Satellite Meteorology & Ocean Applications and MOSDAC

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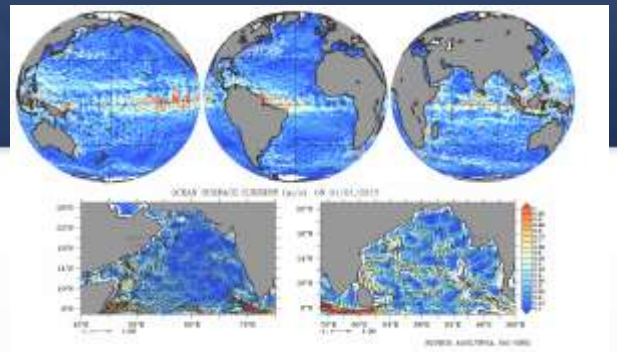
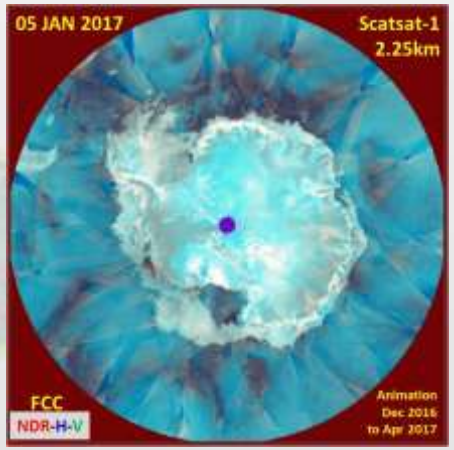
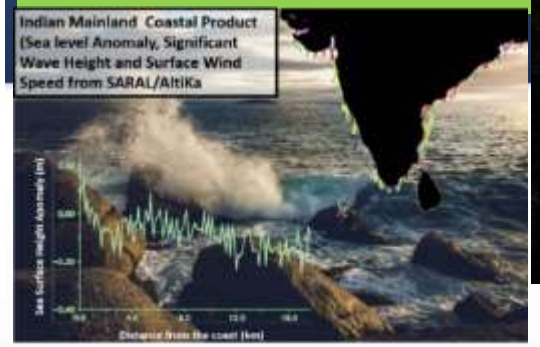
CEOS WG-CapD -8Meeting, IIRS, Dehradun, March 6-8, 2019

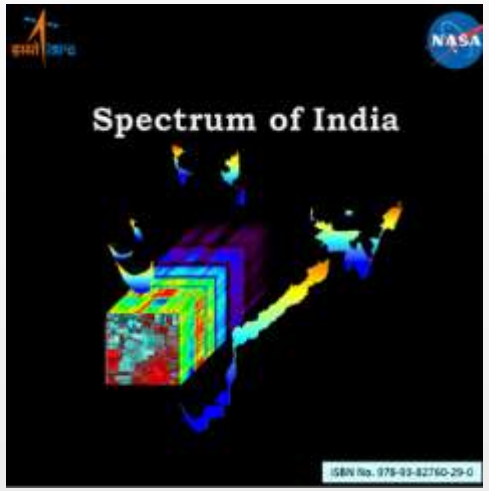
- Predictions at various scales
- Extreme events
- Retrieval /Data Assimilation
- Physical Oceanography
- Biological, Coastal oceanography
- Agriculture
- Environment & Forests
- Water Resources / Snow & Glaciers
- Geology & Minerals / Archeology
- Renewable Energy
- Disaster Management Support R&D
- Climate Change
- Planetary Sciences



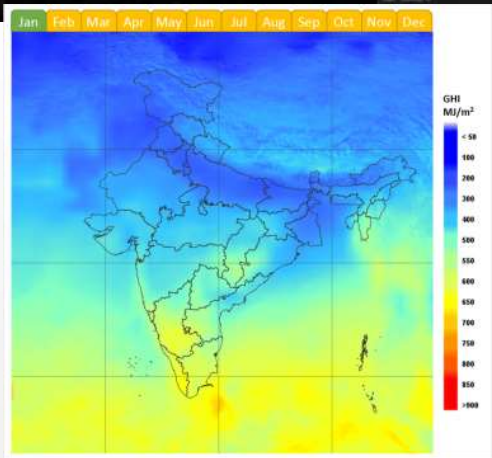


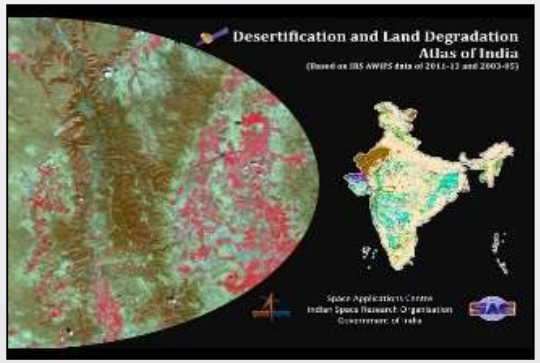
Coastal Altimeter product on MOSDAC





Alpine Treeline Atlas





Desertification and Land Degradation Status Atlas

GEOPHYSICAL-PARAMETER RETRIEVALS OF ISRO MISSIONS

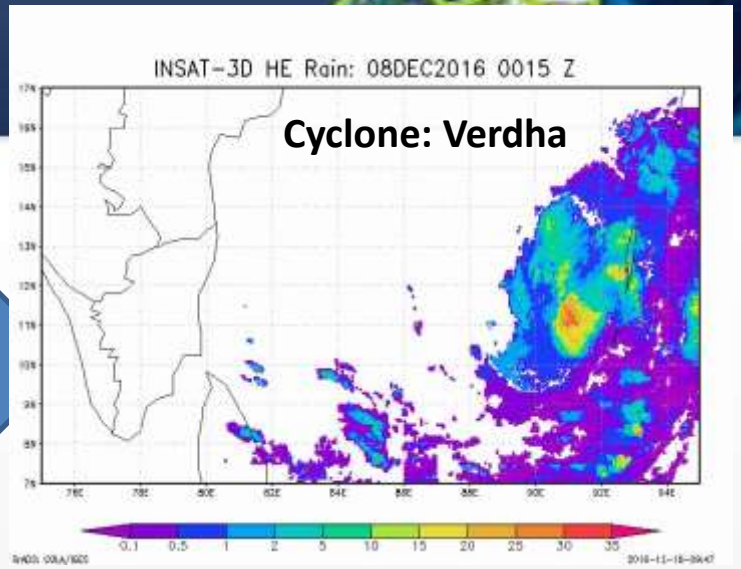
MISSIONS/PROGRAMMES

Missions

- ❖INSAT-3D/3DR SATELLITES
- ❖GISAT
- ❖SCATSAT
- ❖Oceansat-1/2/3
- ❖MEGHA-TROPIQUES
- ❖IRNSS/GNSS
- ❖TSU/HSU
- ❖MOP3 & TDP(Projects)
- ❖NISAR/RISAT
- ❖FUTURE/ OTHER MISSIONS

Activities pertain to

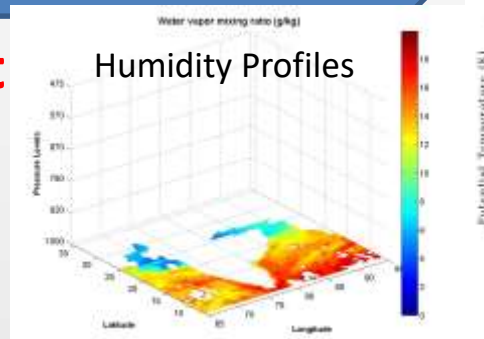
- ➢Simulations
- ➢Sensitivity studies
- ➢Algorithms development
- ➢Operational retrievals
- ➢Calibration – climate quality
- ➢Quality evaluation / Validation
- ➢*Value-addition*
- ➢*Process studies*
- ➢*Applications*

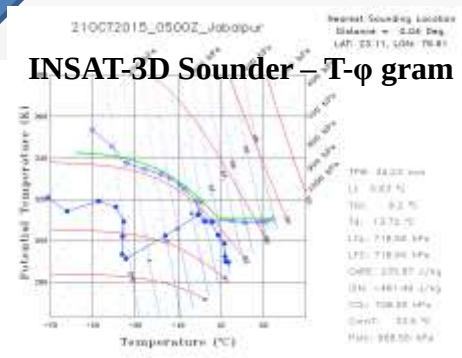


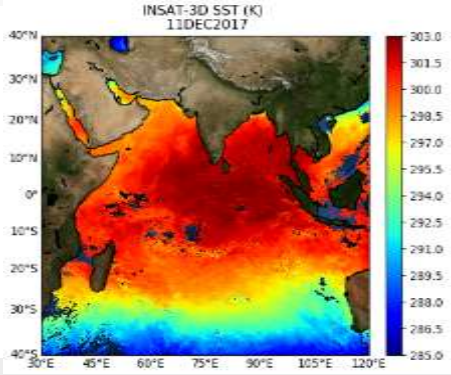
➢ Major Work Involvements in Recent Past

Imager: SST, Rain, UTH, OLR, TPW, Fog, CSBT

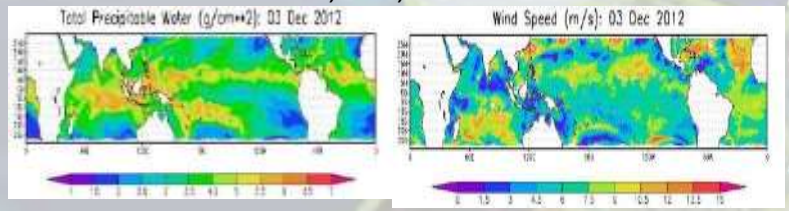
Sounder: T, WV, O_3 profiles, Total O_3, TPW, Cloud Products, Other Thermodynamic Products



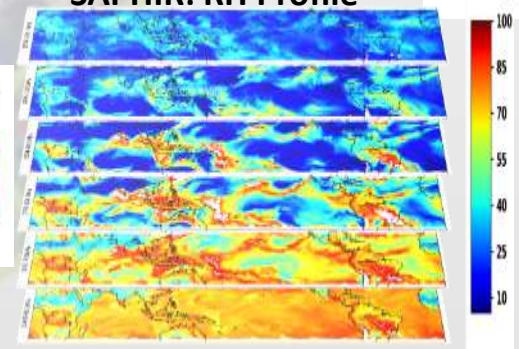




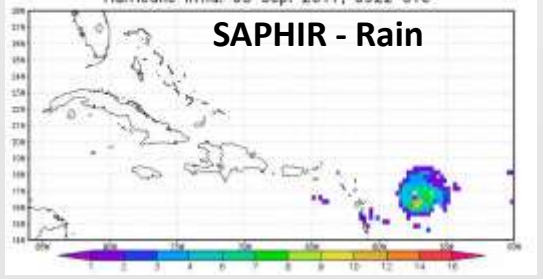
MADRAS: TPW, CLW, OWS & Rain



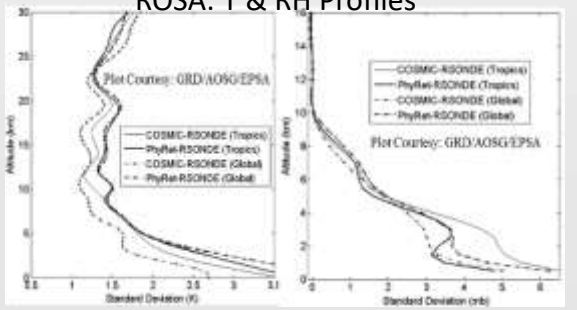
SAPHIR: RH Profile



SAPHIR: Rain



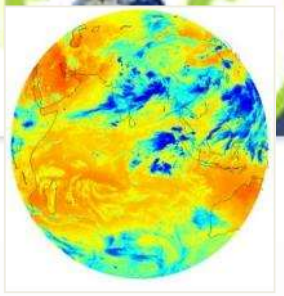
ROSA: T & RH Profiles



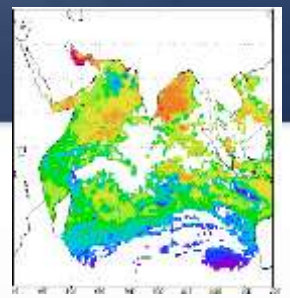
INSAT-3D/3DR Data Products

Imager

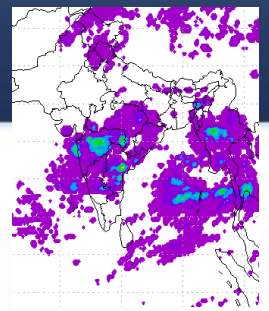
OLR



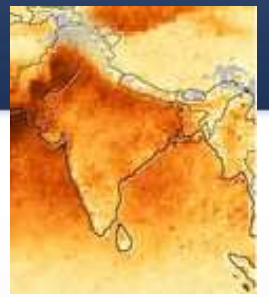
SST



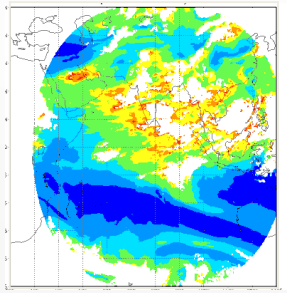
QPE (Rain)



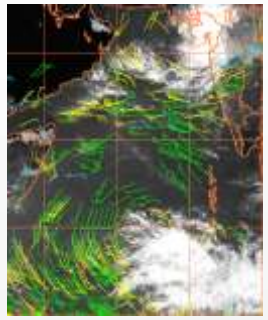
Aerosols



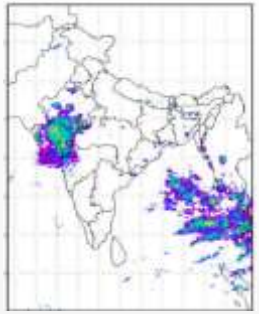
UTH



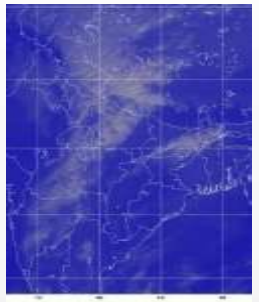
Water Vapor Winds



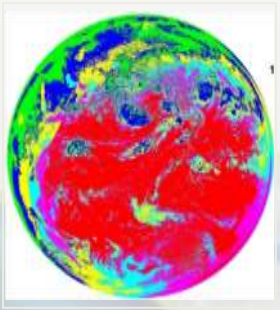
HE-Rain



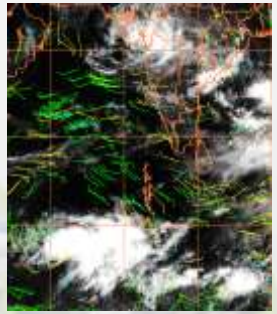
Fog



INSOLATION



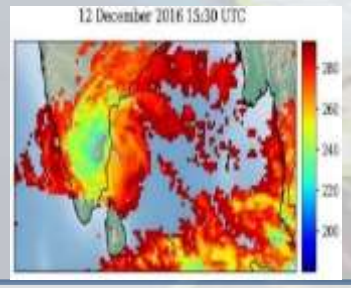
Cloud Winds



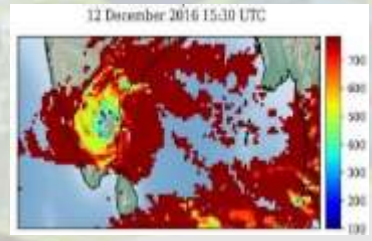
Fire & Smoke

Snow

Cloud Top Temp

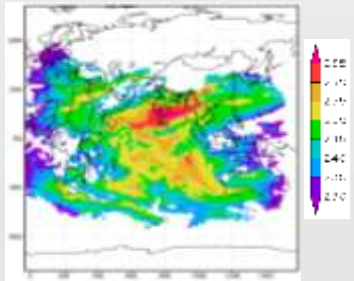


Cloud Top Pressure



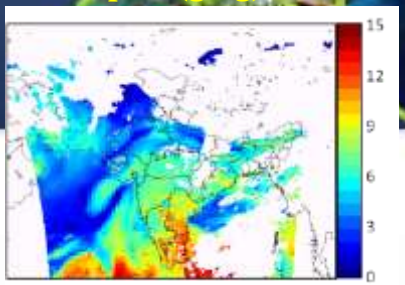
Weekly Rainfall Map

Clear Sky BT

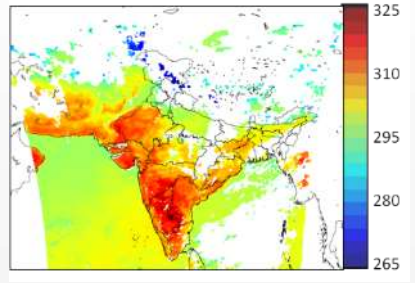


Sounder

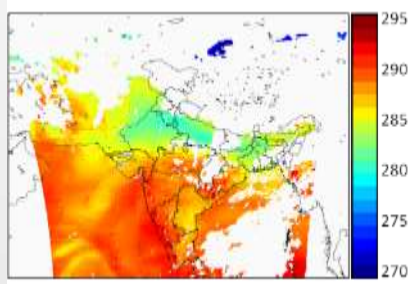
Water vapor (g/kg) 850 hPa



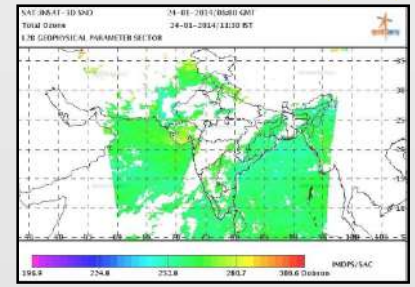
Surface Skin temperature (K)



Temperature (K) 850 hPa



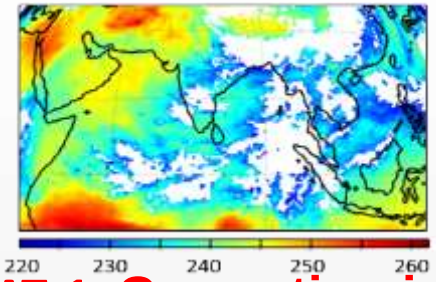
Total column ozone (dob.)

