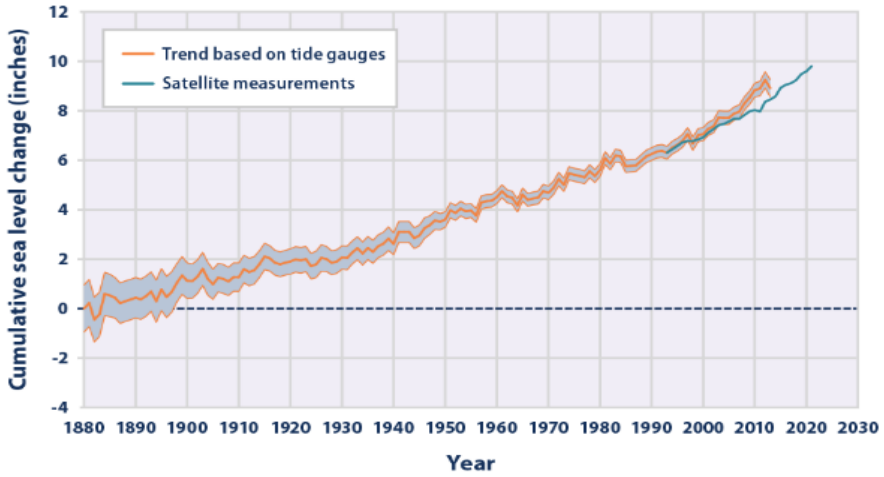
Ocean & Climate Studies Applications

Dr. P.V.Nagamani
Ocean Sciences Group (OSG)
Earth and Climate Science Area (ECSA)
National Remote Sensing Centre (NRSC)

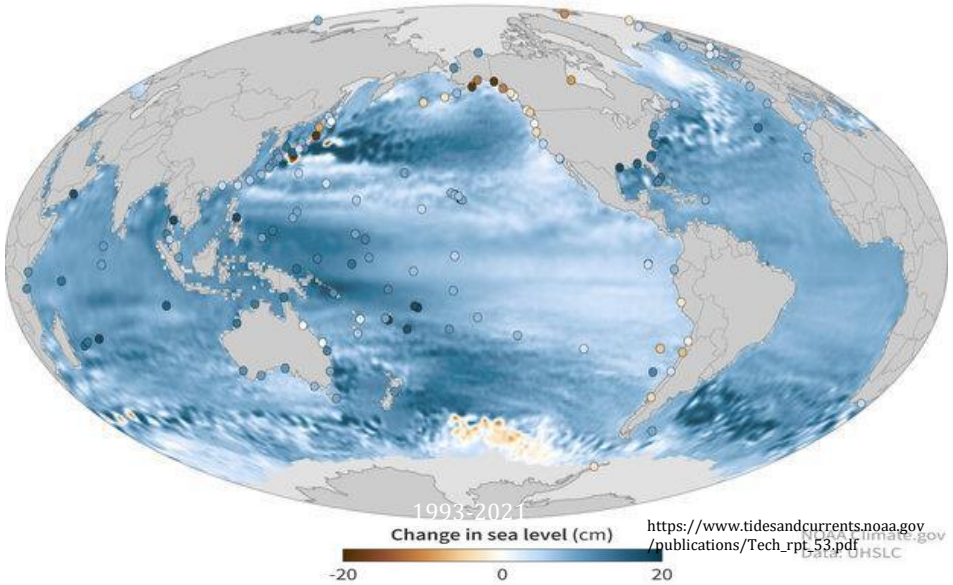
Climate Change : Oceans

By burning fossil fuels and other activities, humans are creating a thick blanket of green house gases around the Earth. This blanket of gases is trapping heat from the sun and warming up the planet. This is called Climate Change.



The Impacts

- *Sea Level Rise*
- *Coastal Flooding*
- *Marine Heat waves*
- *Ocean Acidification*
- *Impact on Marine Biodiversity (Fisheries)*
- *Changes in Ocean Ecosystems*
- *More & Severe Extreme Marine Events*



Why Oceans

Economic Value

Regulates weather & Climate
Produce **half** the **oxygen Carbon sequestration**-
absorb 30% of CO_2 emissions

$3-6 trillion/year
Goods and services: ~ $2.5 trillion/year

Fishery - US$401 billion/year
Employment- 60 million people
20 % of avg. animal protein for 3.3 billion people

Minerals & Oil
Oil reserves- 41 Gt
(28% of the total production)
Gas reserves- 65 trillion m^3

Transportation: 70-90 % of trade

Recreation
upto 50% GDP
Major economy for coastal & Island countries
- Scuba diving
- Water sports
- Cruise liners

Ecological Value

80 % of the planet's biodiversity

Coastal protection
Prevention of erosion
Water purification

Critical Habitats

Blue Carbon
Mangroves, seagrass & seaweeds **remove** C
from atmosphere **10 times faster** than
rainforest

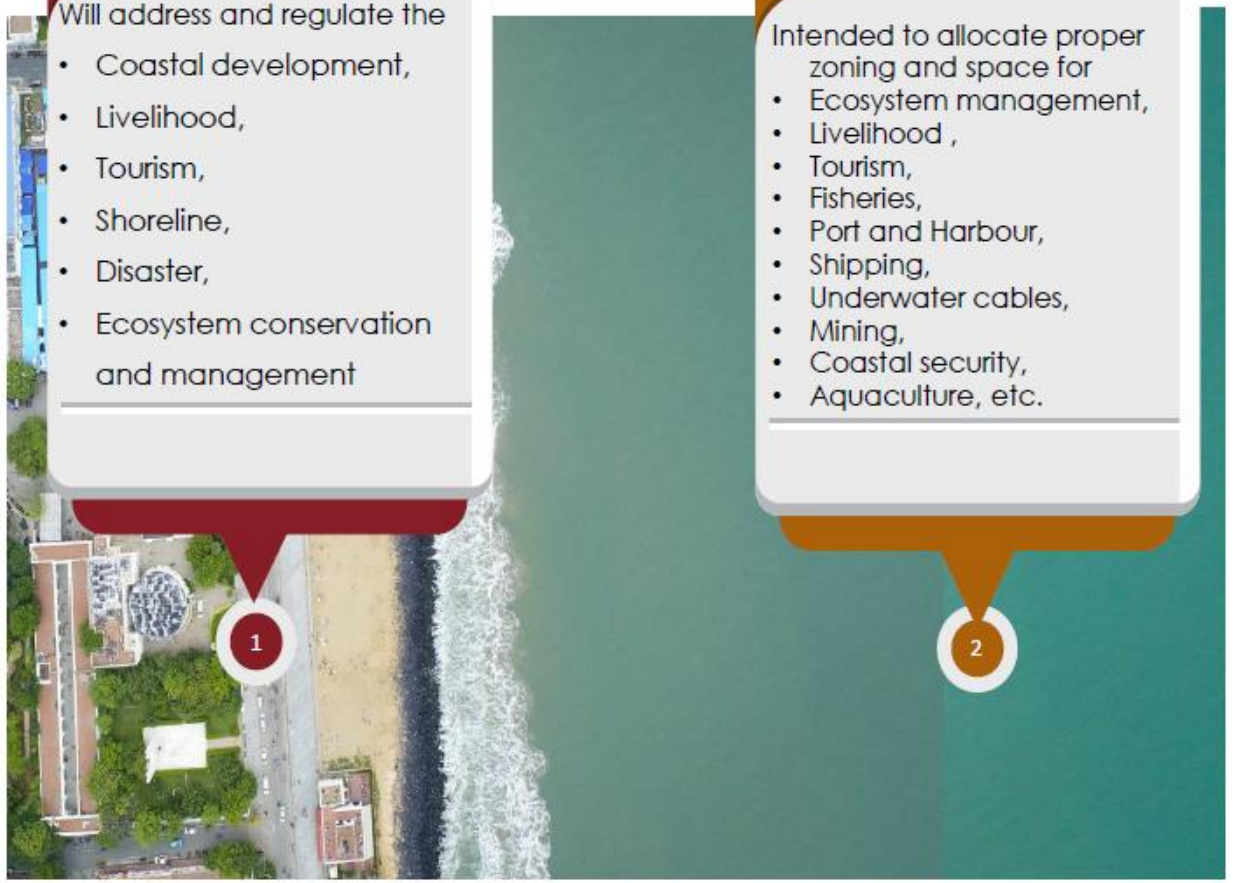
Why Oceans

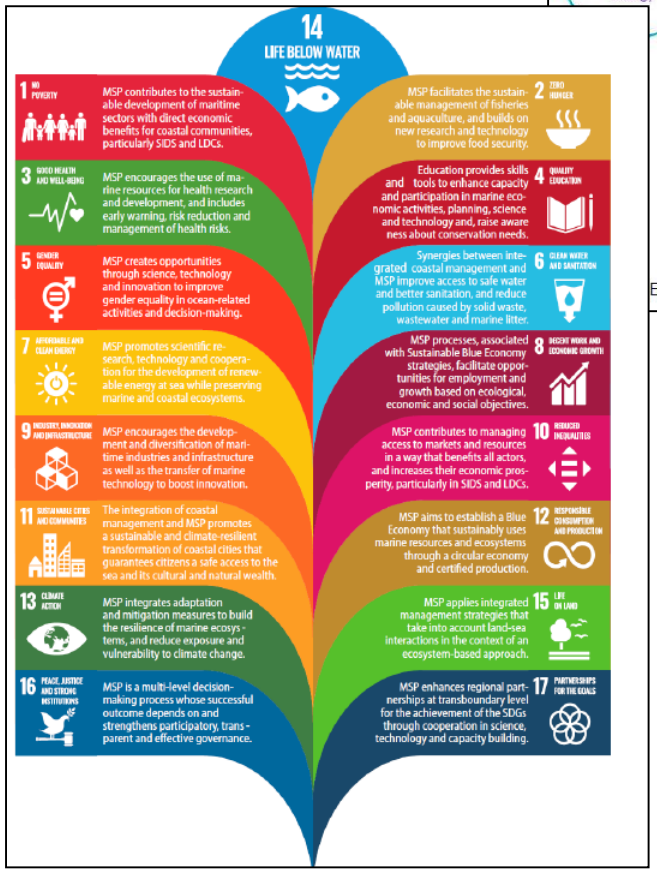
ICZM
(LTL to 500m landward)

Will address and regulate the
- Coastal development,
- Livelihood,
- Tourism,
- Shoreline,
- Disaster,
- Ecosystem conservation and management

MSP
LTL to EEZ (200 nm)

Intended to allocate proper zoning and space for
- Ecosystem management,
- Livelihood ,
- Tourism,
- Fisheries,
- Port and Harbour,
- Shipping,
- Underwater cables,
- Mining,
- Coastal security,
- Aquaculture, etc.

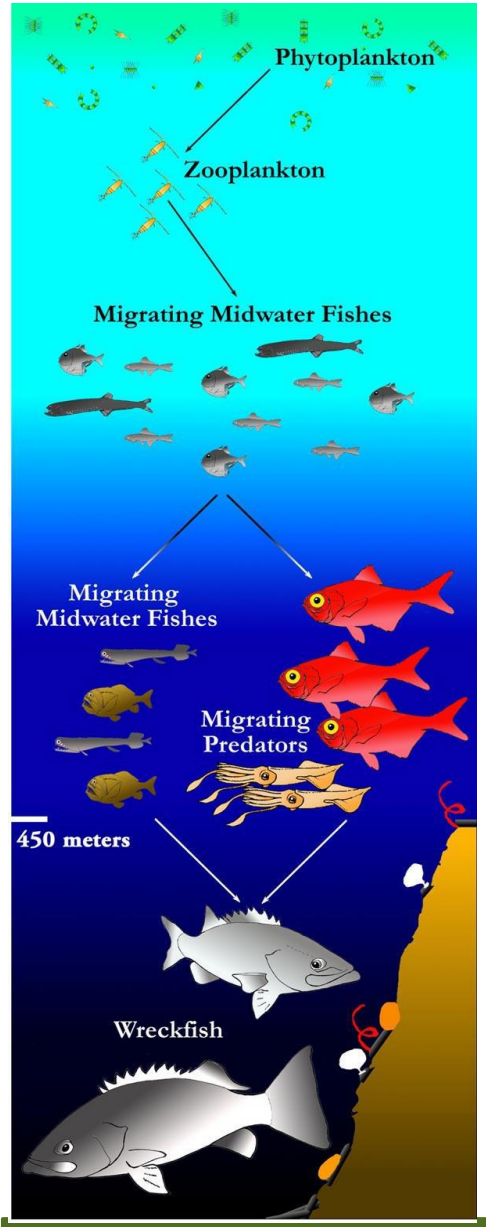




Economy will integrate and implement all the activities from different sectors

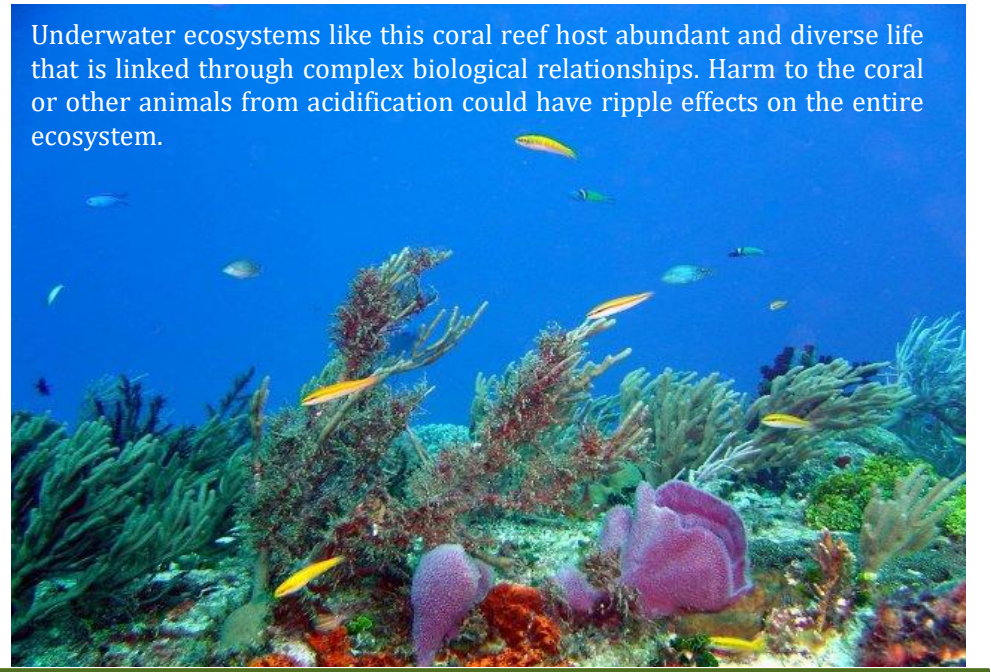
Source : ECONOMIC ADVISORY COUNCIL TO THE PRIME MINISTER, 2021 (NCCR)

Effects of Ocean and Coastal Acidification on Ecosystems



- Ocean life is very diverse, and increased acidity can harm or help individual plant and animal species in different ways.
- Some organisms are likely to become more abundant, and others less.
- For example, seagrasses may grow faster if more dissolved carbon dioxide is available, while the number of oysters may decrease as fewer larvae complete their life cycle due to increased acidity.
- If acidification reduces the populations of small animals like clams, oysters, and sea urchins, the larger animals like fish that feed upon those could run short of food, and soon up the food chain.

Food webs
Ecosystems
Ecosystem services
Traditional tribal fisheries



Underwater ecosystems like this coral reef host abundant and diverse life that is linked through complex biological relationships. Harm to the coral or other animals from acidification could have ripple effects on the entire ecosystem.

