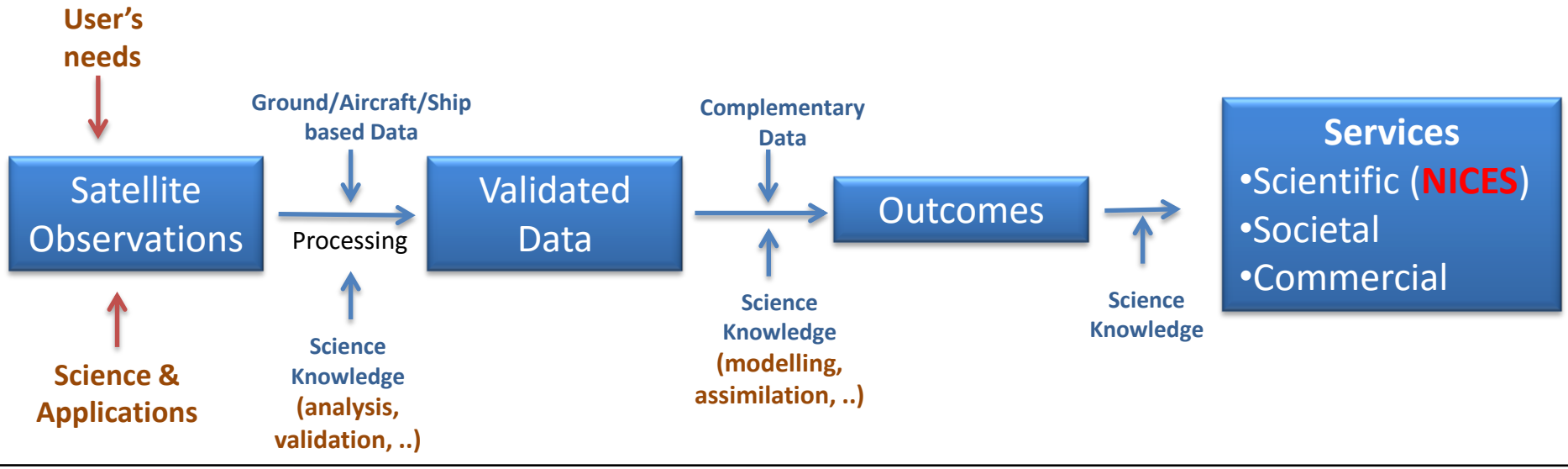
Satellite Observations for Ocean and Climate Studies

