Ocean Colour Science and Applications at ISRO

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ISRO

International Ocean Colour Science Meeting
Darmstadt, 03 December 2025

Indian Earth Observation Programme: Dimensions

Enabling National development, improving quality of life, building resilient society and facilitating enhanced understanding of Earth System

Space Segment

Constellation of Satellites

- Land & Water
- Cartography
- Ocean & Weather

Ground Segment

- Data Acquisition & Processing
- Data Products Generation
- In-situ Observation Network
- Information Dissemination

Space Applications

- National Imperatives & SE develop.
- NR Management & Disaster Mgmt.
- Land-Ocean-Atm. Interactions
- Enabling Geospatial data & Applns.

EO SYSTEM

Institutional Linkages

- Ministries / Departments
- State Remote Sensing Centres
- Industry & Academia
- International Cooperation

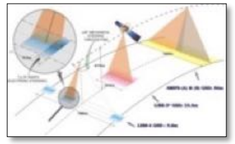
GOALS

- Data Continuity
- Inventory of natural resources
- Meet evolving needs of stakeholders
- Decision tools / Info. Systems
- Maximize outreach

Remote Sensing Capabilities

Space Segment

RESOURCESAT & RISAT
Natural Resources & Disaster Management



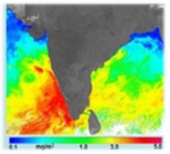
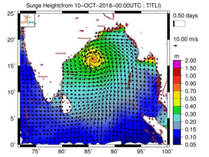
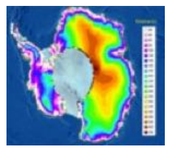
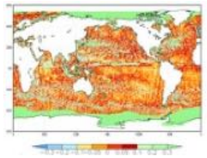

- Three tier imaging : 56 m / 23 m / 5.8 m
- Revisit Capability : 03 / 11 / 03 days
- C-Band SAR (3-50m resolution) / 17 to 24 days repetivity

CARTOSAT
Cartography & Large Scale Mapping



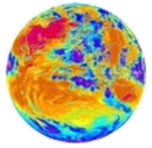
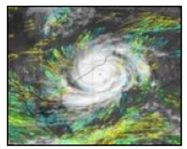
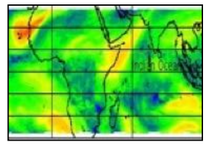
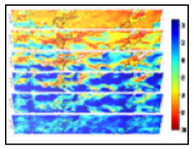

- 60 cm PAN & 1.5 m Multi-spectral
- 28 cm PAN & 1 m Multi-spectral

OCEANSAT-3, SARAL
Ocean State Forecast ; Ocean Altimetry, Wind Vector

- Ocean colour
- Sea-surface wind vector
- Ocean Altimeter

INSAT 3D, 3DR & 3DS, MHS
Weather Forecasting; Atm. and Climate studies

- 6 Channel Imager –48 images per day
- 19 Channel Sounder –Atm. Profiles

Aerial & UAVs


Terrestrial




Evolution of Ocean Remote Sensing in India

1974

Establishment of Ocean Remote Sensing Dept

- Beginning of organized remote sensing activities in India
- Foundation for later ocean remote sensing programs

1979

MONEX (Monsoon Experiment)

ISRO's HS-748 aircraft used for SST and atmospheric observations

- Early airborne oceanographic remote sensing

Early 1980s

Satellite Data for Ocean Studies

- Use of LANDSAT, TIROS-N, NOAA-6 for cyclone and ocean monitoring

Late 1980s

Emerging Applications

- Littoral processes
- Brackish water mapping
- Oil spill detection (using LANDSAT, SPOT, NOAA-AVHRR)

1990s

Algorithm Development

- PFZ experiments
- Validation of MCSST (SST algorithm)
- Indo-FRG & NOAA-NESDIS collaborative programs

Early Experience

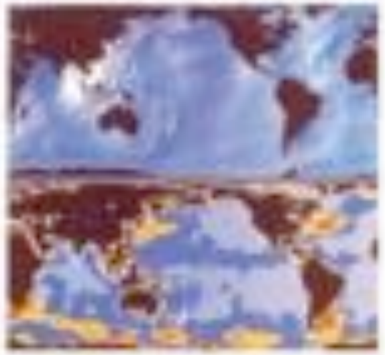
1963 SOUNDING ROCKETS

Atmospheric profiles upto 80 - 100kms

Atmospheric dynamics during Monsoon onset

Stratospheric warming and impact on monsoon

1978 SEASAT

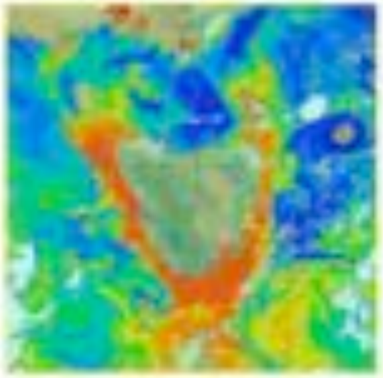


SAR (L-band) Altimeter
Scatterometer
SMMR
VIS/IR Radiometer

1978 NIMBUS - 7

Coastal Zone Color Scanner (CZCS)

SMMR

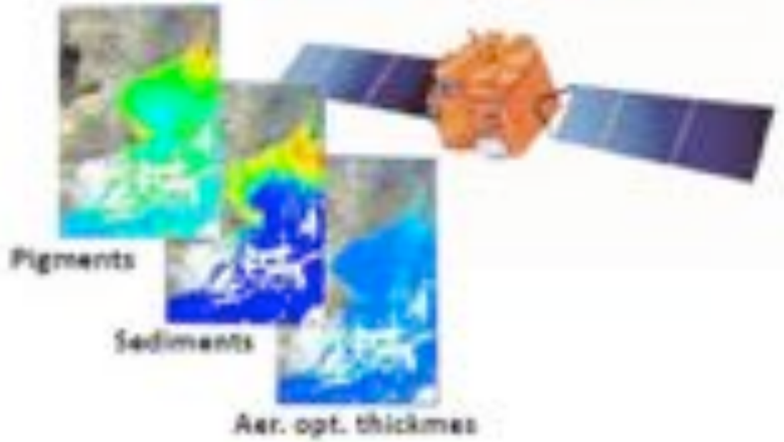


1979 BHASKARA - 1

TV CAMERA

SAMIR

1996 IRS-P3

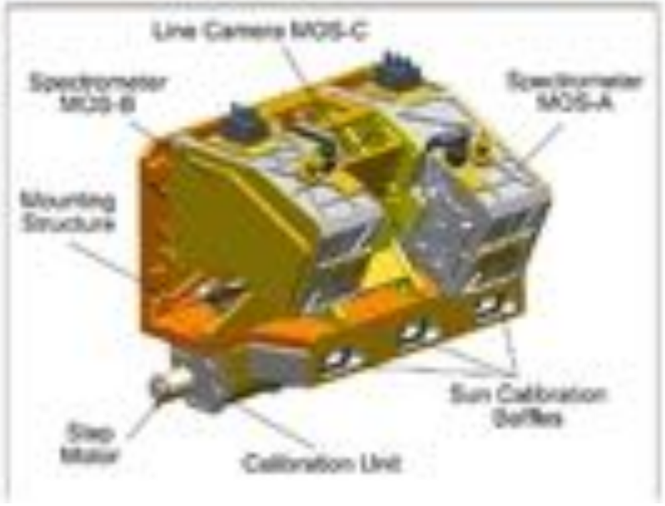


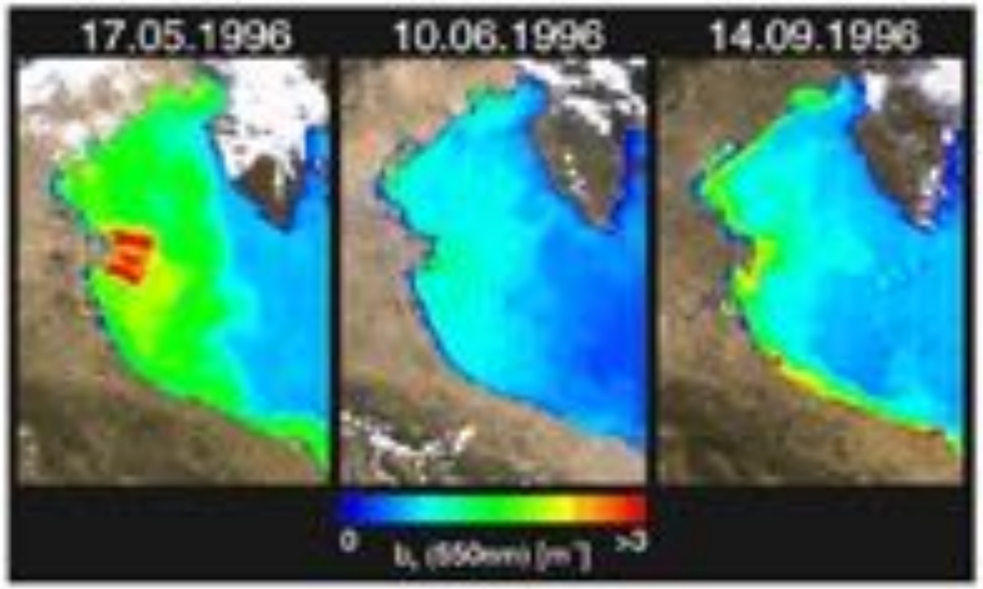
Joint ISRO-DLR Ocean Mission
MOS A – 4 Bands: Aereosol Characterization
MOS B – 13 Bands: Ocean Colour Studies
MOS C – 1 Band: Snow & Vegetation Studies

IRS-P3 / Modular Opto-Electronic Scanner (MOS): A precursor to Oceansat Series

- The German Aerospace Center (DLR) has developed MOS for ocean remote sensing and was launched by ISRO's PSLV-D3 onboard the IRS-P3 satellite in March 1996.
- MOS is a spaceborne imaging spectrometer for the VIS/NIR-spectral range with 18 Channels. It is designed for remote sensing investigations of the Atmosphere-Ocean-System, especially coastal zones.