Climate Indicators

Ocean Heat

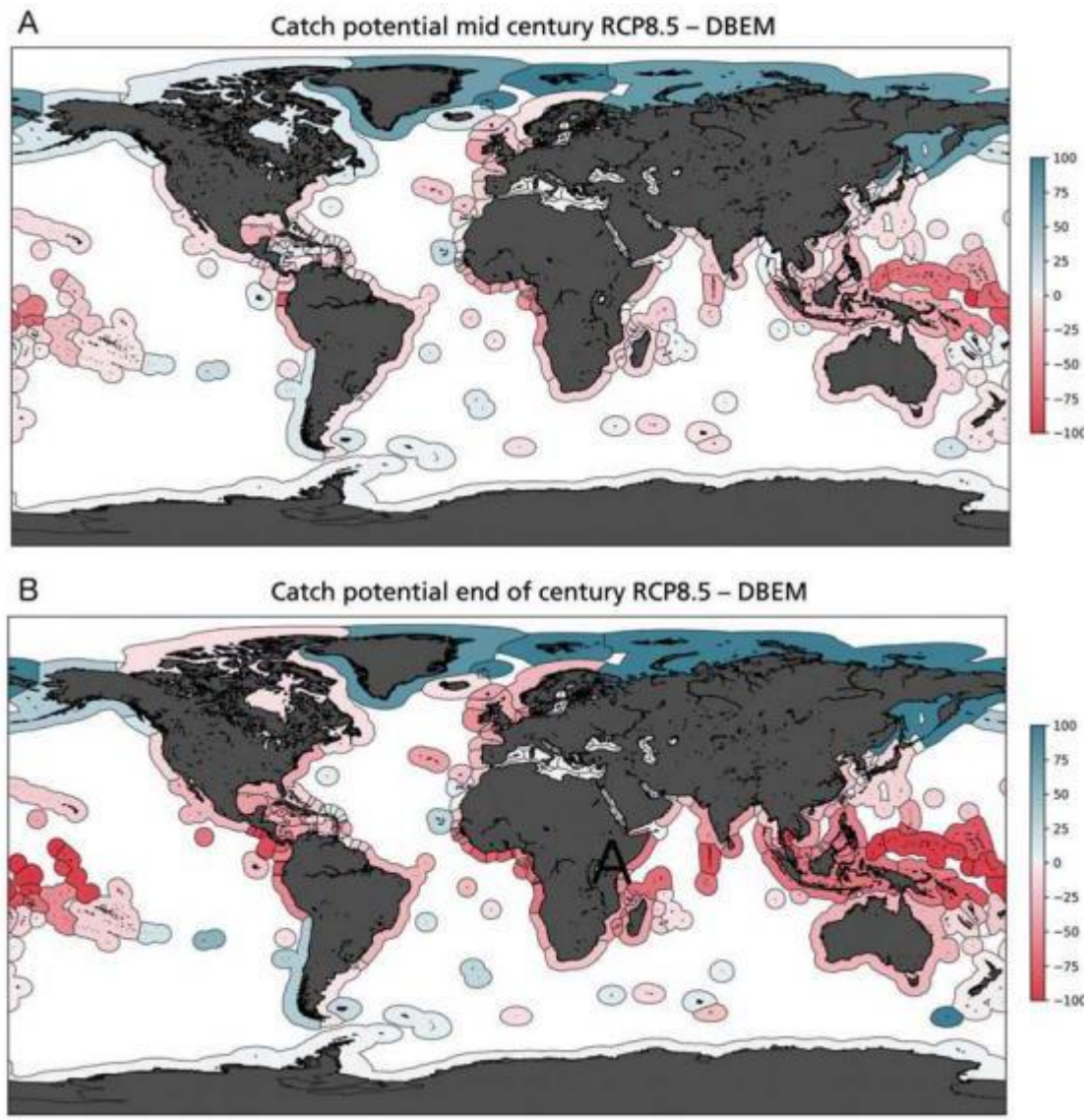
Ocean Acidity

Sea Surface Temperature

Marine Species Distribution

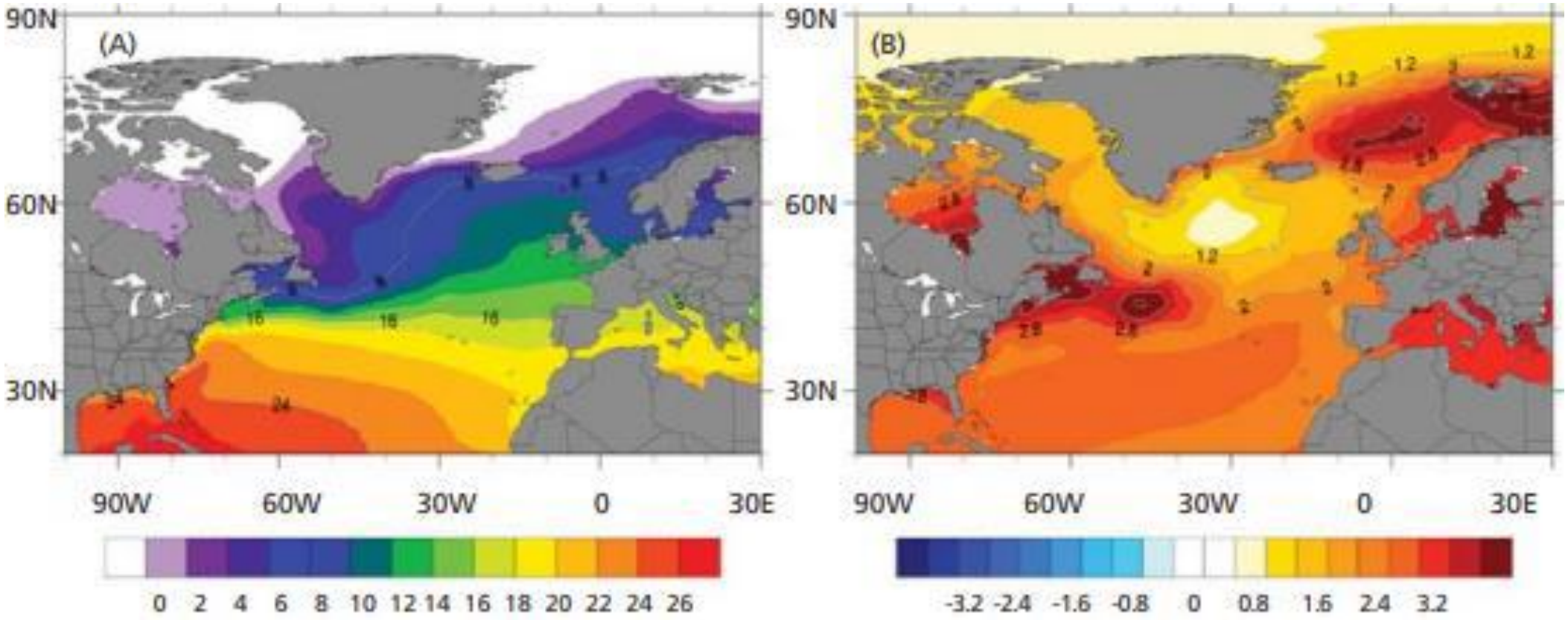
Atmospheric Concentrations of GHGs

Maximum Catch Potential: Model Approach



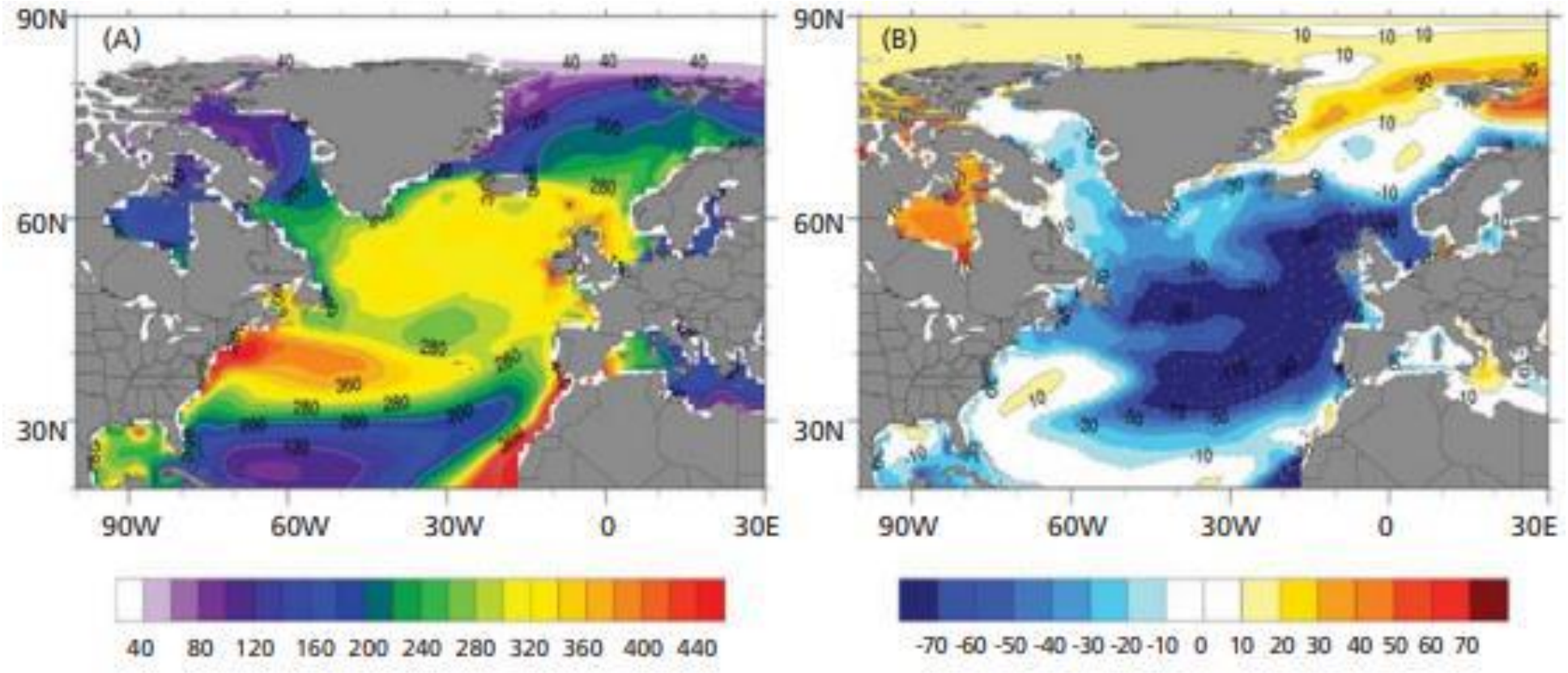
Projected changes in maximum Catch Potential (%) under RCP 8.5 by 2050 (A: 2046 to 2055) and 2095 (B: 2091 to 2100) for the DBEM projection

Sea Surface Temperature: Model Prediction



Sea Surface Temperature (CMIP5) interpolated on a 1x1 grid. (A) Mean climate from the historical experiment for the period (1956to2005); (B) difference in the mean climate in the future time period (RCP8.5:2050to2099).

Primary Productivity: Model Prediction



Sea Surface Temperature (CMIP5) interpolated on a 1x1grid. (A) Mean primary organic carbon production by all types of phytoplankton for the period (1956to2005); (B) difference in the primary productivity in the future time period (RCP8.5:2050to2099).

Climate Adaptation

What We Can Do.....

Reduction of climate change impact on the marine environment in many ways, include:

•**Adapt fishery management**: Fishing professionals and government officials can help people adapt to climate change by changing policies and practices to avoid over fishing and maintain healthy marine ecosystems.

•**Diversify fisheries**: Aquaculture, or sea food farming, helps build resilience against climate change.

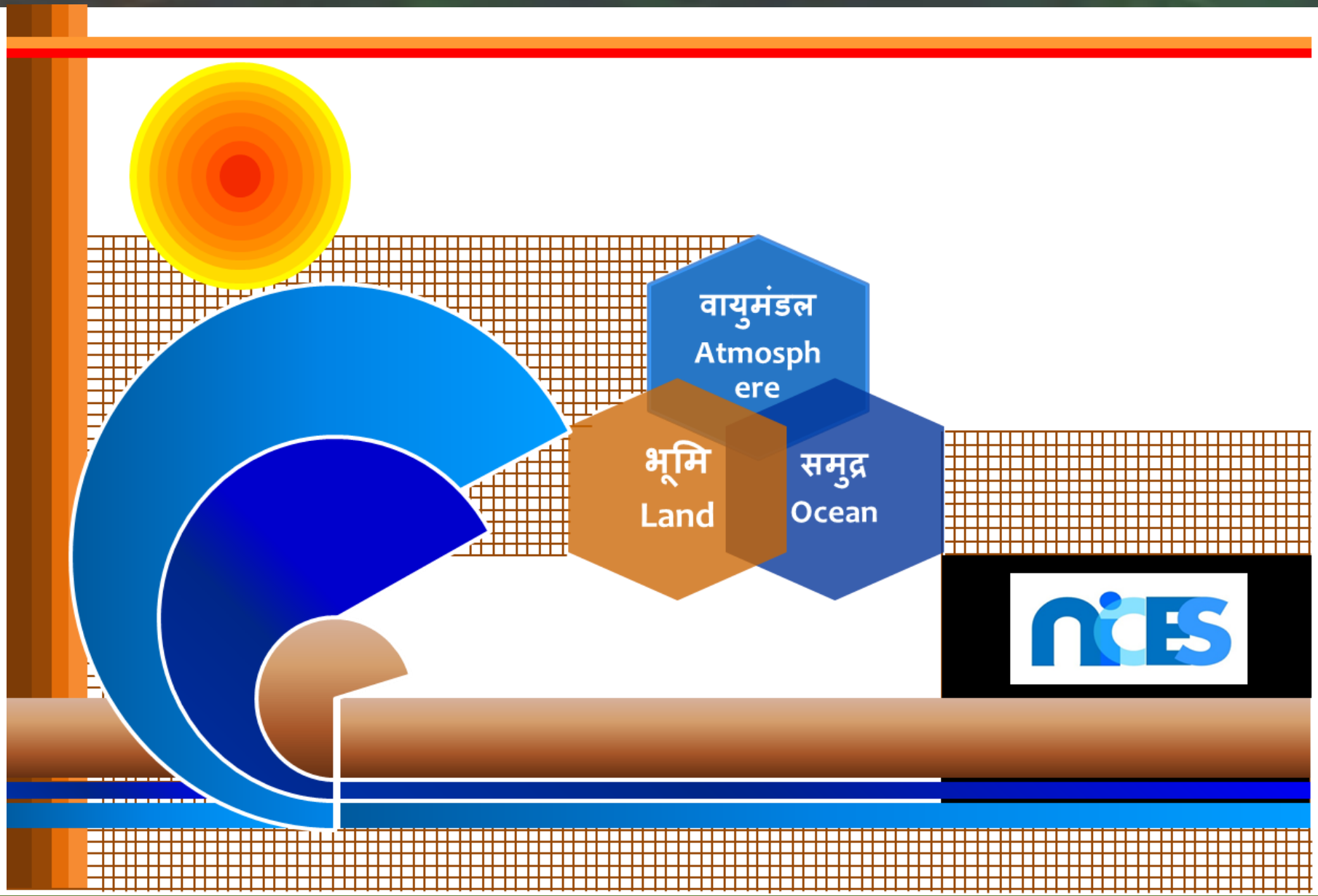
•**Reduce energy use**: Every one can take steps to lower carbon emissions, which can help reduce ocean warming and acidification.

•**Shop sustainably**: Plan your meals with sustainably harvested sea food to keep ocean ecosystems healthy. These are fish and shell fish that have been caught using sustainable techniques and management practices.

•**Recreate responsibly**: Help protect coral reefs. When boating, be careful not to let anchors damage coral reefs or sea grass beds. Never touch coral reefs when diving or snorkelling. Also avoid using sun screens containing chemicals that can harm marine life.

Way Forward.....

जलवायु और पर्यावरण अध्ययन के लिए राष्ट्रीय सूचना प्रणाली
National Information System for Climate and Environment Studies



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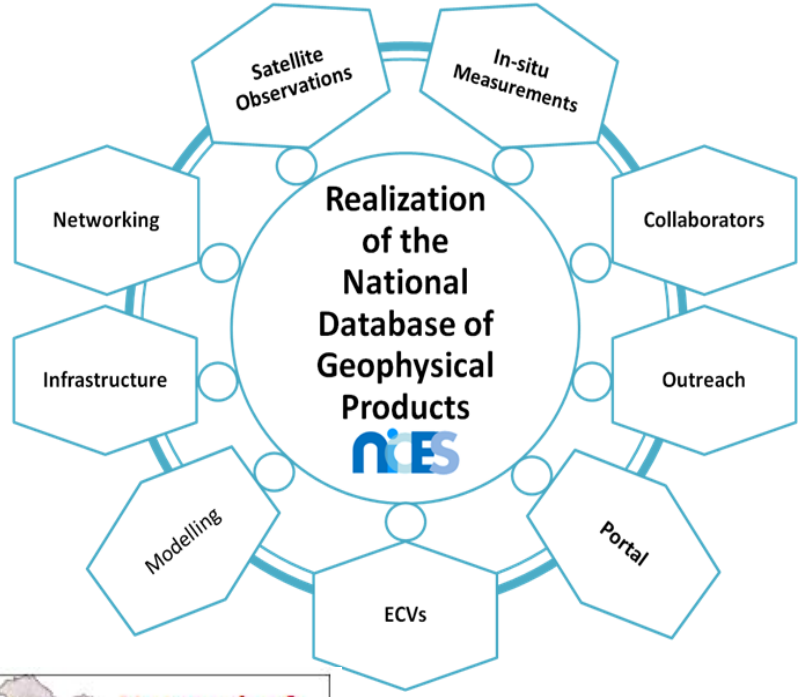
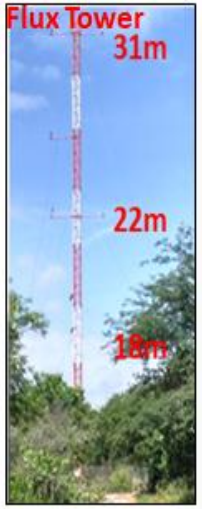
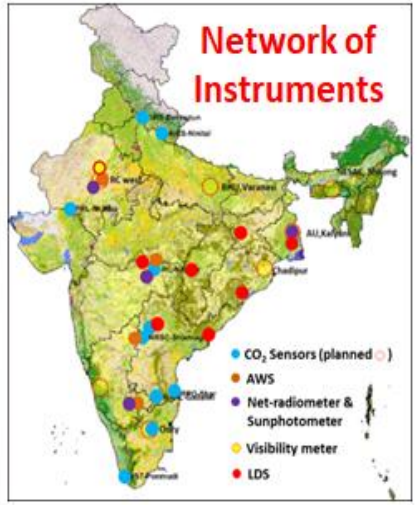
National Information System for Climate and Environment Studies

- Established in **September 2012**, for Realization of nation level database of long term, consistent climate quality **geo/bio-physical products** pertaining to Terrestrial, Ocean, Atmosphere and Cryosphere for climate change studies
- **Multi-institutional endeavour** (ISRO & other Scientific Organisations/Ministries) with contribution (*in-situ* observational & model outputs) from participating institutions
- **Observational network** for **calibration & validation**
- Use of **Essential Climate Variables** (**ECVs**) for **impact assessment, adaptation, vulnerability, mitigation,** etc.
- **Infrastructure, web-enabled services** and **product dissemination – NICES** under ISRO's geo-portal '**Bhuvan**'







Objectives

- Establishment and development of **linkages** with appropriate **observational networks,** and **calibration & validation sites.**
- Bio-geophysical parameter retrieval and development of methodologies for Essential Climate Variables **(ECVs)** generation **from Indian EO missions.**
- Acquisition and processing of international missions data and other relevant parameters to support Indian EO ECVs, cal/val experiments, and **generation of long term data records.**
- **Generation of spatially & temporally blended ECV products** based on Indian, foreign satellites and *in situ* observations through multi-institutional participation.
- To establish necessary infrastructure, including hardware and software for NICES and establishment of **NICES portal.**
- Development of methodologies to carry out scientific studies with national organisations in **using ECVs for impact assessment, adaptation, vulnerability, mitigation, etc.**
- To develop **outreach** and interaction mechanism **for the effective dissemination and scientific utilization of NICES ECVs** and **collaboration in the area of climate and environment.**
- **Capacity Building**

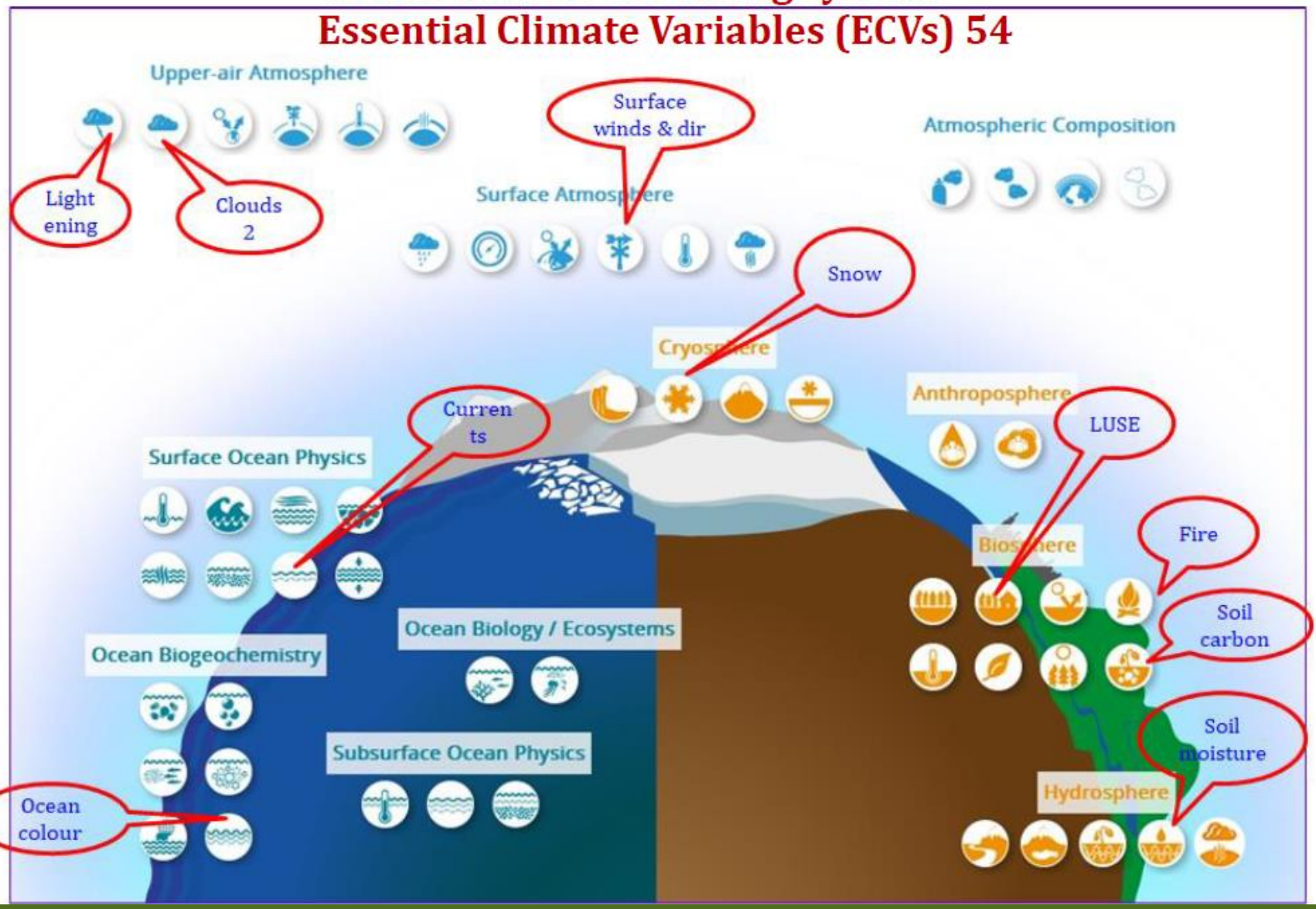
NICES Linkages:

- Ministry of Environment and Forest & Climate Change
- Department of Science and Technology
- Ministry of Earth Sciences
- Council of Scientific & Industrial Research (CSIR)
- Other Institutions & Academia (TERI, ICAR, IISc, IITs, NITs, Universities, etc)

Essential Climate Variables (ECVs)

- ECV is a physical, chemical, or biological variable or a group of linked variables that critically contribute to the **characterization** of Earth's climate.
- ECV datasets provide the empirical **evidence** needed to understand and predict the evolution of climate, to guide mitigation and adaptation measures, to assess risks and enable attribution of climatic events to underlying causes, and to underpin climate services.
- **Criteria for ECVs :** ***Relevance, Feasibility and Cost Effectiveness***
- **Current Status:**
- Currently **28 of 54** ECVs are amenable through satellites either directly or indirectly.
- Out of which, **15** ECV products are made available through NICES portal (Albedo, Surface water bodies, Soil moisture, Land cover, Lightning, Cloud fraction, cloud top temperature, Derived tropospheric ozone, Ocean surface current, Sea level, Ocean colour, Total alkalinity, Dissolved inorganic carbon, pCO2 and Snow cover)

Essential Climate Variables (ECVs)



Essential Climate Variables (ECVs)

Terrestrial (30)

Geophysical: **Albedo**, NDVI (**4**)

Hydrology: **Surface water bodies, 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: Ann forest fire density, sd of AFFD, length of fire, f-forest, forest types, NSA, KSA, RSA, f-FA, NEP, NPP (**11**)

Ocean (26)

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 (1)

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

Atmospheric (5)

- **Number of Lightnings**
- **Cloud fraction, cloud top temperature**
- **Boundary layer height**
- **Derived tropospheric ozone**

Cryospheric (5)

- **Snow melt and freeze (Indian Himalaya)**
- **Snow melt and freeze (Antarctica)**
- **Snow cover fraction**
- **Himalayan glacial lakes and water bodies**
- **Snow albedo**

Total 64 geo-biophysical products

15 of them can be taken up for ECV

Ocean Studies

Ocean Remote Sensing:

- Generation of Long-term Chl-a, Ocean Heat Content, Winds & Currents,
- Improved Atmospheric Correction - NRT Data
- Inherent Optical Properties for Retrieval of Rrs, PFTs & PSCs
- FLH based Chl & Phytoplankton Blooms Detection
- Detection of Phytoplankton Functional Types & Size Classes
- Ocean Primary Productivity Estimation
- Regional Sea Level Variability
- Fusion of Shallow Water Bathymetry (Optical & SAR)
- Member of OS-3 ATBD and Cal/Val Team

Ocean Bio-Geo-Chemistry:

- Generation of TA*, DIC* Maps
- Air-Sea Fluxes of CO2 in BoB
- Hydro-Geochemistry of Cauvery Basin
- Ocean Acidification (Long Term In-Situ pH, TA in BoB)

Coastal Ecosystem Dynamics:

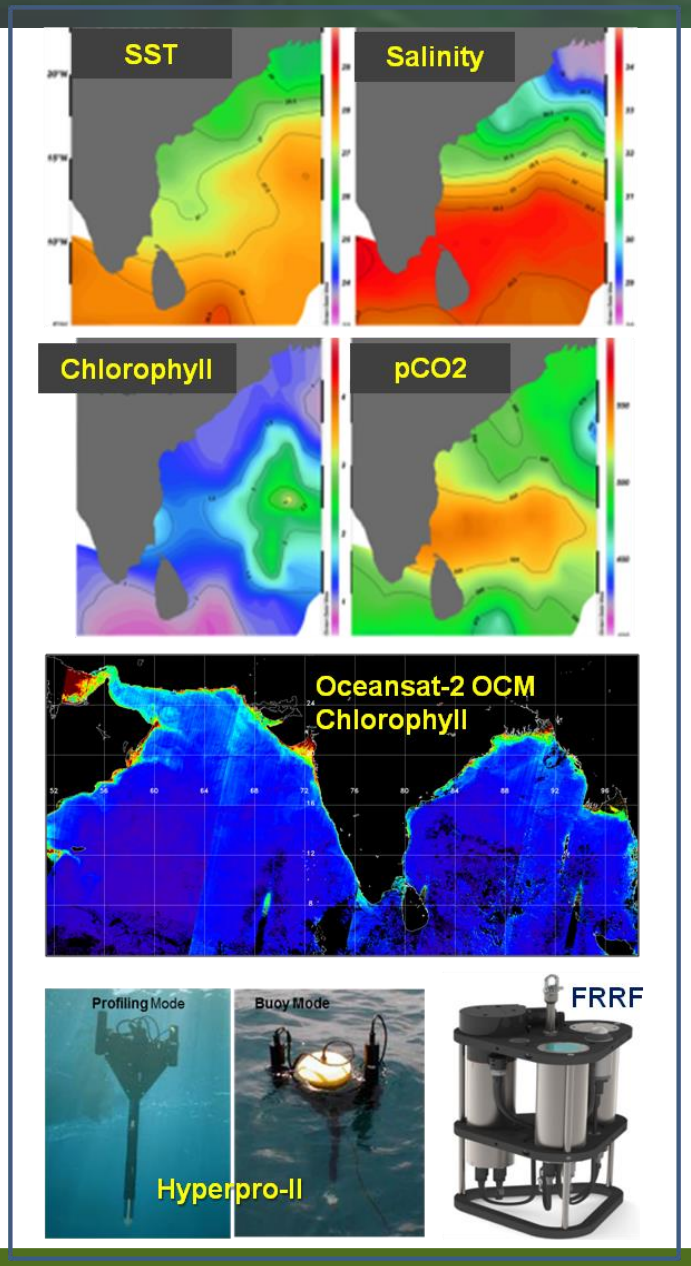
- Health of Ecosystems of Indian Coasts
- Aquatic Invasive Species - Quantitative Assessment

