IOCCG Summer Lecture Series 2026

Frontiers in Ocean Optics and Ocean Colour Science

Past, present and future of satellite OCR

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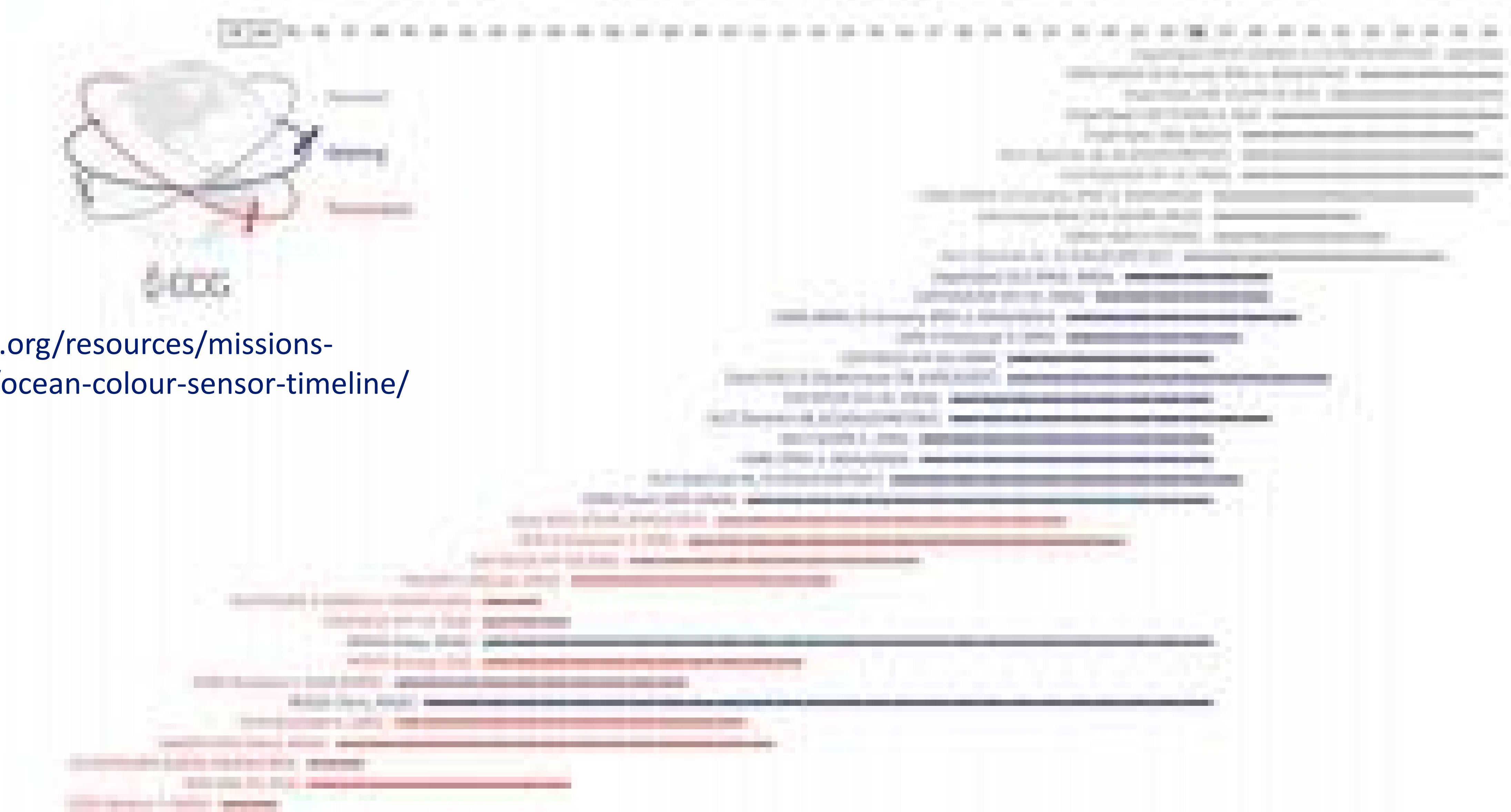
with material by D. Antoine, B. Loveday, J. Concha, C. Giardino

Venice, Italy - 9 July 2026

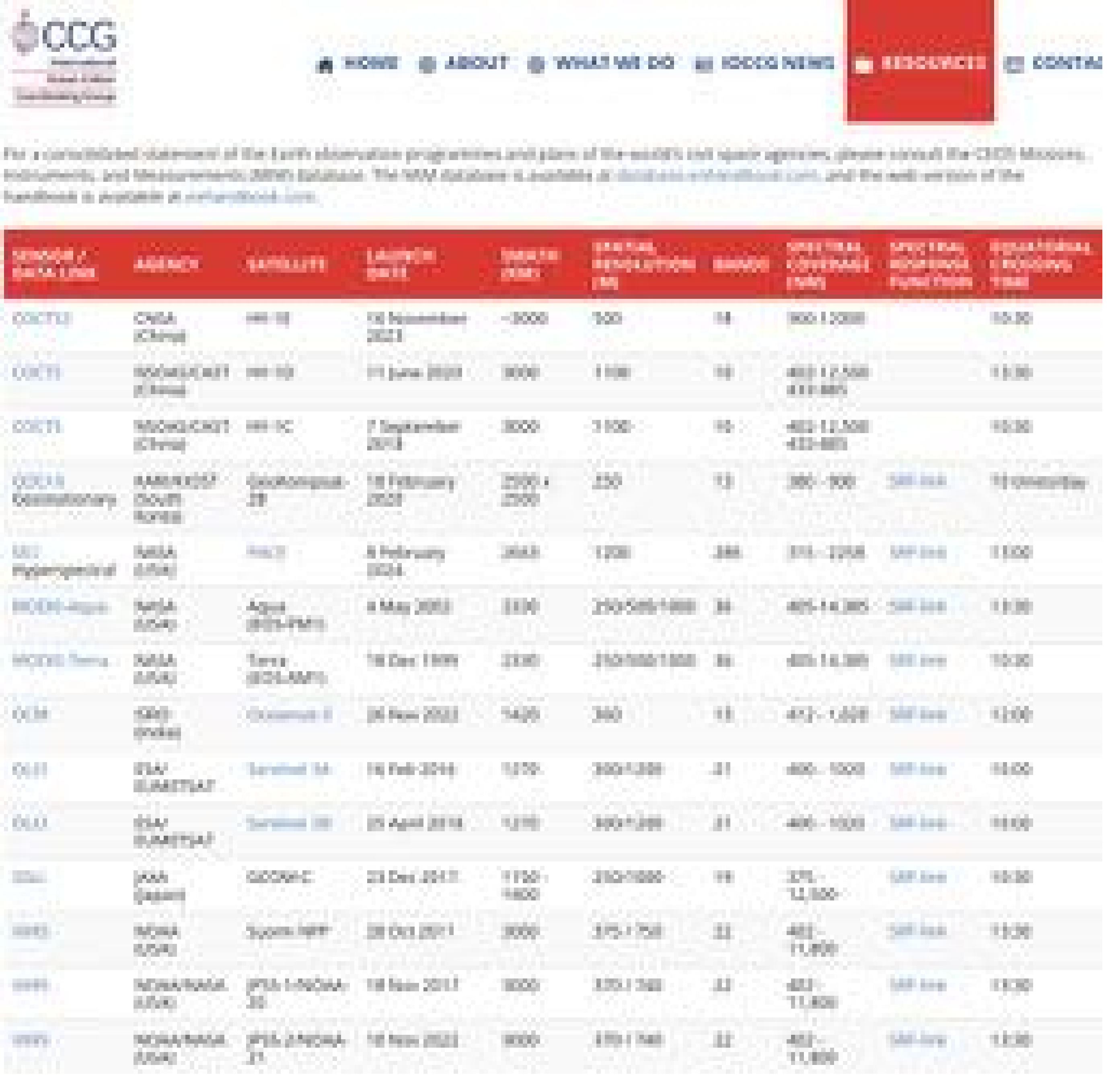
Ocean Colour missions: past, present and future

You are here!



https://ioccg.org/resources/missions-instruments/ocean-colour-sensor-timeline/

Ocean Colour missions: present



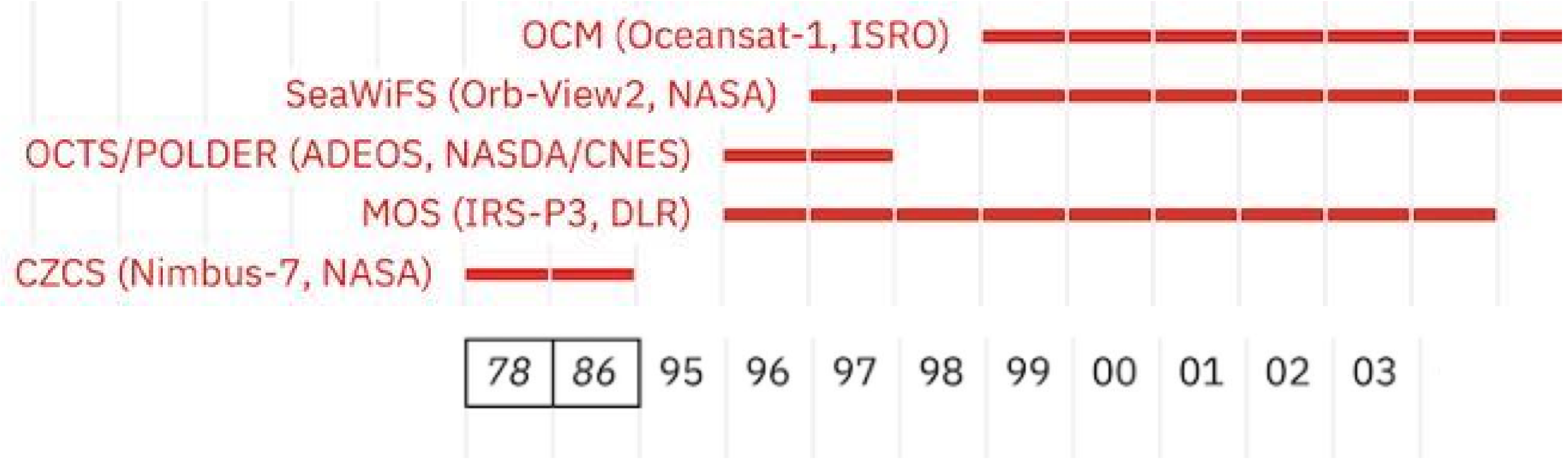
https://ioccg.org/resources/missions-instruments/current-ocean-colour-sensors/

How has ocean colour evolved?

- More than 20 satellites with ocean colour have flown and/or continue to fly.
- What have we learned from them?
- What has changed?
- Do we need to do more?

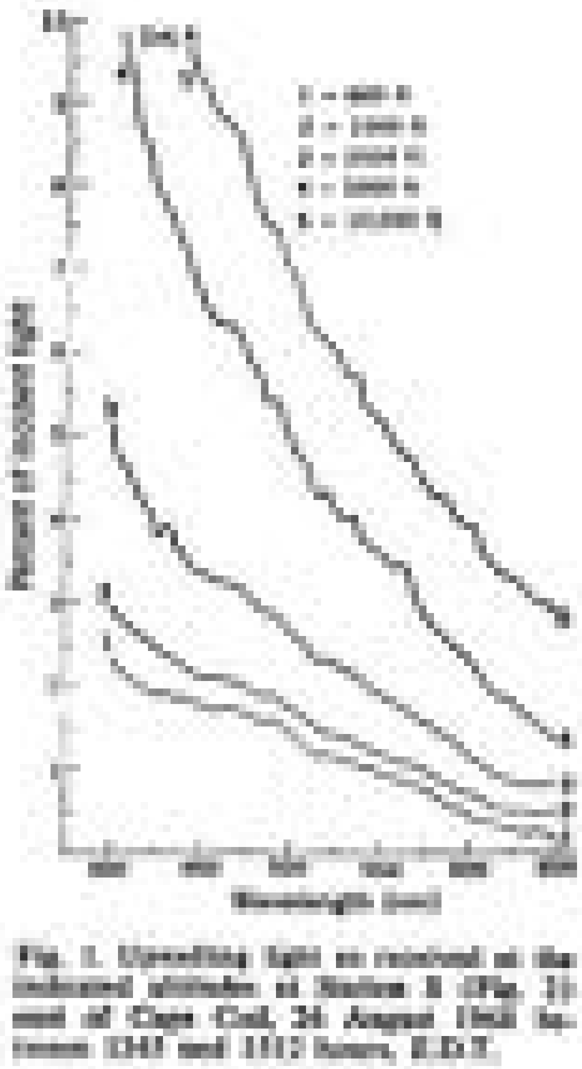
How has ocean colour evolved?

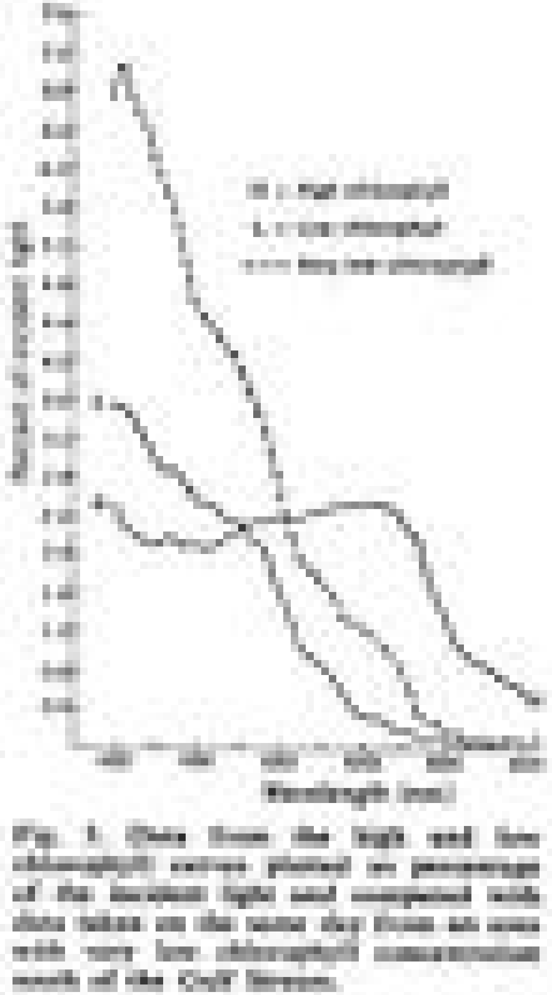
The proof-of-concept era

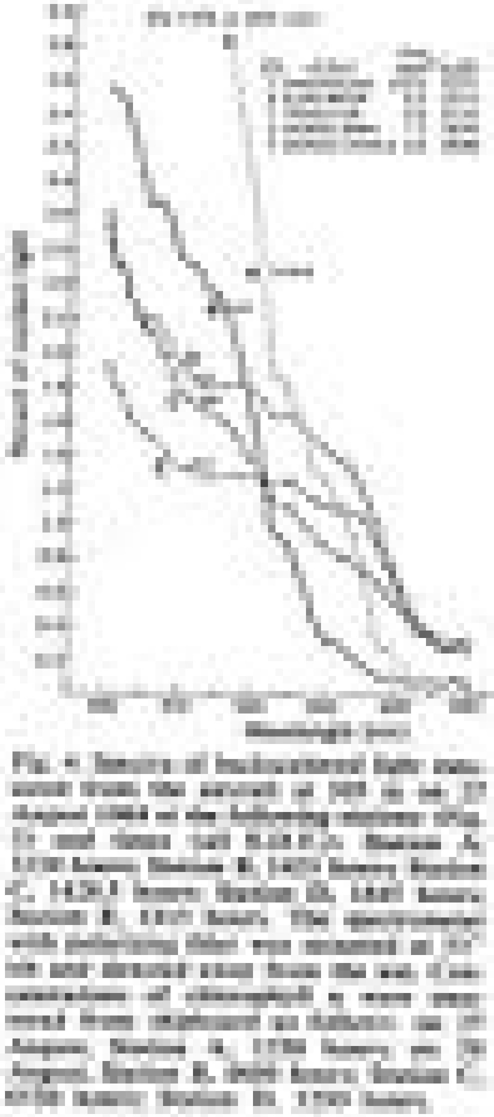


- Can we do this?
- How well can we do this?
- What can we do with this?

The proof-of-concept era







Clarke, G. L. , G.C. Ewing and C. J. Lorenzen, 1970. Spectra of Backscattered Light from the Sea Obtained from Aircraft as a Measure of Chlorophyll Concentration, Science 167 (3921), 1119-1121. DOI: 10.1126/science.167.3921.1119

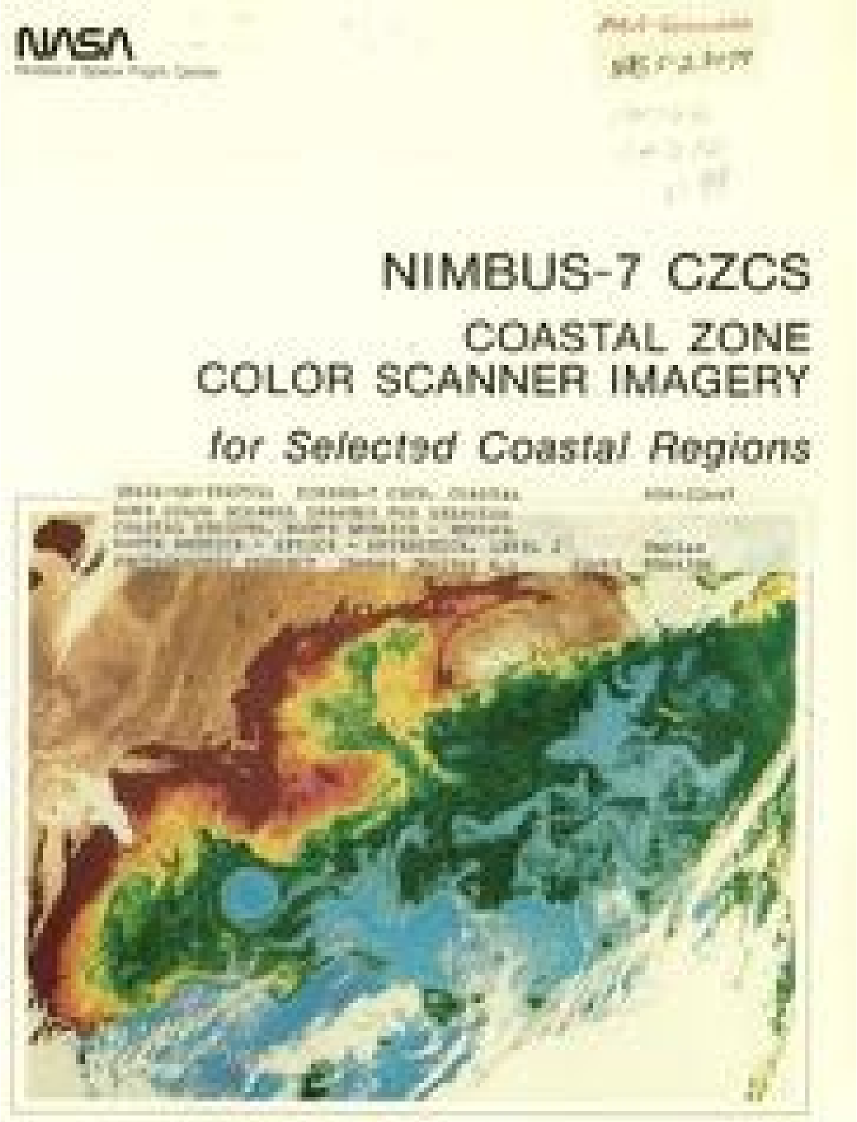
The proof-of-concept era

Abstract.
Spectra of sun and skylight backscattered from the sea were obtained from a low-flying aircraft and were compared with measurements of chlorophyll concentration made from shipboard at the same localities and at nearly the same times. **Increasing amounts of chlorophyll were found to be associated with a relative decrease in the blue portion of the spectra and an increase in the green**. Anomalies in the spectra show that **factors other than chlorophyll** also affect the water color in some instances; these factors include other biochromes, suspended sediment, surface reflection, polarization, and air light.

Last sentence of the paper:
If such interference can be eliminated, or identified and allowed for, **spectrometric procedures from aircraft (and perhaps from satellites) will be of great value in the rapid investigation of oceanic conditions, including conditions important for biological productivity.**

Clarke, G. L. , G.C. Ewing and C. J. Lorenzen, 1970. Spectra of Backscattered Light from the Sea Obtained from Aircraft as a Measure of Chlorophyll Concentration, Science 167 (3921), 1119-1121. DOI: 10.1126/science.167.3921.1119

The proof-of-concept era



The CZCS has six spectral bands, five sensing backscattered solar radiance and one sensing emitted thermal radiance. Table 1 shows the center wavelengths, the spectral bandwidths, and the minimum signal-to-noise ratio specified for the instrument at the most sensitive gain setting; that is, the gain setting that would be used for the darkest targets. The first four channels were selected to cover specific absorption bands and the so-called hinge point. These channels are meant to look at water only and saturate when the field of view is over land surfaces and clouds. The spectral response of Channels 1 through 5 is illustrated in Figure 1.

Table 1. CZCS Performance Parameters.

Performance Parameters	Channels					
	1	2	3	4	5	6
Scientific Observation	Chlorophyll Absorption	Chlorophyll Correlation	Yellow Stuff	Chlorophyll Absorption	Surface Vegetation	Surface Temperature
Center Wavelength λ Micrometers	0.443 (blue)	0.520 (green)	0.550 (yellow)	0.670 (red)	0.750 (far-red)	11.5 (infrared)
Spectral Bandwidth Δλ Micrometers	0.433 – 0.453	0.510 – 0.530	0.540 – 0.560	0.660 – 0.680	0.700 – 0.800	10.5 – 12.5
Instantaneous Field of View (IFOV)	0.865 × 0.865 Milliradians (0.825 × 0.825 km at sea level)					
Co-registration at NADIR	<0.10 Milliradians					
Accuracy of Viewing Position Information at NADIR	<2.0 Milliradians					
Signal-to-Noise Ratio (min.) at Radiance Input N ([mW/cm² · STER · μm])	≥150 at 5.41	≥140 at 3.50	≥125 at 2.86	≥100 at 1.34	≥100 at 10.8	NEΔT of 0.220°K at 270°K
Consecutive Scan Overlap	10%					
Modulation Transfer Function (MTF)	1 at 100 km target size, 0.35 min. at 0.825 km target size					

