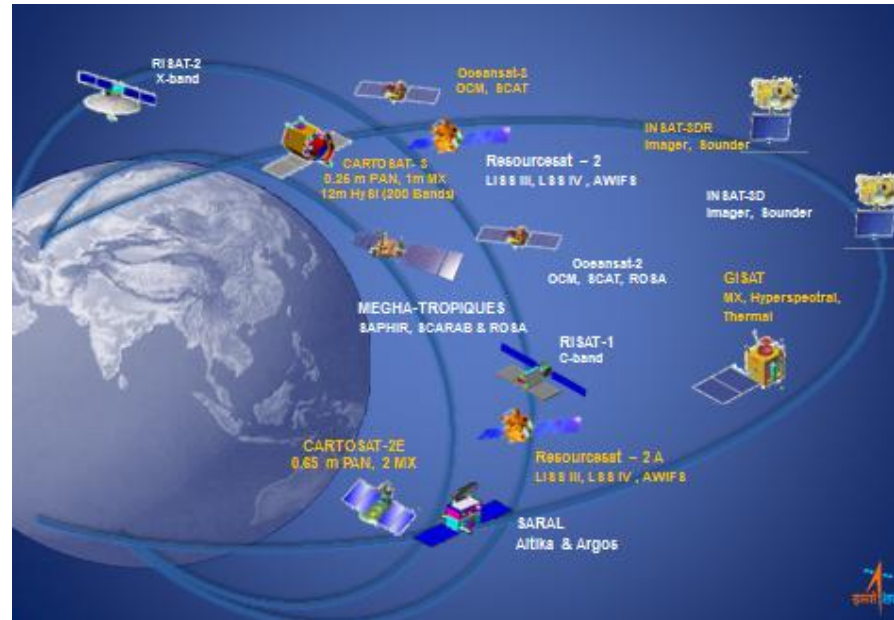
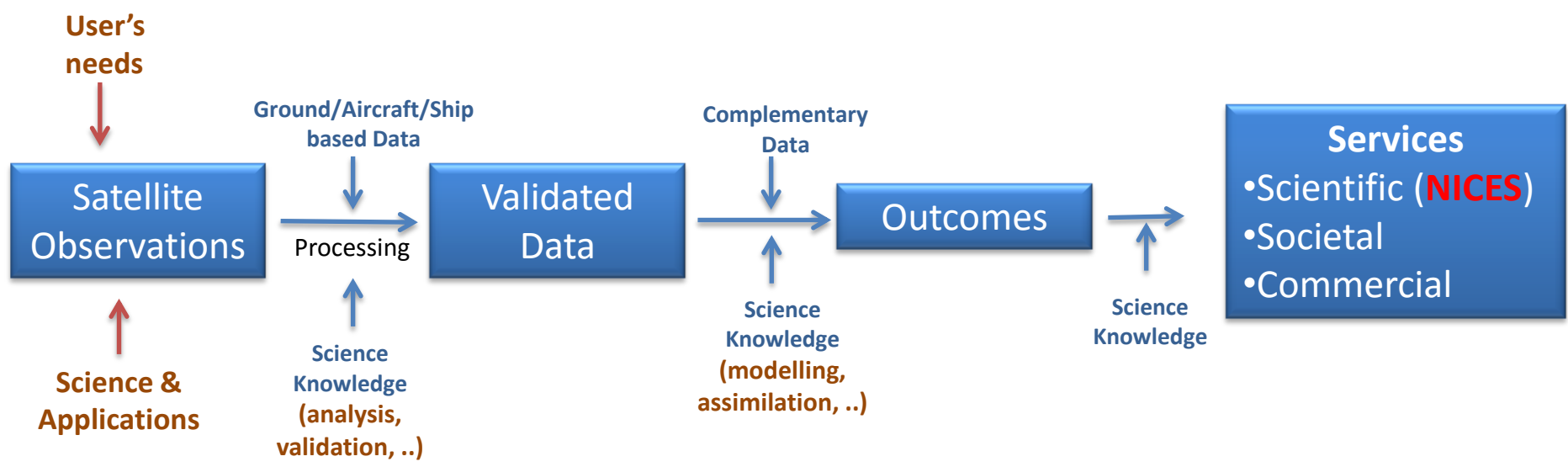


Satellite Observations for Ocean and Climate Studies



M.V. Ramana
Climate Studies Group (CSG)
Earth and Climate Sciences Area (ECSA)
NRSC

Missions - to - Parameter retrieval - to - Models - to - Services



Met Parameters & Clouds



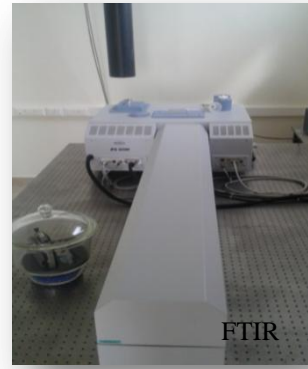
Hyperspectral Radiometer

Precipitation



Micro Rain Radar

Trace gases



FTIR

Ozone, NO_x, CO, SO₂



Ambient Gas Analyser

Aquatic DIC in water samples



For satellite ocean colour data validation and generation of potential functional types by pigment separation

