

ISROs Earth Observation Missions for Societal Benefits



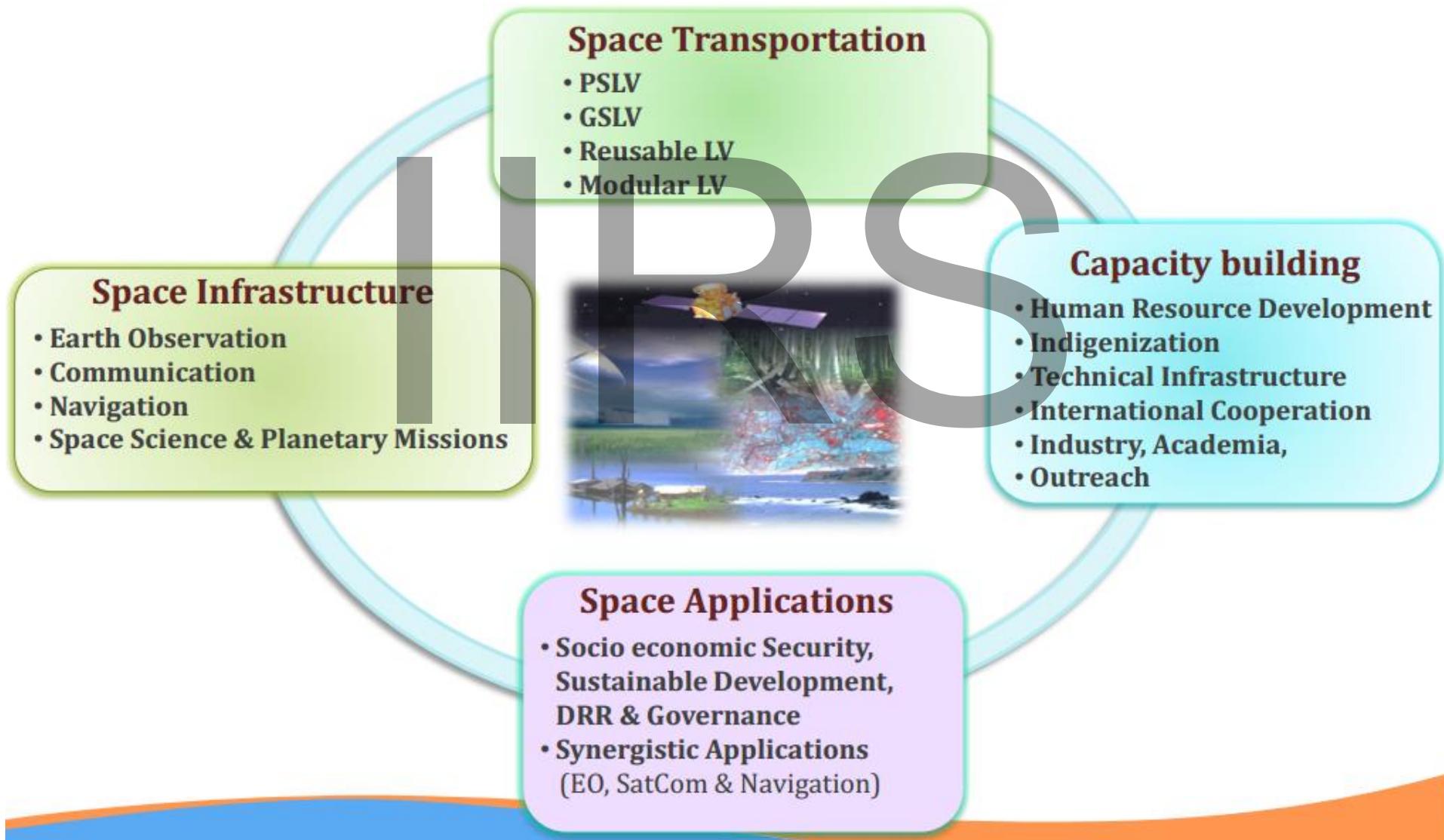
Prakash Chauhan, Ph. D. FNASC

Director

Indian Institute of Remote Sensing, (ISRO) &
Center for Space Sciences and Technology Education in Asia & the Pacific (Affiliated to UN)
Dehradun, India

Indian Space Programme: Dimensions

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



Space Segment

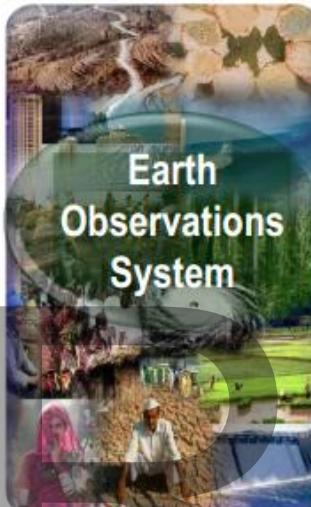
Constellation of Satellites

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



Institutional Linkages

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



Ground Segment

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

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



Large Scale Mapping, Infrastru. Planning & Cartography

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



Oceanography

OCEANSAT-2 ; SARAL ; SCATSAT-1



Weather & Climate

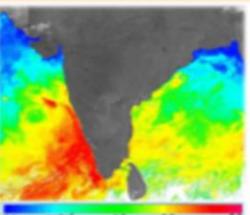
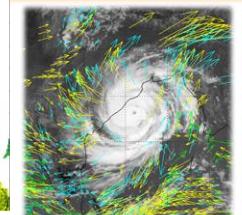
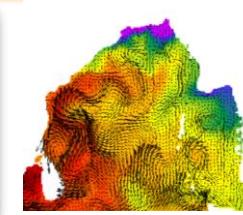
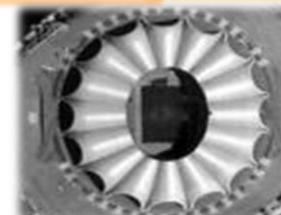
INSAT 3D & 3DR ; MEGHA-TROPIQUES

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

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

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

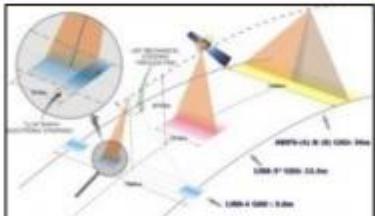
- 6 channel Imager – 48 images per day
- 19 Channel Sounder – Atm. Profiles
- Radio Occultation – humidity profiles



Remote Sensing Capabilities

Land & Water Resources, Cartography

RESOURCESAT-2/2A



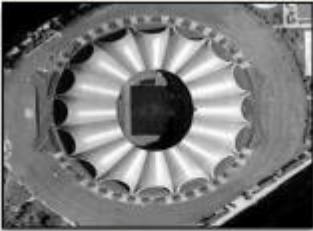
56 / 23 / 5.8 Meters

CARTOSAT - 1



2.5 Meter - Stereo

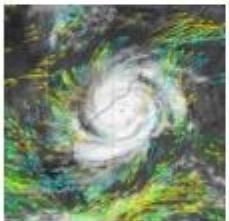
CARTOSAT-2S



Sub- meter

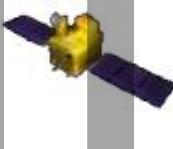
Weather & Climate

INSAT-3D & 3DR



6 Bands IMAGER
19 Channel Sounder
48 images per day
Imager - 1 / 4 km

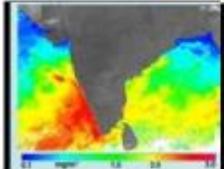
MEGHA-TROPIQUES



Radiation Budget
Atm. Profiles
Radio Occultation

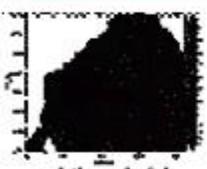
Oceanography

OCEANSAT-2



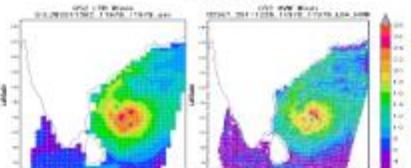
Ocean Color
360 m / 2 days

SARAL



Ocean Altimetry
Ka BAND ALTIMETER

SCATSAT-1



Wind Vector
Ku BAND SCATTEROMETER

In-situ

Automatic Weather Station



Micro Rain Radar



Sun Sky Photometer



Met and Ocean Buoy



Agro-met Station



Doppler Weather Radar



Flux Tower



GPS Sonde

- 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

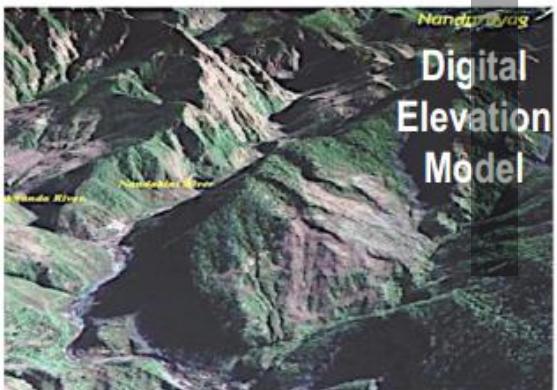
Framework for Space Technology based Applications



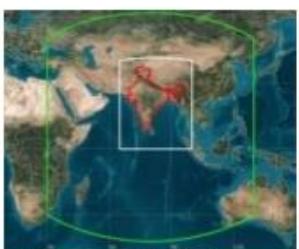
Satellite Data - Multi-Spectral
Multi-Spatial, Multi-Temporal



Ortho Image



Digital
Elevation
Model



Ground Data –
Nav. Enabled
Positioning



In-situ
Sensors



Geoportal for
Applications

Models & Decision
Support Systems

Indigenous tech. &
Industry



SOCIO-ECONOMIC SECURITY

Food, Water, Energy, Health, Shelter,
Infrastructure, Information

SUSTAINABLE DEVELOPMENT

Resources Conservation, Impact
Assessment, Fragile Ecosystem,
Climate Change Impacts



DISASTER RISK REDUCTION

Preparedness, Early Warning
Response & Recovery



GOVERNANCE

Planning , Monitoring
Evaluation & Decision Support

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

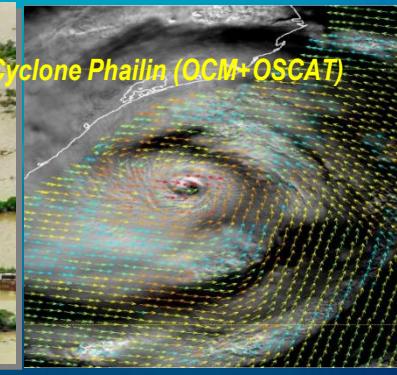
Societal Empowerment

- 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



Ocean & Marine Resources

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

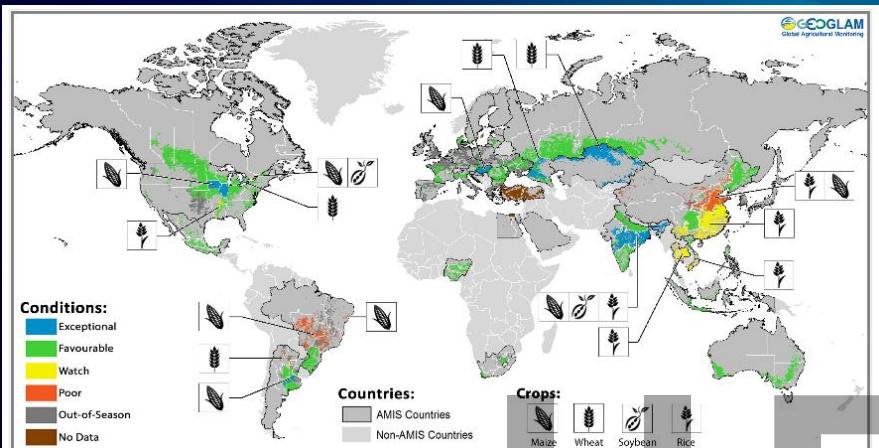
Disaster Management

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

Weather & Climate

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

Diversity of Indian Agriculture



India ranks second worldwide in farm output. Agriculture sector accounts 13.7% of the GDP.



India holds the second largest agricultural land (179.9 million hectares) in the world.



Net Sown Area : 141 Mha (44 %)

Food Grain Production : 275.68 Mt

Horticulture Production : 295 Mt

Net Irrigated Area : 66 Mha

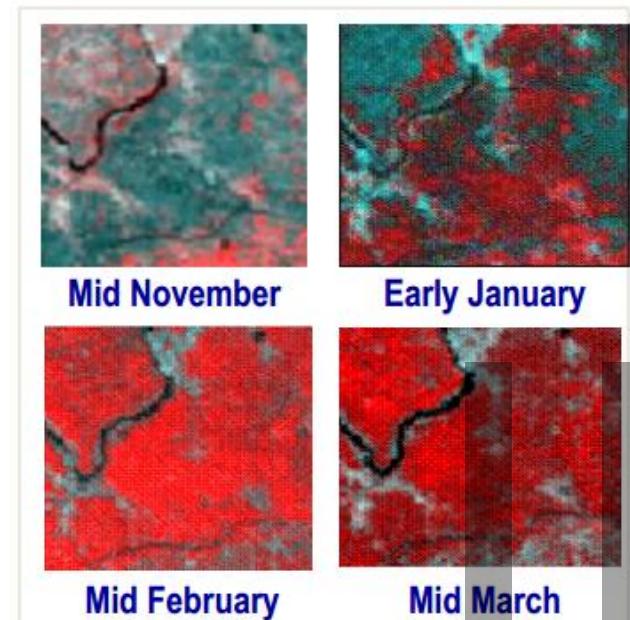
GDP contribution ~ 13.7 %

Employment Opportunity : 55%



Agriculture Applications (Operational @ MNCFc)

Crop Production Forecast- 8 Crops & Rabi Pulses



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

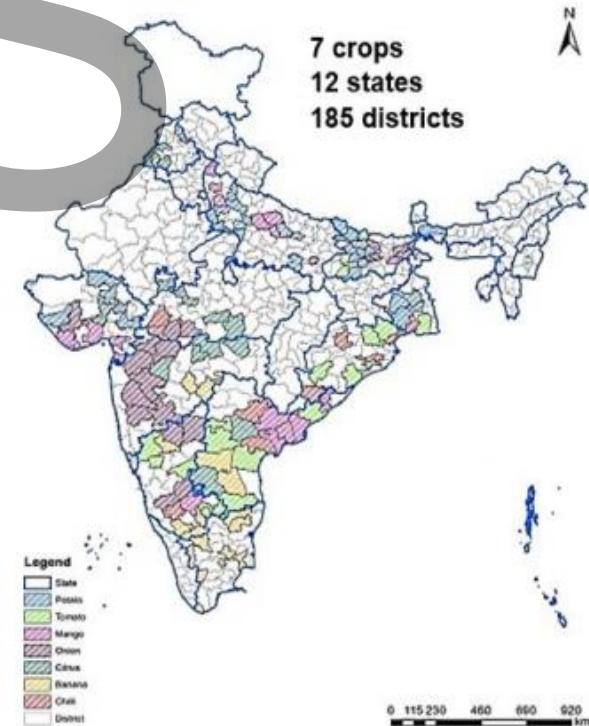
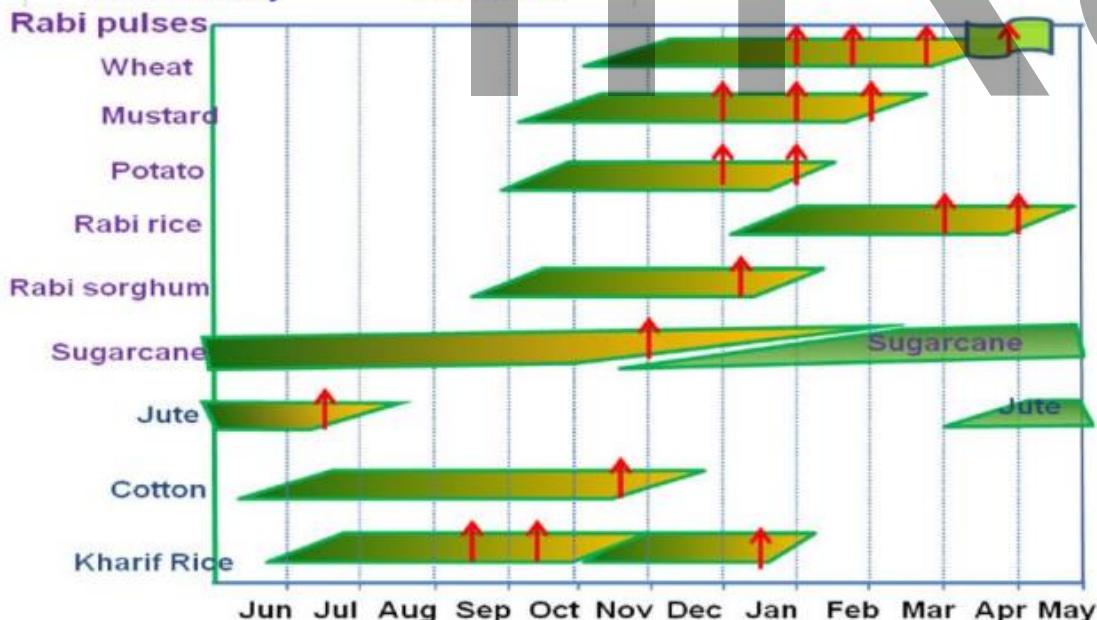
Pre-harvest Production Estimation Rice, Wheat, Mustard, Sugarcane, Potato, Cotton, Sorghum, Jute, Pulses