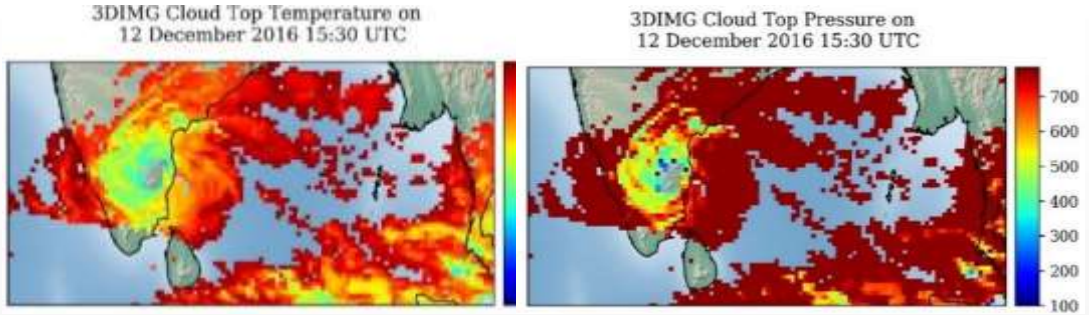


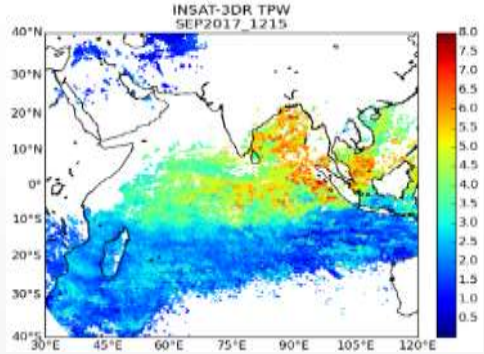
Retrievals of geophysical parameters & essential climate variables from space-borne data

- **INSAT 3D/3DR – New Products**

Clear Sky Brightness Temperatures (CSBT), Cloud Top Pressure (CTP), Cloud Top Height (CTH), and TPW



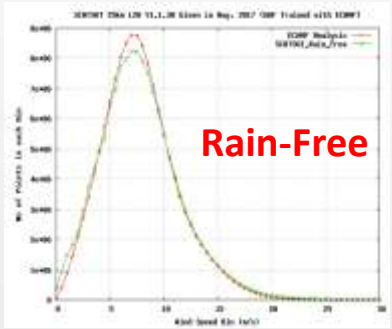




- **SCATSAT-1: Correction in Winds for Rain**

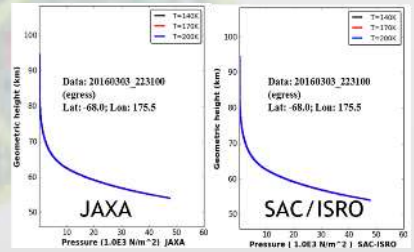
Bayesian approach for correcting rain corrupted wind from SCATSAT-1.

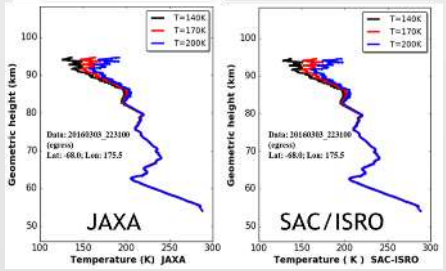
Range L2B 25 km (3-30 m/s)	WS BIAS (m/s)	WS RMSE	WS URMSE	NP(#) (*10⁶)
Rain free	0.02	1.10	1.10	124.21
Rain flagged – w/o Corr.	2.12	3.79	3.16	5.98
Rain flagged – With Corr.	-0.07	1.93	1.93	5.96

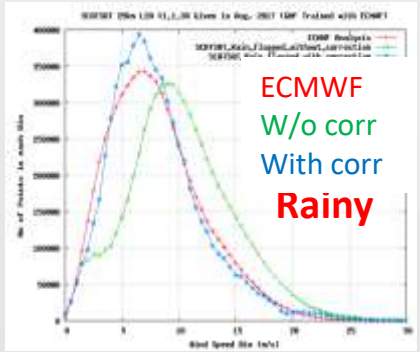


- **GNSS: RO Retrievals**

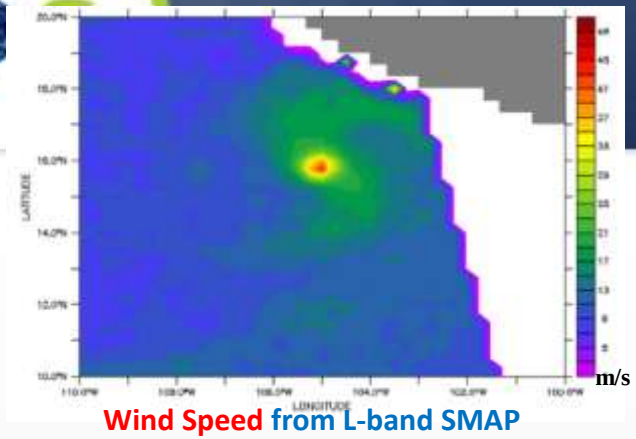
Retrieval of T, P and RH from M-T and O2 ROSA . Also retrieval of T and P from Akatsuki mission for Venusian atmosphere carried out.



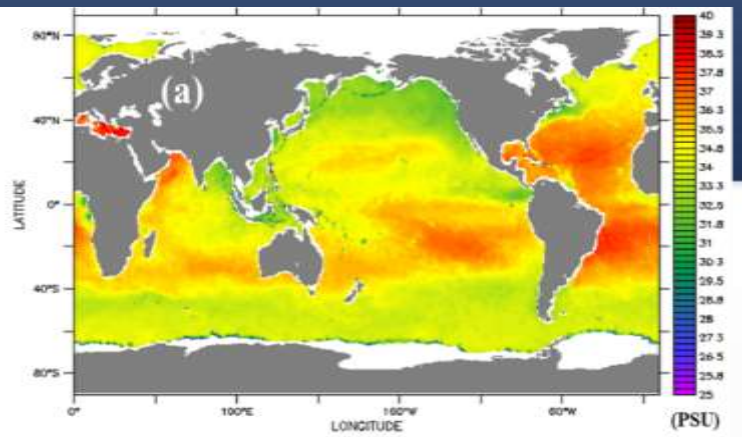




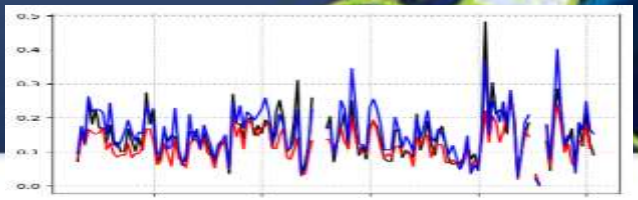
Retrievals from Passive Microwave Sensors



Wind Speed from L-band SMAP



Sea Surface Salinity from SMAP



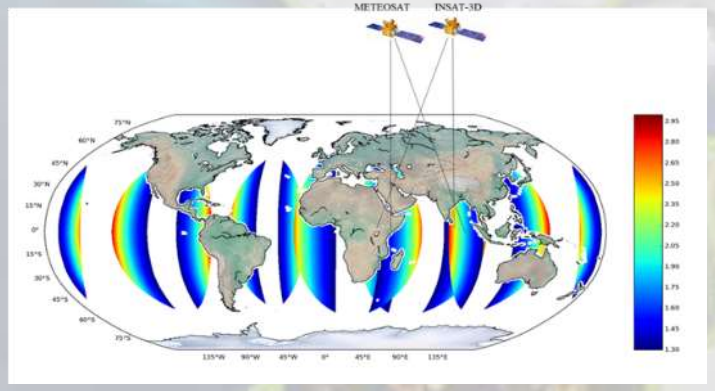
Daily mean rain-land (mm/day)

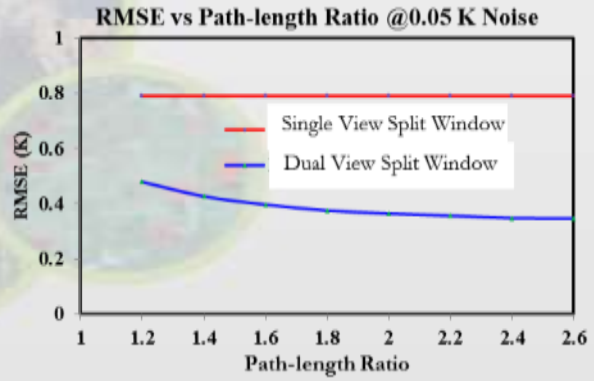
IMERG-rain
SAPHIR-operational-rain
Bayesian-rain

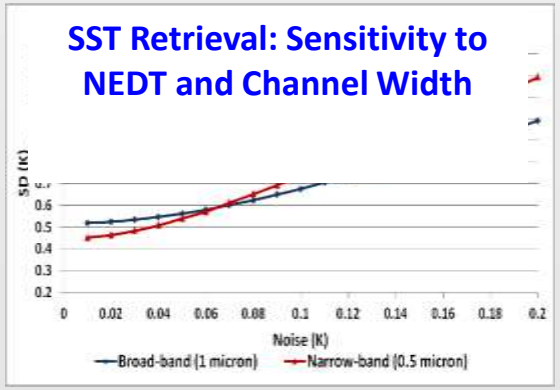
MT-SAPHIR using Bayesian algorithm.

Future Missions

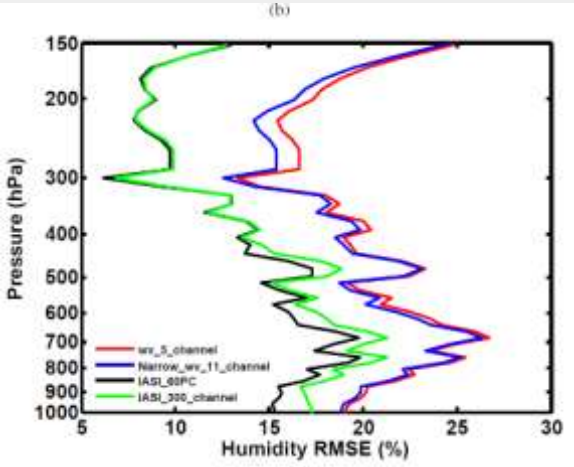
- Algorithm development for Met/Ocean parameters from
  - **Oceansat-3, GISAT, TSU/HSU, and PMR**
- Inclusion of sounding over cloud top from 3D/3DR sounder
- Sensor definition studies for future EO Missions, i.e., 4th Gen-INSAT, Microwave Radiometers, Soil moisture/Salinity missions,
- Cloud-cleared radiances for partially cloudy pixels
- GNSS Reflectometry for sea surface wind retrieval







Humidity retrieval from Multispectral and Hyperspectral Sounder

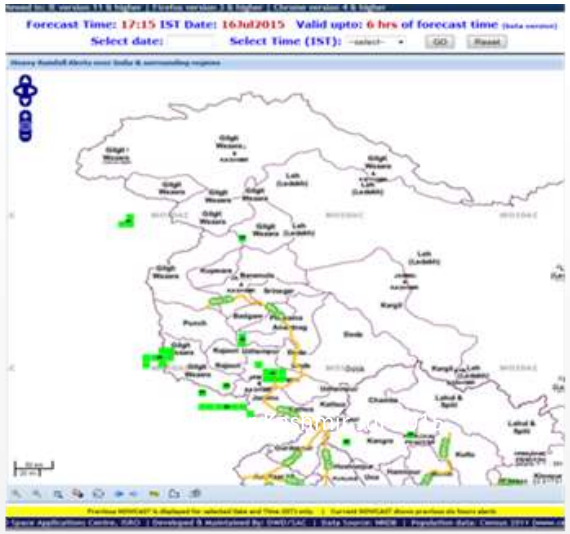


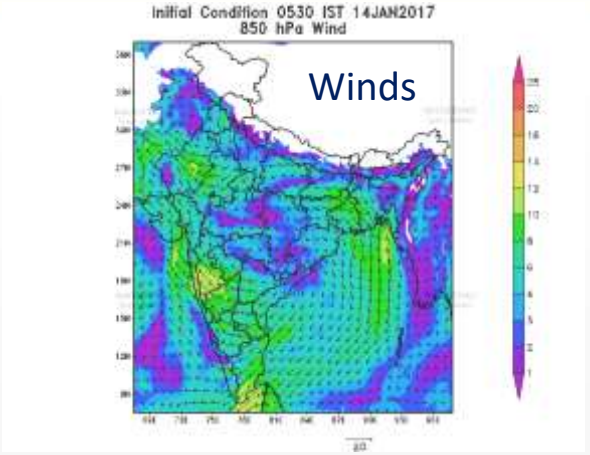
Weather Prediction using satellite data

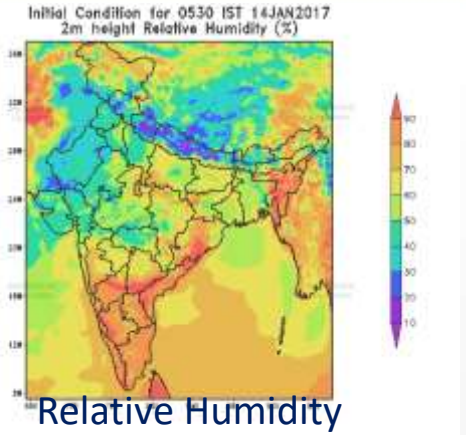
Nowcasti… at SAC

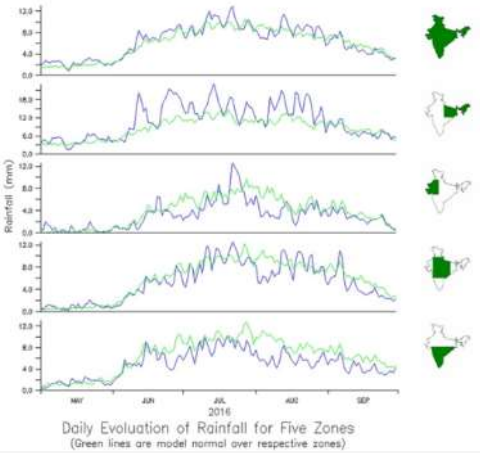
Short Range Weather Prediction
WRF model with 3DVAR

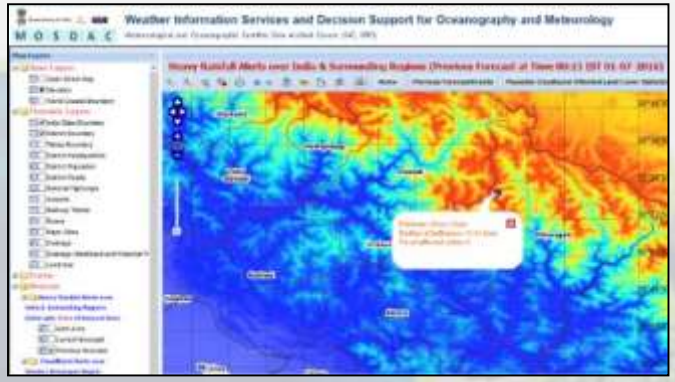
Monsoon Prediction



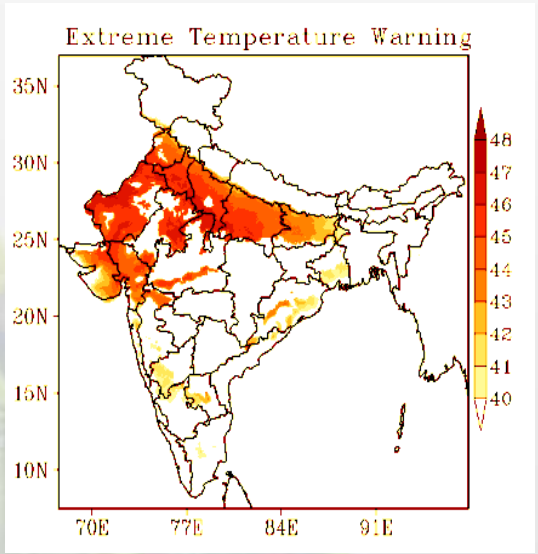




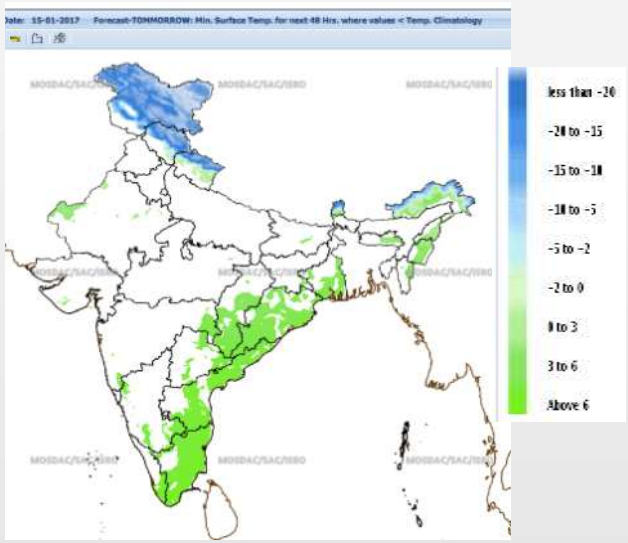




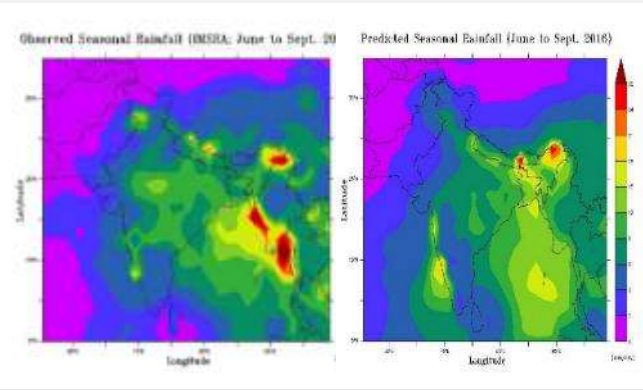
Cloudburst Alert over Pithoragarh, 01 July 2016



Prediction of heat wave conditions.