The Modular Opto-electronic Scanner (MOS) – IRS P3





The images represent a time series of sediment maps in the Northern Adriatic Sea. Note the large plume in the mouth of the River Po in the May image, taken after heavy rainfalls. (Image Source: IOCCG)

Pigment concentration in the Arabian Sea off the Gujarat Coast of India. MOS IRS-P3 image, March 4th, 1998. (Image Source: IOCCG)

ISRO's Oceansat Missions

1999

Band No	OCM-1		Potential Applications
	Central wavelength (nm)	Bandwidth (nm)	
1	412	10	Yellow substance absorption
2	443	10	Low Chlorophyll-a concentration
3	490	10	Moderate Chlorophyll-a concentration, diffuse attenuation coefficient
4	510	10	High Chlorophyll-a concentration
5	555	10	Chlorophyll-a hinge point
7	670	10	Suspended sediments
11	765	20	Atmospheric correction
12	865	20	Atmospheric correction

2009

Band No	OCM-2		Potential Applications
	Central wavelength (nm)	Bandwidth (nm)	
1	412	10	Yellow substance absorption
2	443	10	Low Chlorophyll-a concentration
3	490	10	Moderate Chlorophyll-a concentration, diffuse attenuation coefficient
4	510	10	High Chlorophyll-a concentration
5	555	10	Chlorophyll-a hinge point
7	620	10	Suspended sediments
11	740	20	Atmospheric correction
12	865	20	Atmospheric correction

Mission Objectives

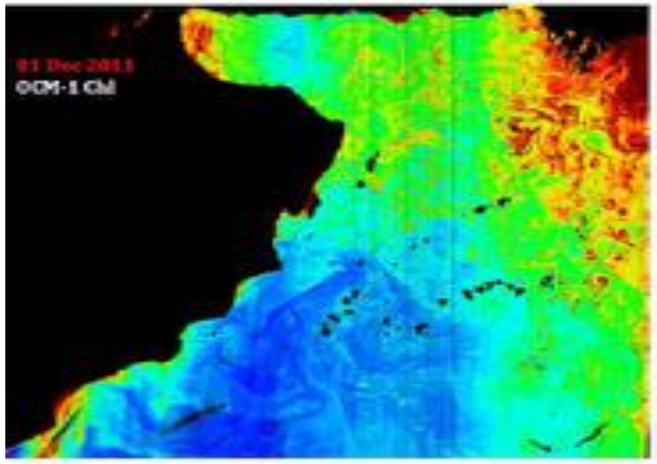
- To ensure the data continuity of Ocean colour and wind vector data to sustain the operational applications.
- Some additional datasets such as SST & Scatterometer to improve the applications & Mission utility
- More no. of bands in the VNIR & SWIR region for fluorescence and atmospheric corrections.

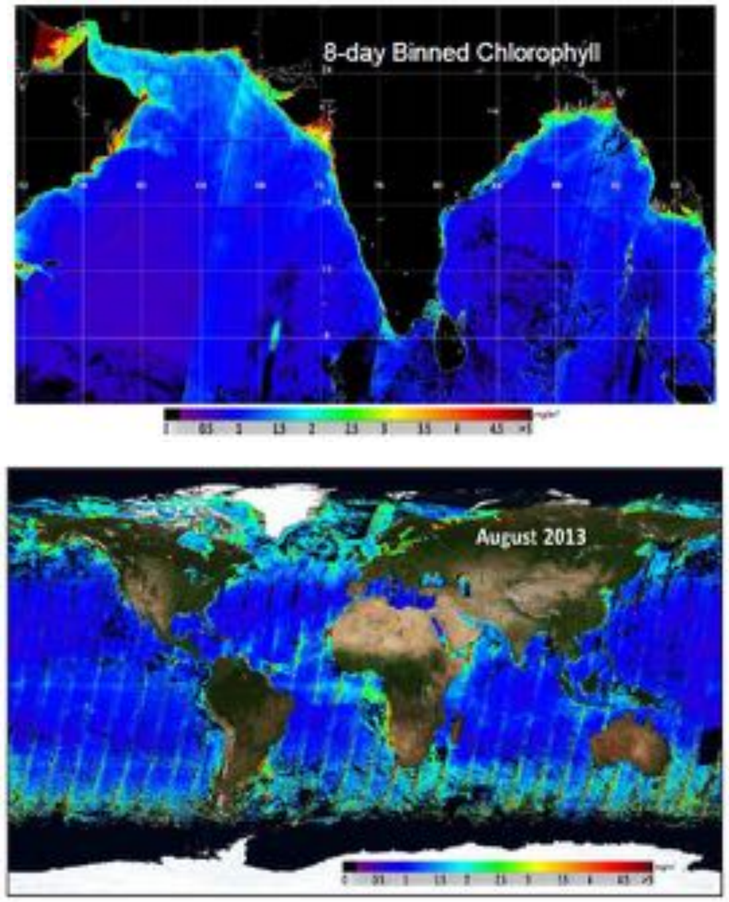
Band No	OCM-3		Potential Applications
	Central wavelength (nm)	Band width (nm)	
1	412	10	Yellow Substance absorption
2	443	10	Low Chl-a concentration
3	490	10	Medium Chl-a concentration, Diffuse attenuation coefficient
4	510	10	High Chl-a concentration
5	555	10	Chl-a reference, turbidity
6	**566**	**10**	**Trichodesmium identification**
7	620	10	Suspended sediments, cynobacteria, turbidity in case-2 waters
8	**670**	**10**	**Baseline for Chl fluorescence**
9	**681**	**08**	**Chlorophyll fluorescence**
10	**710**	**10**	**Baseline for Chl fluorescence, red edge**
11	780	10	Atmospheric correction
12	870	20	Atmospheric correction, spectral scattering
13	**1010**	**40**	**Atmospheric correction for turbid waters, aerosol-white foam discrimination**

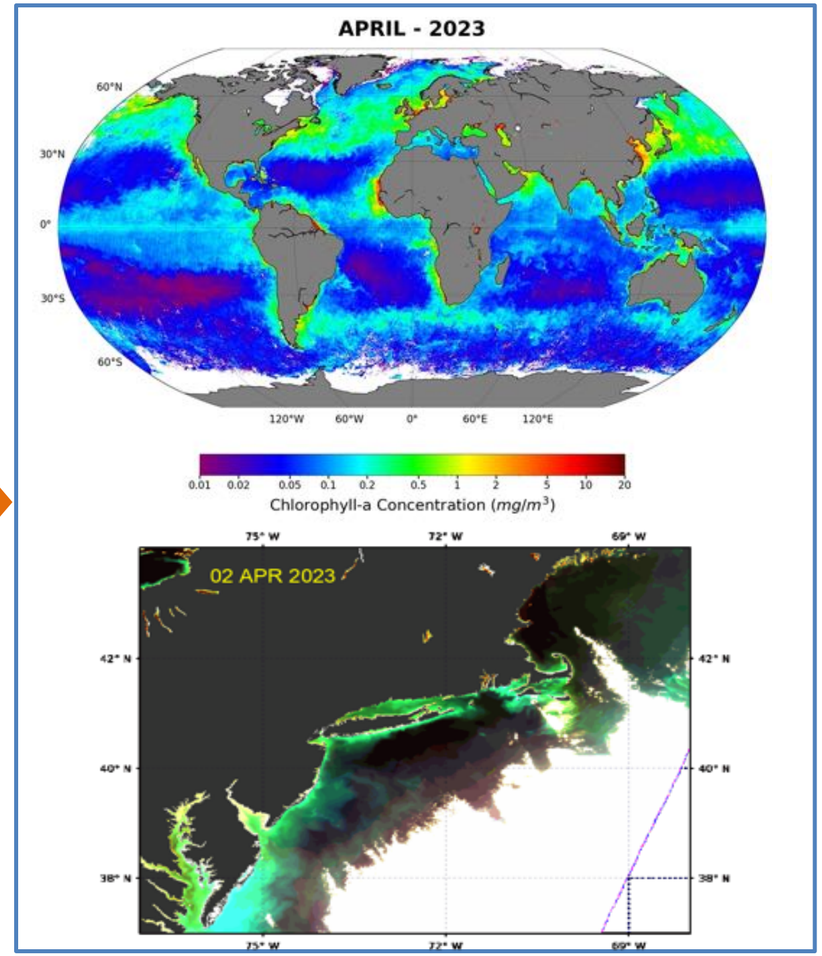
Glimpses of OCM-1, OCM-2 & OCM-3

International Ocean Colour Science Meeting 2025

Ocean chlorophyll concentration is very important parameter in ocean biology studies. It is the main proxy for fisheries, primary production. It is in conjunction with Sea Surface Temperature is used for Potential Fishing zone advisory INCOIS for Indian marine fisheries community. ISRO had heritage of 3rd generation of Ocean Colour mission from Oceansat-1 to Oceansat-3 & the upcoming Oceansat-3A.