New Challenges

- Soil Health Card
- Crop Insurance
- Crop Intensification

Working Towards 25 crops

Horticulture Mission (CHAMAN) Phase-1 is completed



Village level crop assessment

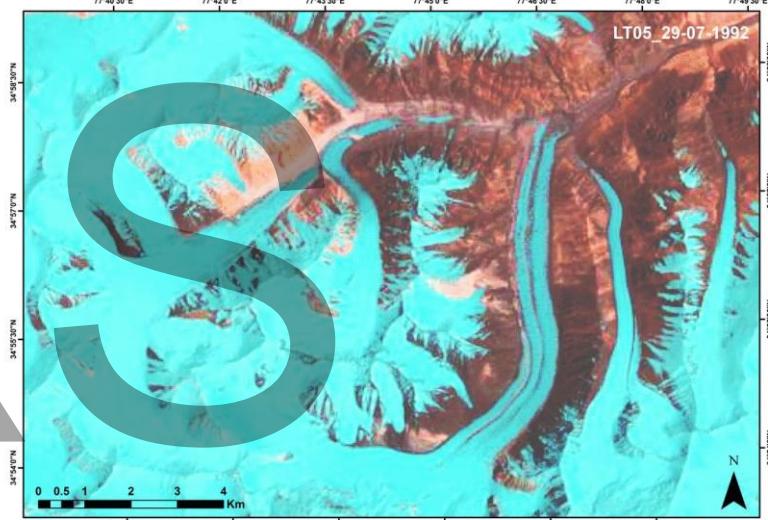
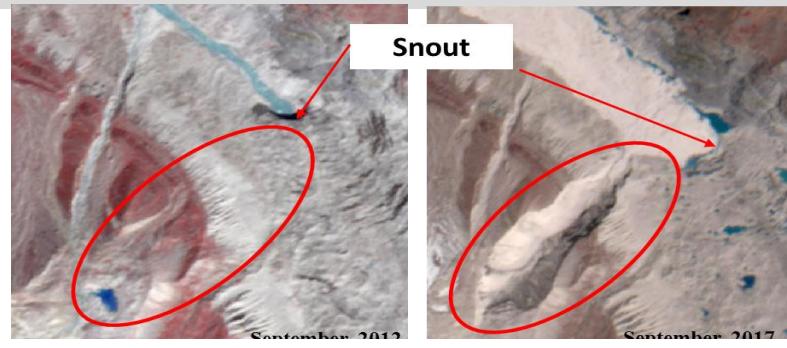
Village: Ughrojpura
Taluka: Mandal
Dist: Ahmedabad

Imagery Date: 31 JAN 2016



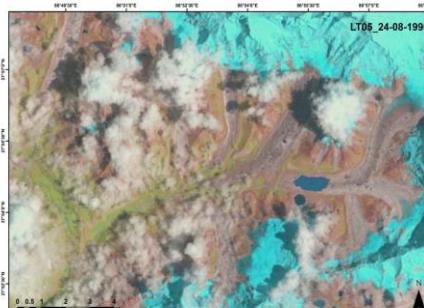
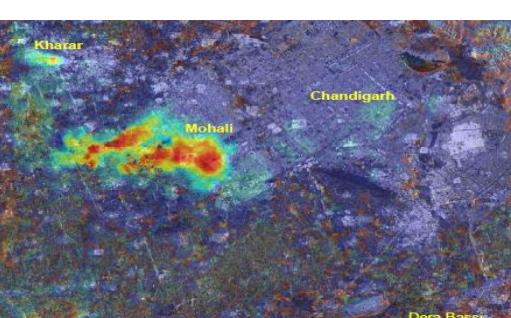
Glacial Dynamics & Debris Flow at Gomukh

- Simulation of debris flow due to lake breach using pre & post-CartoDEM & UAV DEM
- 120 glaciers in the western Himalaya were monitored. Most of the glaciers in the region are retreating.
- Average rate of retreat 15 m/year in the last two decades (1994-2015).
- Lake terminating glaciers are retreating faster.** Parbati glacier in the Parbati valley was found to be retreating alarmingly at a rate of **43m/year from 1994 to 2017.**



Flood inundation modelling & Ground water subsidence

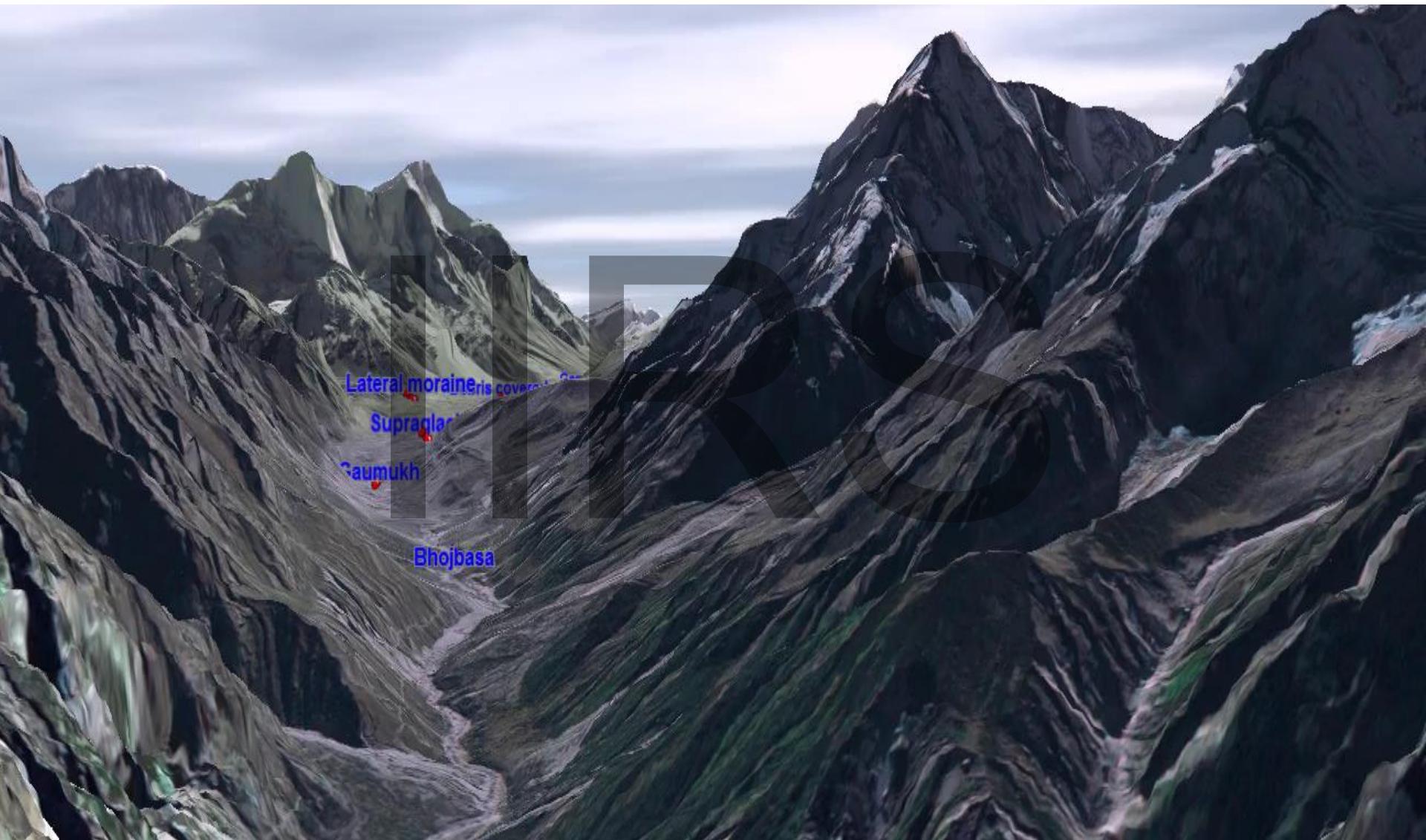
- Simulation of flood inundation and scenario generation
- DInSAR based land subsidence estimation due to ground water withdrawal in Chandigarh area (~6 cm/year)



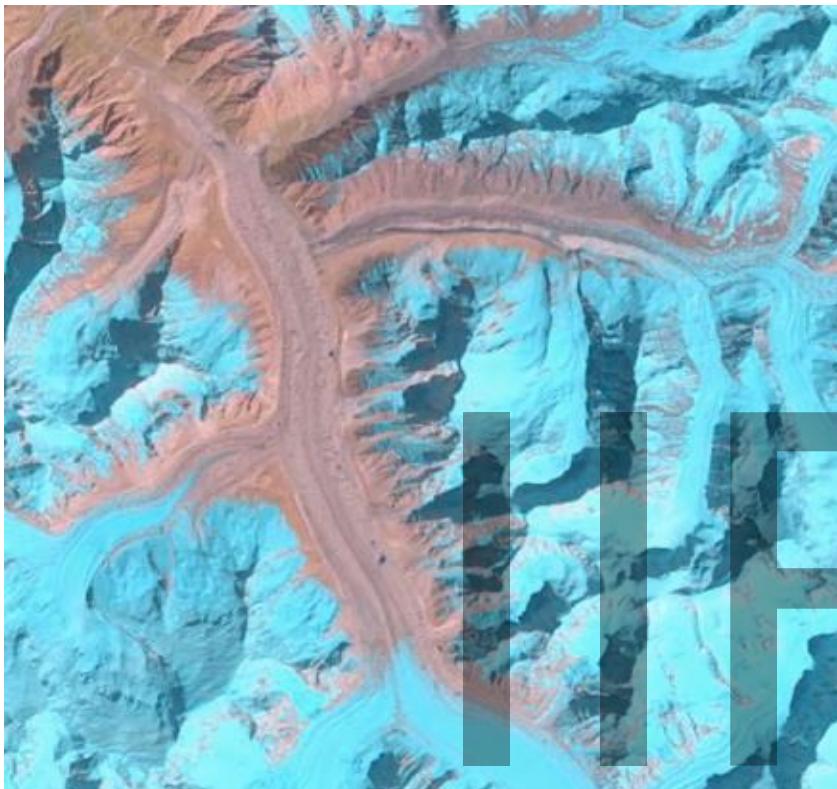
CGWB & SOI

Remote Sensing for Himalayan Glaciers Dynamics

3D visualisation of Char Dhams, Uttrakhand using CARTOSAT



Himalayan Cryosphere Studies: Glacier dynamics



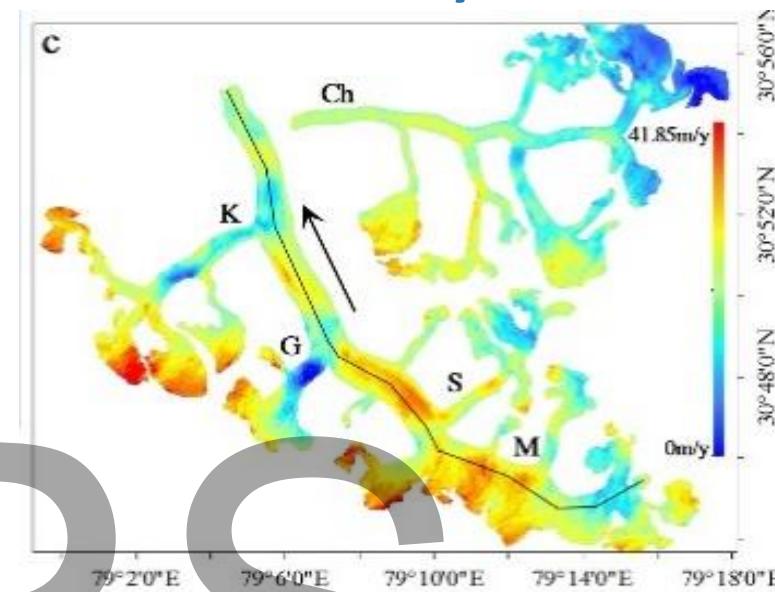
Gangotri Glacier Flow Visualisation

nature
geoscience

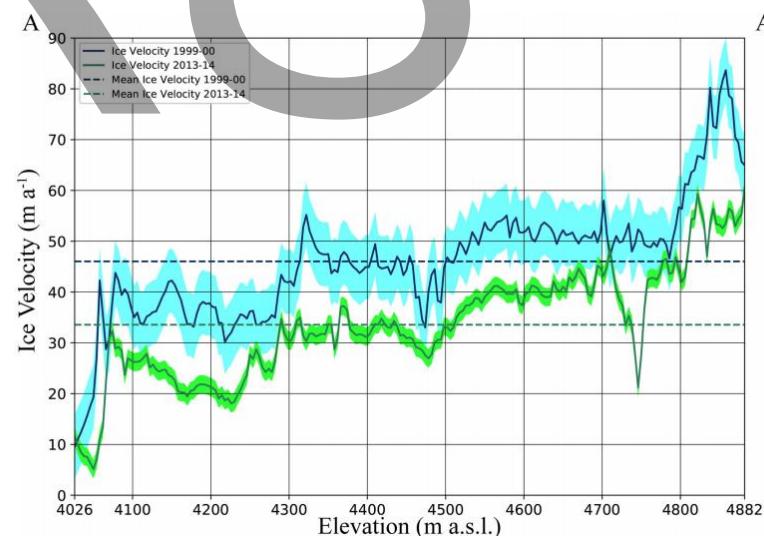
Article | Published: 10 December 2018

Twenty-first century glacier slowdown
driven by mass loss in High Mountain Asia

Amaury Dehecq, Noel Gourmelen, Alex S. Gardner, Fanny Brun, Daniel Goldberg, Peter W. Nienow,
Etienne Berthier, Christian Vincent, Patrick Wagnon & Emmanuel Trouvé



DInSAR based Surface Velocity Estimation (2017-18)