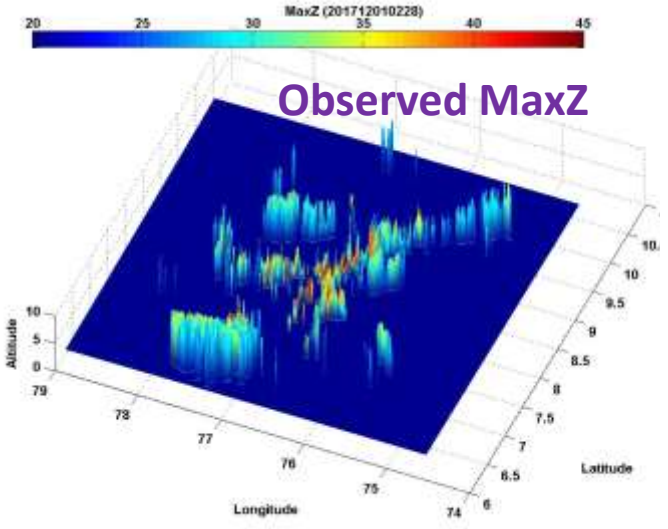
Prediction of cold wave conditions

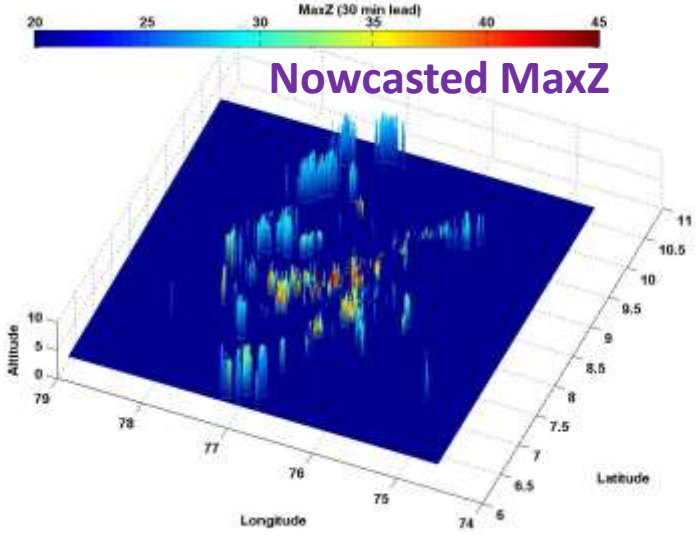


Comparison of predicted seasonal monsoon rainfall for 2016 with the satellite observations

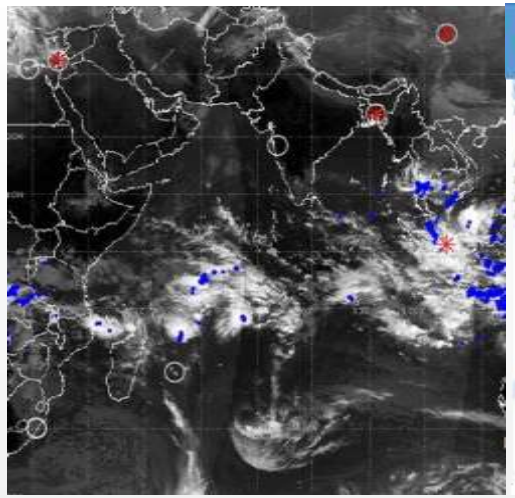
High Impact Weather Events: Satellite and Radar based storm tracking, Nowcasting and cloud microphysical studies

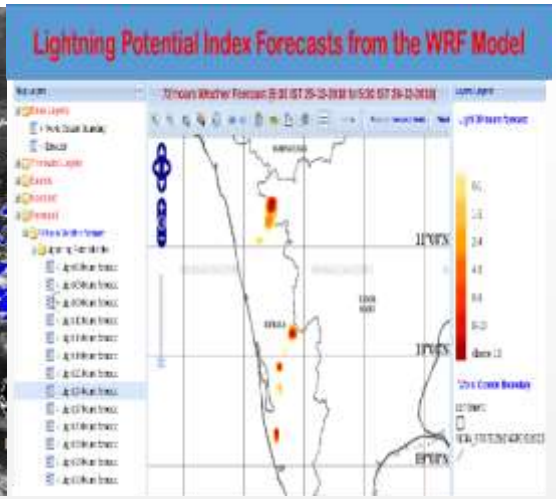
- **Algorithm development for Doppler Weather Radar (DWR) image processing and its application to storm tracking**

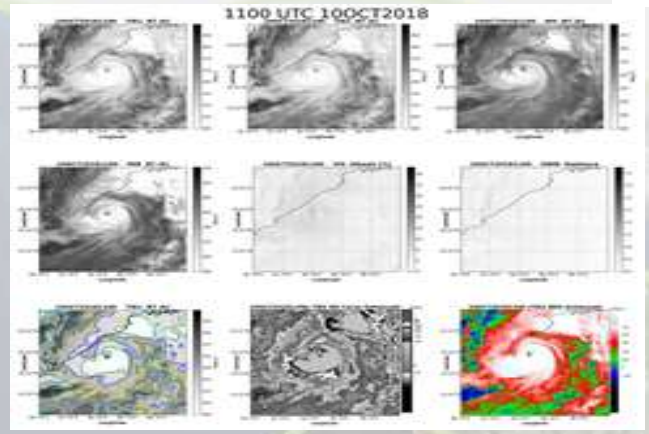




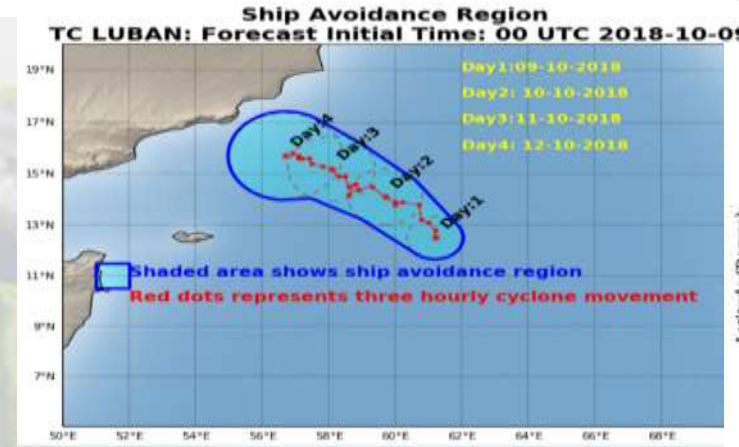
Lightening Activities: Using INSAT, GPM and WWLLN Data





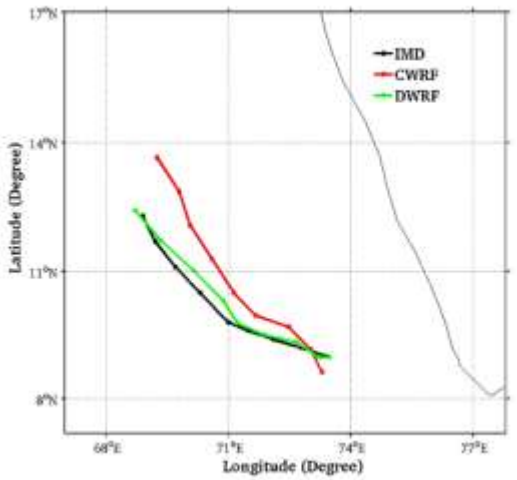


Cyclone centric images from different channels of INSAT-3D

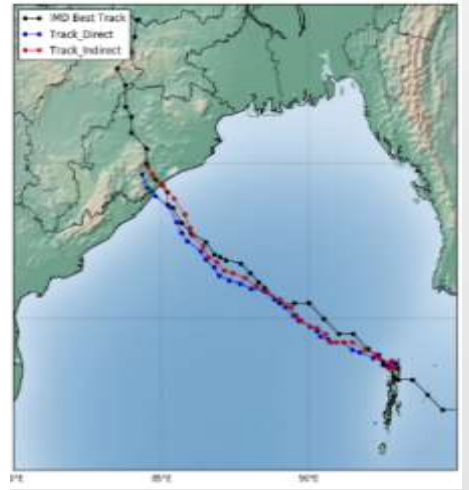


Ship avoidance region guidance during TC LUBAN

Assimilation of ISRO TERLS DWR data on TC Ockhi

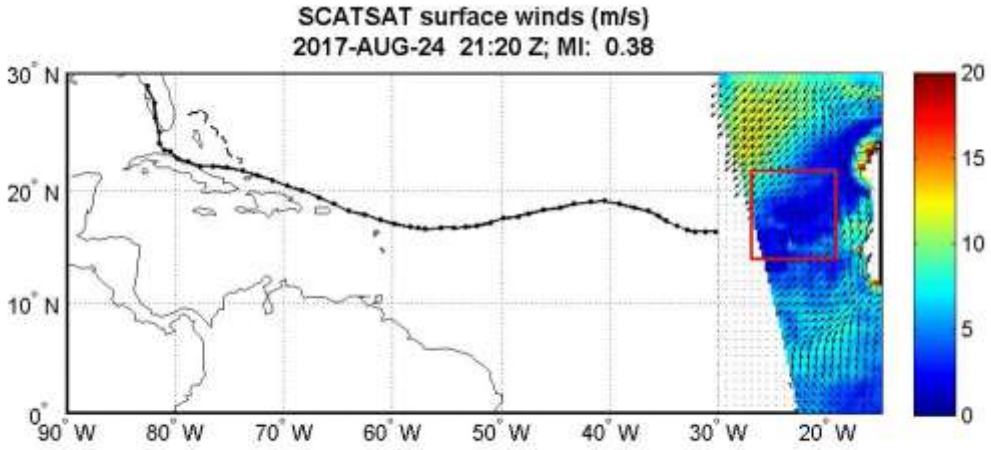


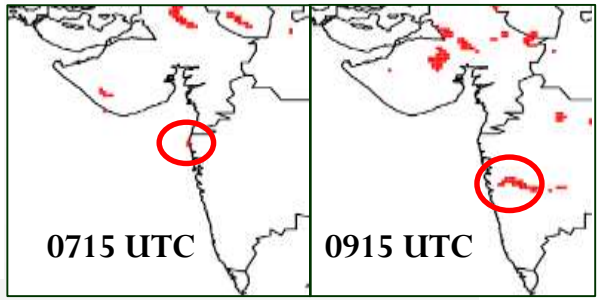
Aerosol Effect on Cyclone

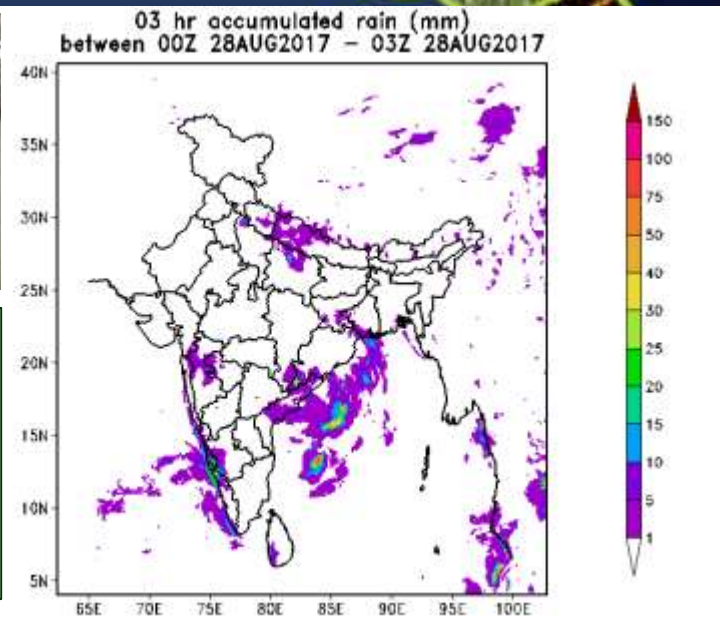


Monitoring and Prediction of Extreme Weather

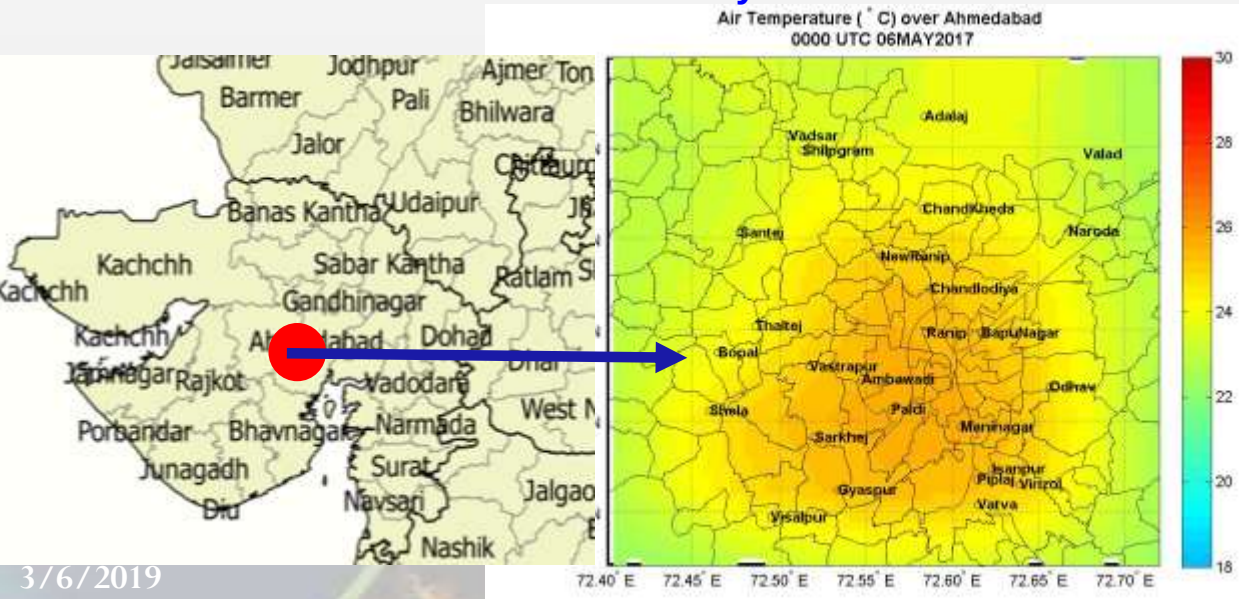
Hurricane IRMA Observed by SCATSAT





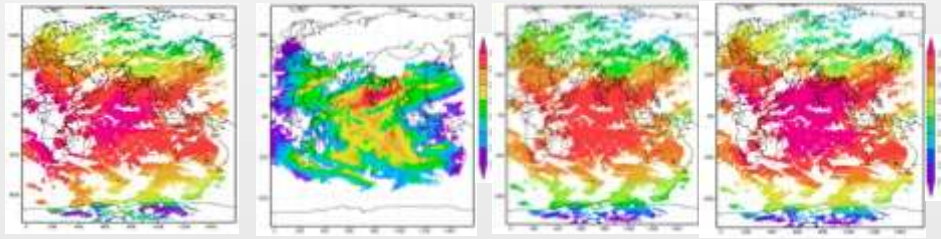


Urban Heat Island Observed by INSAT 3D



Nowcasting & Short-range Prediction of Mumbai Heavy Rainfall 28-29 Aug 2017

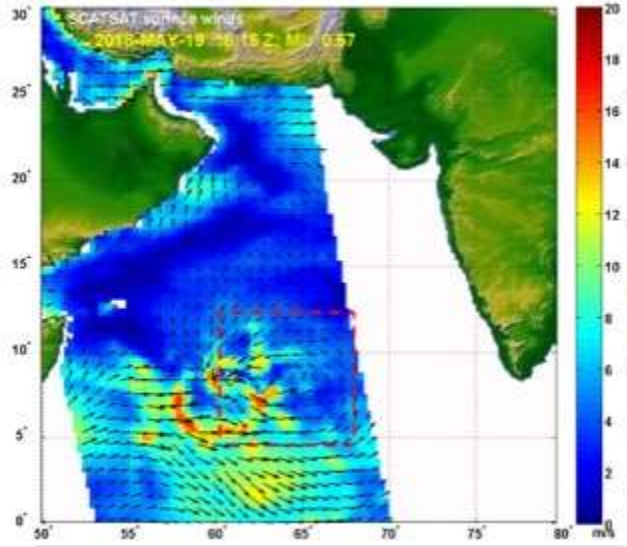
High resolution urban surface temperature monitoring and prediction using INSAT-3D/3DR



INSAT-3D/3DR Clear-Sky radiances for assimilation in global weather prediction model at NCMRWF for improved weather prediction

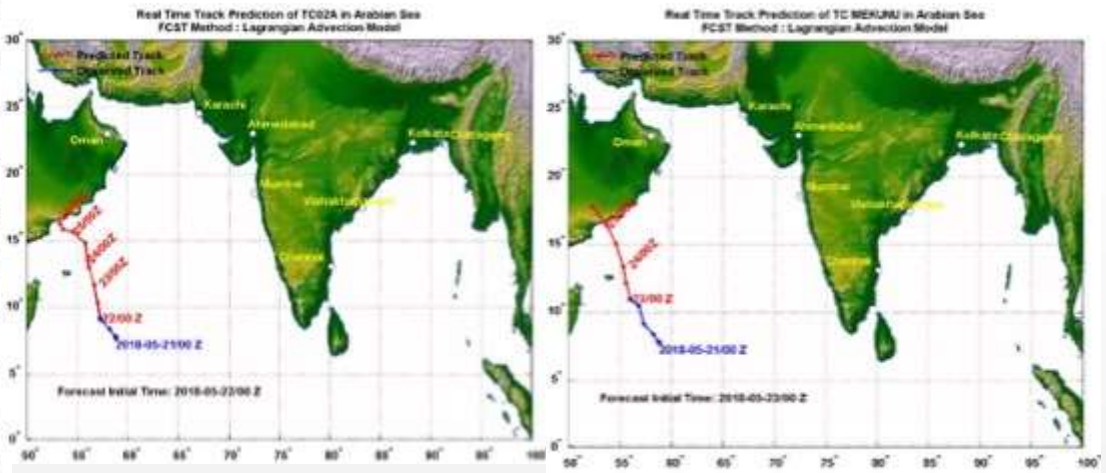
Real-Time Monitoring and Prediction of TC MEKUNU (Active in Arabian Sea)

Cyclogenesis Prediction



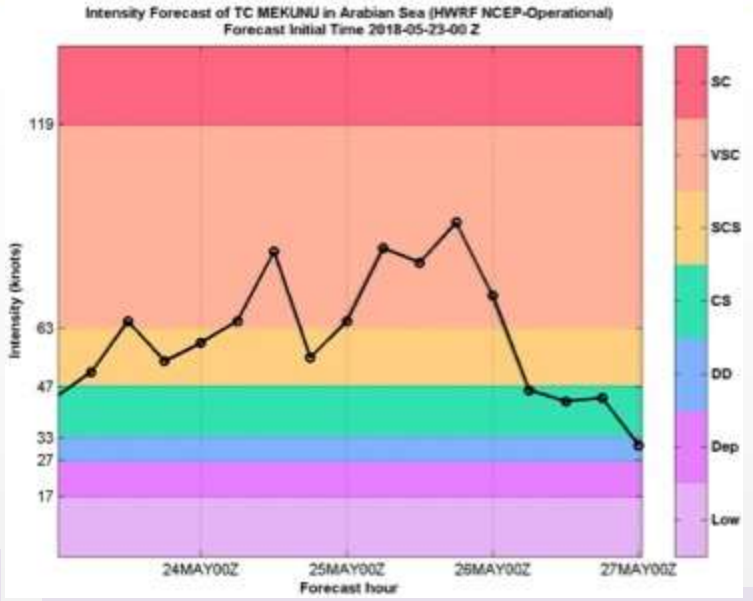
Genesis Prediction: 16 Z, 19 MAY
Cyclone formation: 18 Z 22 MAY
Lead prediction time: ~72 hours

Cyclone Track Prediction



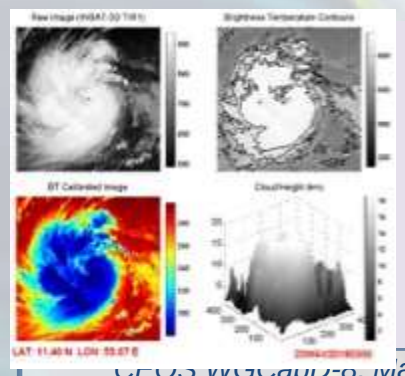
Real-time cyclone Track prediction at 00 during 22 and 23 MAY using in-house developed SAC-Lagrangian track prediction model.