Radiation, Albedo



Netradiometer

Aerosols

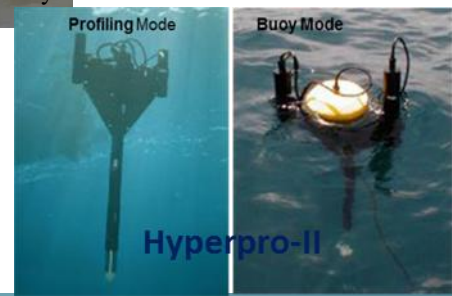


Sky Radiometer



FRRF

IOP Profiler



Profiling Mode

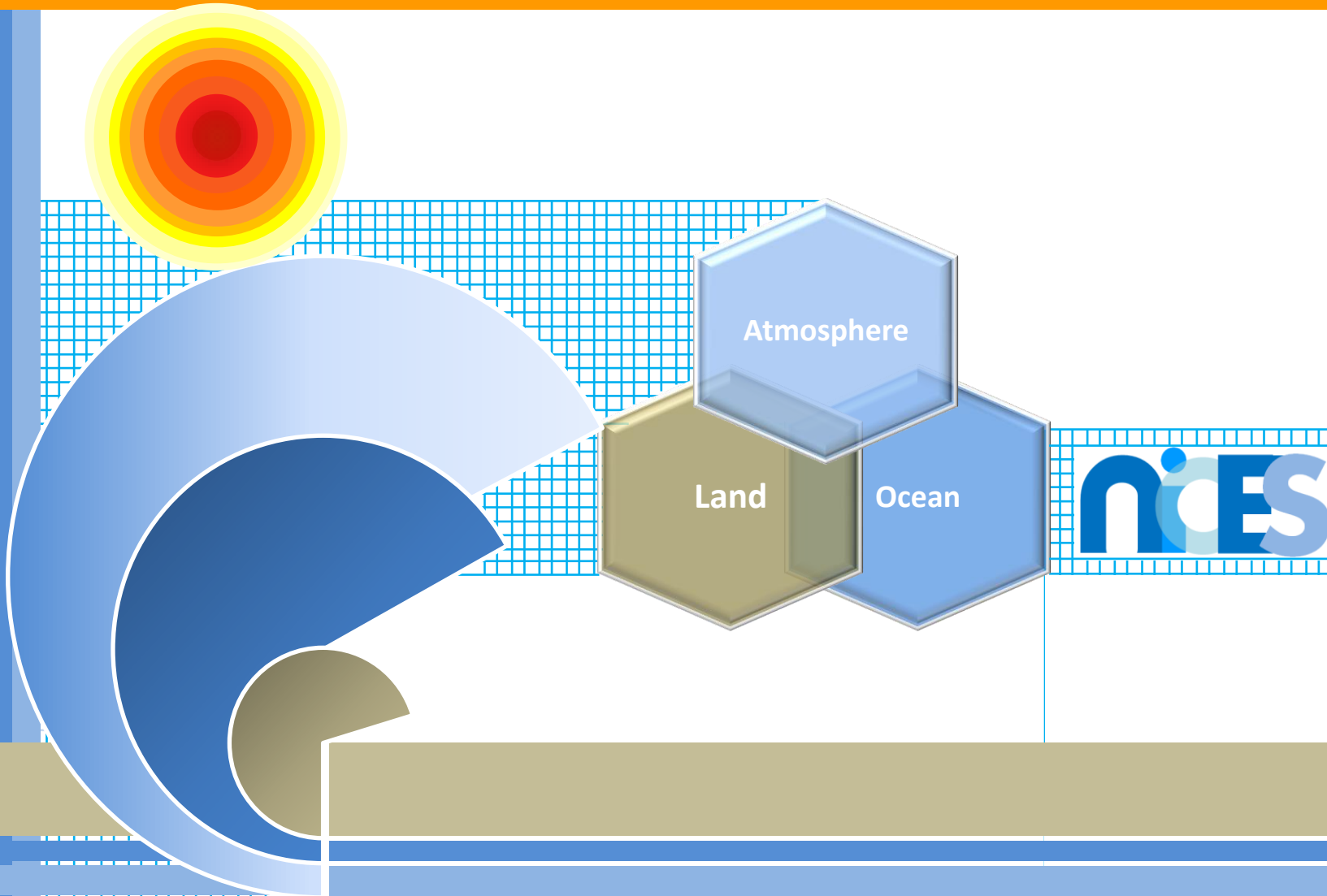
Buoy Mode

Hyperpro-II



National Information system for Climate and Environment Studies

nrsc





url of NICES: <http://bhuvan.nrsc.gov.in/data/download/index.php>

**Terrestrial
Products (30)**

**Ocean Products
(25)**

**Atmospheric
Products (8)**

**Model Derived
Products (9)**

The screenshot displays the Bhuvan web portal interface. At the top left is the Bhuvan logo with the tagline "Gateway to Indian Earth Observation". The top right corner shows a "Welcome User" message with a "Login" link and the "National Remote Sensing Centre" logo. Below the header is a search bar labeled "Open Data Archive" with a search icon. A navigation menu includes links for "FAQ", "Policy", "Disclaimer", and "Feedback".

The main content area is divided into a left sidebar and a right map area. The sidebar contains the following filters:

- NRSC/ISRO Open data and product archive facilitates the user to select, browse and download data from this portal.**
- Select Category:** Radio buttons for "Satellite/Sensor", "Theme/Products", and "Program/Projects".
- Select Project:** A dropdown menu showing "National Information System for Clim".
- Select Group:** A dropdown menu showing "Atmospheric and Climate Sciences".
- Select Product:** A list box with options: "Atmospheric and Climate Sciences", "Ocean Sciences", and "Terrestrial Sciences".

The right side of the interface features a map of India with state boundaries and names. A vertical scale bar on the left of the map indicates distances in kilometers (0, 200, 400). The map shows various states including Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh, Bihar, West Bengal, Tripura, Meghalam, Assam, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Odisha, Madhya Pradesh, Chhattisgarh, Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala, and Lakshadweep. Neighboring countries like Afghanistan, Pakistan, Nepal, Myanmar, and Thailand are also labeled.

National Information system for Climate and Environment Studies (NICES)

- Satellite-retrieved geophysical product inventory (**70-products, including derived products**)
- User downloads: about **40,000 downloads per year**.
- **NICES: 15** products have the potential to become ECVs (*28 of 54 ECVs are amenable through satellites*).

Time span (products)	NICES Geophysical products
20-30 years (4)	Ocean Heat Content, Ocean Mean Temperature, Tropical Cyclone Heat Potential, Eddy Kinetic Energy
15-20 years (4)	Surface Soil Moisture, Forest Fire, Snow Melt and Freeze, Mean Sea Level Anomaly
10-15 years (7)	Chlorophyll, Kd_490, LULC, Land degradation, Tropospheric Ozone, Net sown area (Agriculture), Cloud Cover and Cloud Fraction
5-10 years (15)	Albedo, NDVI, Vegetation Fraction, Surface Water Body Fraction, Snow Cover Fraction, Himalaya Glaciers, Snow Albedo, Model-TCHP, Model-D26, Ocean Surface Currents, Total Alkalinity , Dissolved Inorganic Carbon, Planetary Boundary layer Height, Ocean Surface Winds, Wind Stress, Wind Curl, Sea Level Pressure.

Academia = 45% ; R&D centres = 34%; Others = 21%

Terrestrial (35)

Geophysical: Albedo, NDVI (4)

Hydrology: Surface water body, Soil moisture, ET, Runoff (4)

Land cover: MM-5, WRF compatible, Veg Fraction (3)

Terrain and Soil: OC, IOC, f-soil depth, f-soil texture, f-water erosion, f-wind erosion, f-salt affected, Soil moisture (8)

Vegetation and Ecosystem: Average annual forest fire density, sd of AFFD, length of fire, f-forest, forest types, NSA, KSA, RSA, f-FA, NEP, NPP (11)

Cryosphere (5): Snow melt and freeze (Indian Himalaya & Antarctica) (2), **Snow cover fraction (1)**, Himalayan glacial lakes and water bodies (1), snow albedo (1)

Atmosphere (6)

Derived tropospheric Ozone (1), Boundary layer height (1), Cloud fraction and cloud top temperature (2), Number of Lightnings (1)

Ocean (29)

OHC700 (1)

TCHP (1)

OHC & OMT (2)

Ocean surface winds (2)

Wind stress (2)

Wind curl: Wind curl, Ekman currents, geostrophic current, SSHA, ocean surface current, EKE, MMSLA (7)

Co-tidal map (k101, M2s2) (2)

Model derived: 26 degree isotherm, TCHP (2)

Sea level pressure (1)

