

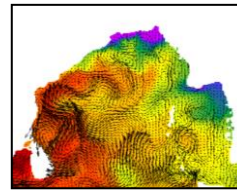
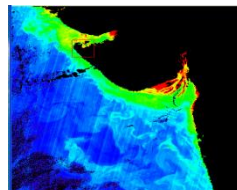
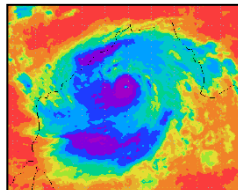
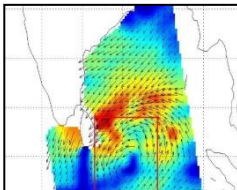
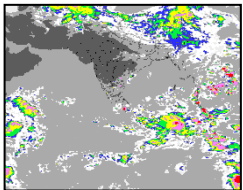
Satellite Meteorology and Oceanography in India



**Indian Space Research Organisation
Department of Space**



**Presentation to: 66th Session of UNCOPUOS
June, 2023**



1963

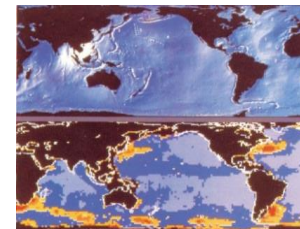
SOUNDING ROCKETS



- Atmospheric profiles up to 100kms
- Atmospheric dynamics during Monsoon onset
- Stratospheric warming & impact on monsoon

1978

SEASAT



- SAR (L-band)
- Altimeter & Scatterometer
- VIS/IR Radiometer

Provided immense insight for initiating Meteorological & Ocean studies

1979 & 1981

BHASKARA - 1 & 2



- Study of moisture content
- Cloud amounts in atmosphere
- Surface wind speed over ocean

1996

IRS-P3

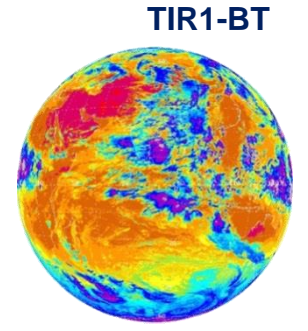
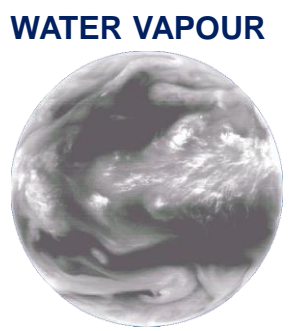
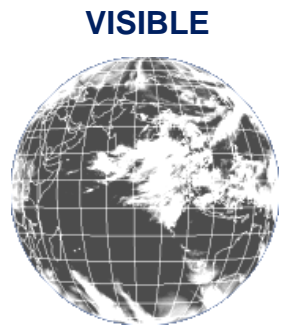
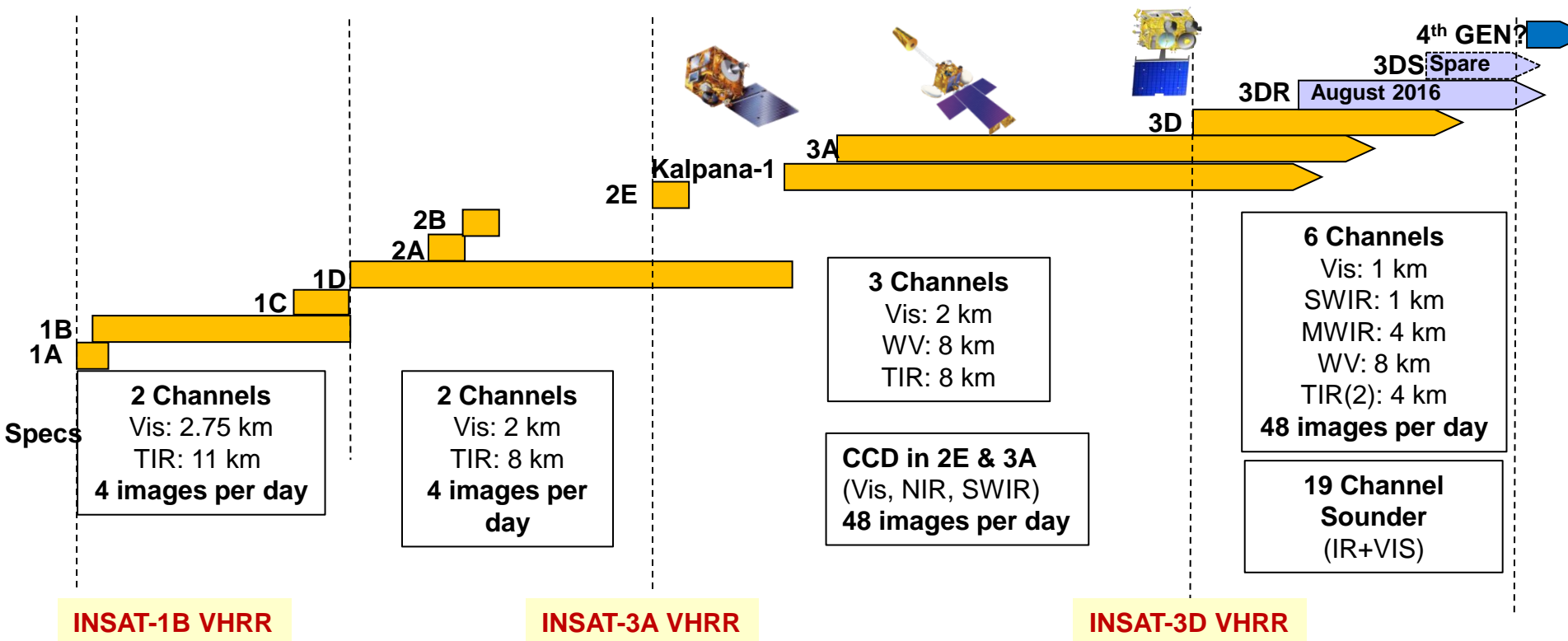
Joint ISRO-DLR Ocean Mission