Permafrost Studies (Polar & Himalayan Regions)

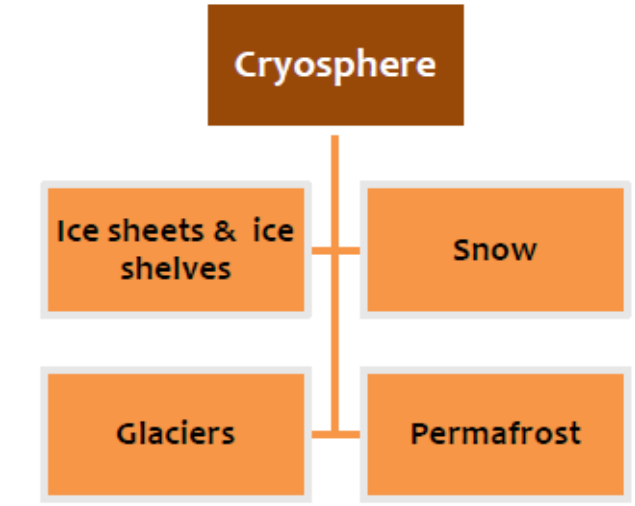
- Establishment of Permanent Permafrost Monitoring Site in Svalbird and Planning in Indian Himalayas

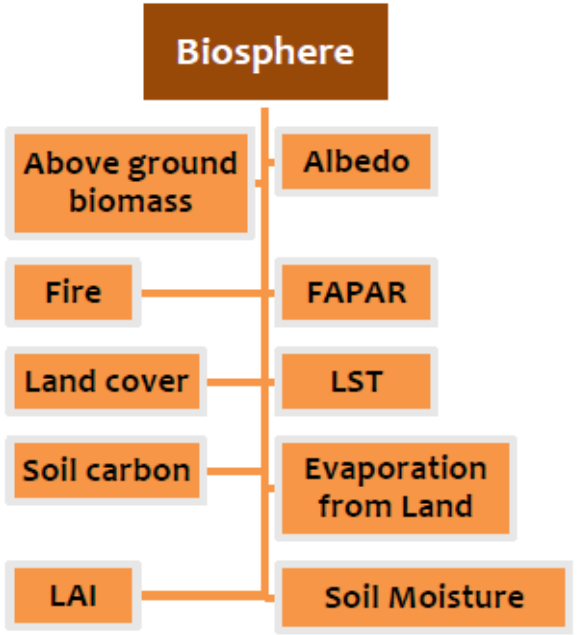
Field Data Collection & Utilization Programmes:

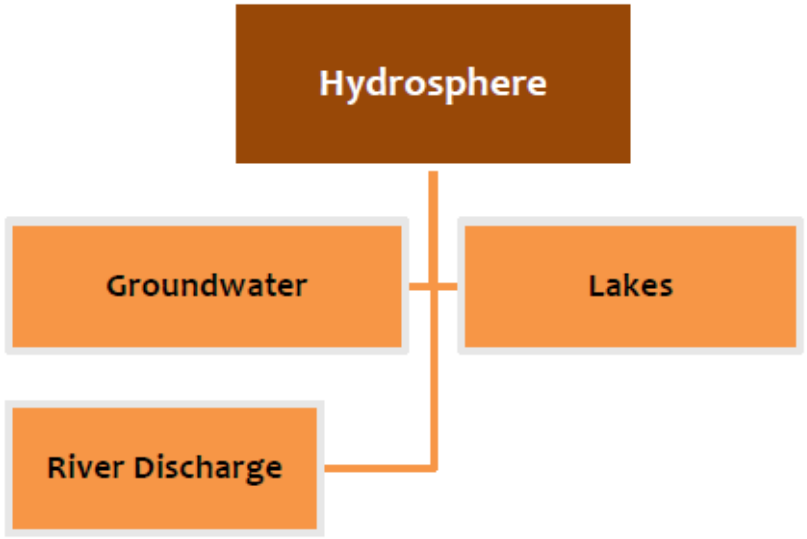
- Coastal and Open Ocean Cruises
- Ocean Monsoon Mixing (OMM)
- Expeditions - Southern Ocean, Arctic & Antarctic

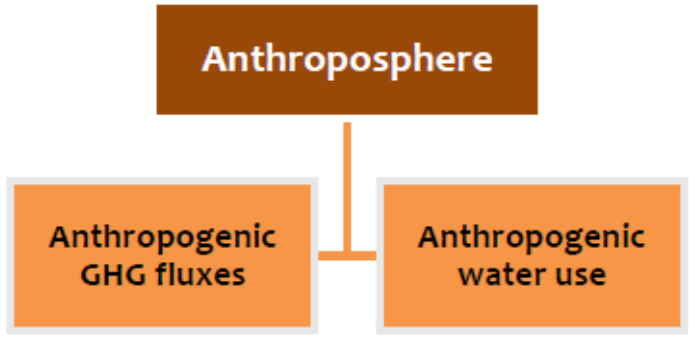


Global ECVs as per GCOS-240 (2021 report) - Terrestrial

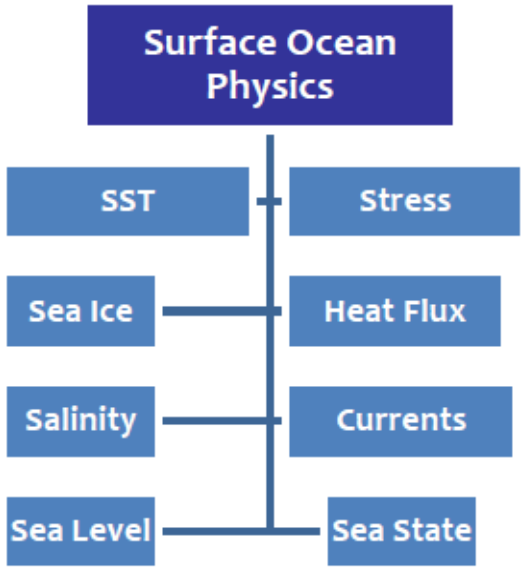


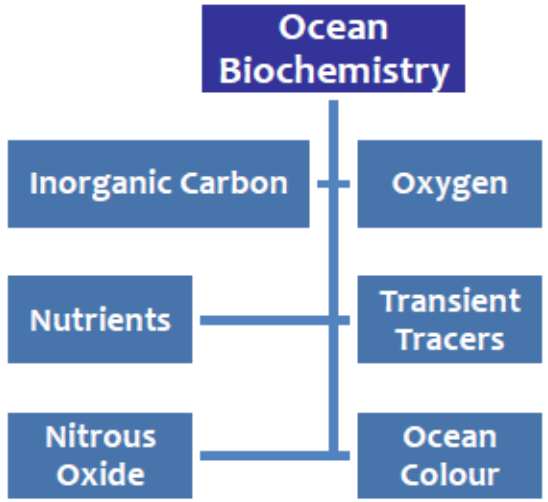


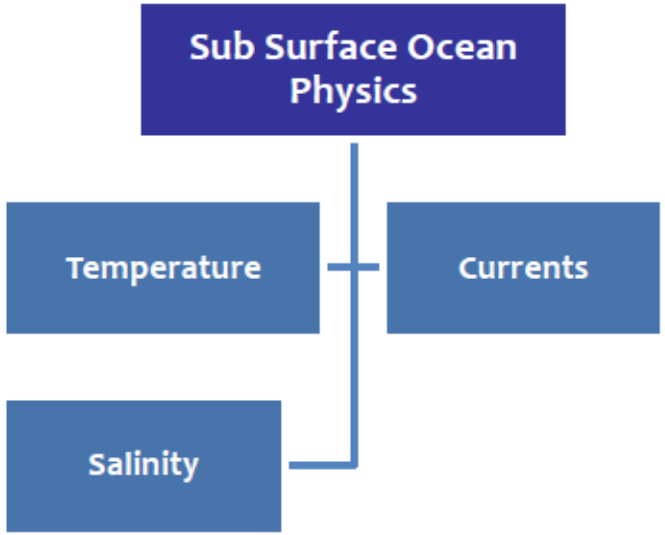


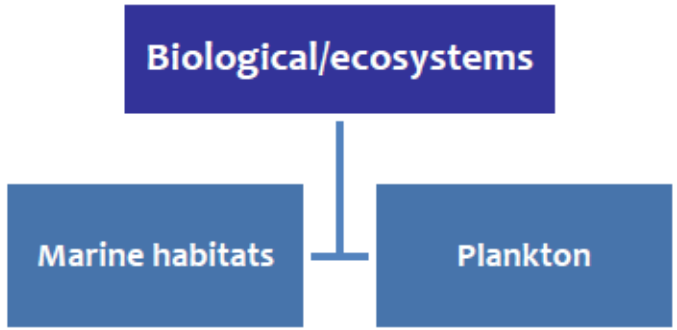


Global ECVs as per GCOS-240 (2021 report) - Ocean

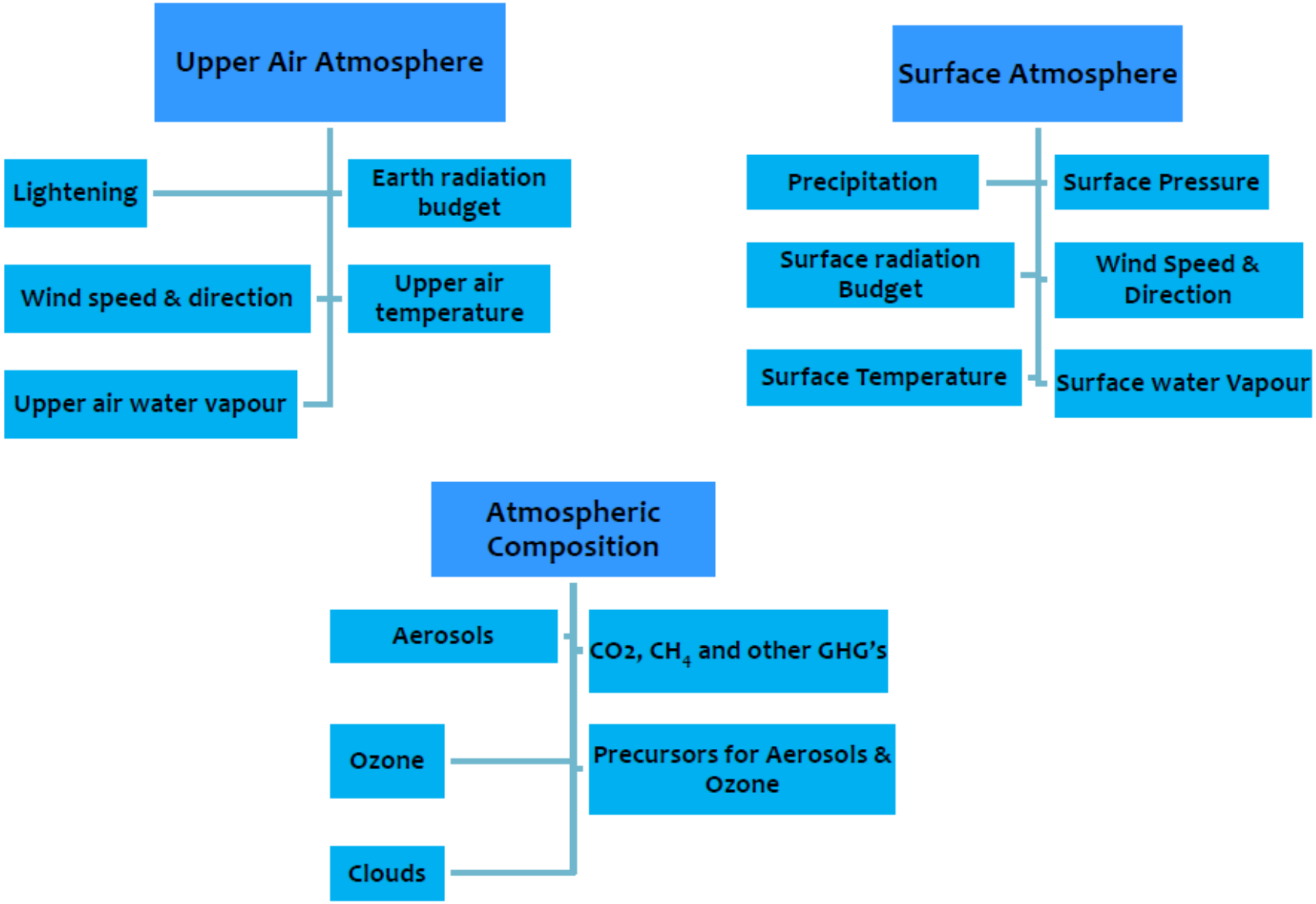








Global ECVs as per GCOS-240 (2021 report) - Atmosphere



NICES Products : Over View

Domain	ECV	Near future	Non-ECV products retrieved	Derived	Satellite + Model based products	Total
Terrestrial	5	1	16	8	5	35
Ocean	3	2	5	11	8	29
Atmosphere	2(+1)	1	0	2	0	6
	10(+1)	4	21	21	13	70

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.

NICES Products : Over View

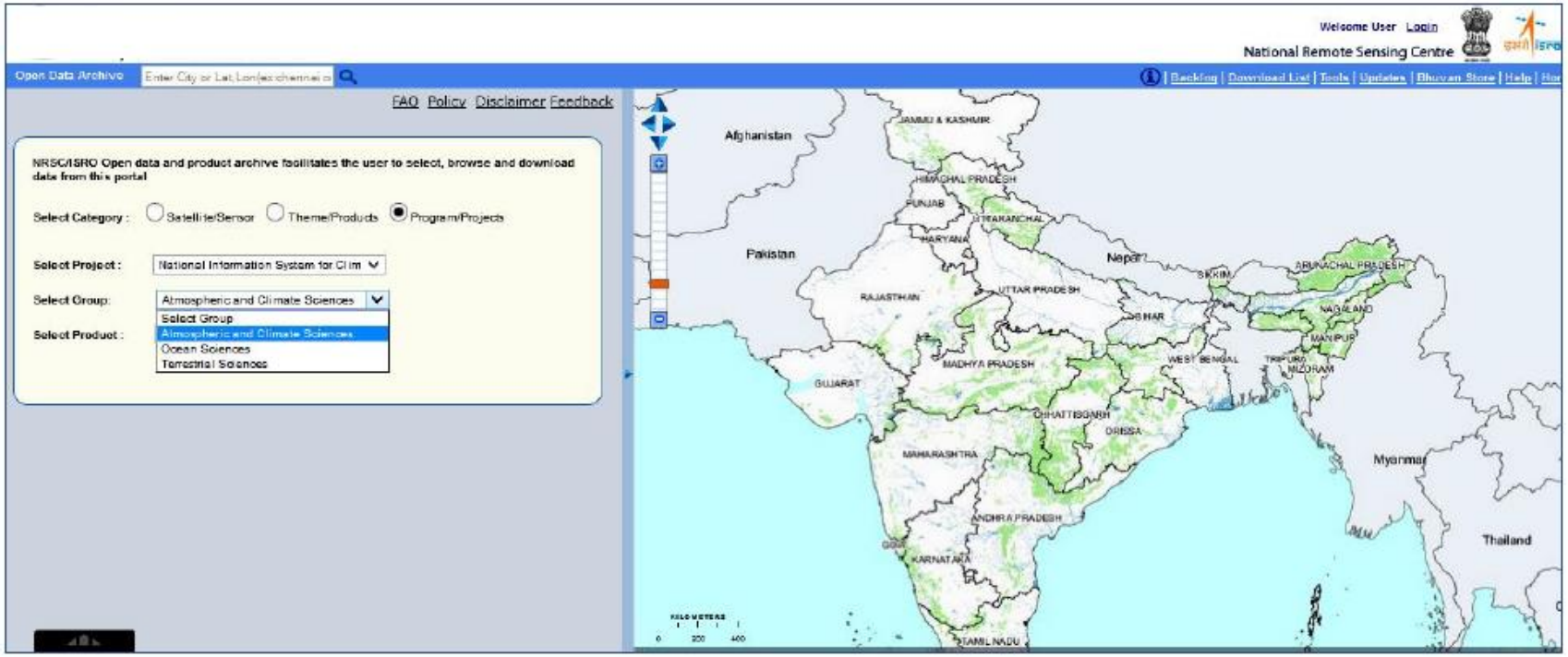
Terrestrial Products

Ocean Products

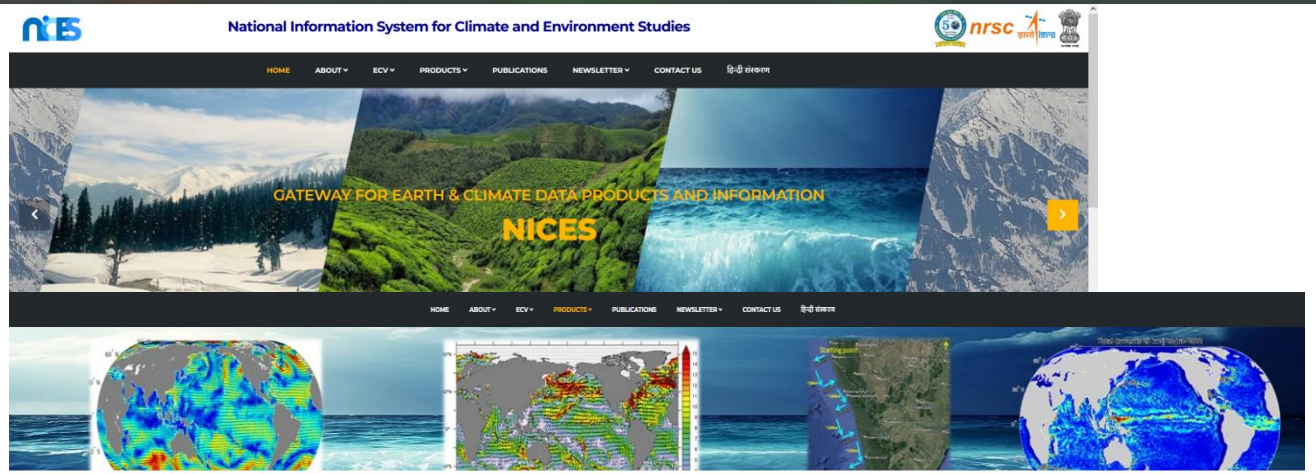
Atmospheric Products

Model Derived Products

Cryosphere Products

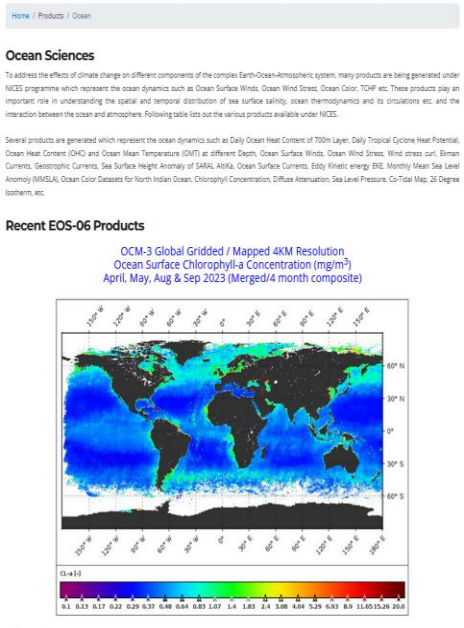


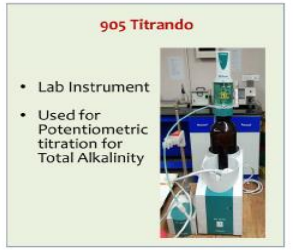
Infrastructure & Outreach

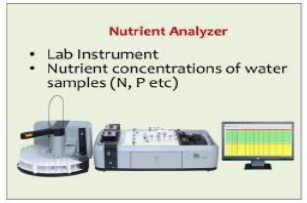


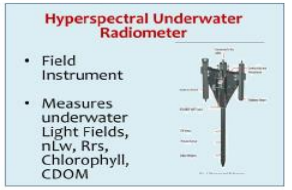
Instruments / Infrastructure

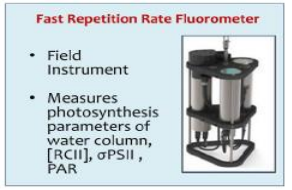
- Hyperpro-II
- IOP profiler
- FRRF
- Coulometer
- HPLC
- pH meter
- Nutrient Analyser
- pCO2 sensor
- CTD