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

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



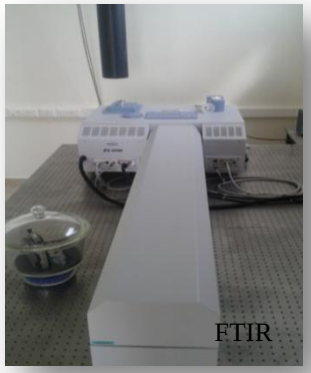
Met Parameters & Clouds

Hyperspectral Radiometer

Precipitation

Micro Rain Radar

Trace gases



FTIR

Ozone, NO_X, CO, SO_2

Ambient Gas Analyser

Aquatic DIC in water samples

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

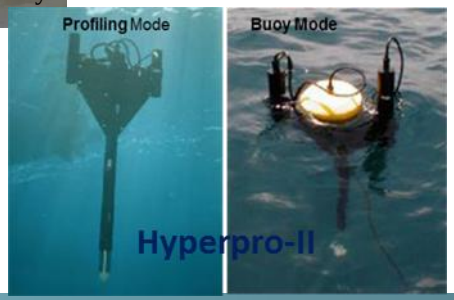
Radiation, Albedo

Netradiometer

Aerosols

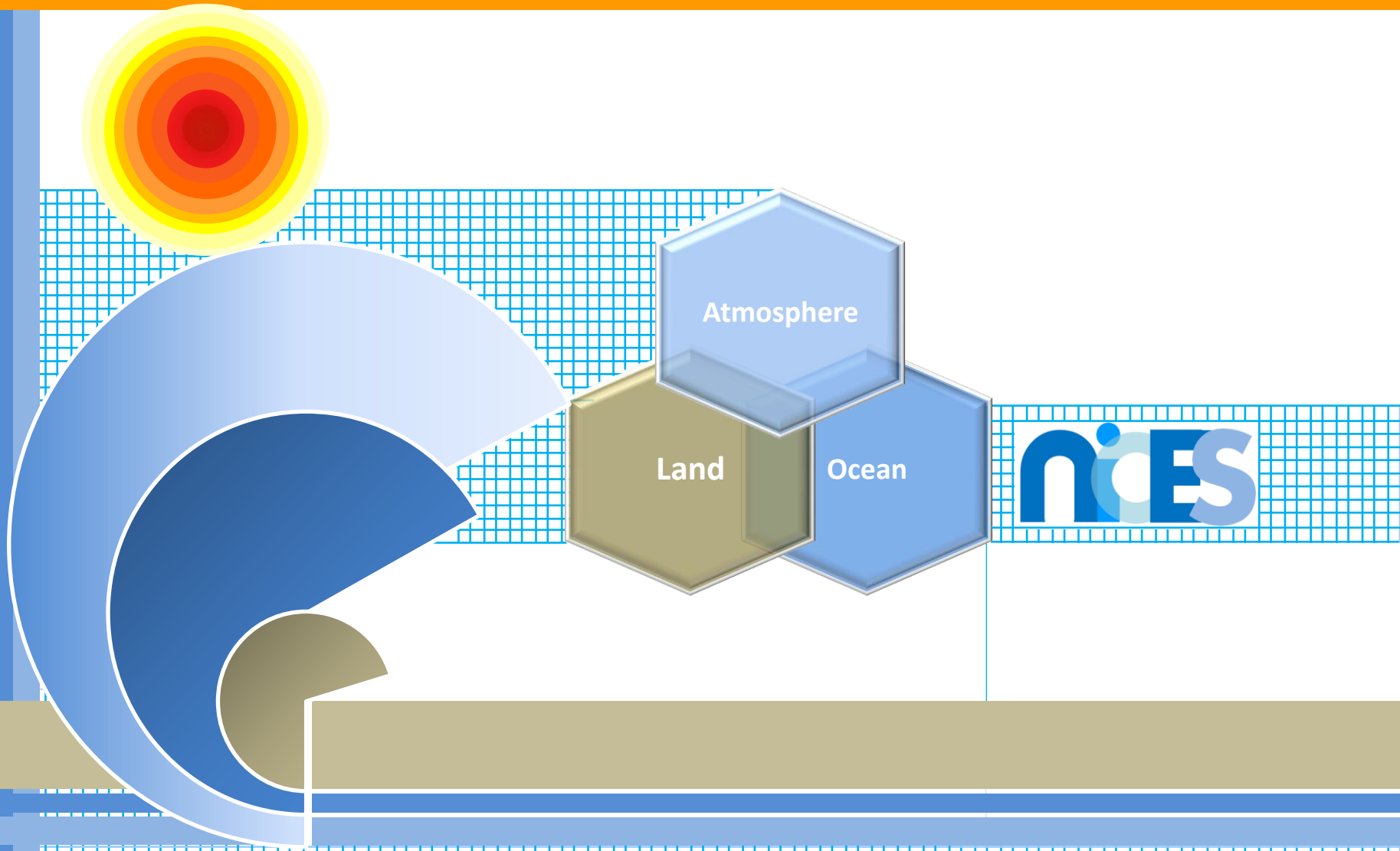
Sky Radiometer

IOP Profiler



National Information system for Climate and Environment Studies

nrsc



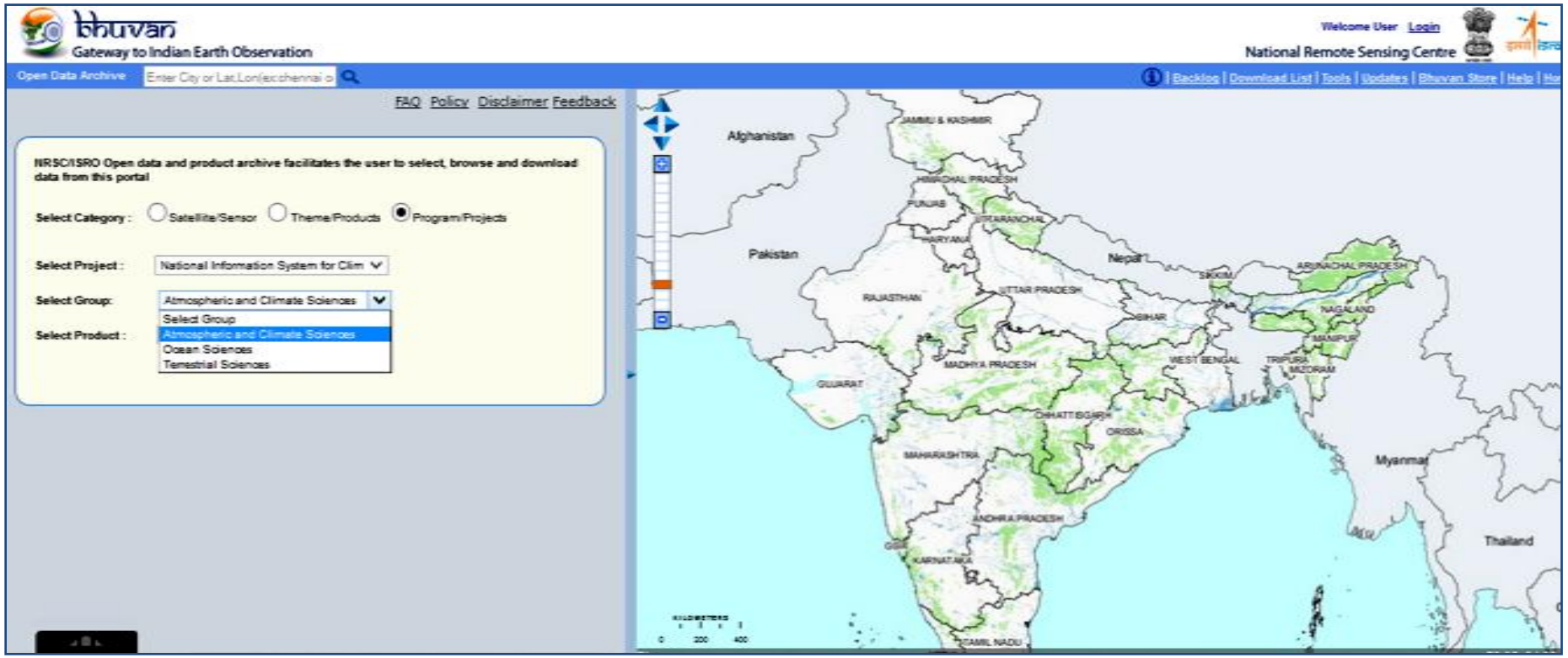
url of NICES: http://bhuvan.nrsc.gov.in/data/download/index.php

Terrestrial Products (30)

Ocean Products (25)

Atmospheric Products (8)

Model Derived Products (9)



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%

Inventory of geophysical products

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)**

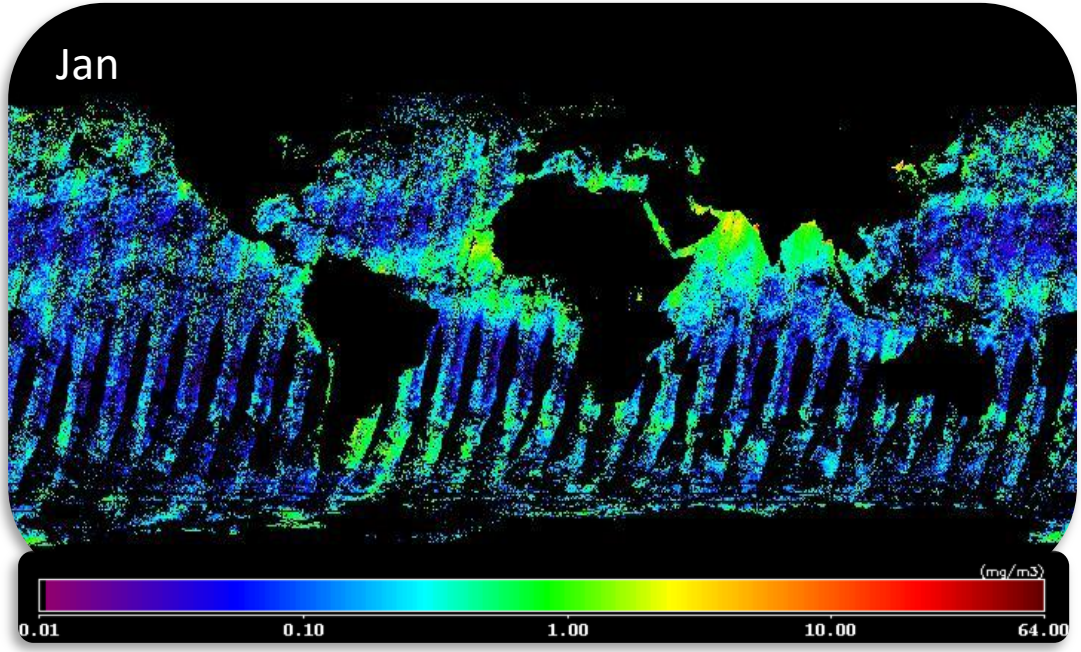
Ocean color: Chlorophyll concn (OC_2, OC_4), Kd_{490}, Total Alkalinity, Dissolved Inorganic Carbon, pCO2 (6)