- Retrieve chlorophyll
- Suspended sediments
- Aerosol Optical Thickness

Evolution of Meteorological satellites - INSAT series

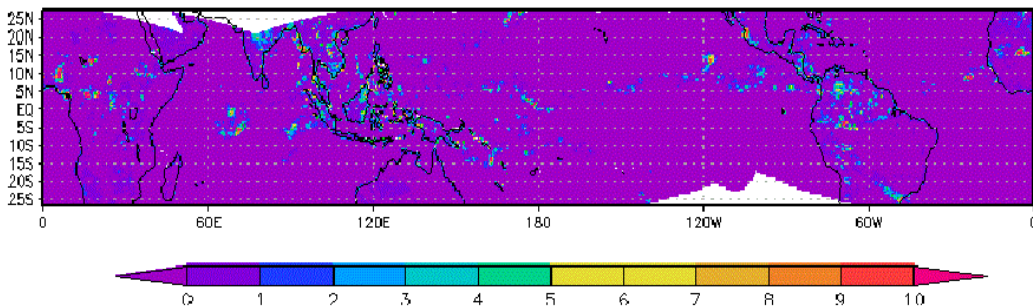
1980-1990	1990-2000	2000-2010	2010- 2025	2025-
-----------	-----------	-----------	------------	-------



Growth of Microwave payloads

1979	1999	2009	2011	2013	2016, 2023	2023
SAMIR	MSMR (IRS-P4)	SCAT (OSAT-2)	Megha-Tropiques	Altika (SARAL)	SCAT	TSU & HSU
						
19.35, 22.35, 31.4 GHz	6.6, 10.6, 18, 21 GHz	13.515 GHz	18.7, 23.8, 36.5, 89, 157 GHz, 6 Channels at 183.31GHz	35.75 GHz Altimeter 23.8, 37 GHz Radiometer	13.515 GHz	23.8, 31.5, 15 Ch. at 50-59 GHz (TSU) Multi-Channels at 183 GHz (HSU)
WV, LWC, Rain, OSW	SST, Wind, TPWC, CLW	Wind Vector	Rain, WV, LW, Cloud-ice, Humidity Profiles	SSH, SWH	Wind Vector	Temp & Humidity Profiles

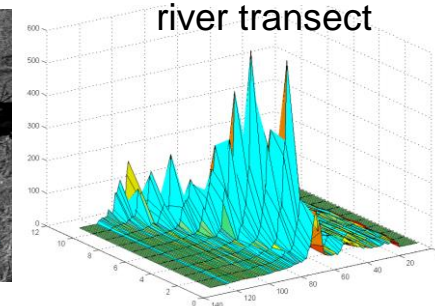
MADRAS Daily Average Rain 07 July, 2012



SARAL track



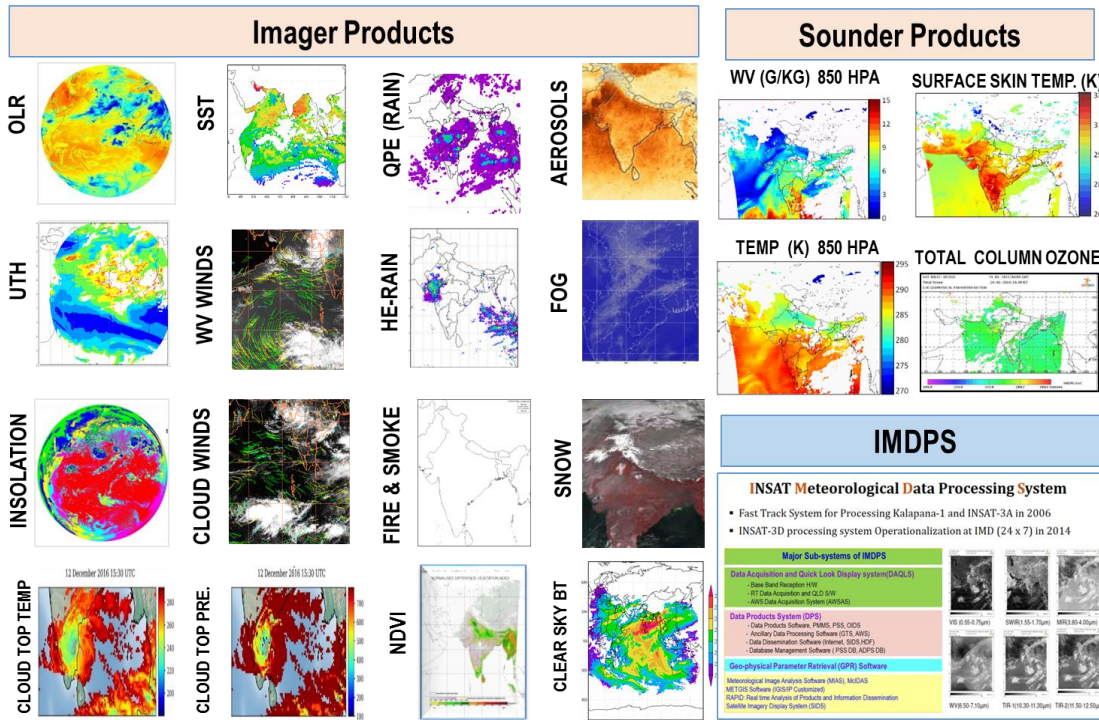
Waveform across the river transect



INSAT - 3D & 3DR

Observations at 15-minute interval : 48 images/ day

- Provide opportunity to capture short-lived cloud processes.
- More no. of Atmospheric Motion Vectors
- Capture structural changes within cyclone during rapid intensification
- 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 μm