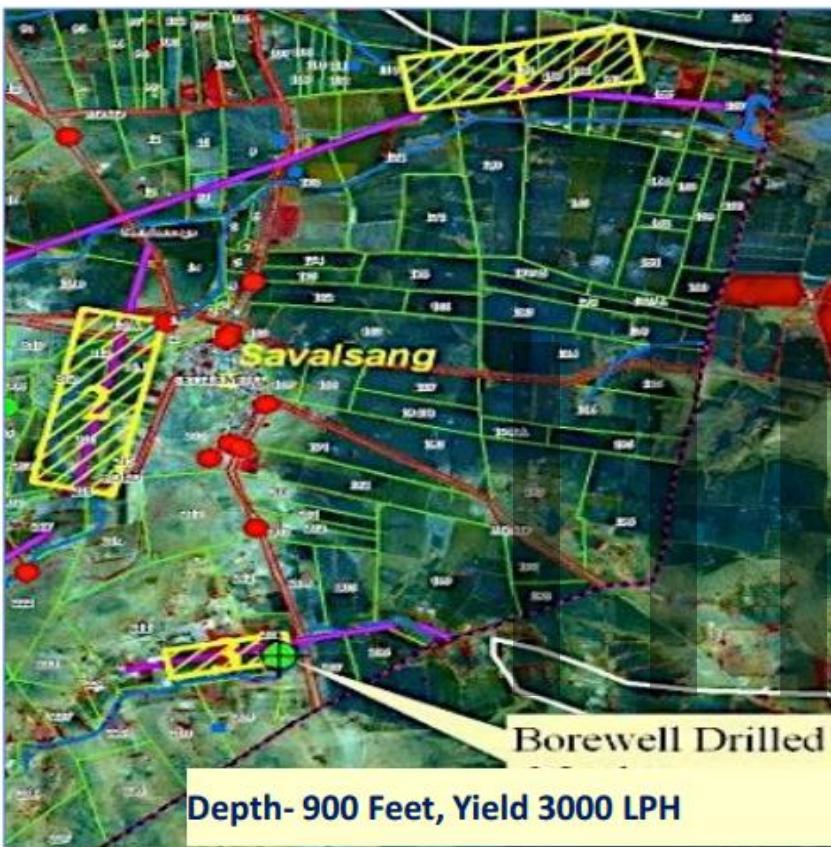
Reduction of Gangotri Glacier Velocity
(Bhusan et al . 2017)

Surging Glaciers of Karakoram Himalaya

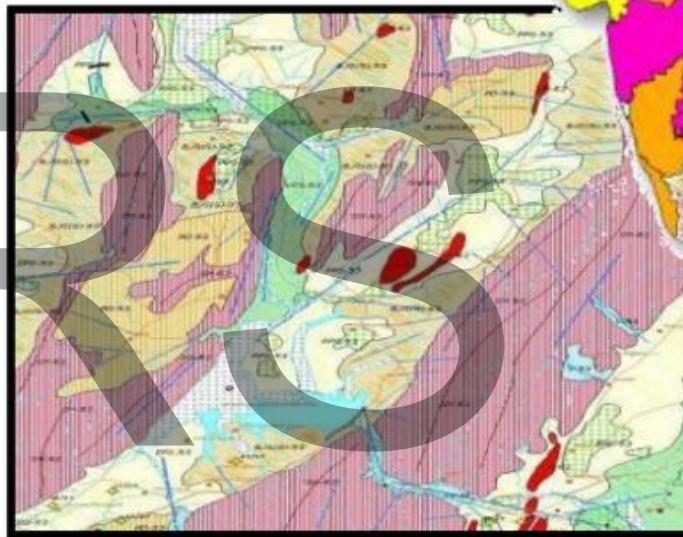
F. Paul



Ground Water Prospects and Sustainability



Bhuvan Bhujal on Geoportal



Ground Water Prospects

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)

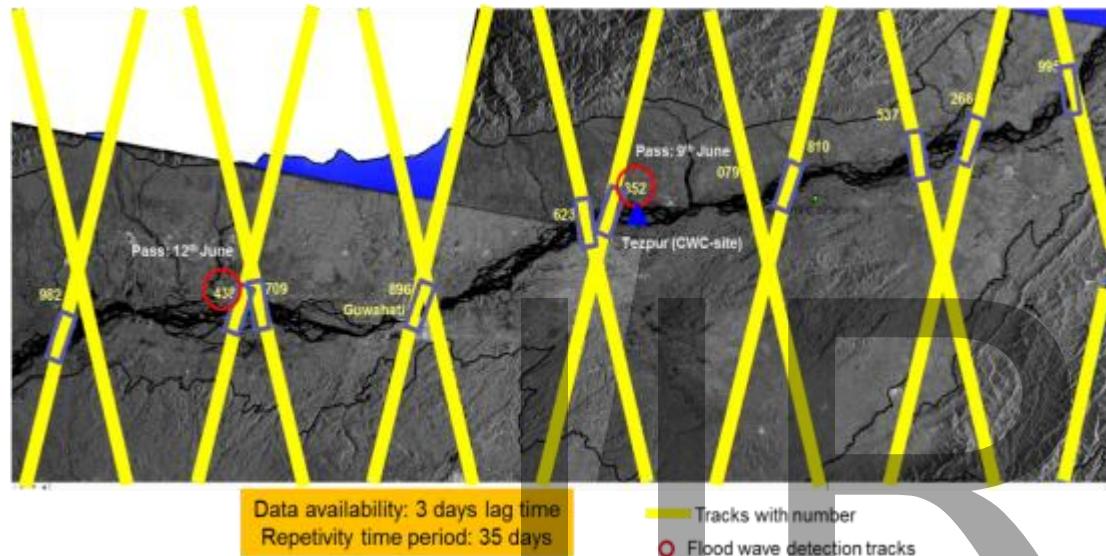
Locations for recharge structures



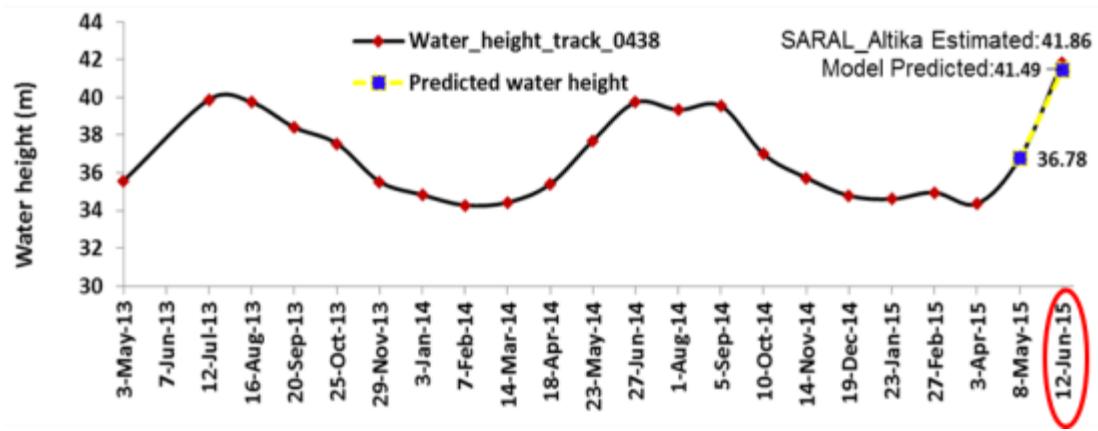
Hydro-geomorphological mapping at village level , 3D aquifer mapping

Altika Data for Inland Hydrology

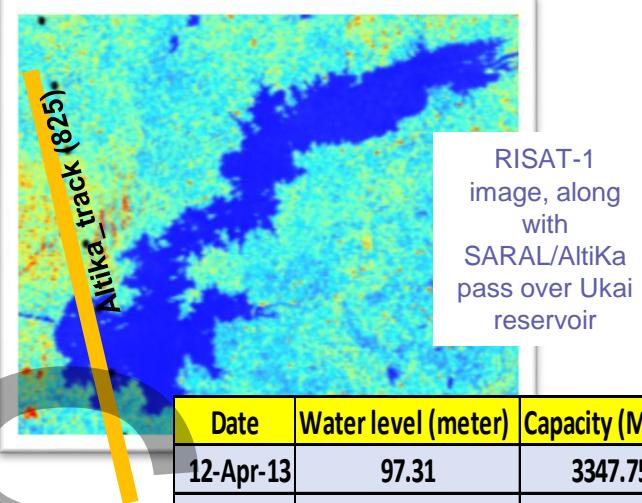
Indian region of the Brahmaputra river along with SARAL-Altika tracks overlaid on RISAT-1 radar image.



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



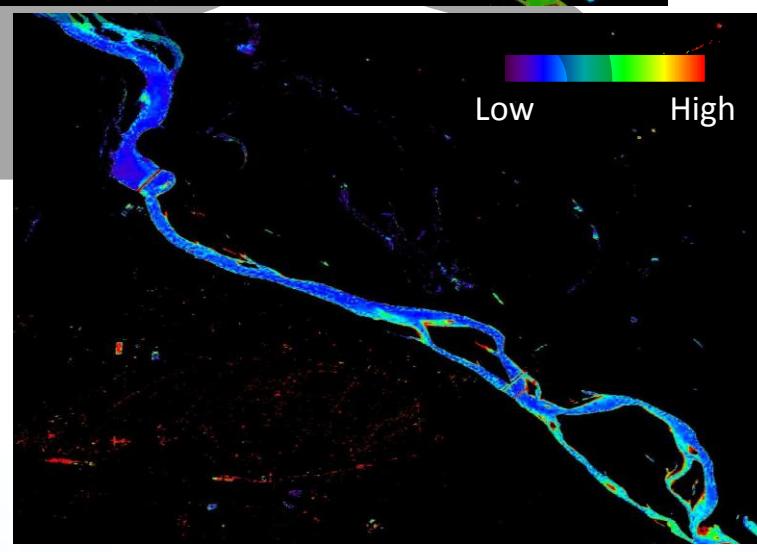
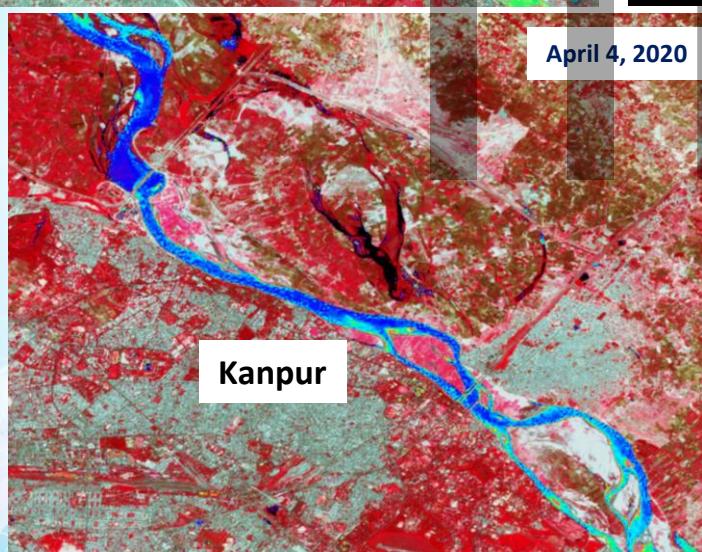
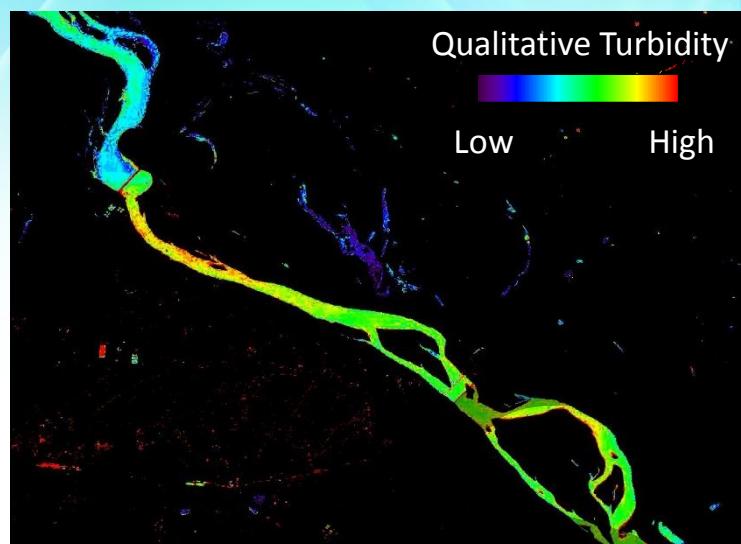
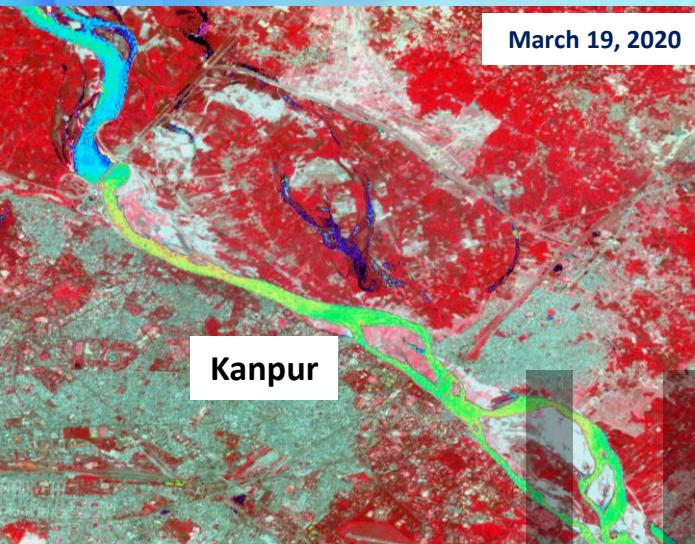
Assessment of water levels for Ukai



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 and tidal correction.
- Retracking algorithms are developed.