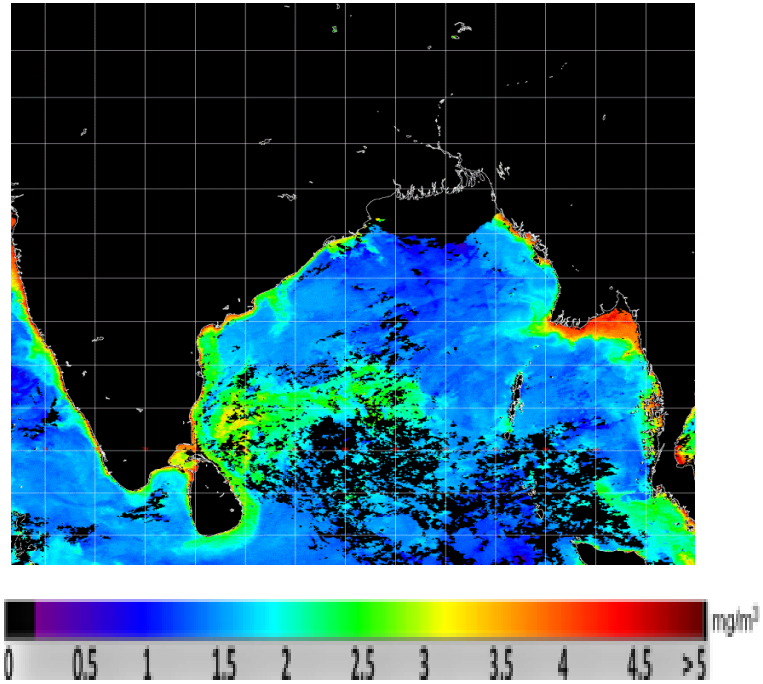
National Satellites: 24 products

International Satellites: 15 products

Model outputs: 8 products

Satellite measured Chlorophyll Concentrations

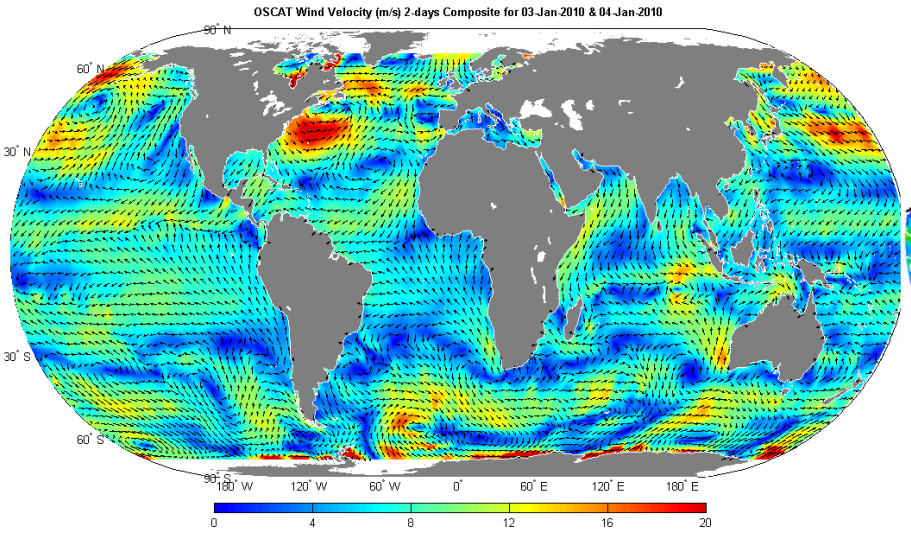




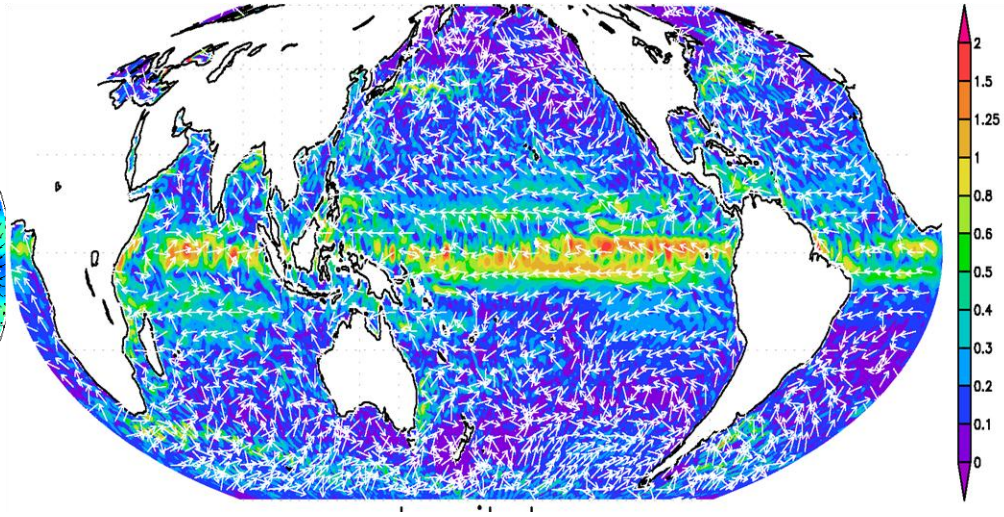
Satellites used: Oceansat-2/OCM II
Period of data availability: 1999 - 2020
Resolution: Spatial- 1km & 4km
Temporal - 2 day, 8 day & Monthly
Level of information: Global & Indian Ocean

- **BLUE ECONOMY potential: a critical parameter**
- **Removal of CO_2 from the atmosphere: pCO_2 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

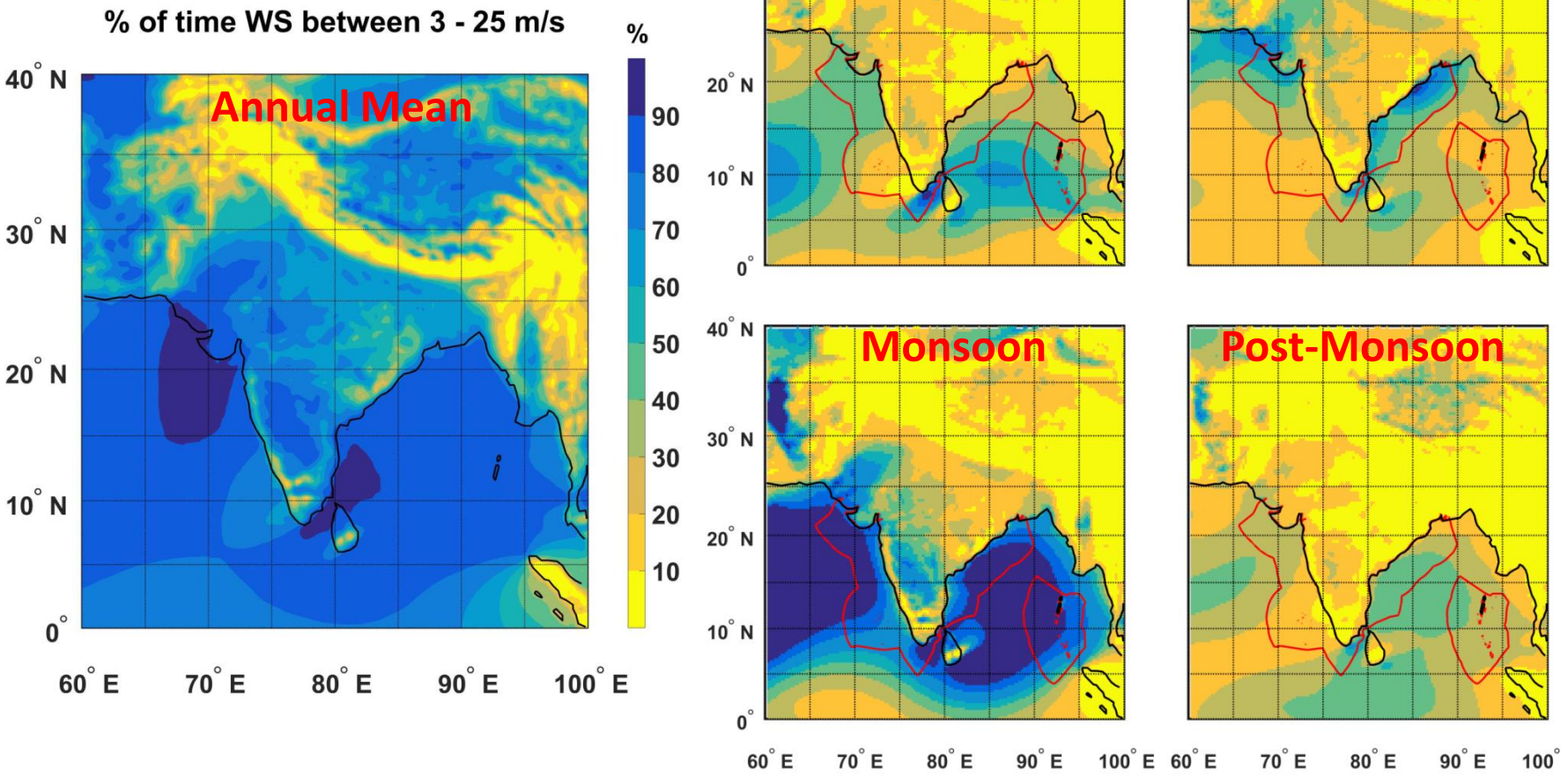
Period of data availability: 2010 – Till date (Data Gap 2014-2016)