Visible : One Band

SWIR : Six bands

MWIR : Five Bands

LWIR : Seven Bands

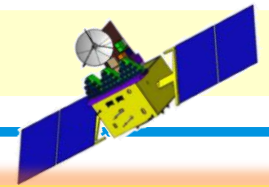
Resolution (km): 10 X 10

40 profiles of Temp. (surface to 70 km)

21 Profiles of Humid. (surface to 15 km)

Integrated Ozone (Surface to ~ 12 km)

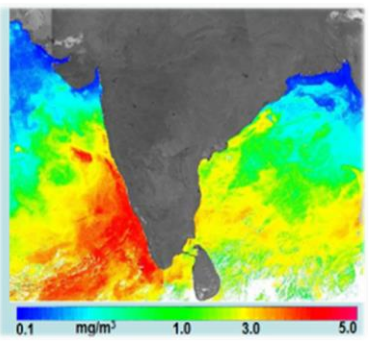
OCEANSAT- 3 (2022) / 3A (2025)



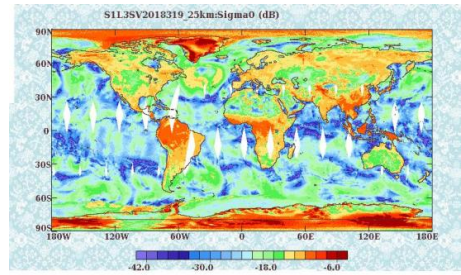
Orbit	Sun synchronous
Payloads	OCM-3 (13 bands: 407 to 1020 nm) : 360 m Scatterometer-3 (Ku Band - 13.51GHz) SSTM-1 (2 Bands: 11 & 12 μm) : 1080 m Argos-4 (CNES Payload)
Swath	1400 x 1400 km

Daily global observation with 2 satellites

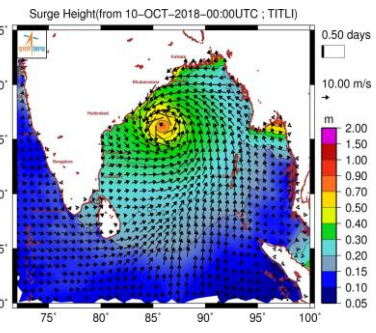
- 13 bands than OCM-2 (08 bands)
- Better SNR (1000)
- Spectral bandwidth improved from 20-40 nm to 10-20 nm (OCM-3).



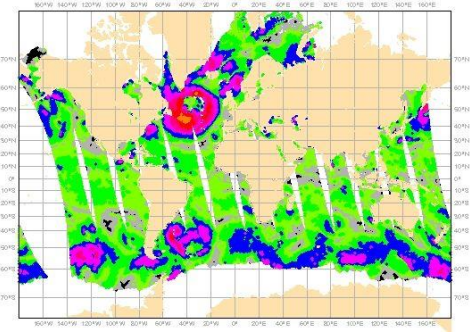
Early detection of tropical cyclogenesis
Mean Prediction Lead Time: ~3 days in advance)



Ocean surface wind vectors at 12.5 km

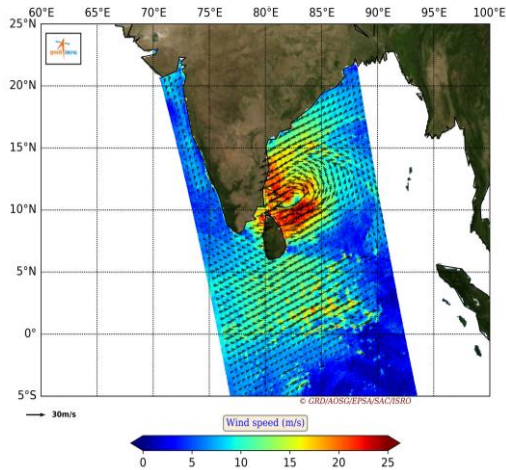


TC NADA	TC KYANT	TC VARDHAH
<p>SCATSAT surface winds 2016-NOV-27 02:33 Z; MI: 0.73</p>	<p>SCATSAT surface winds 2016-OCT-18 14:33 Z; MI: 0.61</p>	<p>SCATSAT surface winds 2016-DEC-5 02:39 Z; MI: 0.76</p>
<p>Cyclone formation: 27 Nov 03Z</p> <p>Cyclogenesis prediction: 30 Nov 00Z</p> <p>Prediction lead time: 69 hours</p>	<p>Cyclone formation: 25 Oct 00Z</p> <p>Cyclogenesis prediction: 18 Oct 14Z</p> <p>Prediction lead time: 144 hours</p>	<p>Cyclone formation: 08 Dec 00Z</p> <p>Cyclogenesis prediction: 05 Dec 03Z</p> <p>Prediction lead time: 72 hours</p>