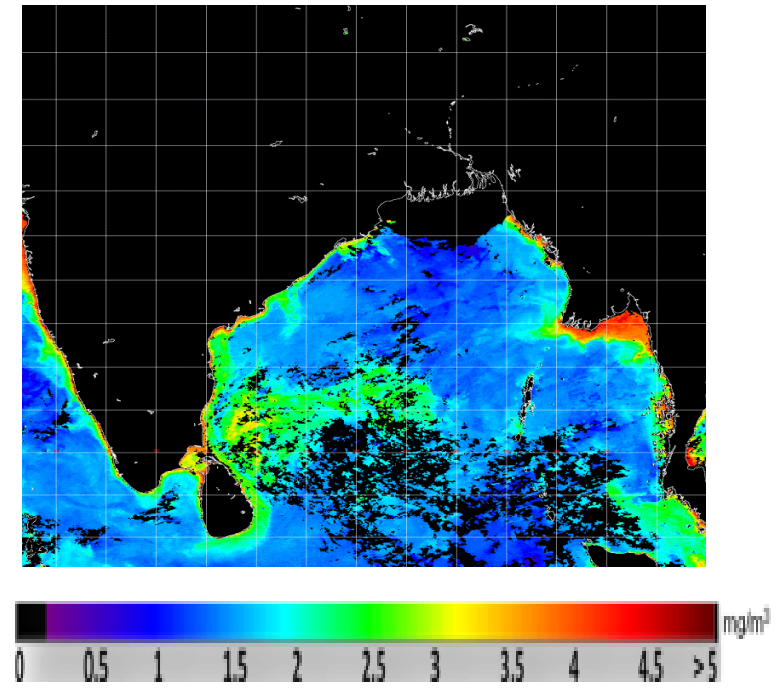
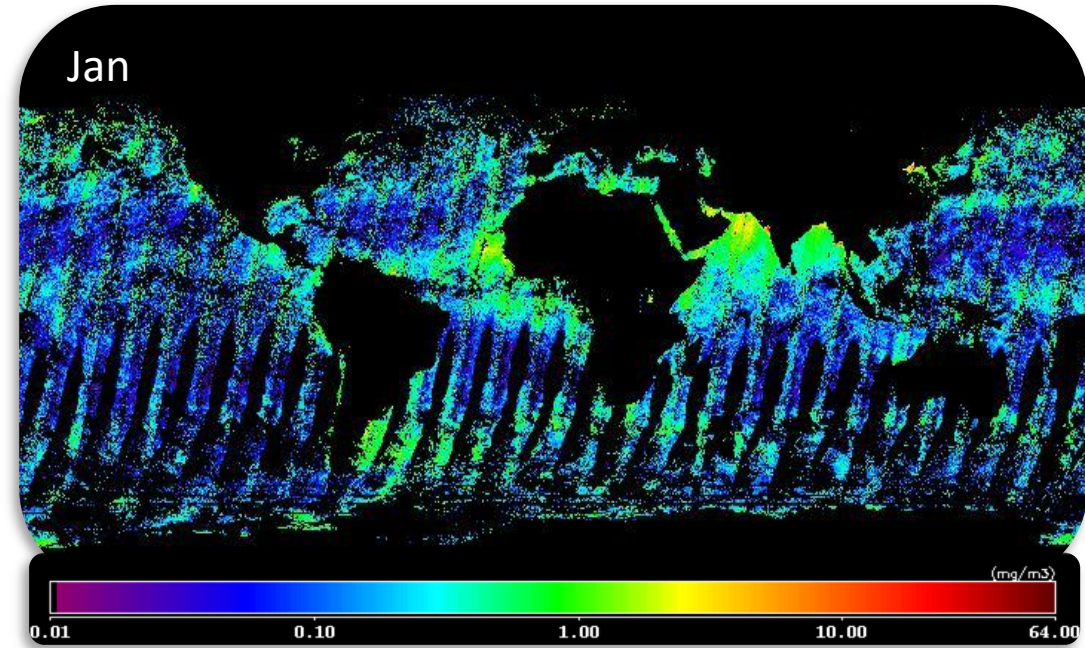
Ocean color: Chlorophyll concn (OC₂, OC₄), Kd₄₉₀, Total Alkalinity, Dissolved Inorganic Carbon, pCO₂ (6)

National Satellites: 24 products

International Satellites: 15 products

Model outputs: 8 products

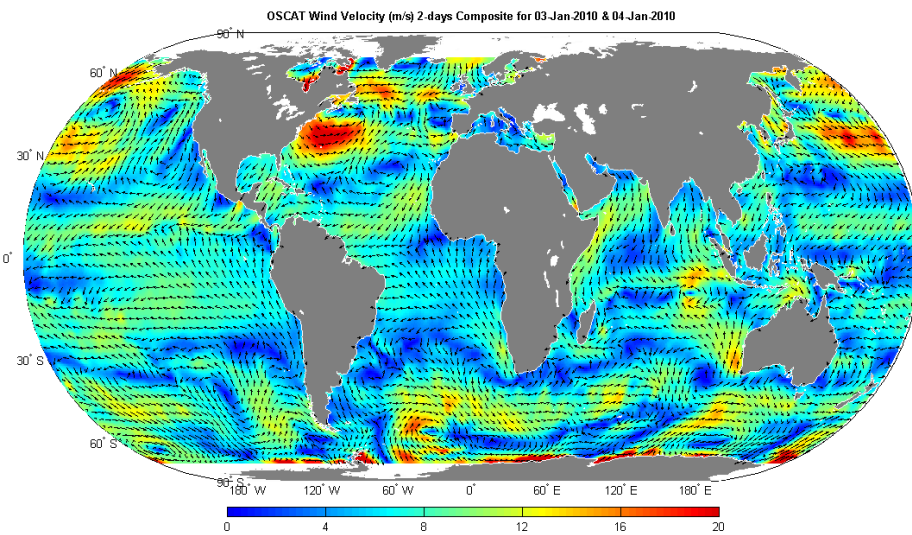
Satellite measured Chlorophyll Concentrations



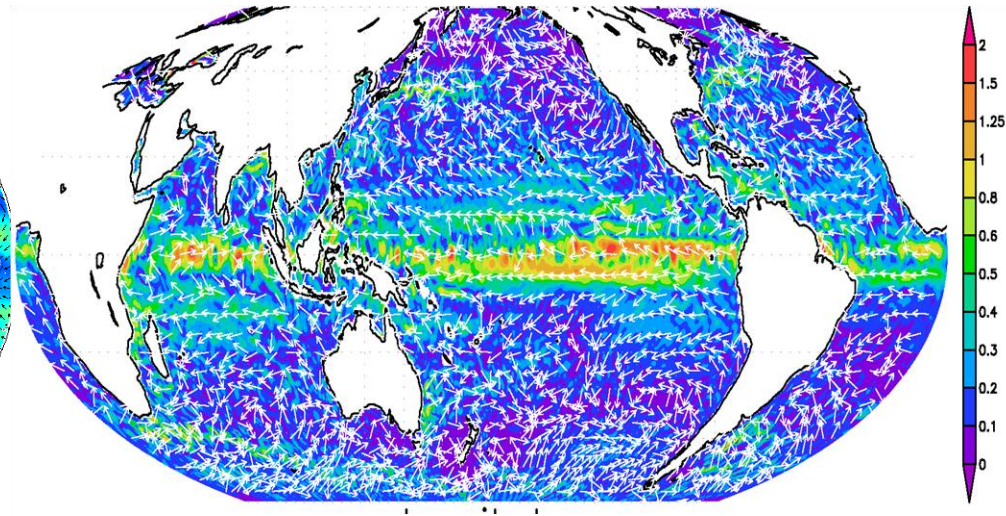
Satellites used: Oceansat-2/OCM II
Period of data availability: 1999 - 2020
Resolution: Spatial- 1km & 4km
Temporal - 2 day, 8 day & Monthly
Level of information: Global & Indian Ocean

- **BLUE ECONOMY potential: a critical parameter**
- **Removal of CO₂ from the atmosphere: ρCO₂ maps**
- **Biological processes in the ocean: PFZ, productivity, ...**
- **Cloud Condensation Nuclei**