https://archive.org/details/NASA_NTRS_Archive_19880013063

The proof-of-concept era

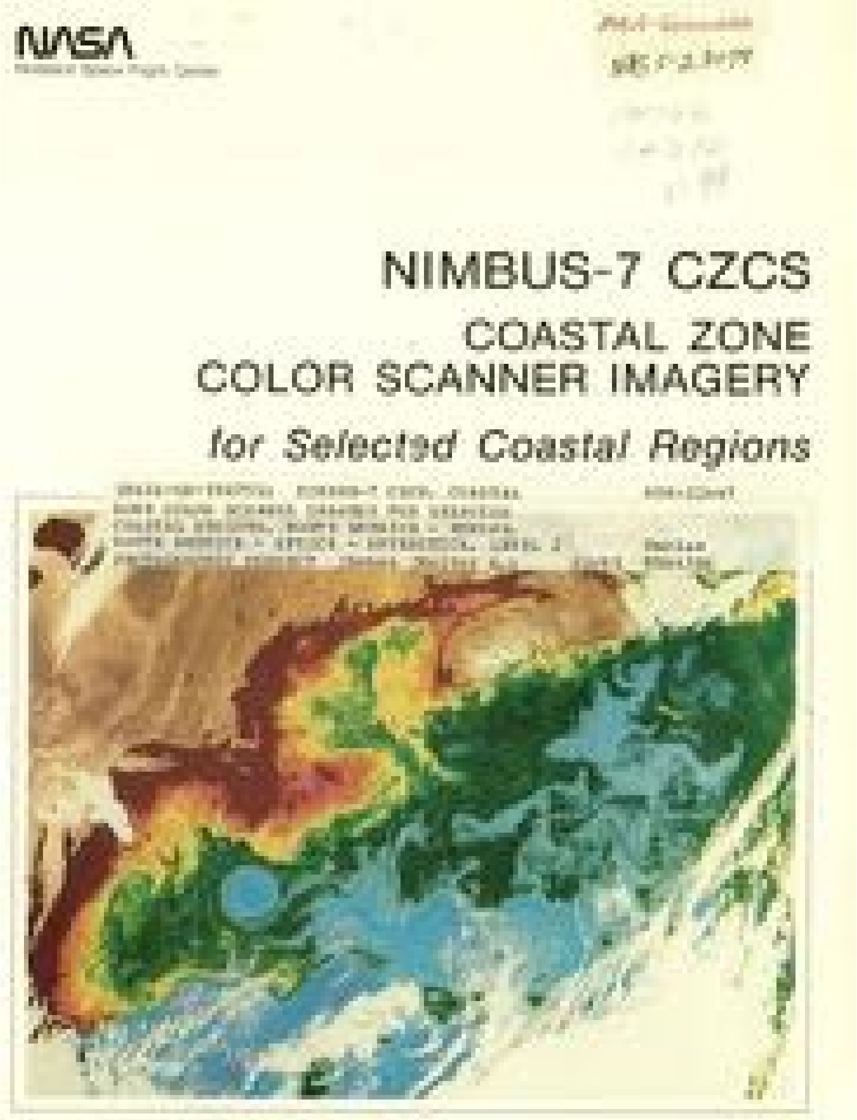


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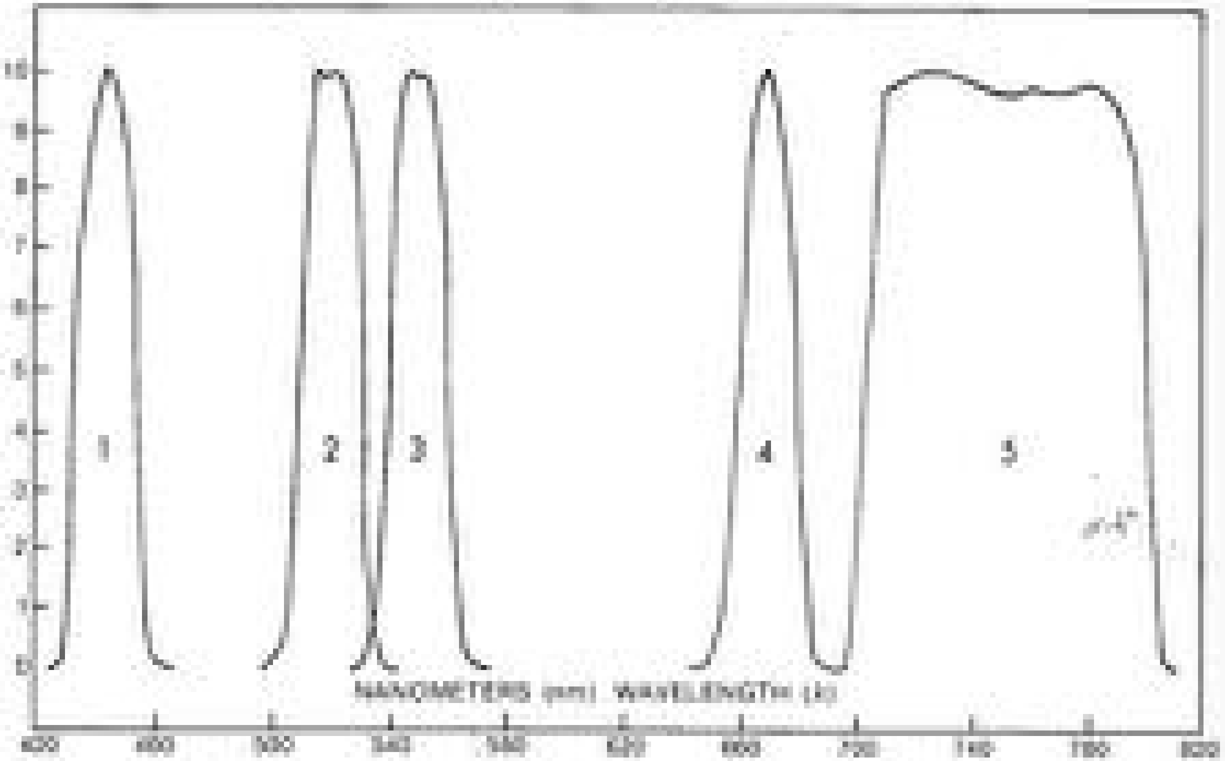
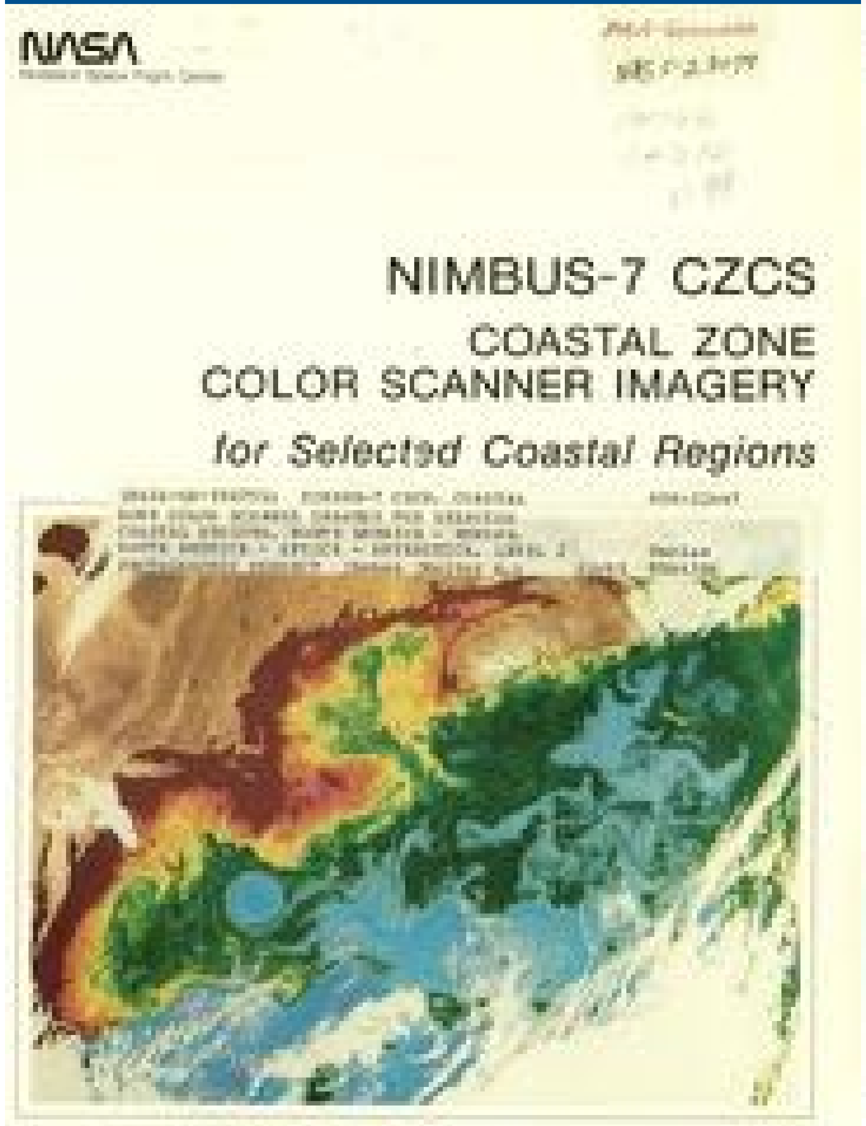
Figure 1. CZCS Spectral Response for Channels 1-5.



Channel 5 has the same spectral response as Channel 6 of the Landsat multi-spectral scanner series. The gain of Channel 5 is fixed and set to produce the same percentage of maximum signal over land targets as the Landsat Channel 6. However, the actual radiance for saturation is higher

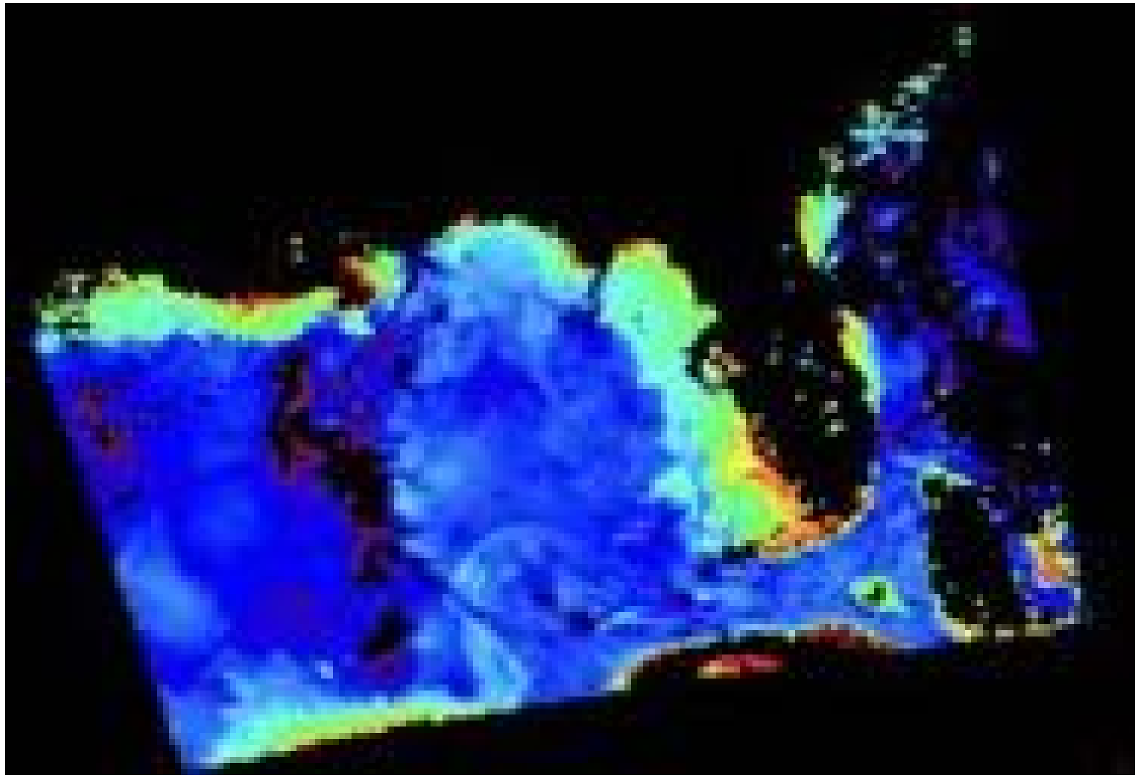
The proof-of-concept era



Gulf Stream Eddies—Circulation Features
April 1979 and April 1982

https://archive.org/details/NASA_NTRS_Archive_19880013063

The proof-of-concept era



https://oceandata.sci.gsfc.nasa.gov/showimages/CZCS/L3BRS/1978/1114/NIMBUS-7_CZCS.19781114.L3m.DAY.CHL.chlor_a.4km.nc.png

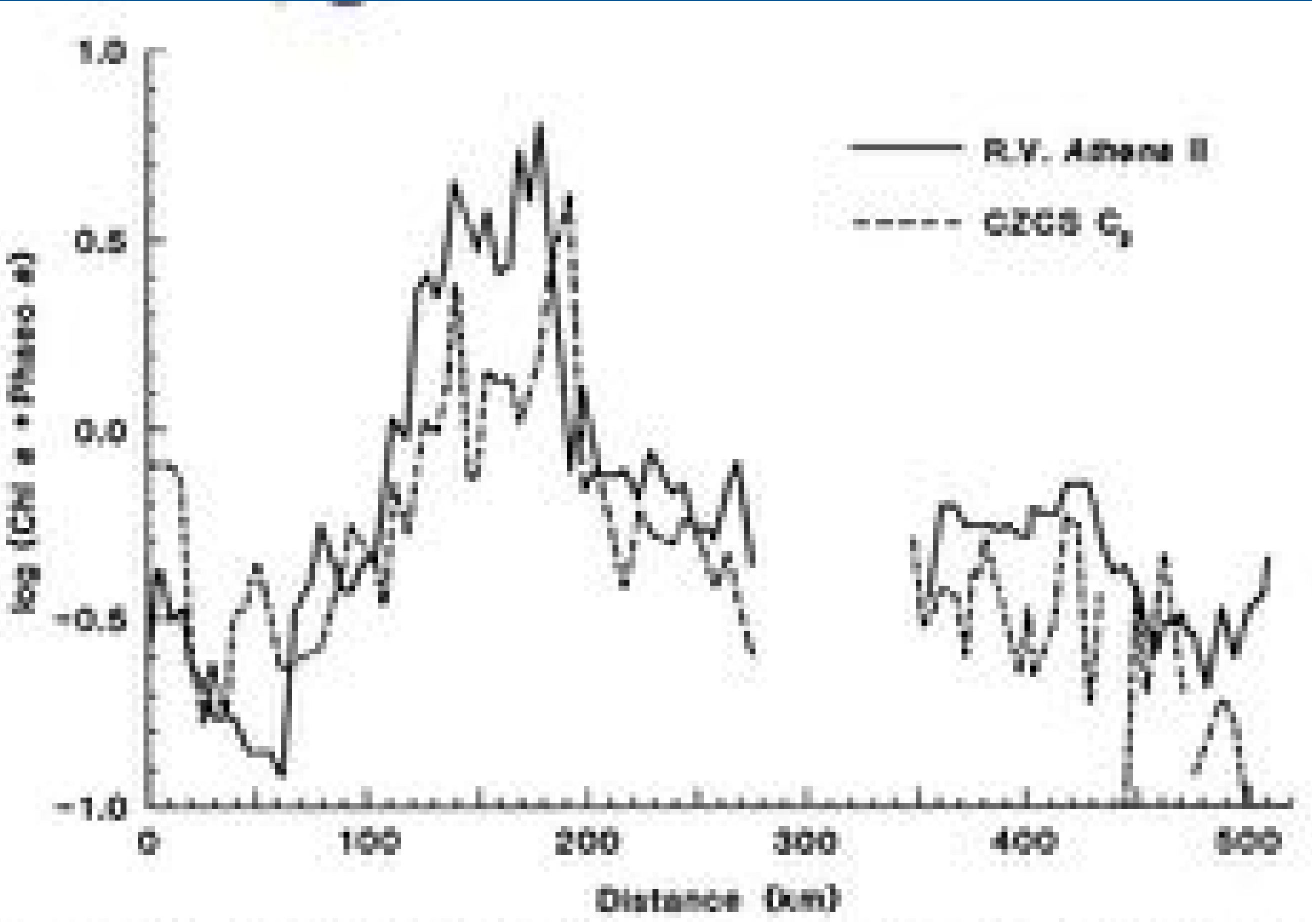


Fig. 3. Values of C = (Chl a + Phaeo a) (in milligrams per cubic meter) from Fig. 2 (14 November 1978) compared with a track line of concentrations measured aboard the R.V. Athena II on 13 and 14 November 1978. The track line is superimposed on Fig. 2, and distance (above) runs from south to north. The estimated CZCS data have been subsampled to coincide with the ship samples for comparison.

Gordon *et al.* Phytoplankton Pigments from the Nimbus-7 Coastal Zone Color Scanner: Comparisons with Surface Measurements.*Science* **210**,63-66 (1980). DOI:10.1126/science.210.4465.63

The proof-of-concept era

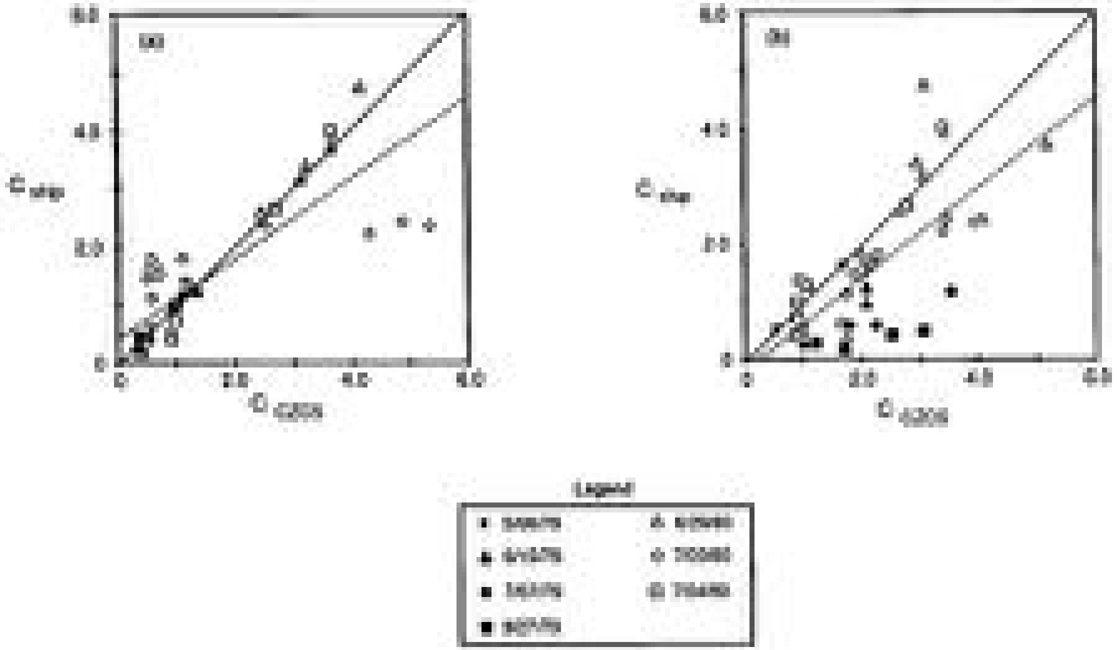
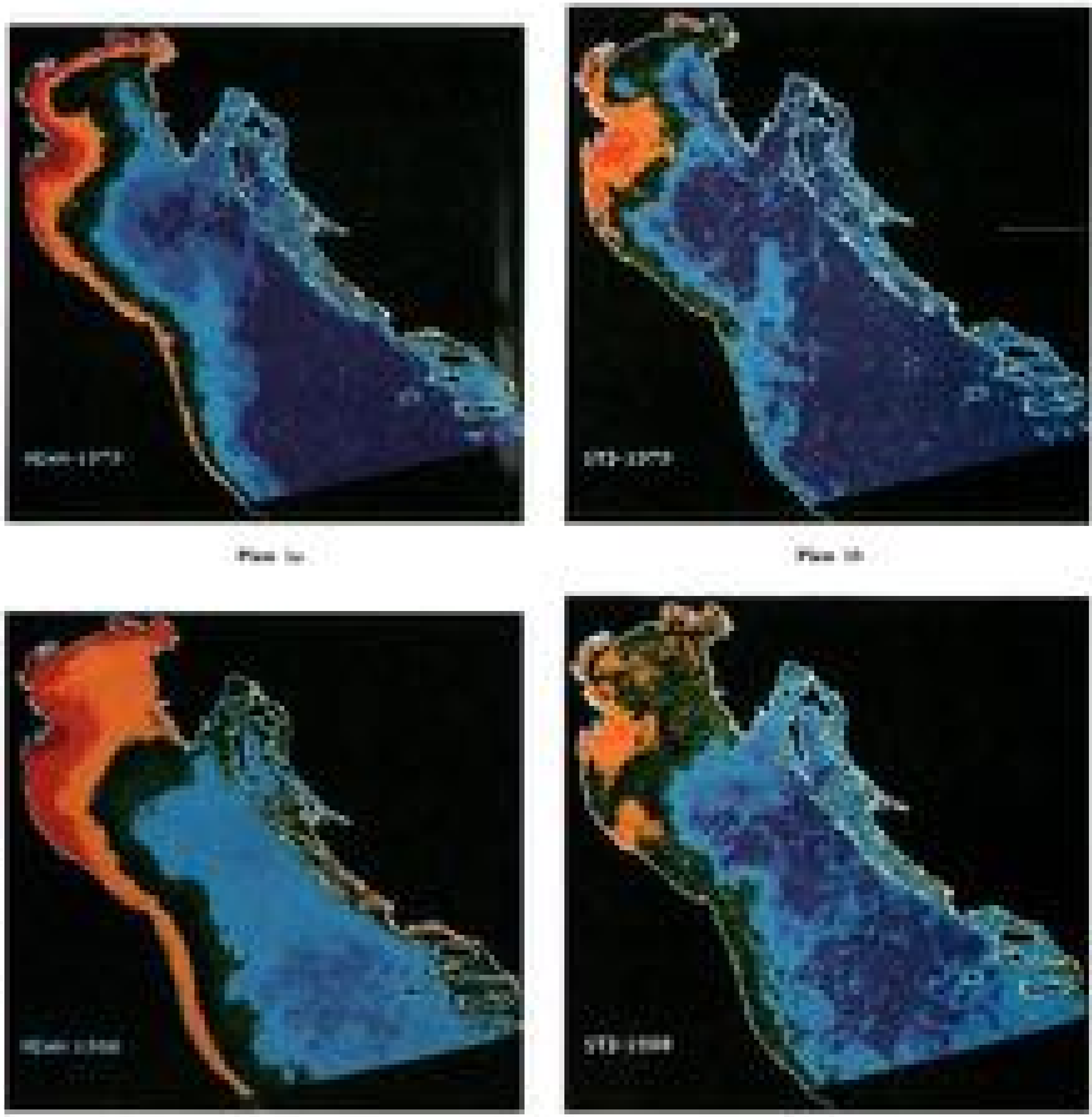


Fig. 3. Intercomparison of ship and satellite derived phytoplankton pigment concentrations [mg/m³]. (a) Satellite estimates from "global" analysis of each scene. (b) Satellite estimates from "local" analysis of each scene. The dotted lines represent, in each case, a linear regression of all 40 points.

TABLE 5. Color Coding Used in the Yearly and Monthly Images for the Phytoplankton Pigment Concentration Mean Values and Standard Deviations

Color	Range, mg/m^3
Black	land mask
Blue	< 0.30
Light blue	0.30–0.40
Aqua	0.40–0.60
Light green	0.60–0.80
Dark green	0.80–1.20
Yellow	1.20–2.00
Orange	2.00–3.40
Red	> 3.40
White	cloud mask

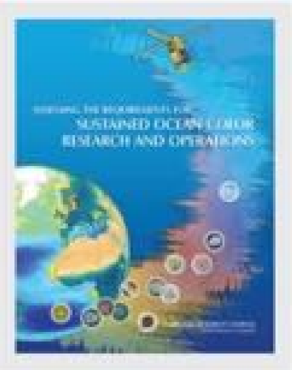


Barale, V., Mcclain, C. R., and Malanotterizzoli, P.: Space and Time Variability of the Surface Color Field in the Northern Adriatic Sea, J. Geophys. Res.-Oceans, 91, 12957–12974, doi:10.1029/Jc091ic11p12957, 1986.

The proof-of-concept era

CZCS was launched on Nimbus 7 and was a prototype mission to demonstrate that ocean color can be retrieved from space. Therefore, CZCS did not routinely or continuously collect global data because it had to share power and tape recorder capacity with other sensors

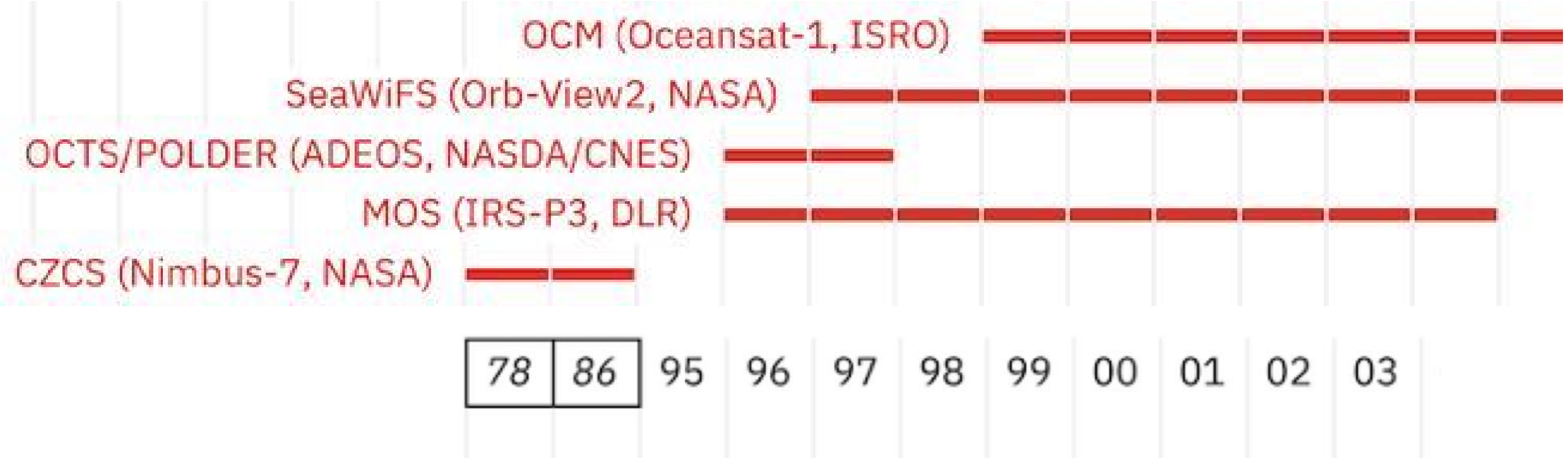
During the CZCS era, scientists learned about the importance of continuous sampling to achieve global coverage, of making in situ measurements throughout a mission's lifetime to assess changes in the sensor's gain over time and to validate the data products, and of atmospheric corrections.
In particular, the need for near-infrared (NIR) measurements to improve atmospheric correction was recognized during the CZCS experience and led to the SeaWiFS band-set.



National Research Council. 2011. Assessing the Requirements for Sustained Ocean Color Research and Operations. Washington, DC: The National Academies Press. https://doi.org/10.17226/13127.

How has ocean colour evolved?

The proof-of-concept era



- Can we do this?
- How well can we do this?
- What can we do with this?

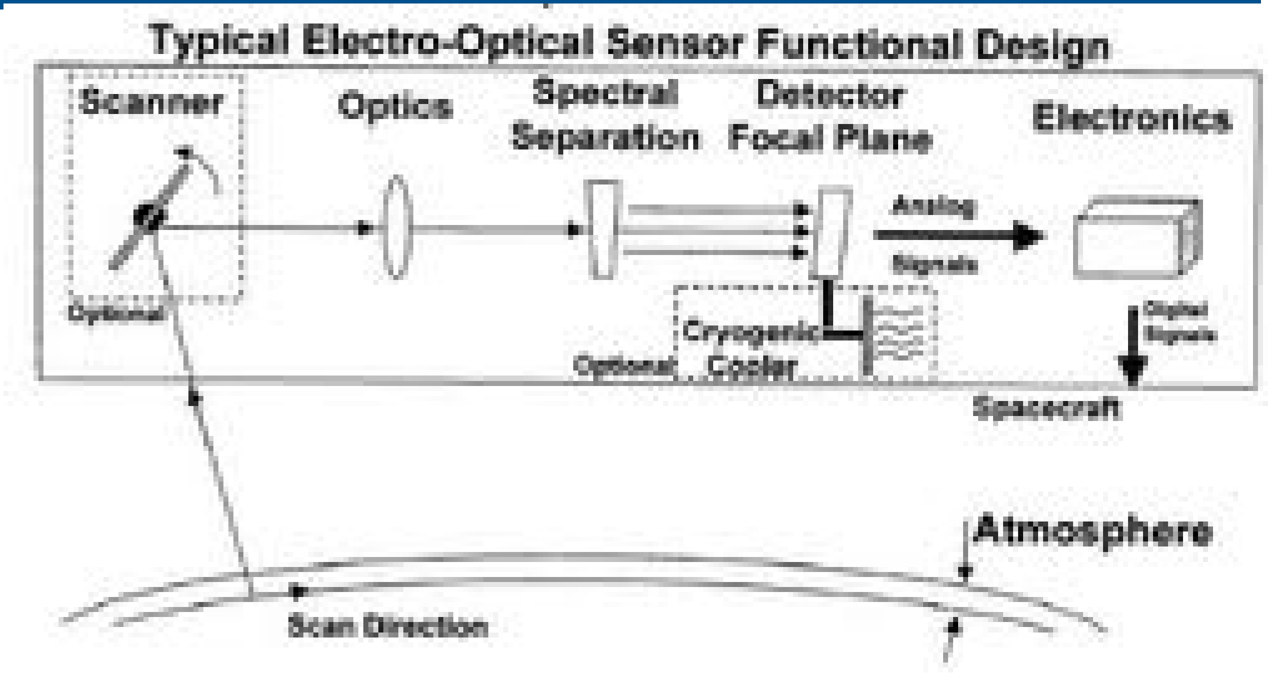
In this era we realised that:

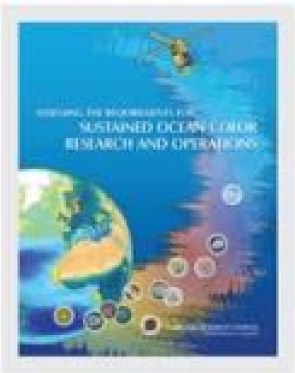
- ocean colour from space was possible
- it could reliably quantify open ocean chlorophyll
- there was a lot of potential to derive other information
- spectral and spatial resolution were particularly critical
- it would be good to do this long term

how does an ocean colour sensor work?