Cyclone Intensity Prediction



Real-time cyclone intensity prediction using NCEP-operational HWRF model Forecasts

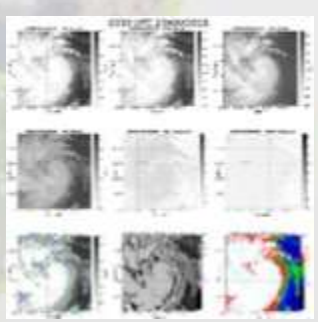
Center Estimation



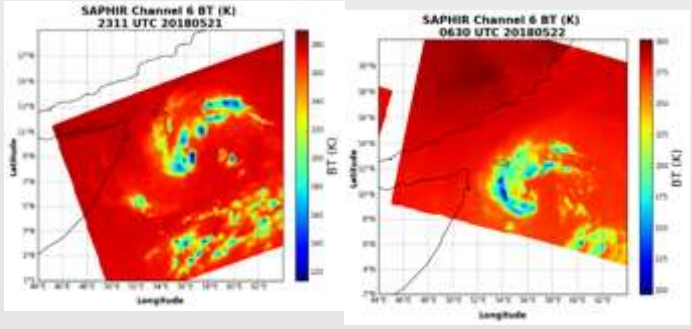
Real-time TC center was estimated and TC centric products were generated using INSAT-3D Imager data

Cyclone centric satellite Products Generation

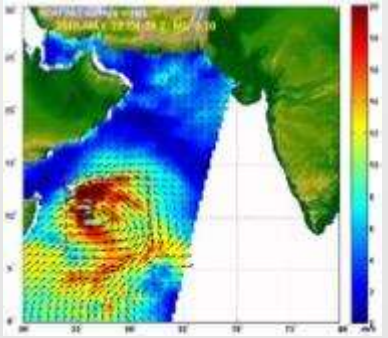
INSAT-3D Imager



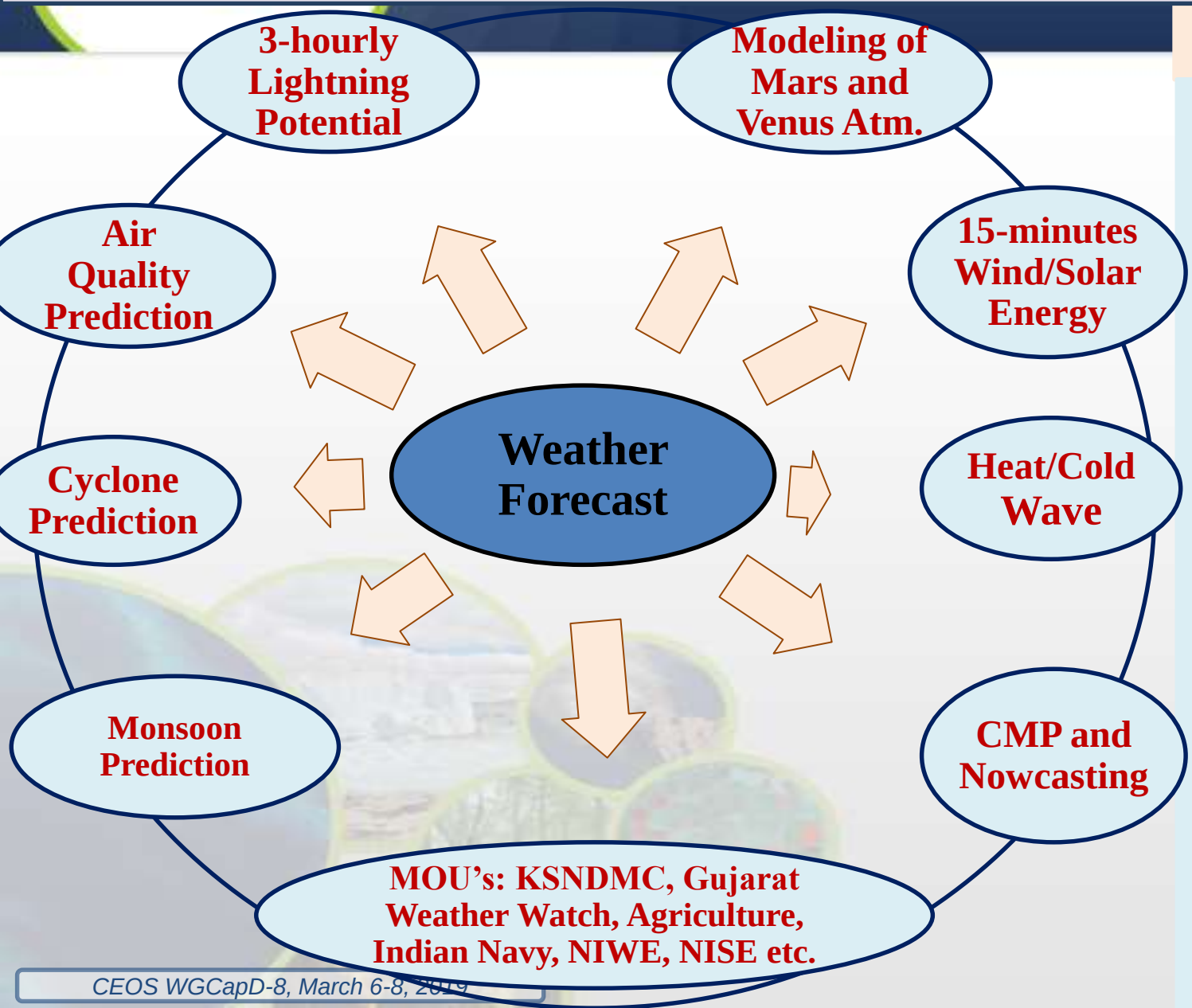
MT-SAPHIR



SCATSAT-1



Atmospheric Sciences : Weather Forecasting and Data Assimilation



Research Activities

- All-Sky Assimilation of SAPHIR radiances
- Development of assimilation system for INSAT-3R radiances
- Assimilation of ISRO TERLS DWR for extreme weather events
- Development of assimilation system for Martian & Venusian Atmosphere
- Seasonal forecast using CESM Model
- Lightening Estimate and Forecasting

Satellite based Marine process understanding, development, Research and Applications for Blue Economy (SAMUDRA)

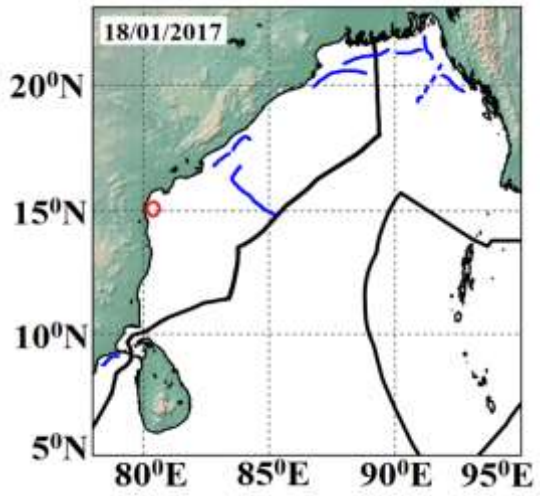
Scope & Objectives

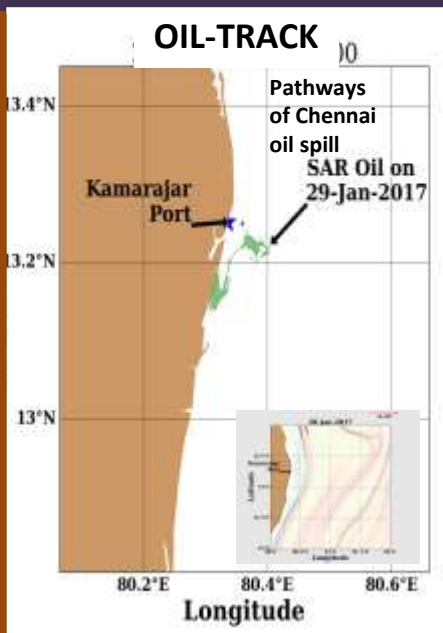
- Identification of zones which are susceptible to extreme conditions using site specific wave and circulation models.
- Provide outlook of potential fishery zones; development & demonstration of FISHTRACK module
- Generation of very high resolution ocean state for Naval and Shipping operations
- Tracking of oil spill; development & demonstration of OILTRACK module
- Identify potential zones for wind, wave and thermal energy
- Synthetic temperature and salinity profile generation using satellite observations
- Optimize model parameters for better mixed layer simulation.
- Development of improved algorithms for momentum, latent and sensible heat flux computation using satellite and in-situ measurements.

Targeted Outcomes

- Marine Ecosystem, Potential Fishing Zones
- Ocean Hazards (RIP currents, extreme waves, oil-spill forecasting,)
- Energy Sector (wind/wave/thermal)
- Oil Exploration, Naval Operations & Ship Routing
- New Sensor Definition / Retrieval / Infrastructure / capacity building
- Disaster Monitoring and Prediction
- Ocean Reanalysis , accurate models for OSF
- Ocean observing systems for satellite cal-val and model optimization

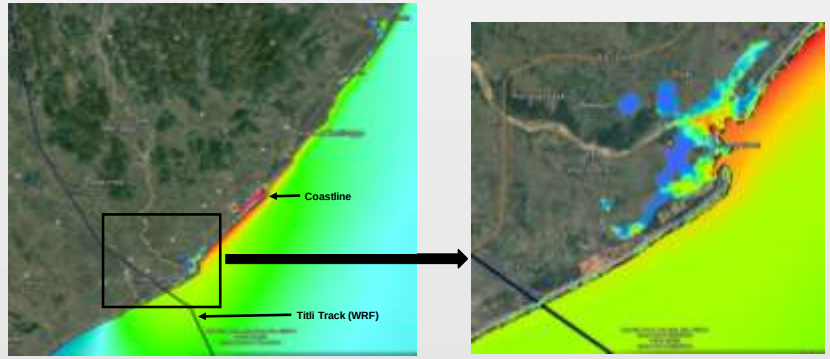
Satellite based new methodology for identifying PFZ locations (in blue lines)





LCS strain lines: Barrier zones

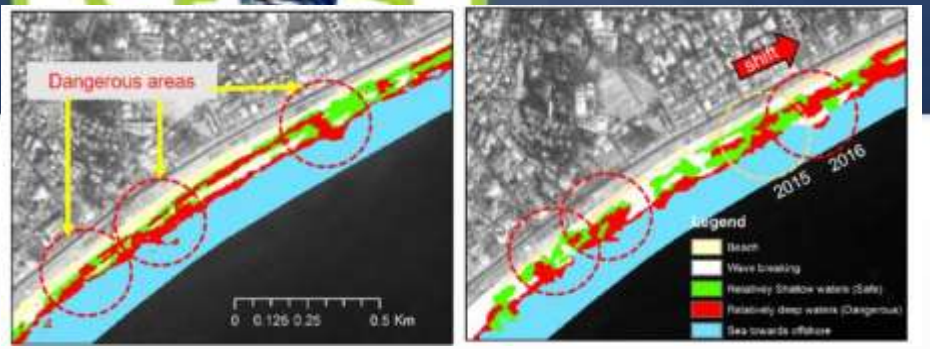
SAMUDRA: Coastal Inundation Forecast for 10/10/2018, 0600 GMT associated with TITLI (Forecast generated on 09/10/2018, 0600 GMT) Validation to be done and plan to host it on MOSDAC



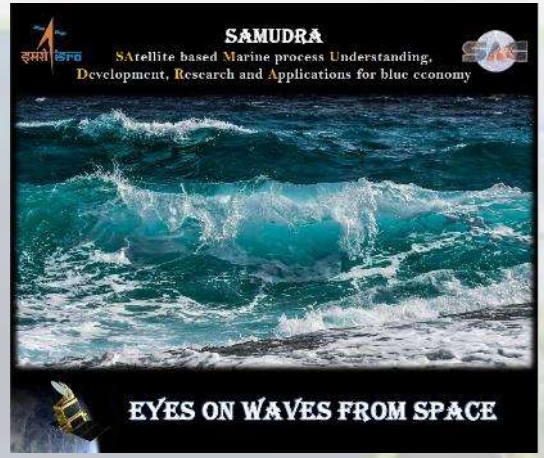
Simulated Coastal Inundation Forecast for Titli Cyclone upon Landfall on 10/10/2018 06:00:00 IST

RIP CURRENTS

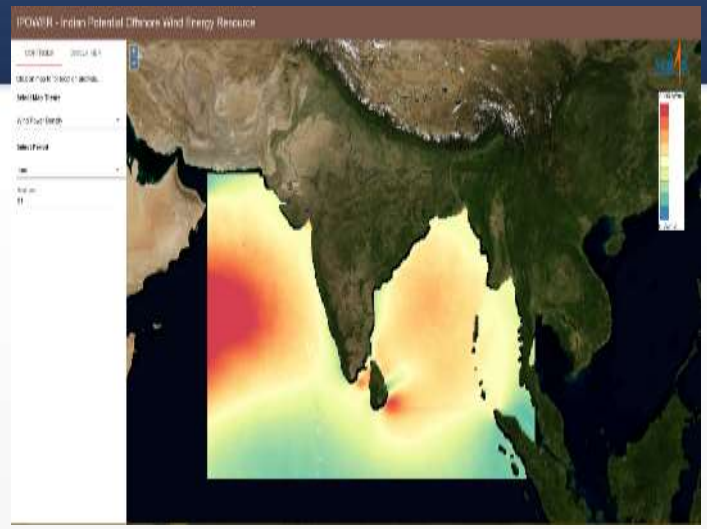
Rip current hotspot detection from satellite RS



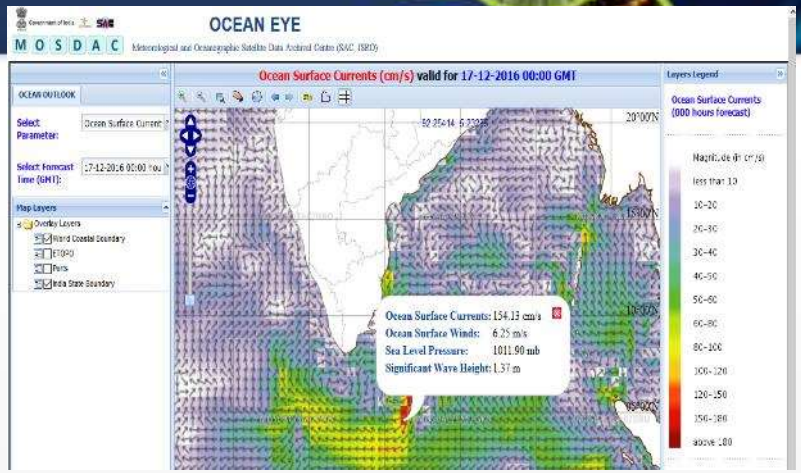
Rip current measurements from low-cost GNSS drifters



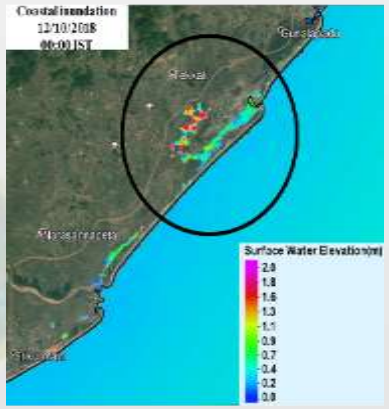
iPOWER hosted on VEDAS

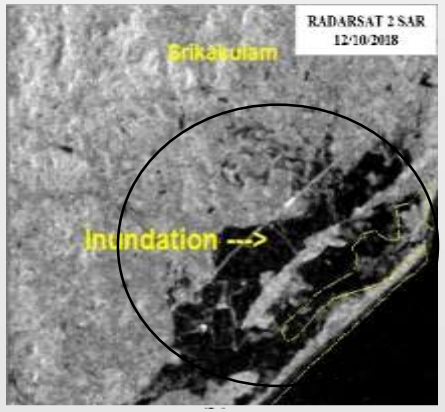


Ocean Eye (MoU with SCI)

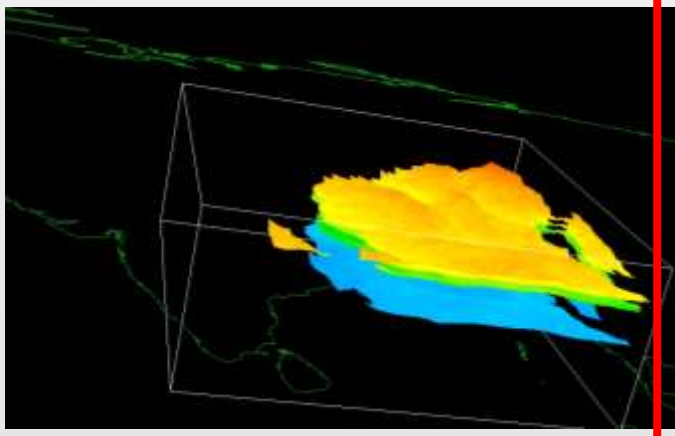


Coastal inundation forecast for TITLI cyclone (left); Validation using RADARSAT image (right); Operationalized on MOSDAC





Sub-surface projection of Density Anomaly (blue to orange in increasing order of its value) from satellite parameters (sea level, sea surface temperature and surface salinity)

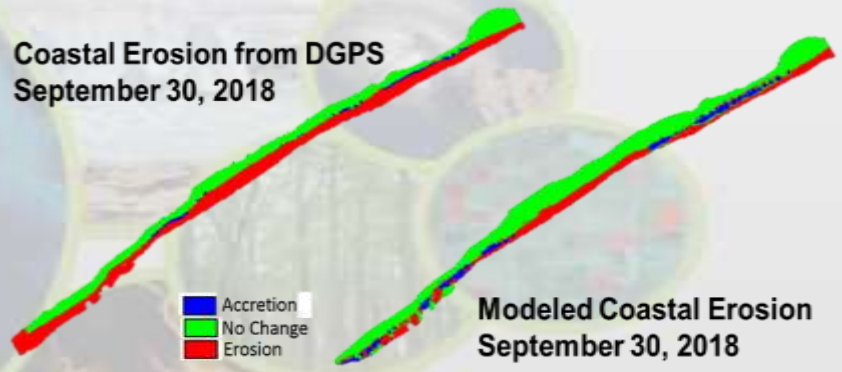


Beach Erosion Forecast

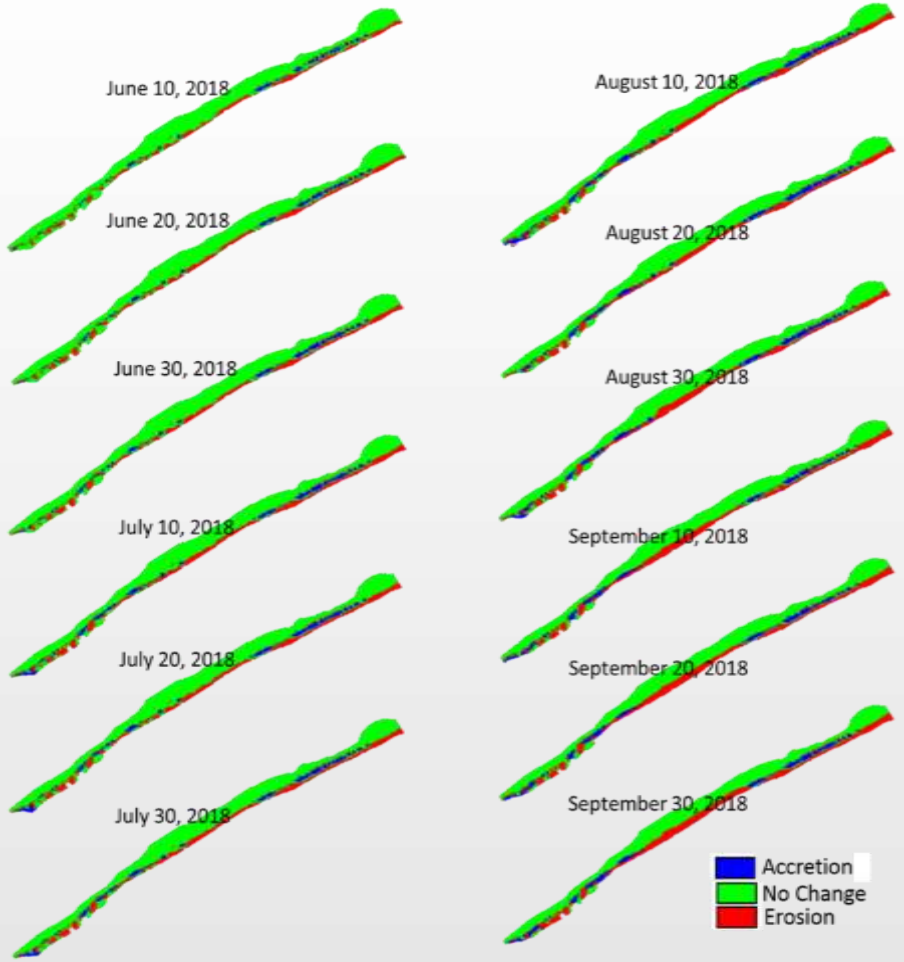
- Initial conditions using DGPS profiles at every 5 m interval along 4 km beach. Morphodynamic model is simulated using forecast wave parameters.