Water Turbidity Changes in Ganga River Water near Kanpur post lockdown

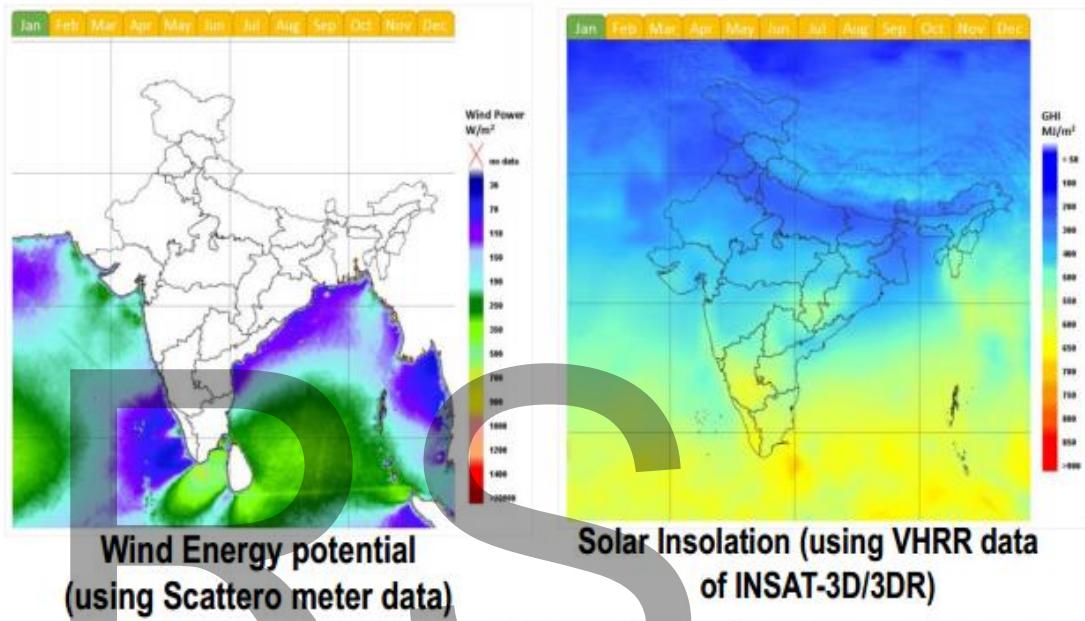


iirs

Energy Management Information System - with NITI Aayog

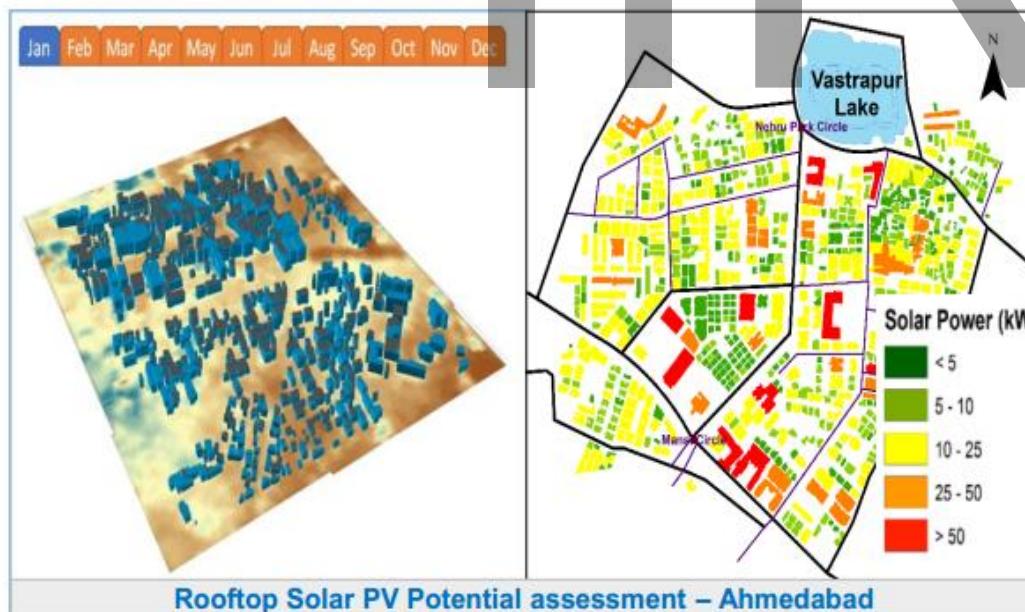


- Atlases of solar, offshore wind & wave energy potential
- 72-Hour solar power forecast developed 6Hrly interval
- Roof-top SE potential
- MobileApp for assessing location-specific Solar & Wind Energy potential



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

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)



Users : 60 ministries

Developmental Governance
Community Participation

Local wisdom for Action Plan



Integrated Geospatial portal

bhuvan.nrsc.gov.in

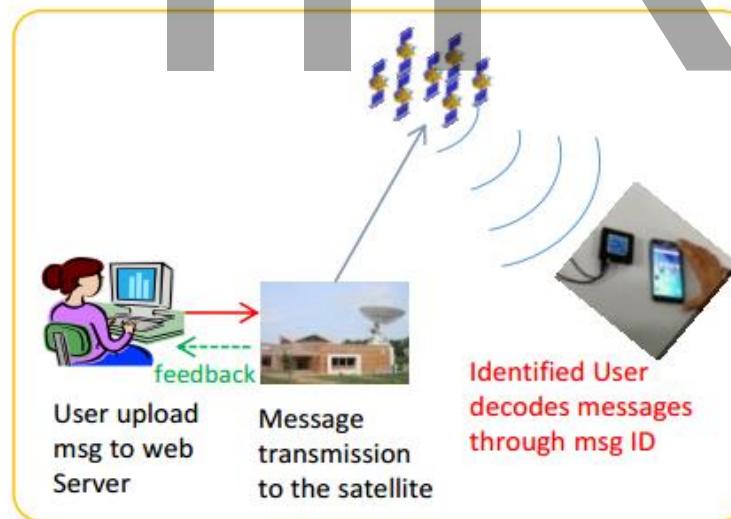
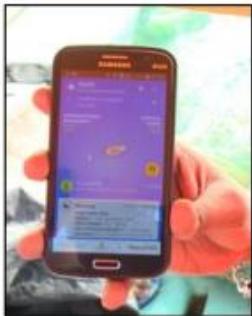


NavIC for Fishermen Community



NavIC based Mobile App Features

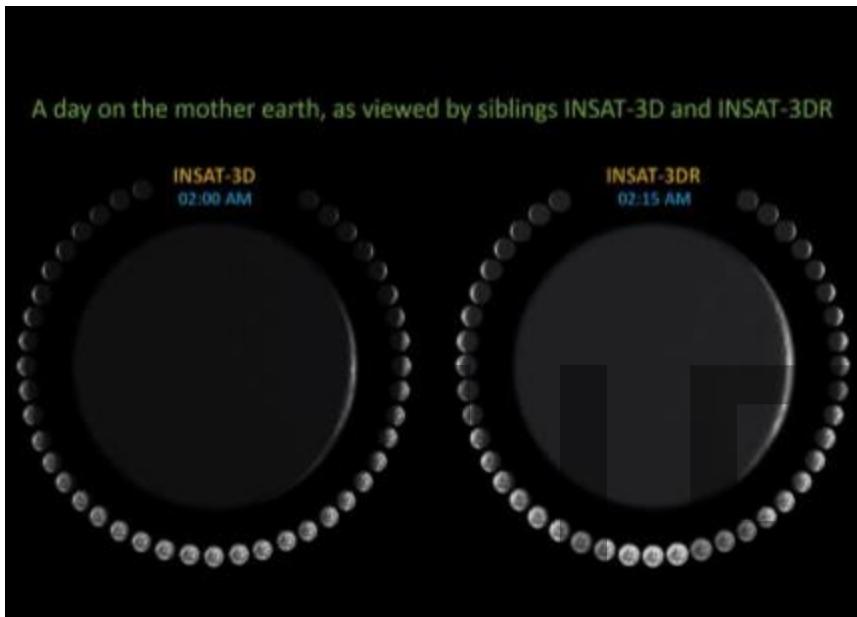
- Location based information
- Maritime Intl. boundaries
- Online potential Fishing Zones
- Weather & Sea State Alerts
- Multi-language support





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

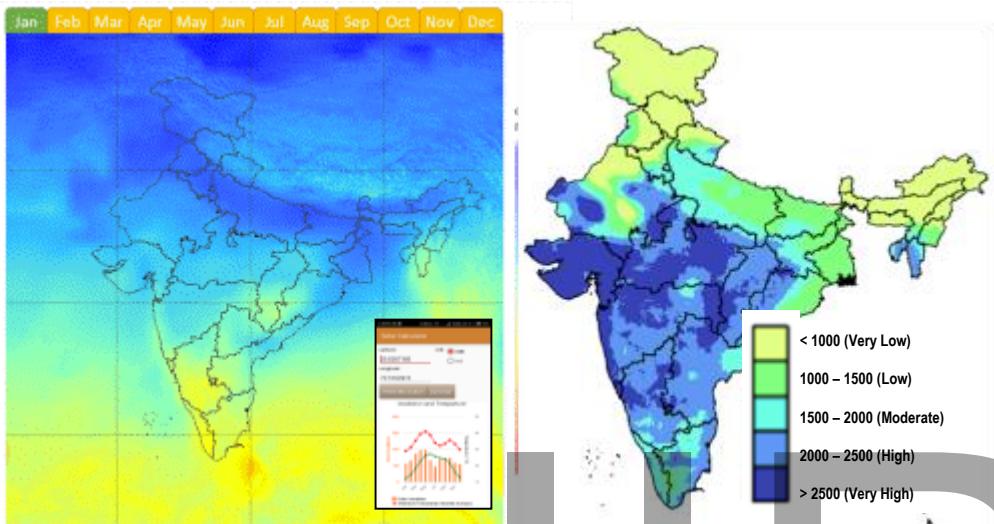
Resolution (km): 10 X 10

40 profiles of Temp. (surface to 70 km)

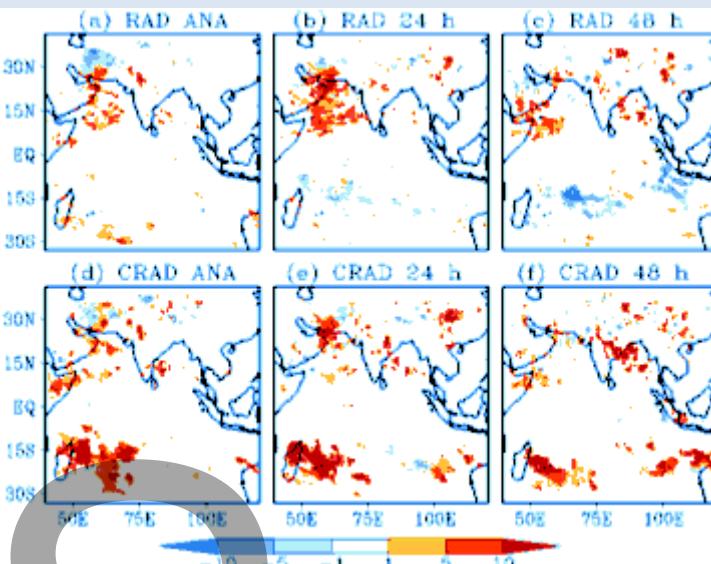
21 Profiles of Humid. (surface to 15 km)

Integrated Ozone (Surface to ~ 12 km)

Solar energy potential & 48-Hour forecast

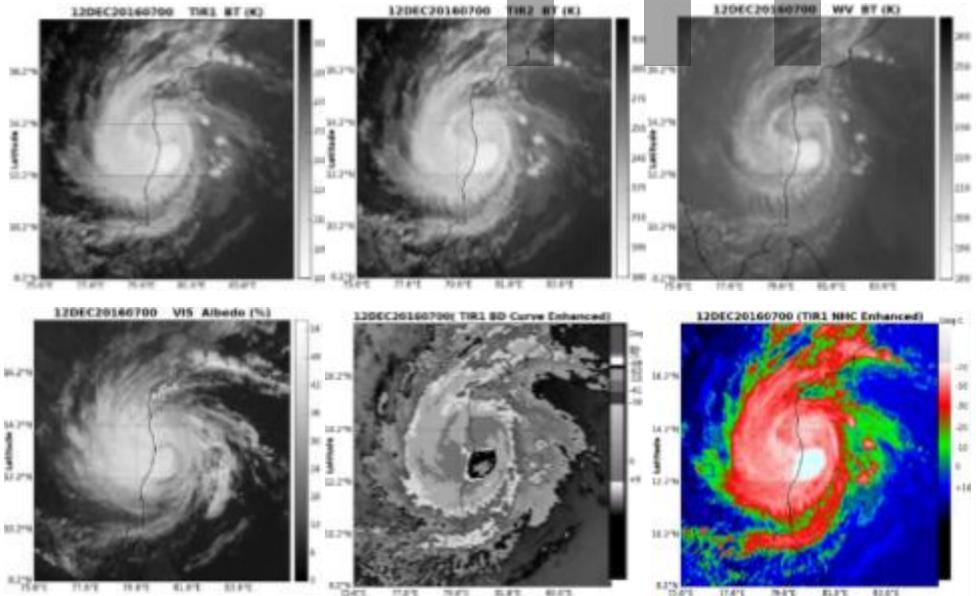


Assimilation of Clear-Sky Brightness Temperature

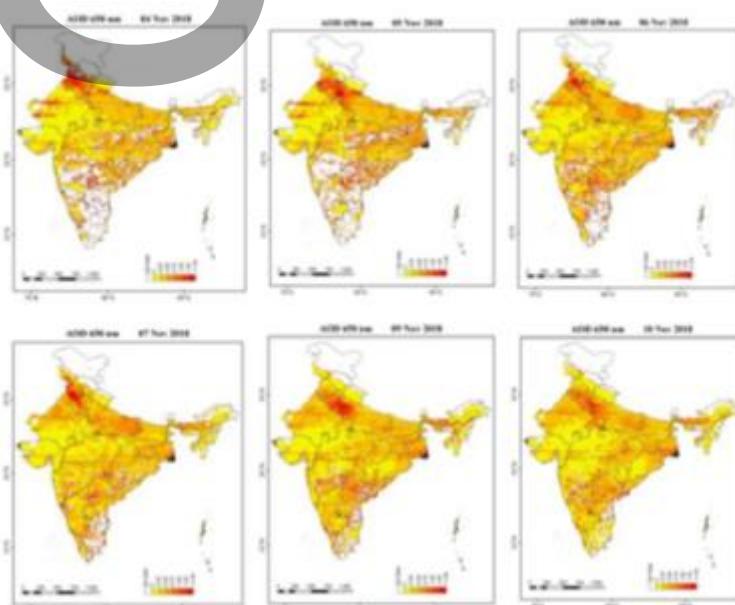


Improved Rainfall prediction

Continuous monitoring of Tropical Cyclones



Spatial distribution of INSAT-3D AOD

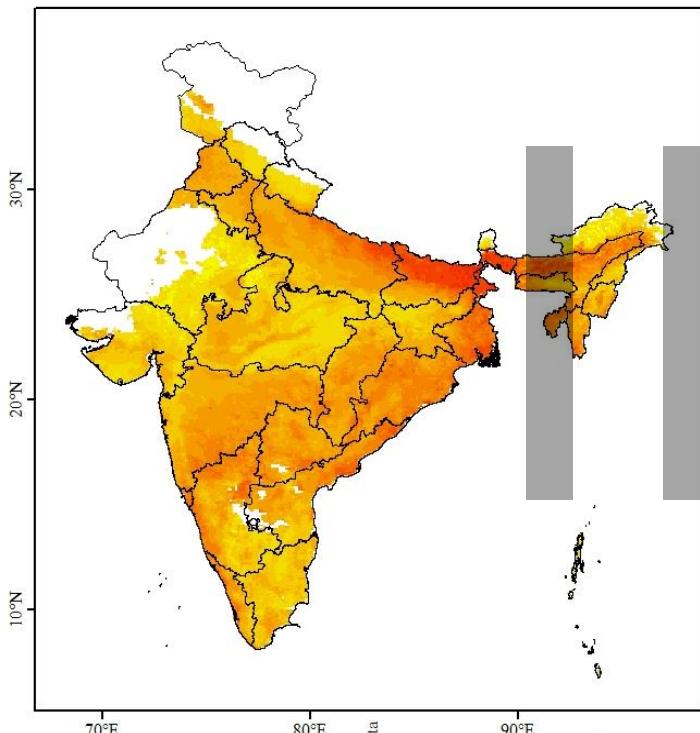


Spatial Distribution of Fog in North India on Dec 23, 2019 from INSAT-3D



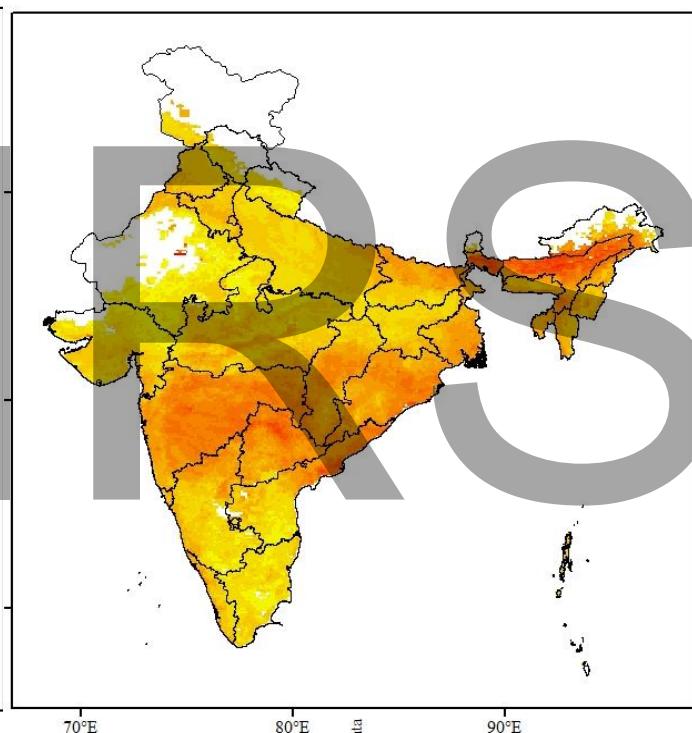
Impact on Aerosol Optical Depth during Lockdown