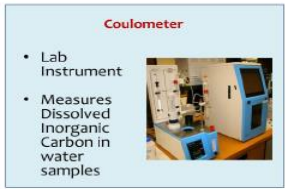


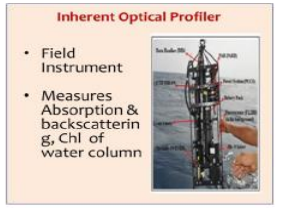


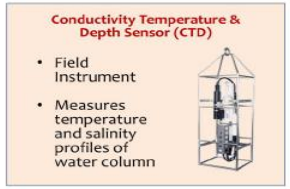












Product Generation & Developments

EOS-06: Oceansat-3

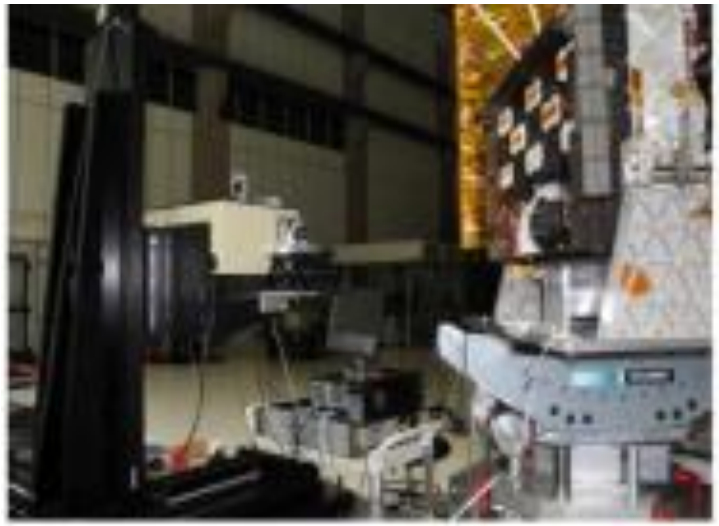
Payloads

- Ocean Colour Monitor (OCM-3)
- Sea Surface Temperature Monitor (SSTM)
- Ku-Band Scatterometer (SCAT-3)
- ARGOS

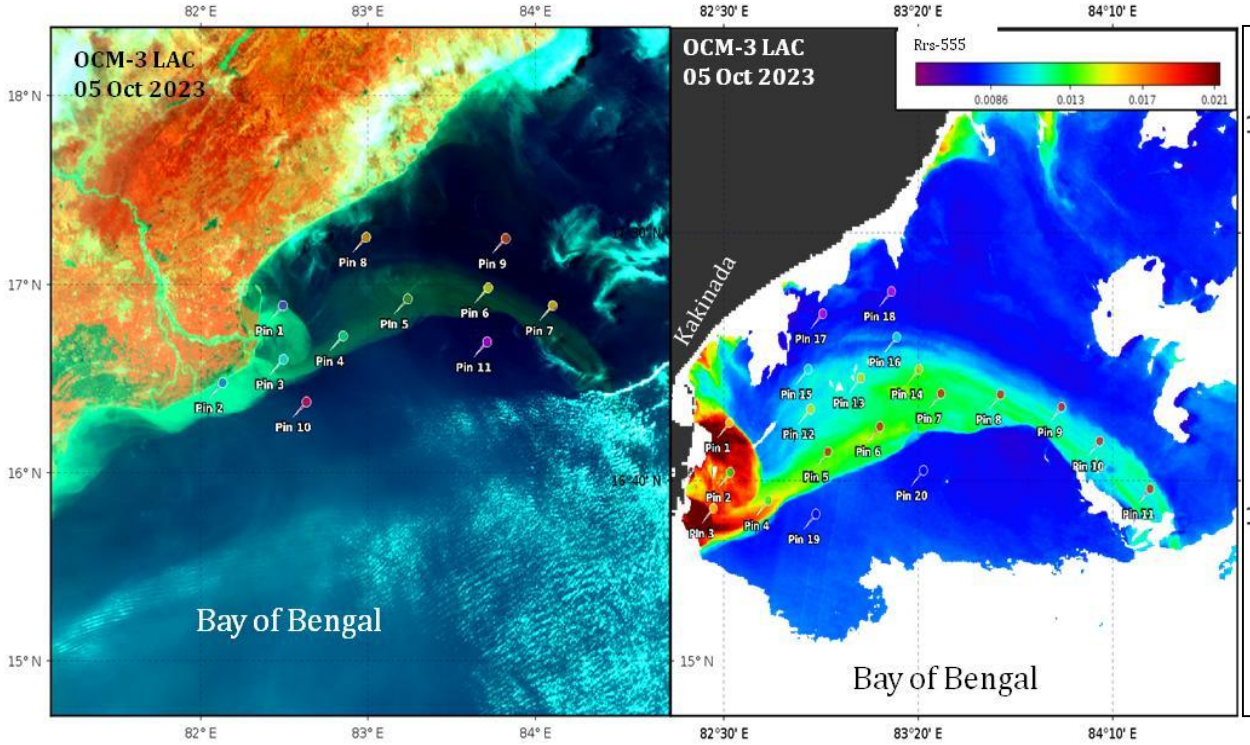
Band Number	Centre Wavelength (nm)	Bandwidth (nm)	Ocean Reference Radiance ($mW\ cm^{-2}\ sr^{-1}m^{-1}$)	SNR @ spectral input / spectral radiance ($W\ m^{-2}Sr^{-1}\ um^{-1}$)	Application
BAND 1	412	10	9.1	1000	CDOM
BAND 2	443	10	8.4	1000	Chlorophyll
BAND 3	490	10	6.6	1000	Chlorophyll
BAND 4	510	10	5.6	1000	Chlorophyll
BAND 5	555	10	4.6	1000	Chlorophyll
BAND 6	566	10	4.3	1000	Bloom Detection
BAND 7	620	10	3.1	1000	Sediments
BAND 8	670	10	2.5.	1000	FLH baseline
BAND 9	681	8	2.3	1000	FLH Peak
BAND 10	710	10	2.0	1000	FLH baseline
BAND 11	780	10	1.6	1000	Atm. Corr
BAND 12	870	20	1.1	800	Atm. Corr
BAND 13	1010	40	0.5	800	Atm. Corr

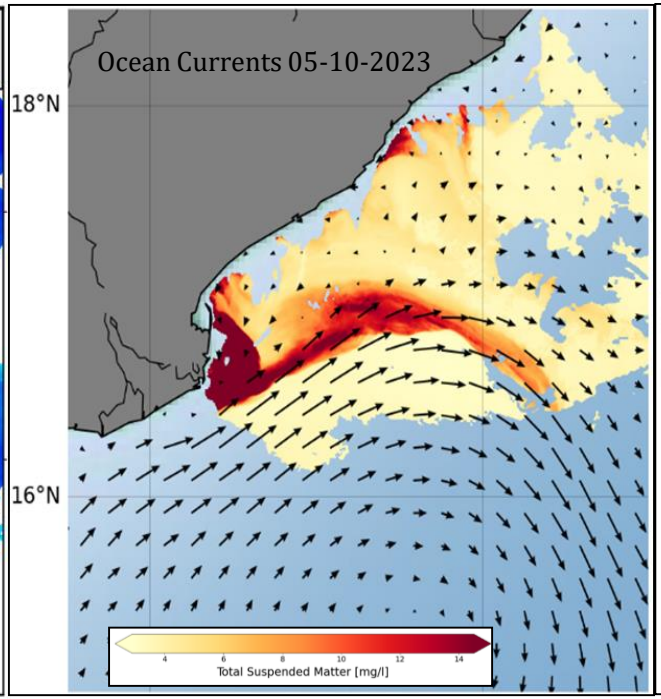
Mission Objectives

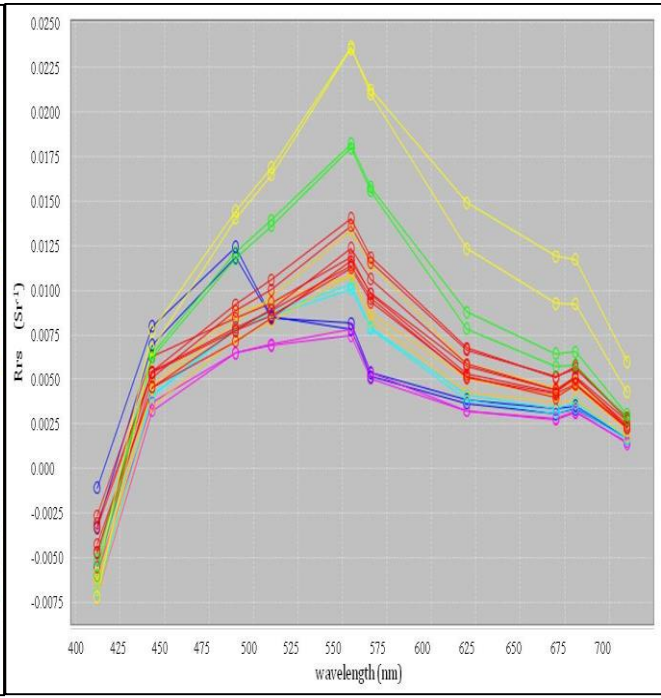
- To ensure the data continuity of Ocean colour and wind vector data to sustain the operational applications.
- To improve the applications, some additional datasets such as SST & more number of bands in Optical region for florescence and in IR region for atmospheric corrections.
- To develop / improve related algorithms and data products to serve in well- established application areas and to enhance the mission utility.



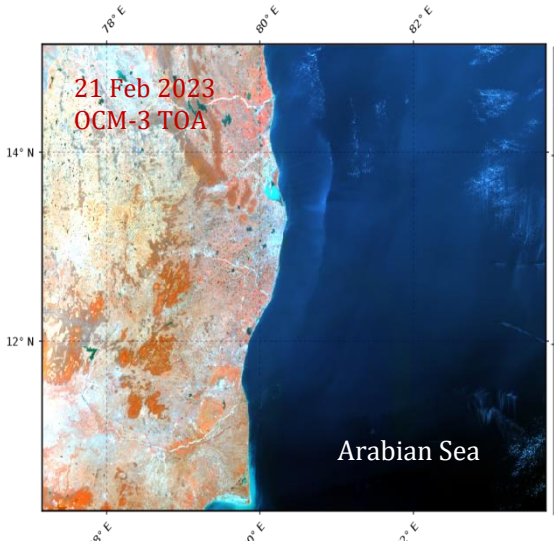
Sediment Dynamics & Spectral Variability