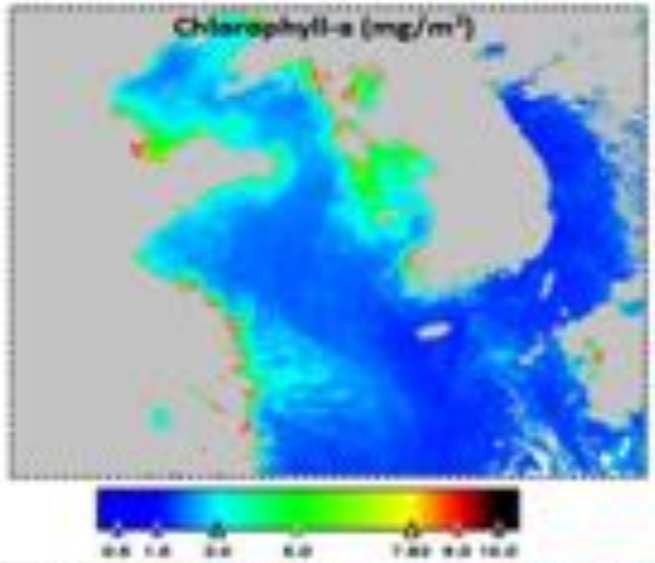


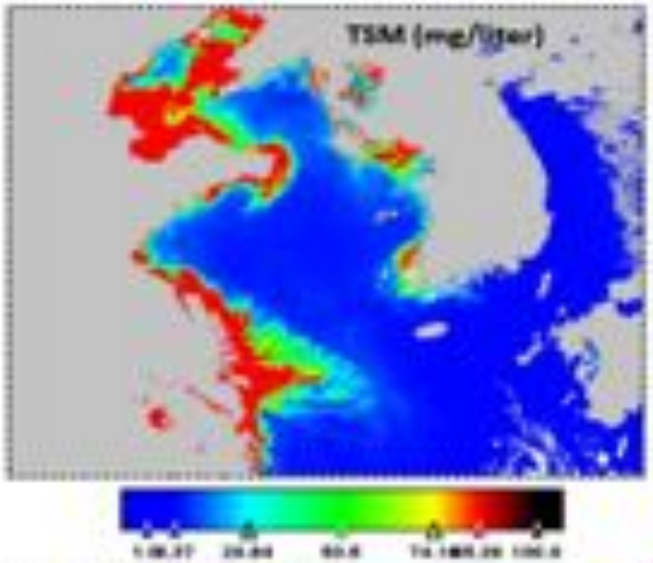
Oceansat-1 OCM-1 (1999-2010)

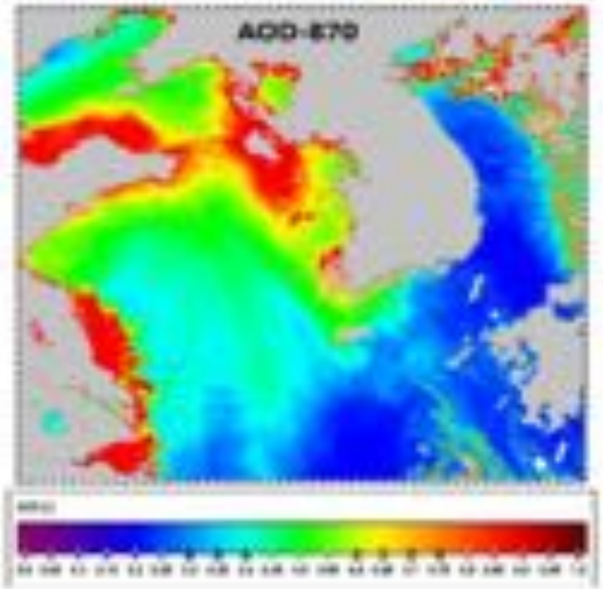
Oceansat-2 OCM-2 (2009-2021)

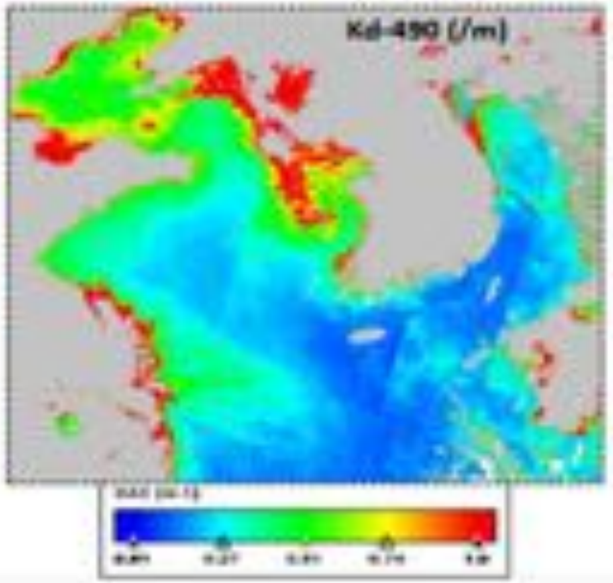
Oceansat-3 OCM-3 (2022- till date)

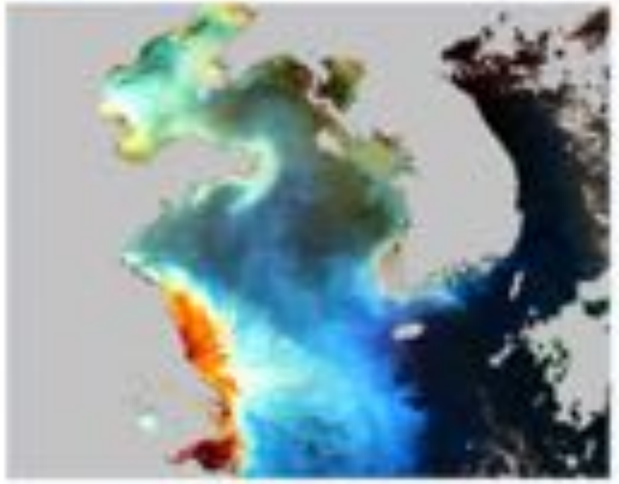
Operational Products from OCM-3





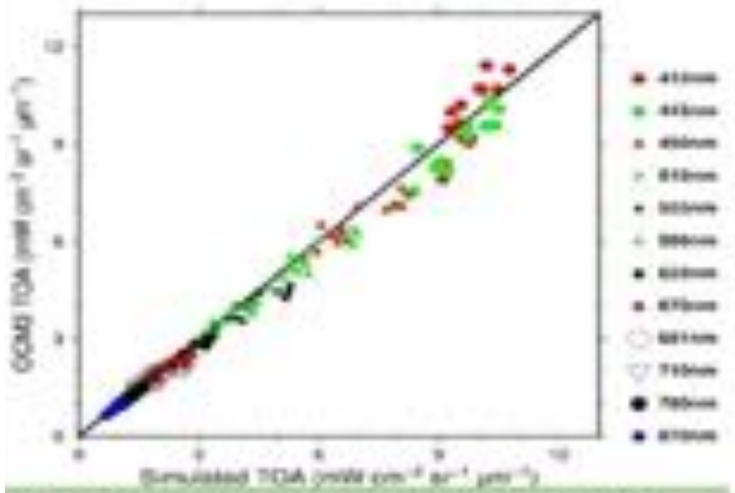


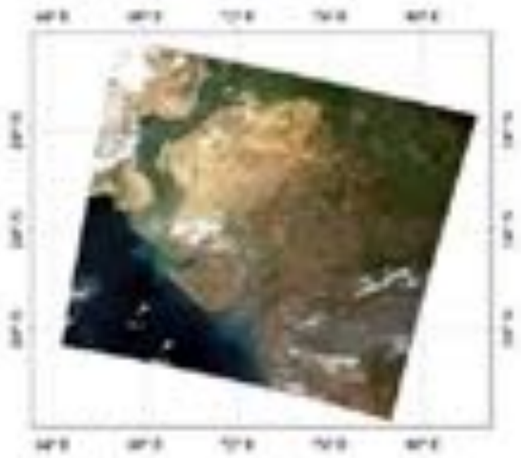




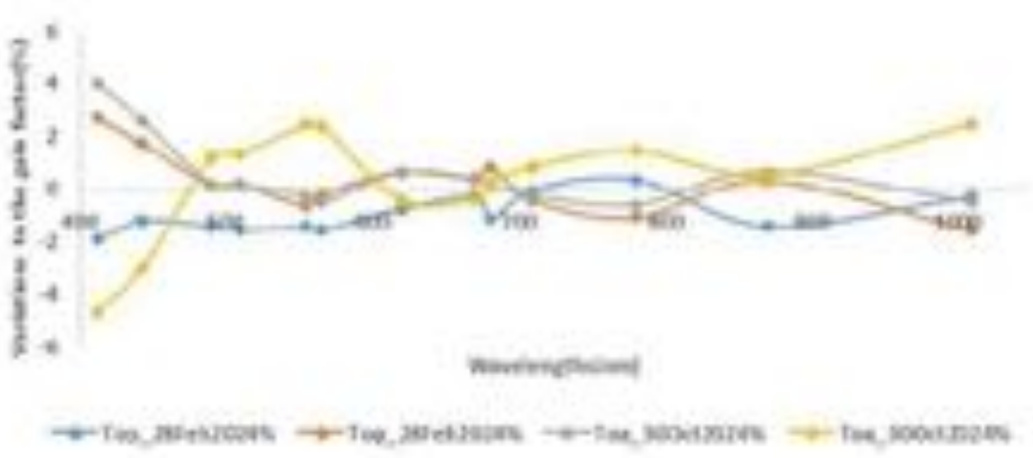
Natural Colour Composite of Indian Remote Sensing Satellite EOS-6/OCM-3 over Yellow Sea , Date of pass 08 January 2023