Steps to make an OCR “imagery”:

1) Collect light (photons): telescope, lenses, mirrors
2) Make this insensitive to the polarisation state (within a few %): design, coatings, scramblers
3) “Sort” this in a number of spectral bands: filters, beam splitters, gratings
4) Convert collected photons in an electric signal: detector(s)
5) Convert this signal into bits: analog-to-digital conversion
6) Send those bits to the ground: transmission capability
7) Inverse path from bits to radiances: calibration (pre-launch + onboard devices such as diffusers)
8) Locate these information on the ground: satellite orbit / attitude control (precise orbit determination, gyroscopes, star trackers)





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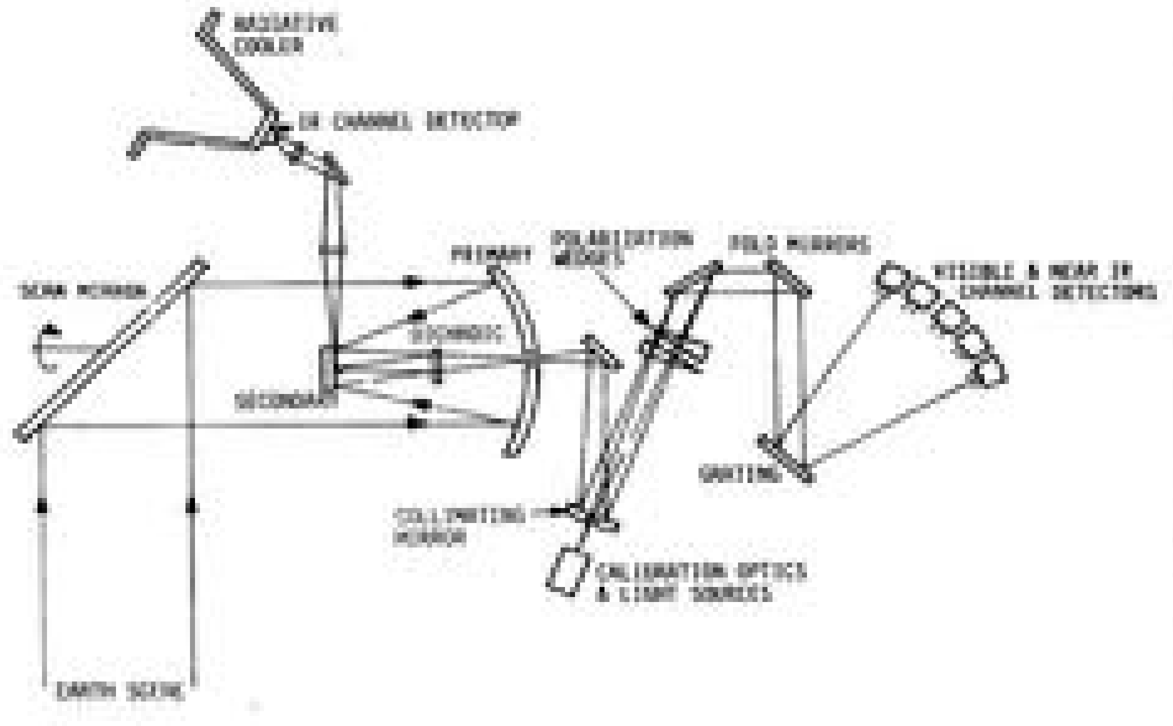
CZCS was a cross-track scanning radiometer



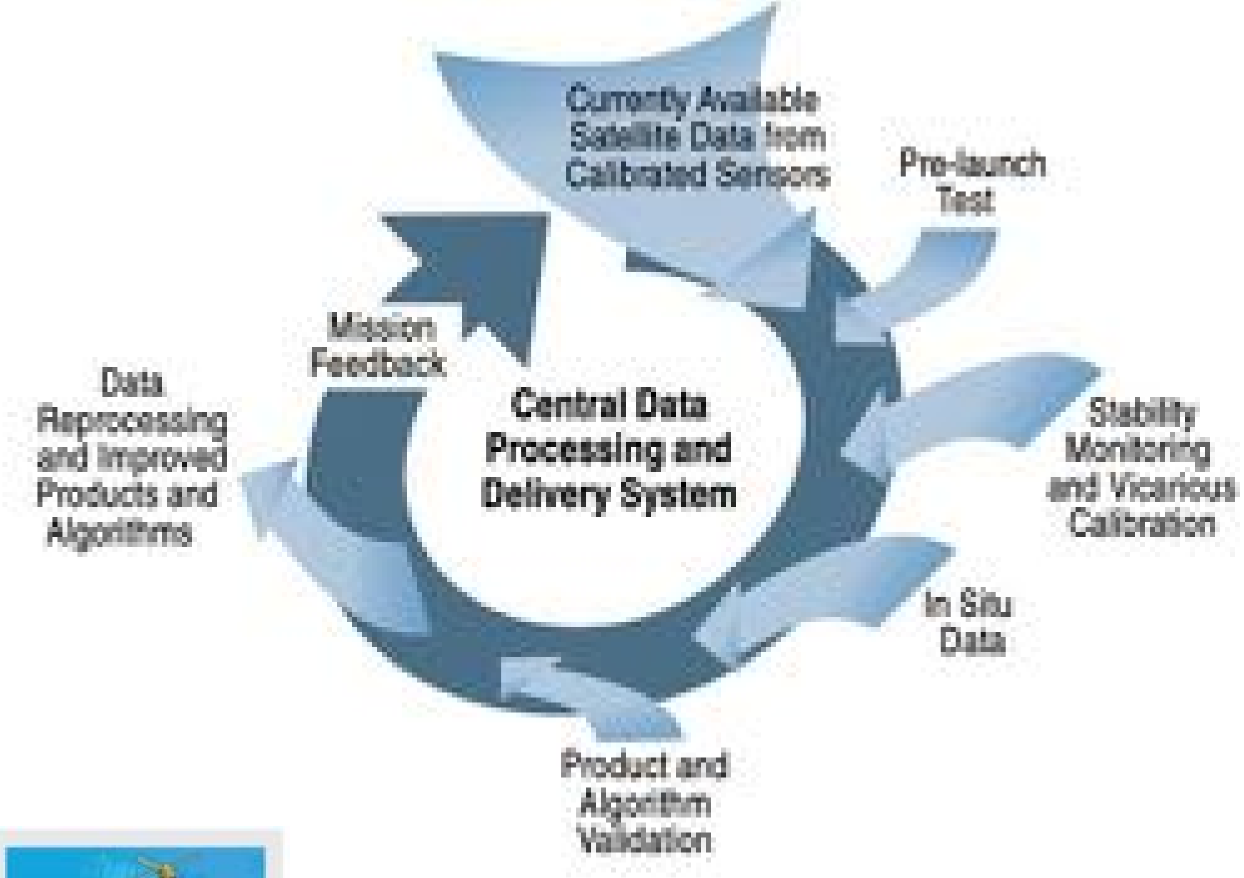
Development of the Coastal Zone Color Scanner for Nimbus 7. Vol. 1: mission objectives and instrument description. Final report F78-11, Rev A, May 1979. NASA-CR-166720-Vol-1. Ball Aerospace Systems Div., Boulder. 76pp.

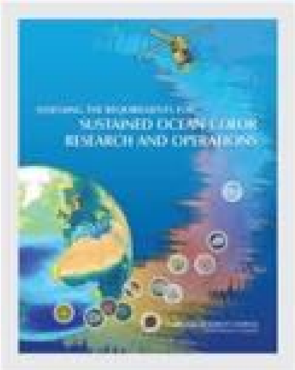
how does an ocean colour sensor work?

To improve the derivation and ensure the high quality of water-leaving radiance from multiple satellite sensors a single group needs to be responsible for the following:

- conduct sensor pre-launch tests,
- ensure that the sensor's stability is monitored throughout the mission,
- perform a vicarious calibration,
- collect in situ data for product and algorithm validation,
- perform the validation, and
- routinely process and reprocess the data to improve the products.

Once the high-quality water-leaving radiance is produced, users can develop and derive primary and secondary products that satisfy specific requirements of their research or operations.





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MERIS: Calibration degradation

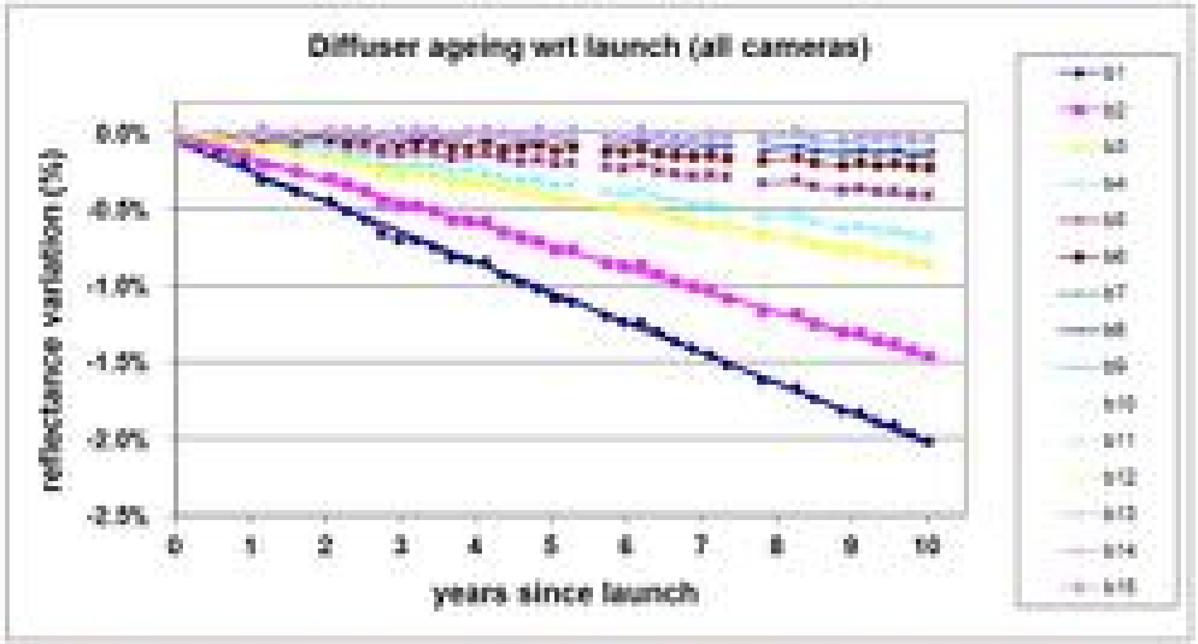

Figure 2-9: Ageing data and fit as derived using the MER4RP methodology over the whole mission.

4th MERIS data reprocessing

Evolutions and Validation report

Ref.: MER4RP Validation Report
Version: 1.0
Date: 01/04/2019
Page: ii

https://earth.esa.int/eogateway/documents/20142/37627/MERIS4RP-Evolutions-and-Validation-Report-V1.0-public.pdf

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MERIS: Vicarious Calibration

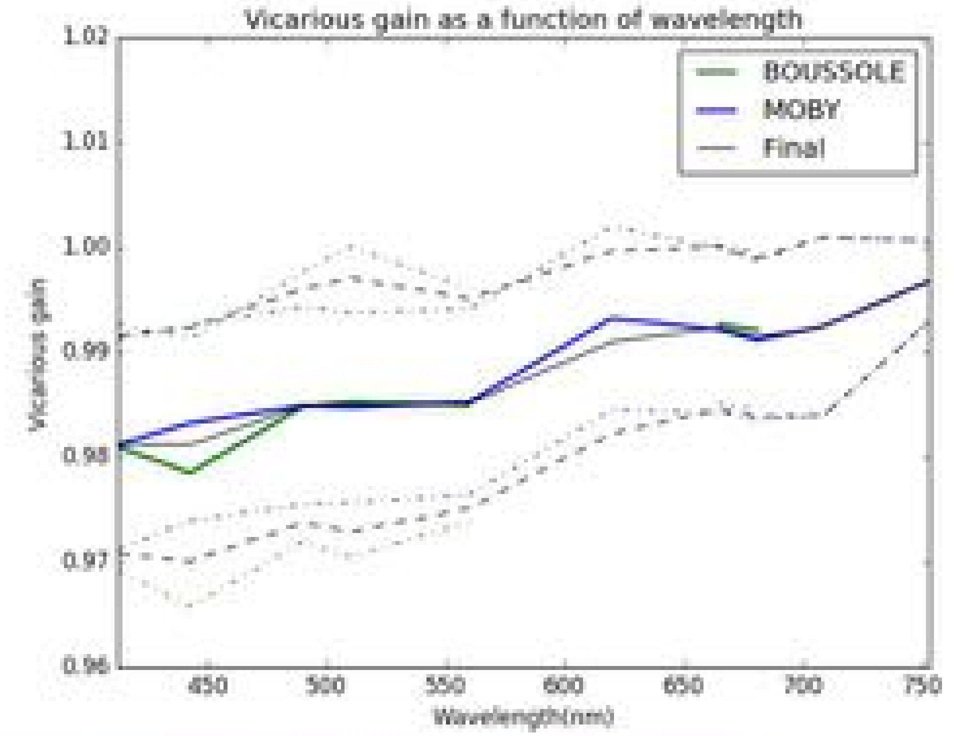

Figure 2-27: Final vicarious gains (green: BOUSSOLE, blue: MOBY, black: final).

4th MERIS data reprocessing
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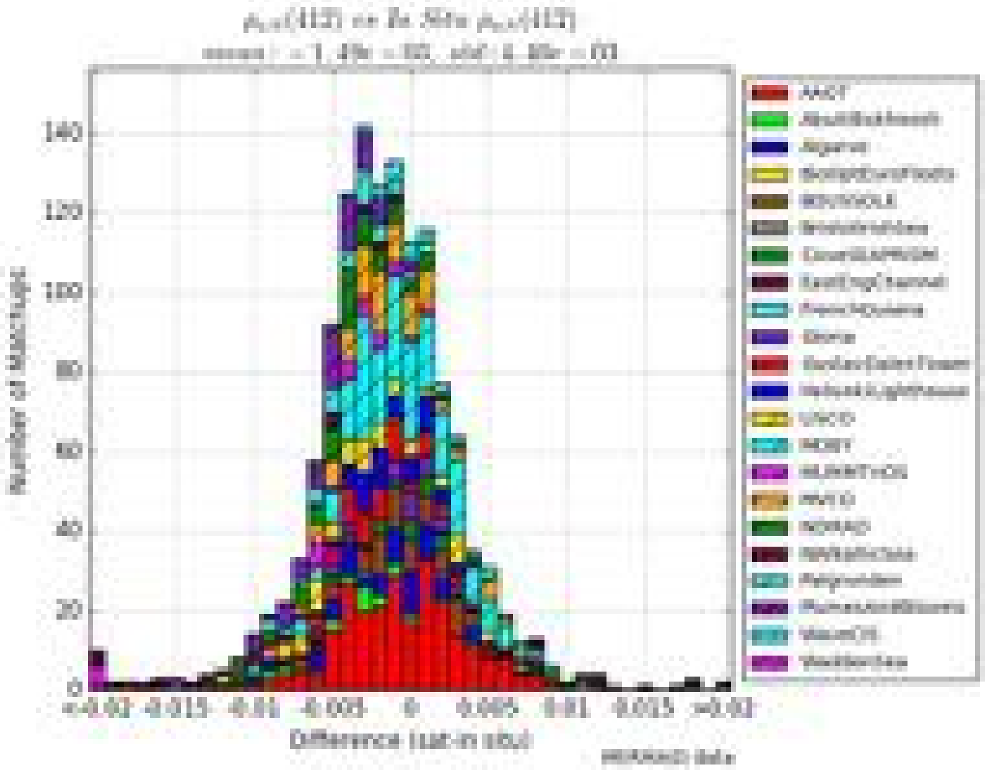
MERIS: Validation



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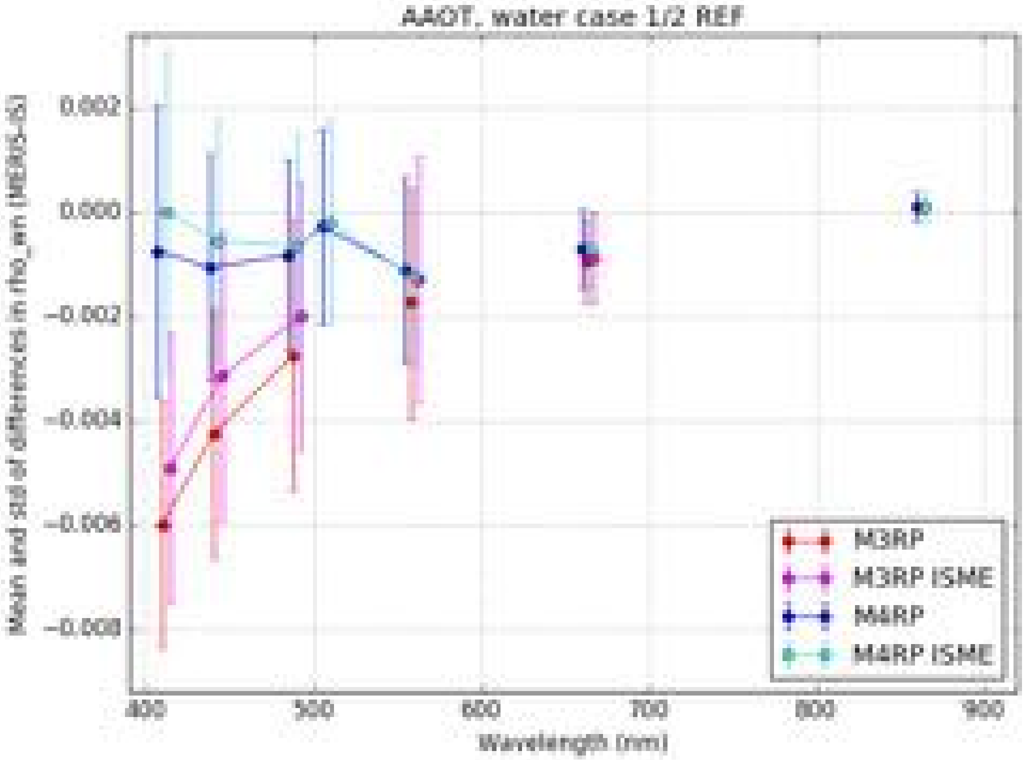

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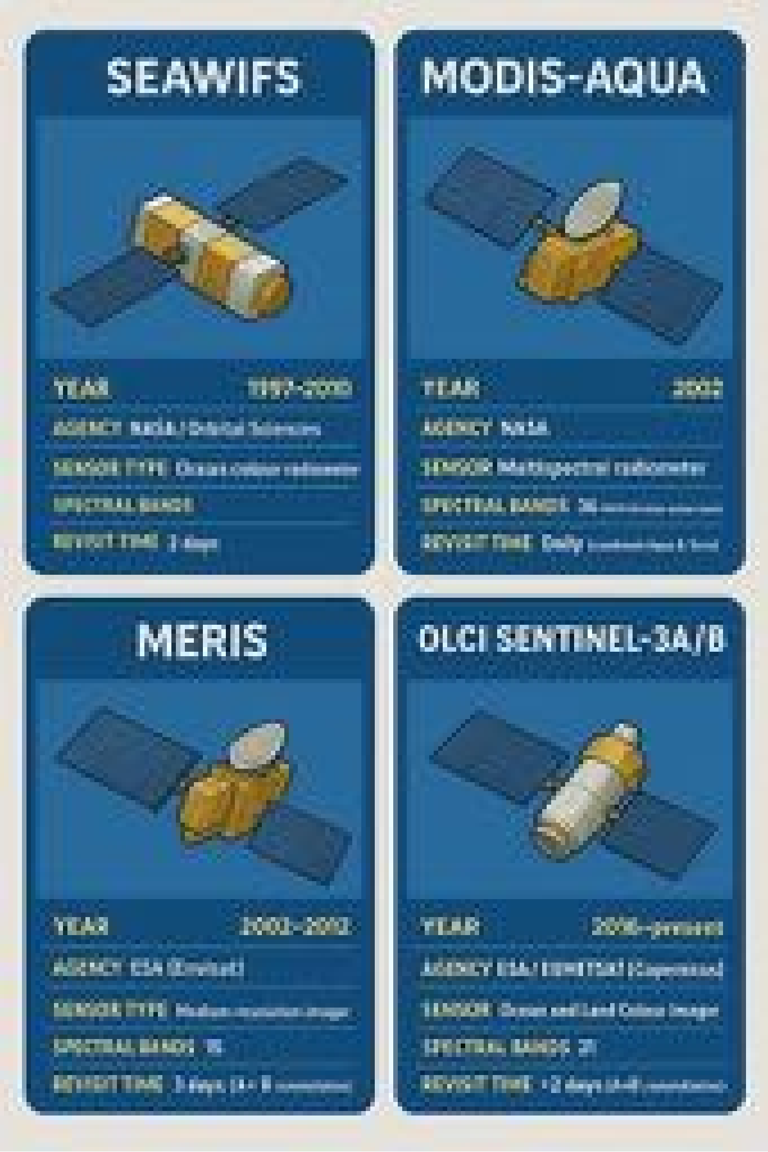
How has ocean colour evolved?

- Our capability to develop applications is influenced by the characteristics of our sensors and programmes
- **Key characteristics** that are important to consider for an ocean colour mission:
  - Spatial resolution
  - Temporal revisit → Coverage, Signal to Noise
  - Spectral resolution
  - Timeliness
  - Operations and continuity



Spatial resolution

You are here!

Spatial resolution

You are here!

Spatial resolution

You are here!

Spatial resolution

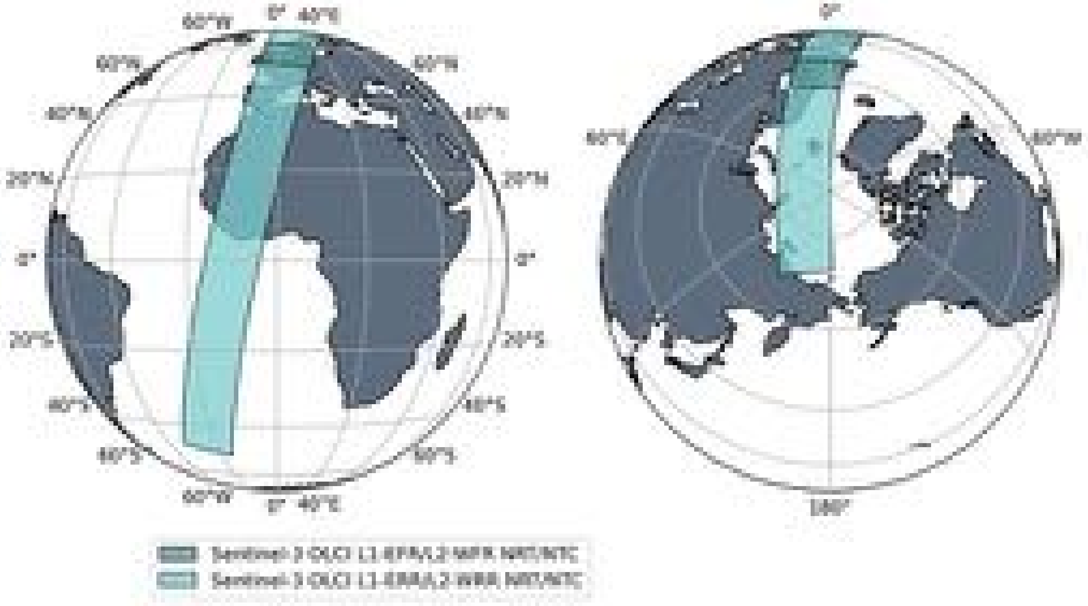
You are here!

Temporal revisit

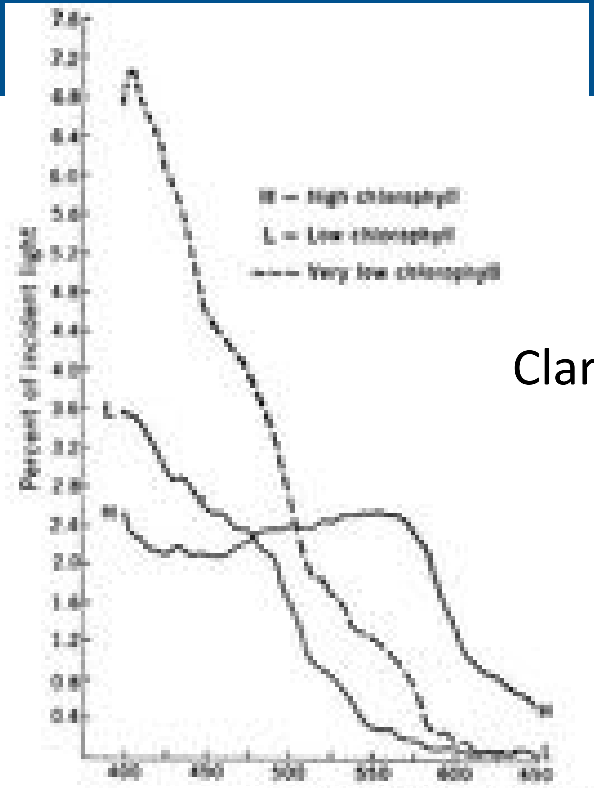
How often the satellite measures your area of interest

Influenced by:

- Orbit (LEO (various), GEO)
- Swath width/scan rate
- Number of satellites
- Operating modes

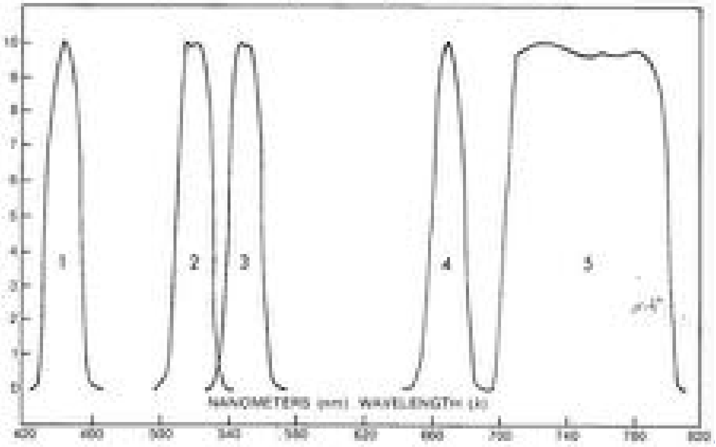


- Ocean colour specific sensors always designed to capture key parts of ocean colour spectral variability.