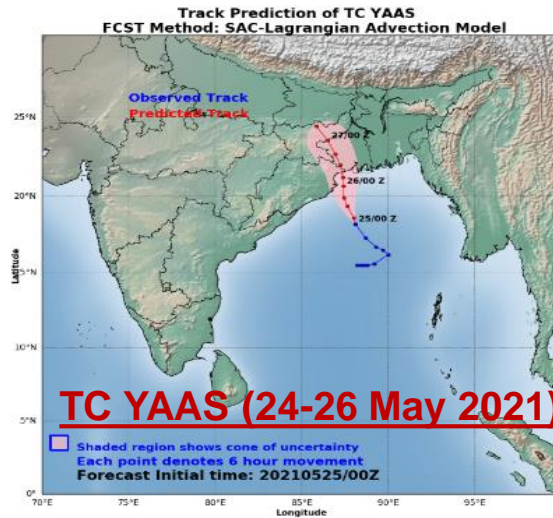
Cyclone genesis, Track & Landfall

Cyclogenesis Prediction



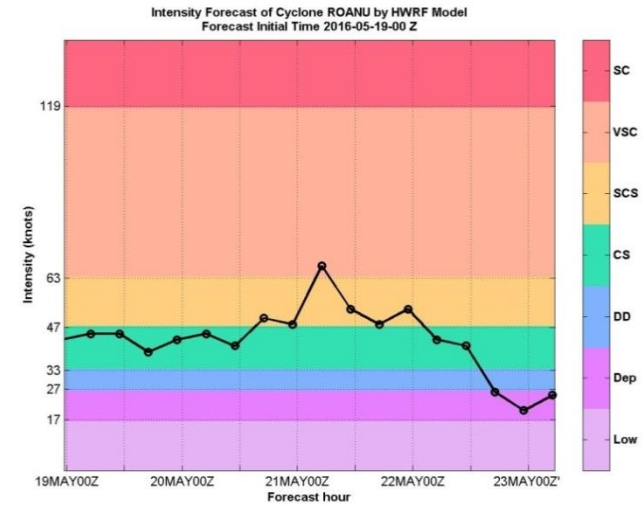
Tropical cyclone “Mandous” as captured by EOS-06 SCAT 08-Dec-2022, 17:58 UTC

Cyclone Track Prediction



Cyclone track prediction by Lagrangian advection Model for different initial conditions

Cyclone Intensity Prediction

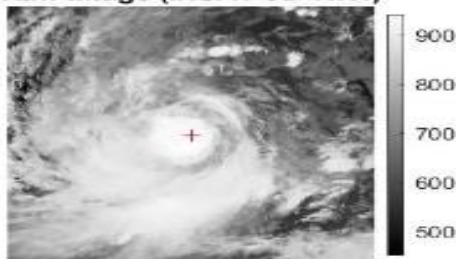


Cyclone intensity prediction using hurricane weather research forecast model

6 hourly cyclone track prediction up to 96 hours

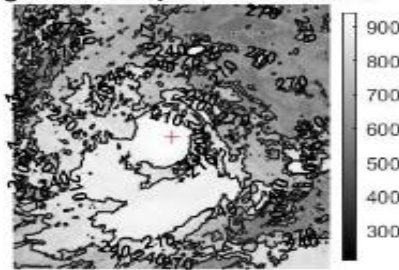
INSAT 3D TIR-1

Raw Image (INSAT-3D TIR1)



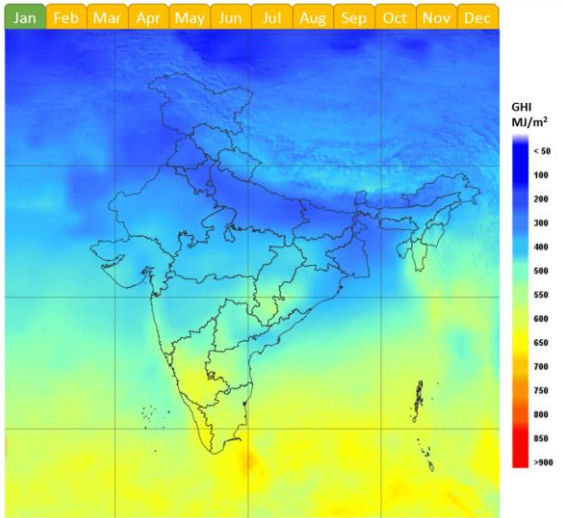
INSAT 3D TIR-1

Brightness Temperature Contours

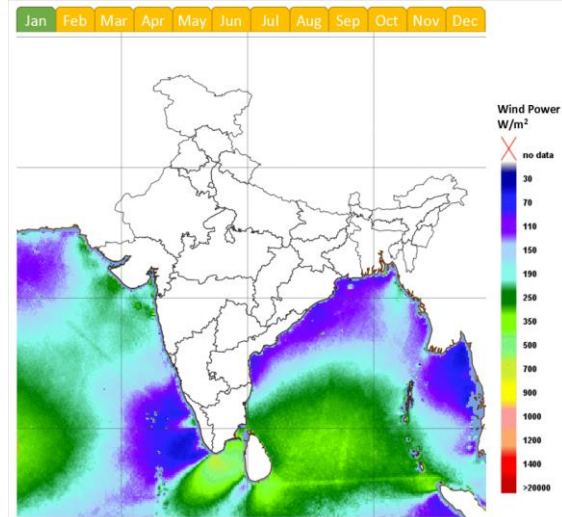


Cloud Height (km)

Cyclone landfall prediction accuracy is ± 25 km and landfall time ± 1 hr.