Post Launch Calibration of OCM-3





The scatter of simulated and OCM3 measured TOA radiance over Kavaratti site.



variations to the gain factors (%) across 412 to 1010 nm derived using Satellite Data Inversion (SDI) model

The mean vicarious calibration gain coefficients and its standard deviation in percentage over the bright target

Band (nm)	412	443	490	510	555	566	620	670	681	710	780	870
Gain	0.952	0.996	0.988	0.998	0.962	1.007	1.005	0.994	1.004	0.999	1.000	1.008
Std (%)	2.51	2.60	3.87	4.36	4.92	5.34	5.73	5.67	5.71	5.35	5.79	5.76

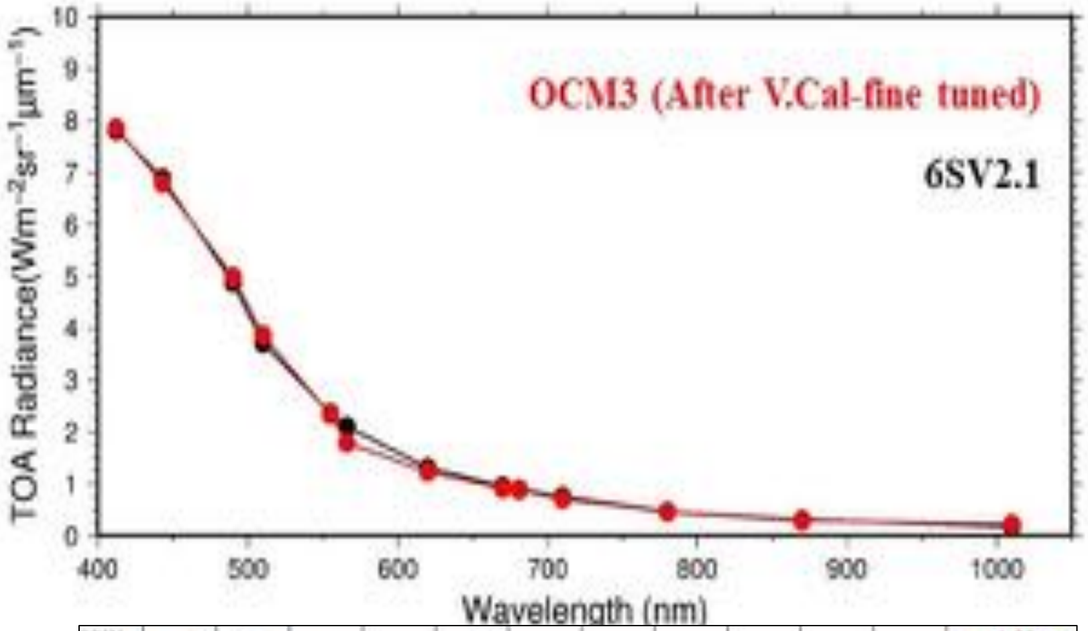
The percentage of relative difference is higher (~6%) for the chlorophyll channels (2-4) and its reference band (5) shows ~7%. The NIR channel of OCM3 showed 4 to 5% relative absolute difference between the simulated and measurements with 0.98 coefficient of correlation. The vicarious gain coefficients corrected TOA radiance of OCM3 radiance are closely matches with the simulation.

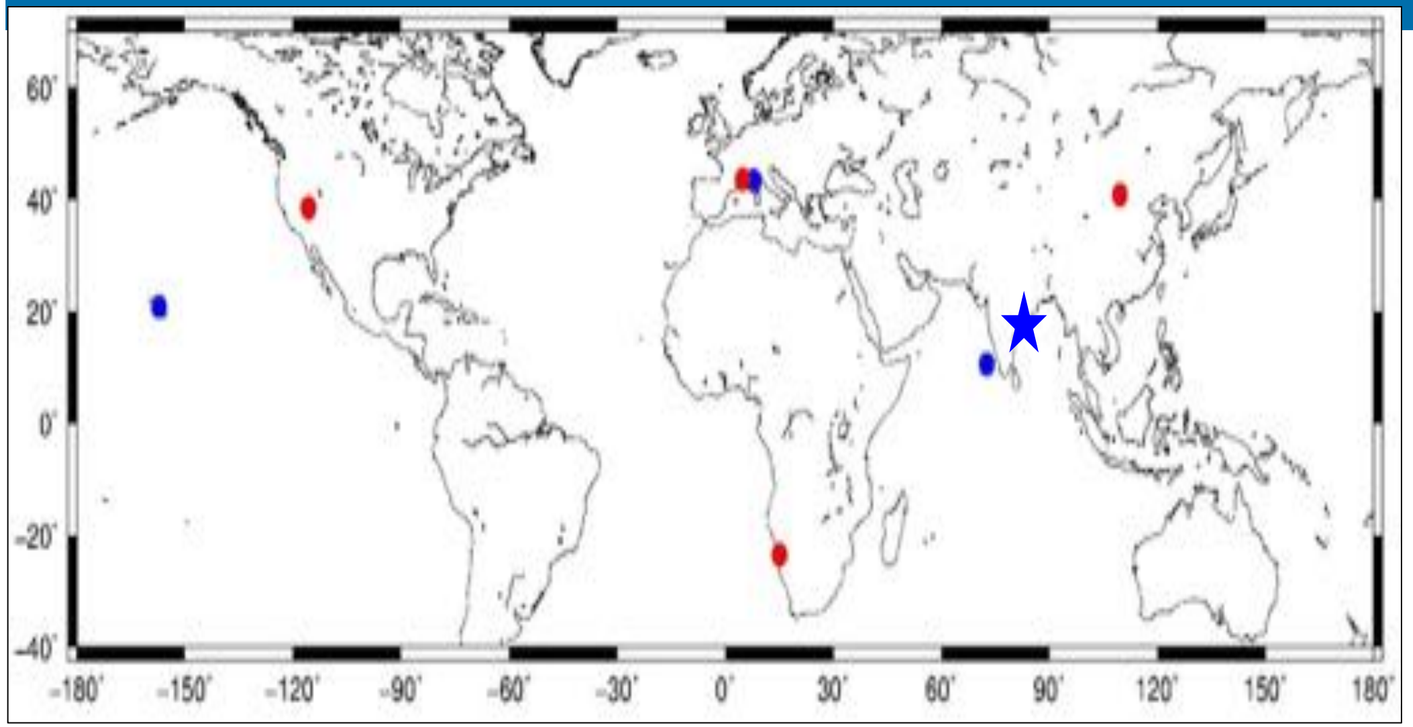
Babu, et. al., 2025

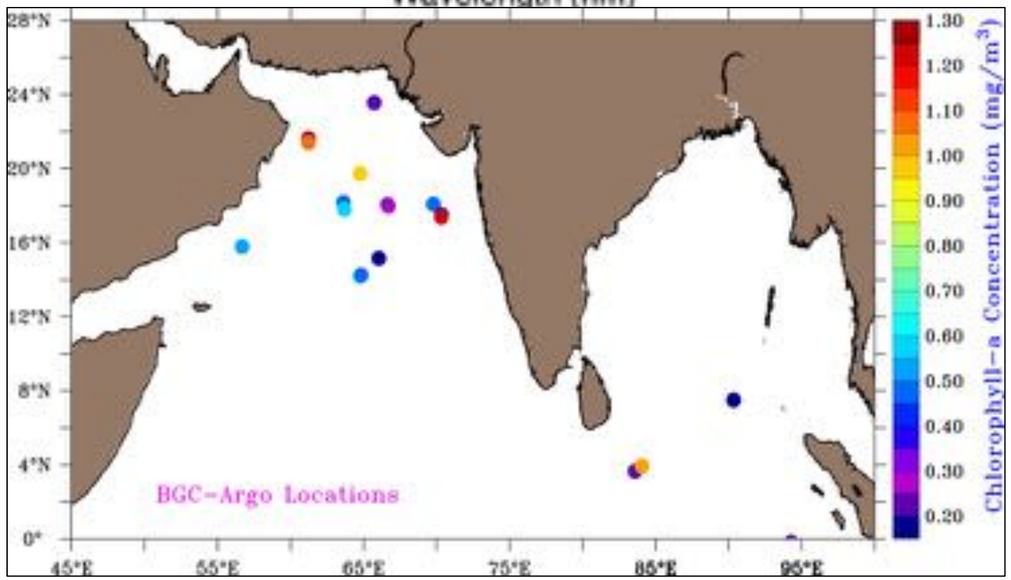
It is observed that out of thirteen channels of OCM, 490, 510, 620, 670, 681, 710, 780, and 870nm bands are found to be much stable as compared to the remaining i.e. 412, 443, 555, 566 and 1010 nm. Because these bands are having relatively less variations associated with the gain factor 1.5% with respect to their mean while others are in between 2 to 3% except 412 nm for which it is 4.7%.