Resolution: Spatial- 0.25° x 0.25°
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



Merged product – Ocean Surface currents

28-year Ocean Surface Currents data from 1993 to 2021

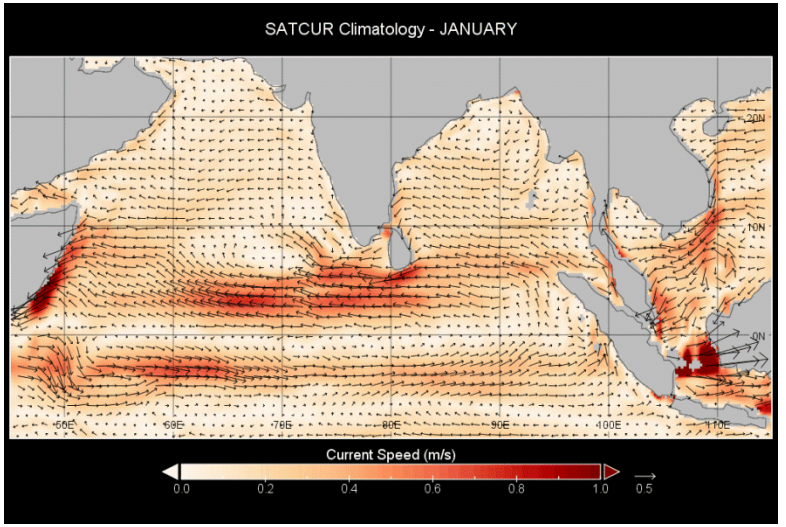
Satellites used: Altimeters (T/P, JASON 1/2/3, SARAL Altika etc.,) & Scatterometers (QuikSCAT, OSCAT, ASCAT, SCATSAT etc.,) and merged NOAA AVHRR SST data

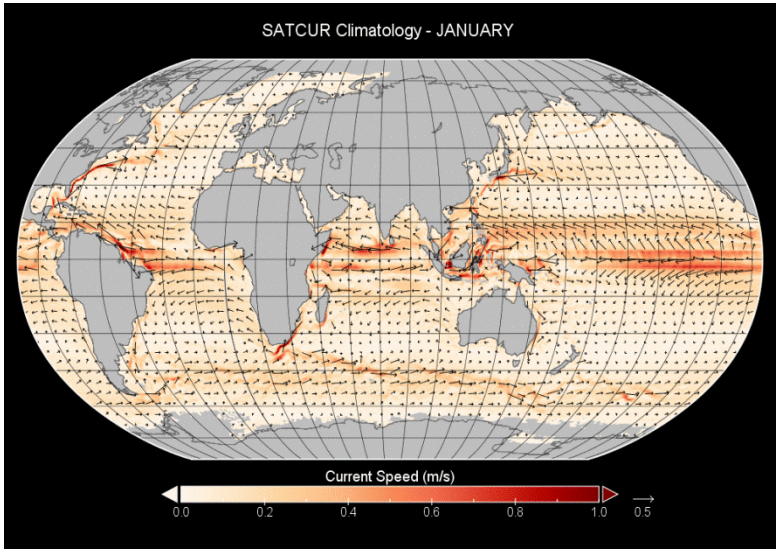
Period of data availability: 1993 - February 2021

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





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

New products: Winds, Water vapour, etc.

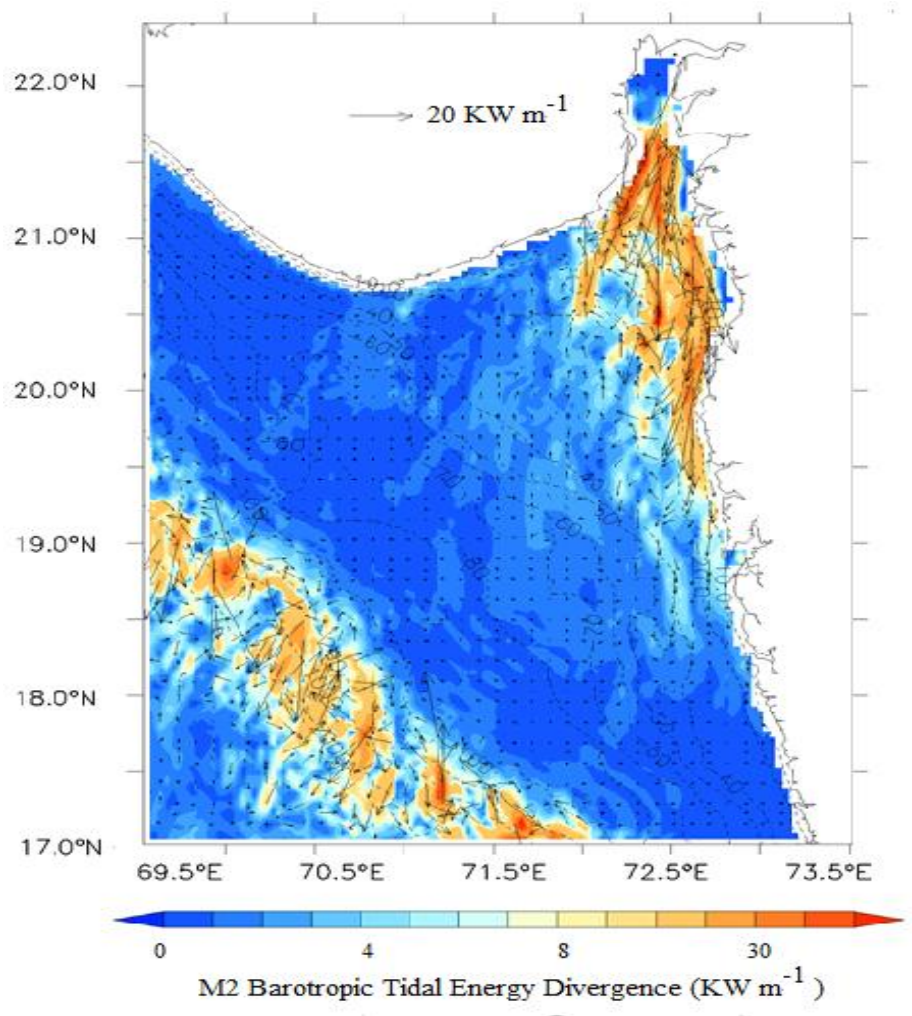
Harvestable Tidal Energy

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.