Ocean Winds and Currents



Ocean Winds

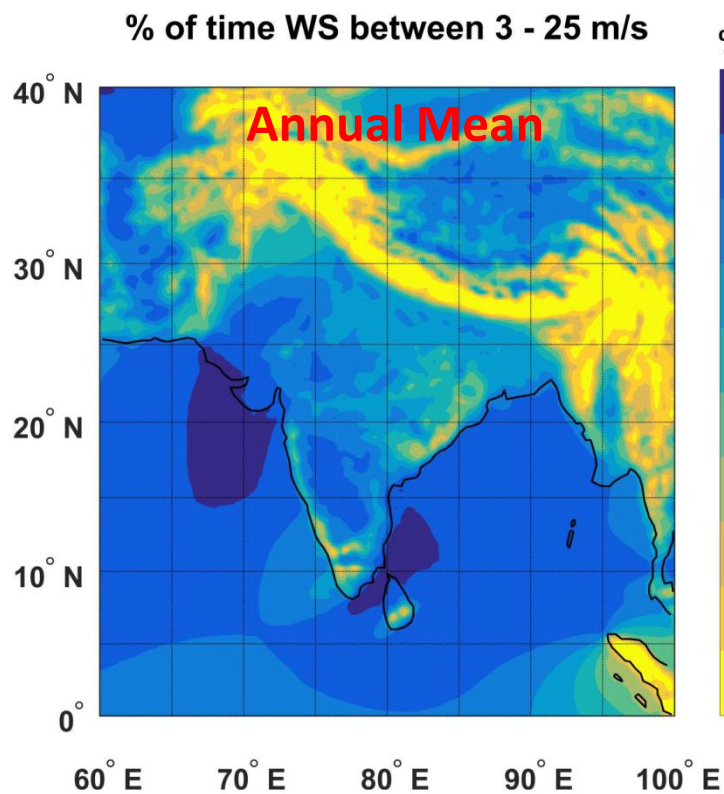


Ocean Currents

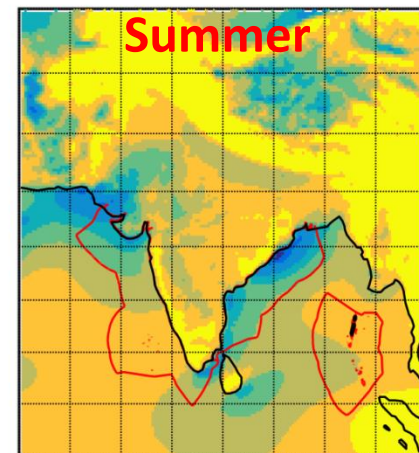
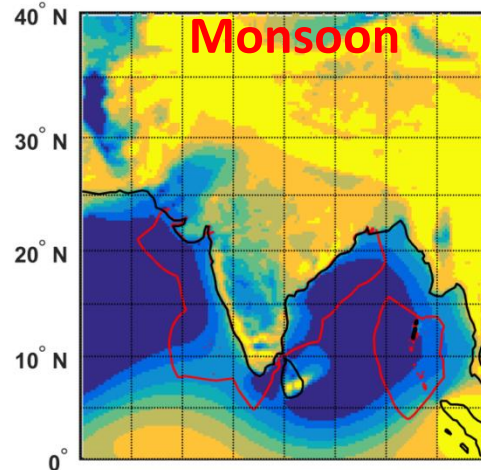
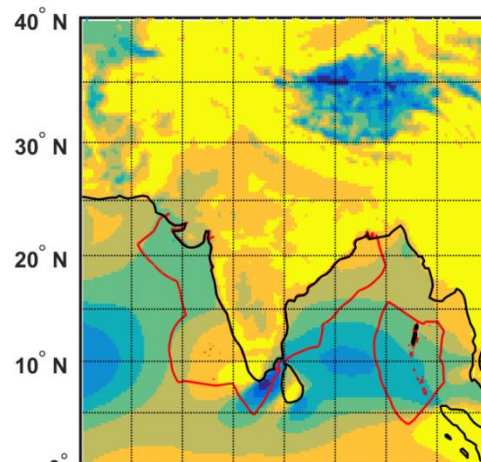
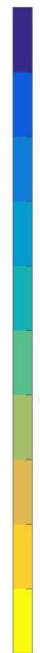
Satellites used:	SARAL:ALTIKA, OSCAT & SCATSAT
Period of data availability:	2010 – Till date (Data Gap 2014-2016)
Resolution:	Spatial- $0.25^\circ \times 0.25^\circ$ Temporal - Daily
Level of information:	Global

Ocean Surface Currents over the global oceans are generated at daily basis based on data of Sea Surface Winds from the ISRO's OSCAT, SCATSAT Winds and SARAL-ALTIKA/AVISO sea level data records.

Harvestable Wind Energy (1979-2018) at 100m level

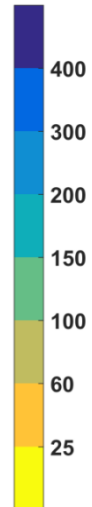


%



60° E 70° E 80° E 90° E 100° E 60° E 70° E 80° E 90° E 100° E

W



28-year Ocean Surface Currents data from 1993 to 2021

Satellites used: Altimeters (T/P, JASON 1/2/3, SARAL Altika etc.) & Scatterometers (QuikSCAT, OSCAT, ASCAT, SCATSAT etc.) and merged NOAA AVHRR SST data

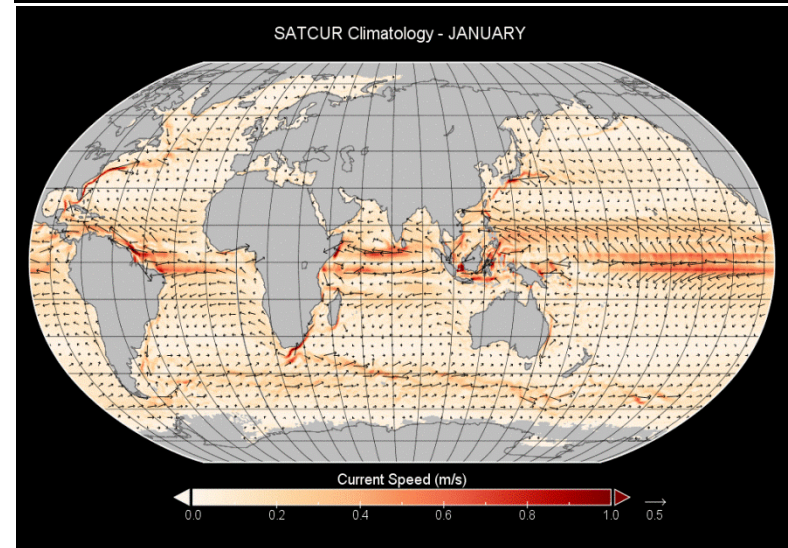
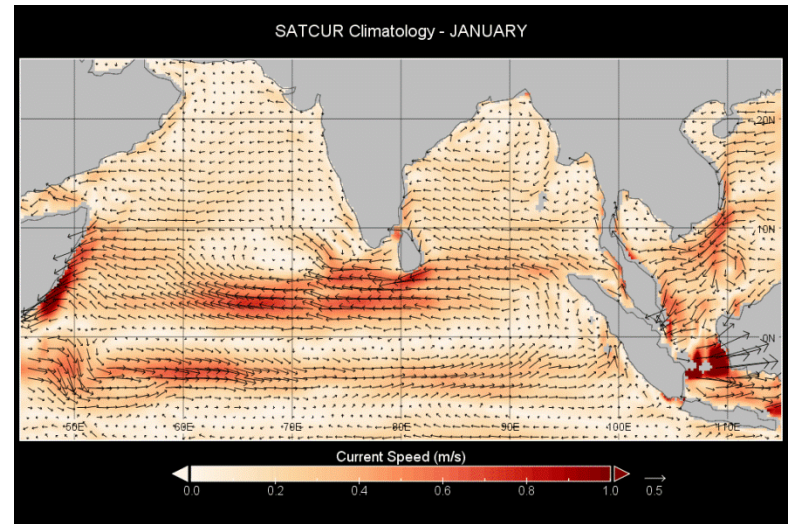
Period of data availability: 1993 - February 2021

Resolution:
 Spatial : 25 km x 25 km
 Temporal: Daily

Level of information: Global coverage

Reference: Rajesh Sikhakolli, Rashmi Sharma, Raj Kumar, B. S. Gohil, Abhijit Sarkar, K. V. S. R. Prasad & Sujit Basu (2013) Improved determination of Indian Ocean surface currents using satellite data, Remote Sensing Letters, 4:4, 335-343, DOI: [10.1080/2150704X.2012.730643](https://doi.org/10.1080/2150704X.2012.730643)

Figures: Monthly Climatology of Ocean Surface Currents (1993-2019) over Indian/Global Ocean