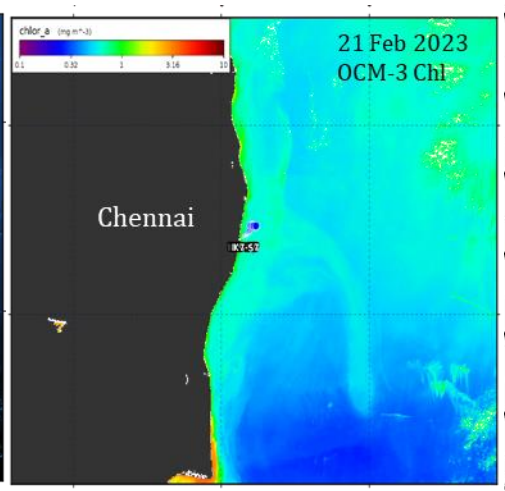


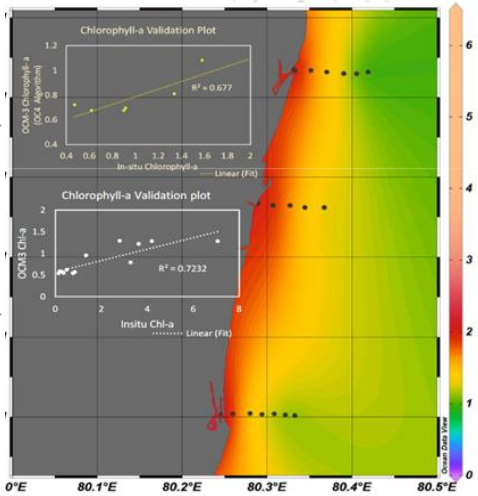


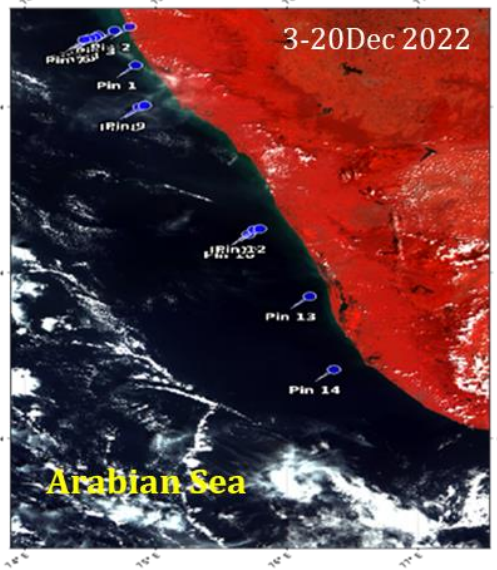


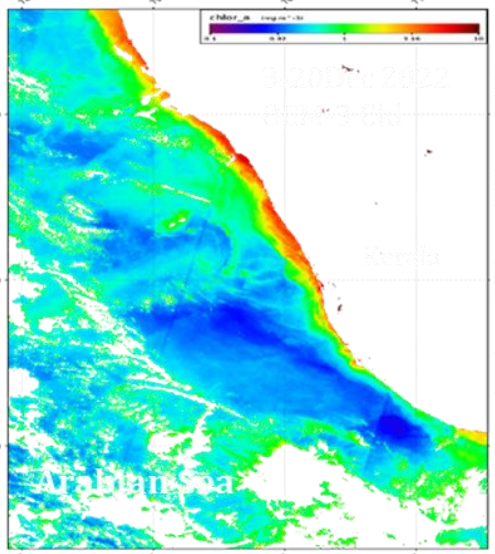
EOS-06 Oceansat-3: Validation

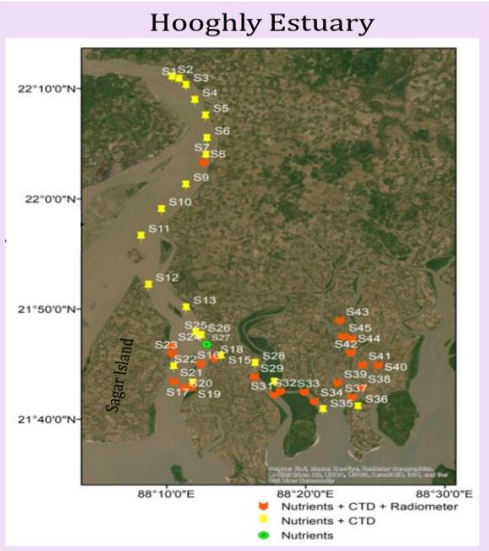




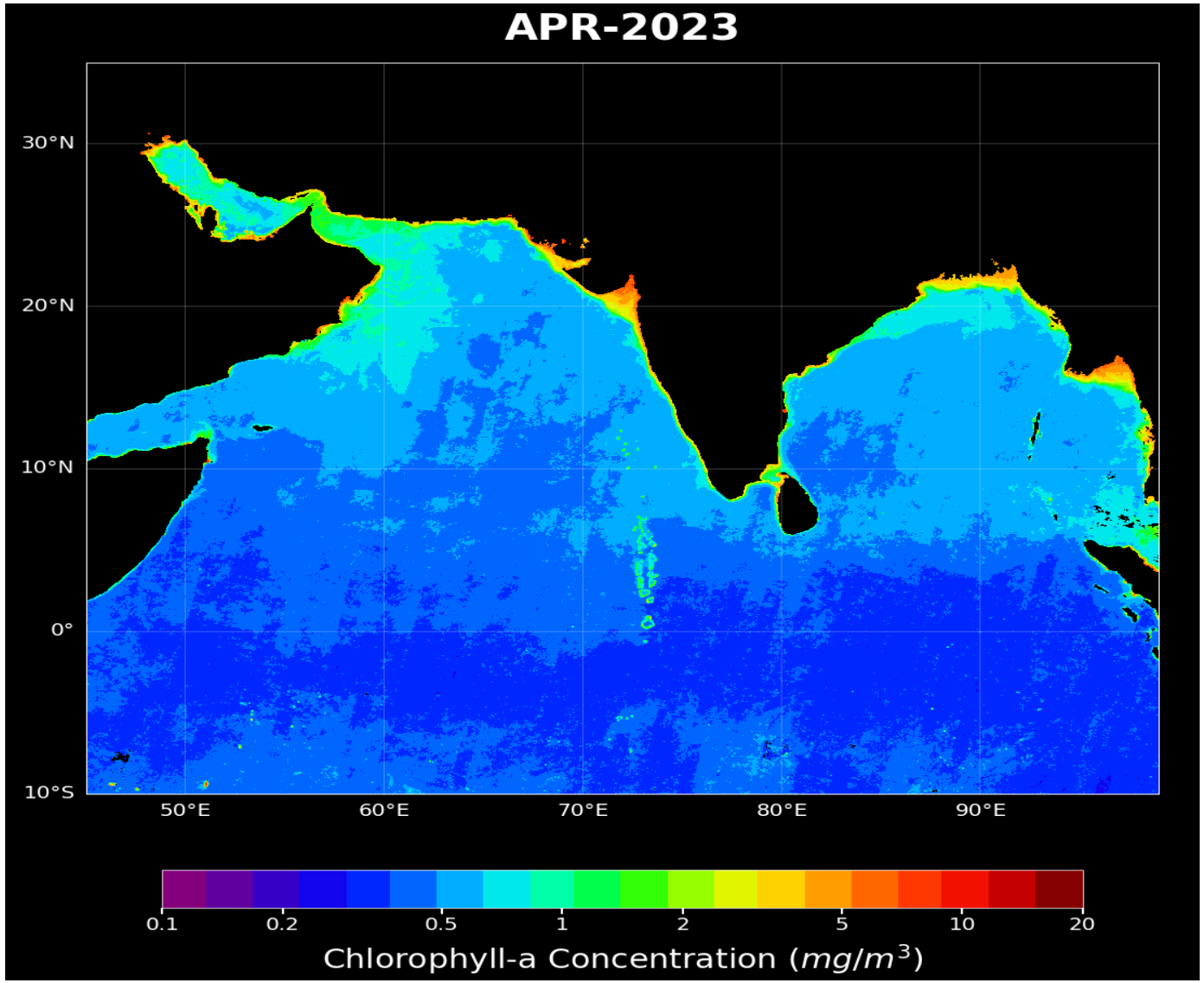




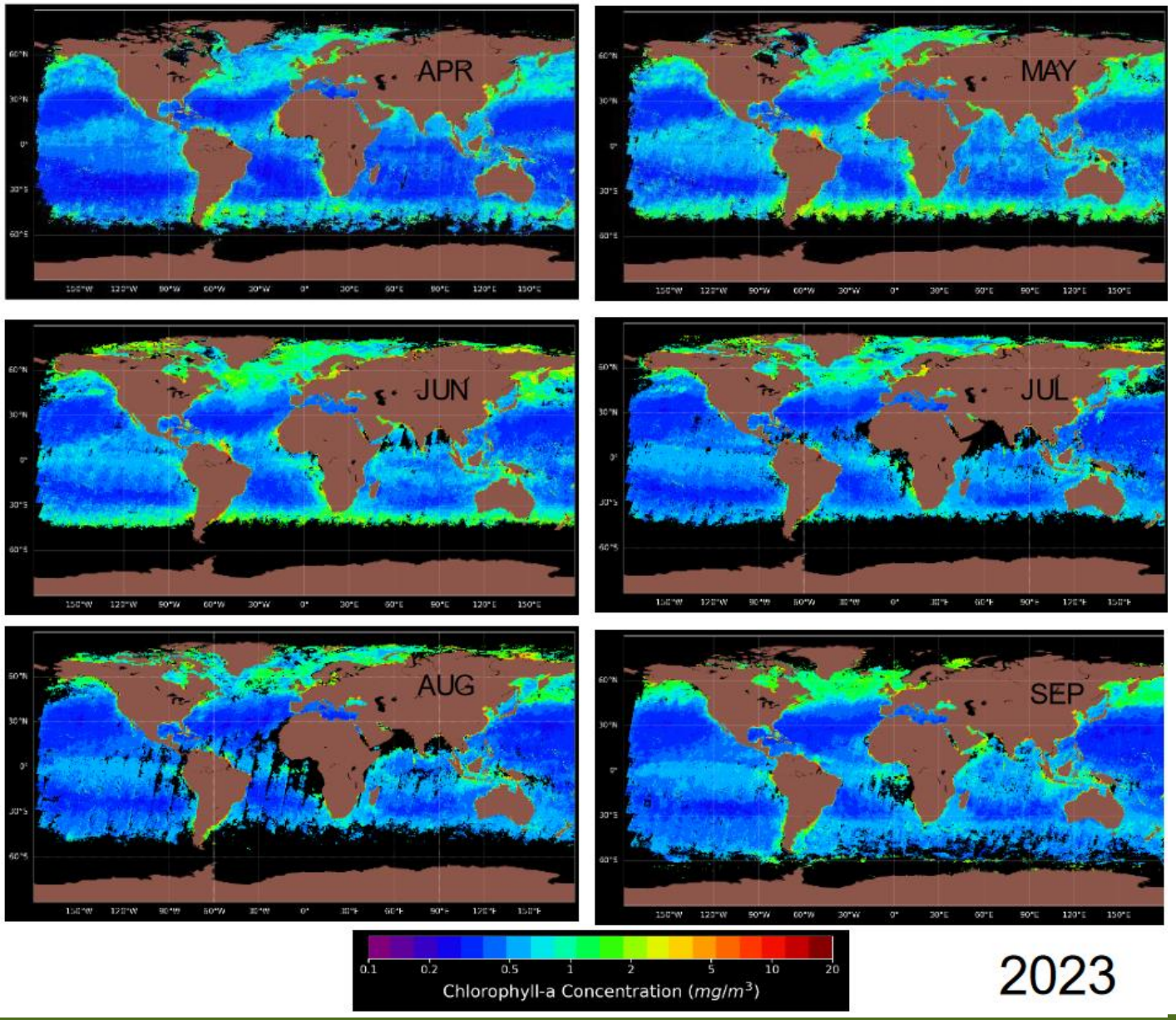




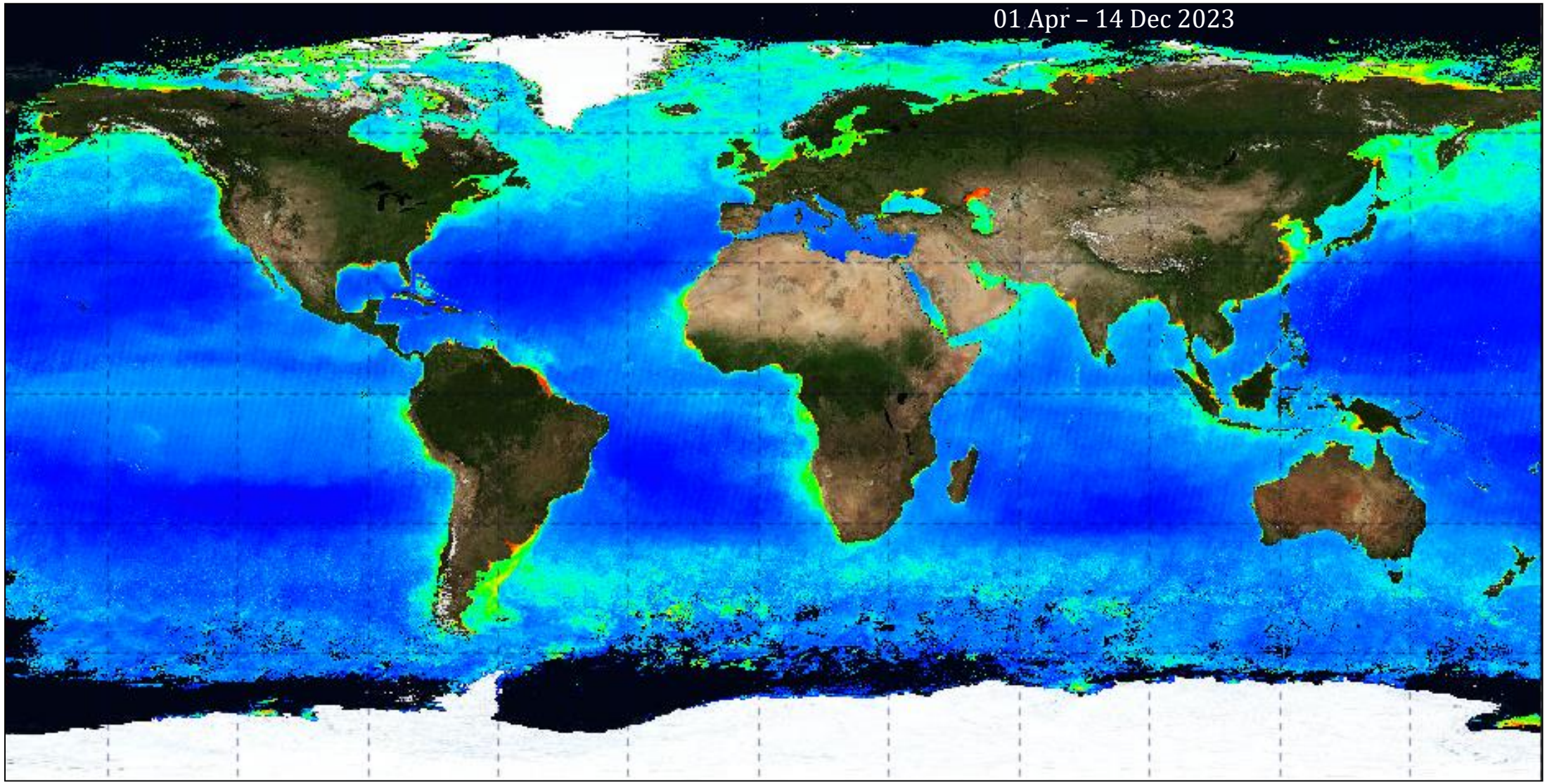
Level-3 Binned Products: Eos-06 OCM



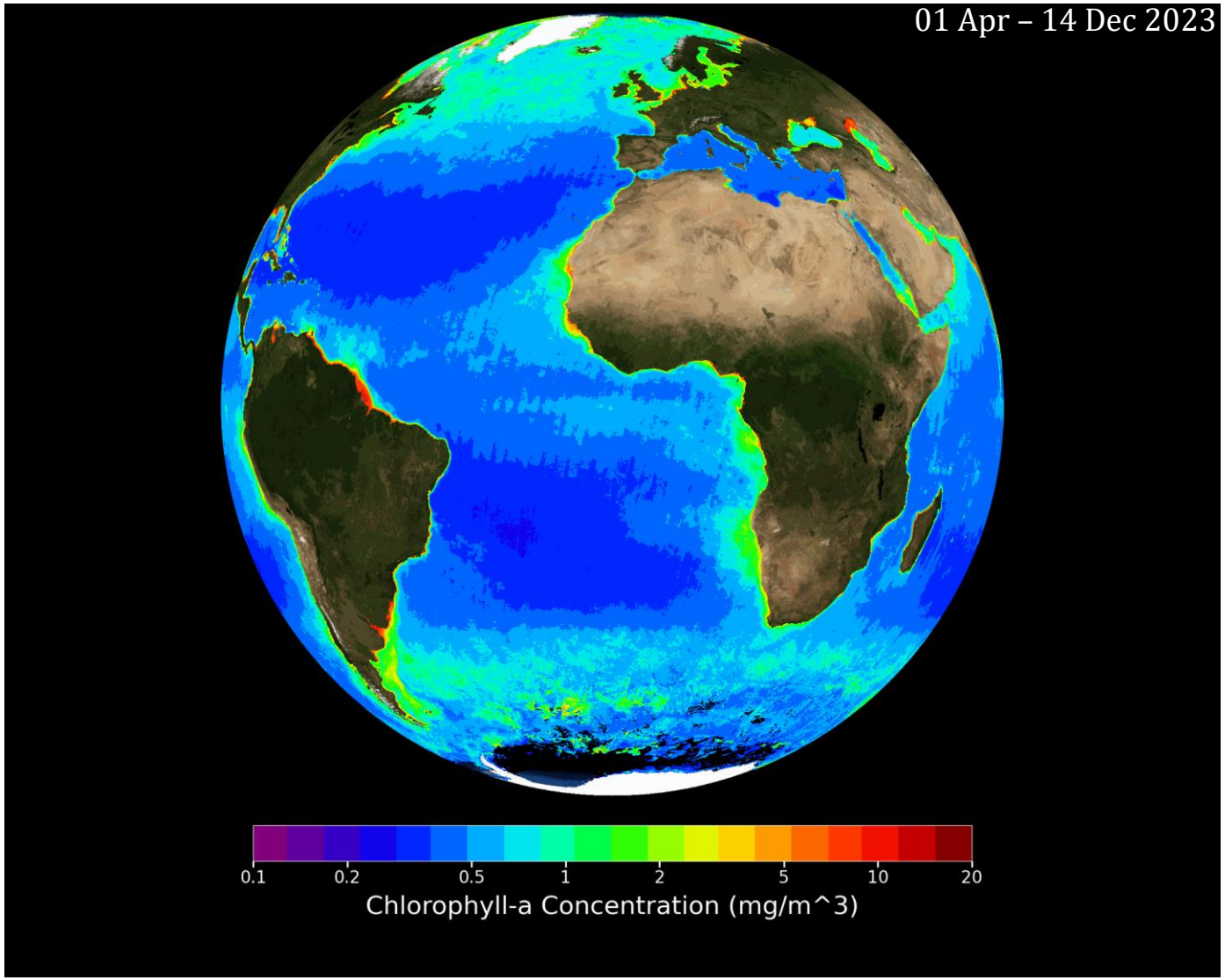
Level-3 Binned Global Mosaics of OCM-3



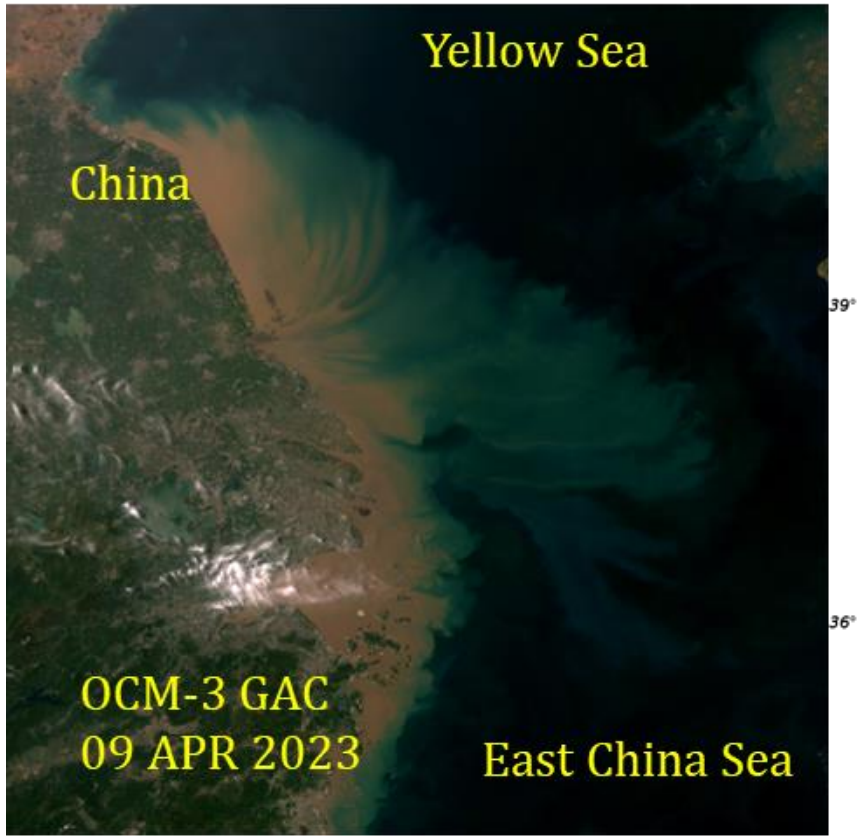
Level-3 Binned Global Mosaic of OCM-3

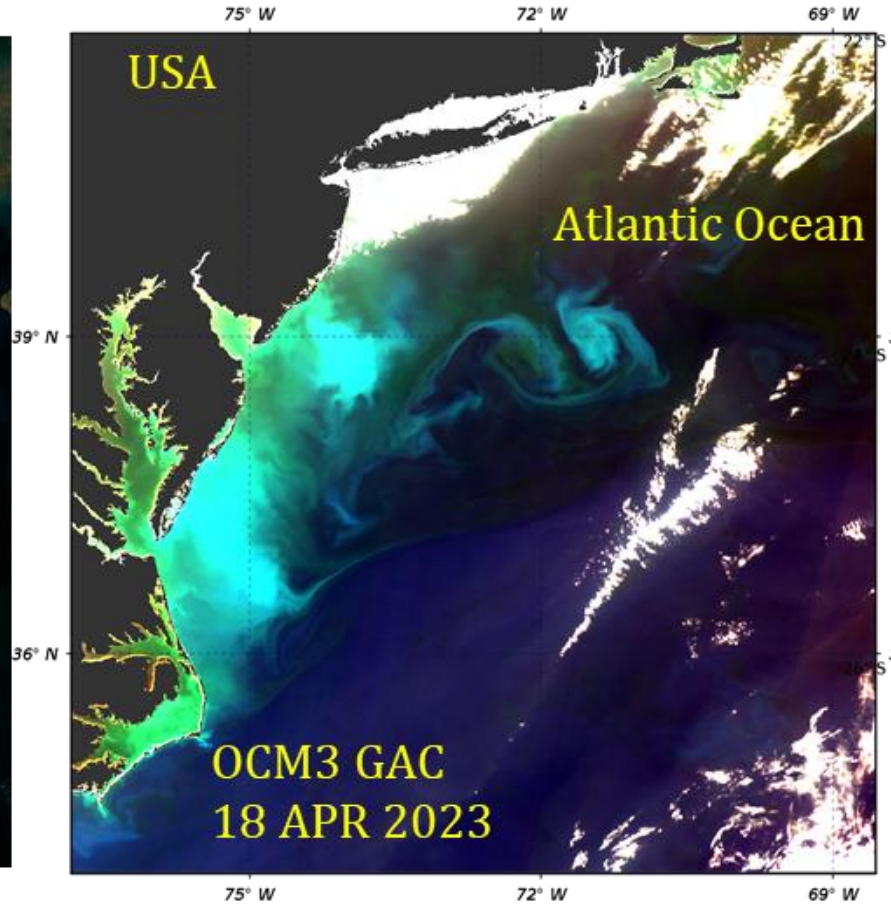


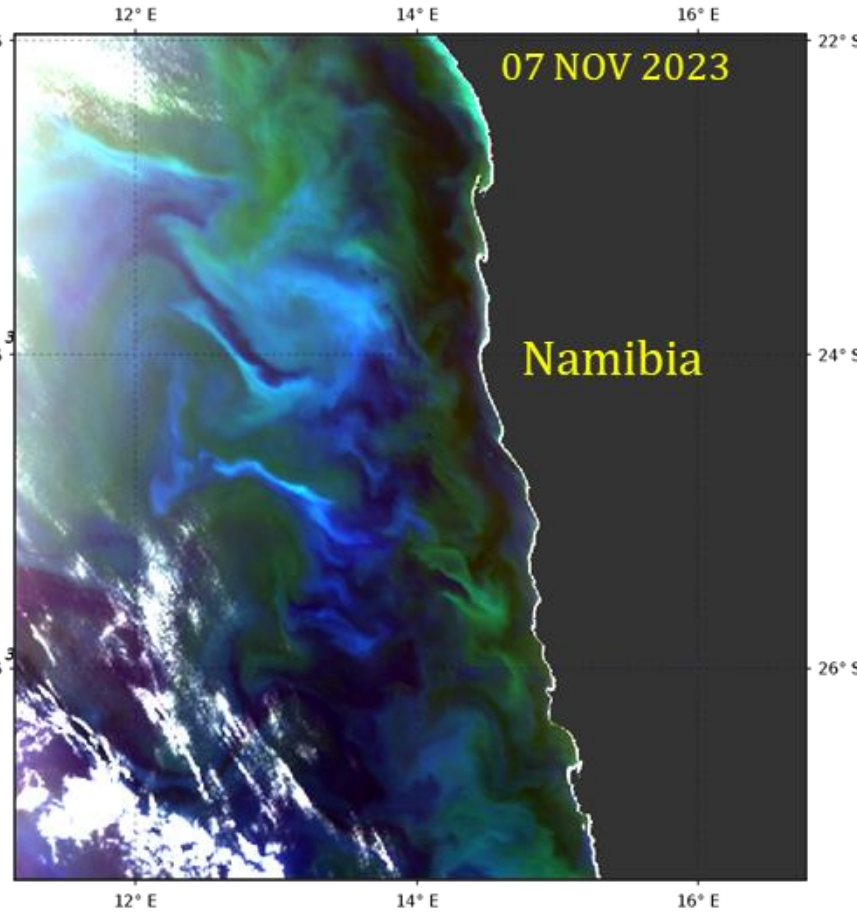
Level-3 Binned Products: Eos-06 OCM



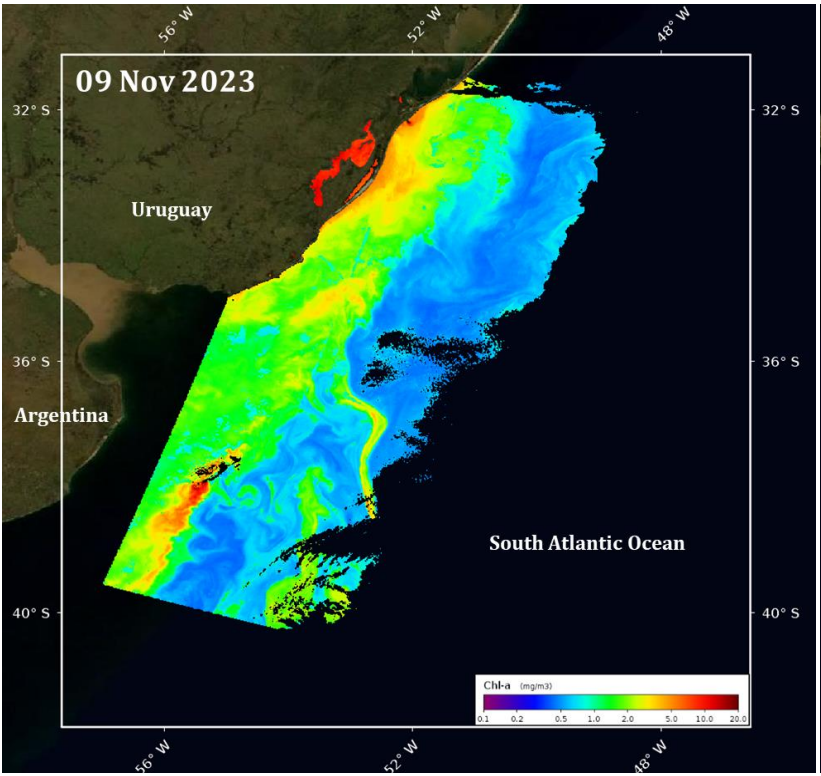