Clarke, G. L. et al , 1970.

Figure 1. CZCS Spectral Response for Channels 1-5.



n et al., 2023

Spectral resolution

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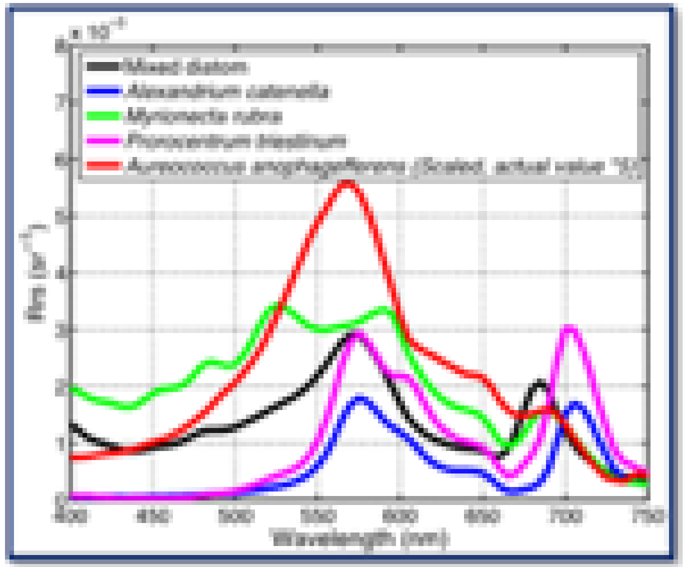

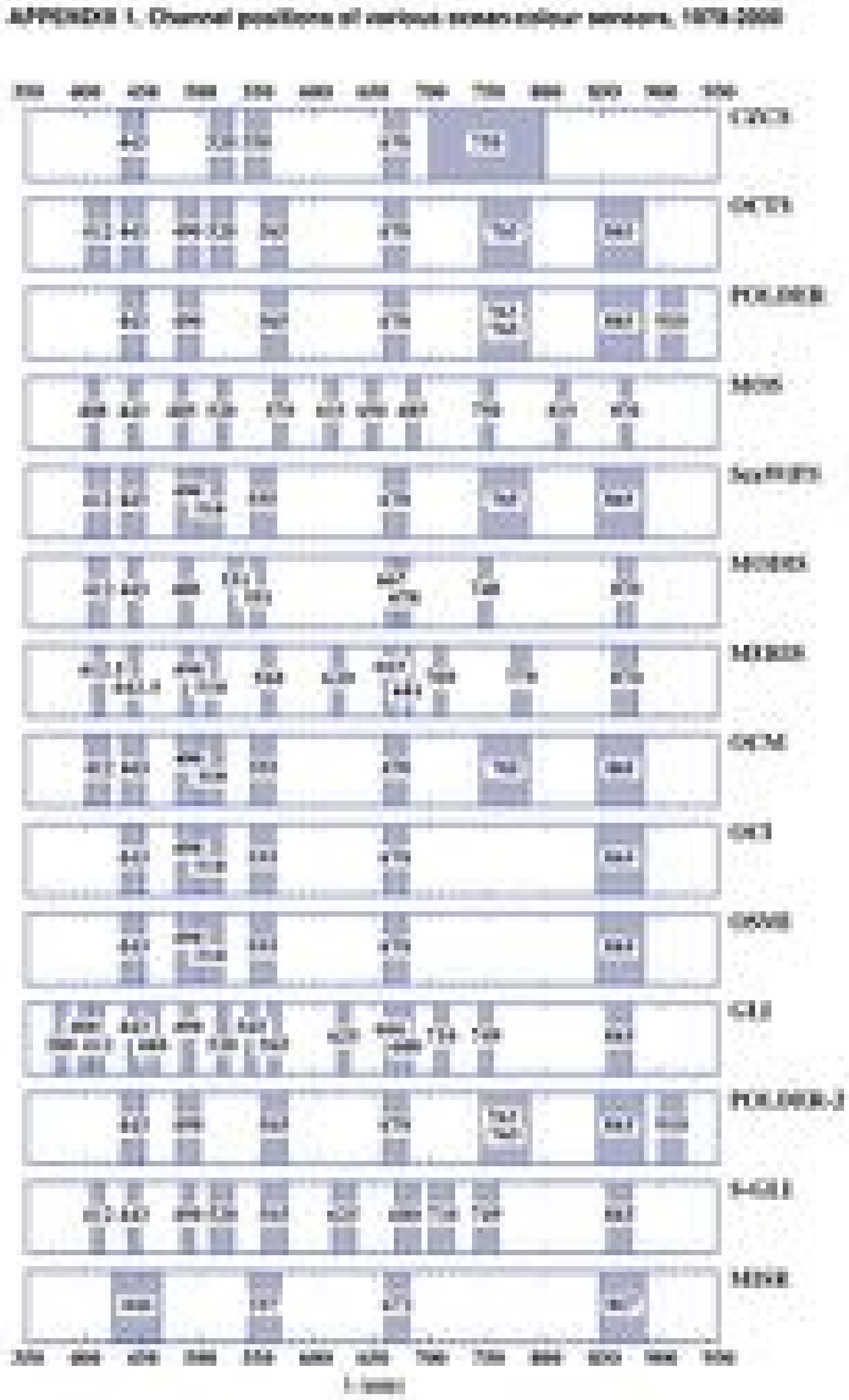

IOCCG Report 1 (1998) Minimum Requirements for an Operational Ocean-Colour Sensor for the Open Ocean. Edited by André Morel, pp.46

Dierssen et al., 2023

Spectral resolution

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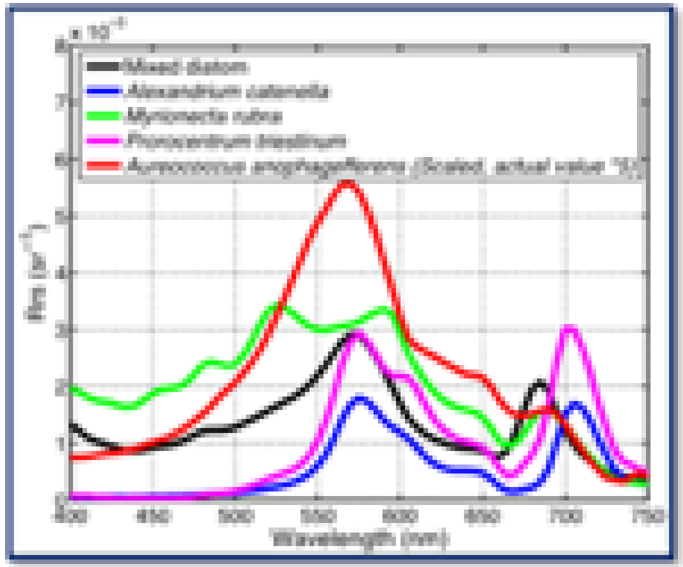
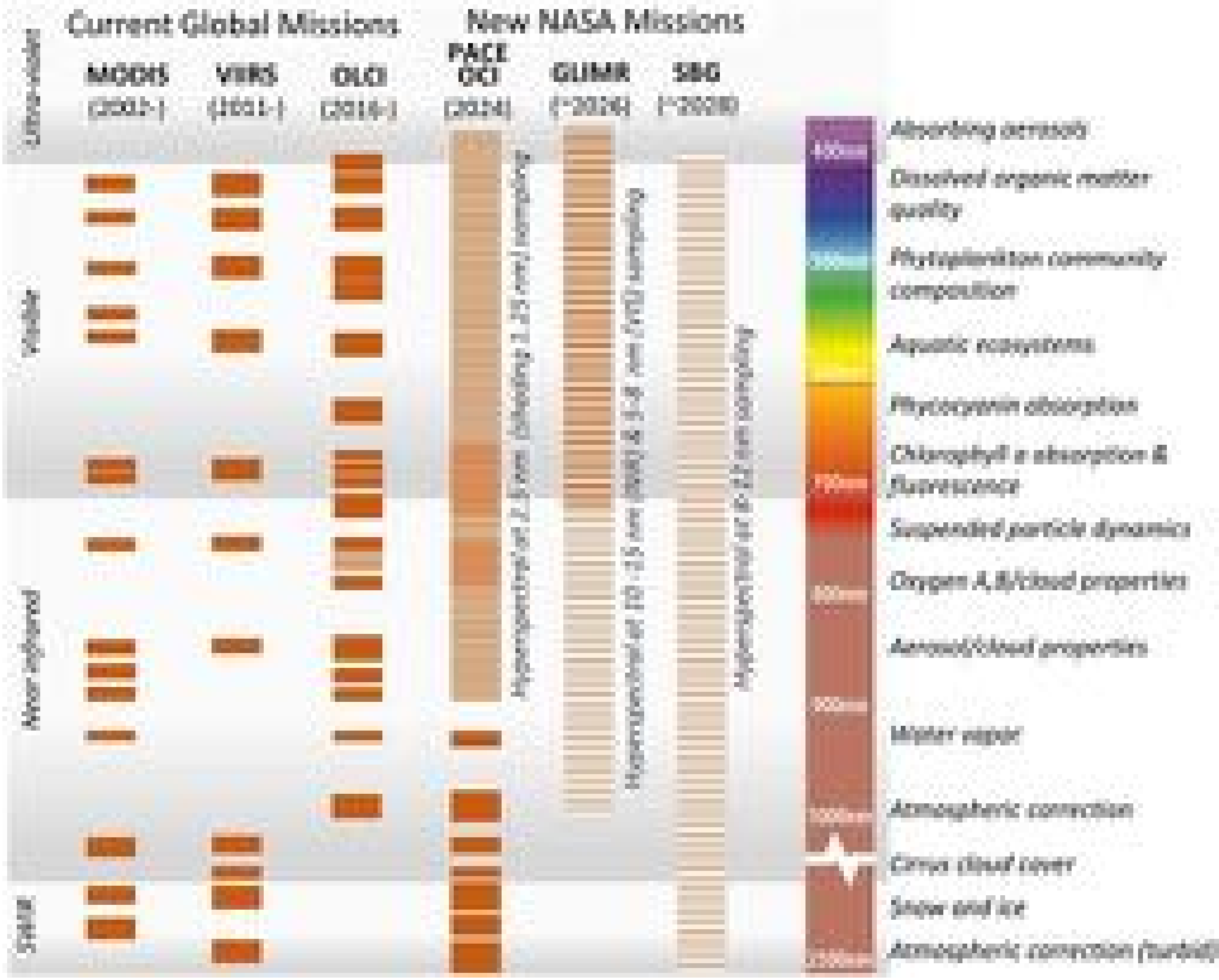


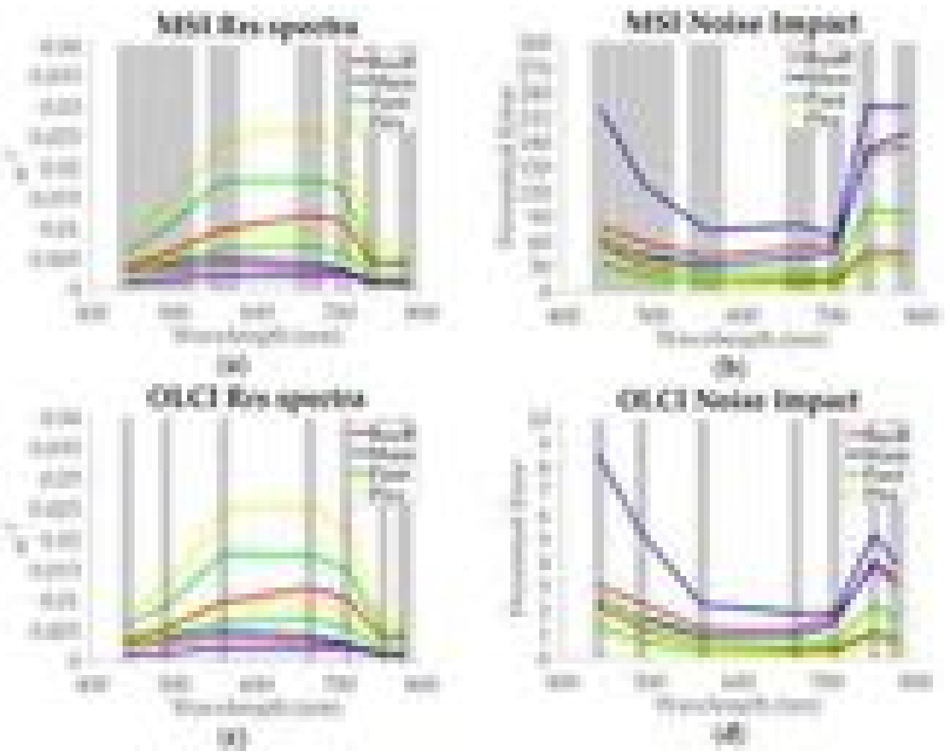


Dierssen et al., 2023

Signal:Noise

- Sensors come with noise and this is influenced by the way they are built and the ways that they measure.
- Impact affected by how much signal they are capturing (spectral, space, and time dependent) and how strong the signal is from the thing you're interested to measure.
- Typically easier when you are measuring a larger area for longer, if your target is dark….if your target is bright, you have the opposite problem of saturation.
- Specific OC sensors are designed for the typical dark ocean target, other sensors for land which is much brighter.

- What does this mean in practice?
  - Consider the sensor characteristics vs the target of interest
    - E.g. a land sensor might well be ok over a bright target
    - Highly absorbing targets benefit from sensor with low SNR
  - Can also bin data to improve SNR.



Subset from Jorge et al., 2017

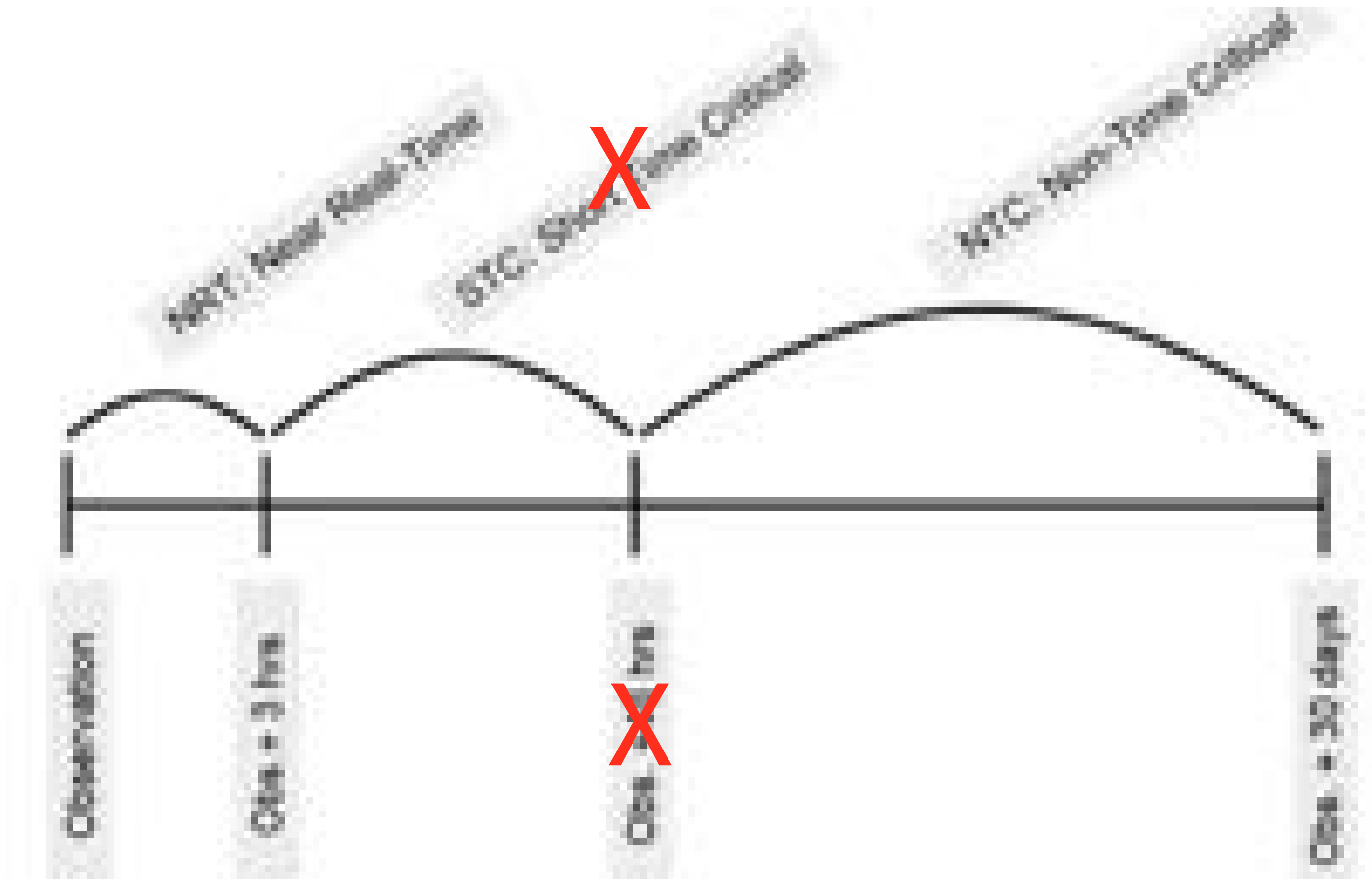
Timeliness (and time series)

Timeliness is how quickly you can get the data after the satellite has made its measurements.

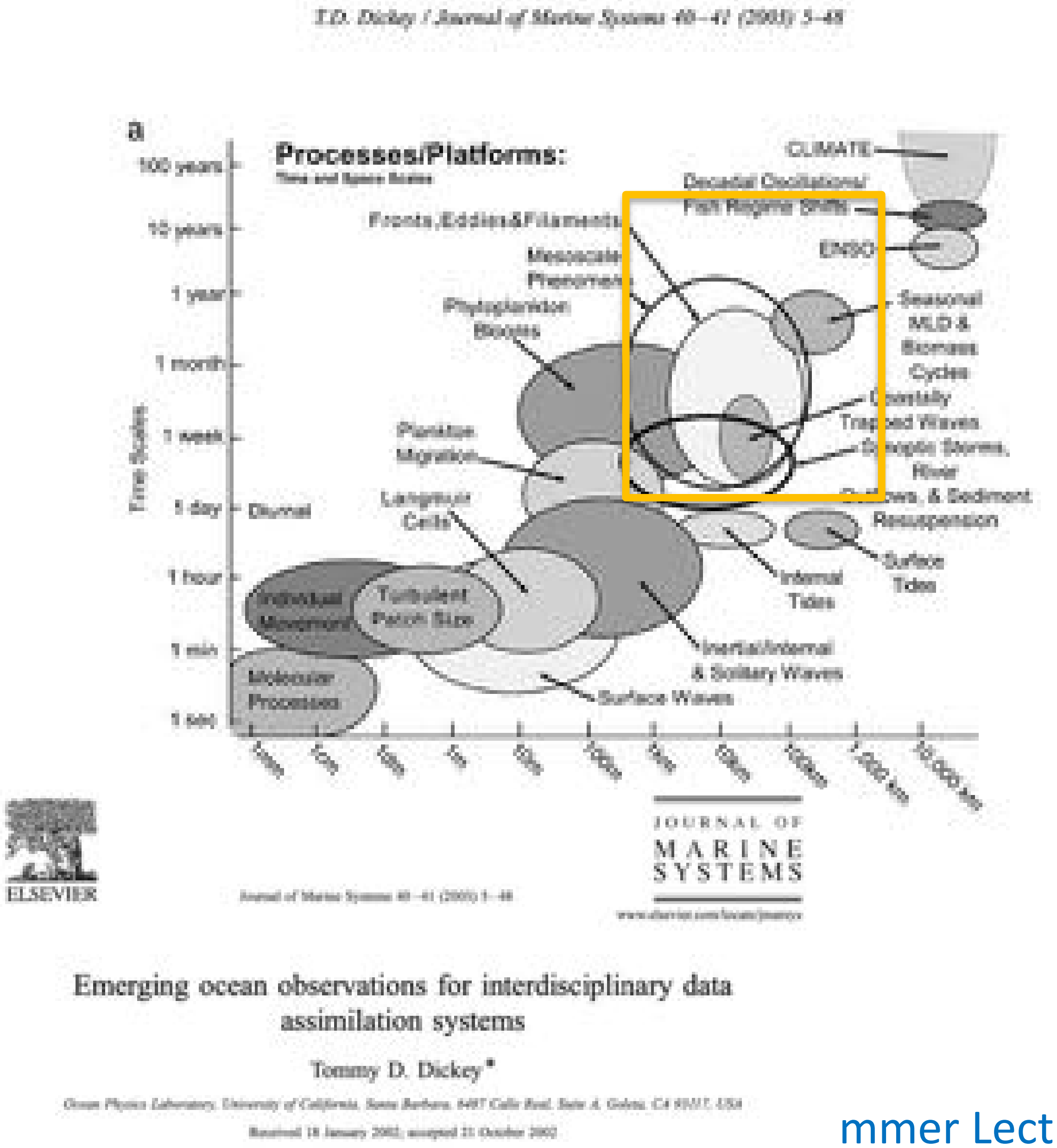
Some trade-offs have to be made with quality e.g. you can’t always get all ancillary data straight away

Similarly with merged and reprocessed time series:

- You can’t take advantage of the high quality of a climate data record approach, in NRT (uses intersensor calibration/bias correction etc).
- Advancements vs too much change
- Compromises wrt to processing/bands used etc.

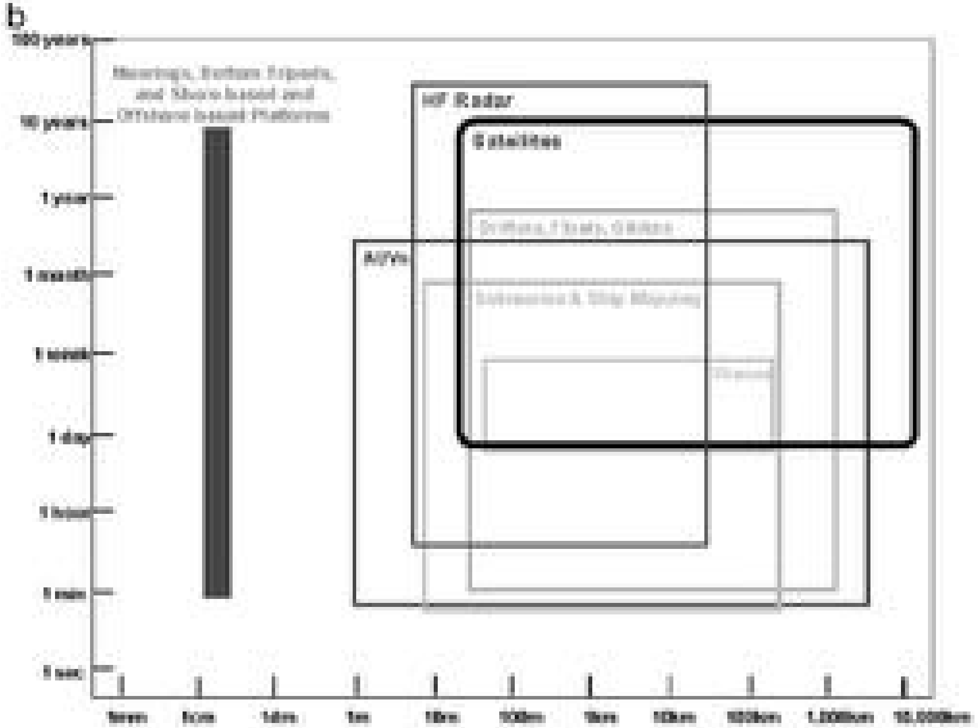


Processes scales and observation



Time-horizontal space scale diagram illustrating several physical and biological processes in ovals.

Rectangles indicate the approximate horizontal and temporal sampling domain capabilities of several platforms at in **2002**.