Harvestable Tidal Energy

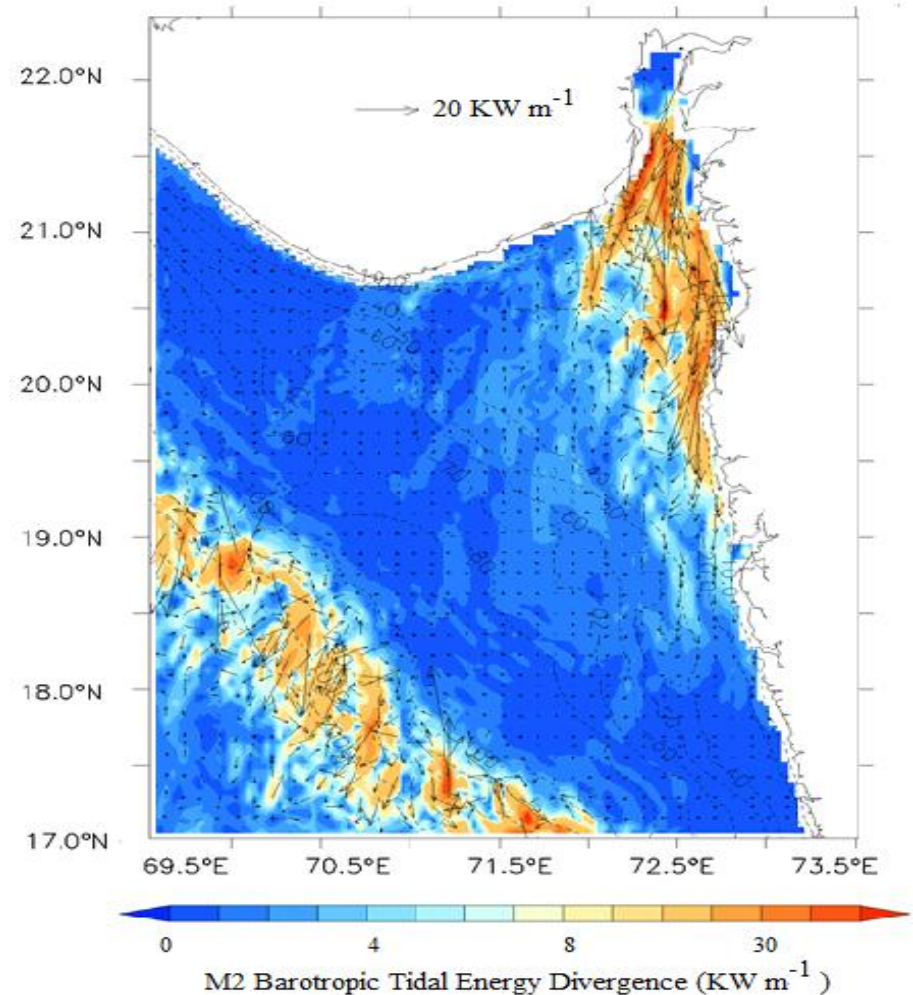
North-western continental shelf of India (Gulf of Khambhat)

Potential location for Tidal Energy Harnessing

Inputs to Ocean model:

Bathymetry, winds, tides, heat fluxes at air-sea interface

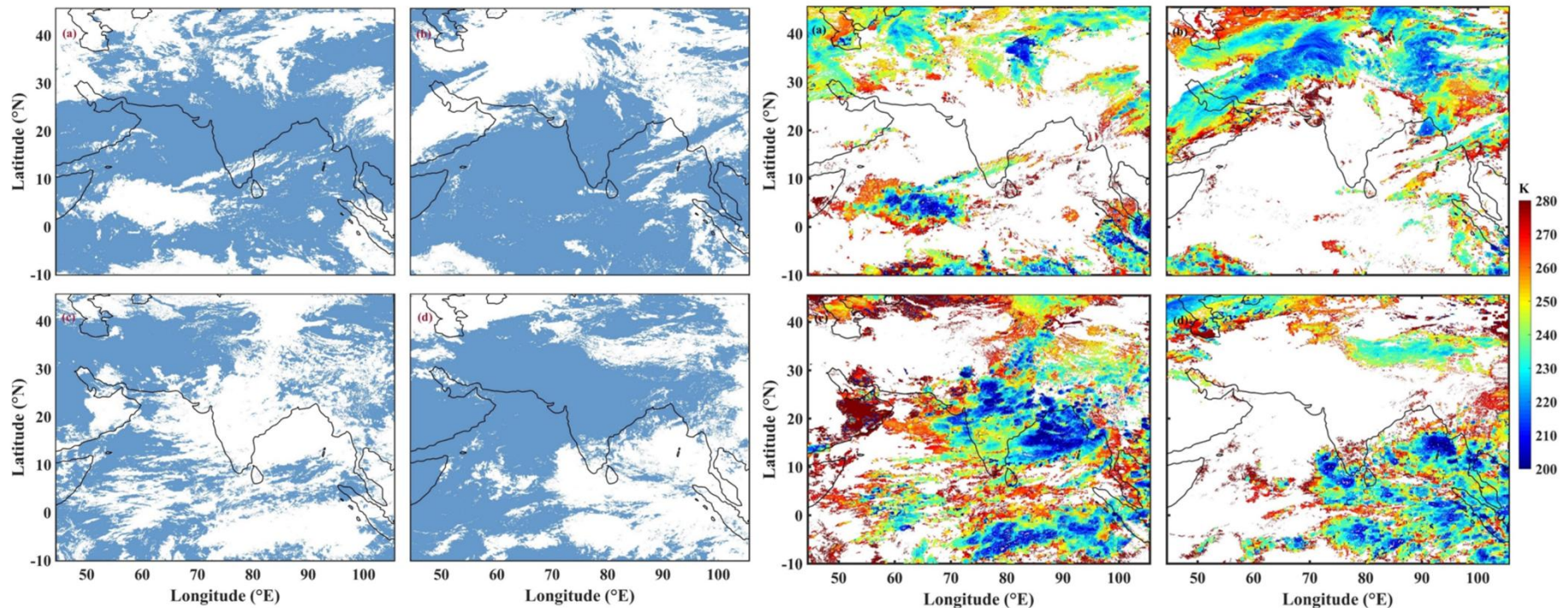
Model outputs the ocean currents; which in turn processed for diagnostic analysis of tidal energy harnessing for the study region.



Color and arrows in the figure indicates tidal energy divergence

Atmosphere: Cloud Cover and Cloud Top Temperatures

Satellites used: Kalpana-1, INSAT-3D
Period of data availability: 2015 - till date
Resolution: Spatial- INSAT-3D (4km x 4km), Kalpana-1 (8km x 8km)
Temporal – Half-hourly



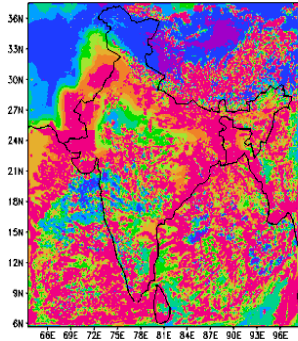
Users:

- (i) Climate Studies & Climate model evaluations
- (ii) Extreme weather events
- (iii) Renewable Energy & Now-casting

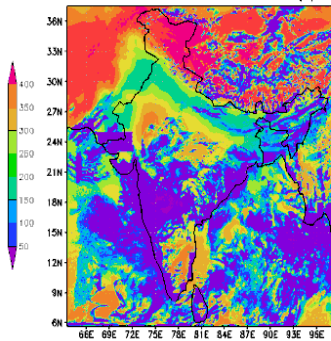
Solar Radiation & Wind Forecast

NTPC: Solar energy forecast over Noida and Ananthapur

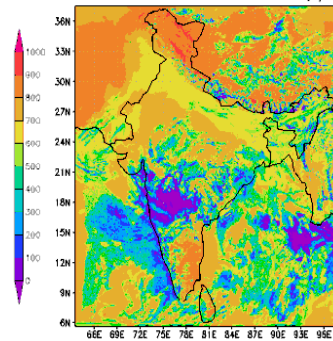
Diffuse



Direct



Global



As evaluated by the NTPC

(observed - predicted < ±50) = 100% clear-sky

(observed - predicted < ± 200) = 80% all-sky

- **Objective:** Day-ahead forecast of surface reaching solar radiation and wind speeds at 10m level using space technology.

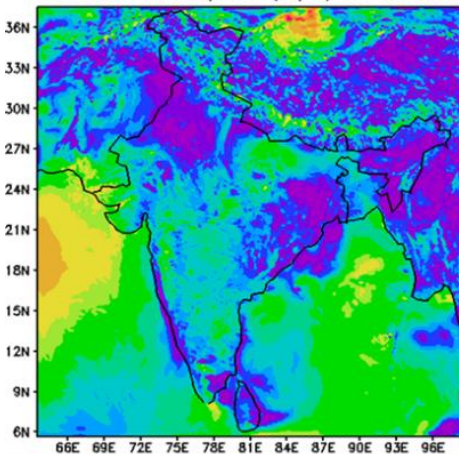
- **Study area:** Over India at 15min interval.