Blooms & Plumes : Global Oceans

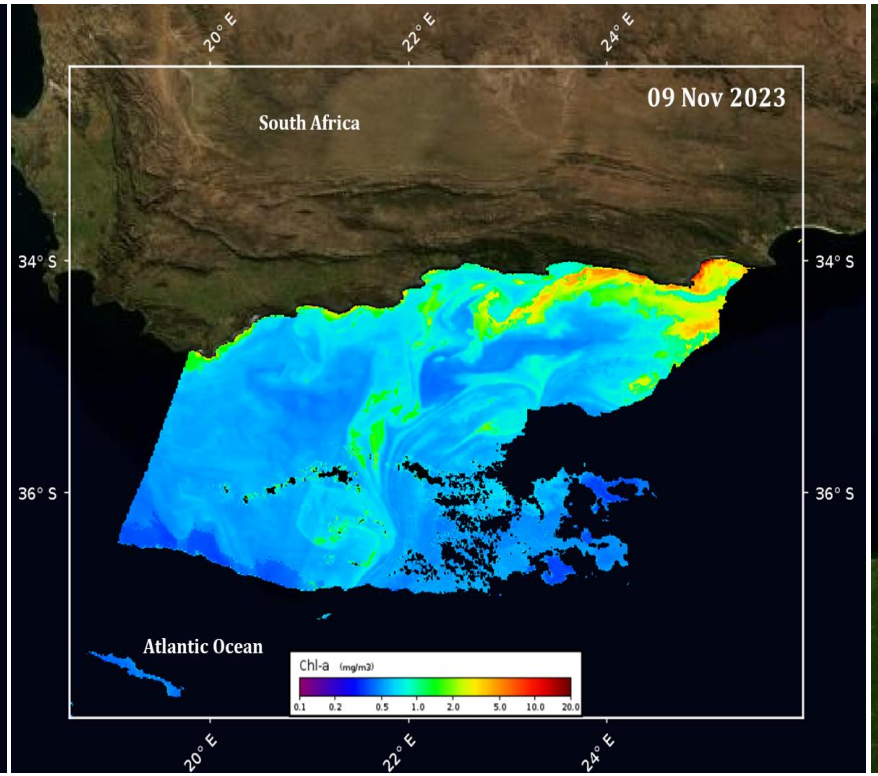


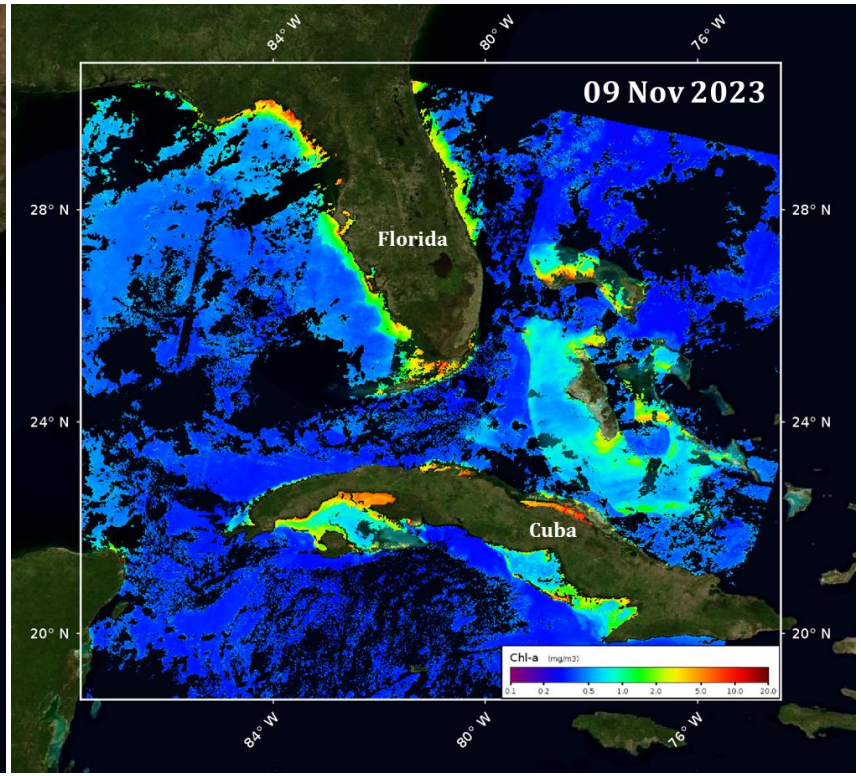




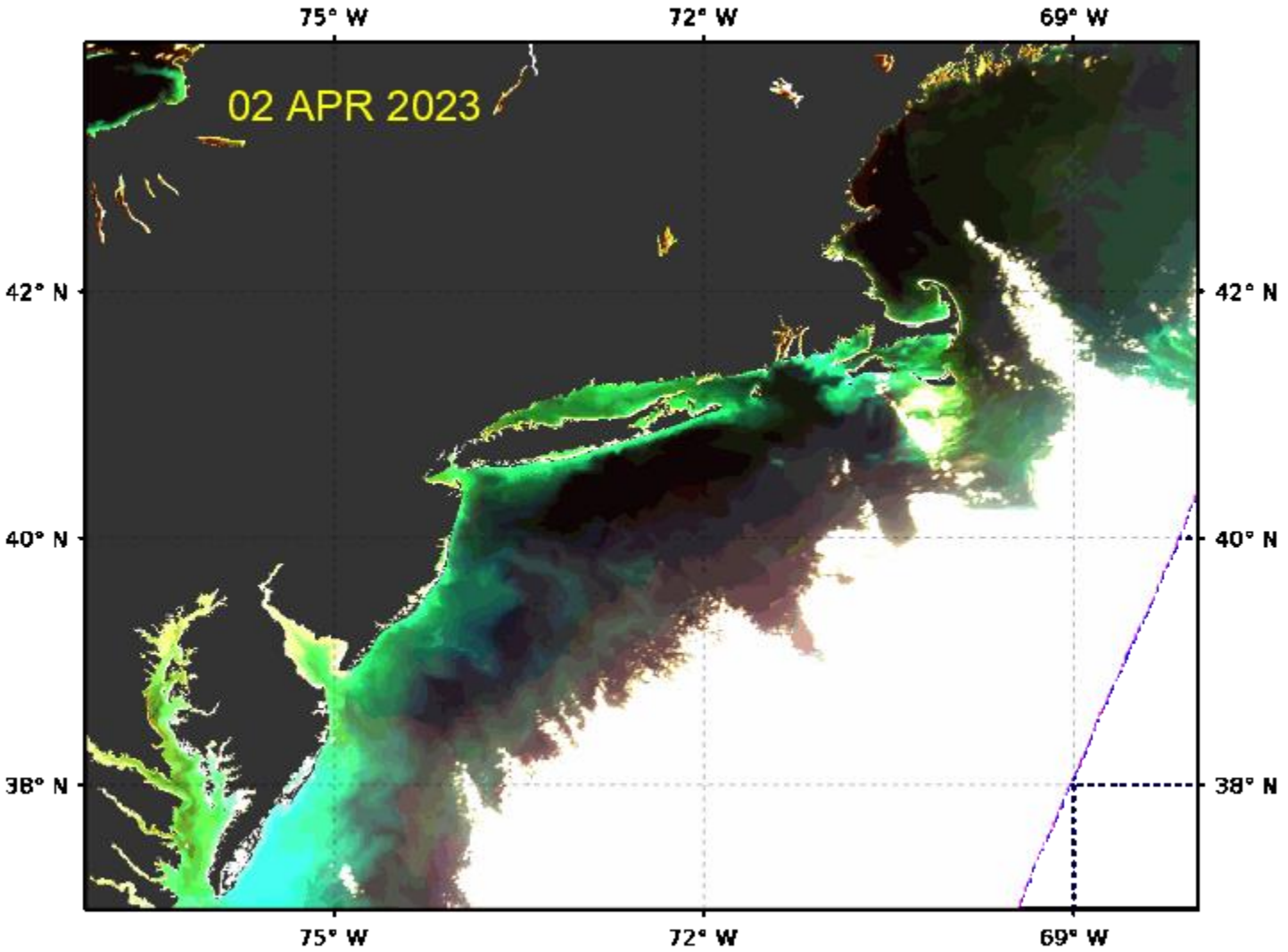
Phytoplankton Blooms : Global Oceans

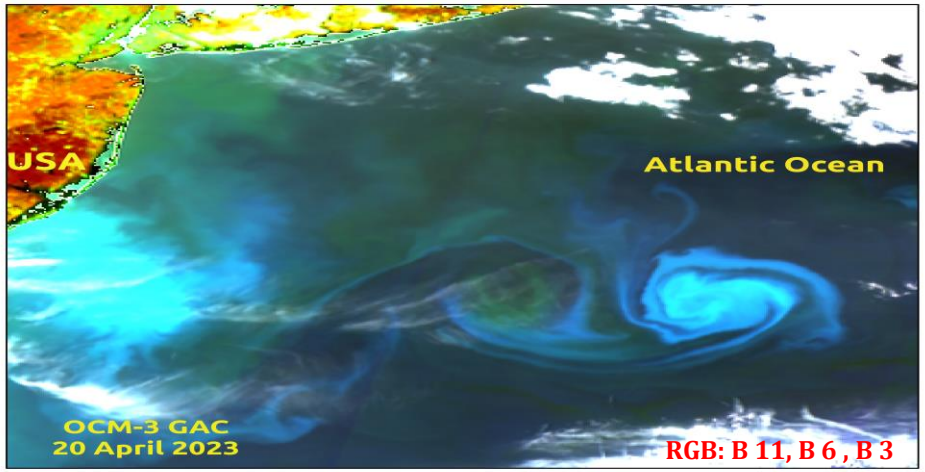


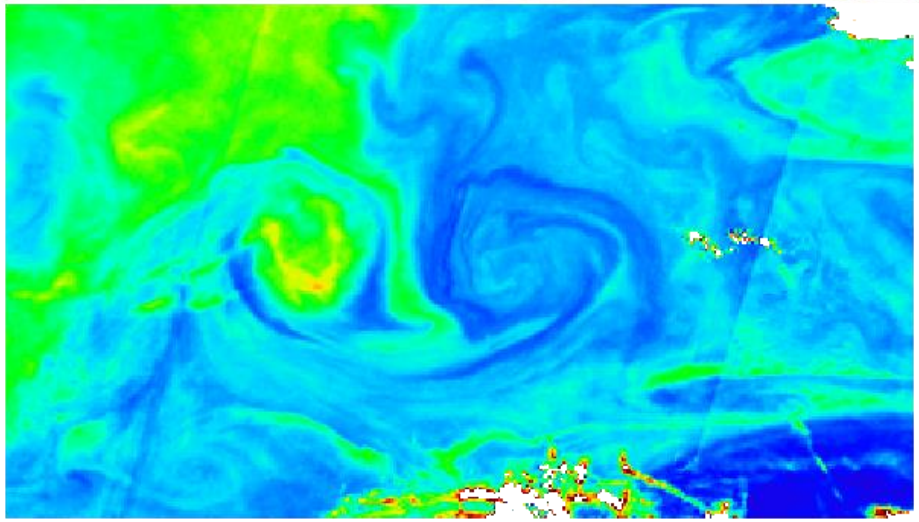




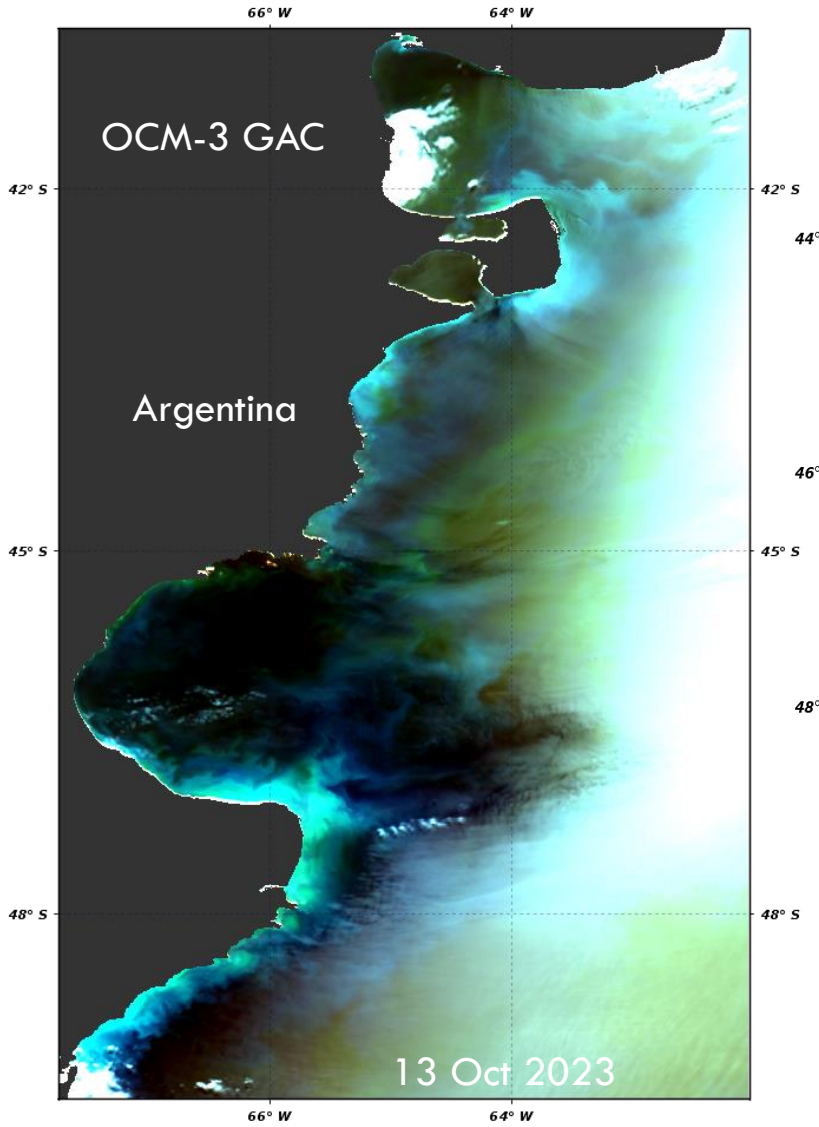
Evolution of Phytoplankton Bloom off the US East Coast

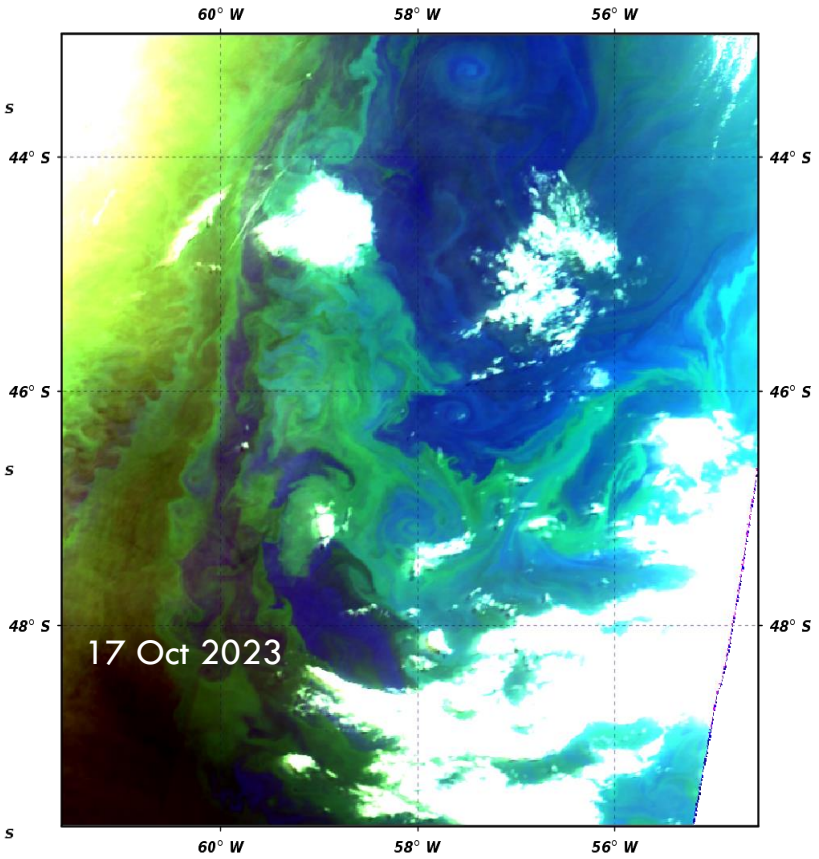


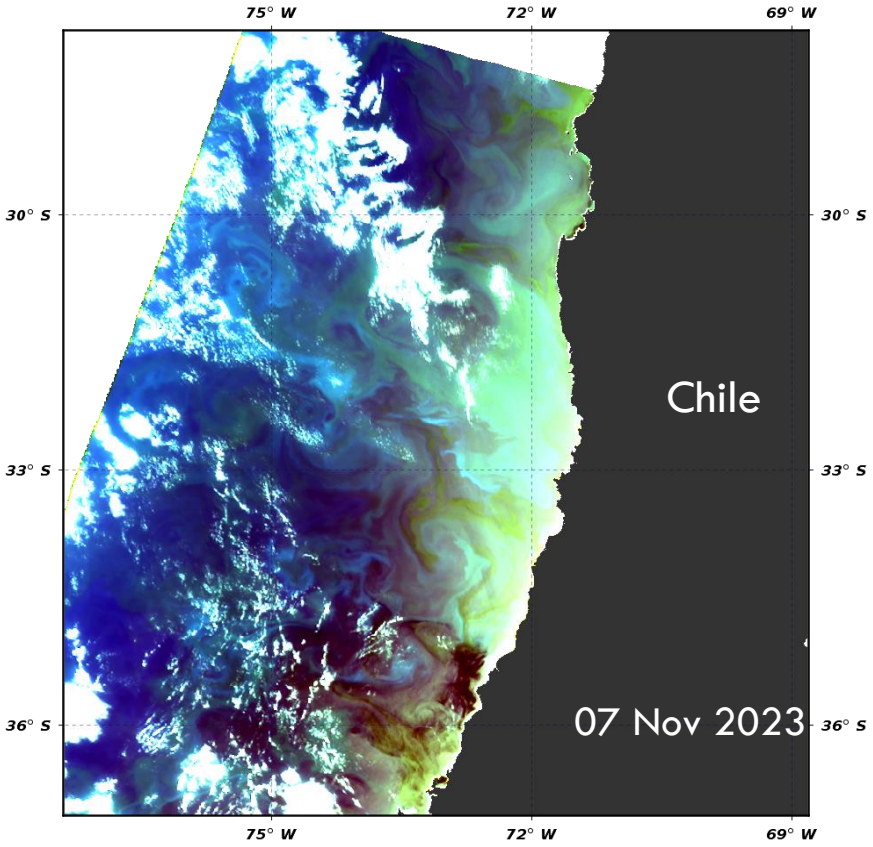




Phytoplankton Blooms: Global Oceans

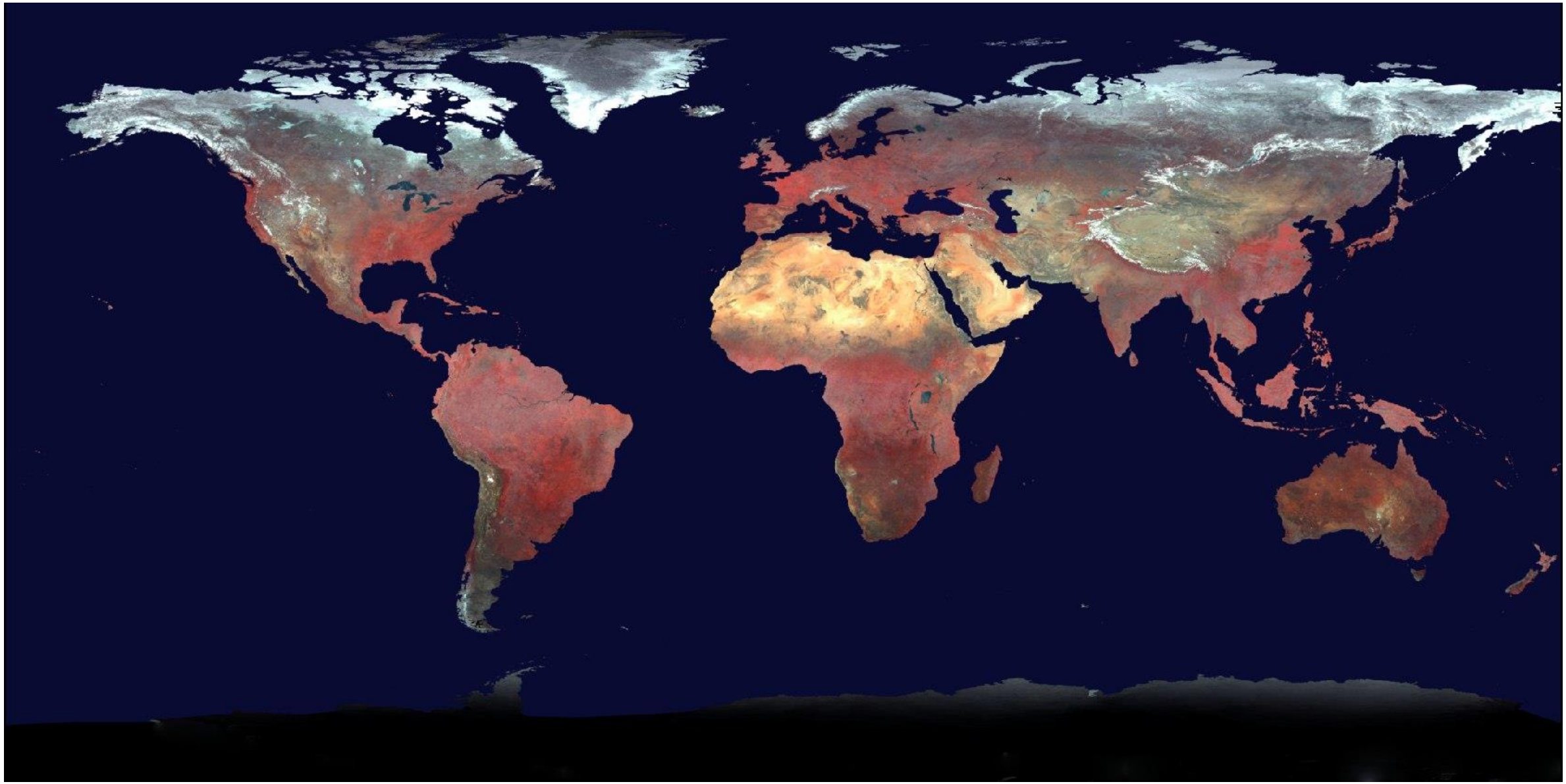




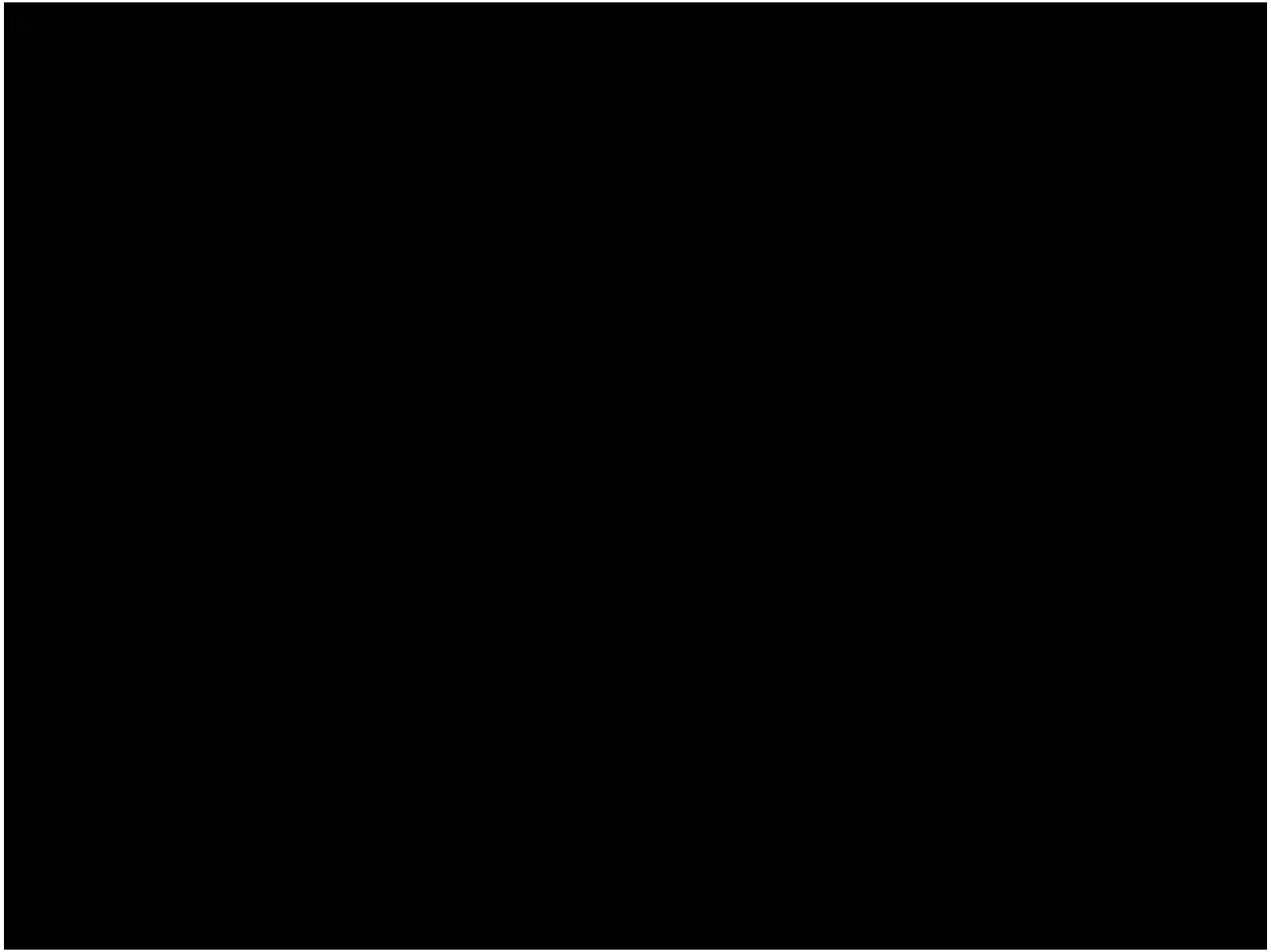


Recent Phytoplankton Bloom off the coast of Argentina and Chile

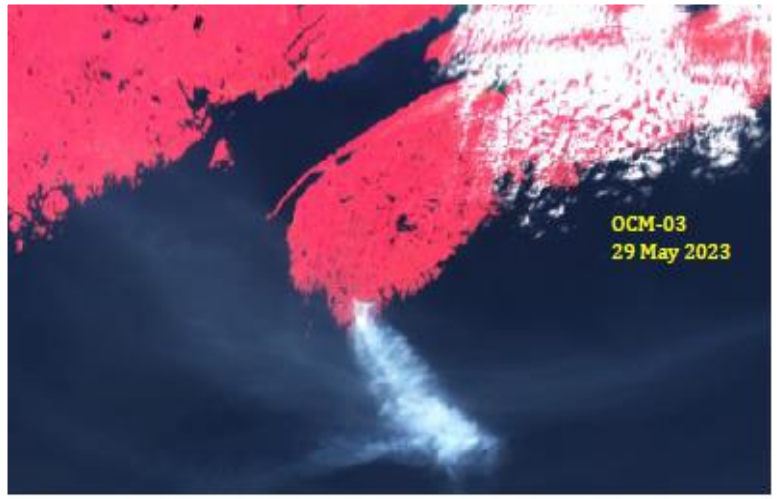
Monthly Global Mosaic of OCM-3 (Apr-May 2023)