Anurag, et. al., 2025

Validation Program: Overview





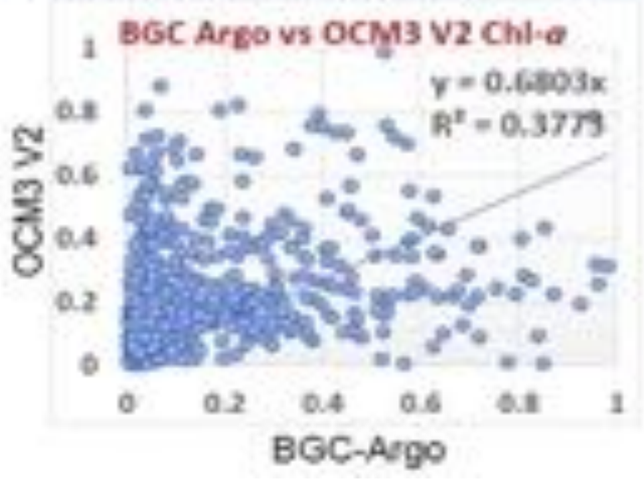


Evaluation of OCM-3 Chl (v.2) using OCCCI & BGC-Argo

Data & Period: Global daily chlorophyll data of OCM-3 Ver. 2 during August 2024 – March 2025. (**Chl-a Range: 0.02 – 1 mg m^{-3}**)
In-situ Chlorophyll: BGC-Argo across global oceans
OCCCI Chlorophyll: Daily data for August – December 2024 (Jan – Mar 2025, not available till date)

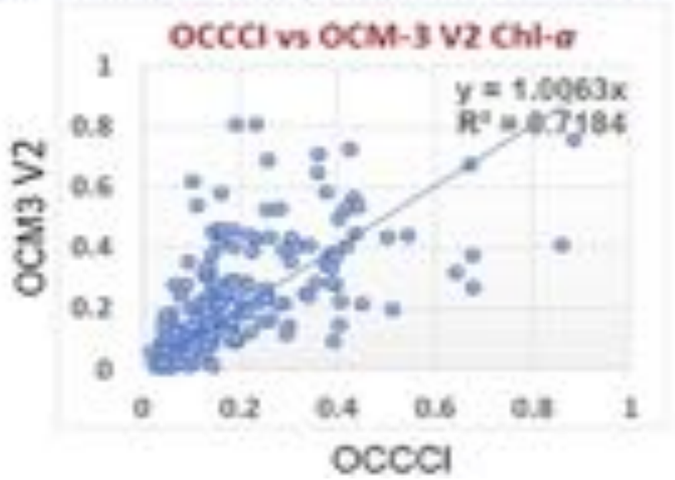
BGC-Argo vs OCM3 Ver. 2.0

Statistical Estimate	Value
No. of Points	704
Root Mean Square Error	0.227
Bias	-0.063
Correlation	0.287
Standard Deviation OCM3	0.168
Standard Deviation BGC	0.194
Mean Absolute Error	0.163
Mean Absolute Percentage Error	3.814



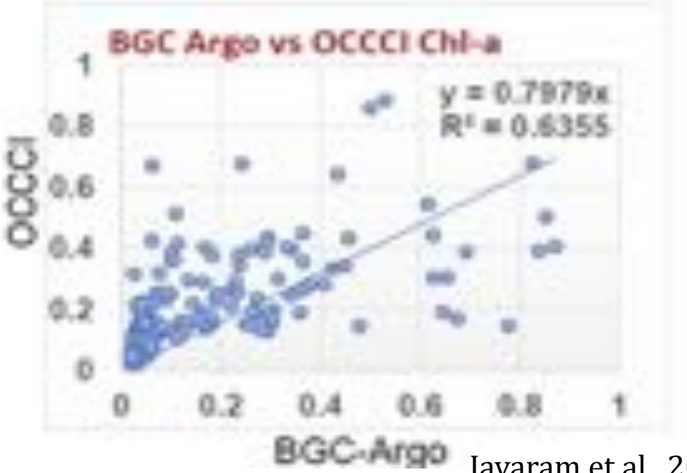
OCM3 Ver. 2.0 vs OCCCI

Statistical Estimate	Value
No. of Points (Collocated with BGC-Argo)	183
Root Mean Square Error	0.159
Bias	-0.040
Correlation	0. 572
Standard Deviation OCM3	0.177
Standard Deviation OCCCI	0.153
Mean Absolute Error	0.110
Mean Absolute Percentage Error	0.695