- **Satellite Data:** LULC,AOD, SSA From OMI

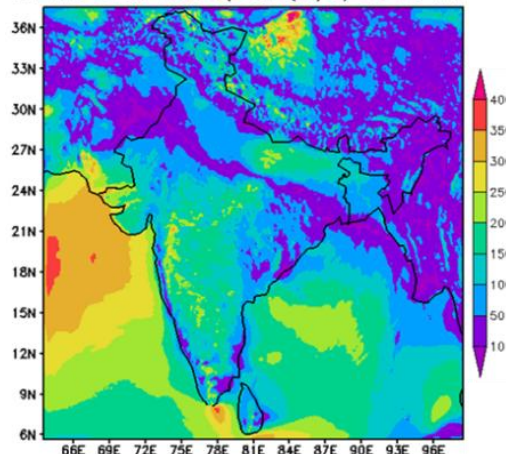
- **Benefits:** Expected power production on various temporal and spatial scales.

User: NTPC, Renewable Energy, Carbon footprint, Climate studies

12:30 IST Wind Speed (m/s) at 10 mete

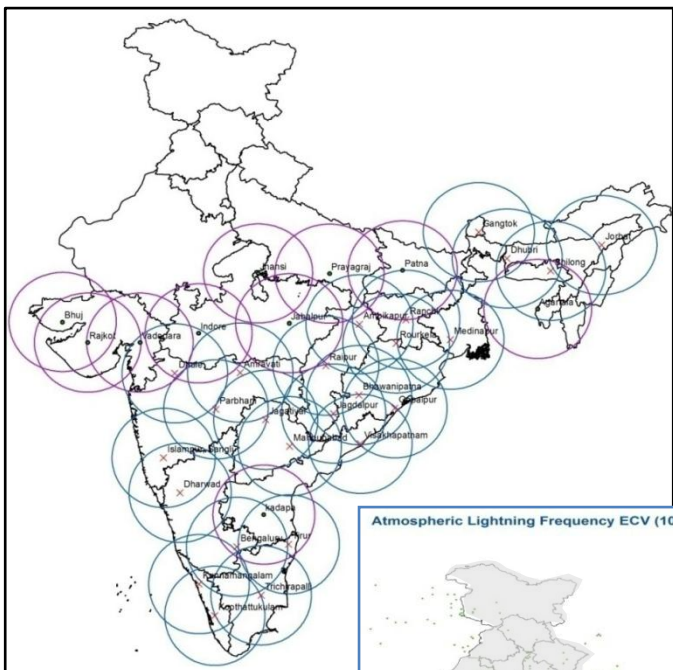


24 hrs Total Wind Speed (m/s) at 10 mel

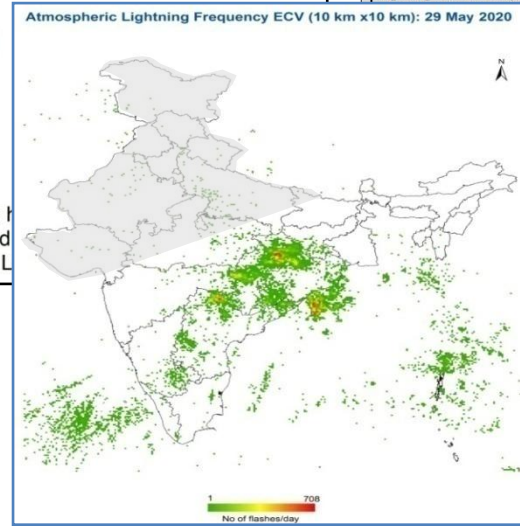


Atmospheric Lightning Detection Sensor Network

link: <https://bhuvan-app1.nrsc.gov.in/lightning/>



Circle Represents 300 km of area
Blue Circle: Established
Purple Circle: Proposed