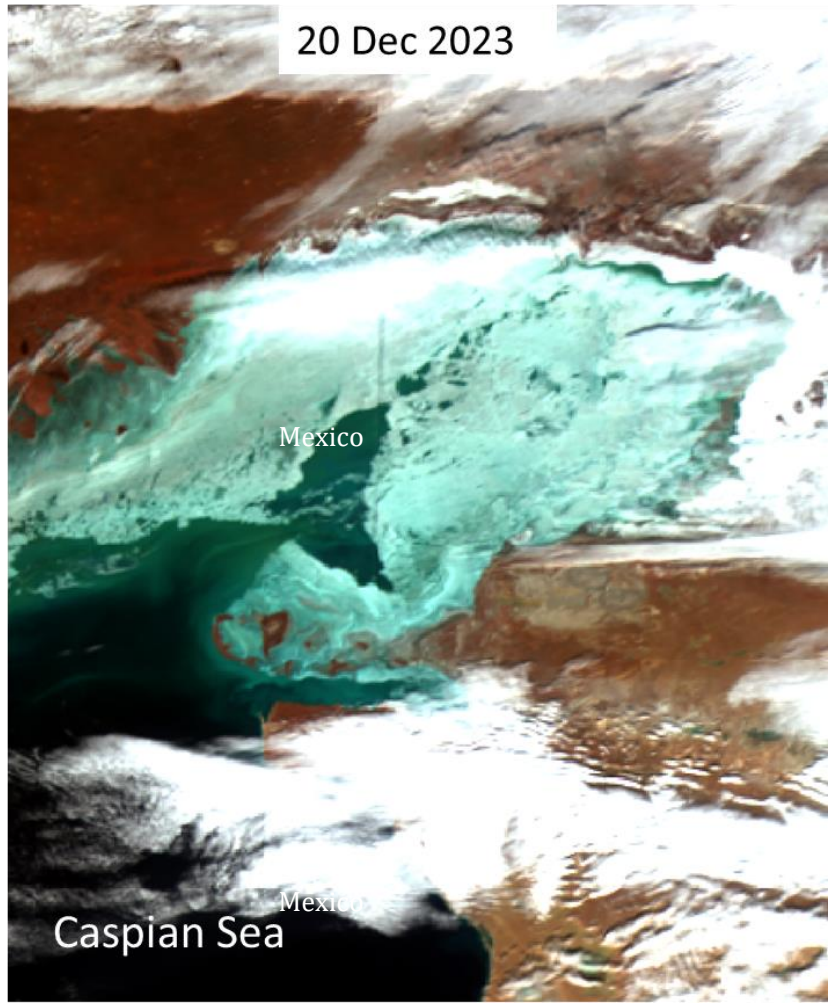


NDVI from OCM-3 (Jun-Oct 2023)

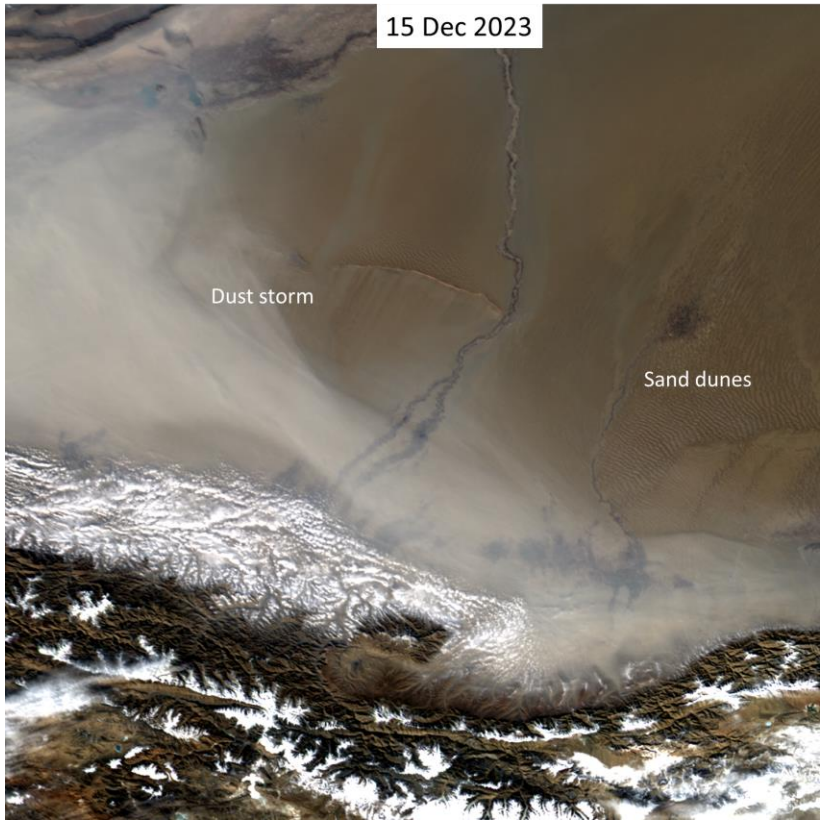


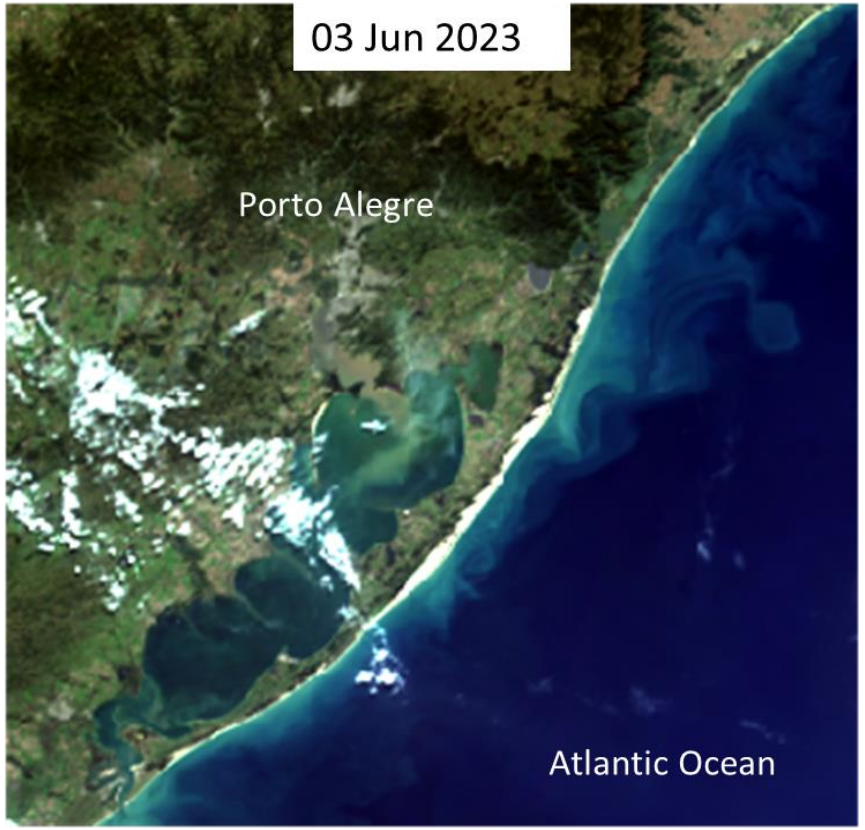
Extended Applications of EOS-06 OCM





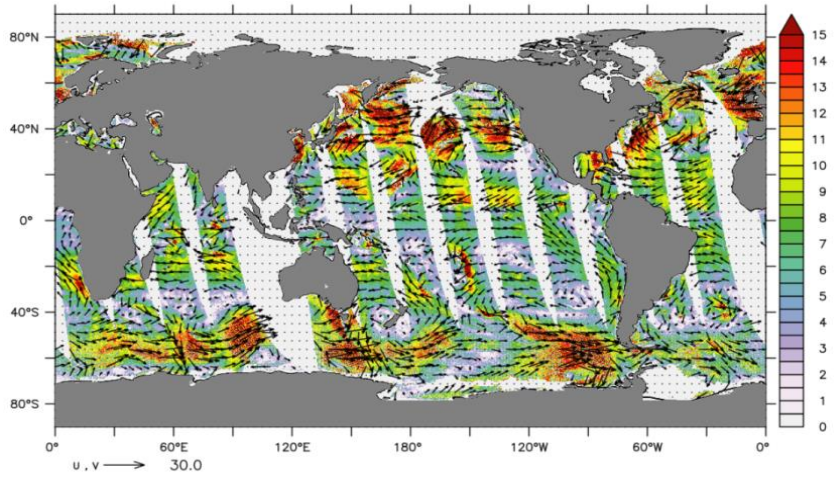
Extended Applications of EOS-06 OCM



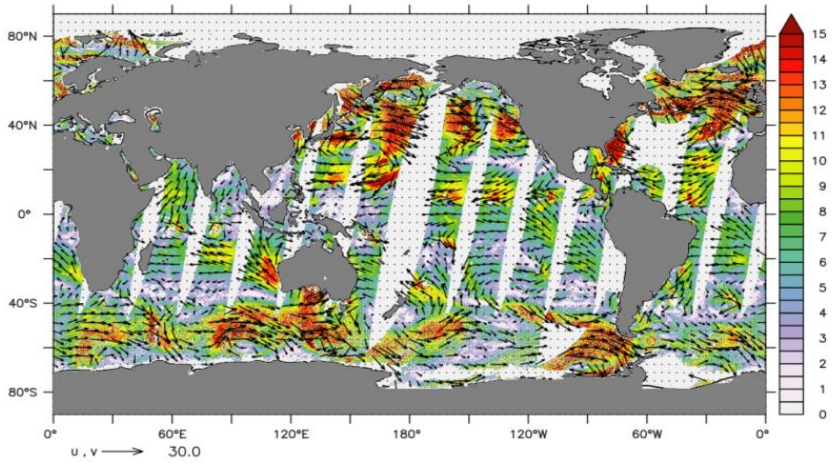


EOS-06/Oceansat-3 Scatterometer: Value-added Products

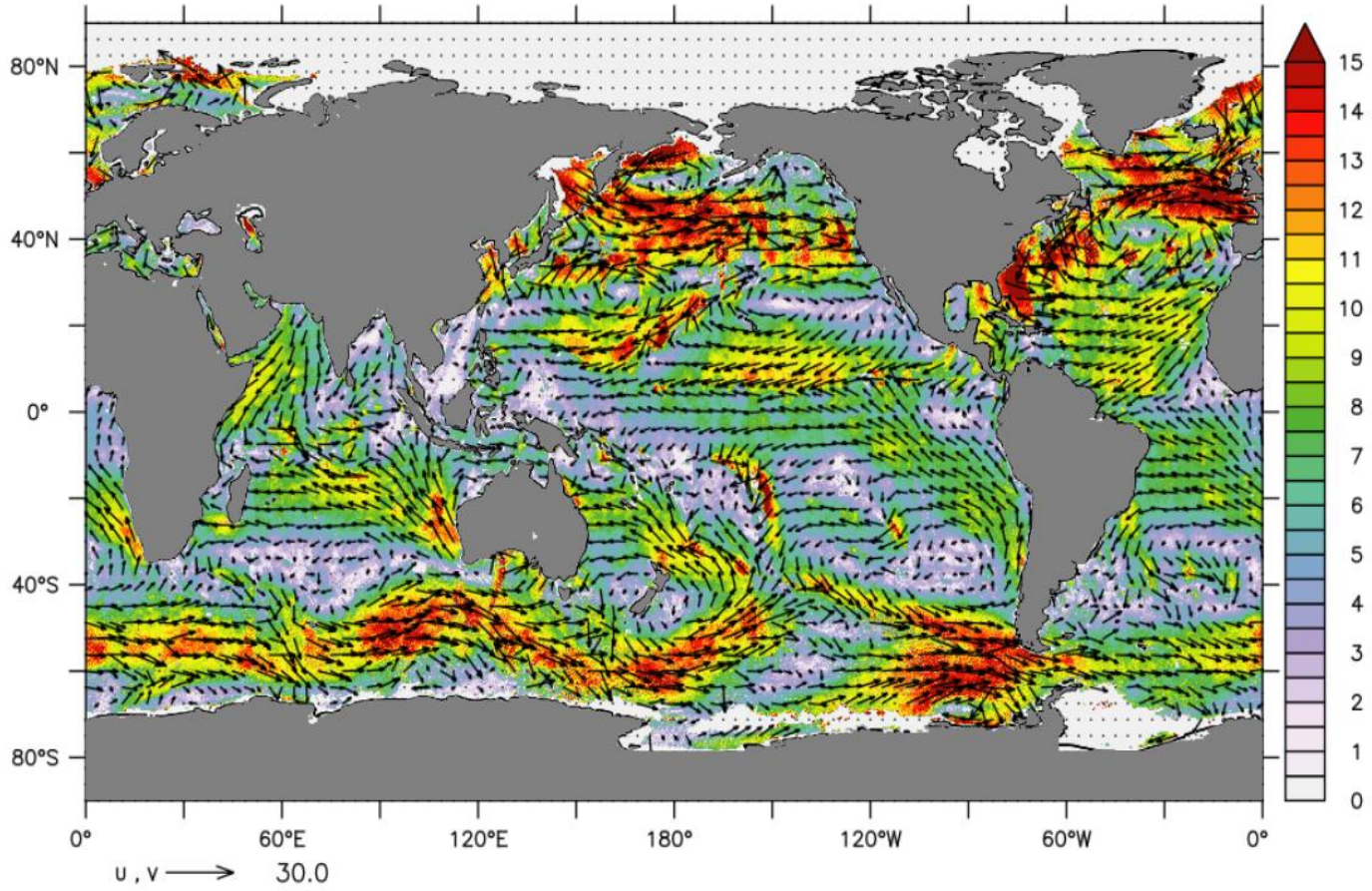
Sample Global Coverage of O3SCAT Winds (m/s)
(Data from 14th January 2023) (Ascending Passes)



Sample Global Coverage of O3SCAT Winds (m/s)
(Data from 14th January 2023) (Descending Passes)



Sample Global Coverage of O3SCAT Winds (m/s)
(Data from 14th & 15th January 2023) (ALL Passes)



EOS-06/Oceansat-3 Scatterometer: Applications

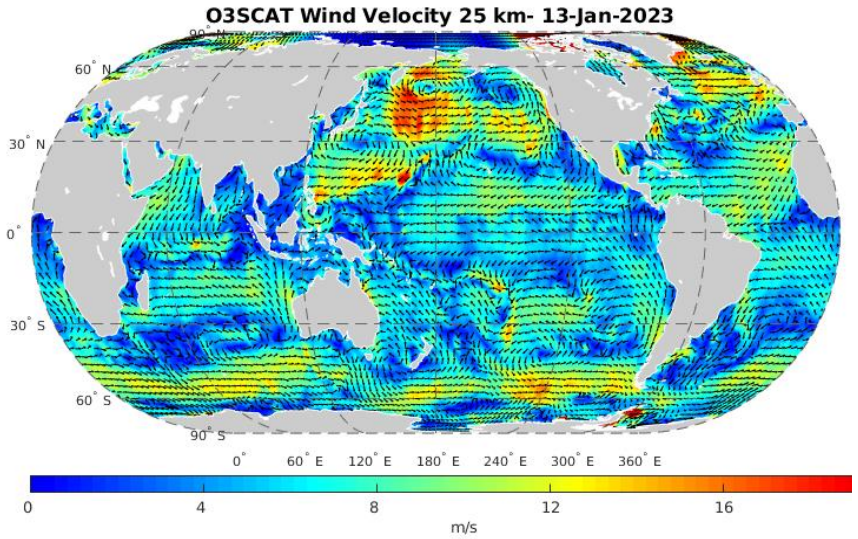
Operational Applications :

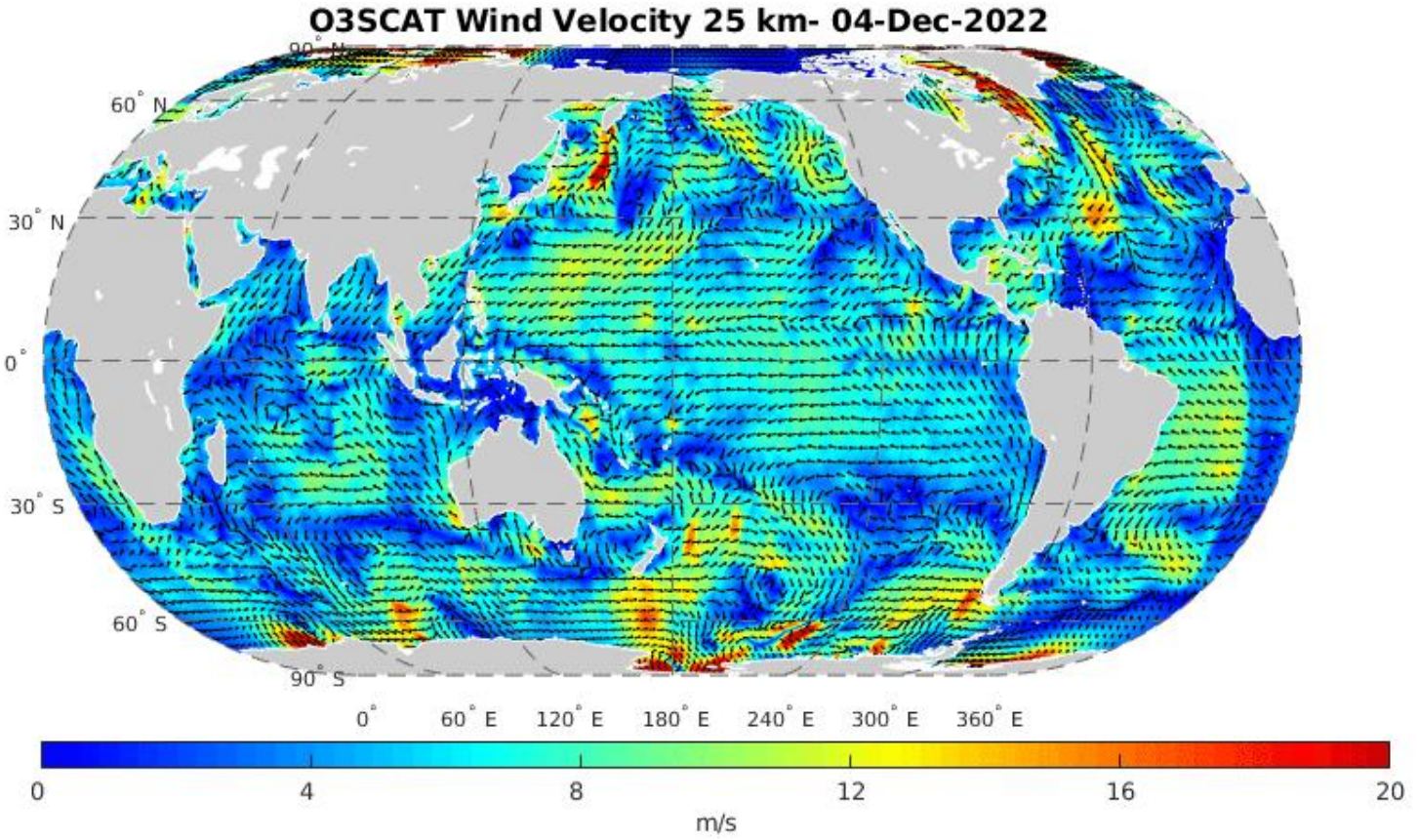
- Cyclone Forecasting
- Ship Routing
- Shoreline Management Studies
- Harbor and port management
- Oil spill management
- Search and rescue
- Ship Detection in coastal waters
- Pollution Dispersion studies

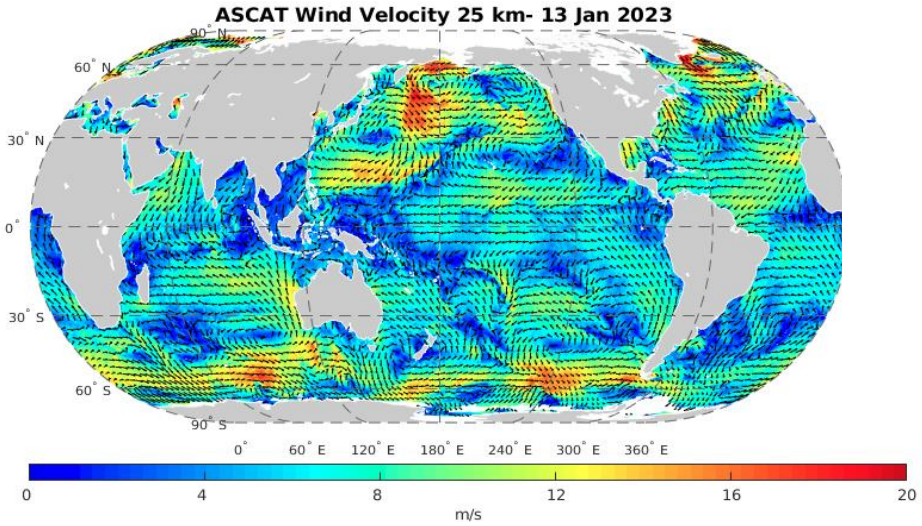
Scientific Studies:

- Designated as ECV- Climate studies of ocean circulation variability, Heat Transport etc.,
- Wind-Wave-Current Interaction studies
- Understanding Coastal Ocean circulation
- Air-Sea interaction studies
- PFZ Forecast studies