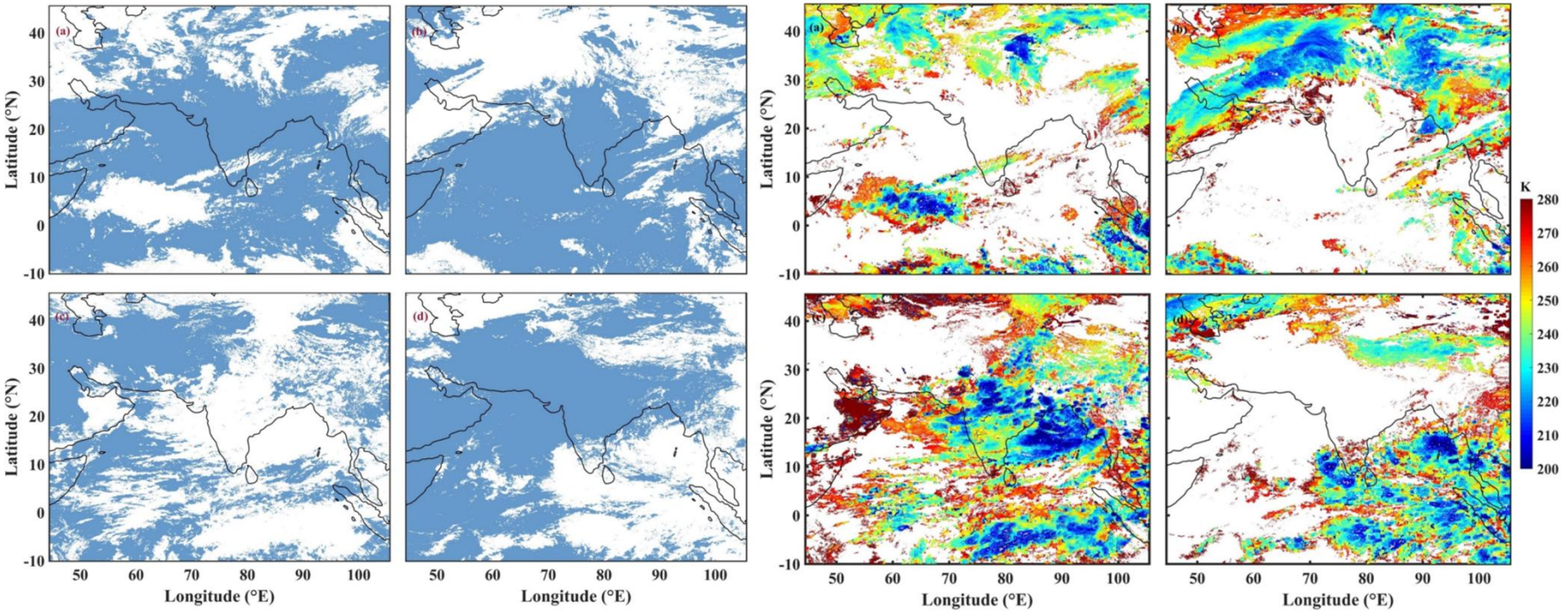
Color and arrows in the figure indicates tidal energy divergence

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



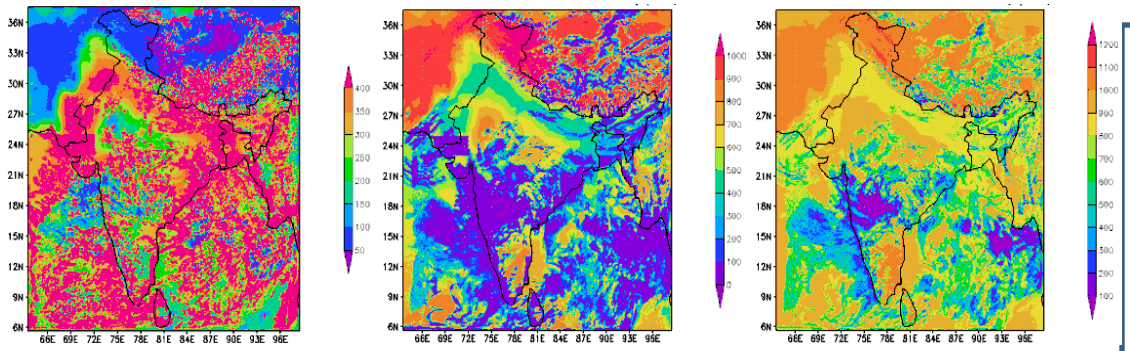
Users:

- **(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

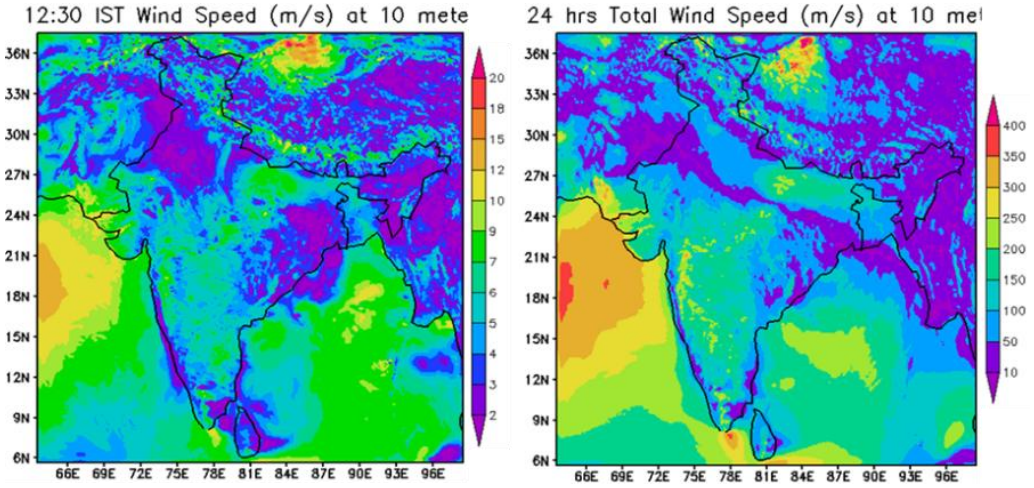
Diffuse | Direct | Global



As evaluated by the NTPC

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

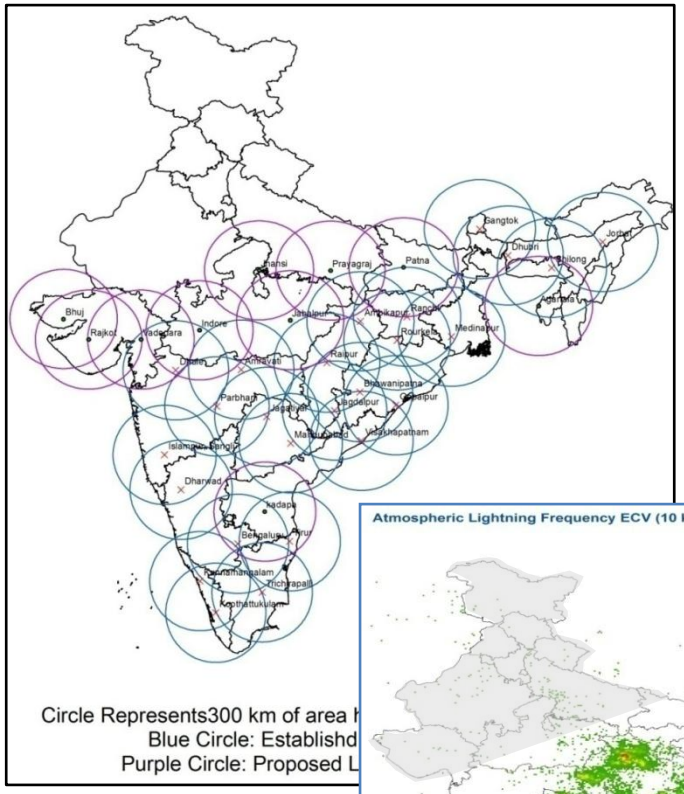
(observed - predicted < ± 200) = 80% *all-sky*

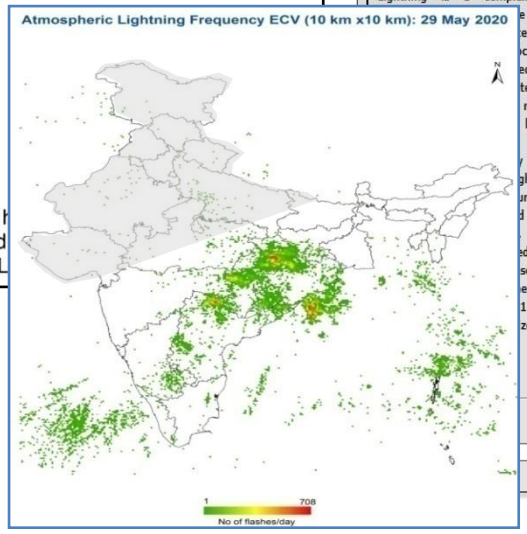


- **Objective: Day-ahead forecast of surface reaching solar radiation and wind speeds at 10m level using space technology.**
- **Study area: Over India at 15min interval.**
- **Satellite Data: LULC,AOD, SSA From OMI**
- **Benefits: Expected power production on various temporal and spatial scales.**

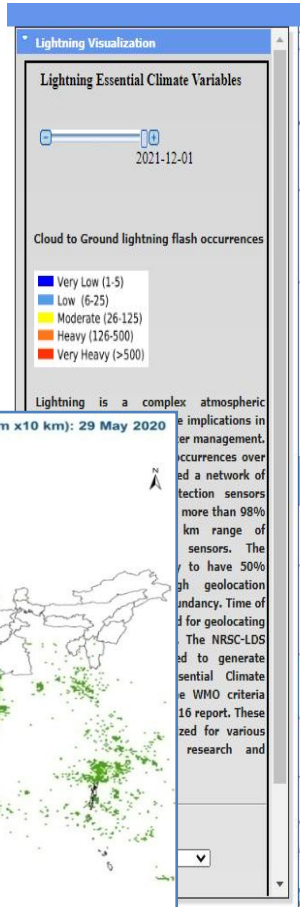
User: NTPC, Renewable Energy, Carbon footprint, Climate studies

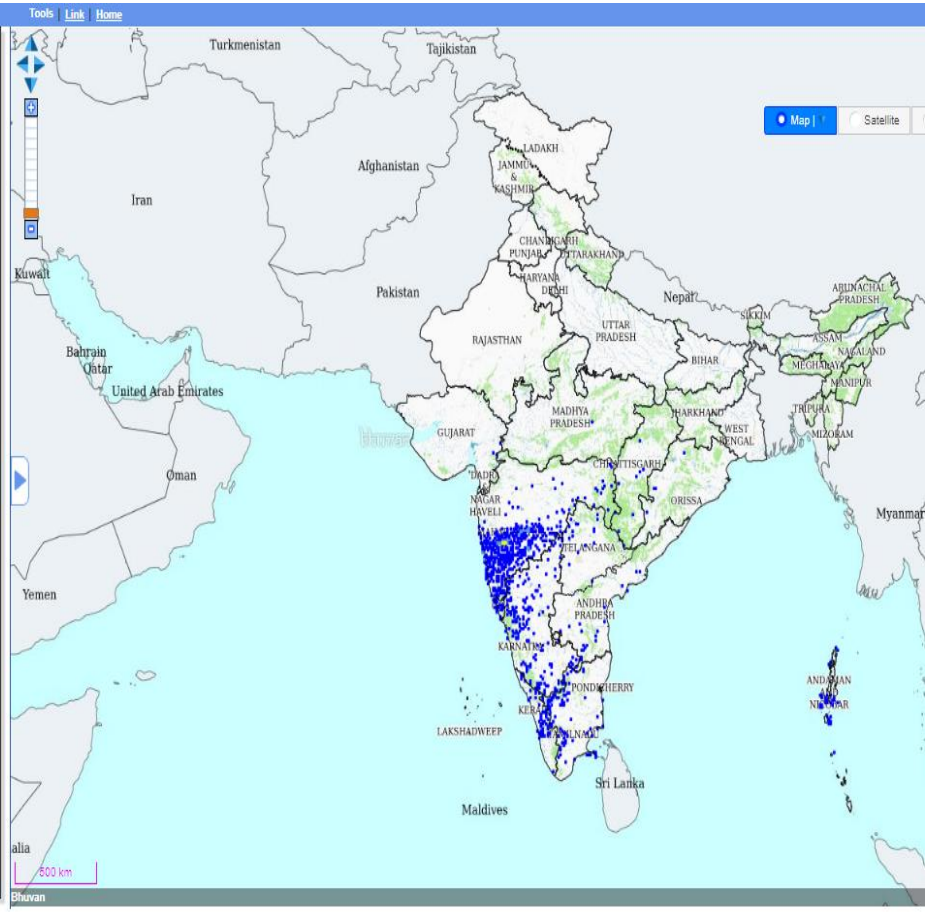
Atmospheric Lightning Detection Sensor Network