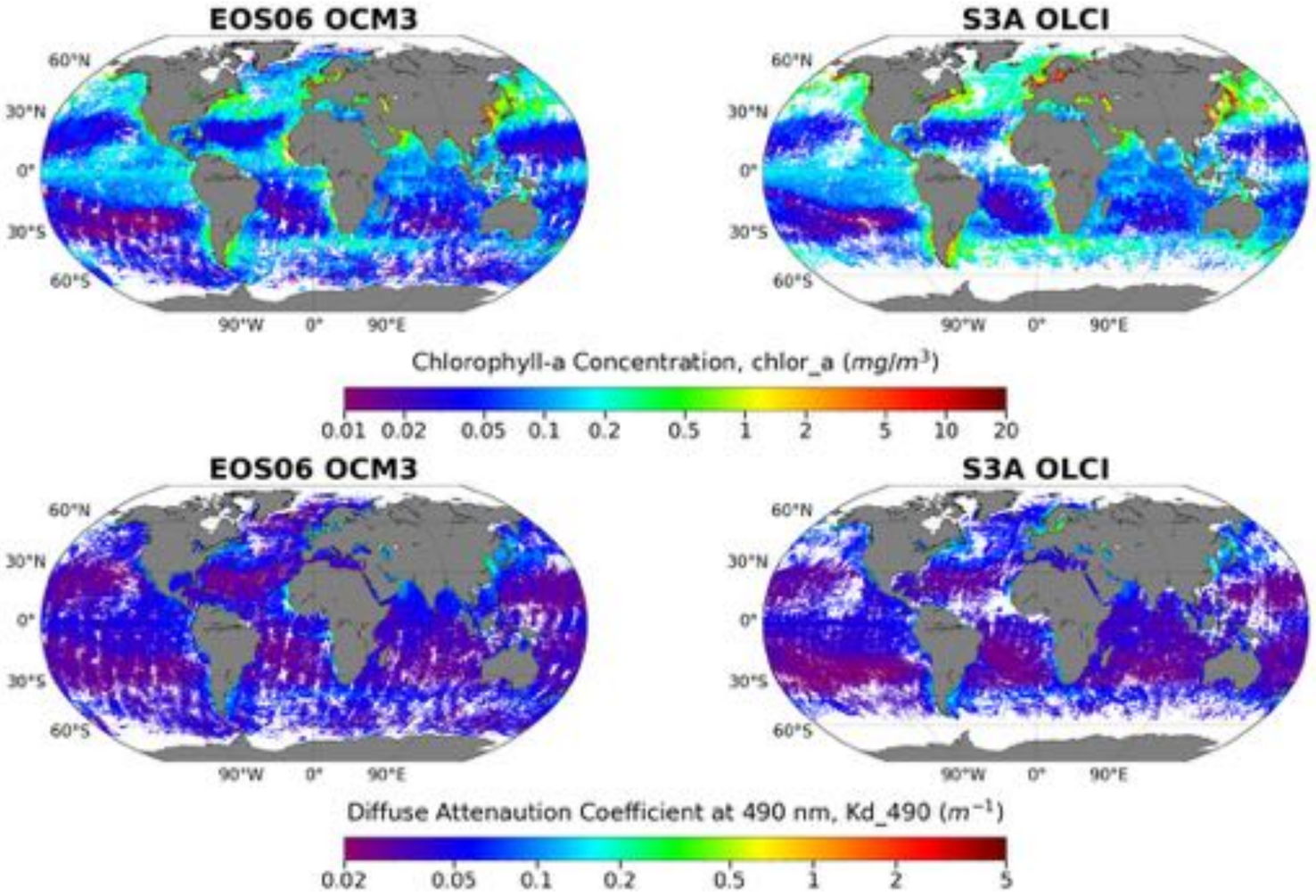
BGC- Argo vs OCCCI

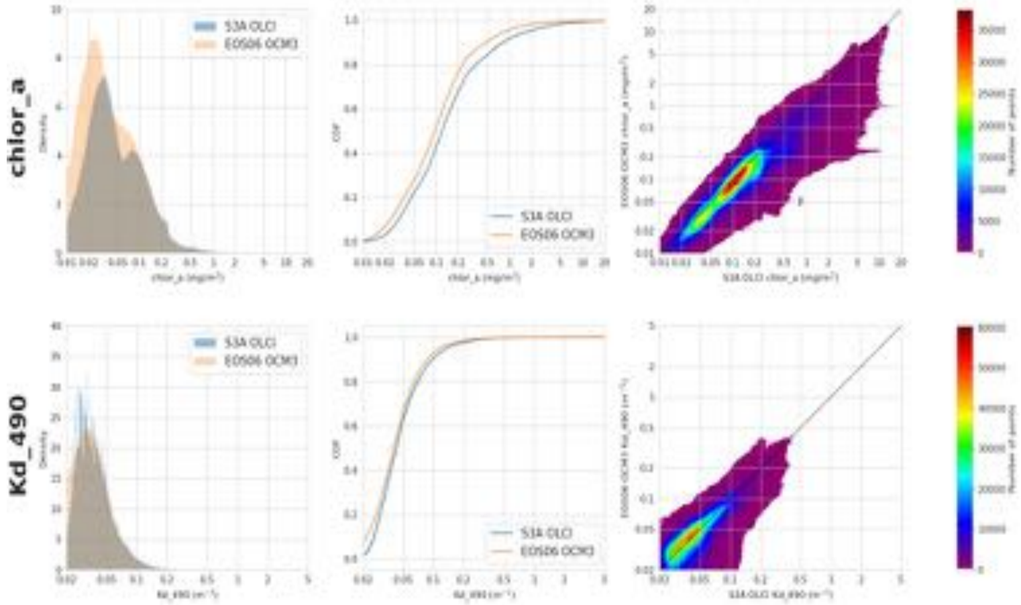
Statistical Estimate	Value
No. of Points (Collocated with BGC-Argo)	183
Root Mean Square Error	0.160
Bias	-0.037
Correlation	0. 607
Standard Deviation OCM3	0.177
Standard Deviation OCCCI	0.153
Mean Absolute Error	0.111
Mean Absolute Percentage Error	1.303



Jayaram et al., 2025

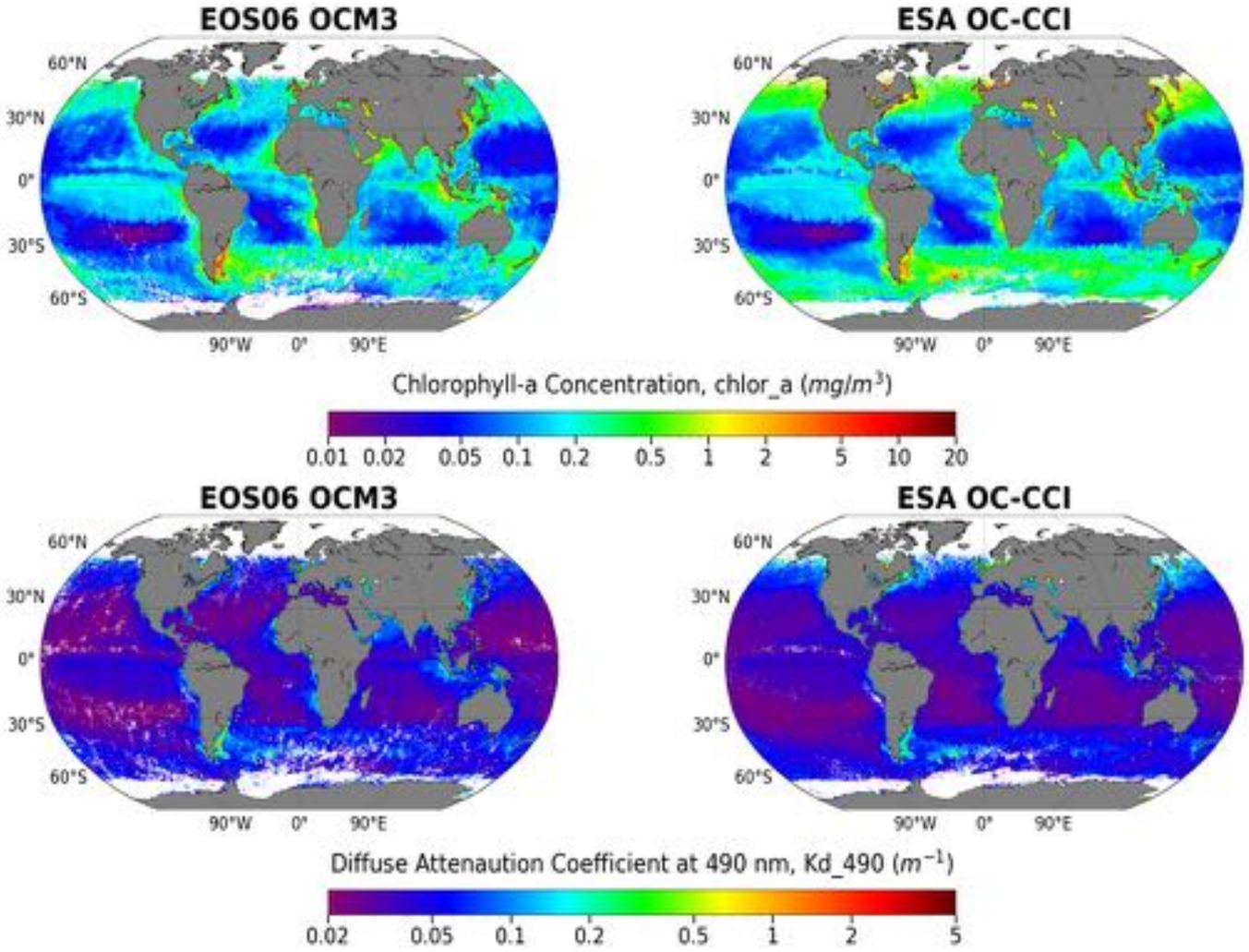
EOS06 OCM3 vs Sentinel-3A OLCI (Level-2 Comparison)

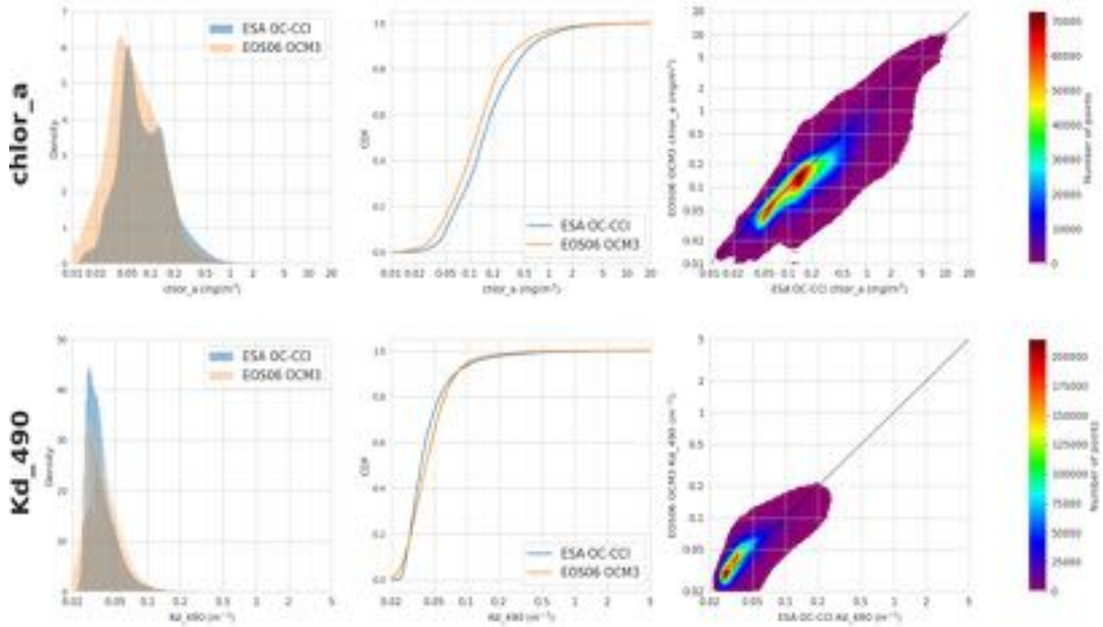




Suhail et al., 2025

EOS06 OCM3 vs ESA OC-CCI (Level-3 Comparison)