- Beach erosion forecast/advisories are provided in a test mode for monsoon season, 2018 all with a lead period of 10 days.

Validation of Beach Erosion Forecast



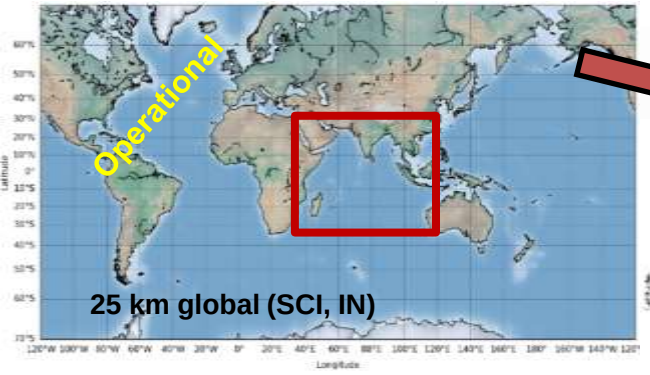
Beach Erosion Advisory (lead period of 10 days)



Work is planned for operational beach erosion forecasting system for selected beach with INCOIS

Ocean Modelling (wave, circulation, biogeochemistry and coupled): AOSF

(Multi-nested interactive modelling set-up)



The Road Map

Very high resolution process modelling (~ 100m)

Motivation:

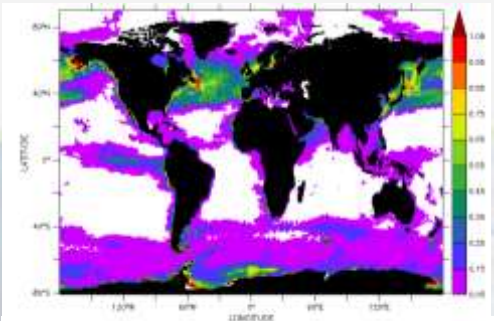
- Observing System Simulation Experiment (OSSE): Defining the Future Ocean Sensors
- High Resolution Site/Event – ISRO's Satellite Recovery Program
- Naval and Shipping Needs
- Development of Model : Optimising model parameters using non-linear data assimilation Methods

R&D Components:

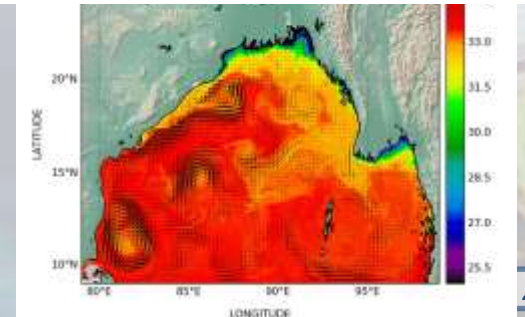
(i) Assimilation of sea level (altimeter obs), currents, SST, SSS & Argo Profiles (T & S), ocean color--- A complete assimilation package

(ii) HR-Satellite image assimilation (GISAT & SWOT)

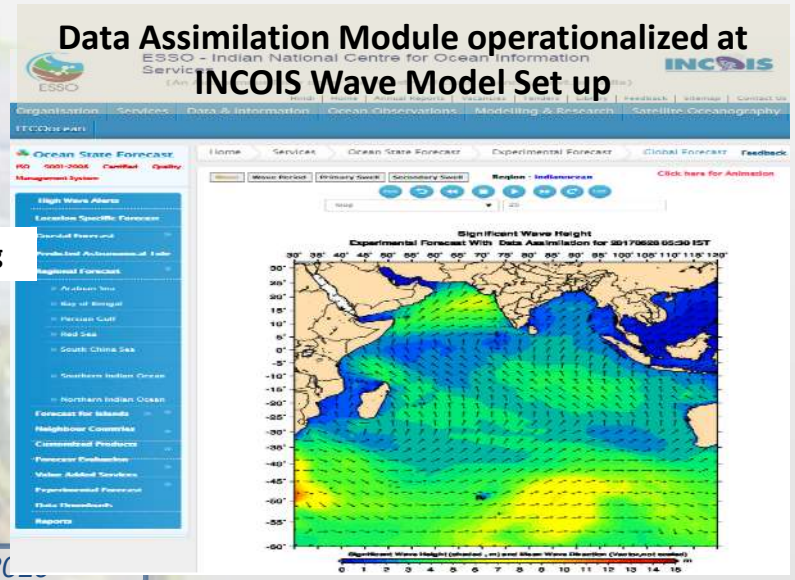
Coupled Bio physical modelling



Very high res. circulation and wave modeling

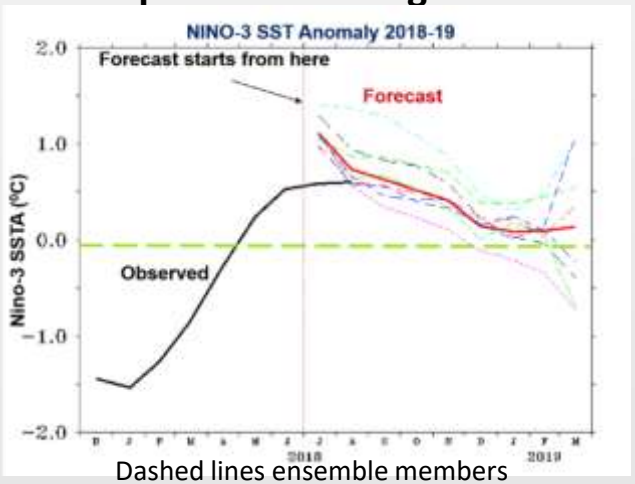


Data Assimilation Module operationalized at INCOIS Wave Model Set up



Coupled ocean atmosphere modelling for El-Nino forecasting

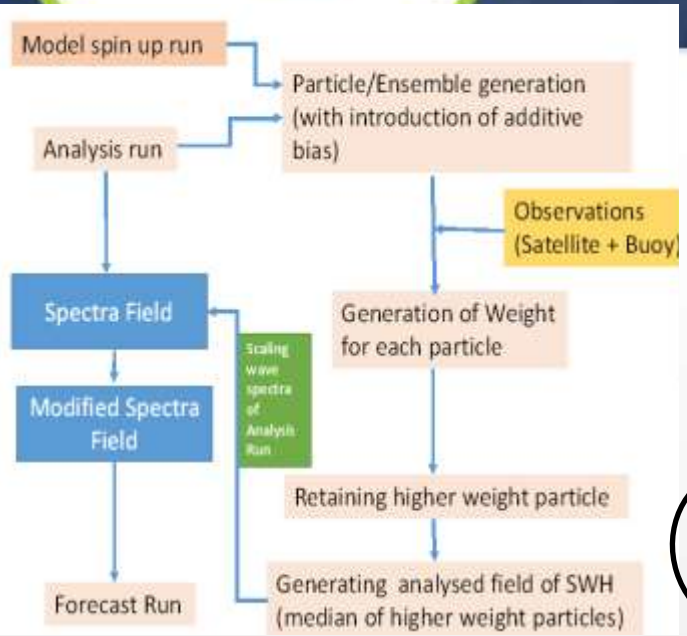
- Forecast generated using initial conditions of April, May and June
- 6 month lead time forecast for December 2017 predicted neutral conditions in the Pacific.

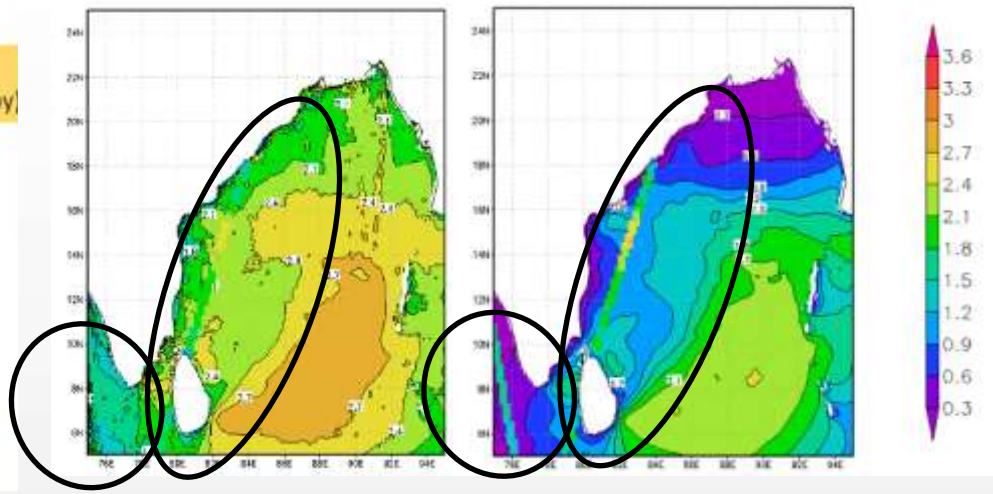


Dashed lines ensemble members
thick red line is ensemble mean

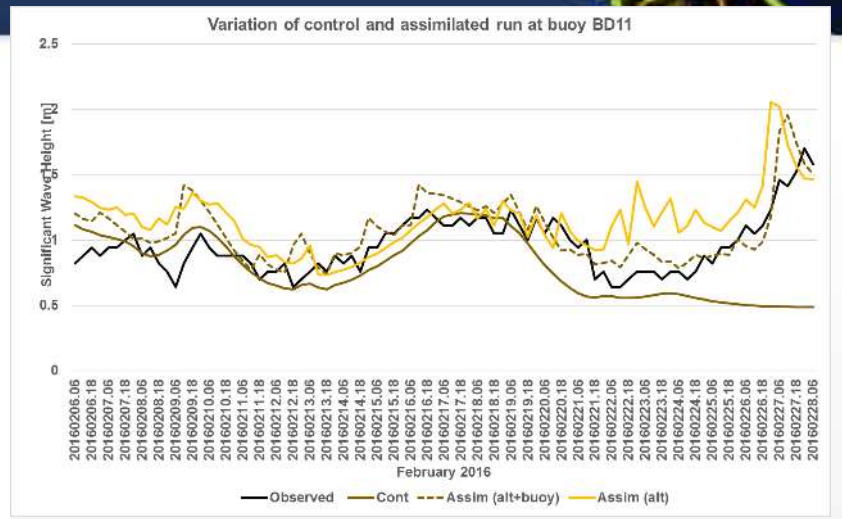
El-Nino **Forecast for December 2018** using coupled ocean-atmosphere model : Mild El Nino

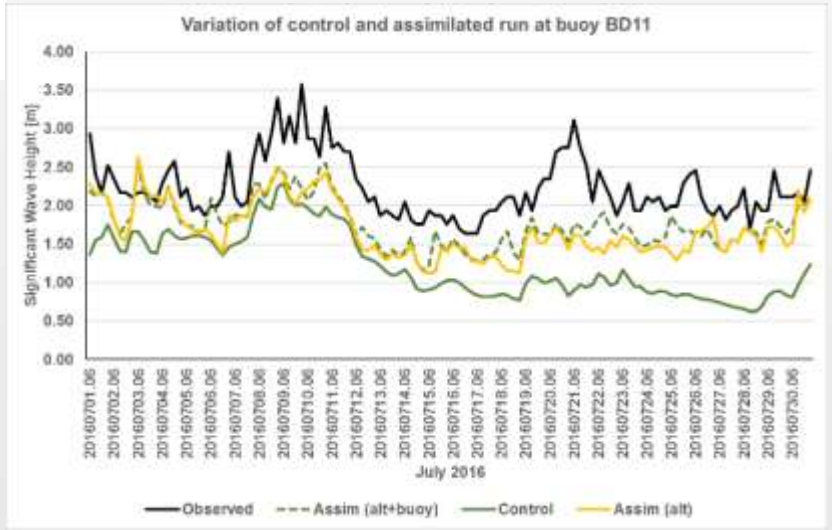
Development of Particle Filter based assimilation scheme for wave model incorporating altimeter and Indian ocean buoy





The SWH over Bay of Bengal on 31st July 2016 at 00:00 GMT from a) Analyzed field and b) Control field with overlaid SWH from altimeter tracks.





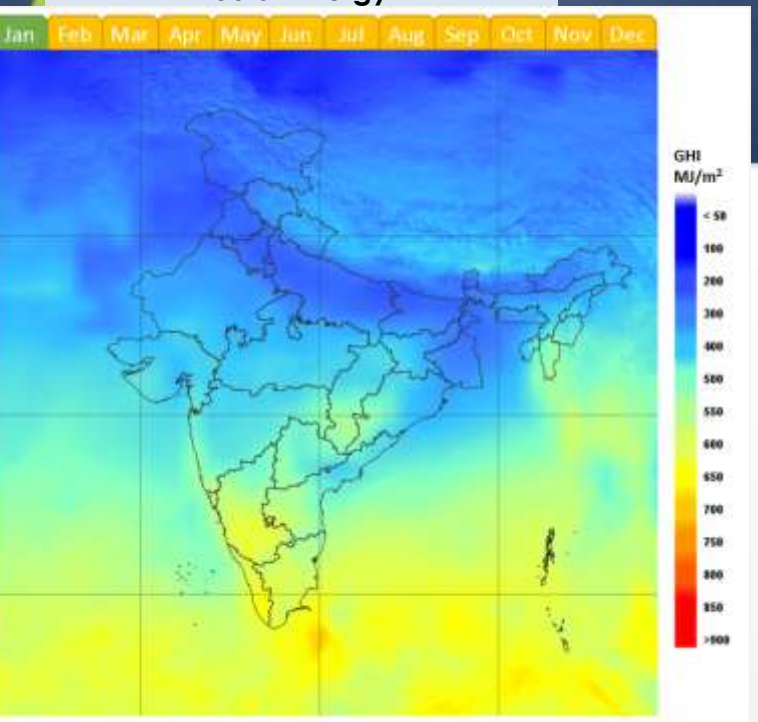
The SWH over Bay of Bengal February and July 2016 from various runs. Alt-J2,J3,SRL/ALTIKA
BUOY: INCOIS BD buoys no 11, 8 and 14

Future plans:

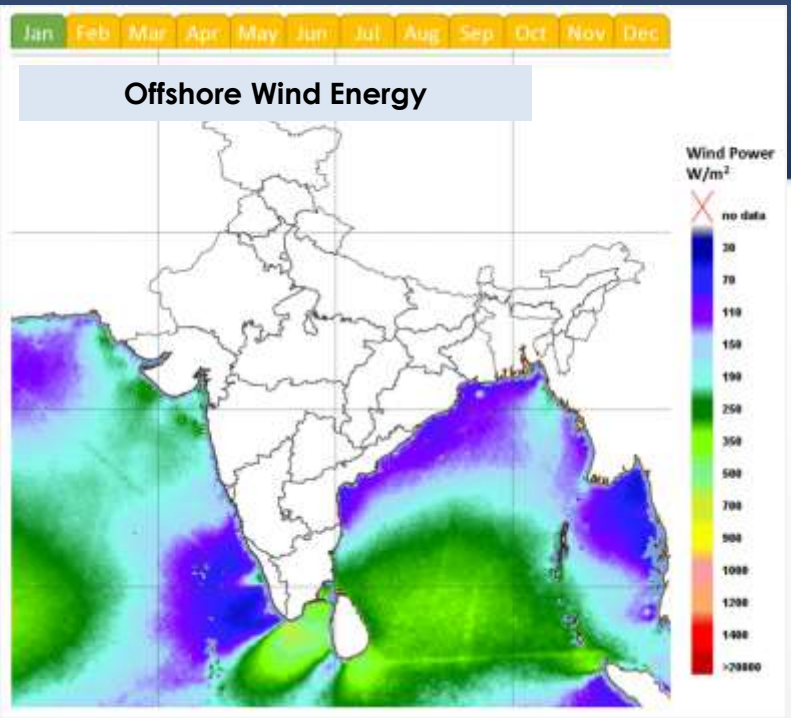
1. Climatological run using particle filter assimilation technique in progress. This is for generation of high resolution BOB wave assimilation based reanalysis product and would incorporate all BOB buoys/ altimeter data