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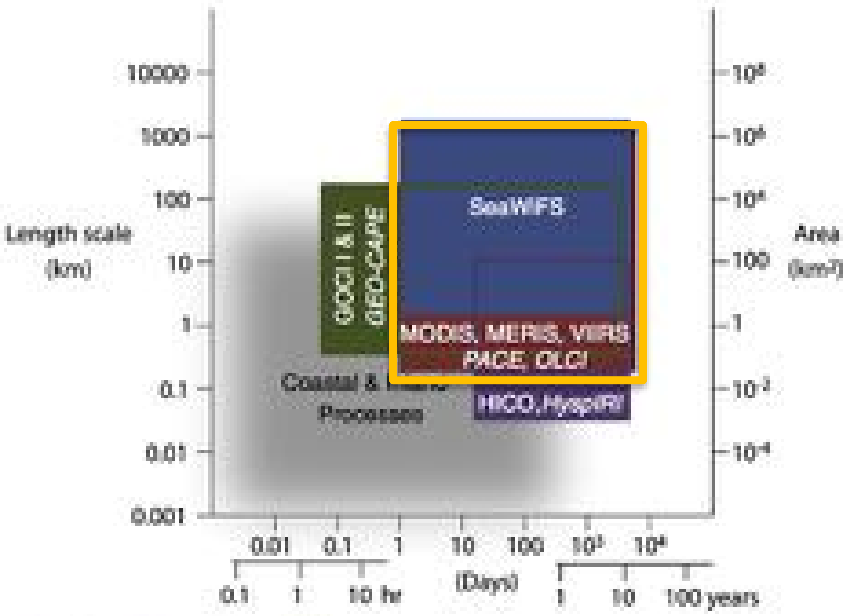

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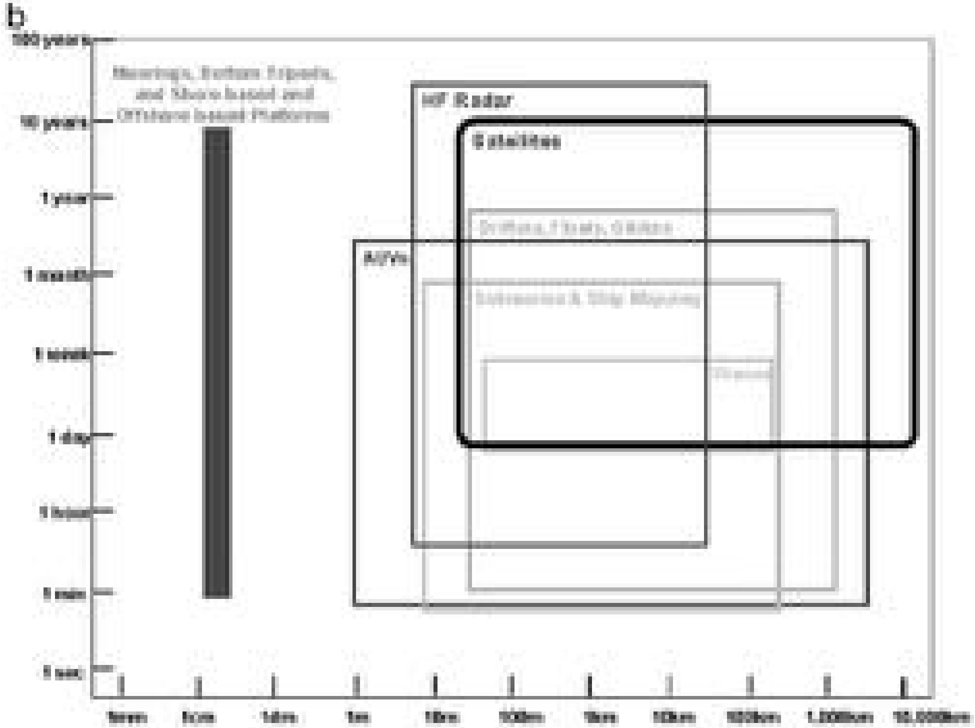

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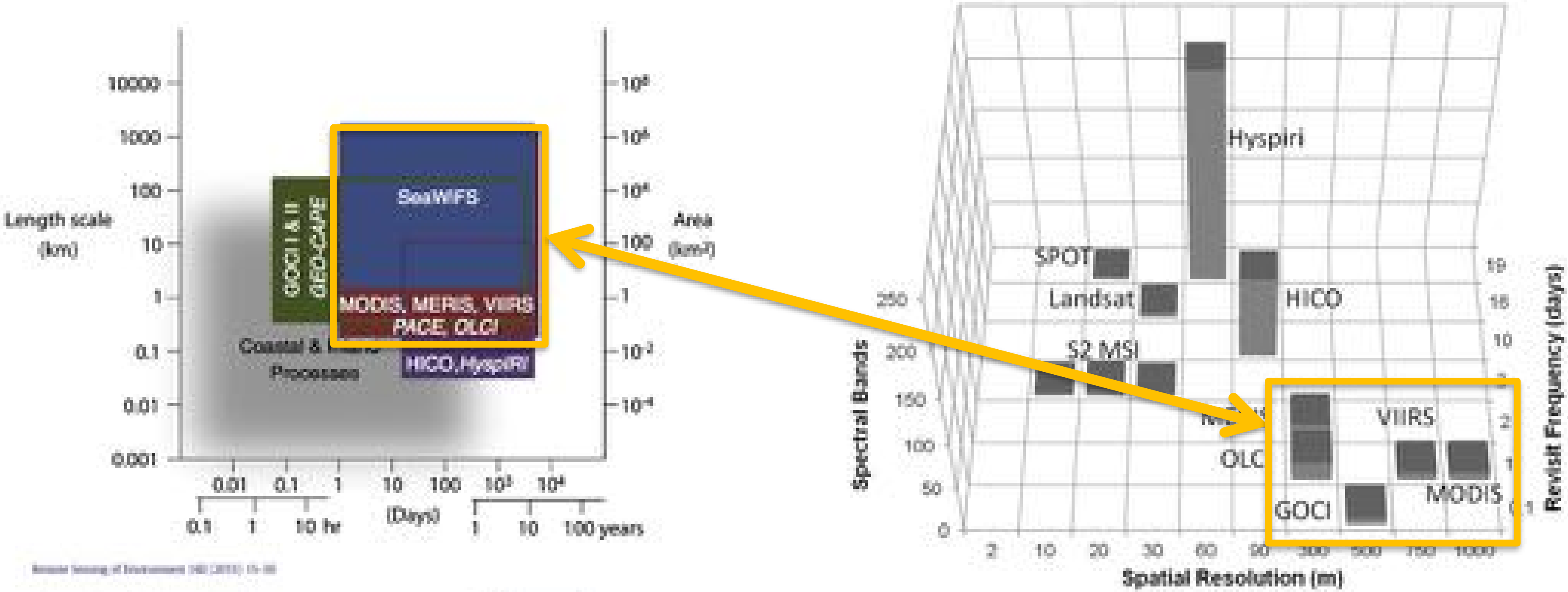

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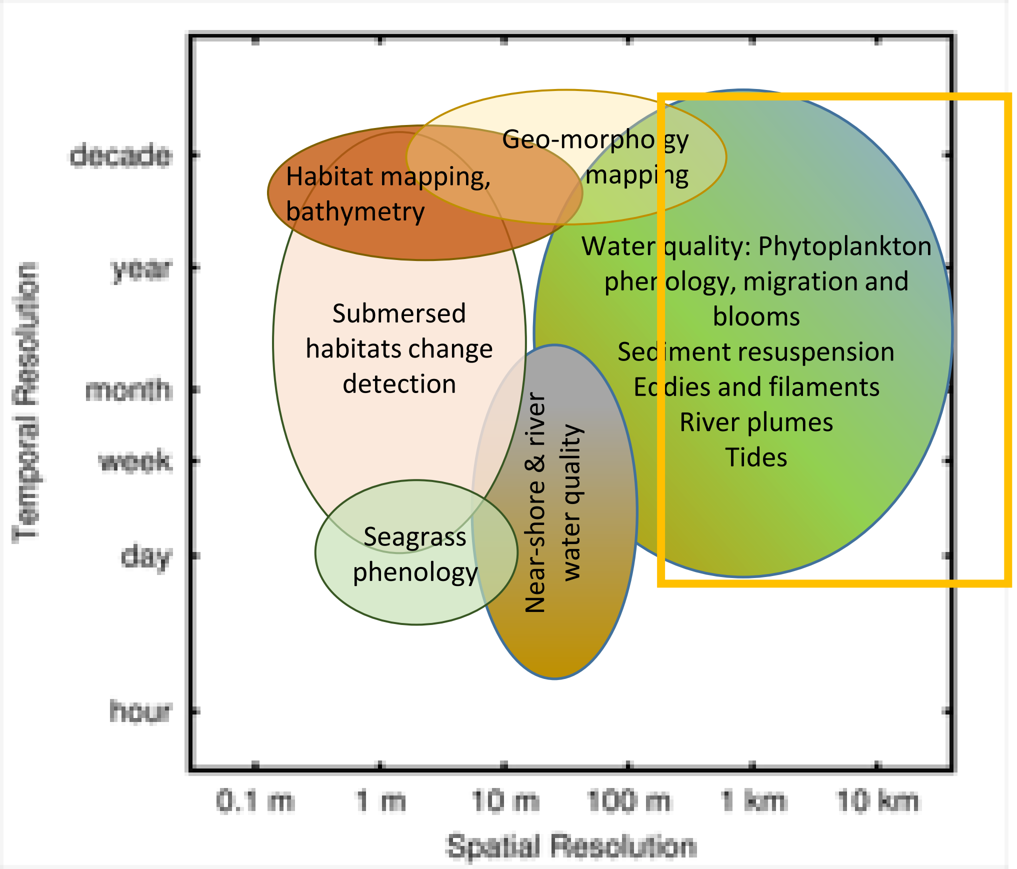
Processes scales and observation: focus on inland/coastal processes



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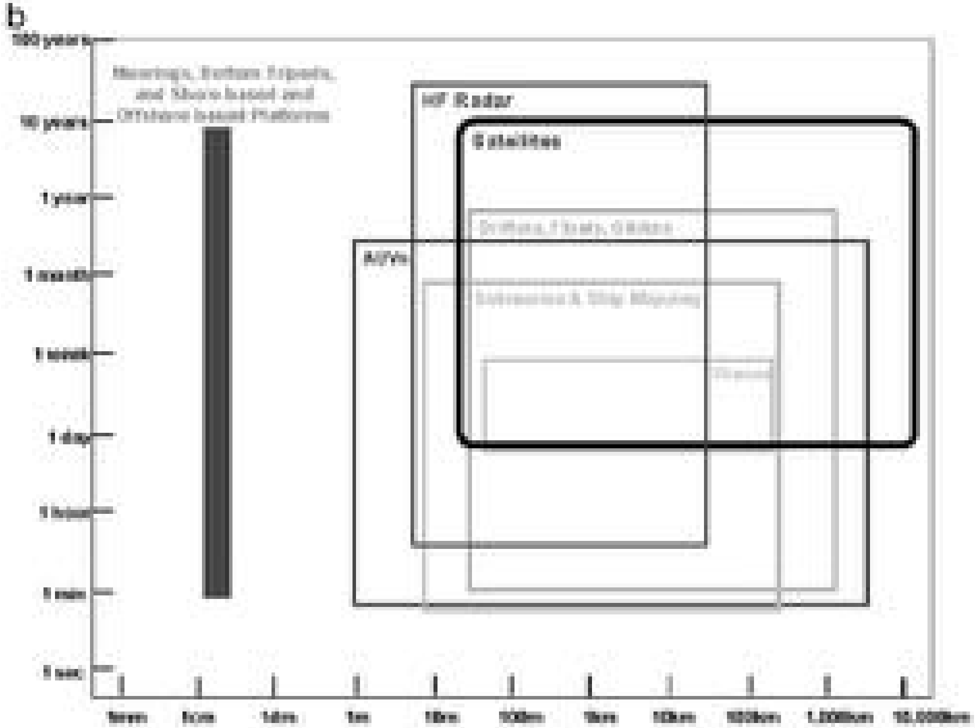


Focus on inland/coastal processes
Giardino and Brando, based on Hedley et al., RSE 2018 - *Modified*

Processes scales and observation: focus on inland/coastal processes

Ocean Imagers

- ✓ Many spectral bands
- ✓ High radiometric fidelity
- ✓ Frequent revisit time (~daily)
- × Large pixels (300 m – 1 km)

Land Imagers (< 2014)

- ✓ Small-medium pixels (10-30 m)
- × Just a few spectral bands
- × Lower fidelity
- × Low revisit time (16 days)

Processes scales and observation: focus on inland/coastal processes

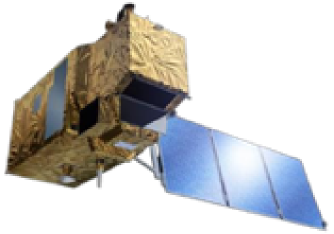
Ocean Imagers

- ✓ Many spectral bands
- ✓ High radiometric fidelity
- ✓ Frequent revisit time (~daily)
- × Large pixels (300 m – 1 km)

Land Imagers (S2+L8/9)

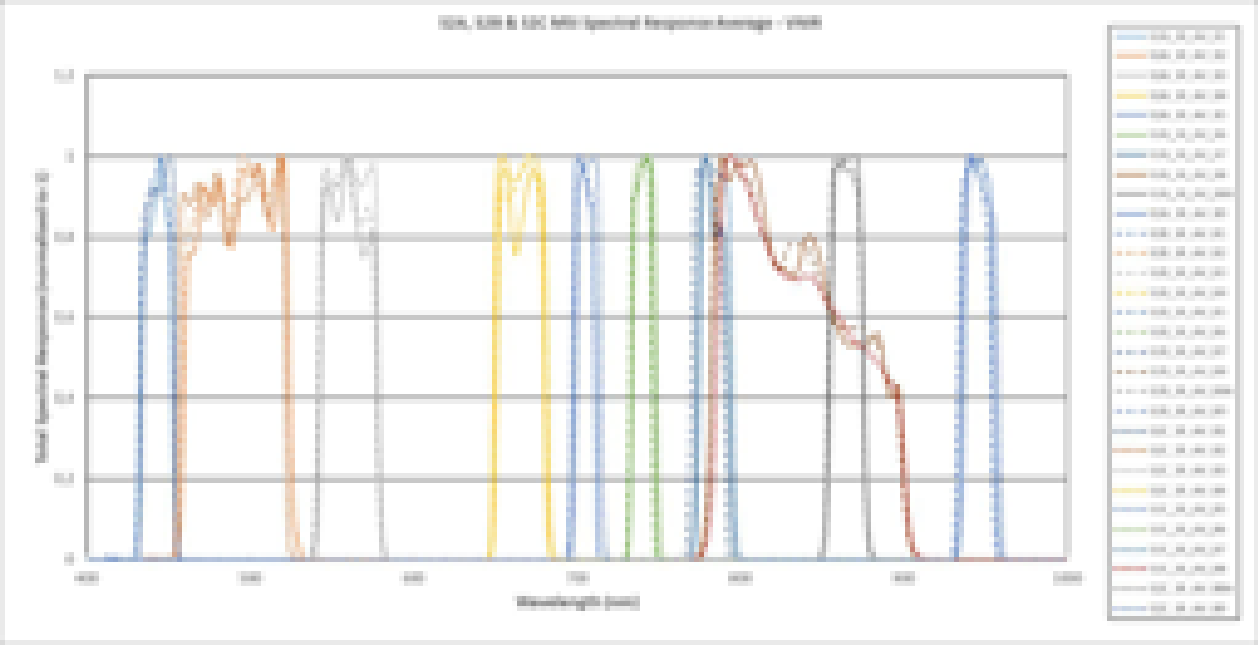
- ✓ Small-medium pixels (10-30 m)
- ✓ better revisit time (5 days or less with S2+L8/9)
- ✓ improved fidelity
- × Limited spectral bands

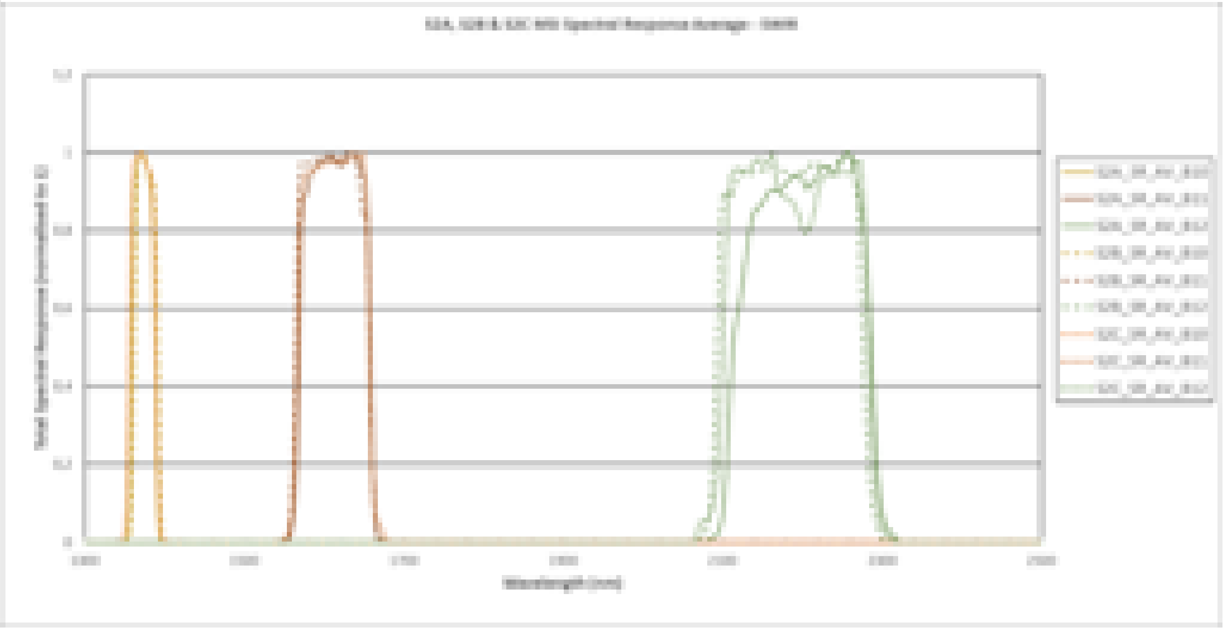
Sentinel-2 Mission Key Features



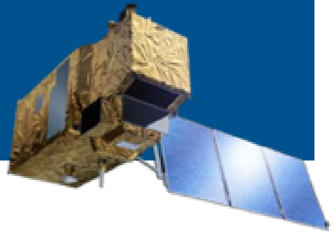
Credits: Ferran Gascon (ESA)

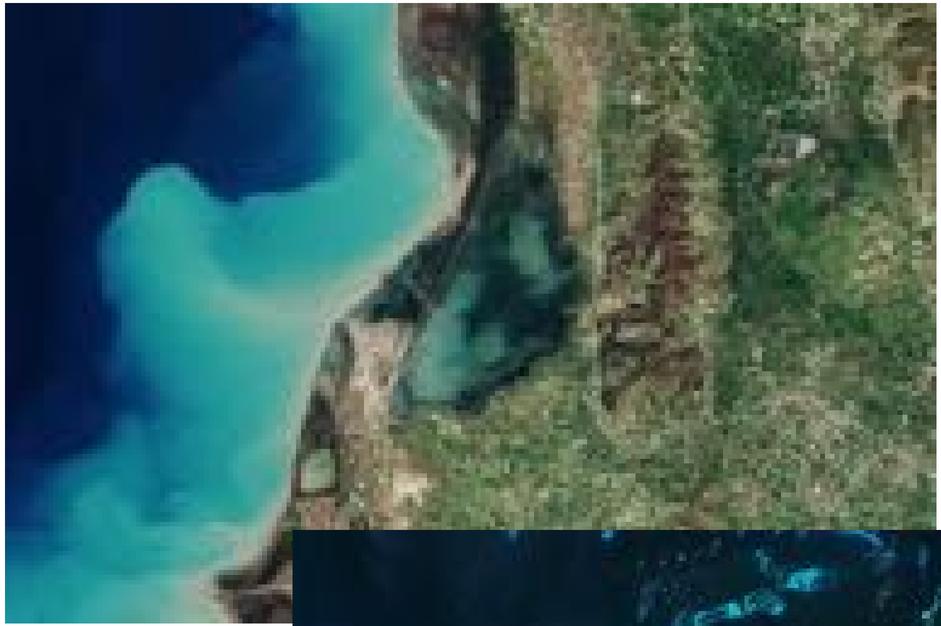
Spectral Response for the Sentinel-2



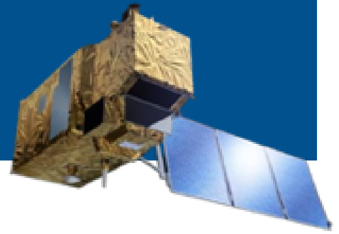


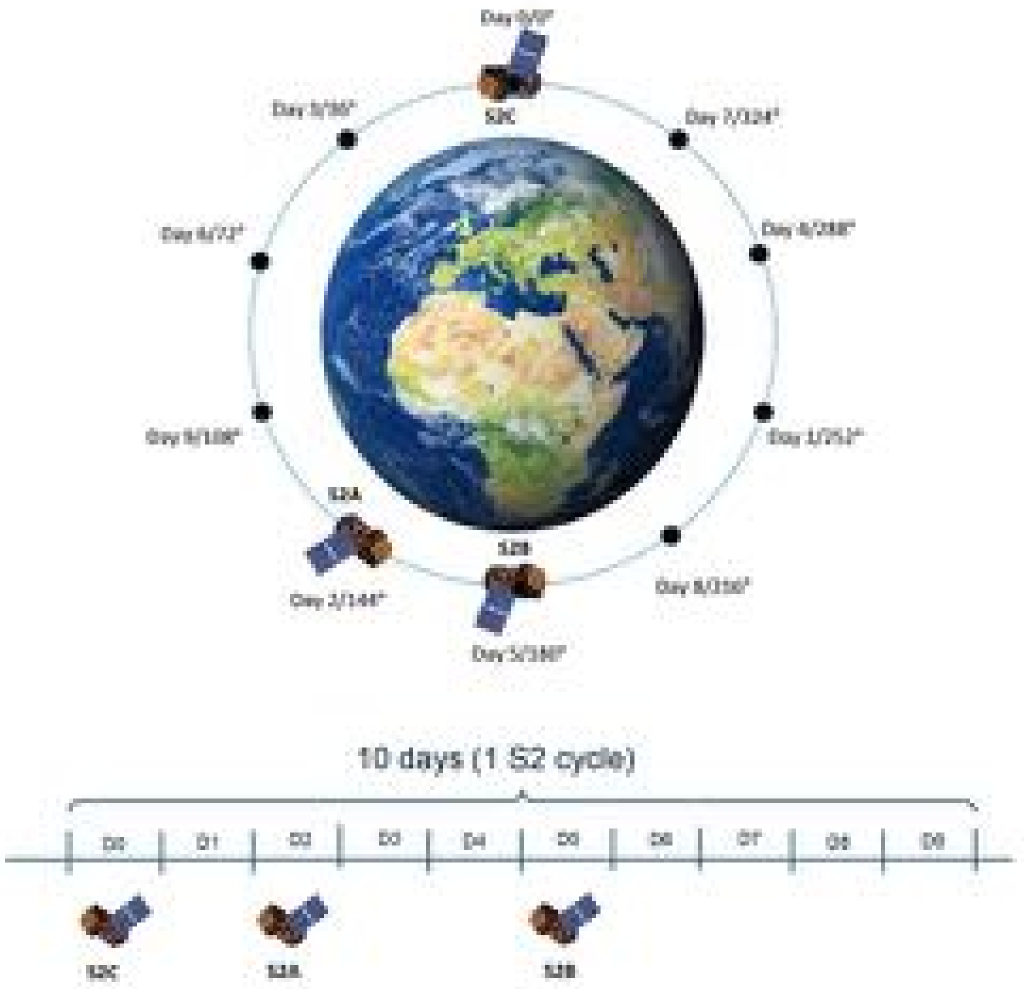
Sentinel-2 Images





Sentinel-2 coverage





Sun-synchronous orbit: Maintains consistent sunlight angle on Earth → minimizes shadows & illumination variability → ensures reliable time-series data.

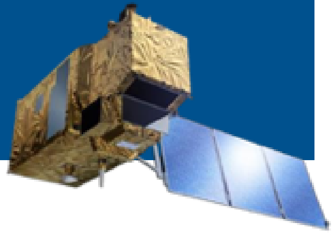
Orbit characteristics:

- Altitude: 786 km
- Inclination: 98.62°
- Period: 100.6 min
- Repeat cycle: 10 days
- Local Time at Descending Node (MLST): 10:30 am → balances solar illumination & cloud cover; aligns with Landsat & SPOT-5 for long-term time series integration.

Constellation configuration:

- Sentinel-2B and Sentinel-2C separated by 180°
- Extended scenario: Sentinel-2A 36° from Sentinel-2B

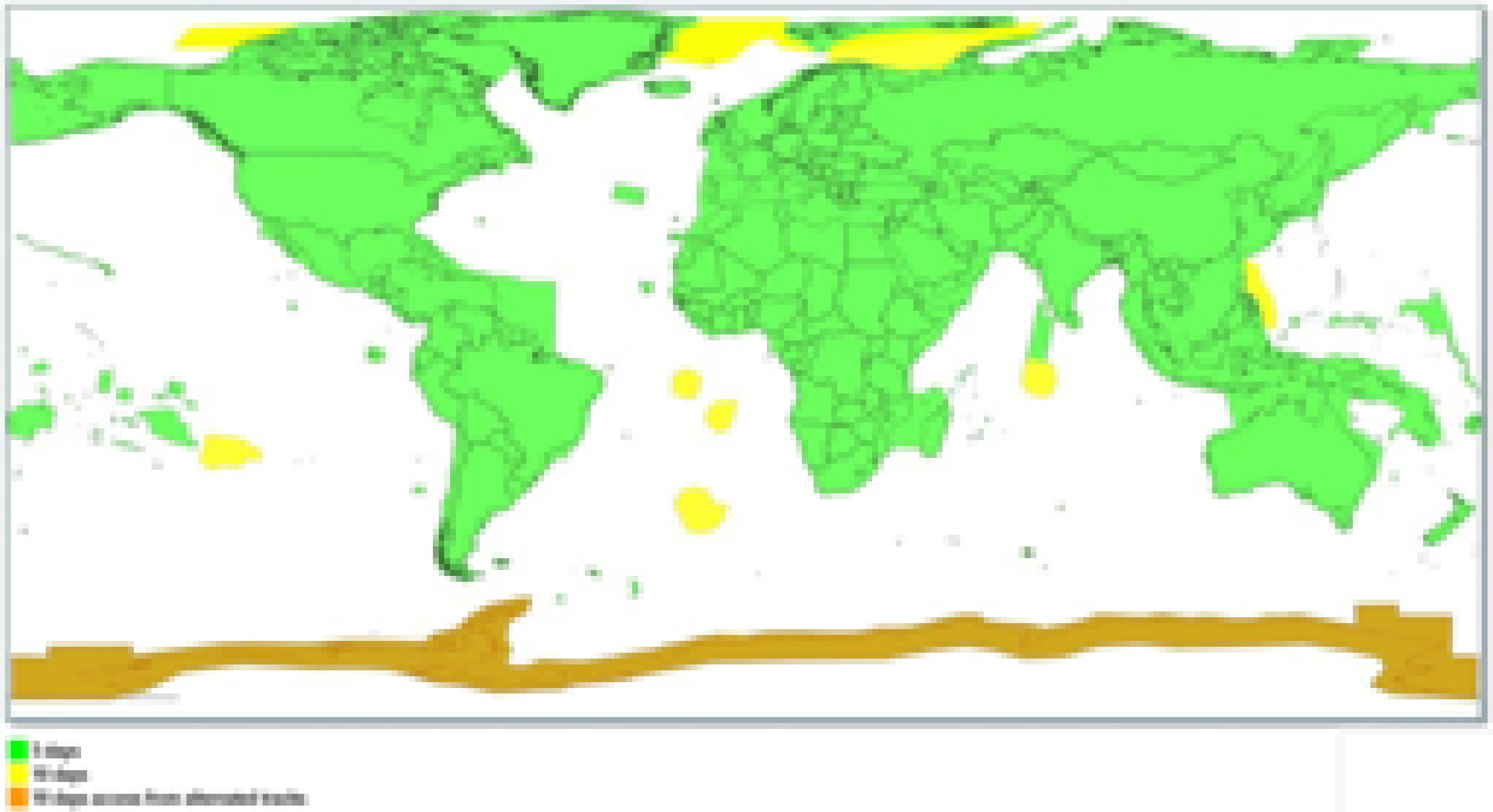
Sentinel-2 coverage



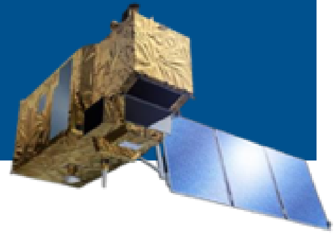
Systematic coverage over the following areas:

- all continental land surfaces (including inland waters) between latitudes 56° South and 82.8° North
- all coastal waters up to 20 km from the shore
- all islands greater than 100 km2
- all EU islands
- the Mediterranean Sea
- all closed seas (e.g. Caspian Sea).

baseline scenario of MSI acquisitions (two satellites in orbit).