Solar Energy Potential (INSAT-3D/3DR)

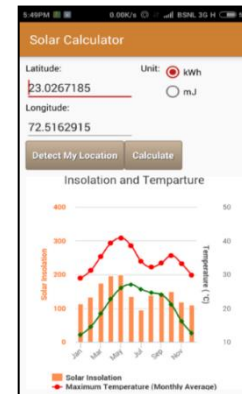
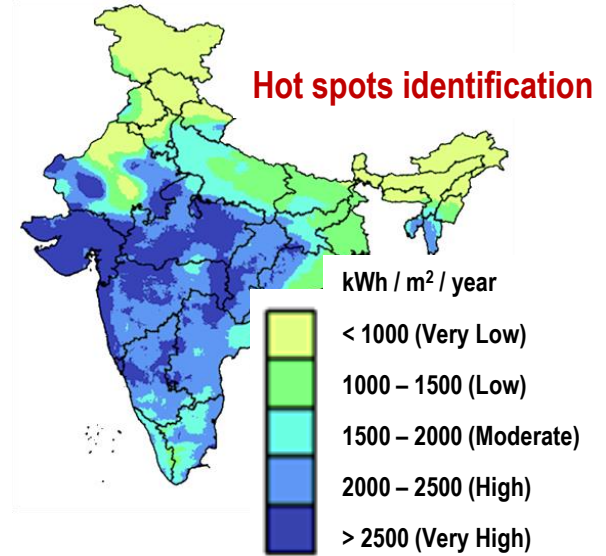


Wind Energy Potential (using Scatsat Data)

Potential areas to achieve target of 500 GW by 2030

- Digital Energy Atlas
- 48 Hour forecast for solar insolation & wind speed - for plant operators supplying power to the grid
- Development of Geo-spatial Energy portal & Apps

Assured Annual Solar Energy



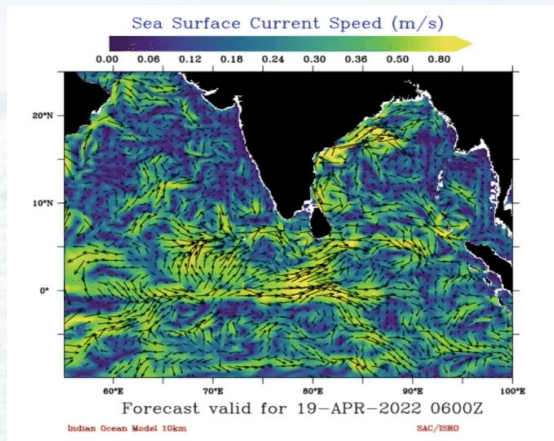
Month	Wind Speed (km/h)	Wind Direction (°)
January	2.8	345
February	2.8	373
March	2.4	341
April	2.0	304
May	2.3	338
June	2.4	292
July	2.9	304
August	2.0	328
September	2.7	345

Mobile Apps for assessing location-specific Solar & Wind energy potential

Space Technology for Blue Economy

OCEAN STATE FORECAST

Sea level, Wave & Wind for Cost effective & Safe navigation

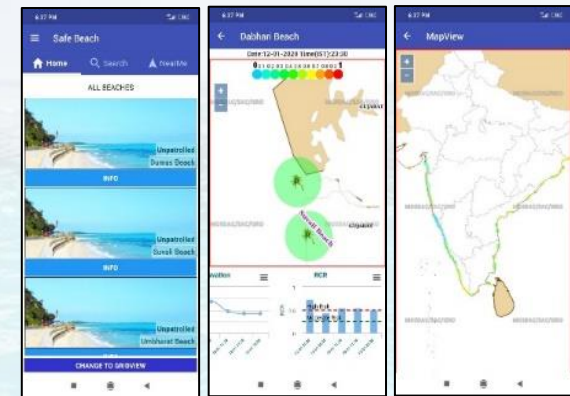


Navigation

Tourism

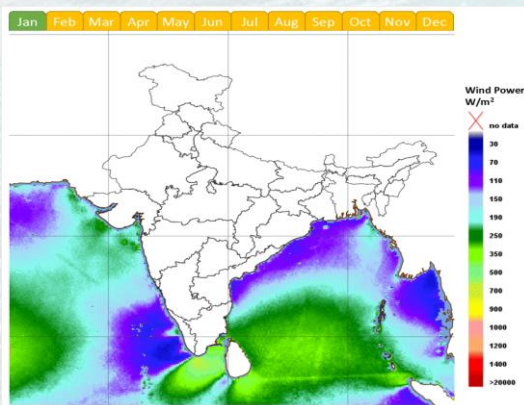
RIP CURRENT FORECAST

Alerts issued to reduce drowning at 175 beaches



OFFSHORE WIND ENERGY

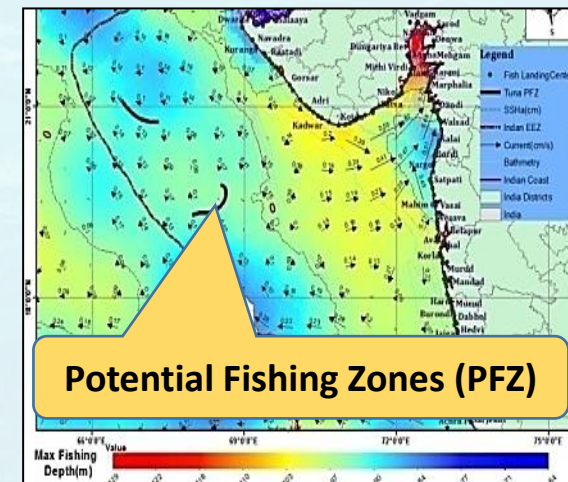
Offshore Wind, Wave & Tides to locate energy rich zones