Renewable Energy from Space

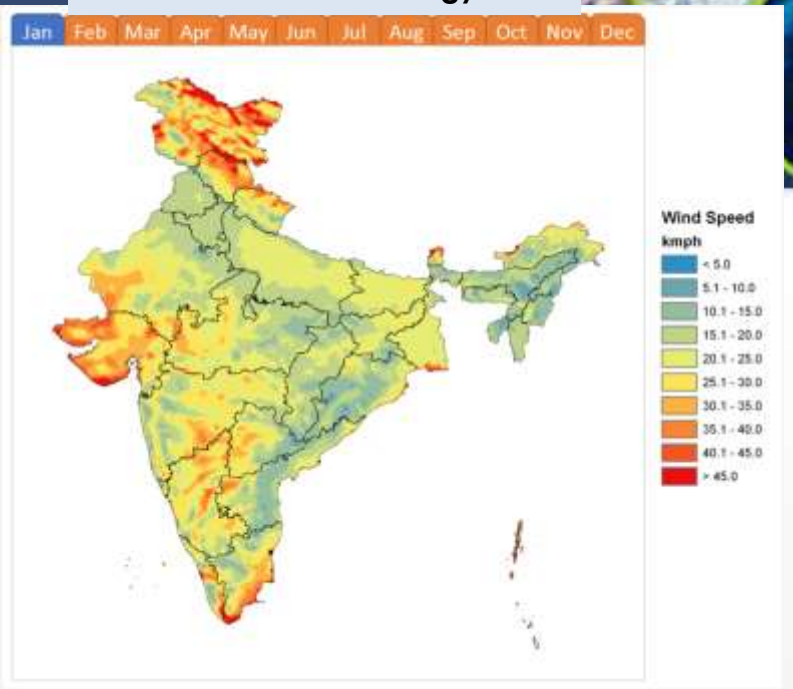
Solar Energy



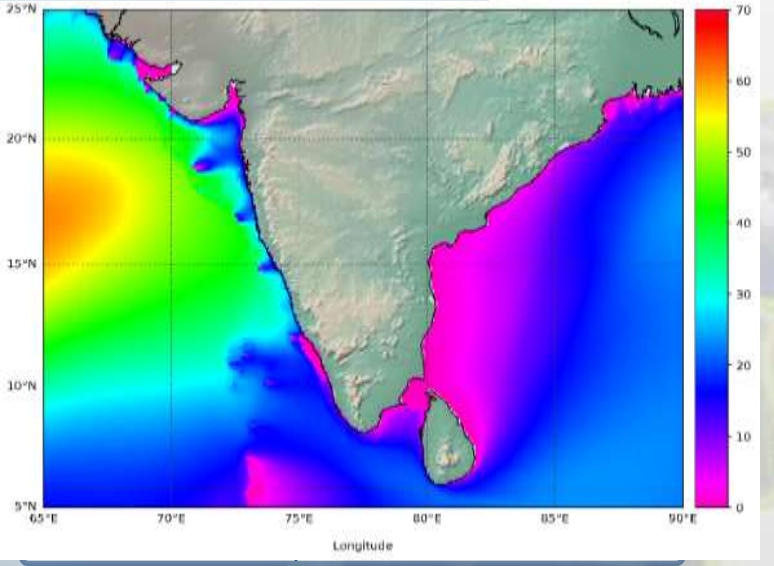
Offshore Wind Energy



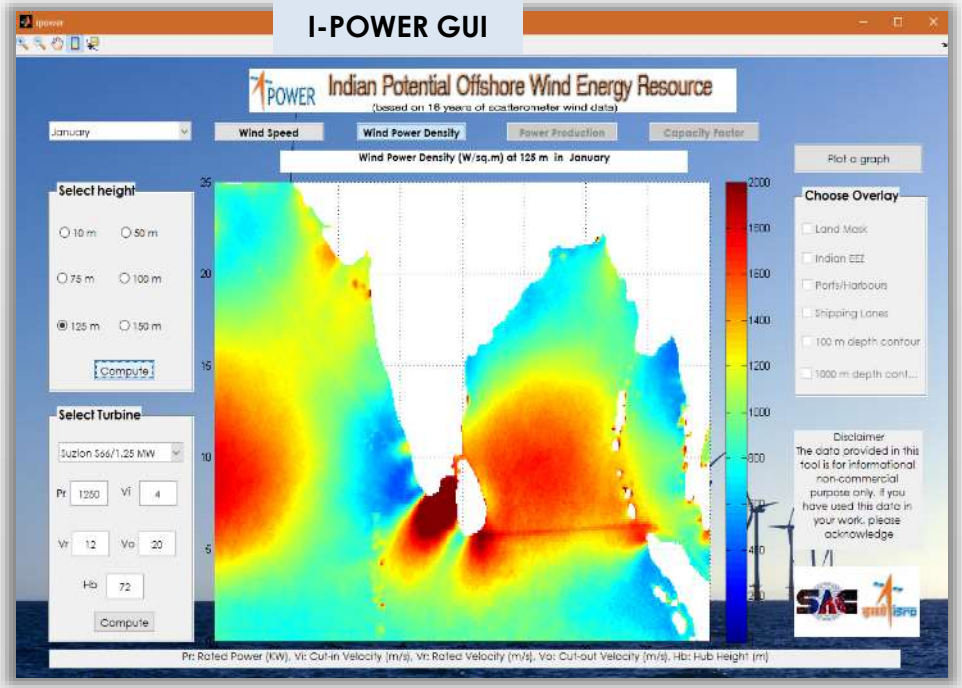
Onshore Wind Energy



Ocean Wave Power



I-POWER GUI



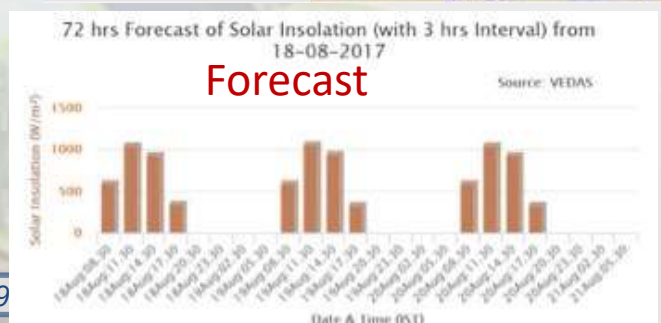
Solar Energy Potential on Mobile & Solar Site Selection Tool

Tabular Description

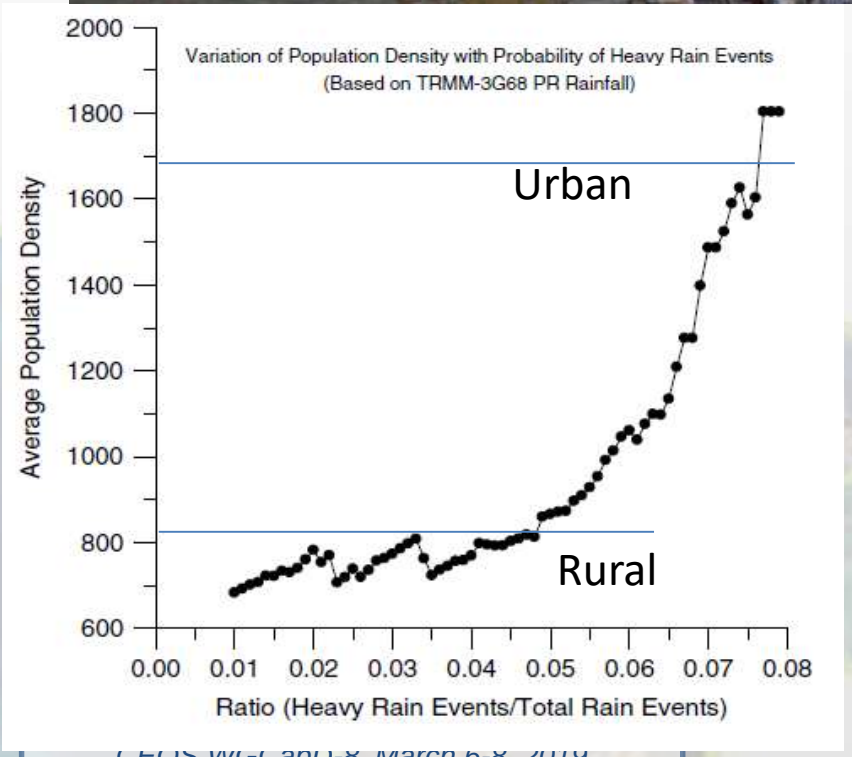
Graphical Representation

Geo-spatial analysis based site selection tool using following layers of information

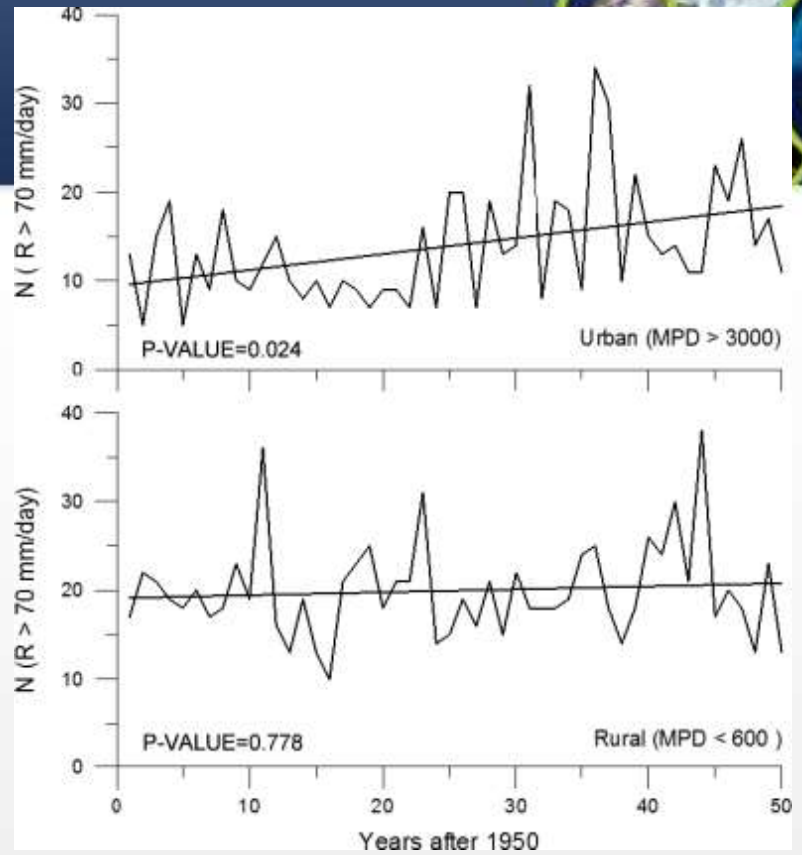
1. Distance from Power line
2. Distance from Road
3. Maximum Slope
4. Minimum Solar Insolation
5. Type of Land Use



How Urbanization is affecting the rainfall, mainly the Heavy Rain Events



Satellite observations from recent years also confirm that urban areas (indicated by high density of population) have higher (almost twice as high) proportion of heavy rainfall events compared to rural areas.

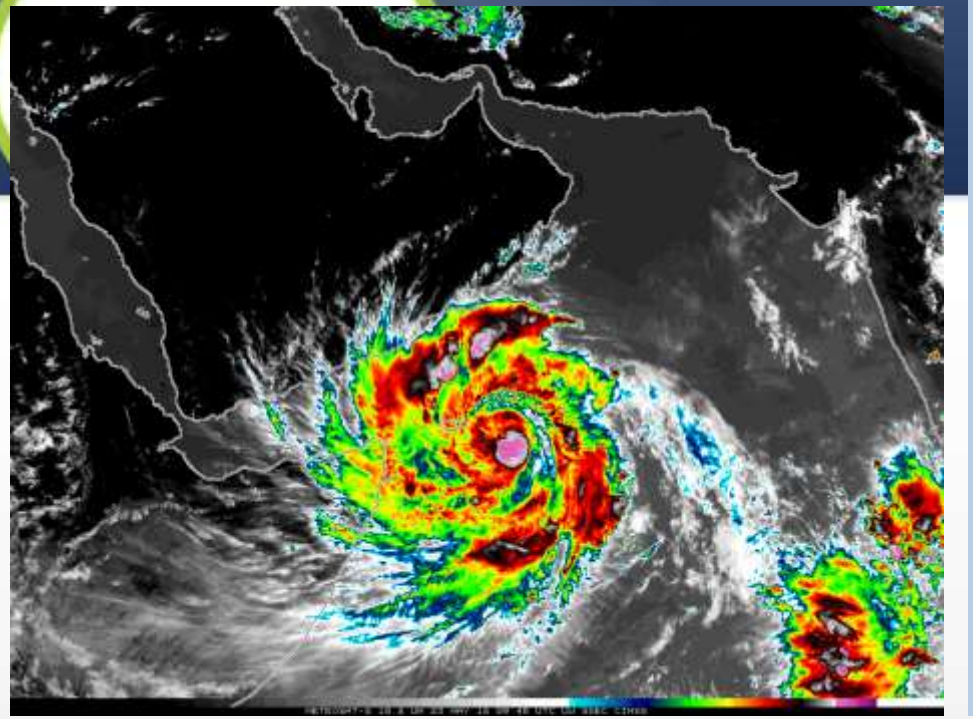


During past 5 decades, there have been a significantly increasing trend in heavy rainfall events over urban events during monsoon.

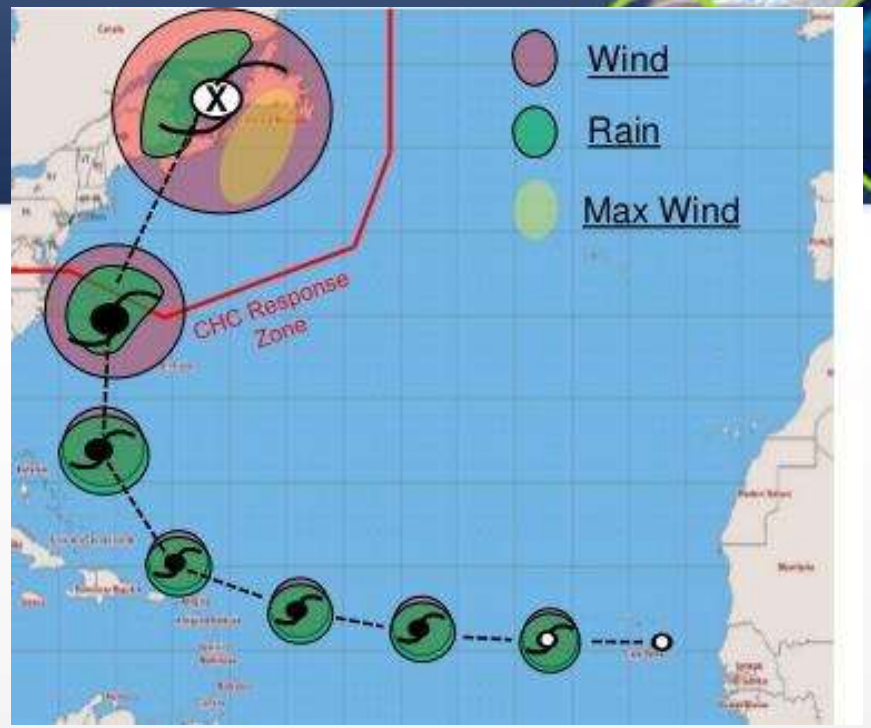
INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. 30: 1908–1916 (2010)
Published online 20 November 2009 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/joc.2044
RMetS
Royal Meteorological Society

Urbanization signature in the observed heavy rainfall climatology over India

C. M. Kishtawal,[a,b] Dev Niyogi,[b*] Mukul Tewari,[c] Roger A. Pielke Sr[d] and J. Marshall Shepherd[e]



How global climate change has affected the tropical cyclone behavior ?



Tropical cyclone intensification trends during satellite era (1986–2010)

C. M. Kishtawal,[1] Neeru Jaiswal,[1] Randhir Singh,[1] and D. Niyogi[2]

Received 14 March 2012; revised 17 April 2012; accepted 19 April 2012; published 26 May 2012.

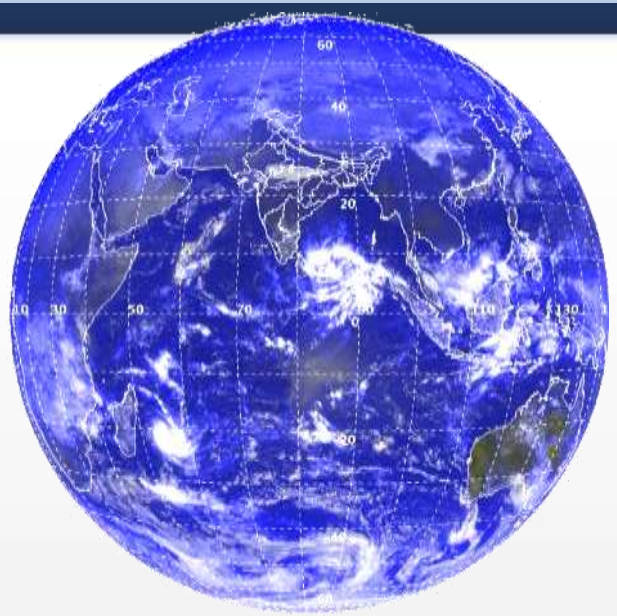
[1] Using International Best Track Archive for Climate Stewardship (IBTrACS, version v03r03) analysis during satellite era (1986–2010) we determined the trends of intensification of tropical cyclones (TC) over all the global basins, except the North Indian Ocean. Over all the basins, the rate of TC intensification from 64 kt to first peak of intensity maxima (global average value = 104 kt) was found to be positive. The above trends were significant for 4 out of 5 basins, except the North West Pacific. The trends indicate that the TCs now intensify from 64 kt to 104 kt nearly 9 hours earlier than they did 25 years back. The maximum reduction in intensification time is noticed over the North Atlantic Ocean where the average time needed for TC to intensify from 64 kt to 112 kt has reduced by nearly 20 hours during the past 25-year period. **Citation:** Kishtawal, C. M., N. Jaiswal, R. Singh, and D. Niyogi (2012), Tropical cyclone intensification trends during satellite era (1986–2010), *Geophys. Res. Lett.*, *39*, L10810, doi:10.1029/2012GL051700.

of the strongest tropical cyclones. Theory suggests that a rise of 1°C in SST can indeed result in ~4–5% increase in TC maximum sustained wind speed [*Emanuel*, 2005] but some researchers are skeptical about whether such small trends can be detectable at all [*Landsea et al.*, 2006]. For example, study by *Balling and Cerveny* [2006] showed no significant trends in TC intensification rates over the Atlantic during 1970–2003. Similarly *Klotzbach* [2006] has shown the absence of any linear trend in the cyclonic activity during the recent 20 year (1986–2005) period. The period after 1985 has specific significance in TC research because most of the operational meteorological centers started to use satellite-based observations for TC detection and more importantly the TC intensity analysis based on the Dvorak technique [*Dvorak*, 1984, 1995] that used infrared satellite images [*Knaff et al.*, 2010].

[3] Detection of climatic trend of severe cyclonic activity from such a small record of reliable observations can be done only after successfully addressing issues related to the data

- **A Study carried out at SAC concluded that the global warming has enhanced the *rate of cyclone intensification* in most of the global basins.**
- **The rate of cyclone intensification was found to be largest in the Southern Indian Ocean followed by North Atlantic Ocean.**
- **In some basins (like North Atlantic) now it takes a cyclone about 24-hour less time to intensify from severe cyclone to super cyclone, than it did 25 years ago.**

MOSDAC - Meteorological and Oceanographic Satellite Data Archival Centre



INDIAN Storehouse for Space based Weather and Ocean Data

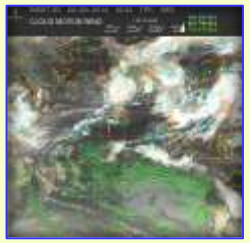
मॉसडेक

अंतरिक्ष आधारित मौसम एवं समुद्र विज्ञानीय आँकड़े का भारतीय भंडार

INSAT-3D & INSAT-3DR Data Products

IMAGER

Visible Wind



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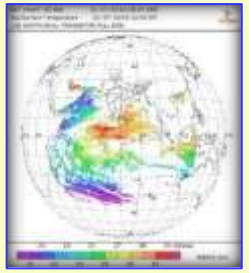
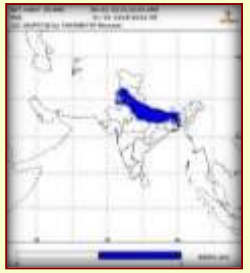
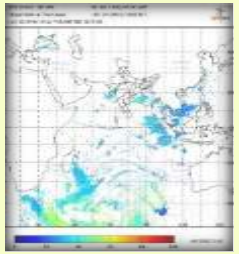


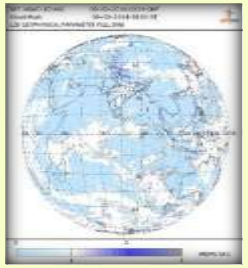
Sea Surface Temp



Fog

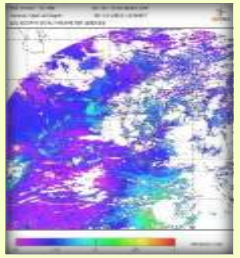


Cloud Opt



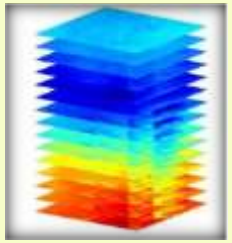
Cloud Mask

Snow

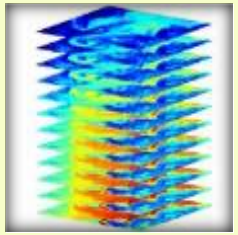


Aerosol OD

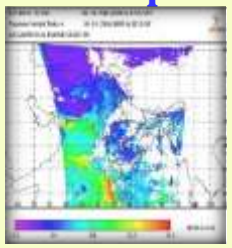
SOUNDER



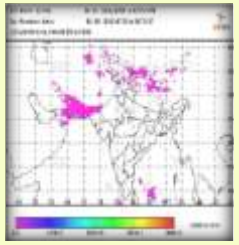
Temp.