Sentinel-2 coverage



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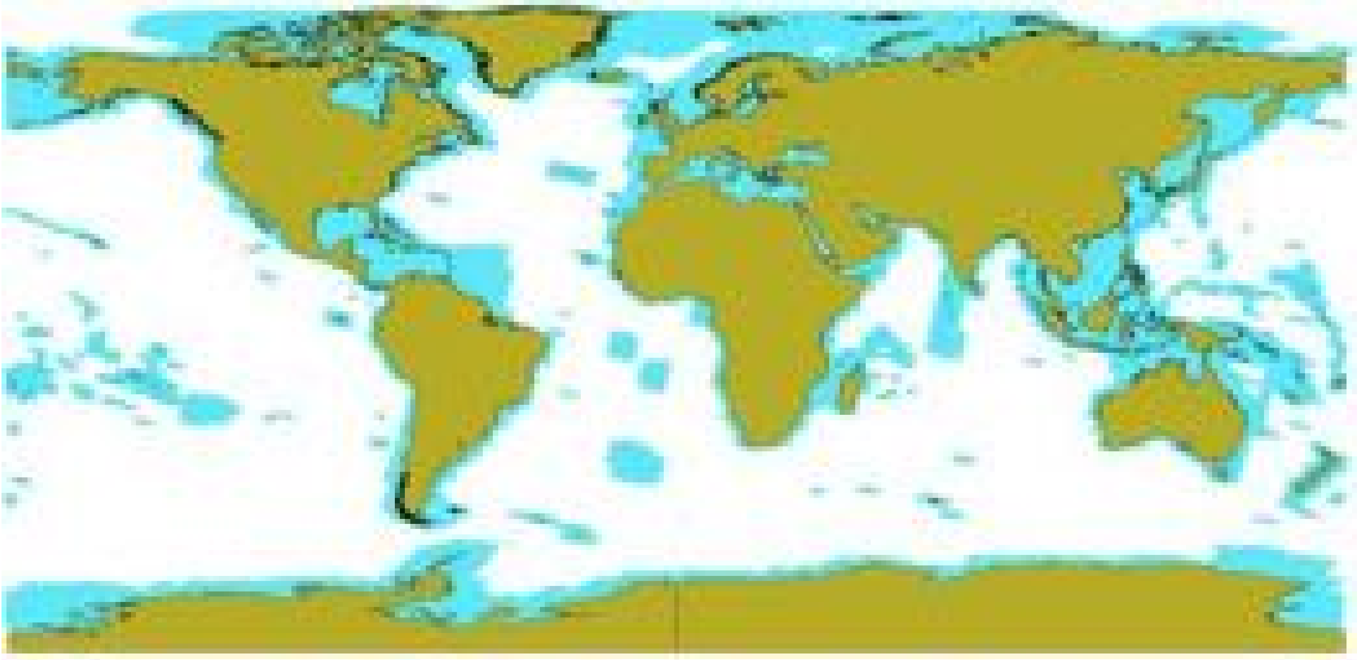
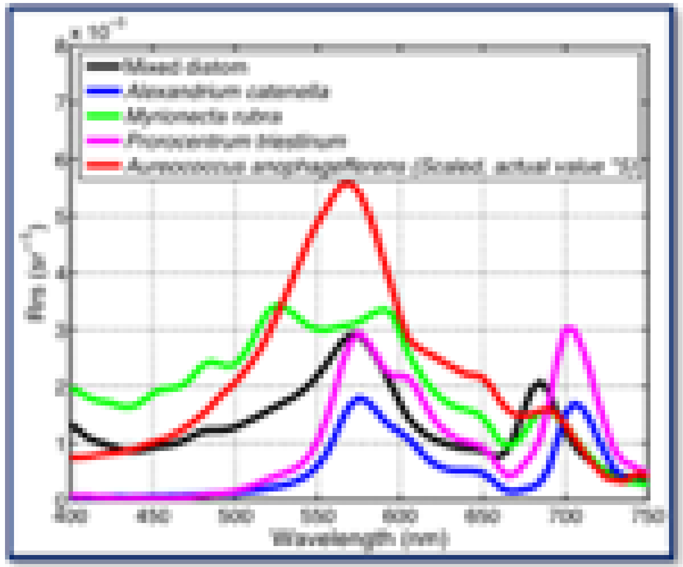
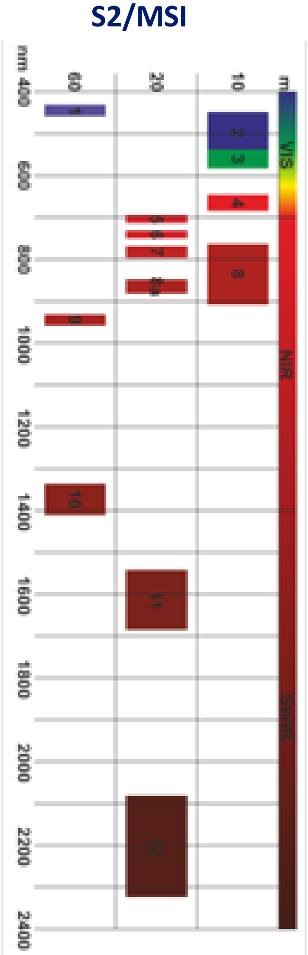


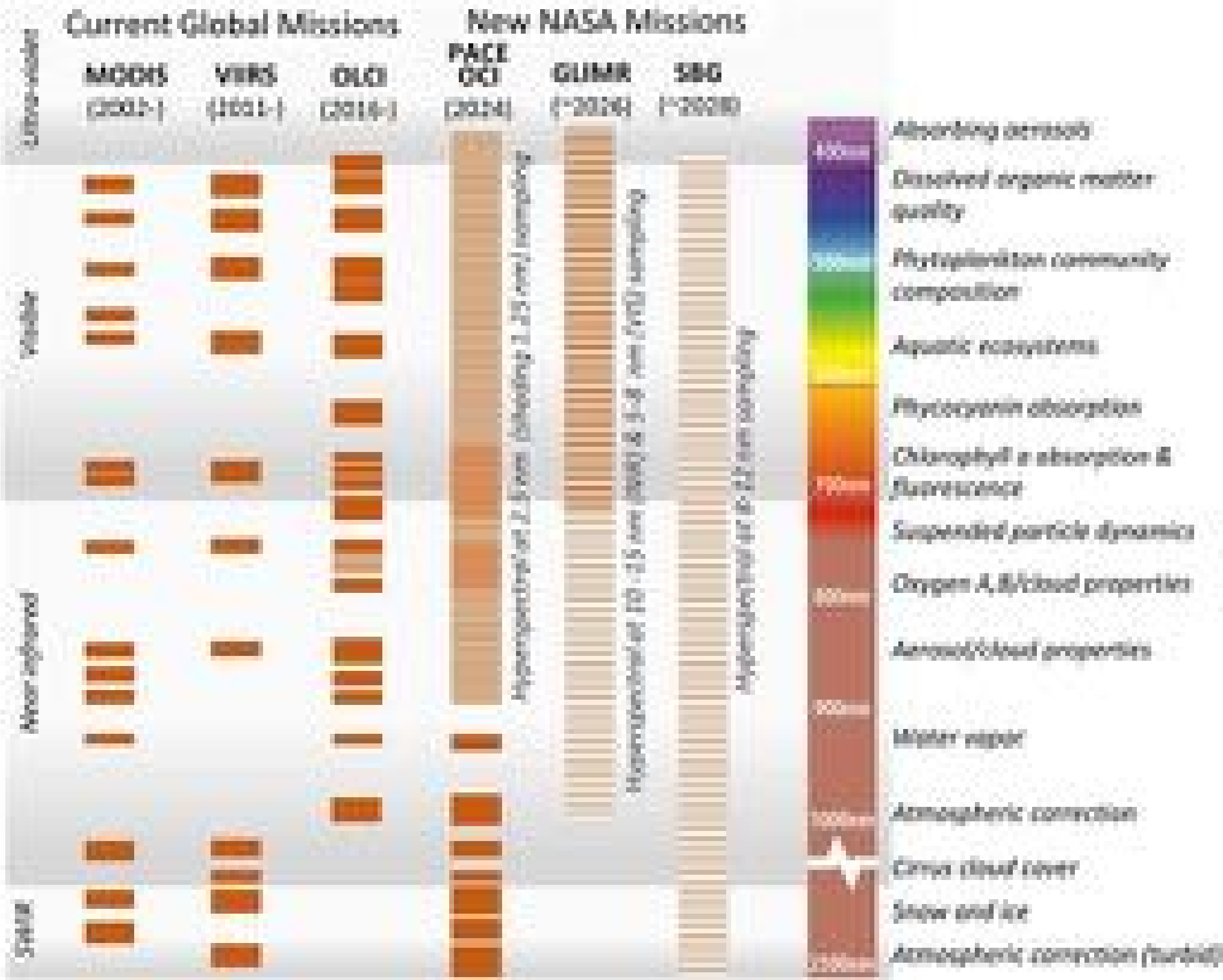
Water masses observed by Sentinel-2 are 37% since 2022

Spectral resolution

- Ocean colour specific sensors always designed to capture key parts of ocean colour spectral variability.
- Other “non-OC” sensors have fewer/wider bands that can make their usage more challenging



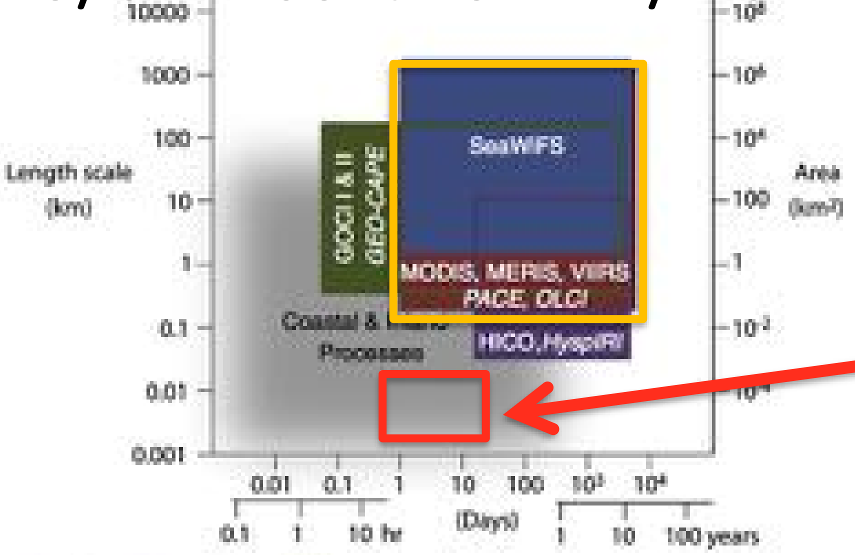


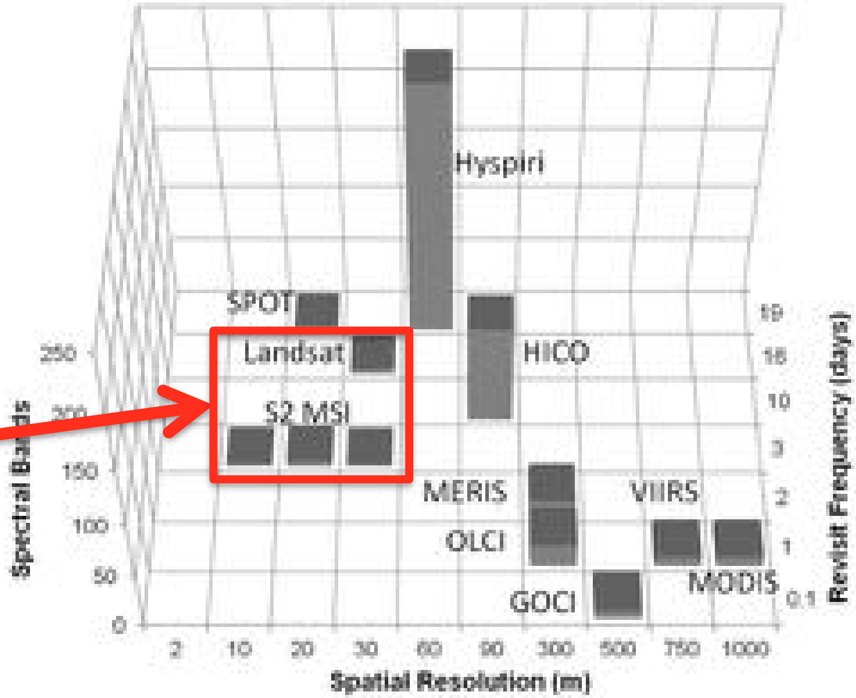


Dierssen et al., 2023

Processes scales and observation: focus on inland/coastal processes

New "observation class":
Landsat-8+9/OLI + Sentinel-2AB/MSI





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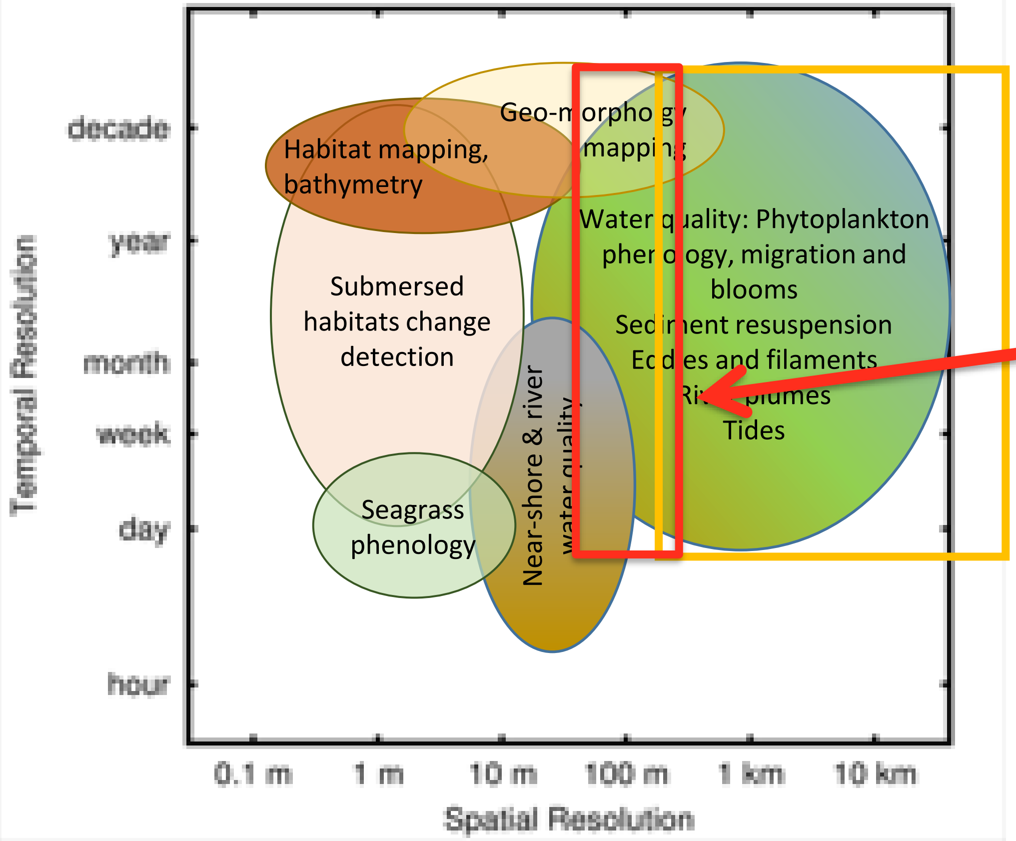

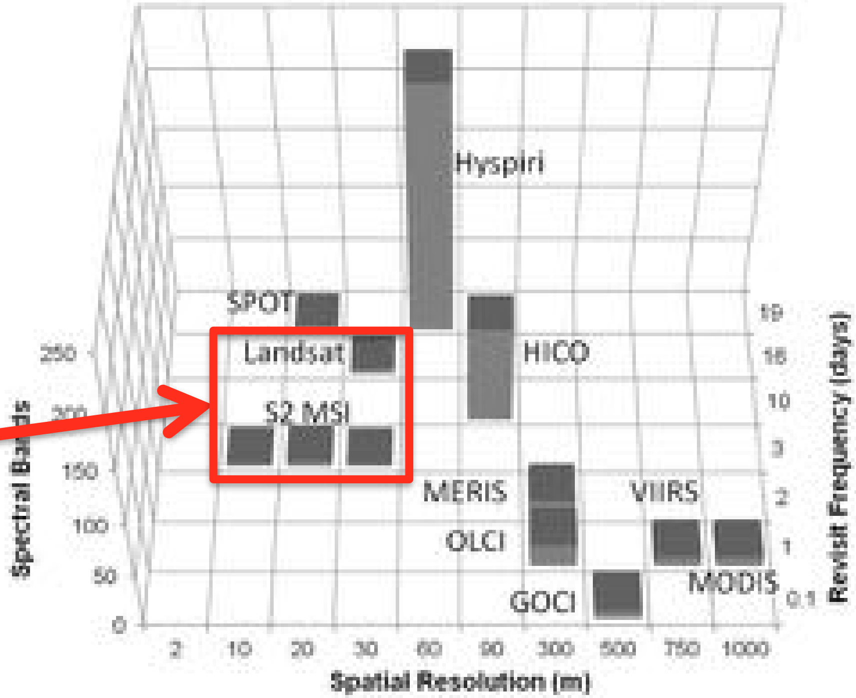

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Focus on inland/coastal processes
Giardino and Brando, based on Hedley et al., RSE 2018 - *Modified*

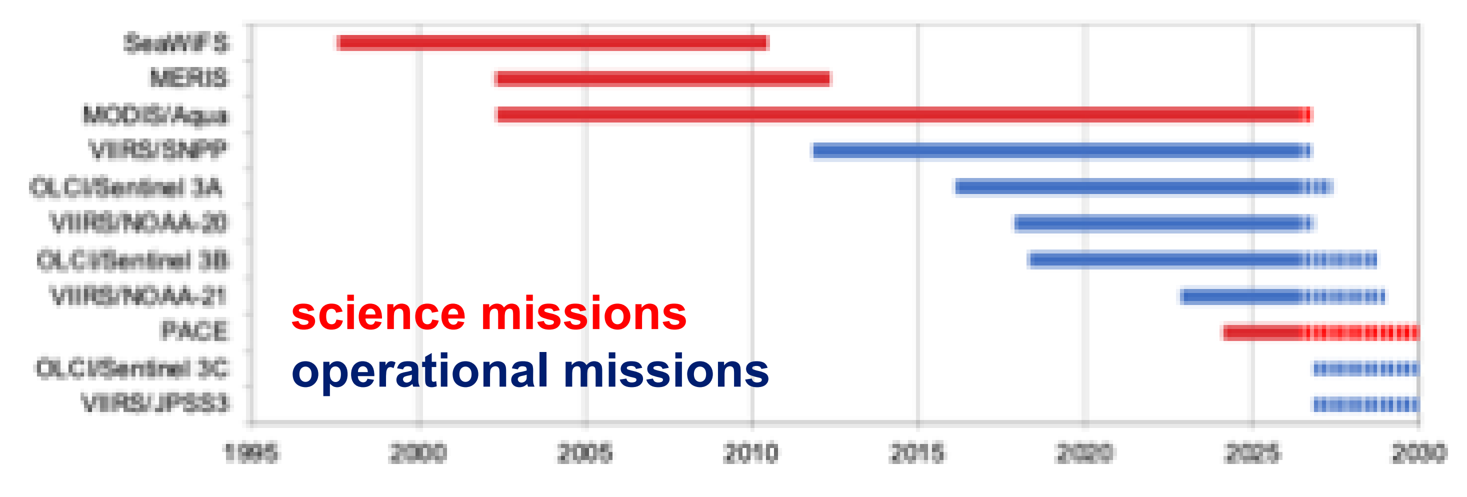
How has ocean colour evolved?

The operations era

Let’s do this…all the time…consistently…with redundancy!

In this era we:

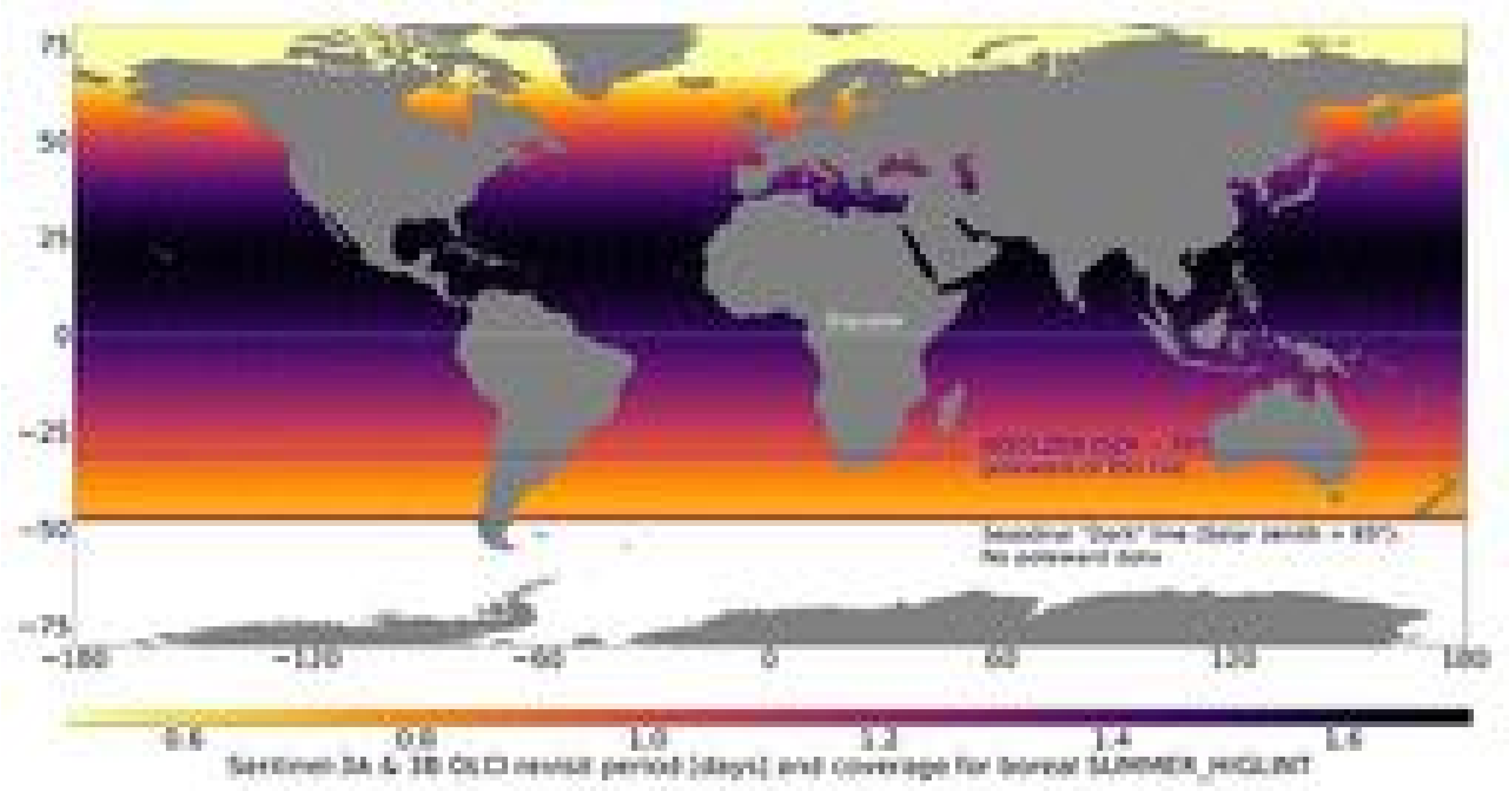
- Linked up with agencies typically responsible for operating ‘weather’ satellites
- Developed long-term programmes to maintain the ocean colour record
- Developed approaches to merging records from multiple sensors towards ECVs, EOVs, CDRs.



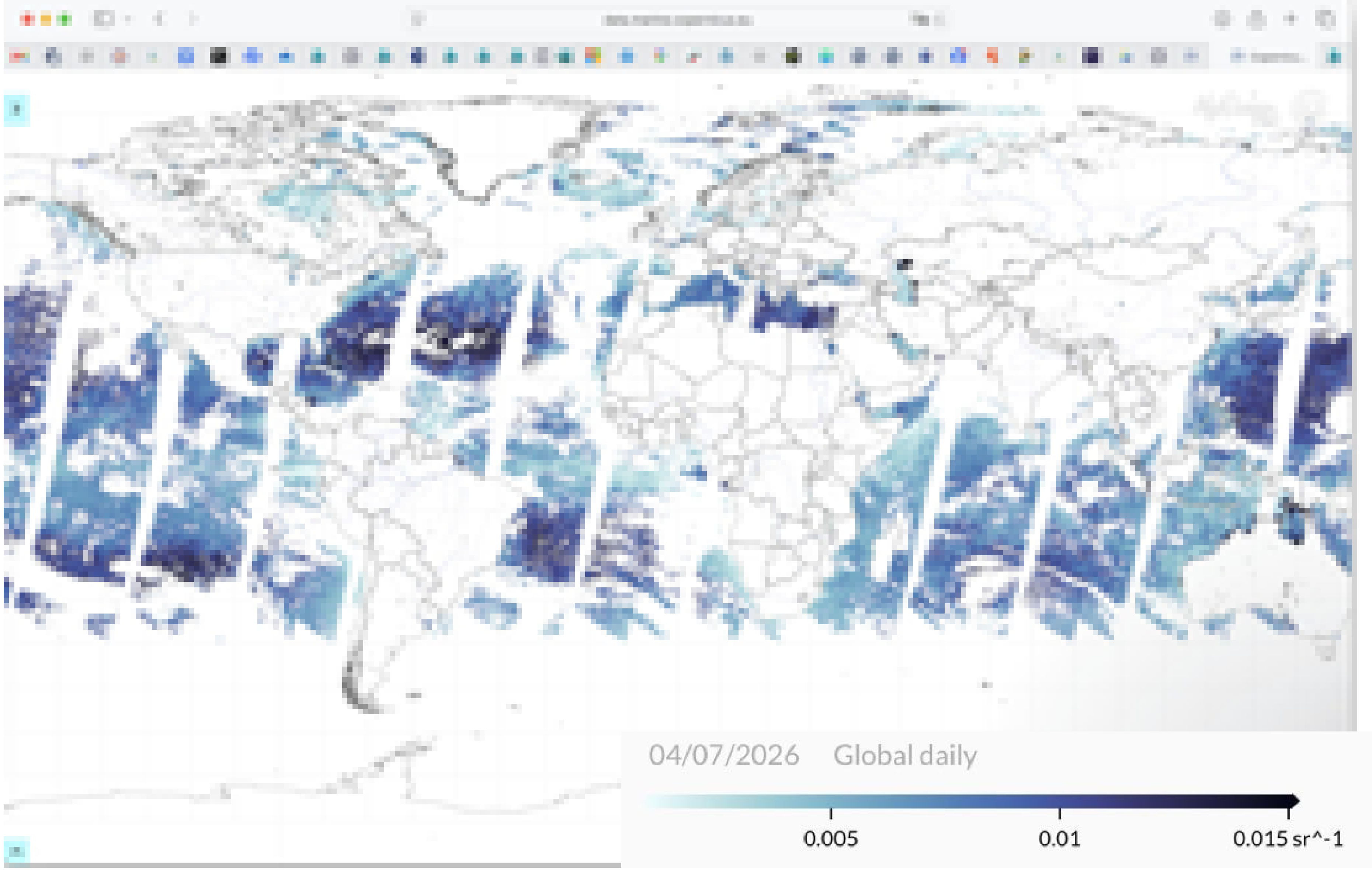
Series of consistent mission/sensor

- USA: 4 VIIRS to cover 2015-2038
- EU: 4 OLCI to cover 2016-2036
- constellations of at least two sensors in orbit at the same time

The operations era



The operations era



S3/OLCI A+B
Rrs(443)
4/7/2026

The operations era

We could design the best sensor/mission in the world but if it doesn't have:

- Reliable data production and serving
- Continuous data quality analysis and improvement
- Explodes on launch/gets hit by space junk etc and has no replacement

….then the value of our ultimate applications will be limited

Many elements have evolved to make ocean colour more operational. E.g.