MODIS AOD 550nm during 25Mar-05Apr, 2019

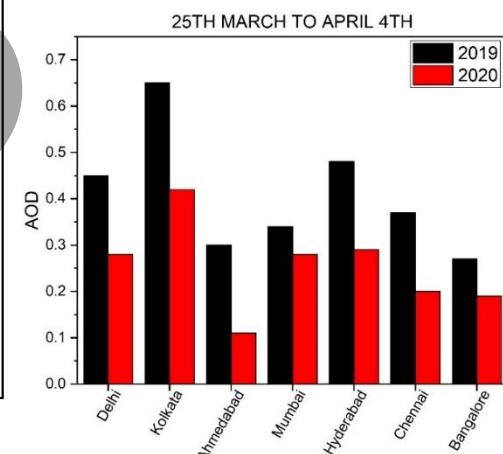


Spatial Resolution= 10 km

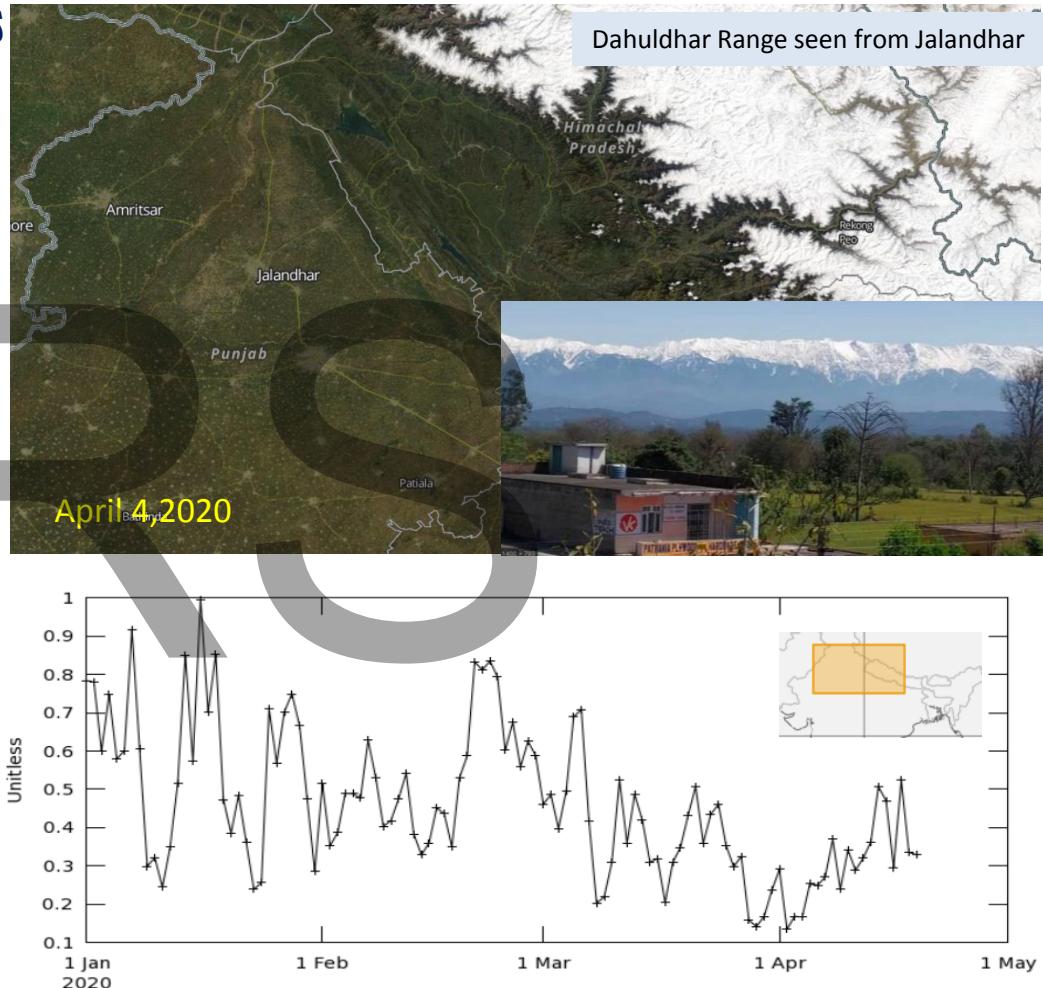
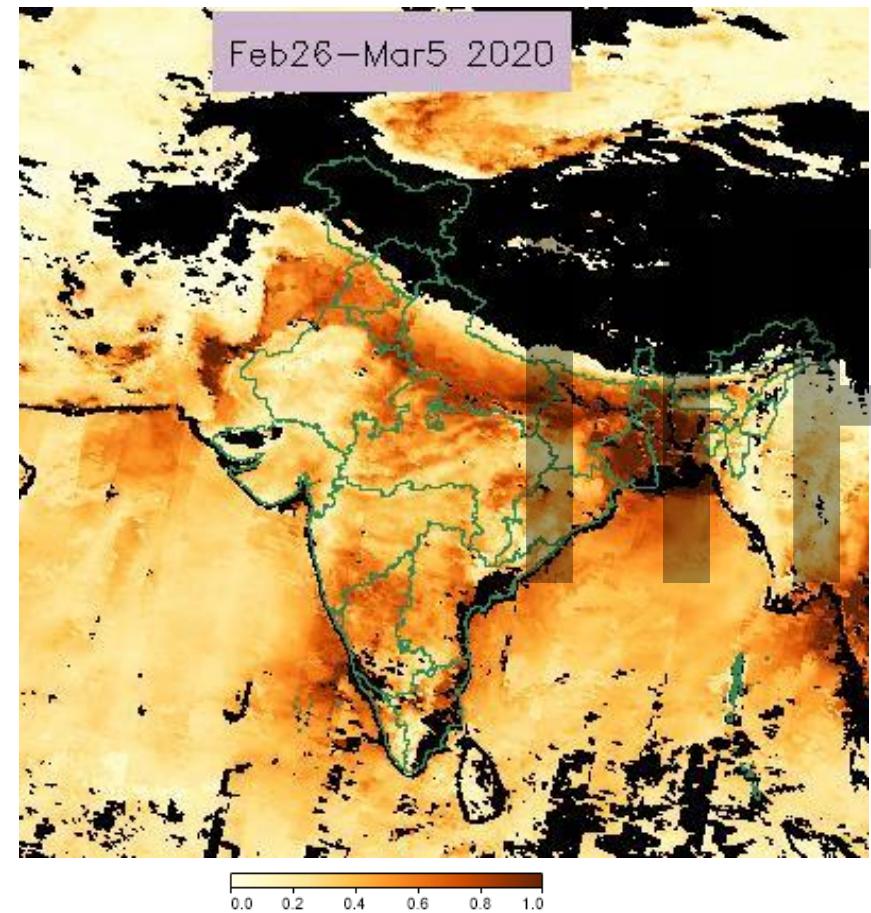
MODIS AOD 550nm during 25Mar-05Apr, 2020

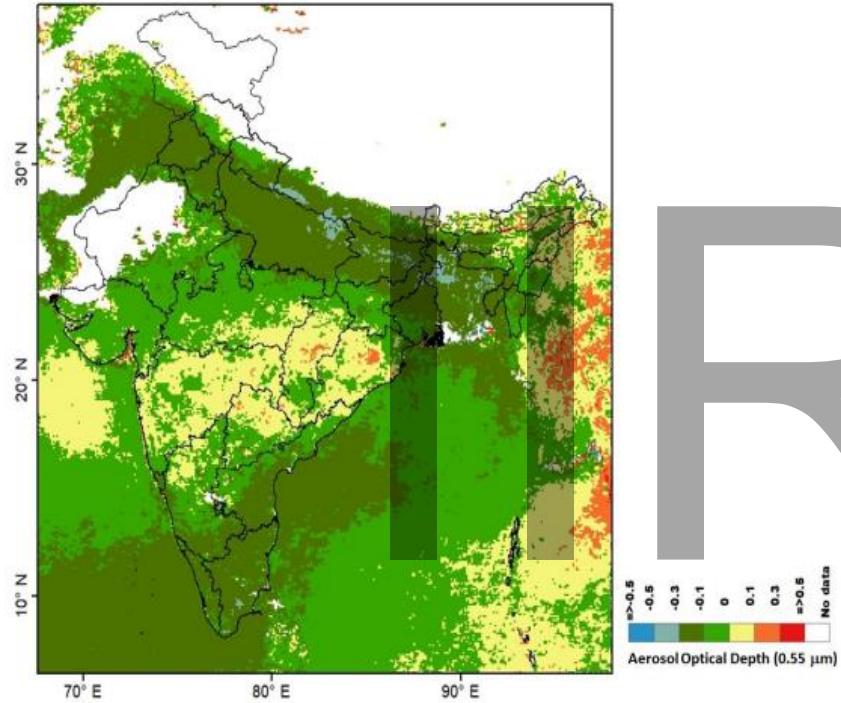


There is average of 21-37% reduction (compared to 2019 period) in spatial distribution of Aerosols effecting the Air Quality



People started seeing Himalayas from IGP plains





(a)

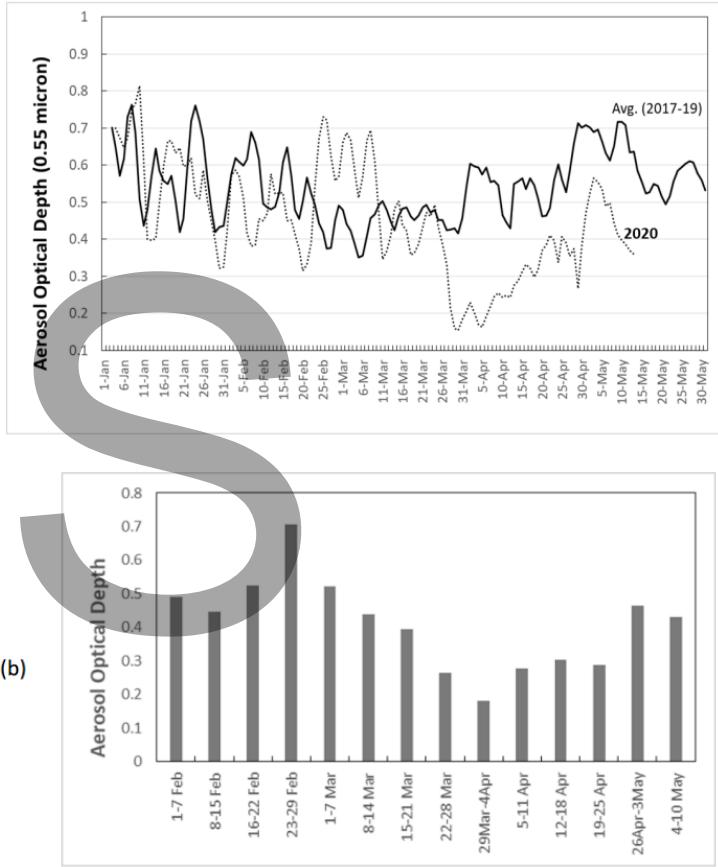
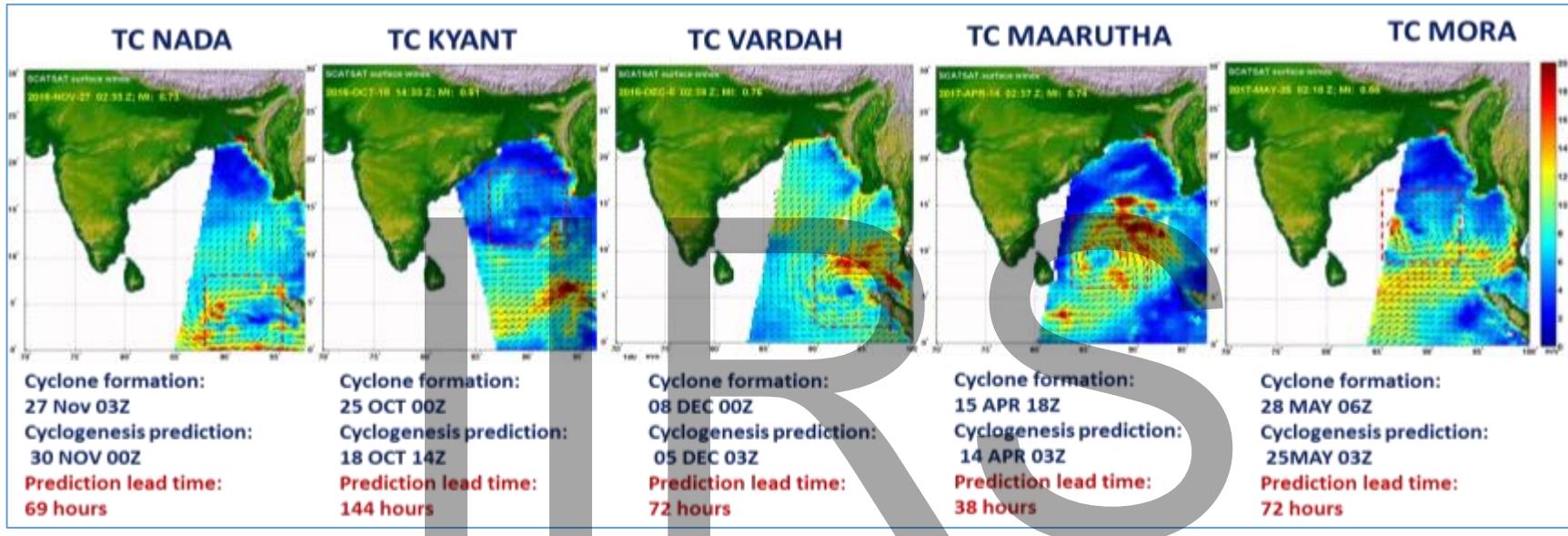


Figure 3: Aerosol Optical Depth Anomaly in 2020 (25Mar-3May) with average for 2017-19 same time period

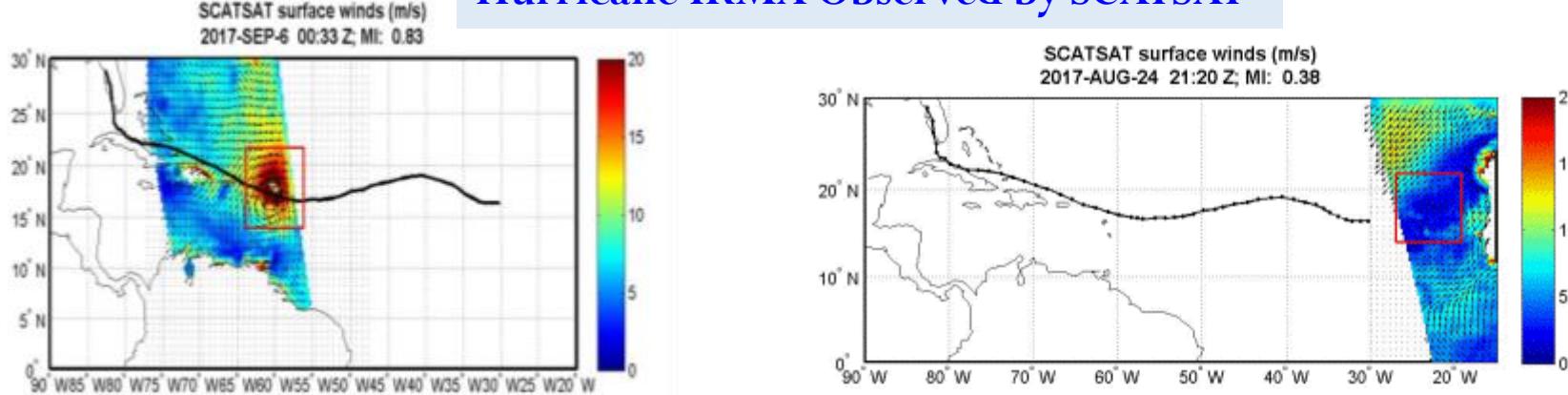
Figure 4: Time series analysis over northern India (a) during 2020 and its comparison with period of 2017-2019, (b) weekly variation of AOD from Feb-May 2020