Energy

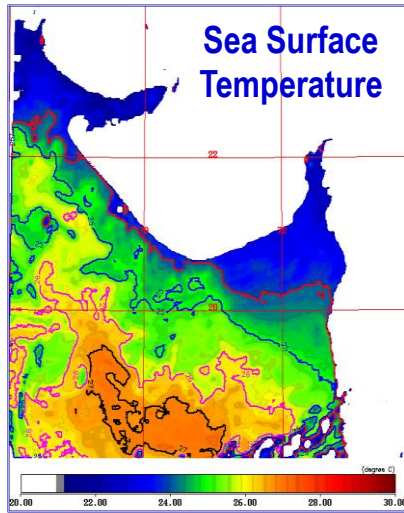
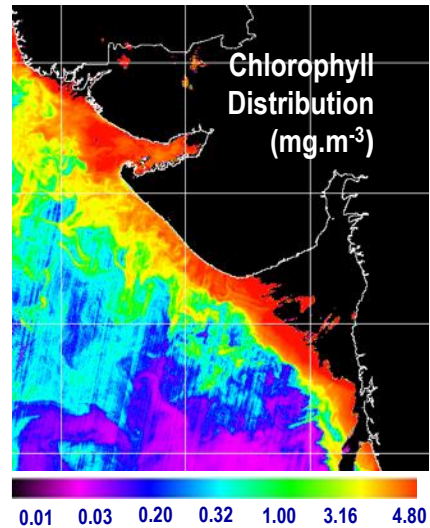
Livelihood

PFZ FORECAST

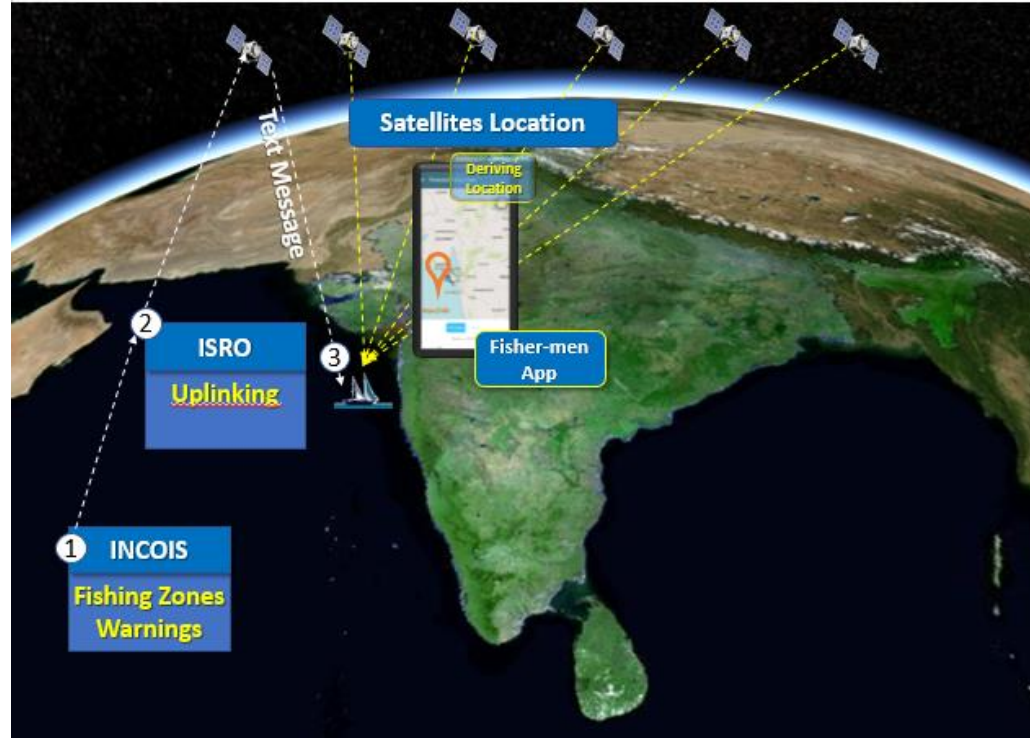


Potential Fishing Zone & NavIC services for Fishermen

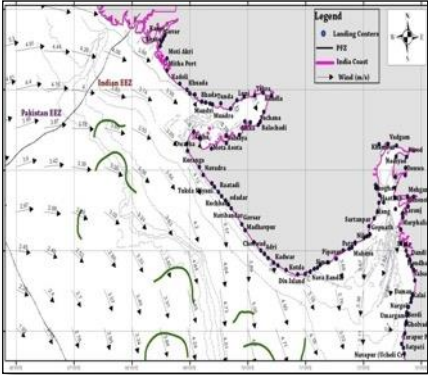
- 7500 km coastline
- > 7 M people dependent on fishing