- Sentinel-3 mission has 2 satellites operating, with two more in development and NG underway
- Initiatives supporting calibration, validation,
- Moves towards better data serving (including online archives and cloud)
- Consistent user support, training, and community engagement

How has ocean colour evolved?

Continuity era vs advancement era?...

- Where next?

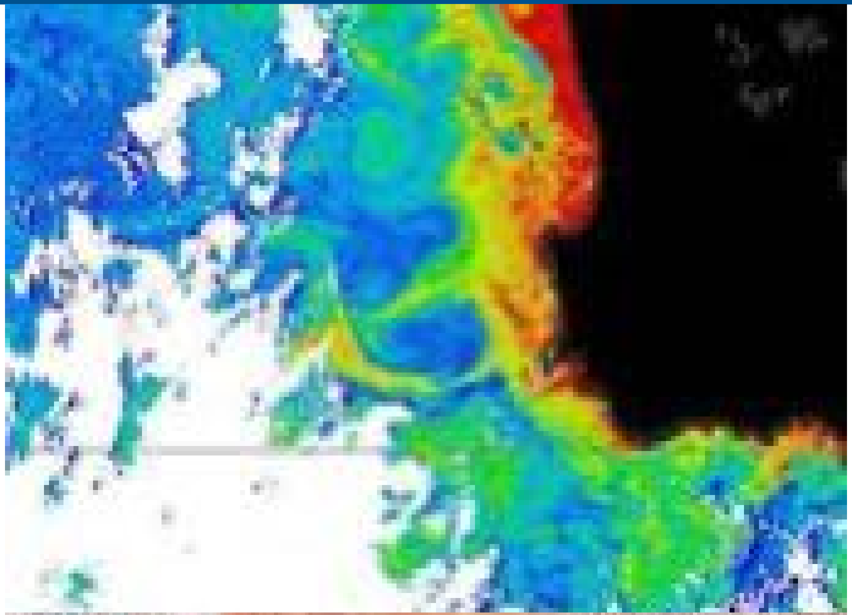
In this era we:

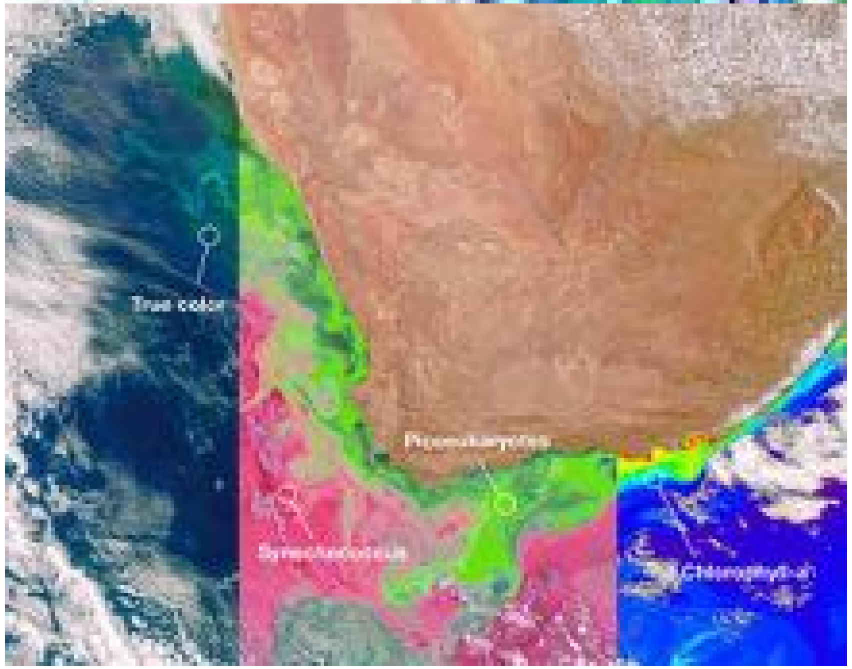
- Maintain continuity
- Advance the technology from spectral, temporal and spatial perspectives
- Drive towards downstream impact

How have ocean colour applications evolved?

Then…

- Chlorophyll-a
- In the open ocean
- Science
- For how long?



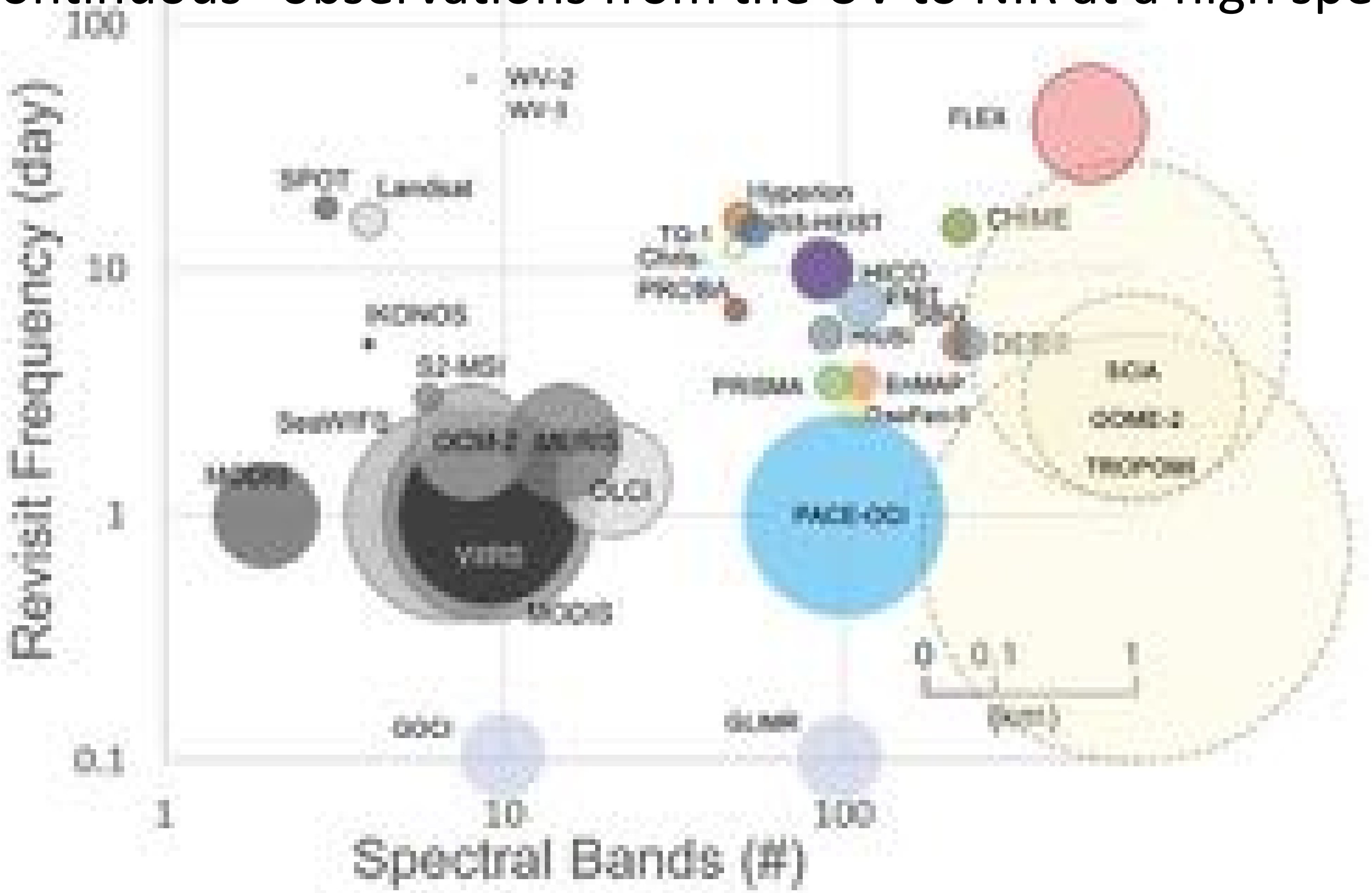


Now…

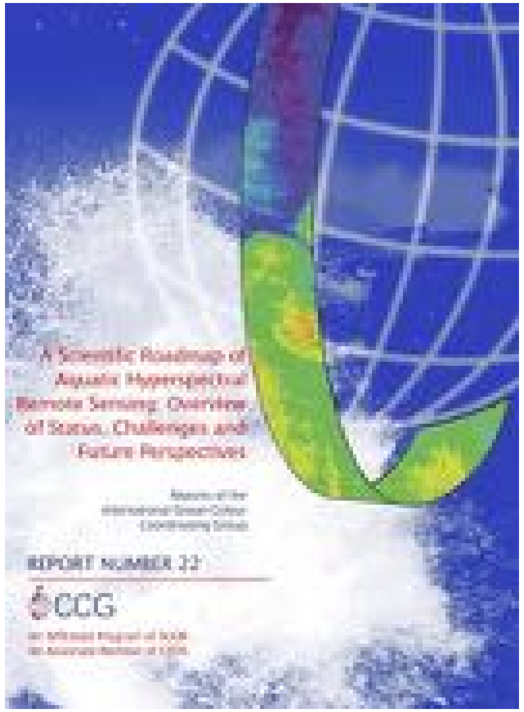
- Chlorophyll-a, Carbon, HABs, debris, ecosystem mapping…
- Open ocean, coastal, (inland)
- Science, business, policy
- For the foreseeable future!

Hyperspectral sensors

“continuous” observations from the UV to NIR at a high spectral resolution



Multispectral missions are in grey, and hyperspectral missions are coloured.



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A Scientific Roadmap of Aquatic Hyperspectral Remote Sensing: Overview of Status, Challenges and Future Perspectives. Version 1.0. Edited by Astrid Bracher, Ana I. Dogliotti, and Jeremy Werdell. pp.102.
https://doi.org/10.25607/OBP-2062

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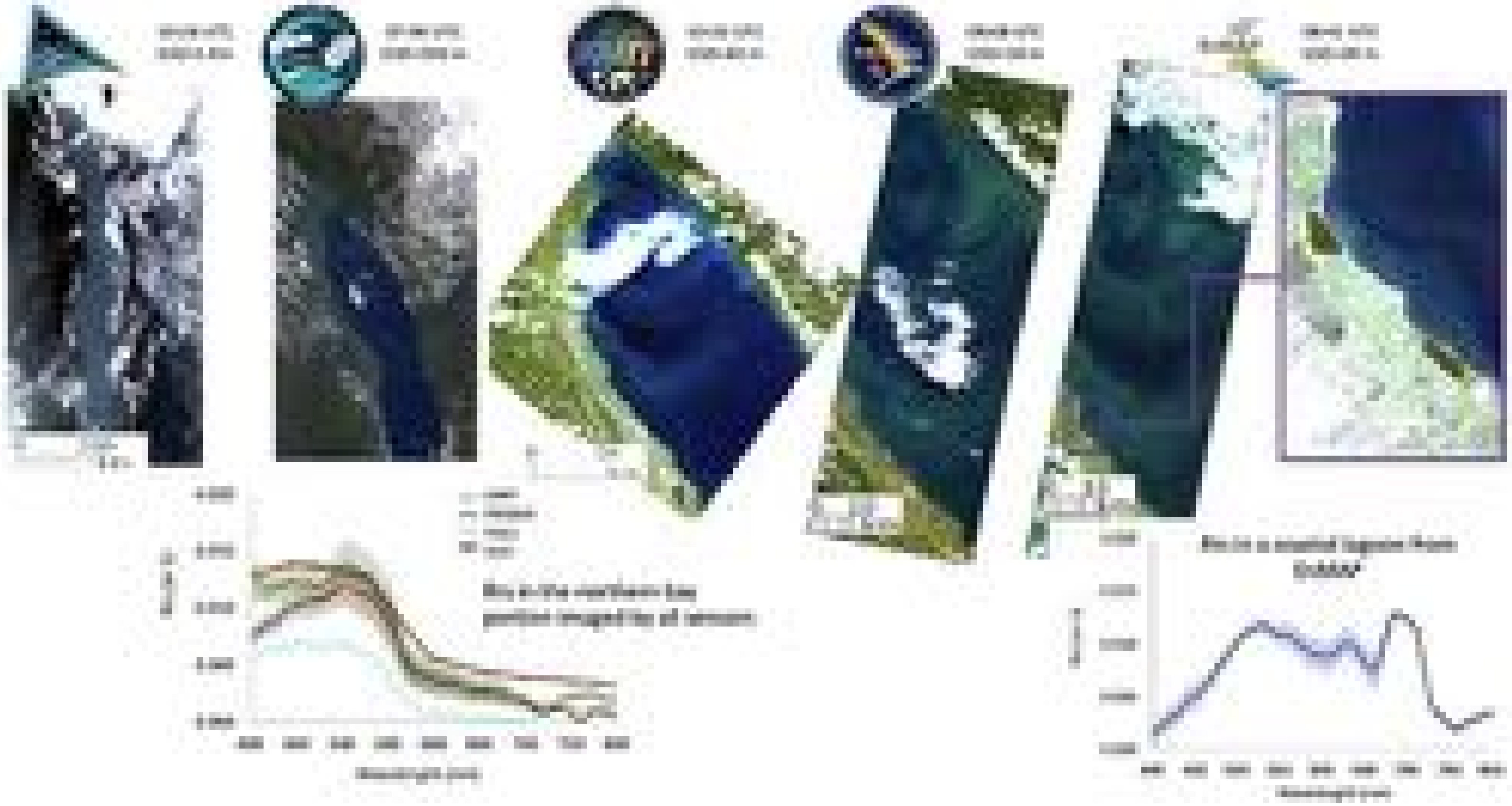
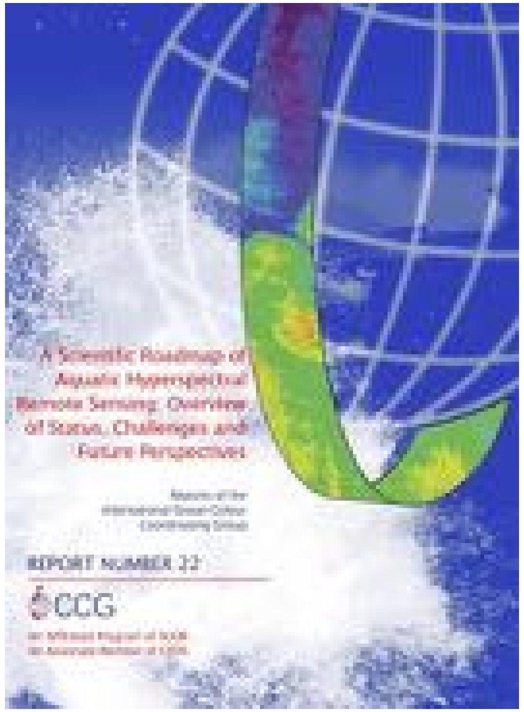


Figure 2.2 True-colour composite of the spaceborne hyperspectral images from PACE, EMIT, PRISMA and EnMAP, along with Sentinel-3 OLCI, all acquired on 21-05-2025 in Lake Malawi; bottom left: the R_{rs} spectra from Level-2 products covering a common portion of waters in the Northern part of the lake; bottom right: an R_{rs} spectrum from EnMAP over the coastal lagoon.



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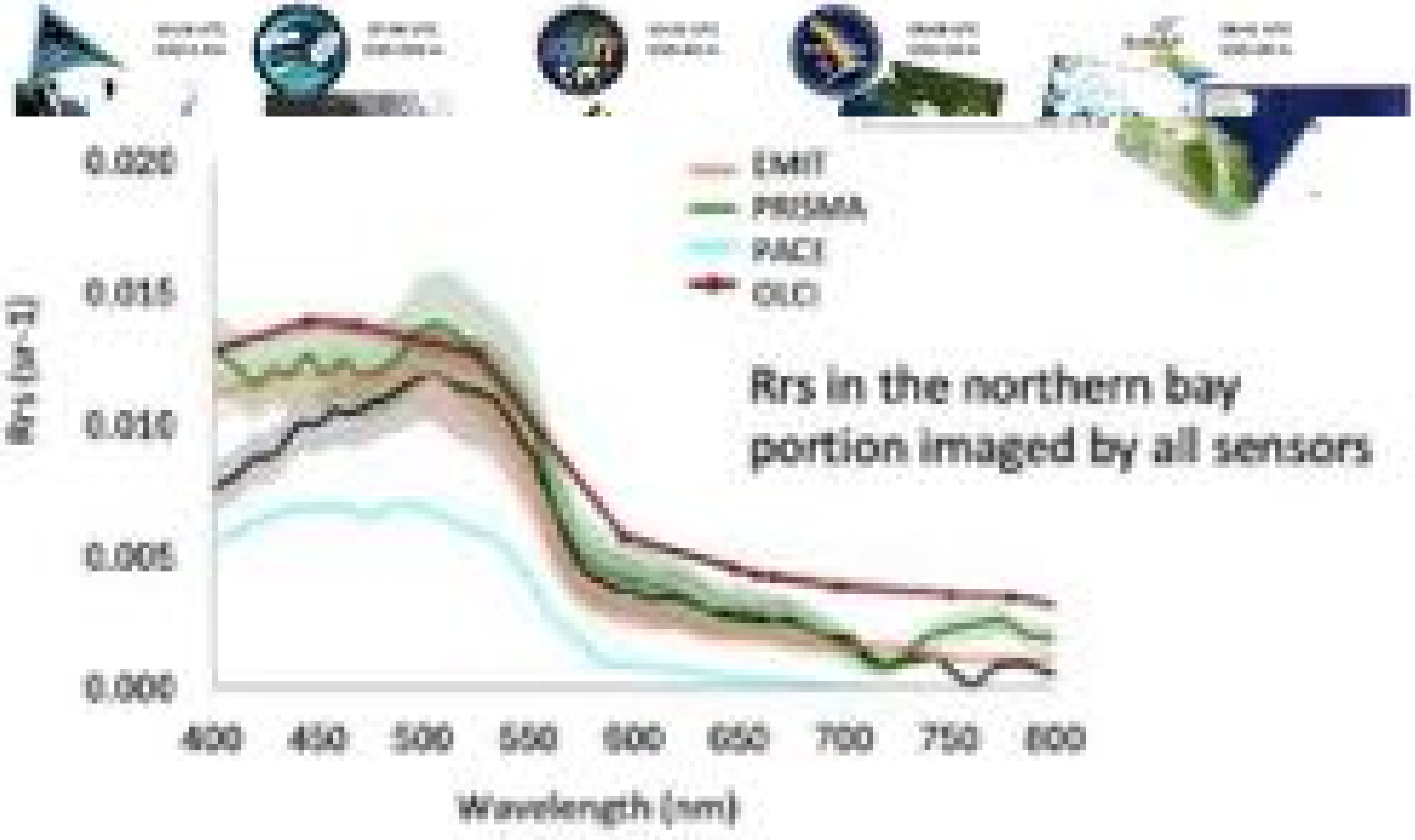

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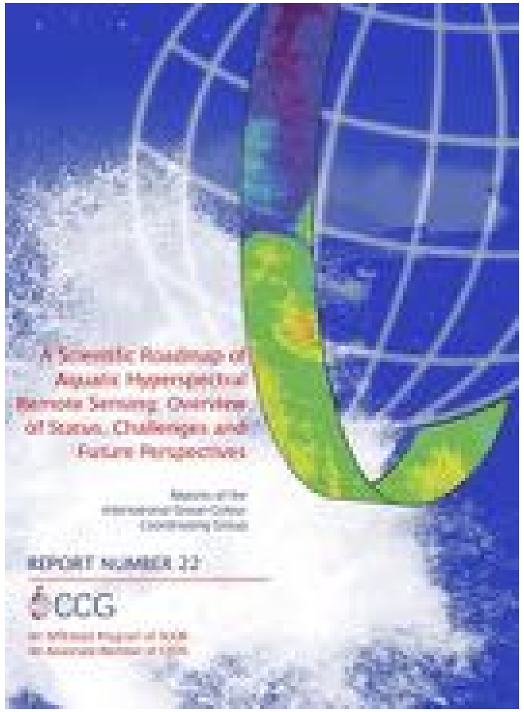

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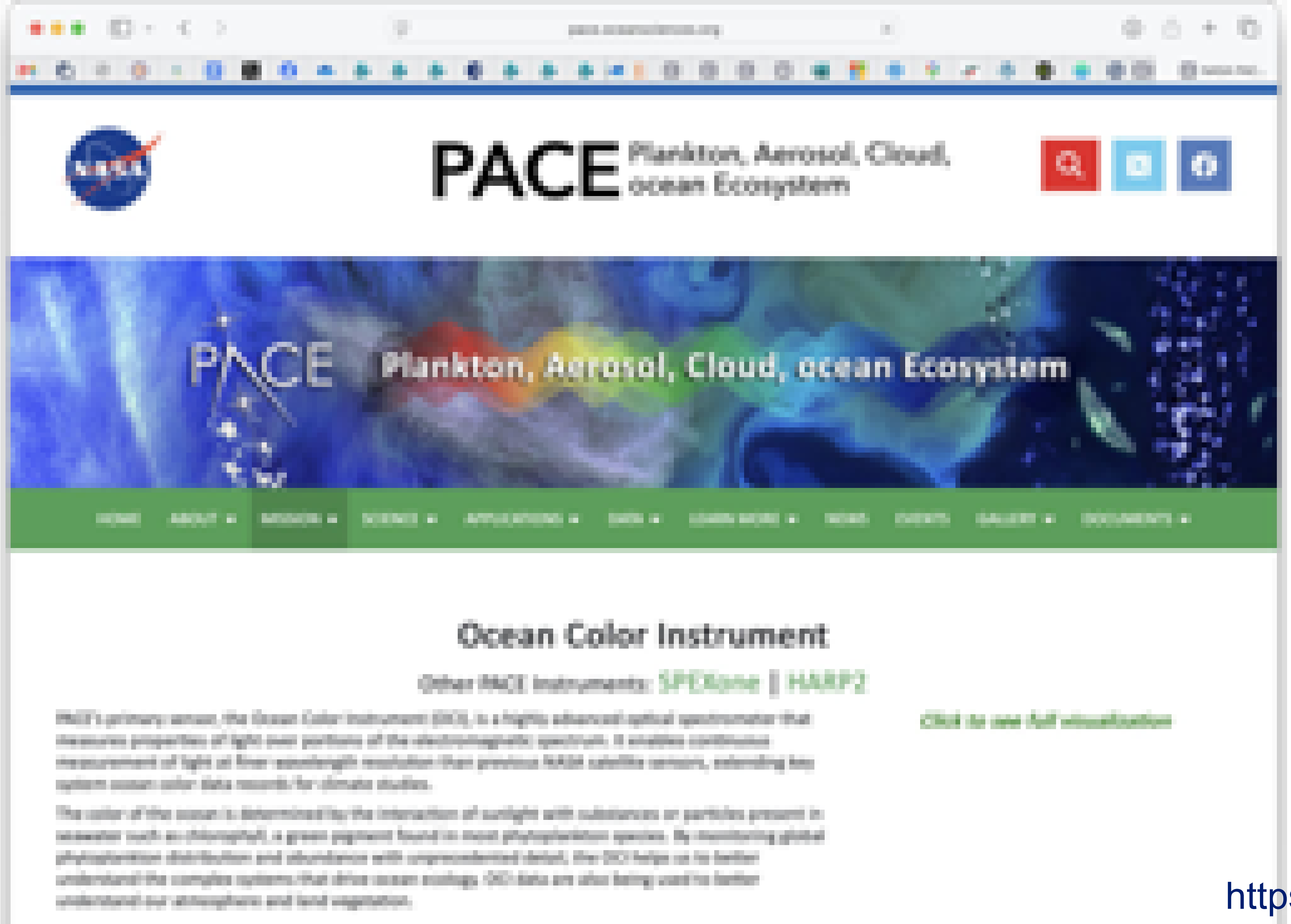
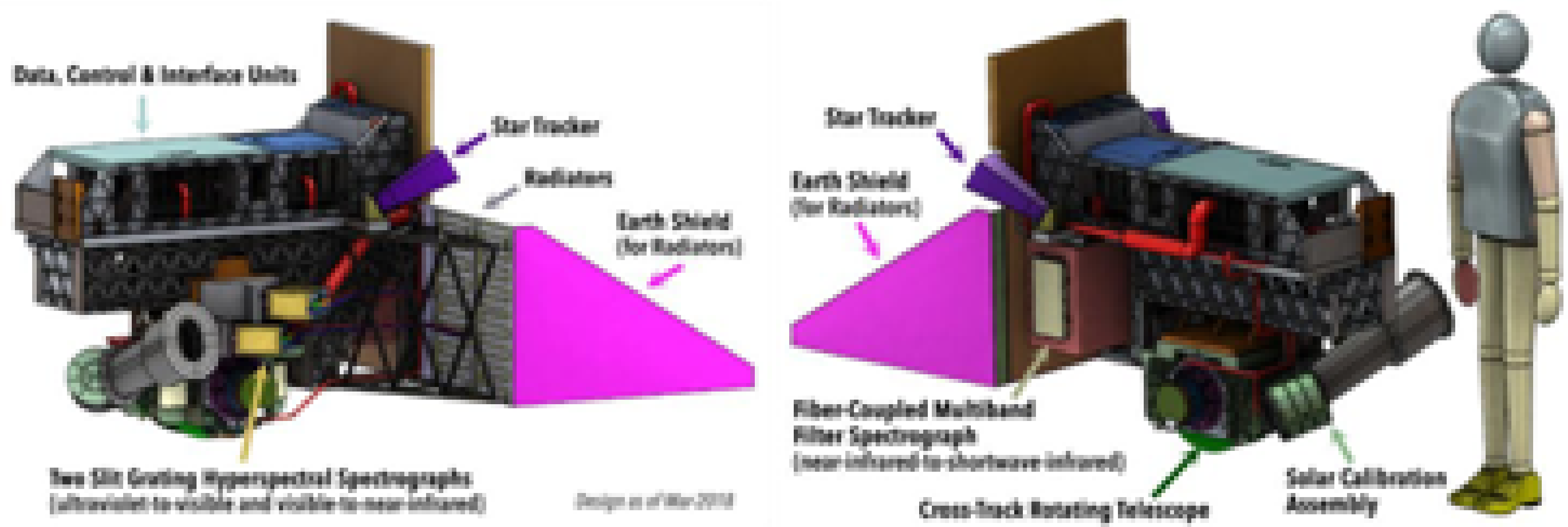
PACE



- crossing time of 13:00 at an altitude of 676.5 km
- 20° tilt maneuver in the track direction away from the sun to avoid glint from the ocean surface
- maps more than 95% of the sunlit Earth daily
- mission is designed to last at least 3 years; spacecraft fuel is sufficient for 10 years

https://pace.oceansciences.org/mission.htm

PACE: Ocean color instrument (OCI)



The primary science instrument for PACE is the **Ocean Color Instrument (OCI)** which measures ocean colour from ultraviolet to shortwave infrared.