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



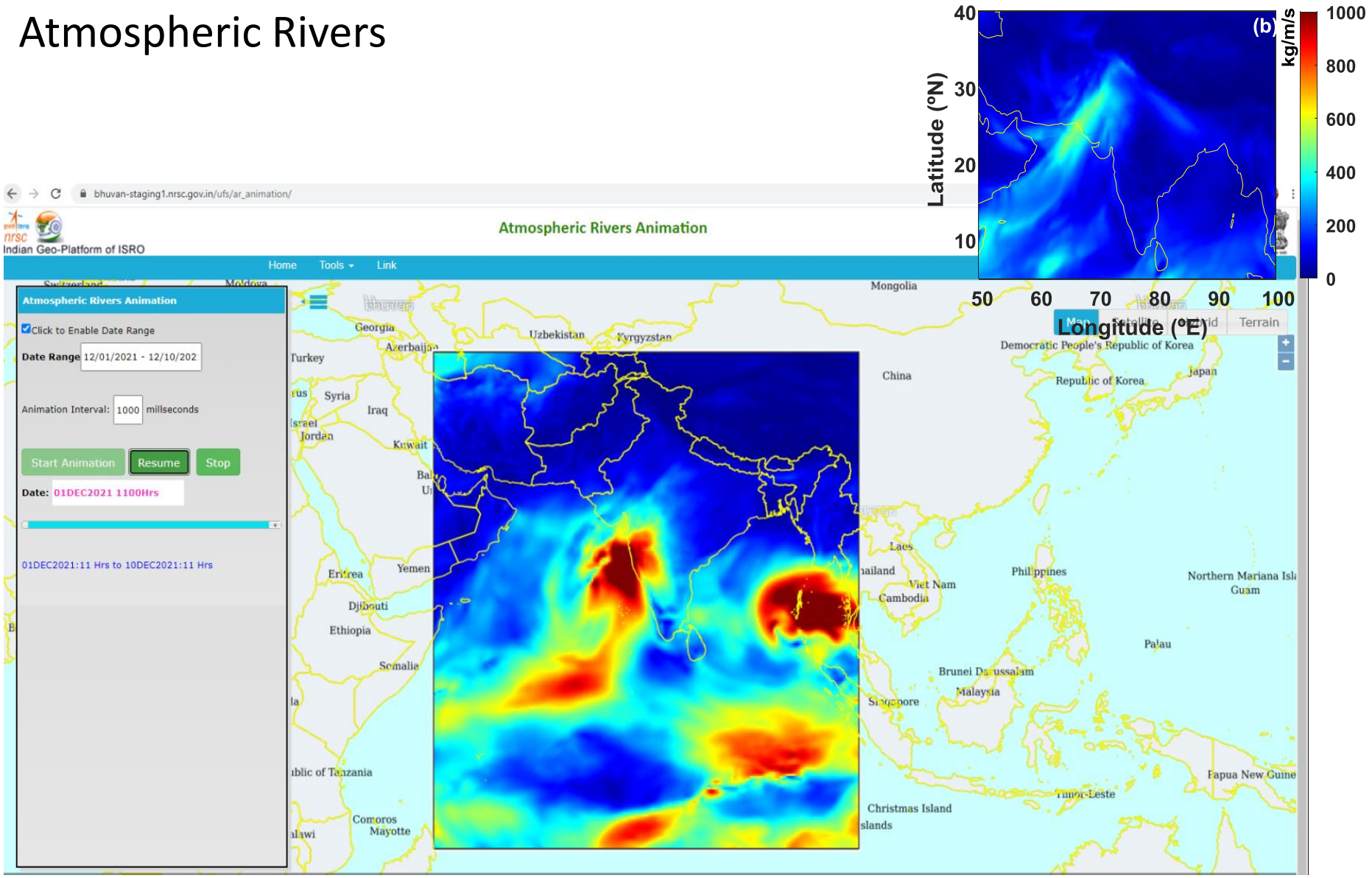


Prominent Registered Users (93+):

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....