Supporting Fishermen Livelihood

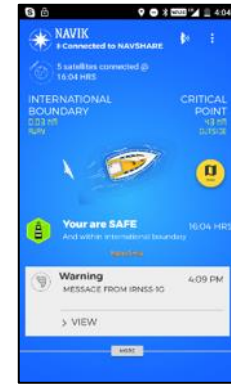


Fish Landing Centers 1200

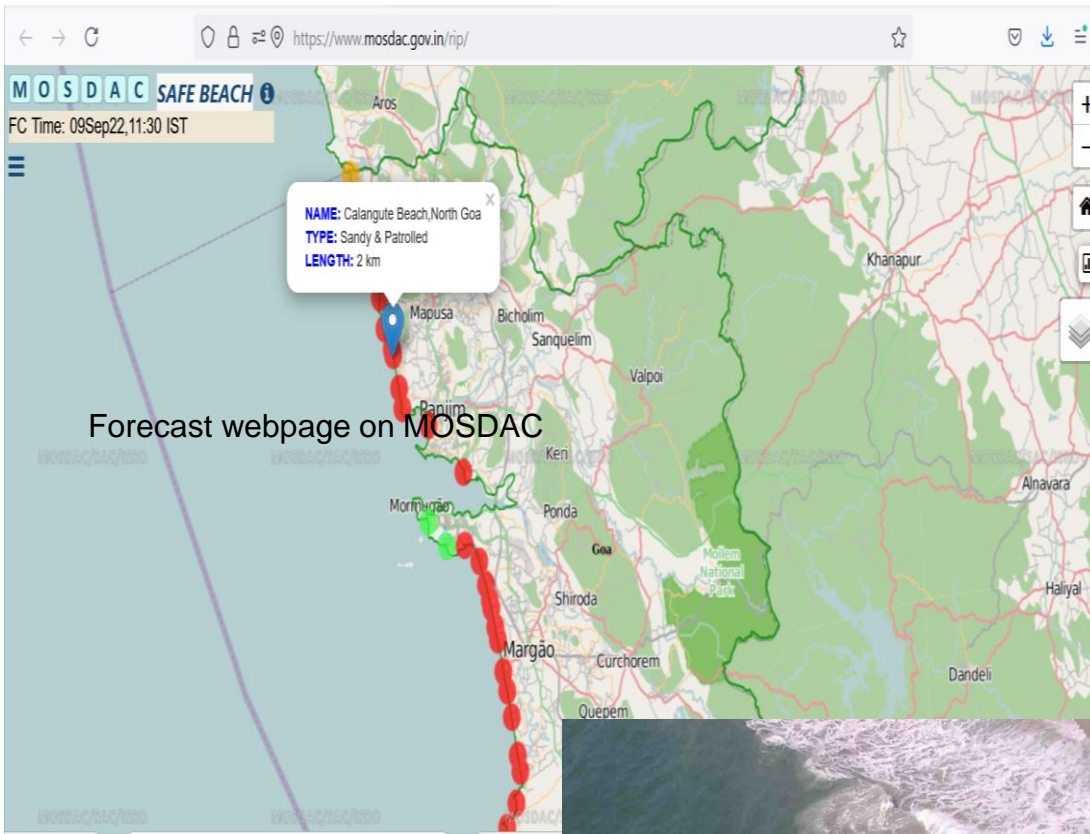


- Increased Fish catch per unit effort - by 2-4 times.
- Reduced Search time by 60-70% - saving of fuel
- Improved welfare of community – Better livelihood

- Potential Fish Catch
- Navigation Support
- Rough Weather Alerts
- Approaching international boundary



Safety at Beach (Rip Current Prediction)



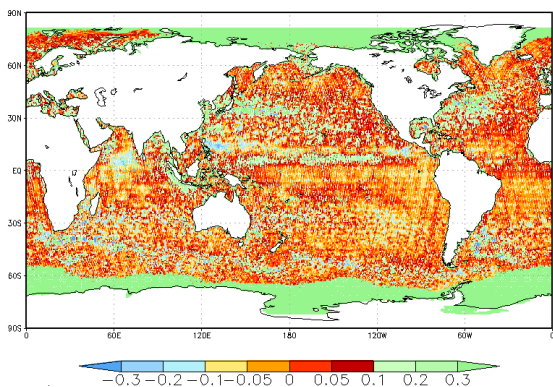
<https://www.mosdac.gov.in/rip/>



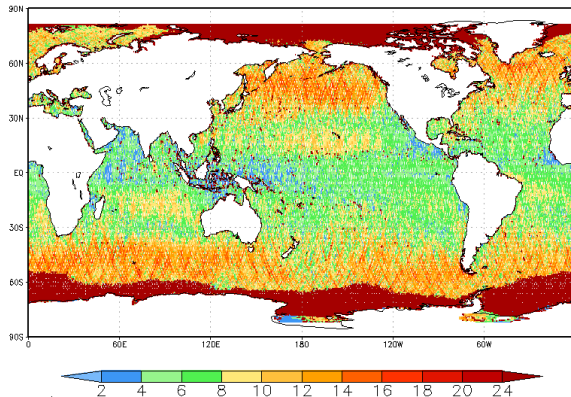
- Fully-automated Forecast for 175 Indian beaches
- HR 2.5 km altimeter satellite assimilated WAVEWATCH-III model
- Very useful for lifeguards, Police, Beach Patrol and can save many lives. Can boost **Beach Tourism**.
- **Developed SAFE BEACH app for issuing alerts to the beach users, in 2021.**

Operational products from SARAL - AltiKa

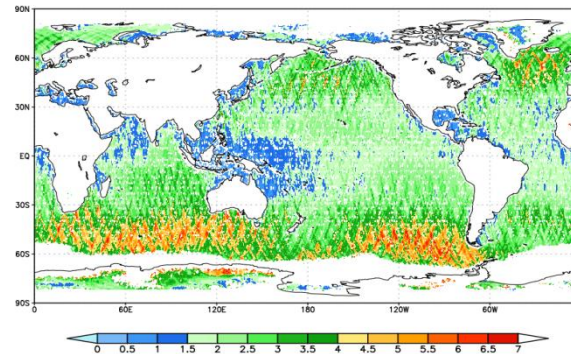
**Sea Surface Height Anomaly (cm)
1-Cycle Plot (35 days)**