Suhail et al., 2025

Fluorescence Line Height (FLH) from OCM-3

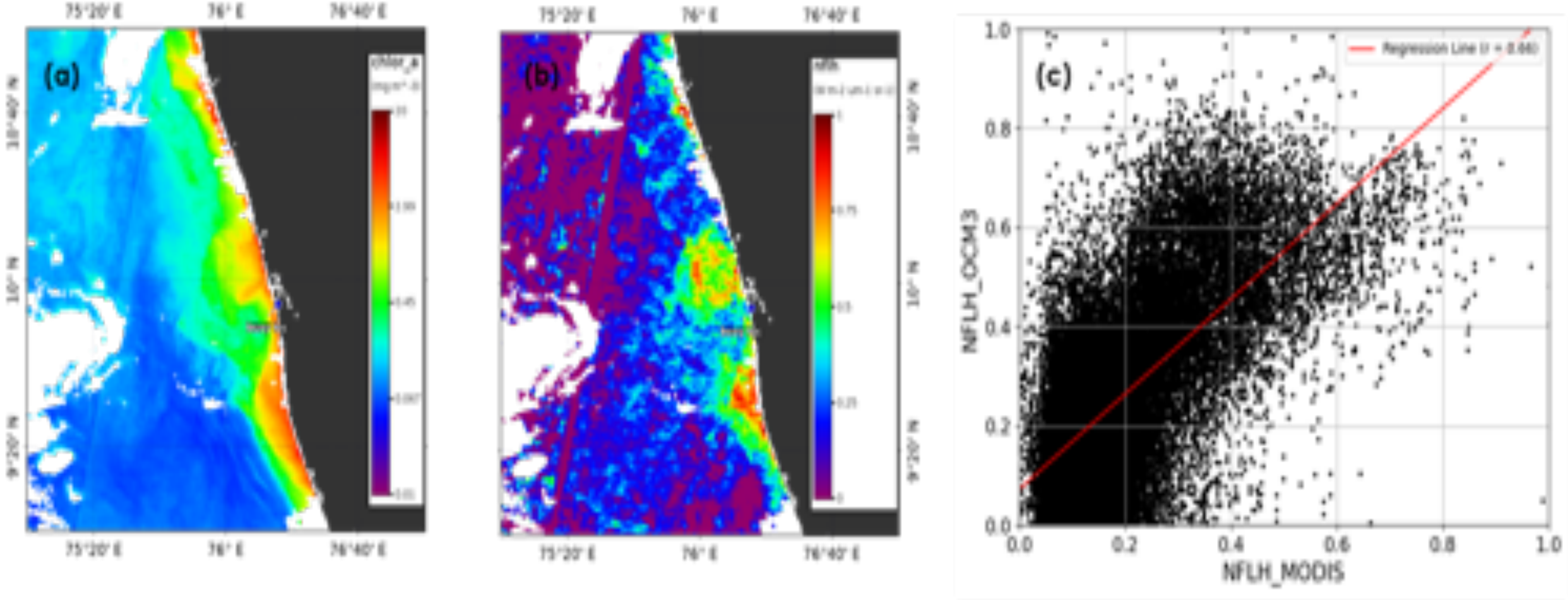


Fig. (a)OCM3 Chl-a, (b)OCM3 FLH, (c)scatter plots between MODIS and OCM3 nFLH

Rema et al., 2025
(internal report)

Retrieval using 1010nm over Coastal & inland waters

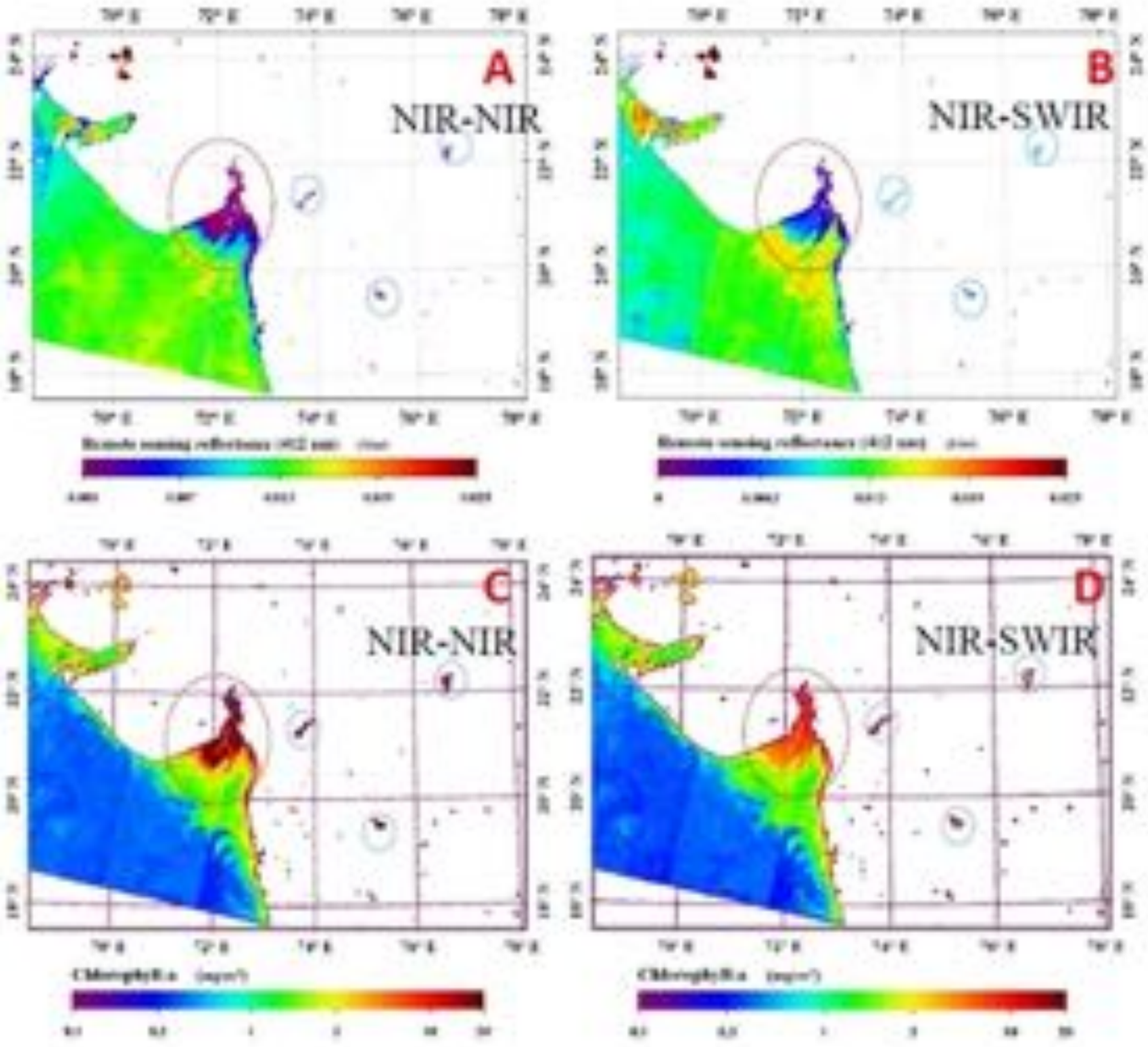


Figure-A **Remote sensing reflectance** (412 nm) derived from top of the atmosphere (TOA) radiance using OCM-3 L1C (Feb 16, 2023) path 53 row 13, after atmospheric correction based on NIR-NIR band selection.

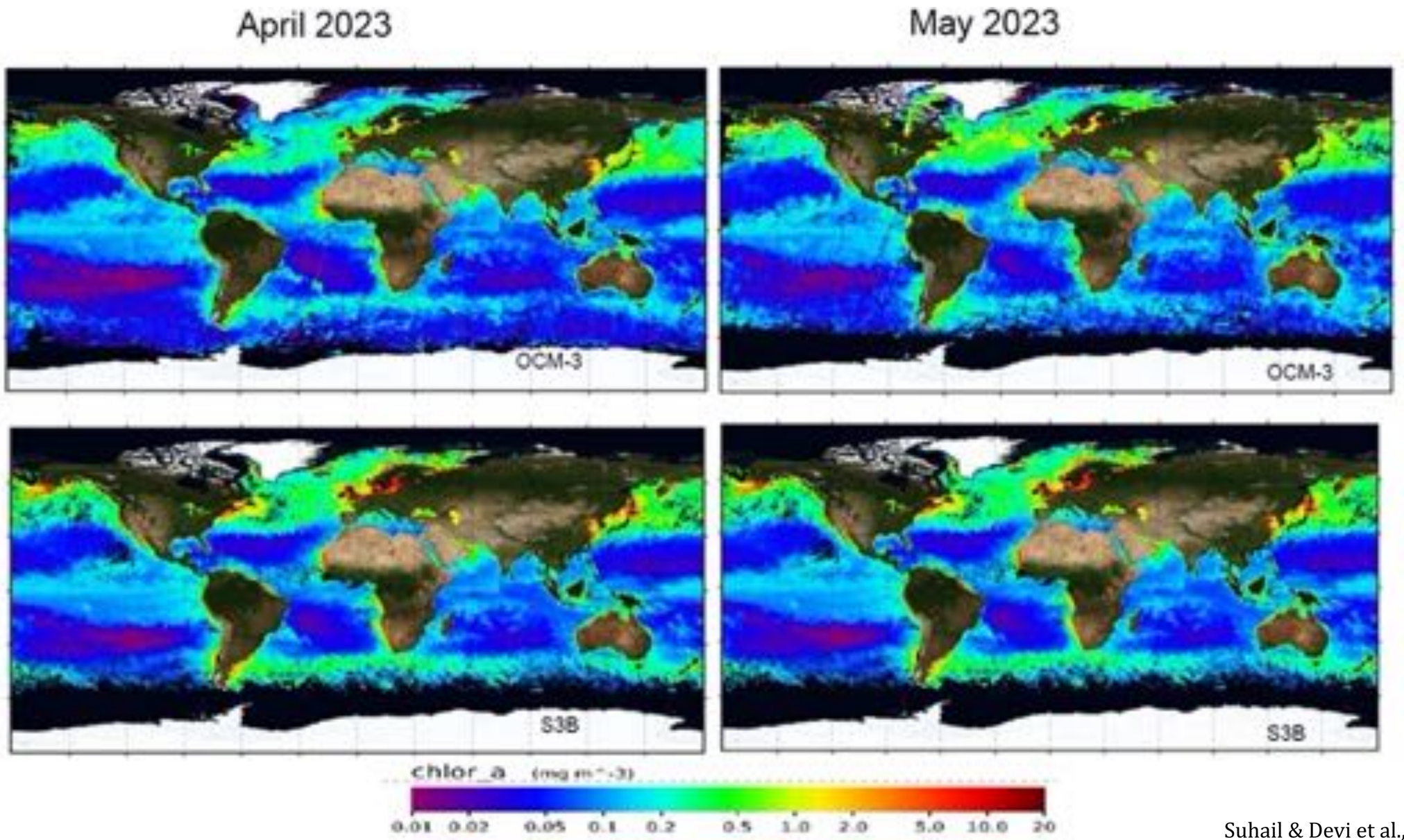
Figure-B **Remote sensing reflectance** (412 nm) derived from top of the atmosphere (TOA) radiance using OCM-3 L1C (Feb 16, 2023) path 53 row 13, after atmospheric correction based on NIR-SWIR band selection.

