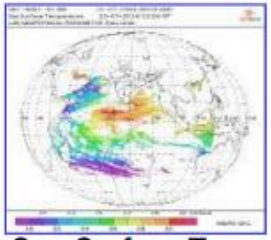


CLOUD BURST
Half hourly ALERTS

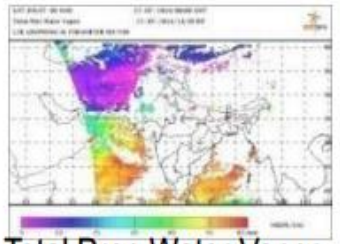
INTENSE RAIN
Half hourly



Total Ozone



Sea Surface Temp



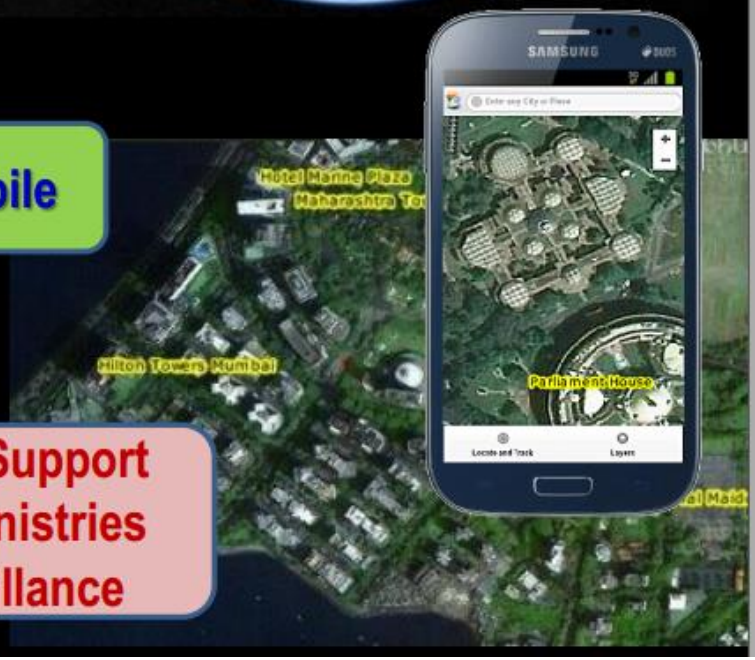
Total Prec Water Vapor

BHUVAN Geoportal – National Geospatial Engine

- 1 m and 2.5 m Satellite data for Nation
- Plans to have twice National coverage
- Digital Surface Model from Cartosat Stereo
- Multi-temporal & Multi-sensor data coverage
- Multi-Theme Map layers / database
- 10 Million Geotags/ Point of Interest

- Large Concurrent Users
- 90 K unique visitors /month
- 95 Million map tiles/month
- 1500 Gigabytes of data flow/month
- 6.5 Lakhs data downloads
- 6200+ OGC Services

2D, 3D, on mobile



- Online Disaster Support
- Central/ State Ministries
- Crop Pest Surveillance

Capacity Building for User Community for Remote Sensing and Geospatial Technology

IIRS Training & Education Programmes

Training Programs

- **PG Diploma** (10 months, 9 Specialisations)
- **Certificate Course for University Faculty** (8 weeks, NNRMS–ISRO Sponsored)
- **Certificate Course** (8 weeks) (ITEC/MEA)
- **Decision Makers Course** (1 week)
- **Special /Tailor made Courses** (for User Depts.)

Education Programs

- **M .Tech. in RS & GIS** (8 Specialisations) (Affiliated to Andhra University)
- **M.Sc. in Geo-information Science & Earth Observation** (Specialisation – Geoinformatics) (JEP with ITC, University of Twente, The Netherlands)

Outreach Program

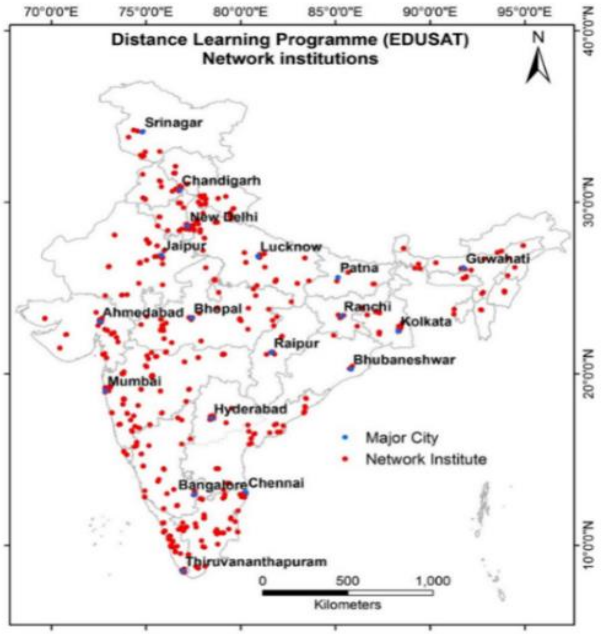
- **Live & Interactive courses**
- **E-Learning courses**