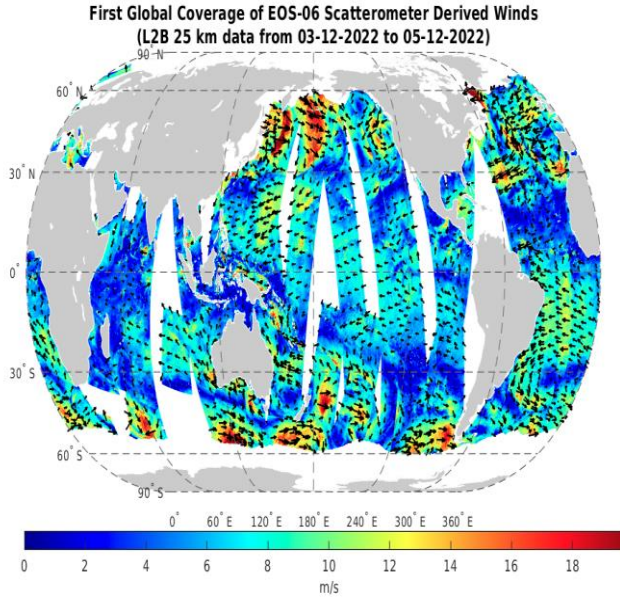
EOS-06/Oceansat-3 Scatterometer: Value-added Products

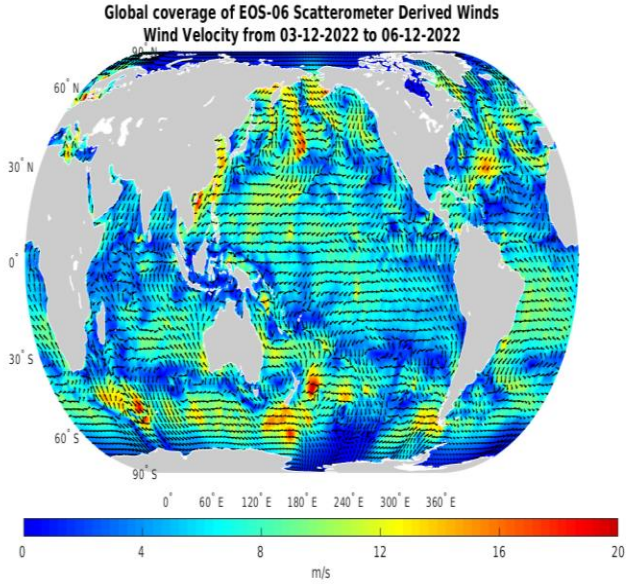


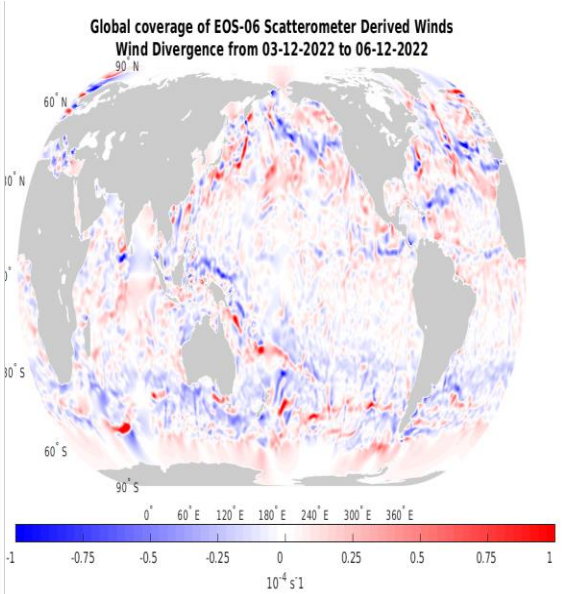


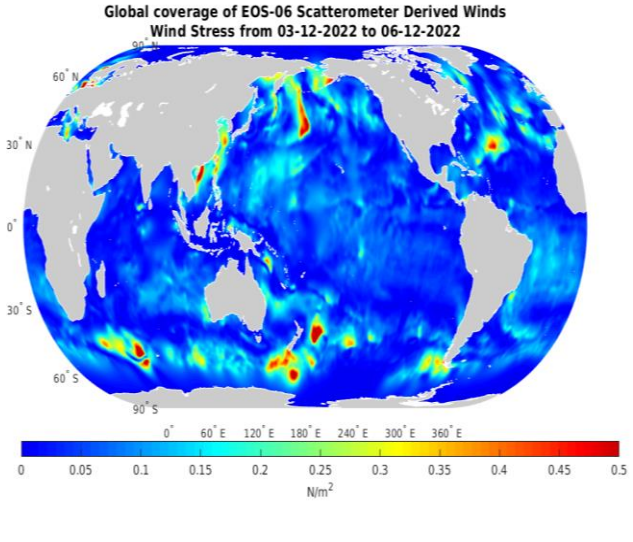


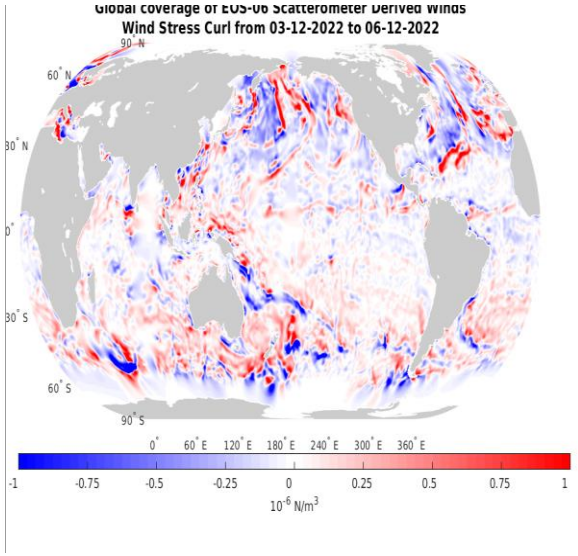
EOS-06/Oceansat-3 Scatterometer: Value-added Products

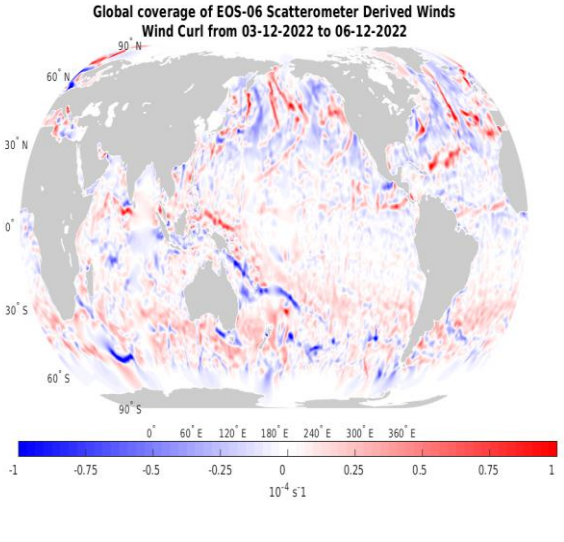




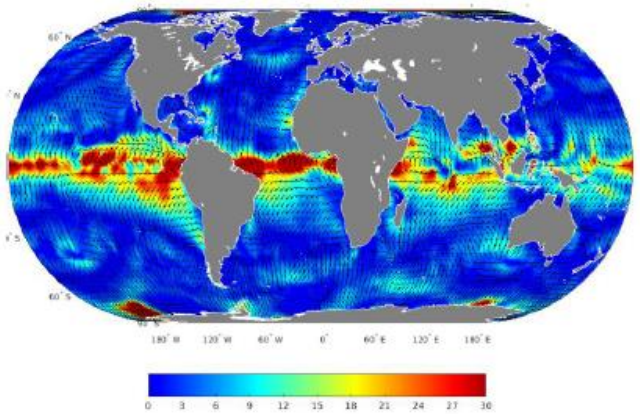




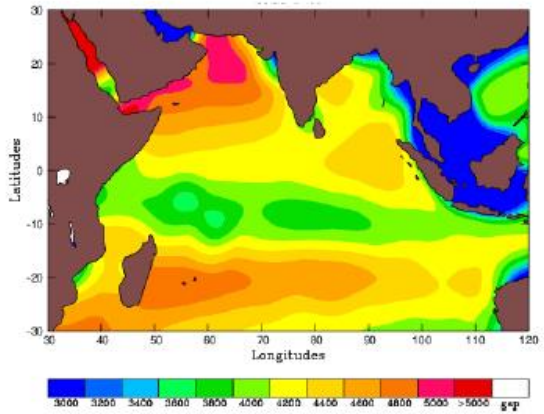


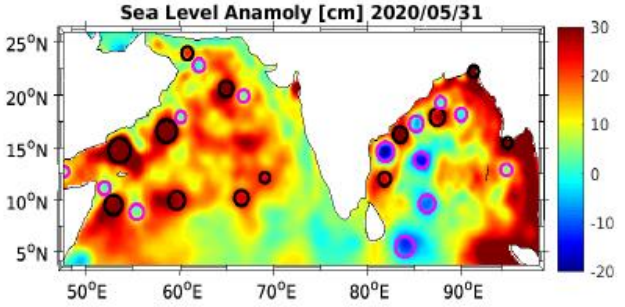


22 सितंबर, 2020 के लिए एकमान धाराएं (सेमी/सेकंड)
Ekman Currents (cm/sec) for Sept 22, 2020

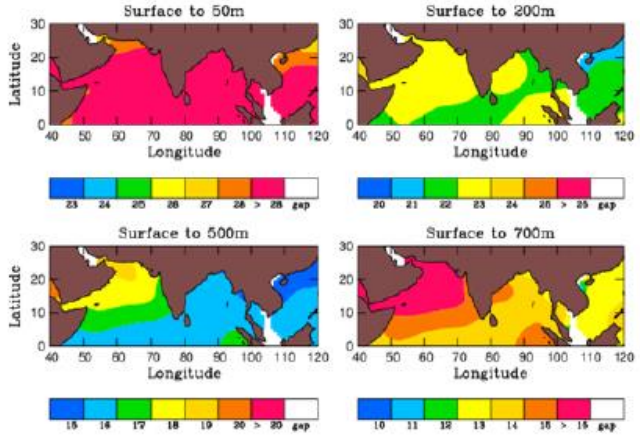


OHC 700 (KJ/cm²) on May 25, 2022

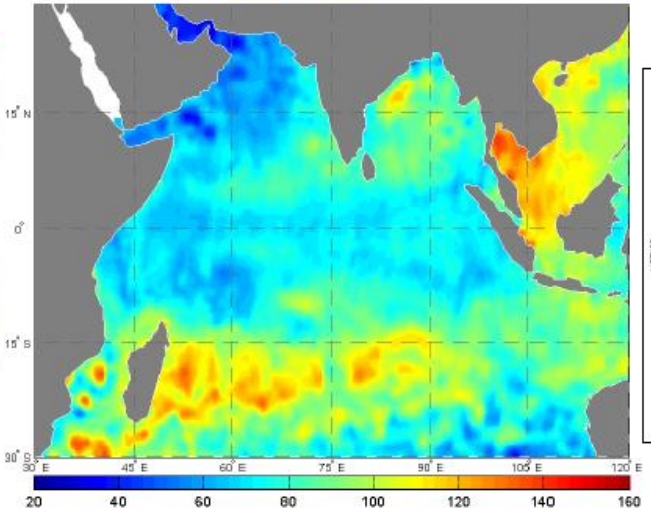




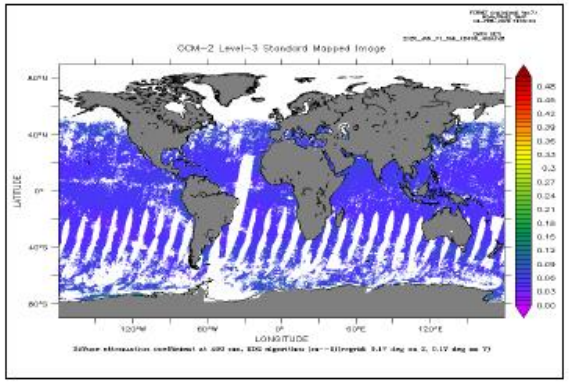
Ocean mean temperature (°C) on 25.5.2022



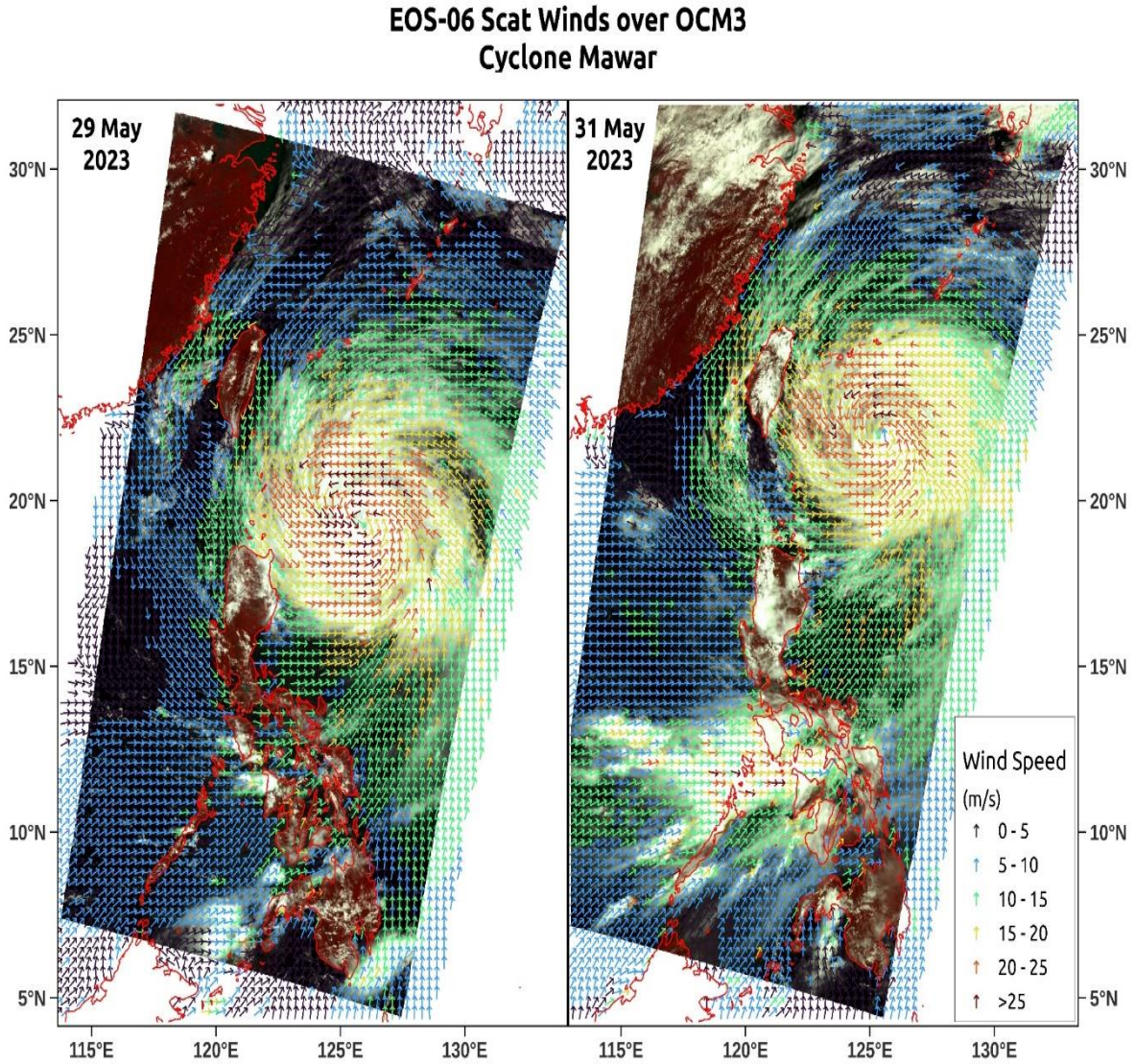
SSHA map

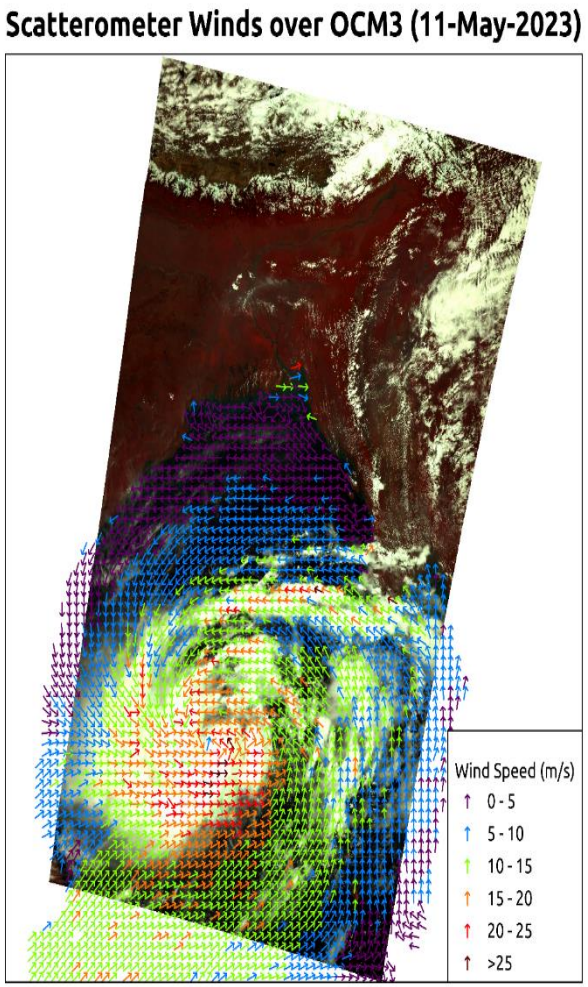


Kd at 490 nm Global (4km) in January, 2020

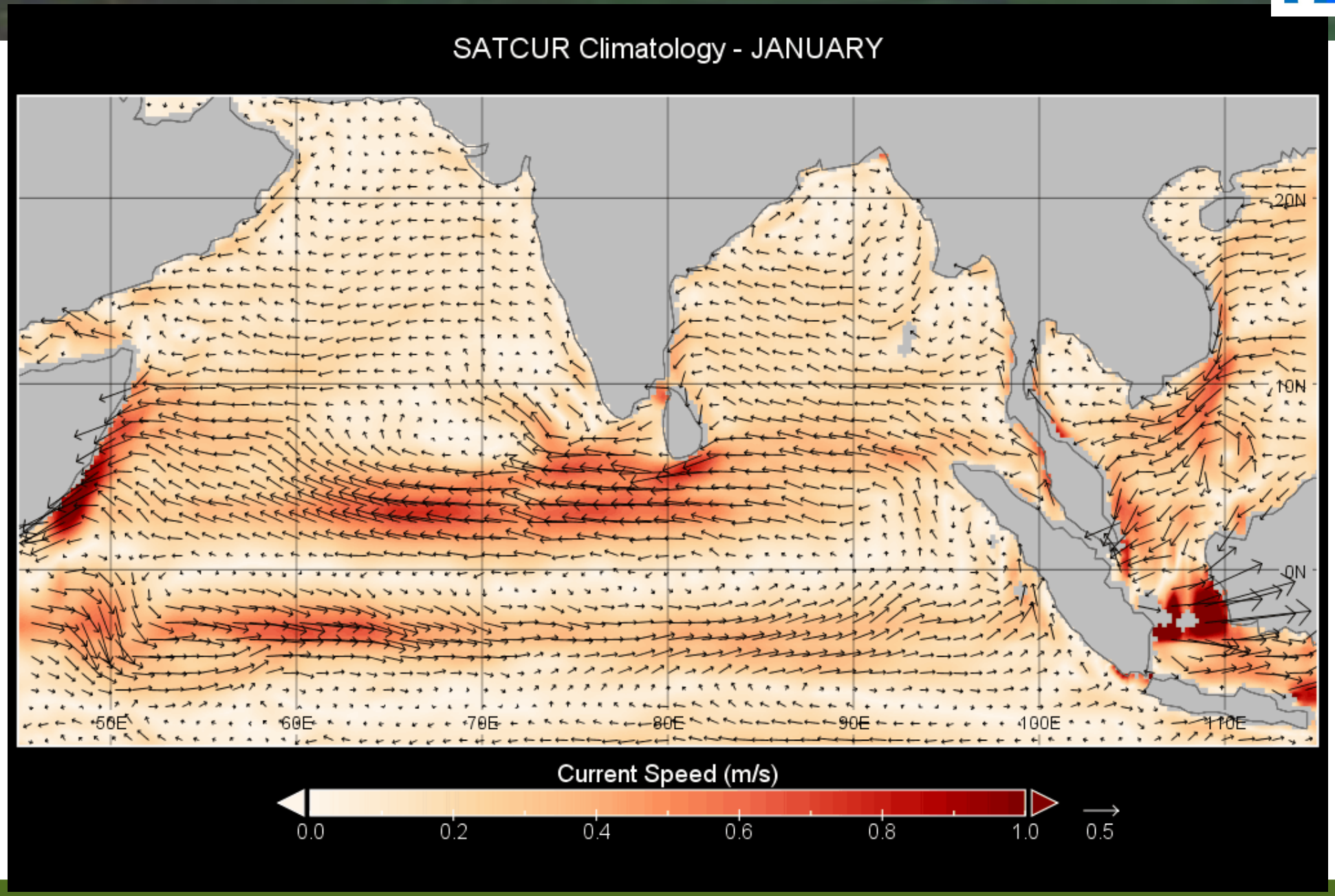


Cyclone monitoring using EOS-06 Scat data





Climatology of Currents



NICES - Outreach

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Director
National Remote Sensing Centre
Indian Space Research Organisation
Department of Space, Govt. of India,
Hyderabad 500 037
Phone:+91-40-23884001
director@nrsc.gov.in

Programme Director (NICES)
National Information System for Climate and Environment Studies
National Remote Sensing Centre
Indian Space Research Organisation
Department of Space, Govt. of India,
Hyderabad 500 037
Phone:+91-040-23884890 +91-040-23884212
ddecsa@nrsc.gov.in

Thanks for your kind Attention!