Tropical Cyclogenesis Prediction using SCATSAT-1

Scatsat-1 showing earliest detection of tropical cyclogenesis.
Mean Prediction Lead Time: 79 hours (~3 days in advance)

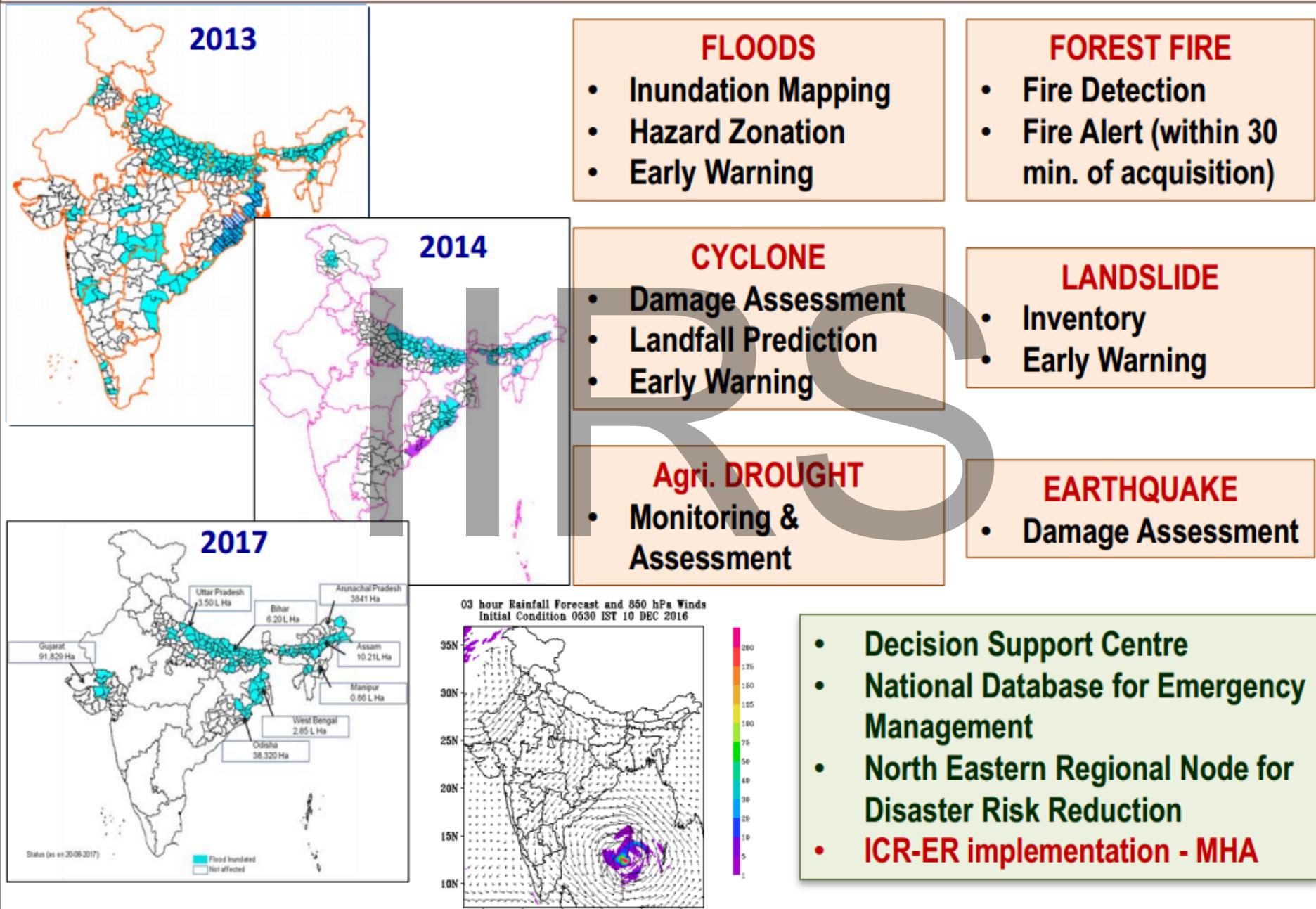


Hurricane IRMA Observed by SCATSAT



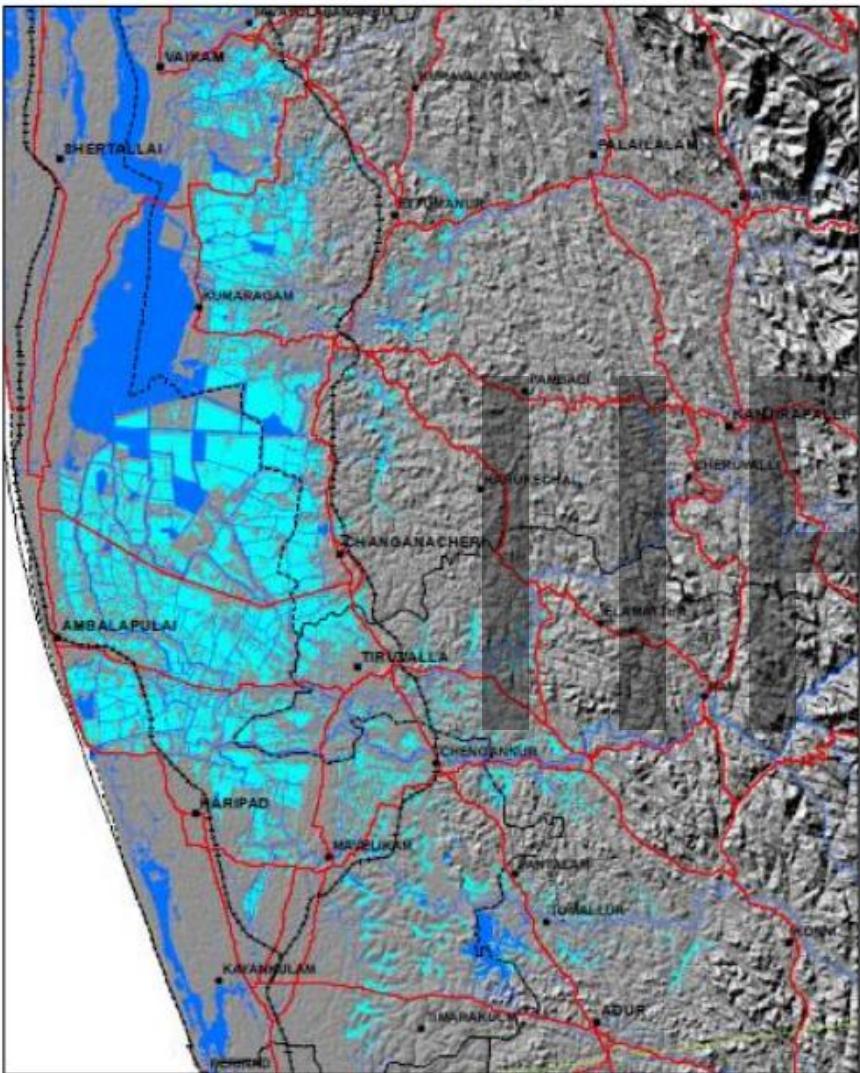
Life cycle of winds captured by SCATSAT during Aug 24 to Sept. 11, 2017

Disaster Management Support



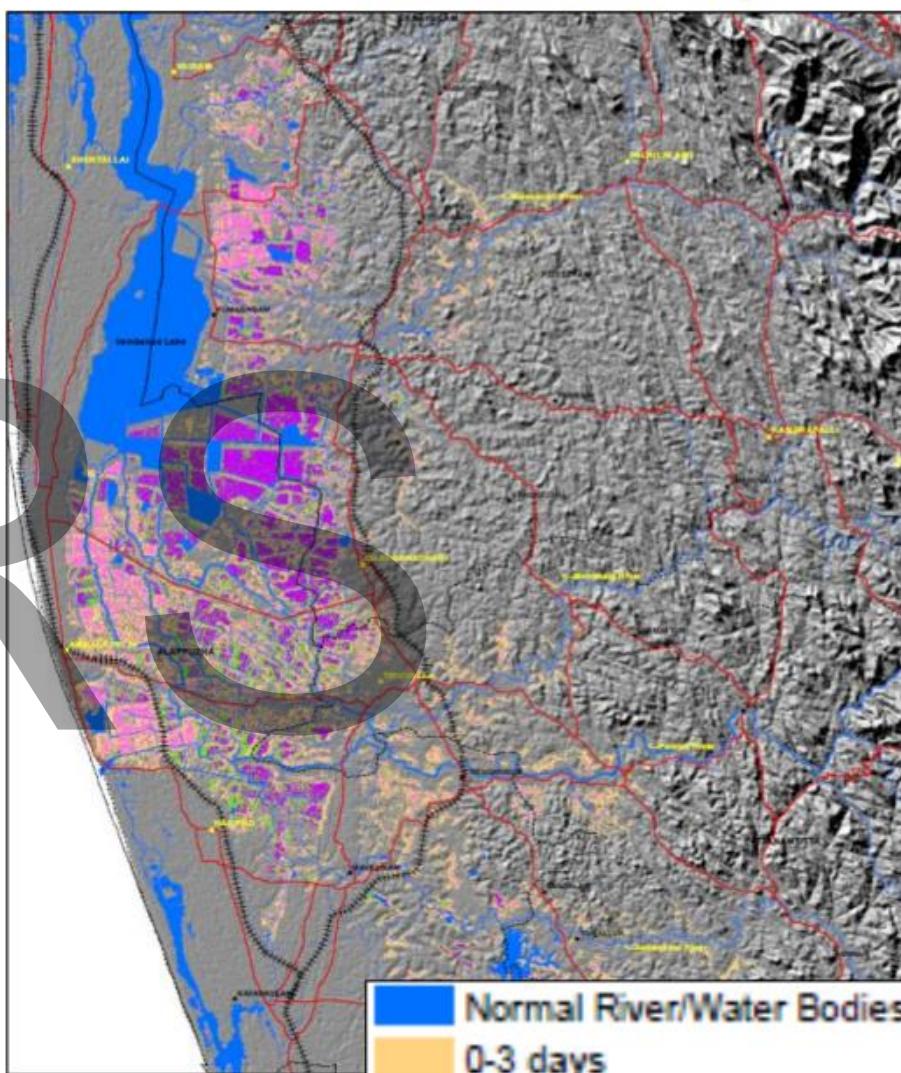
Devastating Floods of Kerala - 2018

Flood Inundation Map



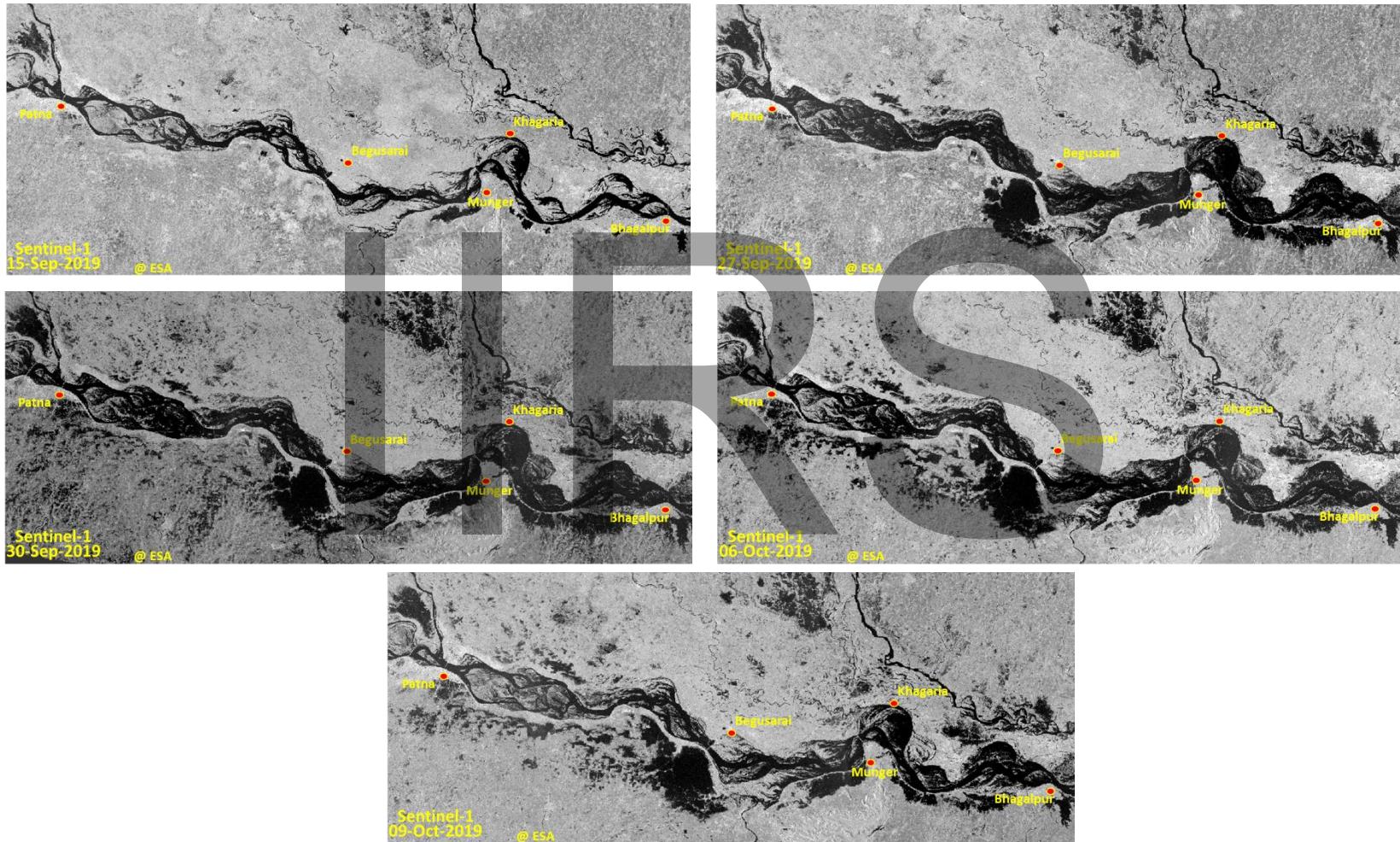
Flooded Area – 90,000 ha
Flooded Roads, Rail segments mapped
Duration of flooding mapped