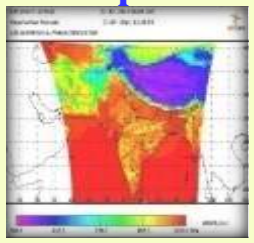
Hum.



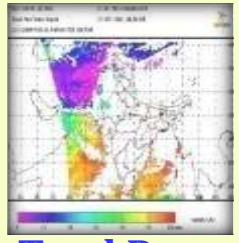
Potential Temp. Diff



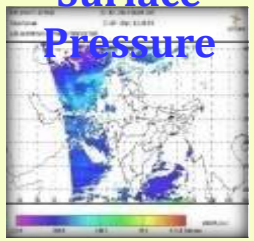
Dry Micro Bust Index



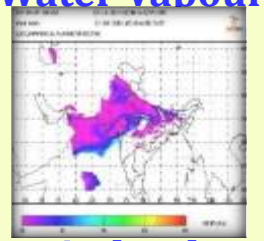
Mean Surface Pressure



Total Prec. Water Vapour

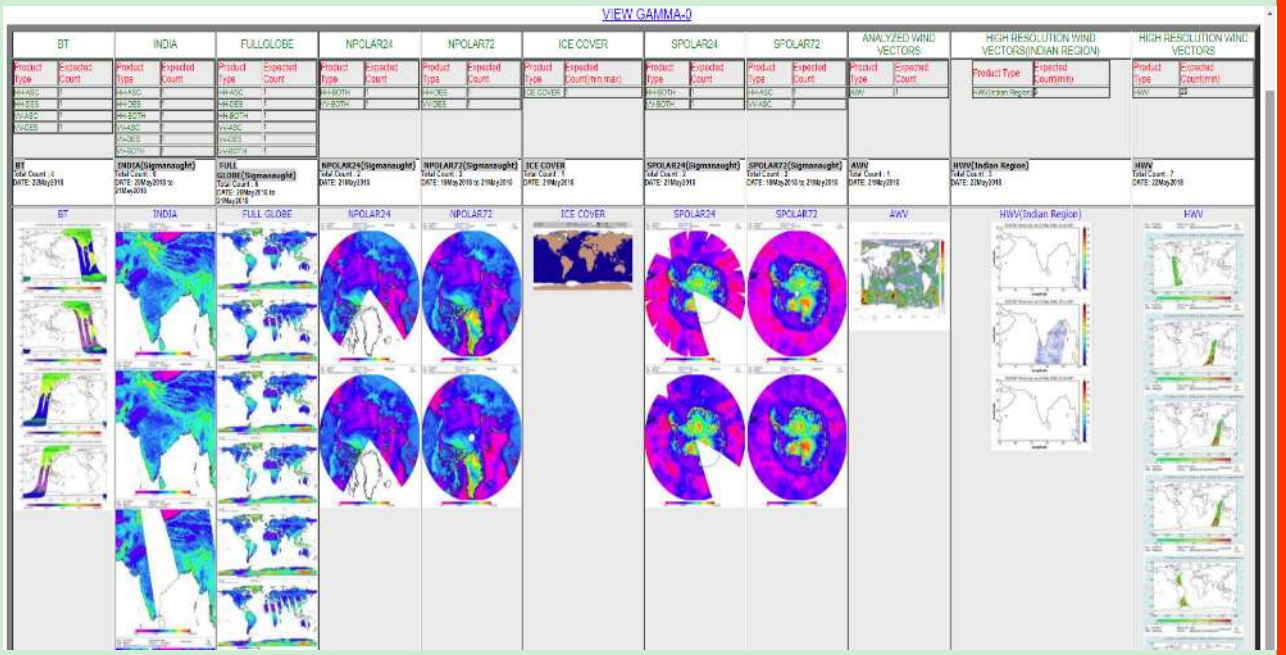


Total Ozone

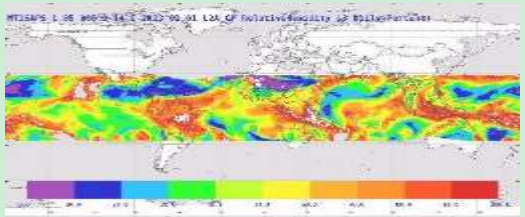


Wind Index

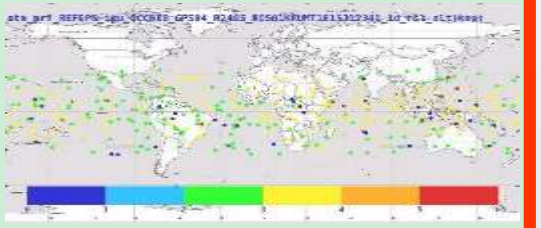
SCATSAT-1



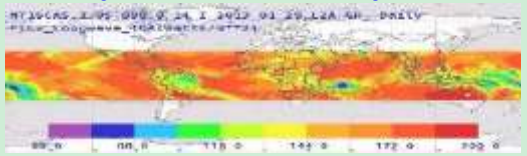
MeghaTropiques/ SARAL



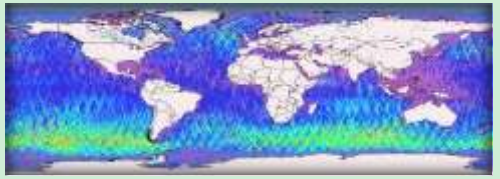
Daily Relative Humidity SAPHIR



Daily Occultation ROSA



Daily Longwave Flux SCARAB



Significant wave height

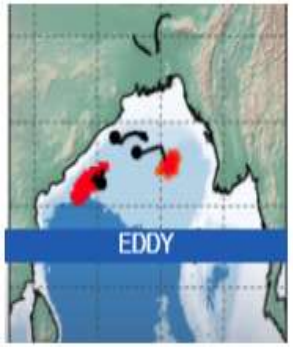
MOSDAC SERVICES मॉसडेक की सेवाएँ

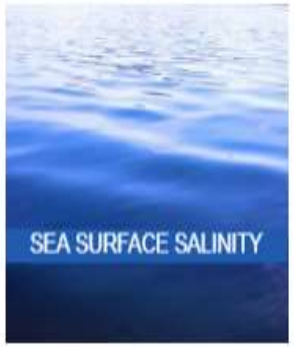
FORECAST पूर्वानुमान

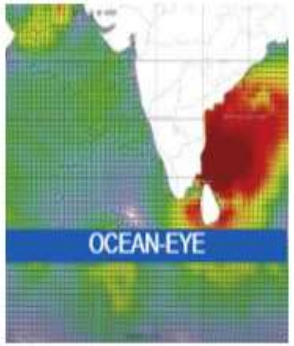
NOWCAST नौकास्ट

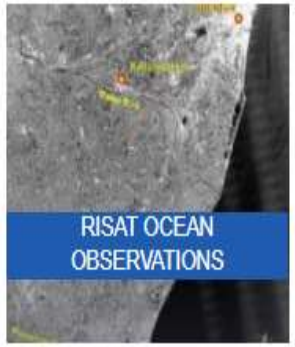
CURRENT EVENTS

Ocean Applications

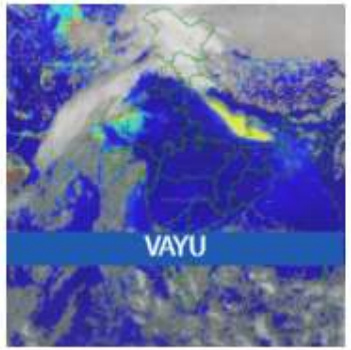




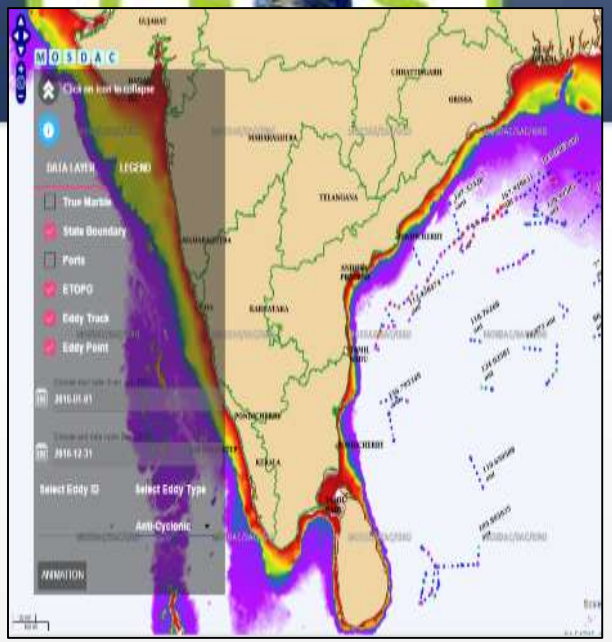


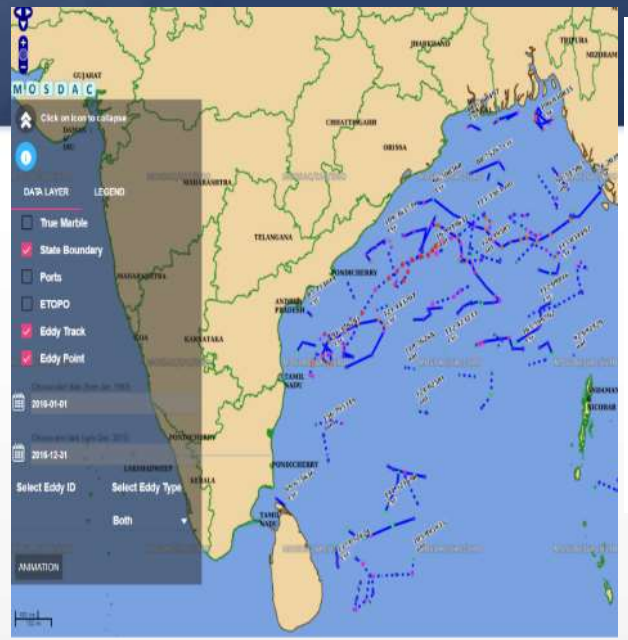


Met Applications



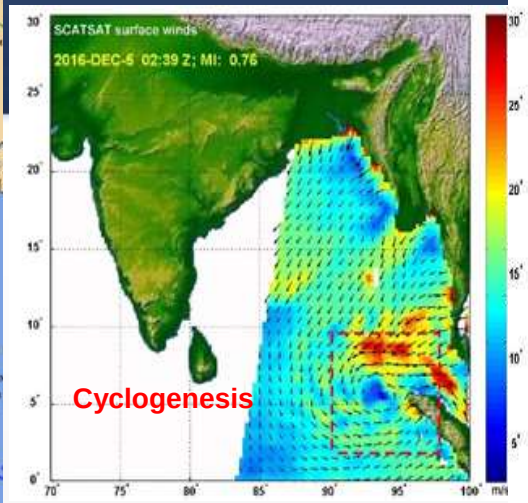
Eddy Visualization

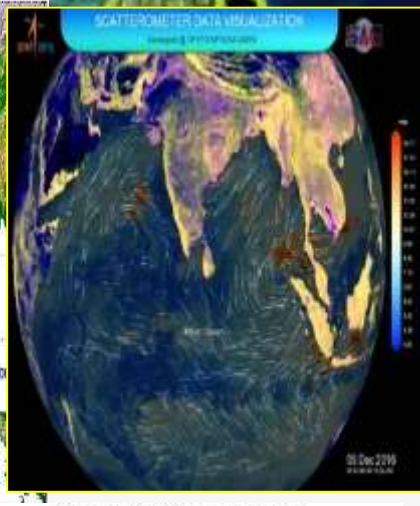


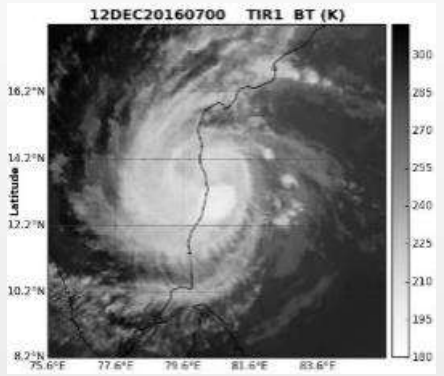


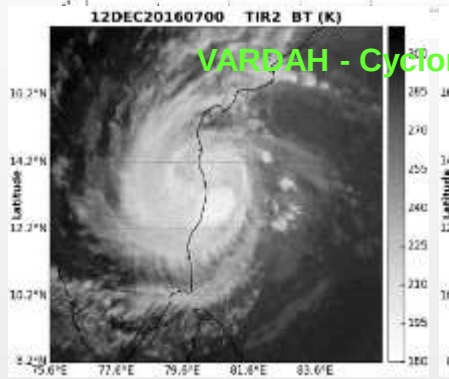
- Oceanic eddy parameter information - visualized for 24 years (1993 - 2016) over Bay of Bengal
- Menu based selection: date wise, Eddy id, Eddy type (cyclonic, anti-cyclonic)
- Animation of eddies on the basis of selected eddy id or eddy type.
- Point probing - Display information regarding amplitude and radius of eddy
- Value addition by adding Ports, Bathymetry & other overlay layers

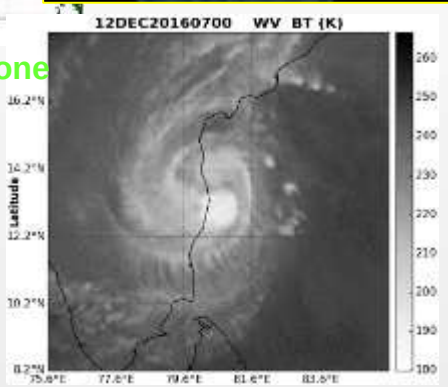
SCORPIO Satellite based Cyclone Observations & Real-time Prediction over Indian Ocean

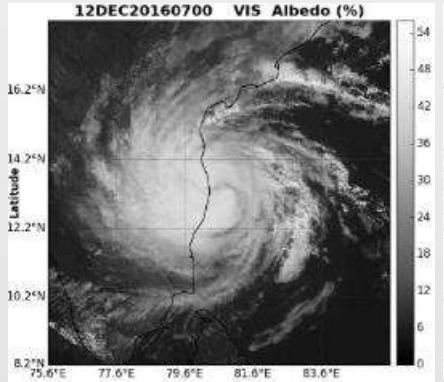


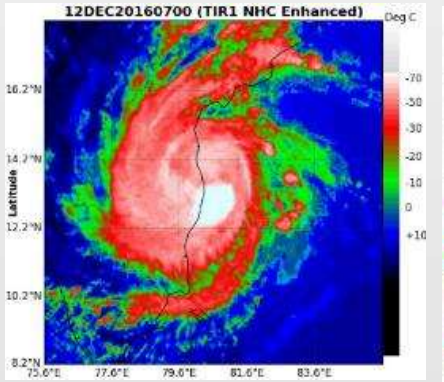


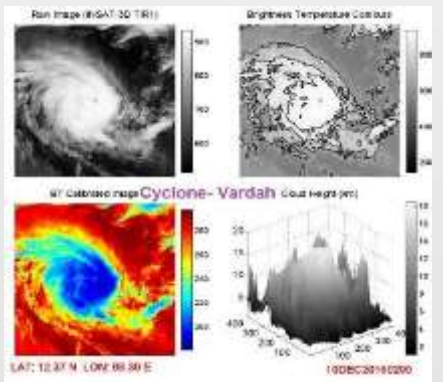












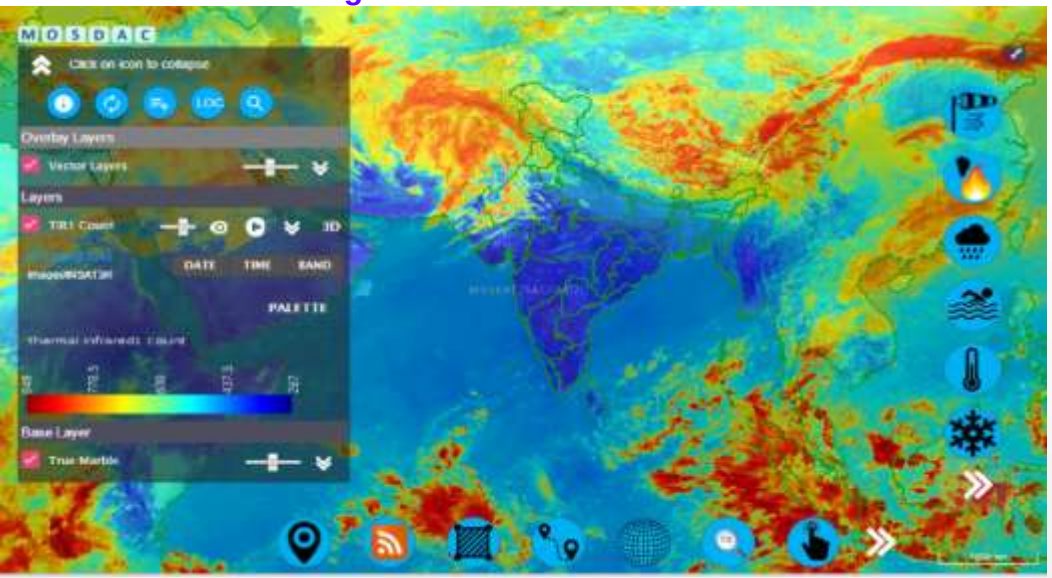
Alert broadcast on MOSDAC and by EMAIL to authorities

LIVE (Let's Interactively Visualise Earth)