**Ocean Surface Wind Speed (m/s)
1-Cycle Plot (35 days)**



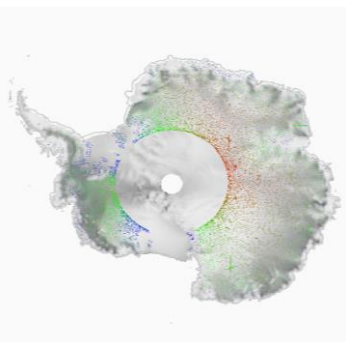
**Significant Wave Height (m)
1-Cycle Plot (35 days)**



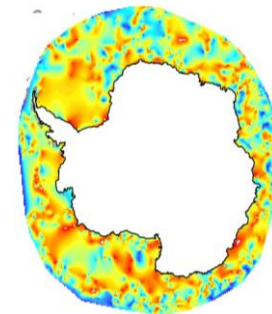
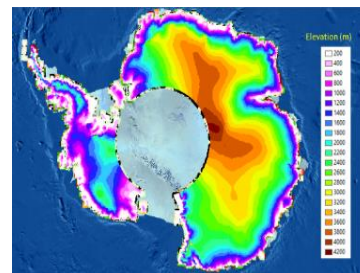
Ice sheet Surface Elevation & Sea ice thickness distribution

Sea Surface Height = ~4 cm
 Significant Wave Height = ~30 cm
 Surface Wind Speed = ~1.7 m/s
 AltiKa Repeat Cycle = 35 days
 Along-track res. for 1-Hz data = 6 km
 Along-track res. for 40-Hz data = 175 m

Ice sheet surface elevation
 derived using re-tracker data

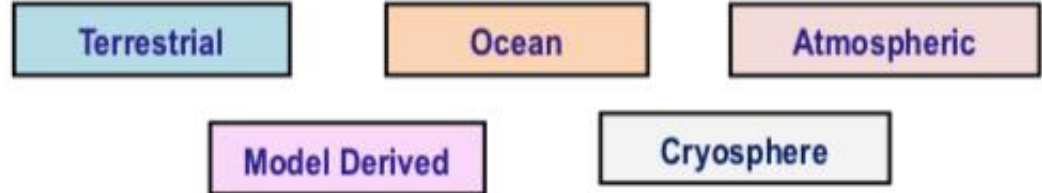


Sea ice thickness
 distribution - using
 waveform data



Climate Change Induced Impacts

National Information System For Climate & Environment Studies (NICES)



Climate change Indicators using Space Obs.

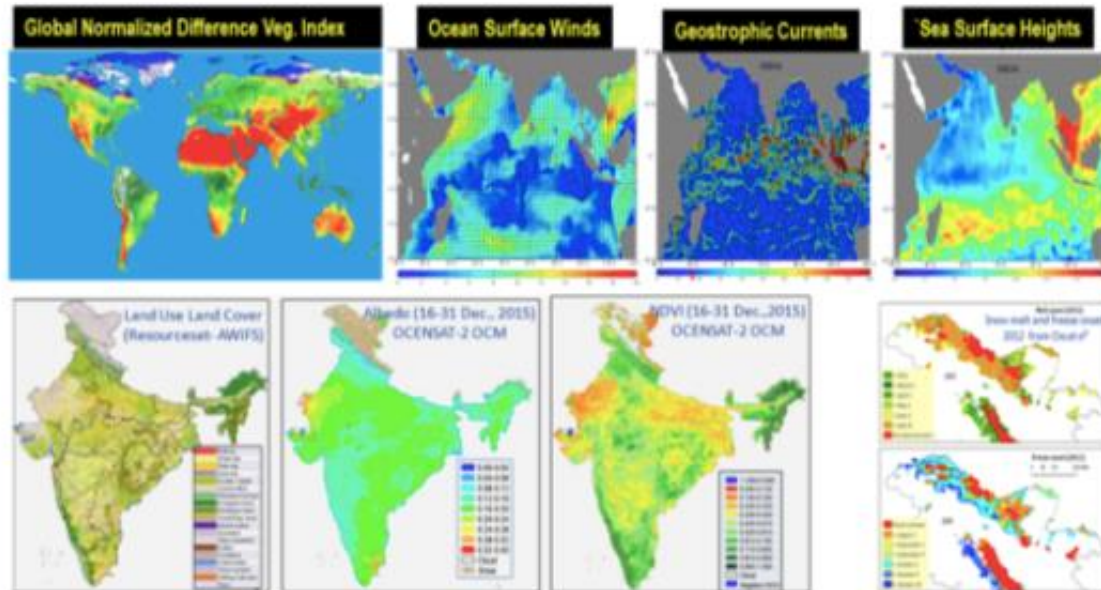
- Glacial Retreat
- Polar Ice Cover
- Alpine zone
- Coral Reefs Bleaching
- Desertification

Monitoring the Agents of Climate Change

- GHGs Variability
- Biomass burning/ forest fire
- Terrestrial Carbon
- Aerosols & Trace gases

Modeling the impacts of climate change

- Impact on Food Security
- Hydrology
- Coastal Zone
- Ocean Productivity
- Land Surface Changes



- Multi-institutional effort - various departments & academia
- Geo-physical data products available through Bhuvan portal
- Hosts more than 70 products & 13 ECVs



Thank You