Flood Duration Map

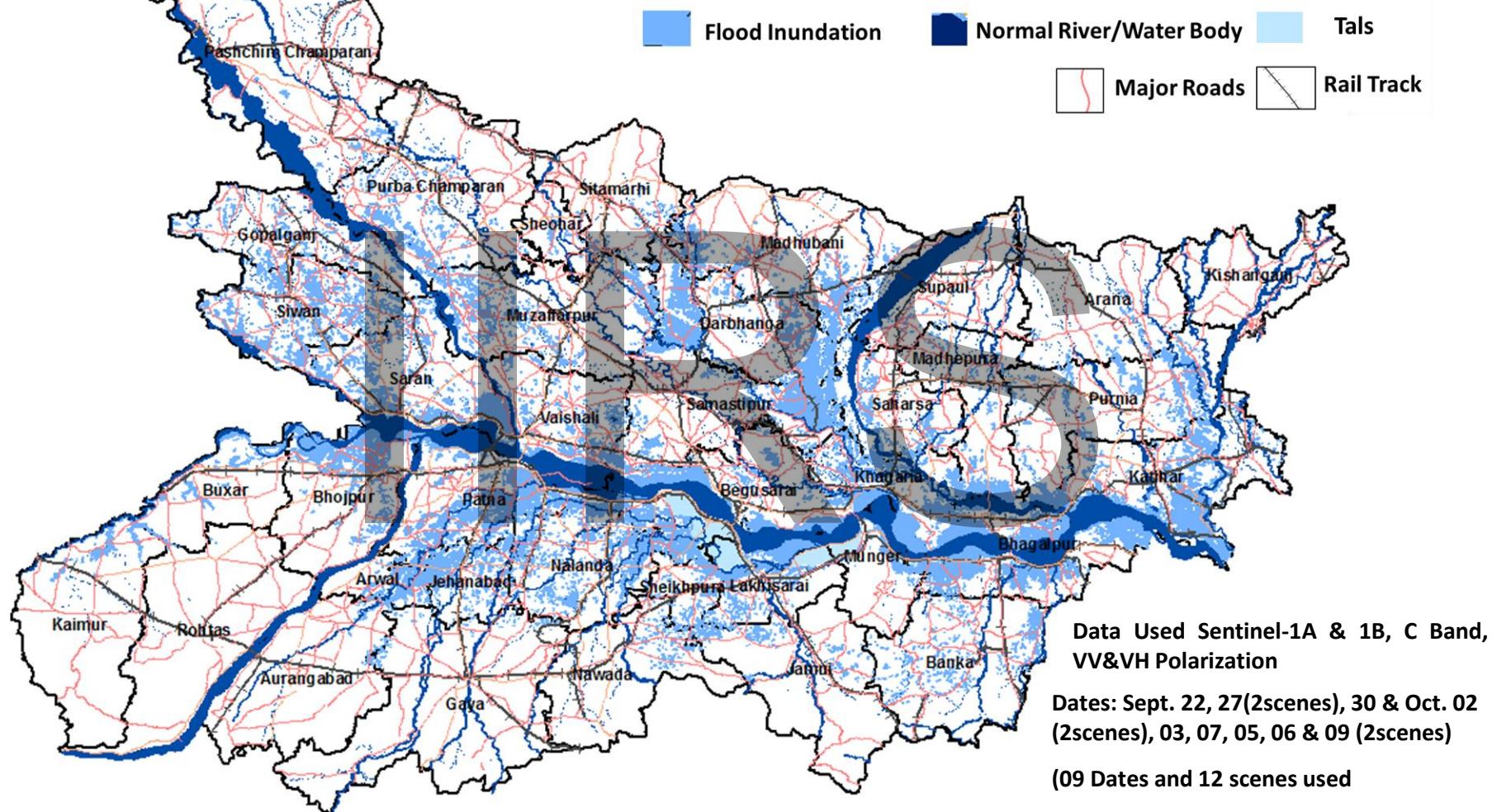


Normal River/Water Bodies
0-3 days
4-6 days
7-9 days
> 10 days

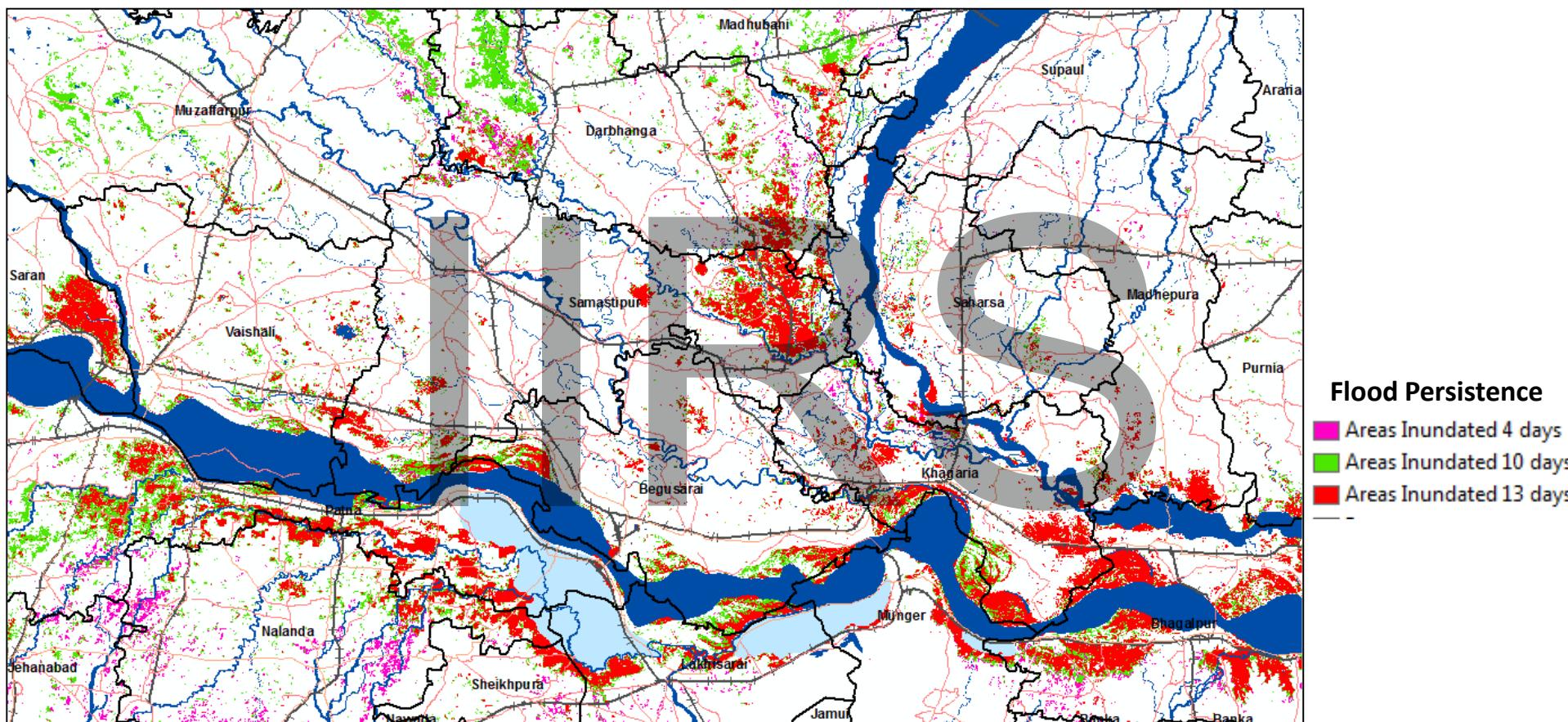
Flood Progression Along Ganga River, Bihar Sept & Oct, 2019



Flood Inundation Extent Bihar during Sept & Oct., 2019



Flood Persistence in Parts of Bihar Sept & Oct, 2019 Floods



Flood Persistence

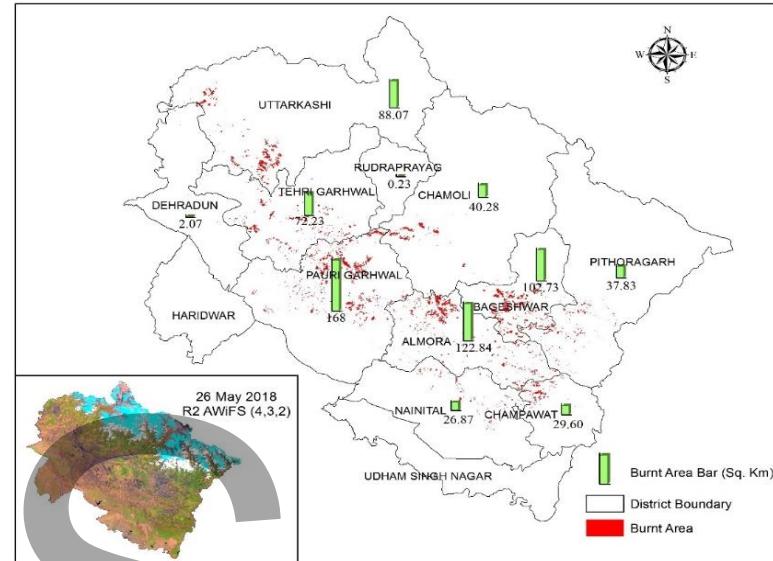
- Areas Inundated 4 days
- Areas Inundated 10 days
- Areas Inundated 13 days

Districts (Patna, Bhagalpur, Begusarai, Munger, Khagaria, Lakhaisarai, Samastipur, Vaishali, Saran, Nalanda, Sheikhpura) adjoining Ganga River and in parts of Darbhanga, Madhepura, Madhubani and Purnia districts were observed to be inundated for about two weeks



Forest Fires in Uttarakhand

- Burnt area assessment:** Using RESOURSAT-2/2A data along with Extensive ground truthing for validation
- Forest Fire Risk Index:** Use of weather, topography, fuel for daily forest fire Risk Index; **Experimental information dissemination to forest officials of Uttrakhand**
- Forest fire reporting Mobile App & dashboard:** Developed Geospatial solution for Forest Fire Reporting; Launched for J&K Forest Dept. in Oct'18; shared also with Uttarakhand Forest Dept.



Mobile App Release (J&K)

National Mission for Himalayan Studies for MoEFCC



Biodiversity Studies (2018-22)

- Indian Bioresource Inform. Network (IBIN Phase-3):** Enriching species & spatial databases; Augment. of portal & integ. With Bhuvan; New BRICs & crowdsourcing; Developed Standards
- Biodiversity at Community Level:** Decadal changes in landscape; Identification of EBVs, Manual for field inventory & sampling protocols developed.

Funded by DBT GOI



Large Scale Deforestation in Assam

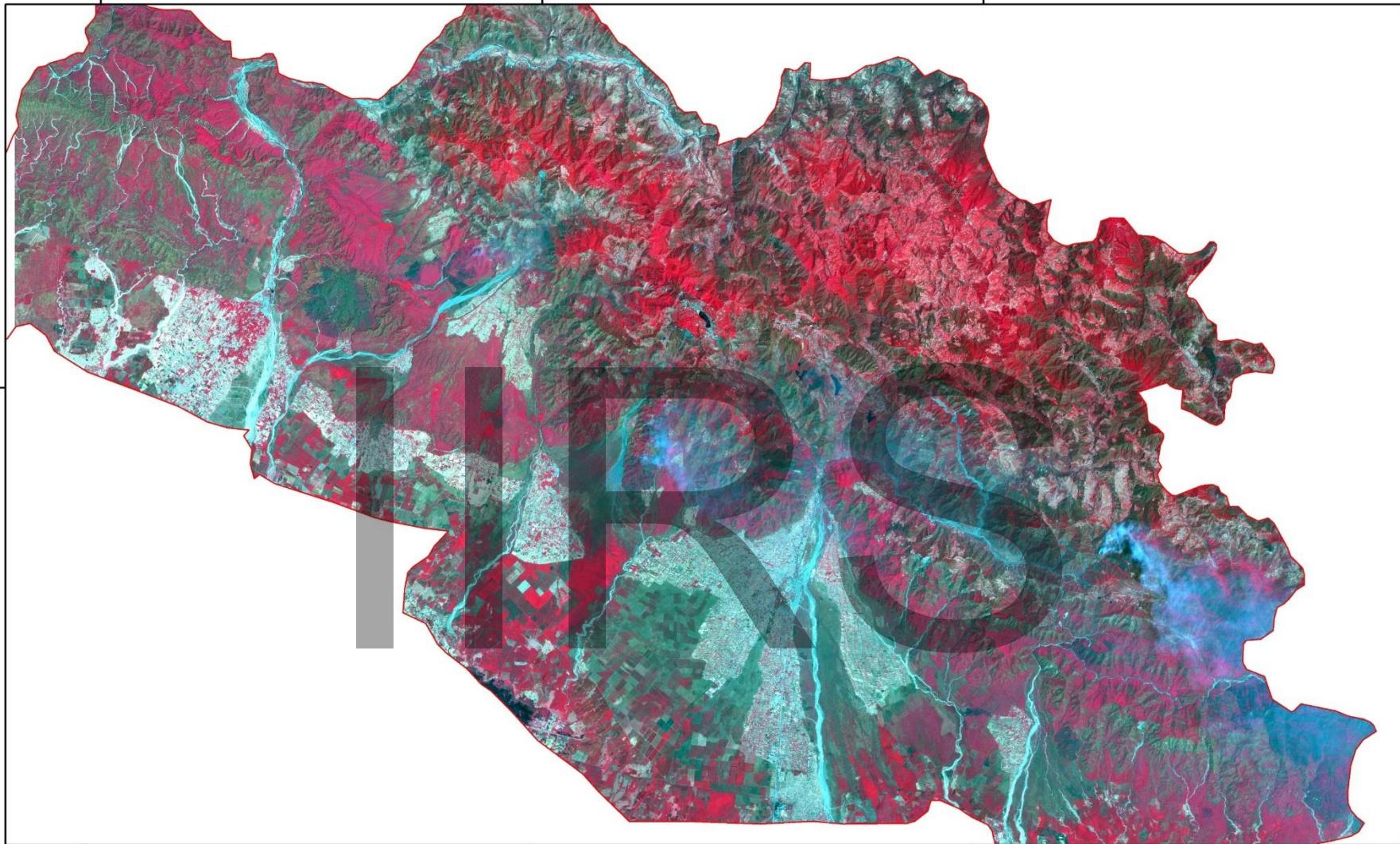


79°0'0"E

79°20'0"E

79°40'0"E

29°20'0"N



Legend

District Bound

FCC

Red: Band_6

Green: Band_5

Blue: Band_4

FOREST FIRE DETECTION USING SENTINEL-2 FCC(8,4
NAINITAL DISTRICT UTTARAKHAND ,3)