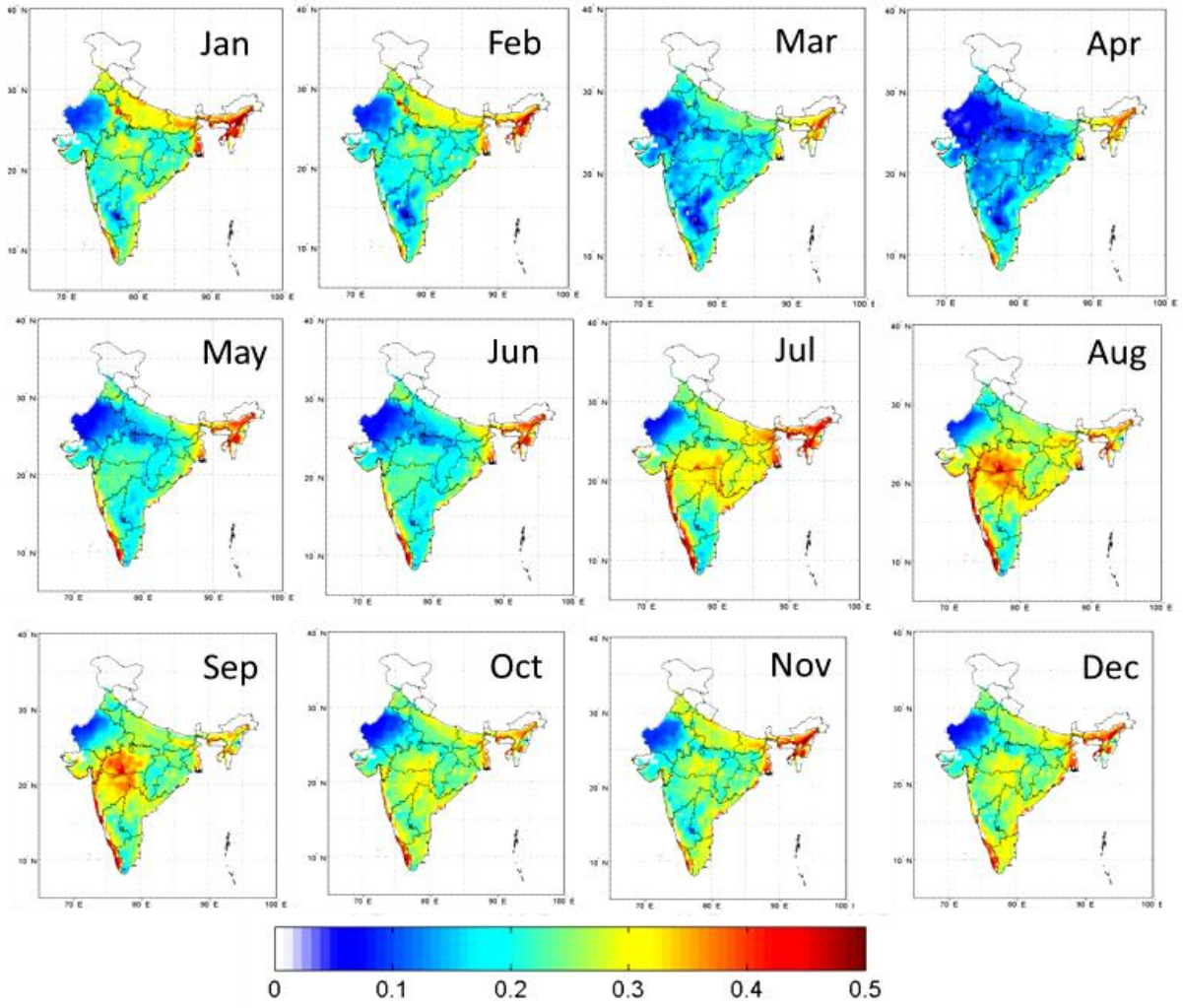
Atmospheric Rivers: Alerts

Atmospheric Rivers



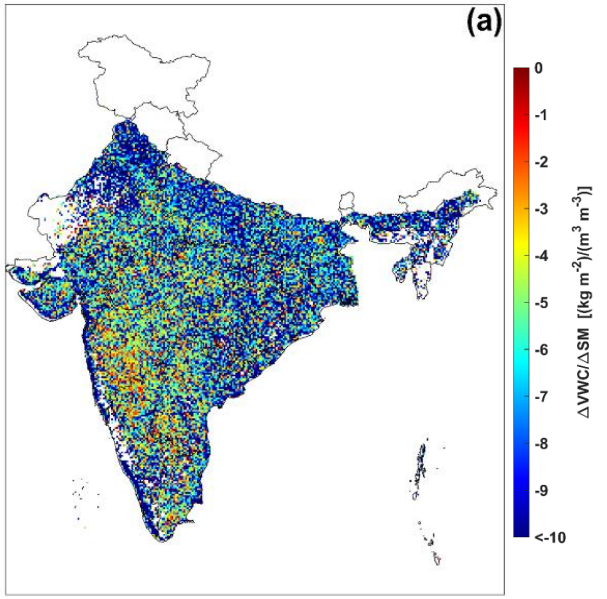
Nationwide Soil Moisture

19-year Soil Moisture data set from 2002 to 2021



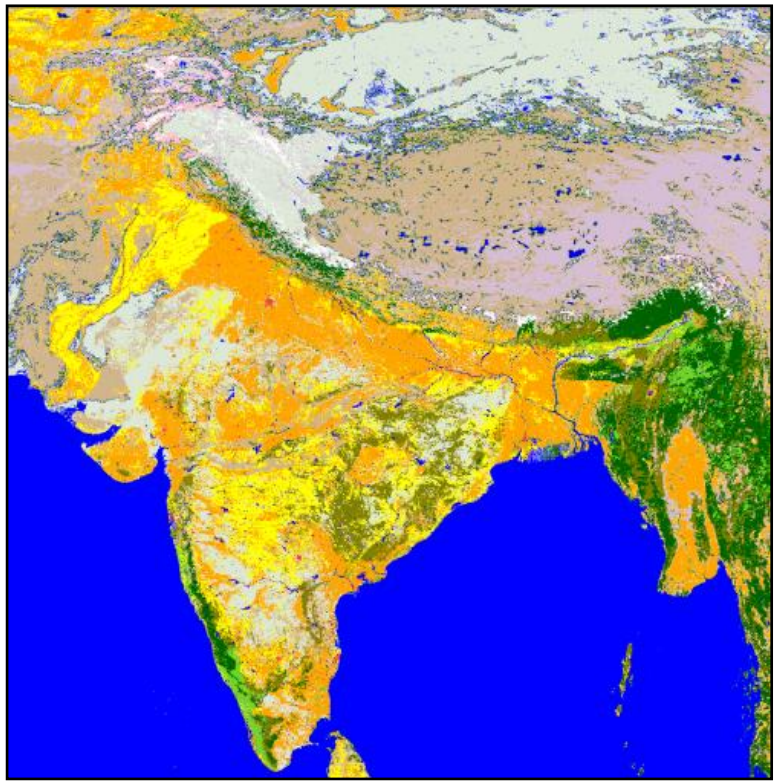
Monthly Averaged Soil Moisture (m3/m3)

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

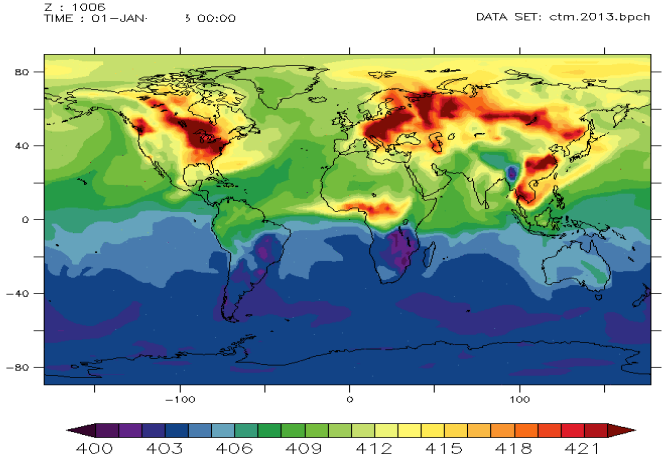
The land use land cover (LU/LC) data generated using 56m basic resolution AWiFS data from the Indian satellite IRS P6, has been remapped and scaled to 5 minute, 2 minute and 30 second resolutions. The Indian region of USGS data has been replaced with the AWiFS derived data such that it is compatible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

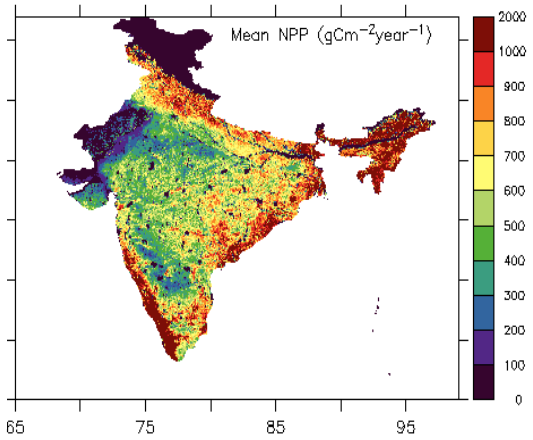
Model: Ecosystem and Carbon Cycle modeling

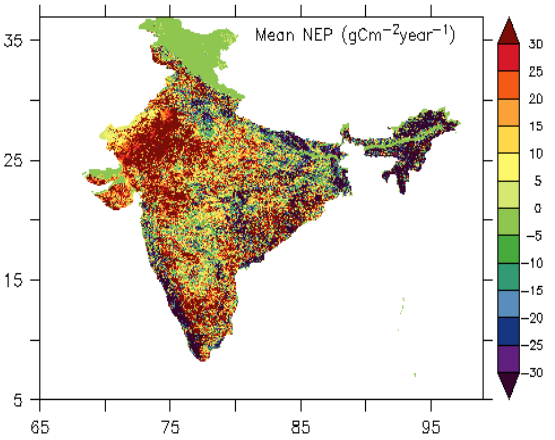
Aim to integrated regional data bases for better and comprehensive understanding of Carbon Cycle over India in response to the climate change (NDVI, LULC, soil attribute map, precipitation, solar radiation, air-temperature)

Simulated Surface Layer CO_2



Terrestrial Net Primary Productivity & Net Ecosystem Productivity





- NEP budgets of India during 1981-2020 shows Indian terrestrial Ecosystem is the net sink of atmosphere CO_2 during most of the years with mean NEP is 20 TgC Yr^{-1}

- These data are useful to assess the health of ecosystem, CO_2 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

Director
National Remote Sensing Centre
Indian Space Research Organisation
Department of Space, Govt. of India
Balanagar, Hyderabad
+91-40-23884001
director@nrsc.gov.in

Programme Director
National Information system for Climate and Environment Studies
Indian Space Research Organisation
Department of Space, Govt. of India
Balanagar, Hyderabad
+91-40-2388 4258/2377 1515
ddecsa@nrsc.gov.in