Lightning Visualization

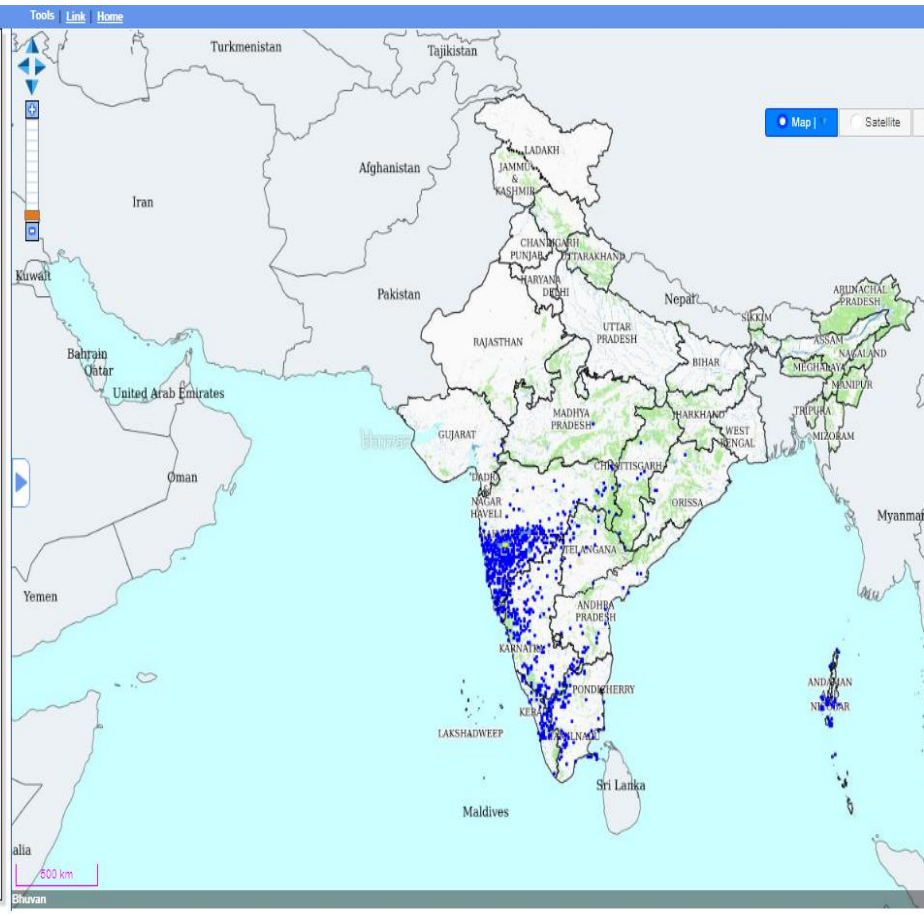
Lightning Essential Climate Variables

2021-12-01

Cloud to Ground lightning flash occurrences

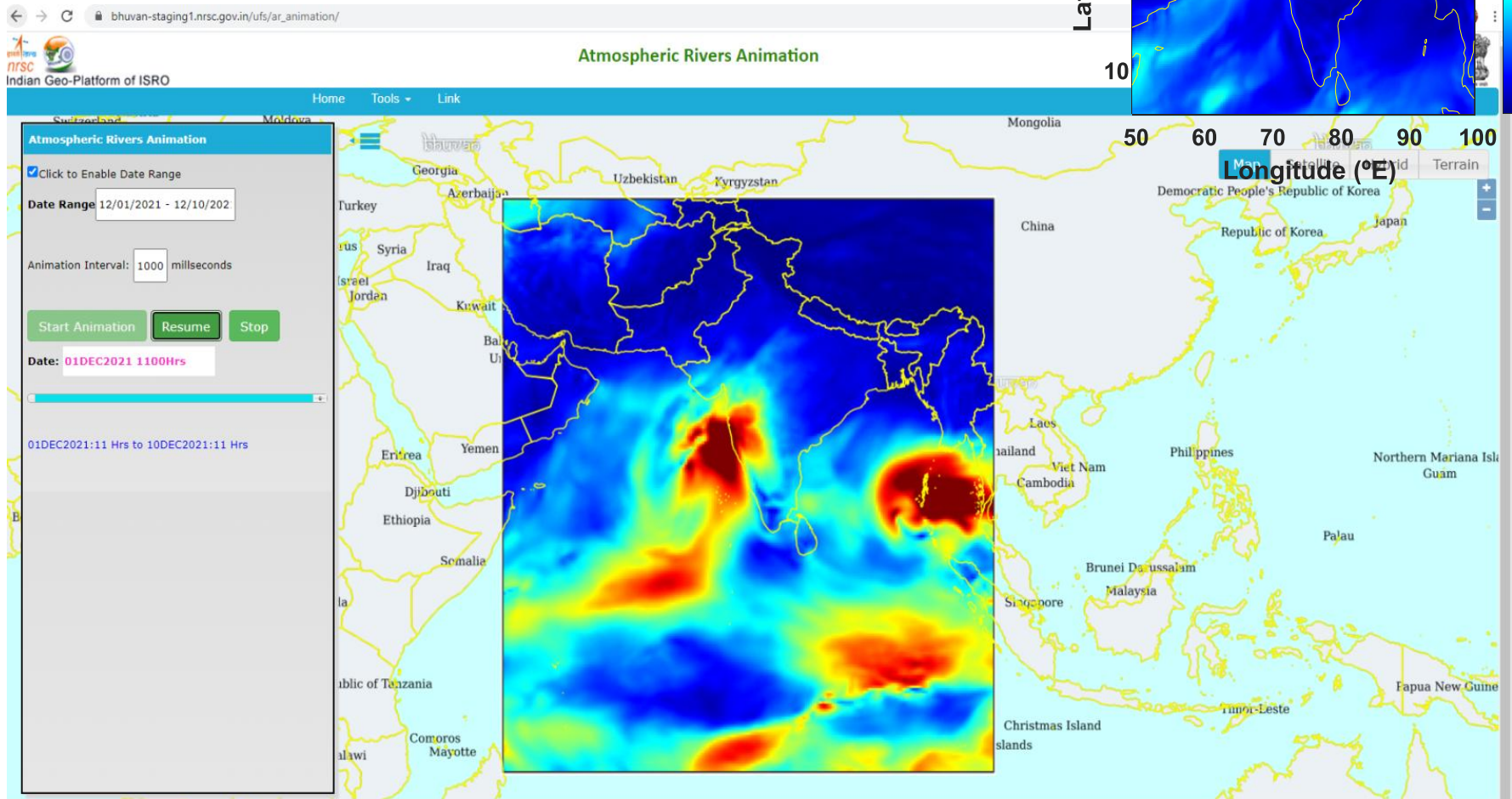
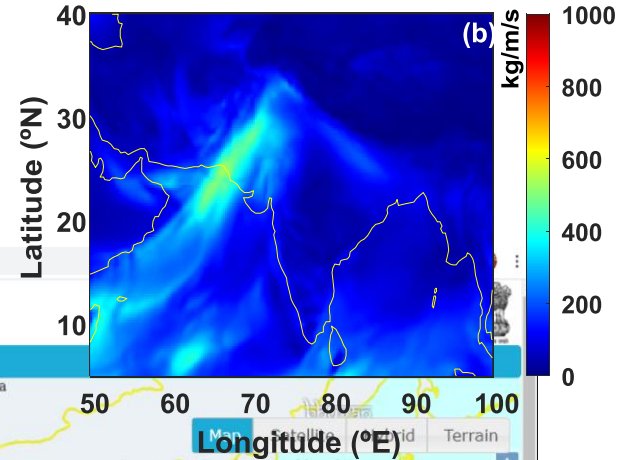
- Very Low (1-5)
- Low (6-25)
- Moderate (26-125)
- Heavy (126-500)
- Very Heavy (>500)

Lightning is a complex atmospheric phenomenon with significant implications for human health, infrastructure, and environmental management. The NRSC-LDS network of sensors covers more than 98% of the Indian landmass. The sensors are spaced at a range of 100 to 300 km. The network is designed to have 50% of the sensors operational at any given time. The NRSC-LDS network is used to generate lightning data for various applications, including research and operational forecasting. The NRSC-LDS network is also used to generate lightning data for the WMO criteria for lightning detection. The NRSC-LDS network is used to generate lightning data for the WMO criteria for lightning detection. The NRSC-LDS network is used to generate lightning data for the WMO criteria for lightning detection.



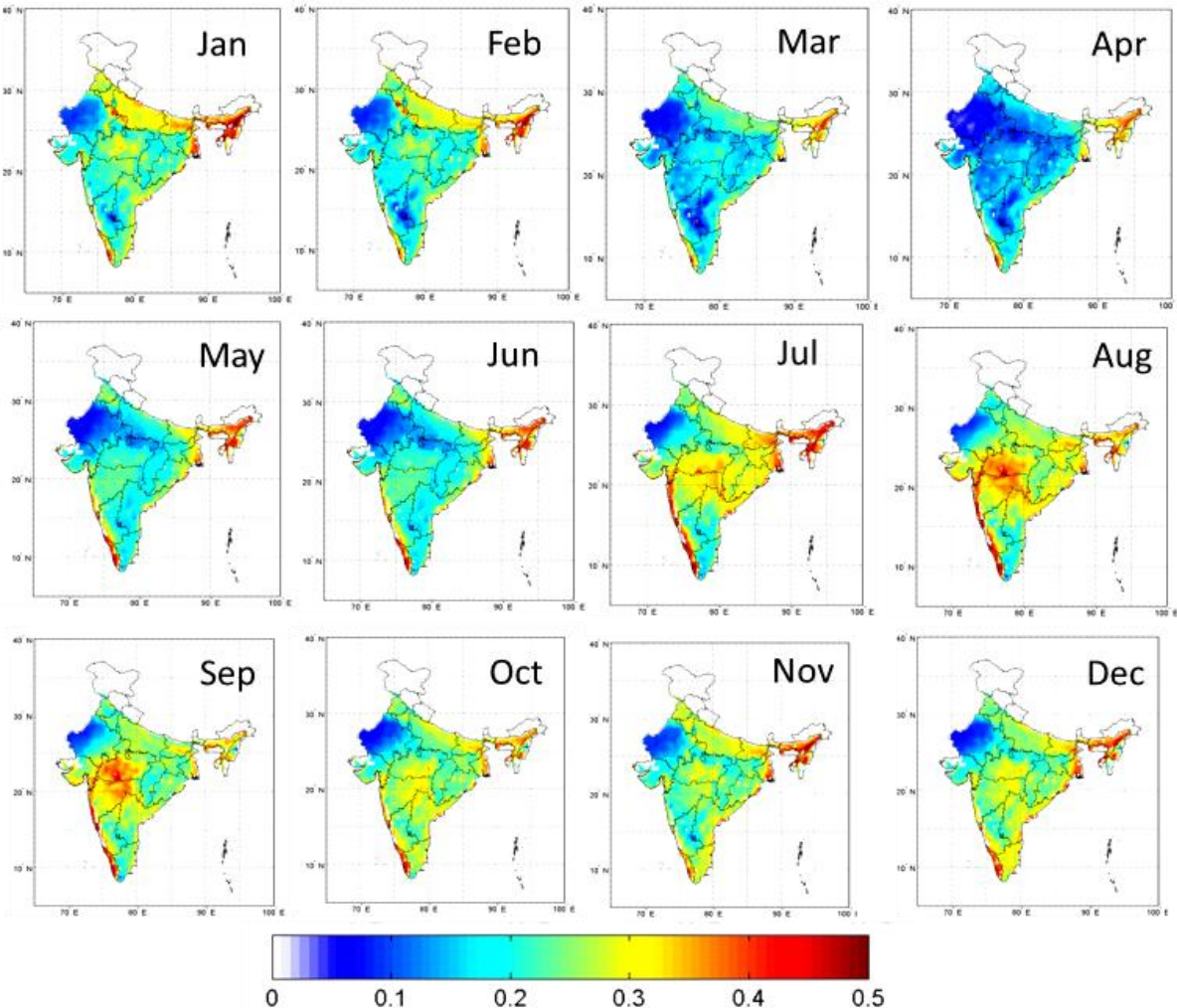
Prominent Registered Users (93+):
IMD, NESAC, NARL, SAC, IITM, IISC, NCESS, NIT-Rourkela, IIT-Bhubaneswar, IIT-Patna, NIT-Allahabad, Andhra University, Tea Research Institute-Assam, DAVV-Indore, Indian Institute of Geomagnetism-Mumbai, Kolhapur university, Vidyasagar university, CGCOST etc....