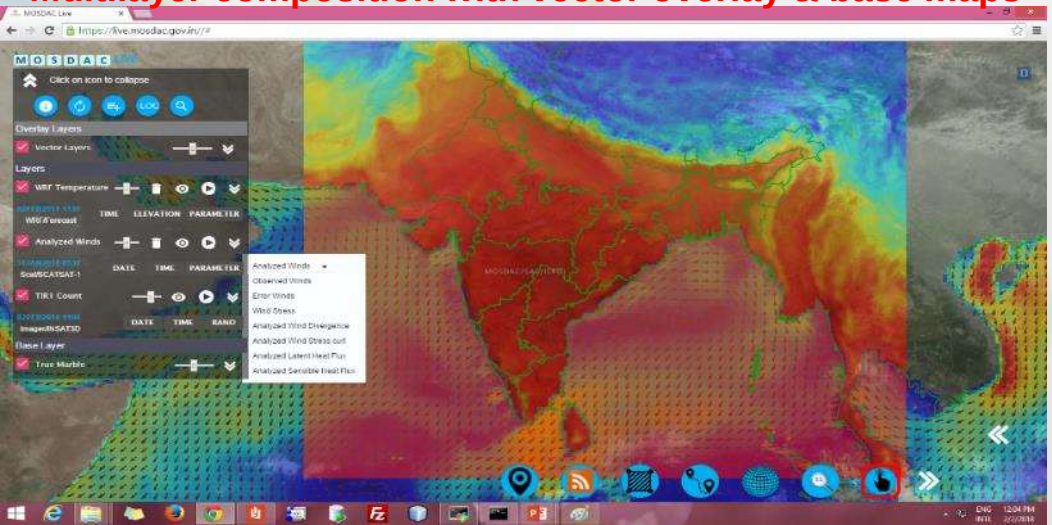
https://live.mosdac.gov.in

Web based visualization and analysis system, provides NRT access

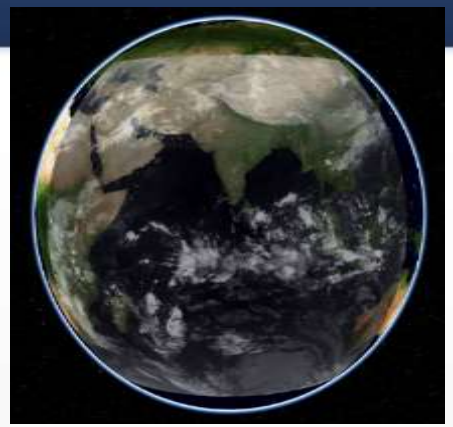
- Earth observation
- Meteorological & oceanographic products derived from satellite
- Model forecast and ground observations



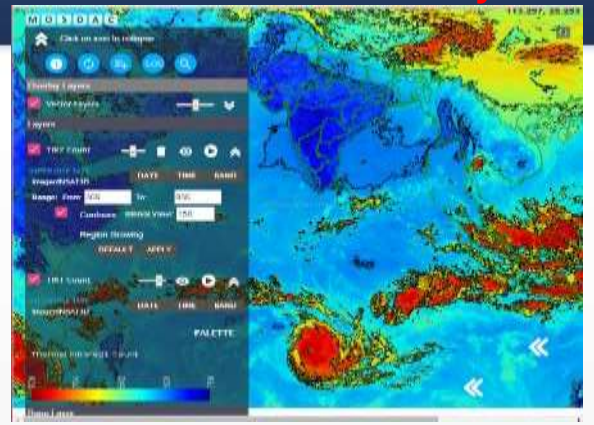
Multilayer composition with vector overlay & base maps



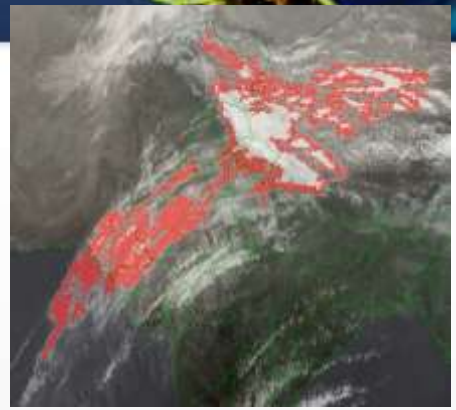
3D View



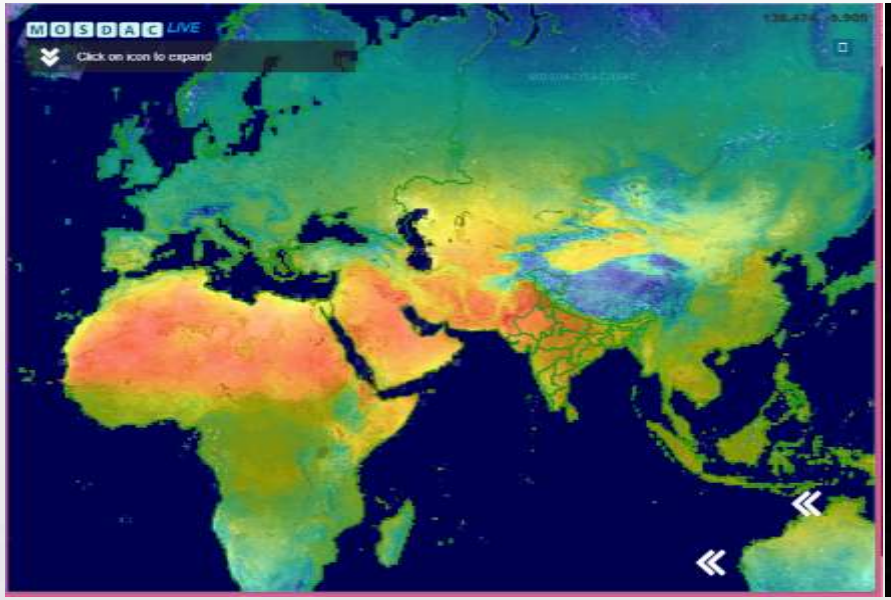
Add Contours for each layer

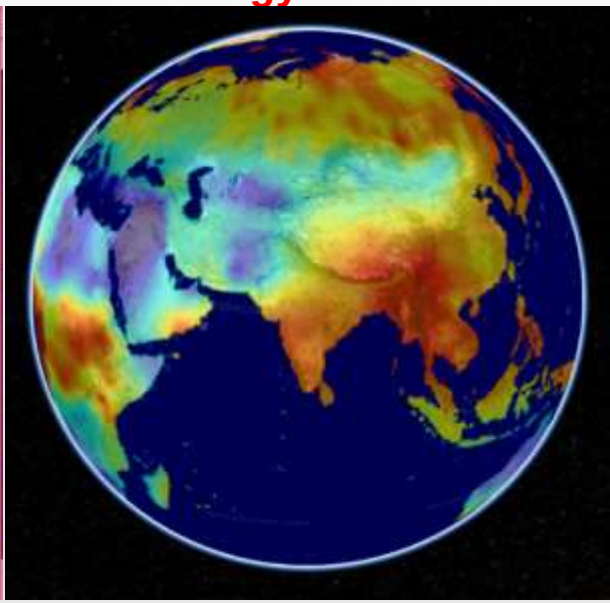


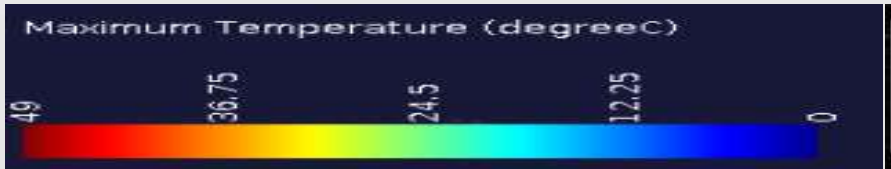
Auto Region Growing



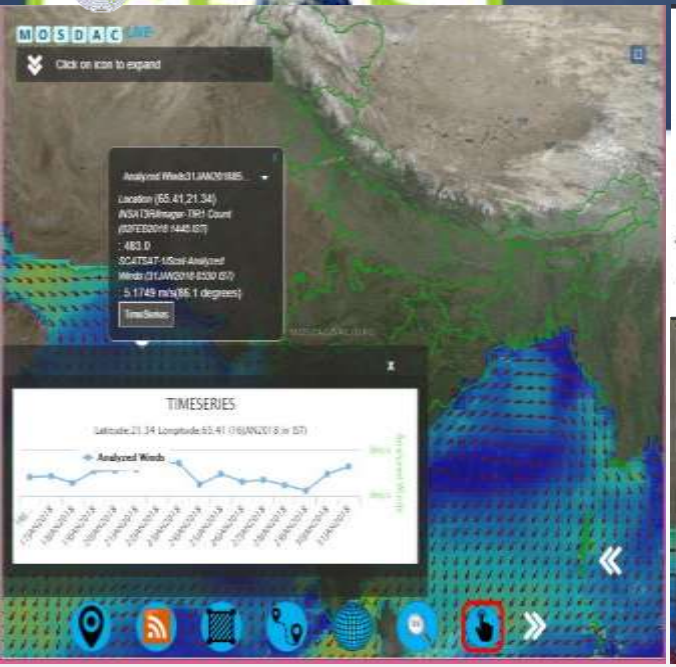
Visualization of Climatology

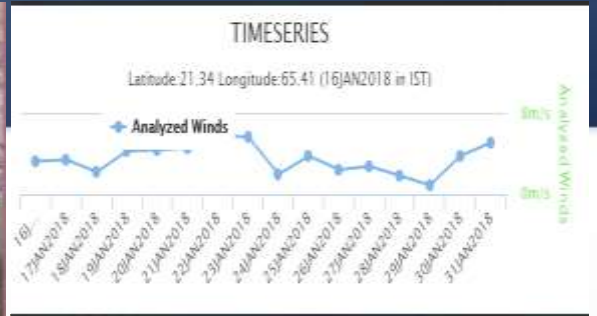






Analysis: Point Probes & Time Series

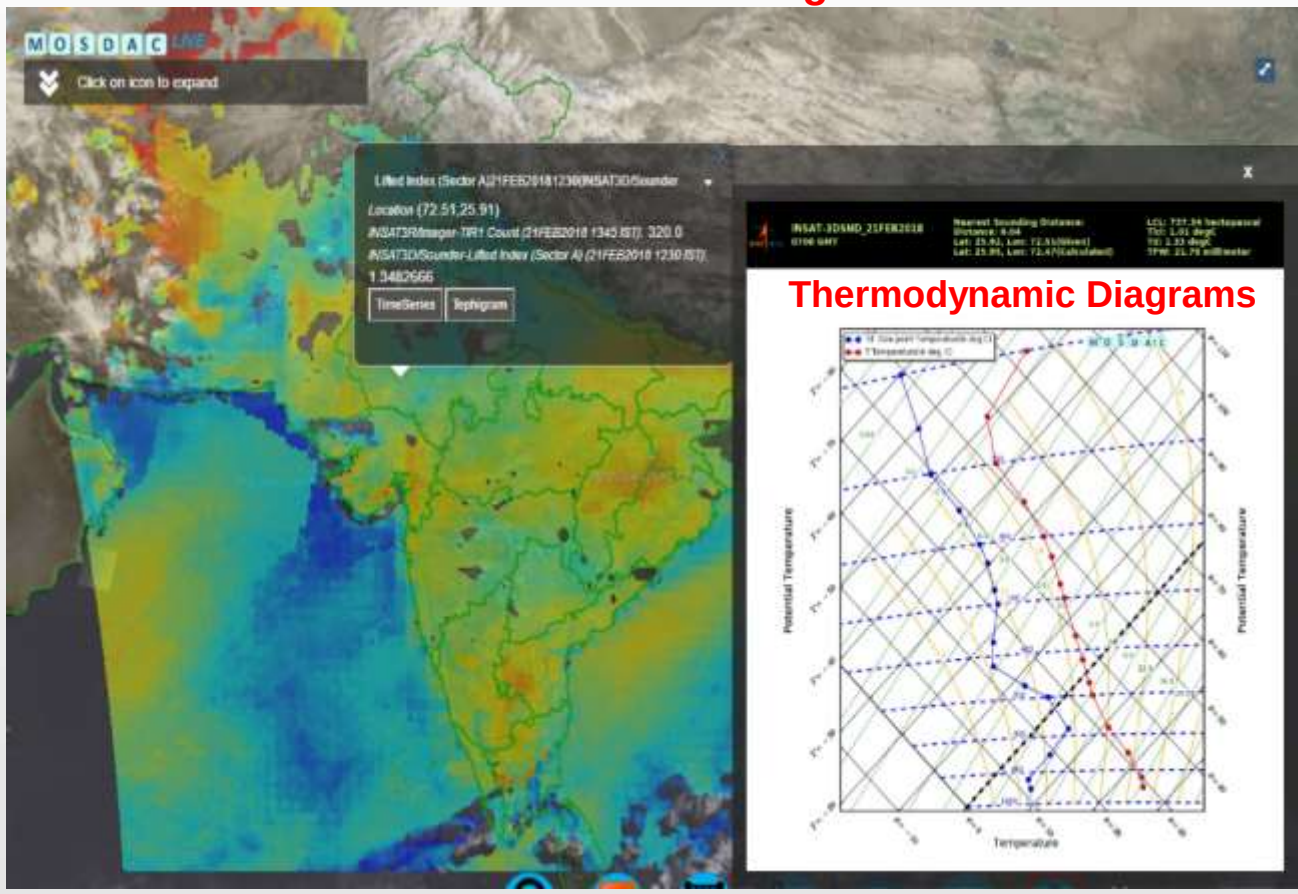




Search and Measurements

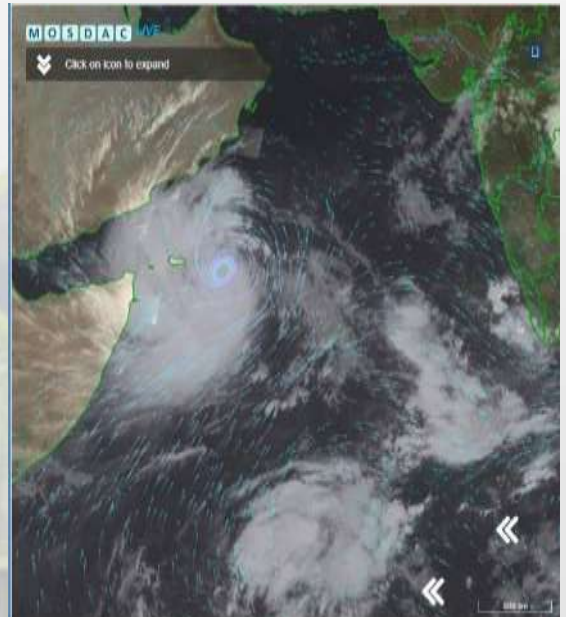
Ground observation

T-Phi & Skew-T Plots using Sounder Profiles

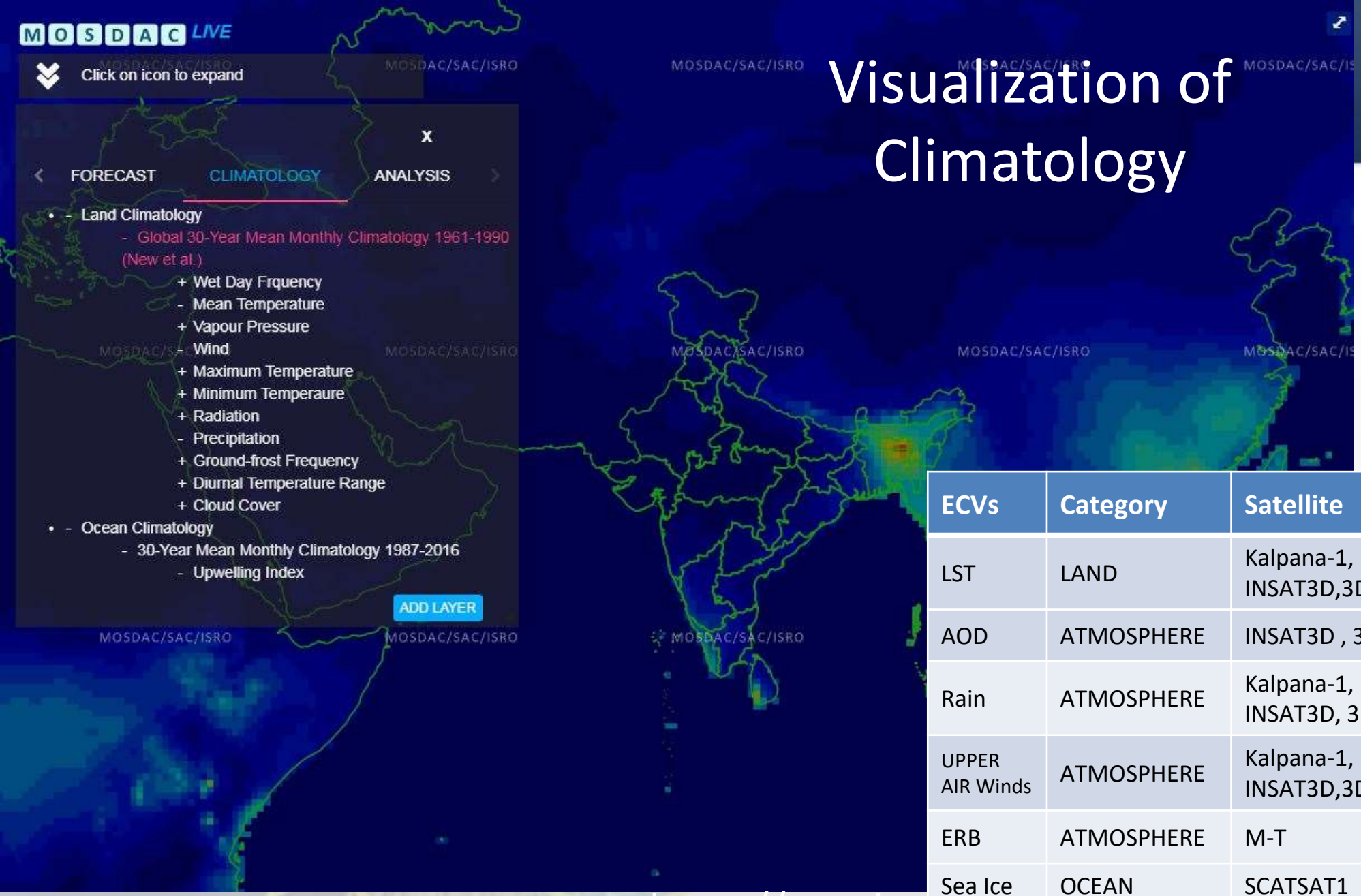


Information Products: Heavy Rain Nowcast

Wind Forecast



Visualization of Climatology



ECVs	Category	Satellite	Start Date	End Date
LST	LAND	Kalpana-1, INSAT3D,3DR	August 2010	till date
AOD	ATMOSPHERE	INSAT3D , 3DR	Oct 2013	till date
Rain	ATMOSPHERE	Kalpana-1, INSAT3D, 3DR	May 2010	till date
UPPER AIR Winds	ATMOSPHERE	Kalpana-1, INSAT3D,3DR	Nov 2009	till date
ERB	ATMOSPHERE	M-T	Nov 2011	Dec 2018
Sea Ice	OCEAN	SCATSAT1	Nov 2016	till date
SST	OCEAN	Kalpana-1, INSAT3D, 3DR	June 2008	till date

https://mosdac

THANK YOU