Guidance to UG/ PG/ Ph.D. students

Distance Learning Programme

(https://www.iirs.gov.in/IIRS-Outreach-Programme)

- **Interactive Classroom** Basic, theme-oriented & advanced courses/workshops
  - Network institutions: **770**
- **E-Learning courses**
  - Self-paced, anytime/any-where (100 hrs content)
  - 1 & 4 months courses
  - **Bilingual** contents: Hindi and English



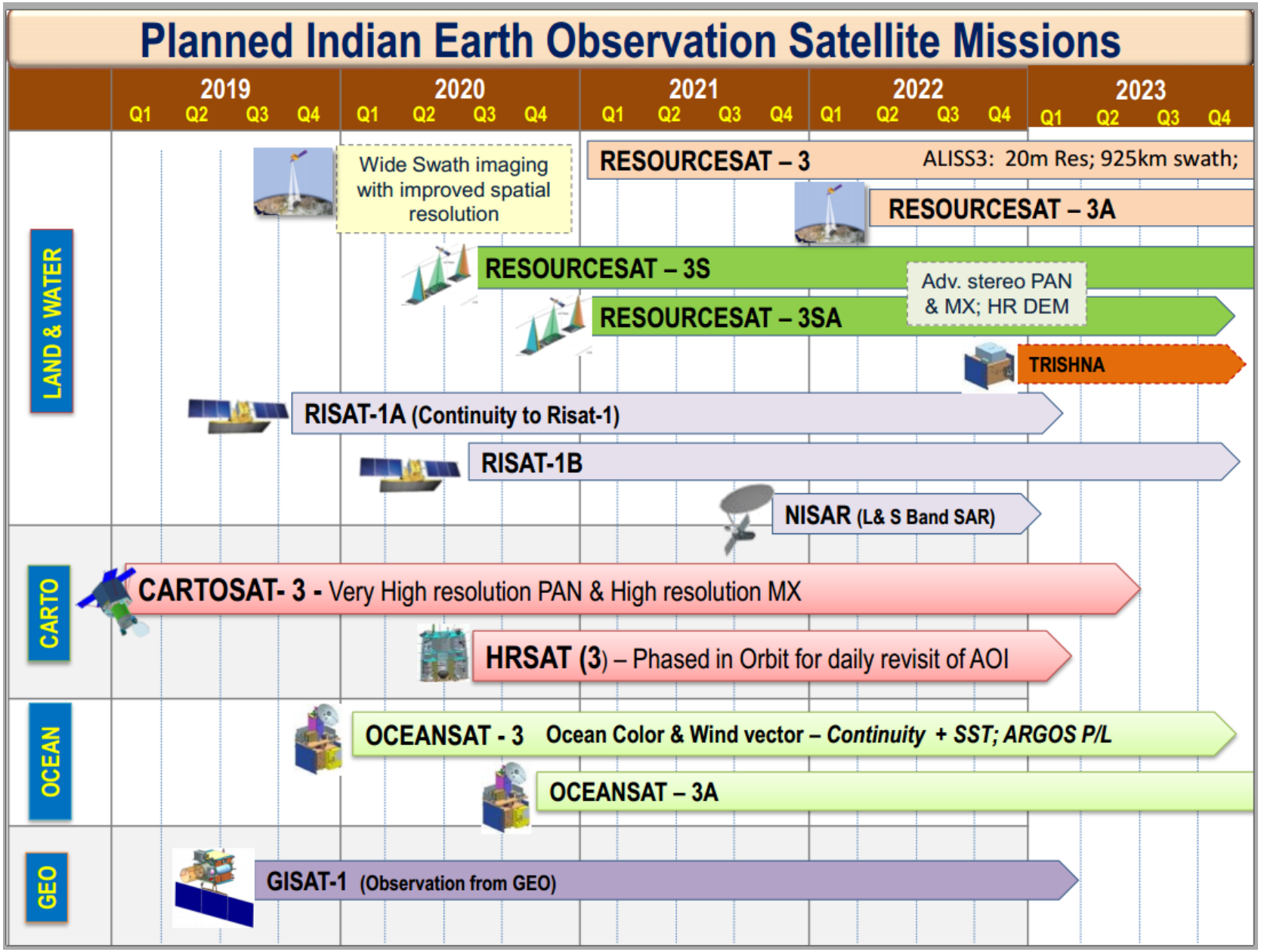
Beneficiaries:

Live & Interactive courses: **70,108**

E-learning courses: **4,440**

(incl. 261 from 47 countries)

Planned Indian Earth Observation Satellite Missions



THANKS...