Atmospheric Rivers

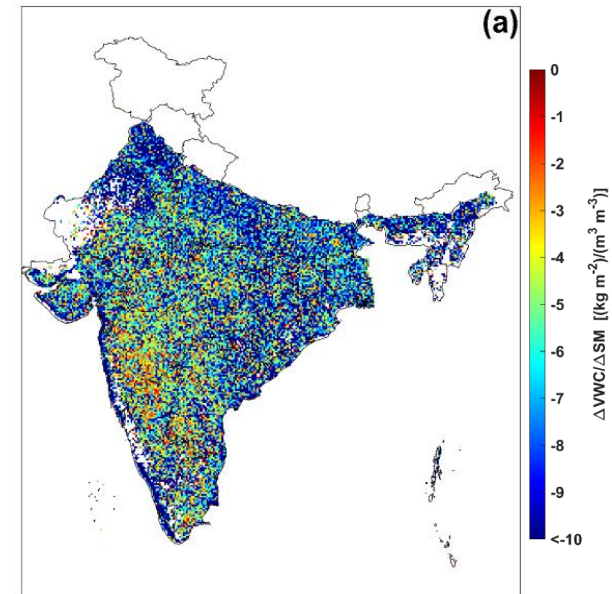


Nationwide Soil Moisture

19-year Soil Moisture data set from 2002 to 2021



Vegetation water content and soil moisture



Satellites used: AMSRE & AMSR2

Data availability: 2002 - till date

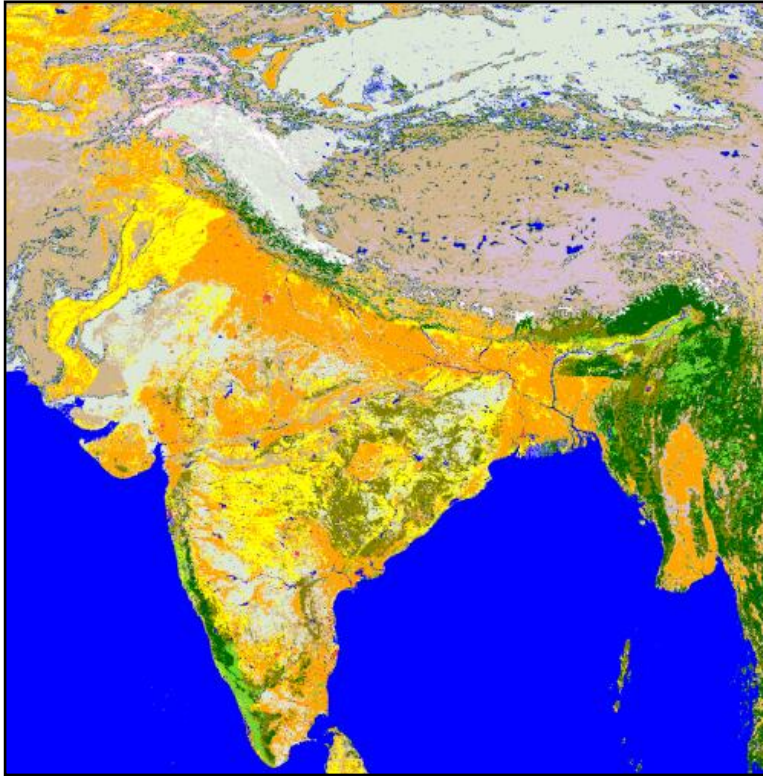
Resolution:

Spatial : 25 km x 25 km

Temporal: 2 days

National coverage

Land Use Land Cover



30second AWiFS derived LU/LC

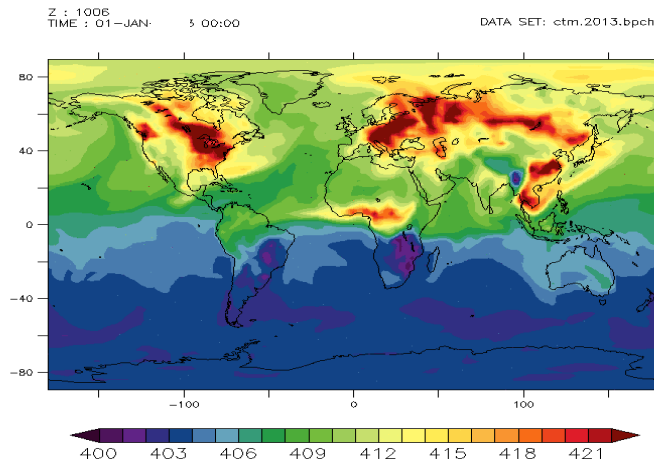
The land use land cover (LU/LC) data generated using 56m basic resolution AWiFS data from the Indian satellite IRS P6, has been remapped and scaled to 5 minute, 2 minute and 30 second resolutions. The Indian region of USGS data has been replaced with the AWiFS derived data such that it is compatible to MM5 and WRF models.

Satellites used:	Resourcesat-2 / AWiFS
Period of data availability:	2004-05 to 2019-20
Resolution:	Spatial- 30"/2'/5' Temporal – yearly
Level of information:	Global

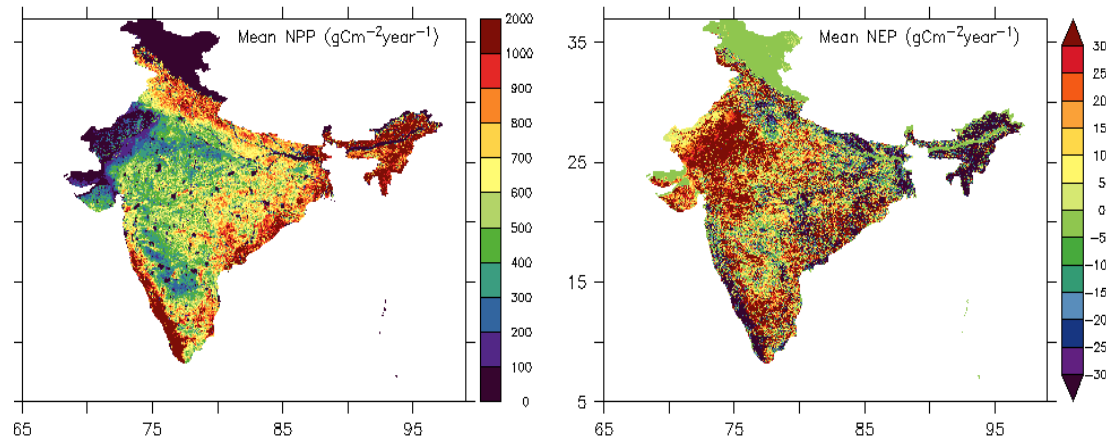
Model: Ecosystem and Carbon Cycle modeling

Aim to integrated regional data bases for better and comprehensive understanding of Carbon Cycle over India in response to the climate change (NDVI, LULC, soil attribute map, precipitation, solar radiation, air-temperature)

Simulated Surface Layer CO₂



Terrestrial Net Primary Productivity & Net Ecosystem Productivity



➤ NEP budgets of India during 1981-2020 shows Indian terrestrial Ecosystem is the net sink of atmosphere CO₂ during most of the years with mean NEP is 20 TgC Yr⁻¹

➤ These data are useful to assess the health of ecosystem, CO₂ source and sink strength and studies pertaining to food and energy security and climatic change variability.

Thank you
For your kind attention

For further details, please contact

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