Figure-C **Chlorophyll-a**(mg/m3) derived from remote sensing reflectance using OCM-3 L1C (Feb 16, 2023) path 53 row 13.

Figure-D **Chlorophyll-a**(mg/m3) derived from remote sensing reflectance using OCM-3 L1C (Feb 16, 2023) path 53 row 13.

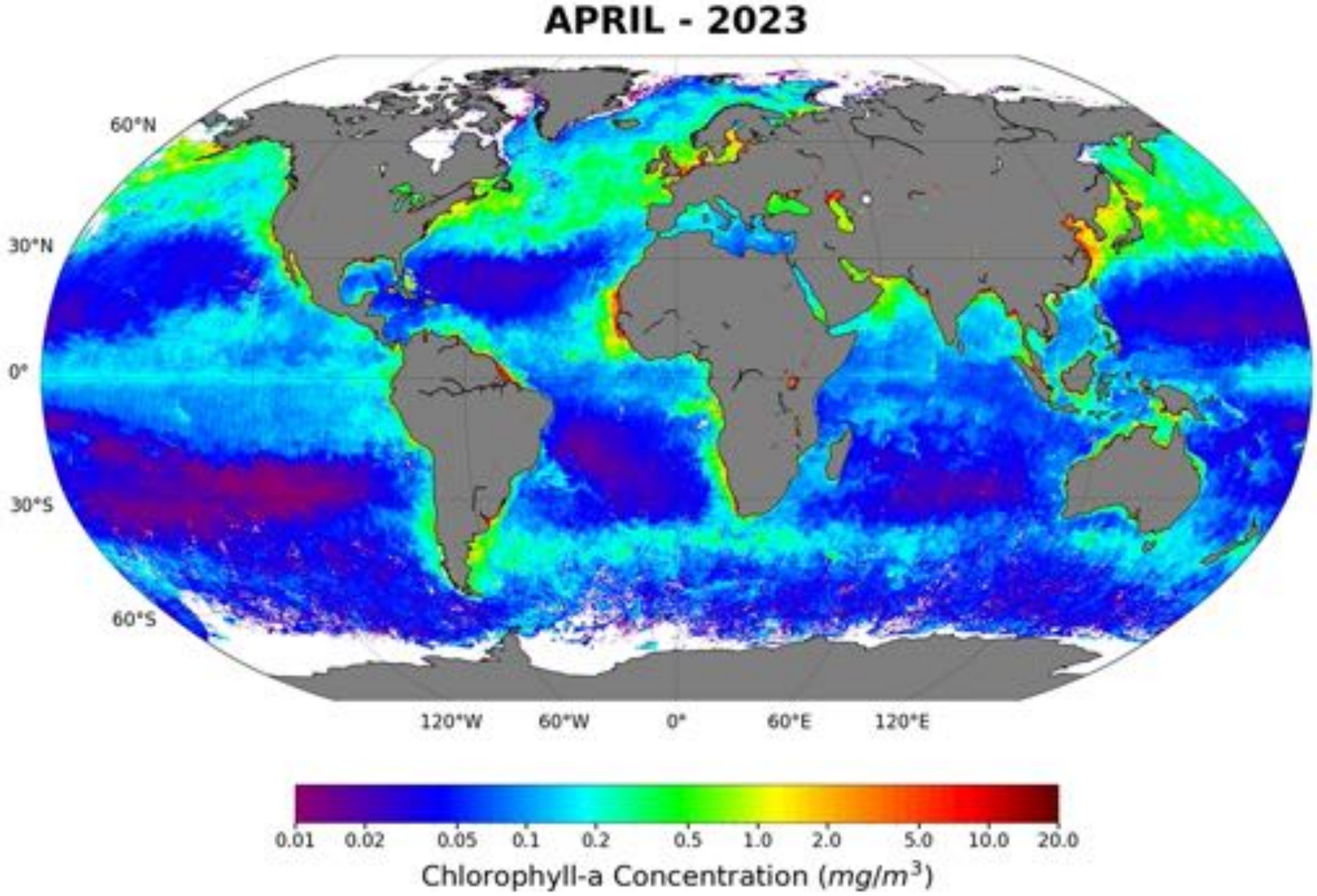
Anurag, et. al., 2025

Assessment of OCM-3 Chl Vs. S3 OLCI



Suhail & Devi et al., (internal report)

Chlorophyll Dynamics from OCM-3



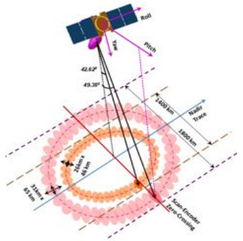
Suhail et al., 2025

Oceansat-3A

Orbit	Sun synchronous ; **720 km ; ECT: 12:00 Hrs**
P/L	**OCM-3 (13 bands: 402 to 1020 nm) : 360 m** **OSCAT-3 (Ku Band - 13.51 GHz)** **SSTM-1 (2 Bands: 11 &12 µm) : 1080 m**
Swath	1400 x 1400 km

SSTM specifications

S. No.	Parameter	Design Goal
1	Instantaneous Geometric Field of View (IGFOV) at nadir (m)	< 1080 m
2	Spectral bands (µm)	10.75 - 11.25 11.75 - 12.25
3	Band Width (µm)	0.5
4	Swath (km)	1440
6	NEdT @ 300K	< 150mK
7	Saturation temperature (K)	> 340



Ku band Scatterometer (13.515 GHz) ;

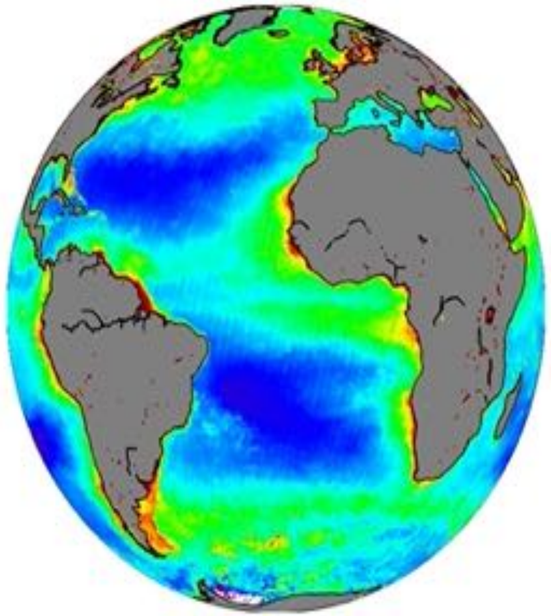
Orbits / day: 14 ½ ; Repeat cycle: 2 days

OCM-3 Band description and their applications

Band#	Central WL (nm)	Primary Application
B1	412	Differentiate yellow substance from chlorophyll
B2	443	Chlorophyll absorption maximum; low chlorophyll
B3	490	Moderate chlorophyll
B4	510	High chlorophyll; Total Suspended Matter (TSM)
B5	555	Reference baseline for Chlorophyll
B6 *	566	Phycoerythrin absorption , Trichodesmium bloom detection
B7	620	Turbidity in coastal Case 2 waters, Phycocyanin absorption
B8*	670	Baseline for fluorescence line height (FLH), chl secondary absorption
B9 *	681	Chlorophyll fluorescence
B10 *	710	Baseline for FLH, vegetation - chlorophyll fluorescence; atmospheric Correction
B11	780	Atmospheric correction; avoids O2 absorption Band
B12	870	Atmospheric correction; good assessment of spectral scattering
B13 *	1010	Atmospheric correction in turbid waters, aerosol – white foam discrimination

Way Forward……

- Generation of long-term Ocean Colour data with multi-sensor integration
- Bias correction & harmonized processing using in-situ observations
- Continuation of Cal-Val activities for improving the data quality



Thanks for your kind Attention!