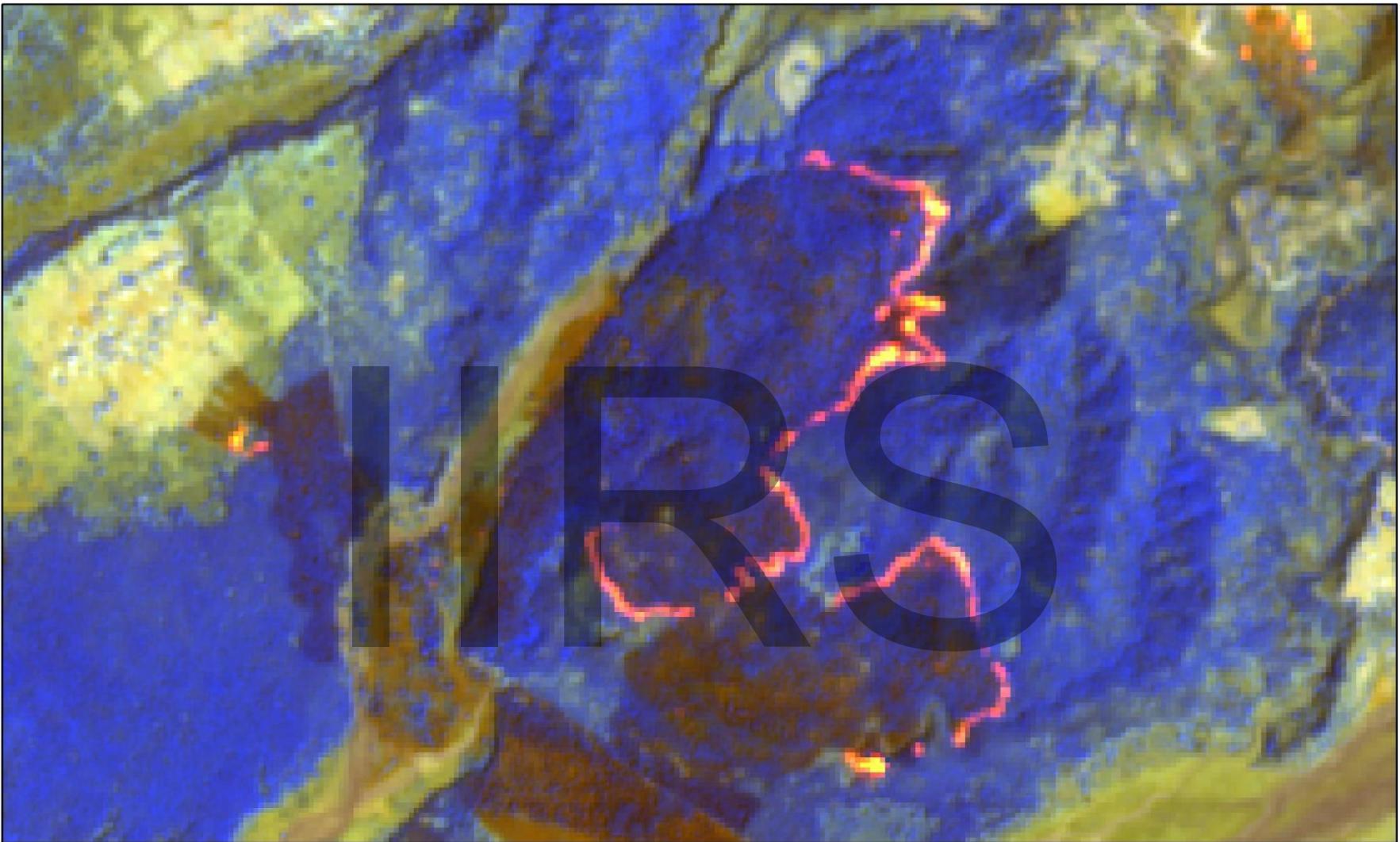
Data used: Sentinel-2A (07/05/2019)

Datum: WGS-84

Projection: WGS-84 _UTM 44N

0 3.25 6.5 13 19.5 26 KM





Legend

District Bound

FCC

Red: Band_6

Green: Band_5

Blue: Band_4

FOREST FIRE DETECTION USING SENTINEL-2 FCC(12,11,8) NAINITAL DISTRICT UTTARAKHAND

Data used: Sentinel-2A (07/05/2019)

Datum: WGS-84

Projection: WGS-84 _UTM 44N

0 0.175 0.35 0.7 1.05 1.4 KM



MOSDAC

M O S D A C

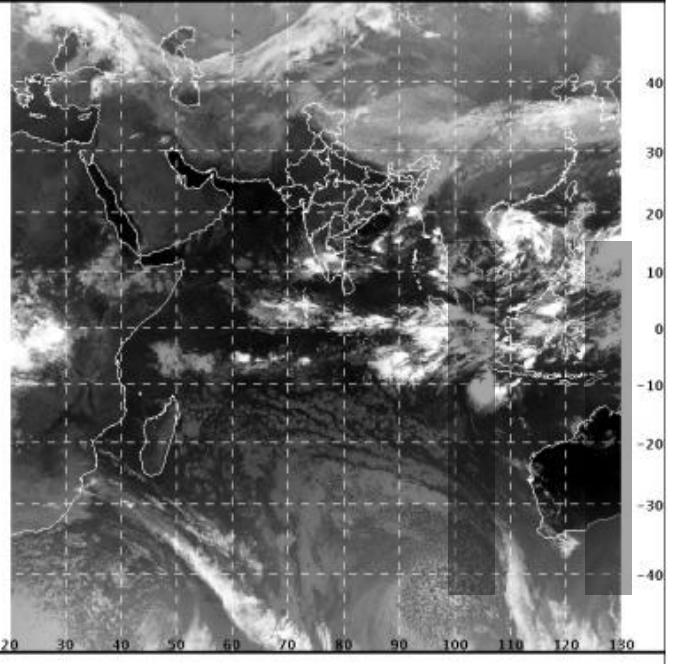
SAT :INSAT-3DR.IMG

13-10-2016/00:14 GMT

IMG, TIR1 10.8 um

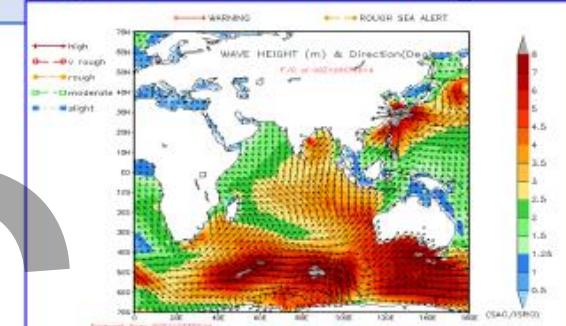
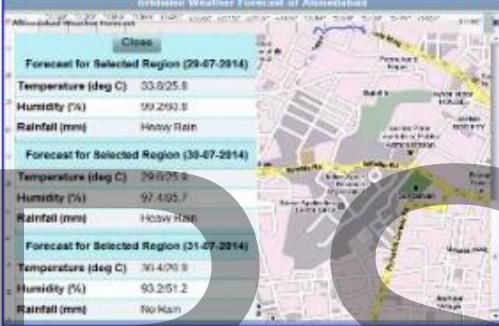
13-10-2016/05:44 IST

LIC Mercator (LINEAR STRETCH: 1.0%)



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



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



इसरो
ISRO

- 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

Distance Learning Programme

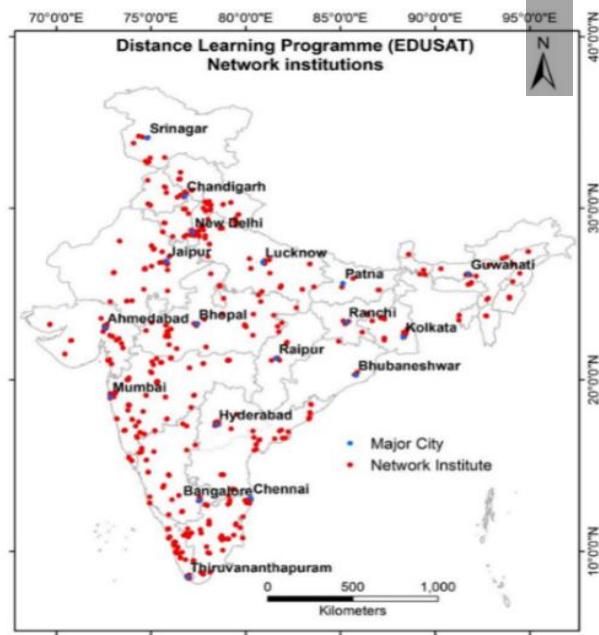
(<https://www.iirs.gov.in/IIRS-Outreach-Programme>)

- **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



**COVID time
Boom for
Online
training**

→ Sensing



S. No.	Course Title	Schedule	Total Beneficiaries	Certificates Issued
1	Basic Principles of Remote Sensing Technology	Apr 13-25, 2020	6273	2699
2	Webinar Series on Crop Monitoring and Assessment (International)	May 19 - Jun 09, 2020	5994	1632
3	Basics of SAR Remote Sensing	May 26-30, 2020	2179	670 *
4	Machine Learning for Remote Sensing Data Classification (Full-day Workshop)	Jun 01, 2020	2745	995*
5	Planetary Geosciences	Jun 08-12, 2020	3906	Examination in progress
6	'Remote Sensing & GIS Technology and Applications' for University Teachers and Government Officials	Jun 13 - Jul 01, 2020	4485	Examination in progress
7	Health GIS	Jun 15-19, 2020	2962	Examination in progress
8	Satellite Photogrammetry and its Application	Jun 29 - Jul 03, 2020	18308	Examination in progress

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

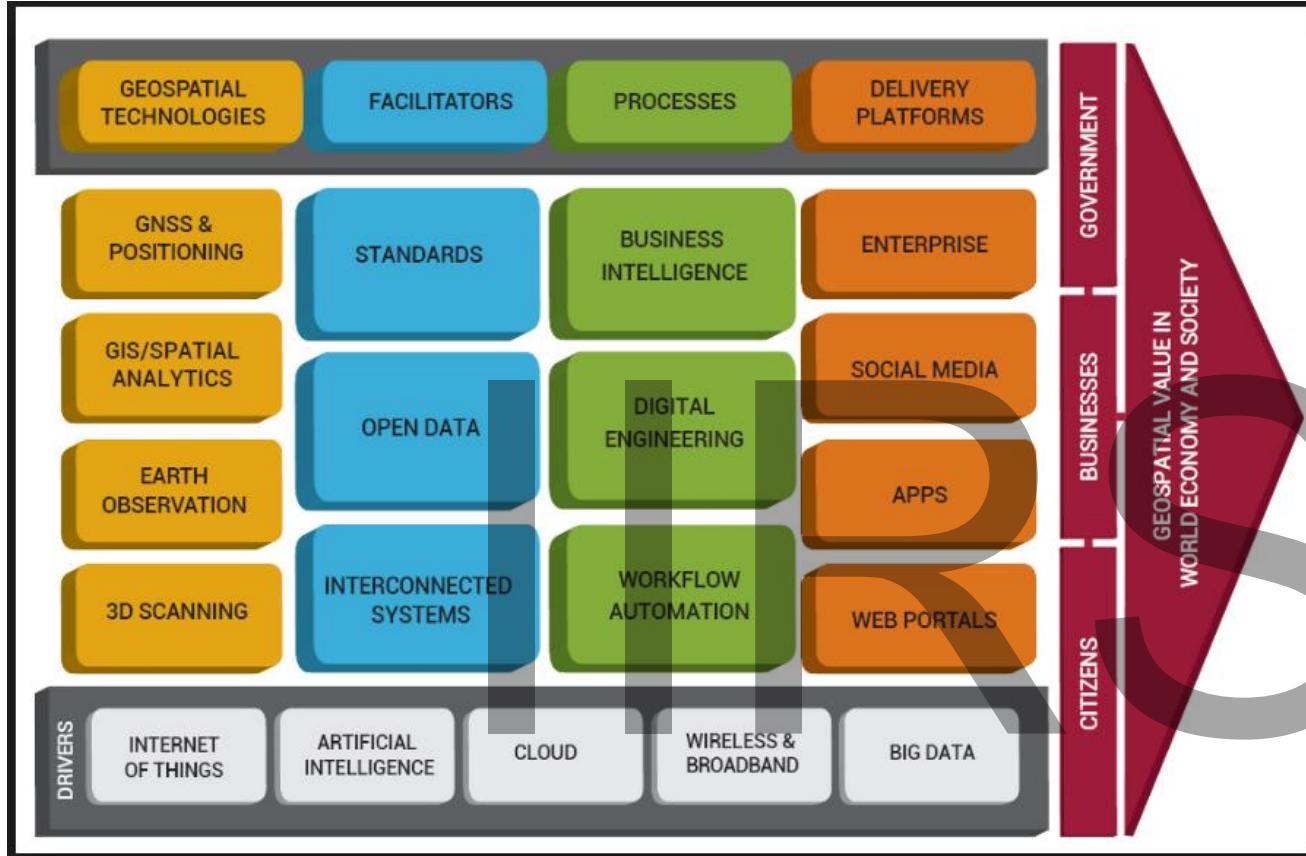
- M.Tech. in RS & GIS (8 Specialisations)
(Affiliated to Andhra University)
- M.Sc. in Geo-information Science & Earth Observation
(Specialisation – Geoinformatics)
(JEP with ITC, University of Twente, The Netherlands)

Outreach Program

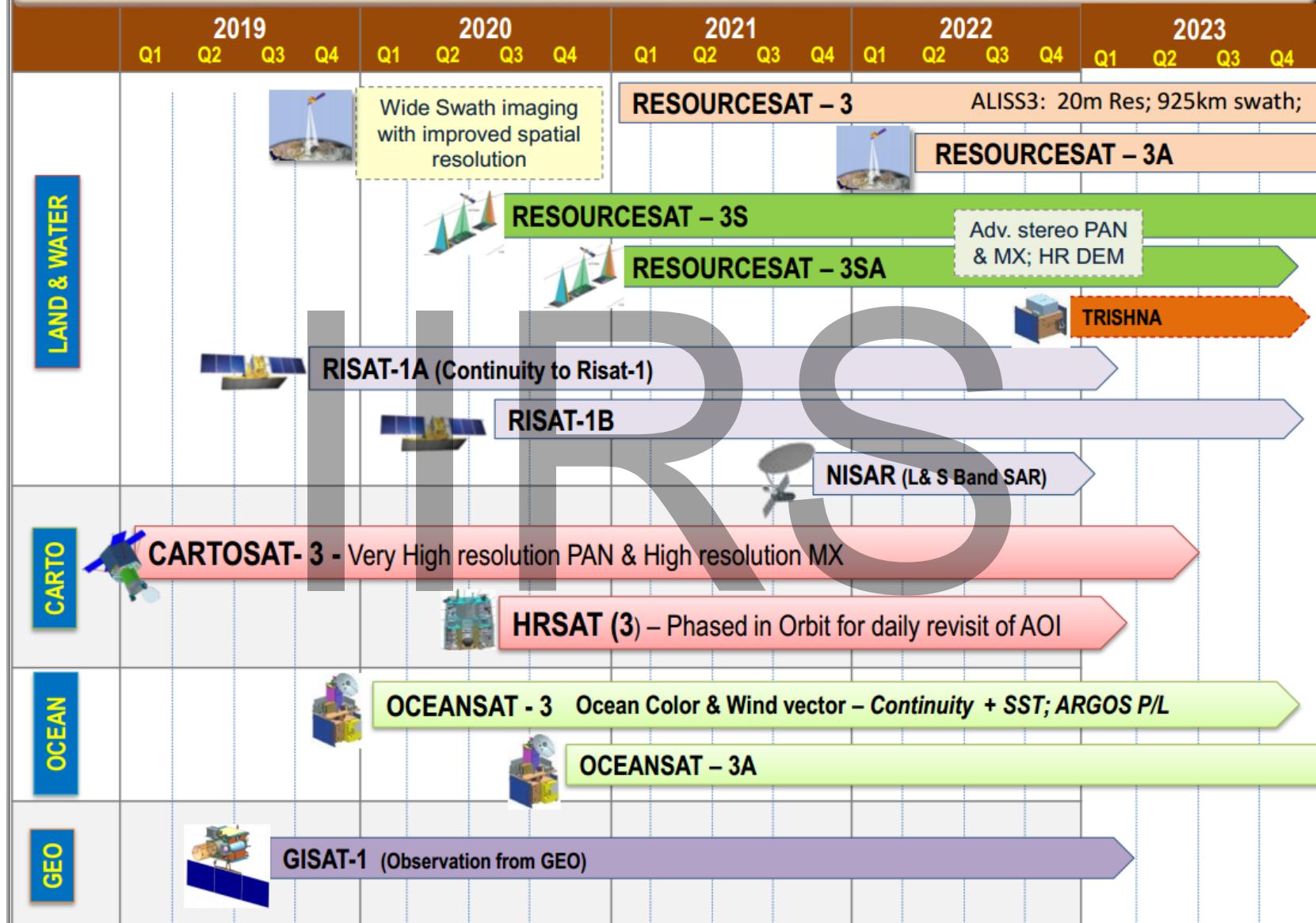
- Live & Interactive courses
- E-Learning courses

Guidance to UG/ PG/ Ph.D. students

Geospatial Technology for Startups and Innovations



Planned Indian Earth Observation Satellite Missions



THANKS...