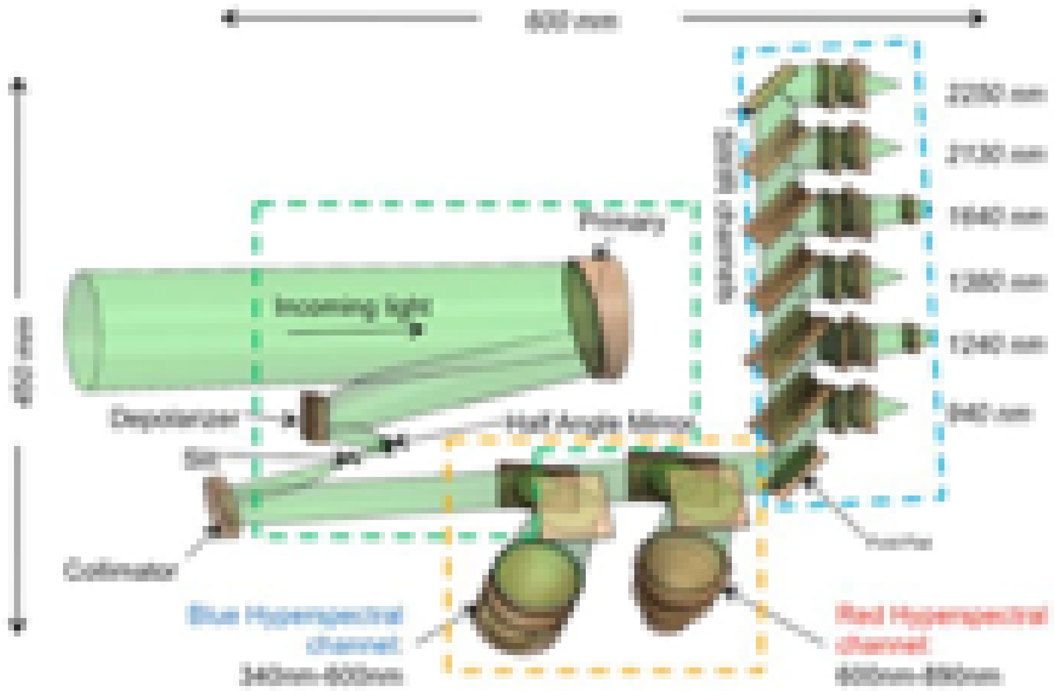
PACE includes **two polarimeters:** the Spectro-polarimeter for Planetary Exploration (SPEXone) and
the Hyper Angular Research Polarimeter (HARP2).

IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 62, 2024

The Ocean Color Instrument (OCI) on the Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) Mission: System Design and Prelaunch Radiometric Performance

Gerhard Meister, Joseph J. Knuble, Ulrik Gliese, Robert Bousquet, Leland H. Chemerys, Hyeungu Choi, Robert E. Eplee, Robert H. Estep Jr., Eric T. Gorman, Samuel Kitchen-McKinley, David Kubalak, Shihyan Lee, Charles McClain, Jeffrey W. McIntire, Frederick S. Patt, Zakk Rhodes, and P. Jeremy Werdell

PACE: Ocean color instrument (OCI)



- two hyperspectral and six SWIR channels
- In the hyperspectral channels, the light is split into blue and red channels by half angle mirrors
- The blue hyperspectral channel captures between 320-600 nm and the red captures 600-890 nm
- Blue and red hyperspectral channels have a grating optimized for the wavelengths of that channel, and a lens assembly that focuses the wavelength-dispersed slit image onto a CCD-> 200+ wavelengths UV-NIR
- 5 nm resolution, 2.5 nm steps (with 1.25 nm steps in several spectral regions)

S3NGO (Sentinel3 Next Generation Optical) and AOLCI (Advanced OLCI)
Context and plans

slides provided by
Paolo Cipollini, Simon Proud
Sentinel-3 Next Generation Optical Mission Scientists

08/07/2026

Copernicus Context for S3NGO

upd. 07/26

esa

CURRENT GENERATION SENTINELS

in orbit — future

Sentinel-1 A + B + C + D
C-Band Radar

Sentinel-2 A + B + C
High Res Optical
→ **Sentinel-2 D**
High Res Optical

Sentinel-3 A + B
MR Optical + Altimeter
→ **Sentinel-3 C + D**
MR Optical + Altimeter

Sentinel-4 A
Atm. Chemistry (GEO)
→ **Sentinel-4 B**
Atm. Chemistry (GEO)

Sentinel-5P + Sentinel-5 A
Atm. Chemistry (LEO)
→ **Sentinel-5 B + C**
Atm. Chemistry (LEO)

Sentinel-6 A + B
Altimeter

NEXT GENERATION SENTINELS

Sentinel-1 NG A + B
C-Band Radar

Sentinel-2 NG A + B
High Res Optical

Sentinel-3 NG Topo A + B
Altimeter

Sentinel-3 NG Opt A + B
MR Optical

Sentinel-6 NG A
Altimeter

COPERNICUS EXPANSION

ROSE-L A + B
L-Band Radar for Arctic and Cryosphere Monitoring, Land and Emergency Mapping, Ground Motion, Soil Moisture

CO2M A + B + C
Carbon Dioxide Monitoring

CRISTAL A + B
Polar Ice & Snow Topogr. Altim.

CHIME A + B
Hyperspectral Imaging

LSTM A + B
Surface Temperature

CIMR A + B
Imaging Microwave Radiometer

Sentinel-3 Next Generation Optical (NGO) - Objectives

Enhanced continuity of observations of the current Sentinel-3 mission (excluding the topographic component)

In particular: follow-on of Sentinel-3 OLCI and SLSTR → Advanced OLCI (AOLCI) and Advanced SLSTR (ASLSTR), ensuring continuity of operational data to feed the **downstream Copernicus applications/services** and to serve evolving user needs by **enhanced continuity**

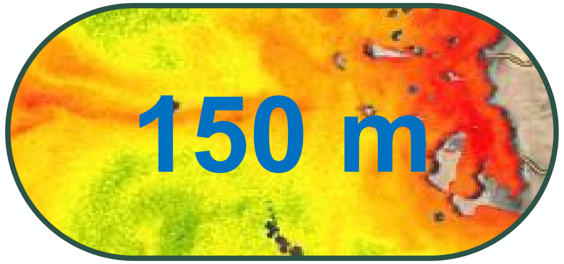
The European wide-swath mission providing:

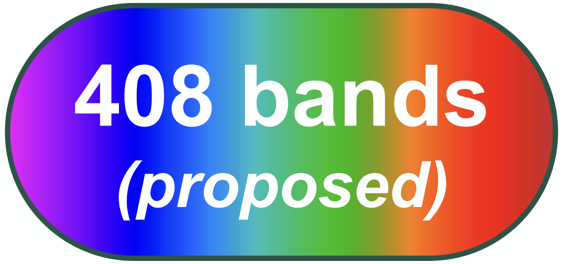
- ocean observation data in routine, long term and continuous fashion with consistent quality and a very high level of availability.
- land optical observation products and land hydrology products.
- …but also improved and fully operational products AOD and FRP used by atmospheric Services

AOLCI: The future of Ocean Colour for Copernicus

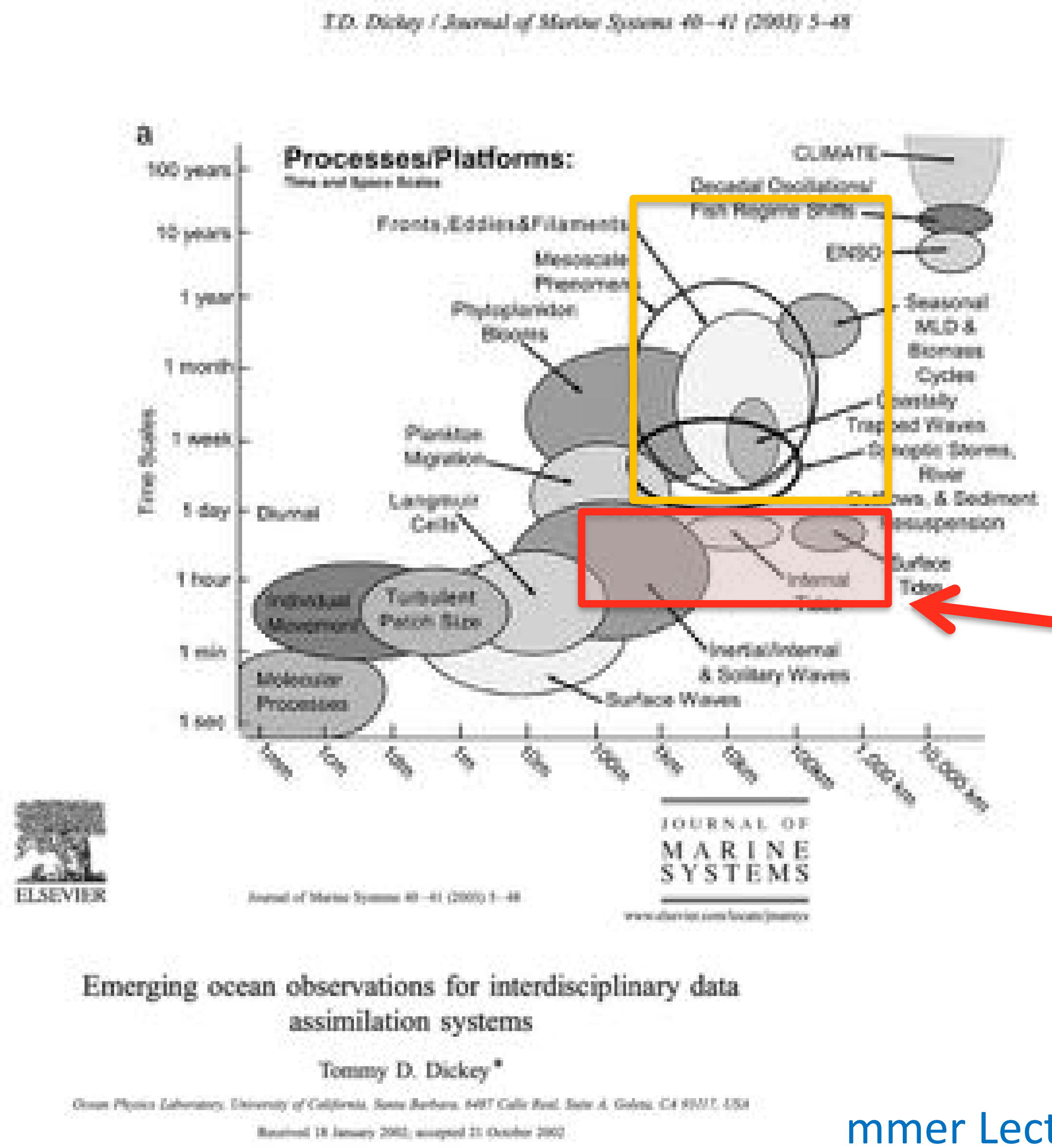
Sentinel-3 Next Generation Optical (S3NGO): European wide-swath mid-resolution reference. Two satellites to be launched in mid-2030s

- **Advanced OLCI (AOLCI) instrument** : 150 m resolution, supporting detailed oceanic, coastal and inland water observations.
- High signal-to-noise ratio and frequent revisit maintained
- Spectral capabilities dramatically expanded: **currently looking at feasibility of 408 hyperspectral bands (340 –1040 nm)**, enabling new ocean colour products (e.g., phytoplankton types, primary production).
- Improved synergy with ASLSTR dual-view VIS/IR radiometer



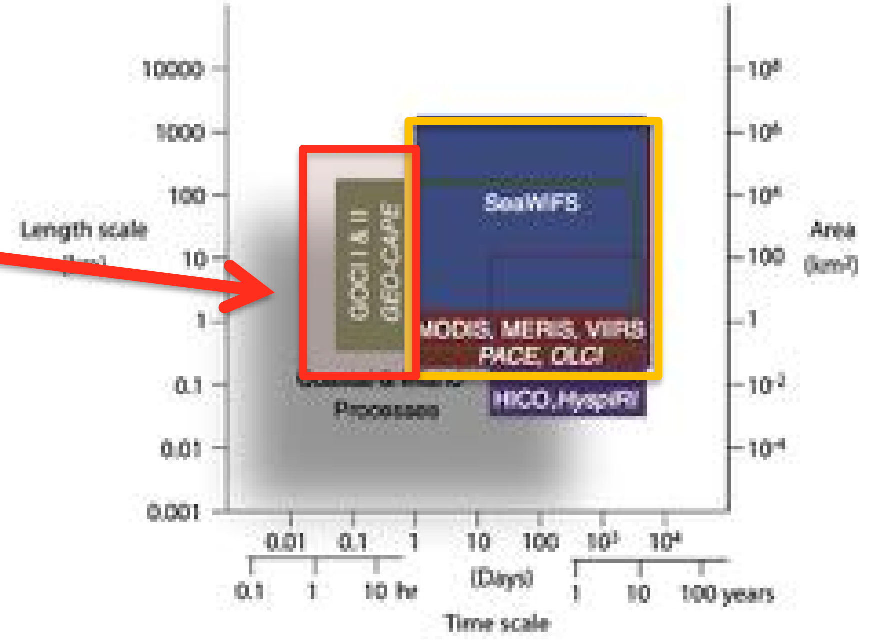


Processes scales and observation

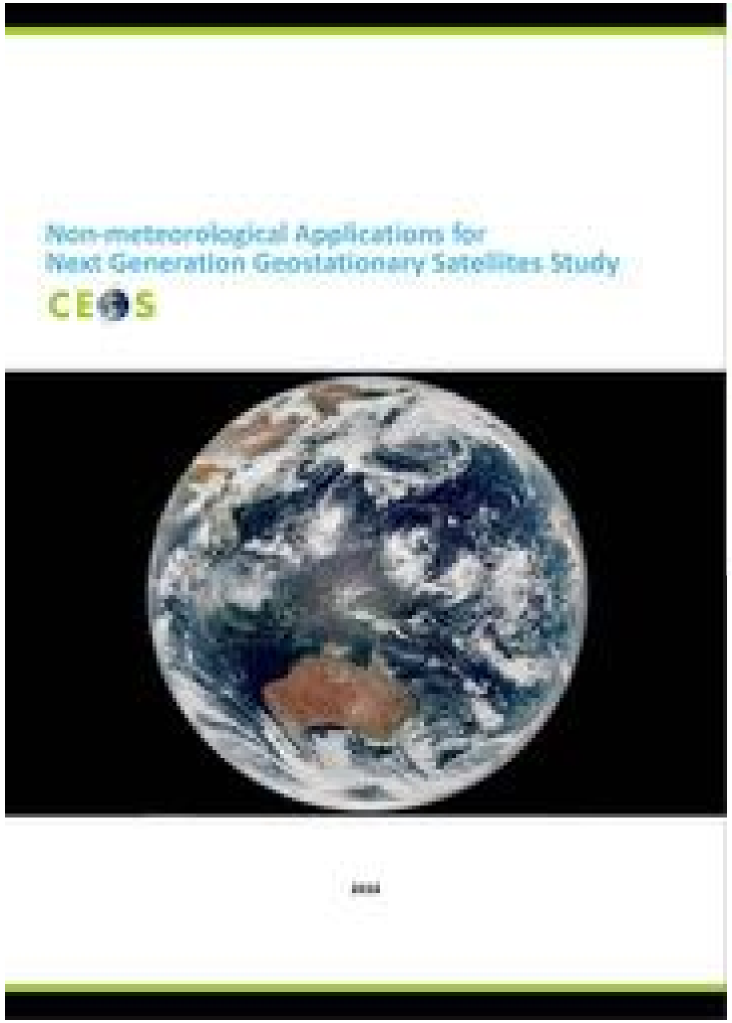


Time-horizontal space scale diagram illustrating several physical and biological processes in ovals.

and Rectangles indicate the approximate horizontal temporal sampling domain capabilities of several platforms at in **2002**.



Future: Geostationary OCR



Product	Parameter	ABI	AHI	AMI	AGRI	FCI	SEVIRI
SST	Skin Temperature	B	B	B	B		
Ice (and lake ice)	Cover/thickness	B*		B			
	Concentration	B*					
	Motion	B*					
	Age	F					
	Skin Temperature	F					
Current		F		F			
Ocean Colour	Water leaving radiance		B				
	Turbidity/TSS					F	F
	Chlorophyll-a		B				
	Blue-green algae				B		

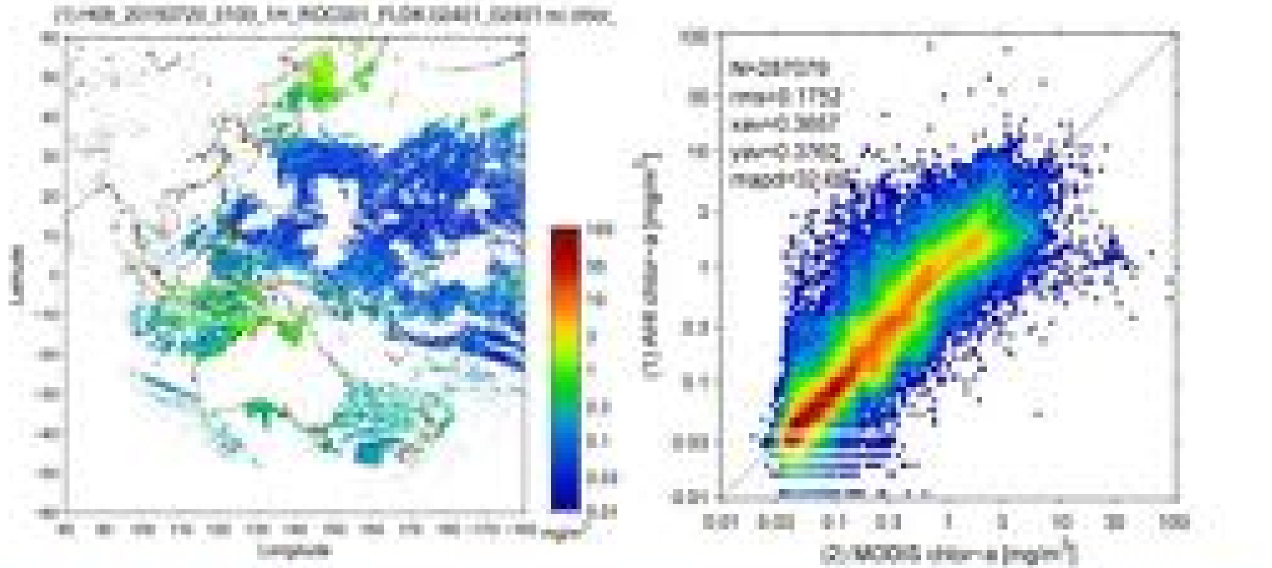


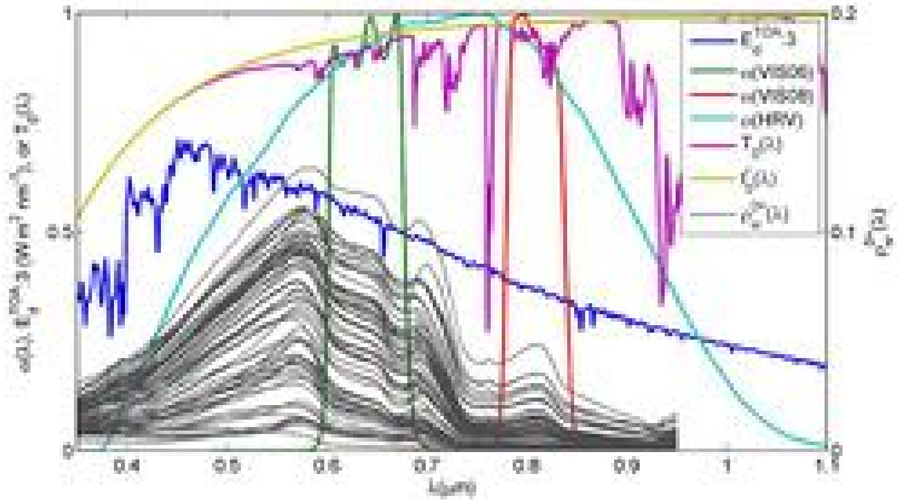
Figure 23: Averaged chlorophyll-a retrieved from Himawari-8 observations 01:00-01:50 UTC on 20 July 2015 for the wider Asia-Pacific region (left) and inter-comparison of Himawari-8 retrievals with MODIS daily Level 3 (right) (Murakami, 2016).

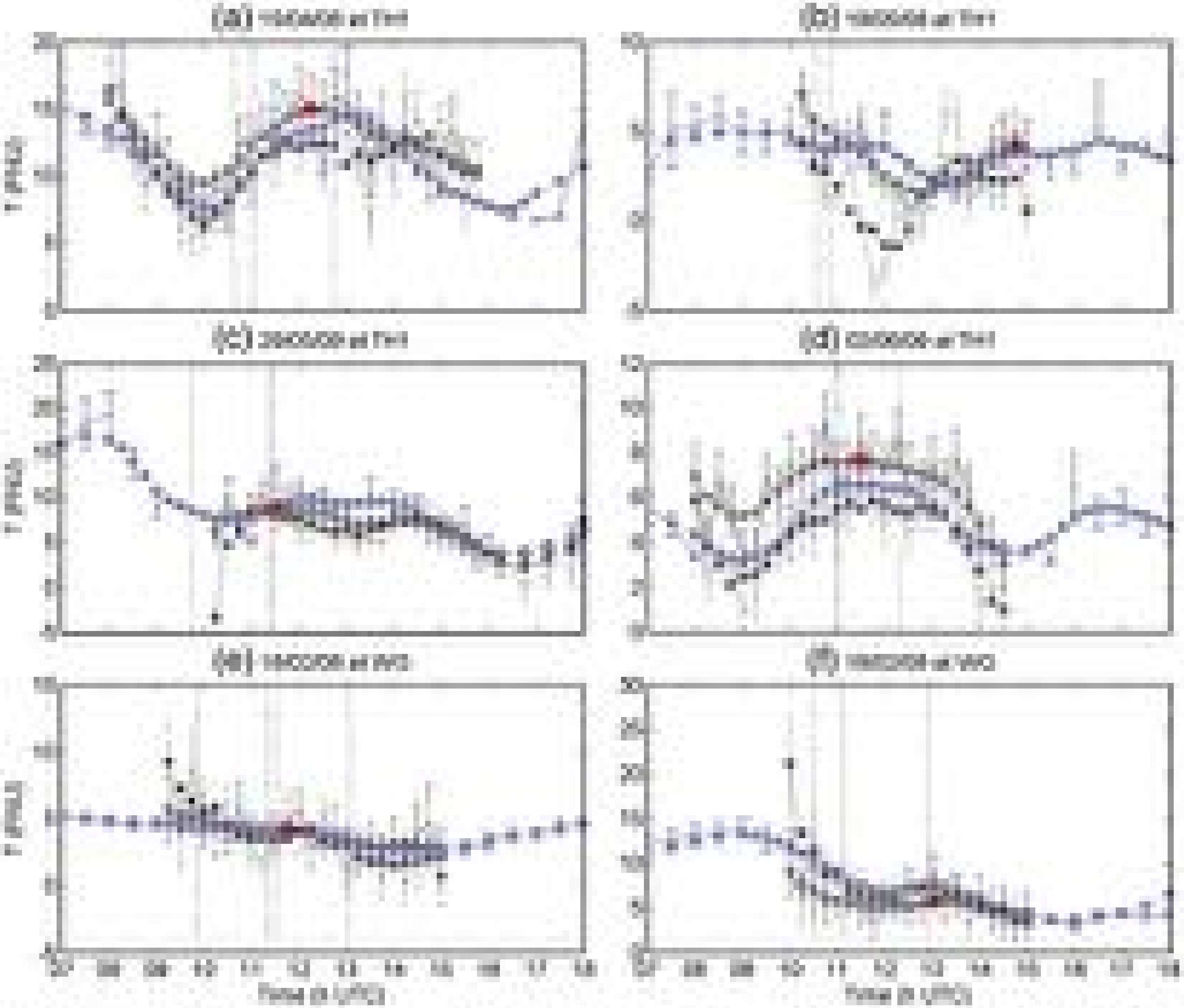
https://publications.csiro.au/publications/publication/PIcsiro:EP2022-2260

Future: Geostationary OCR

proofs of concept with MSG/SEVIRI

G. Neukermans et al. / Remote Sensing of Environment 124 (2012) 564–580





Remote Sensing of Environment 124 (2012) 564–580

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journal homepage: www.elsevier.com/locate/rse

Diurnal variability of turbidity and light attenuation in the southern North Sea from the SEVIRI geostationary sensor

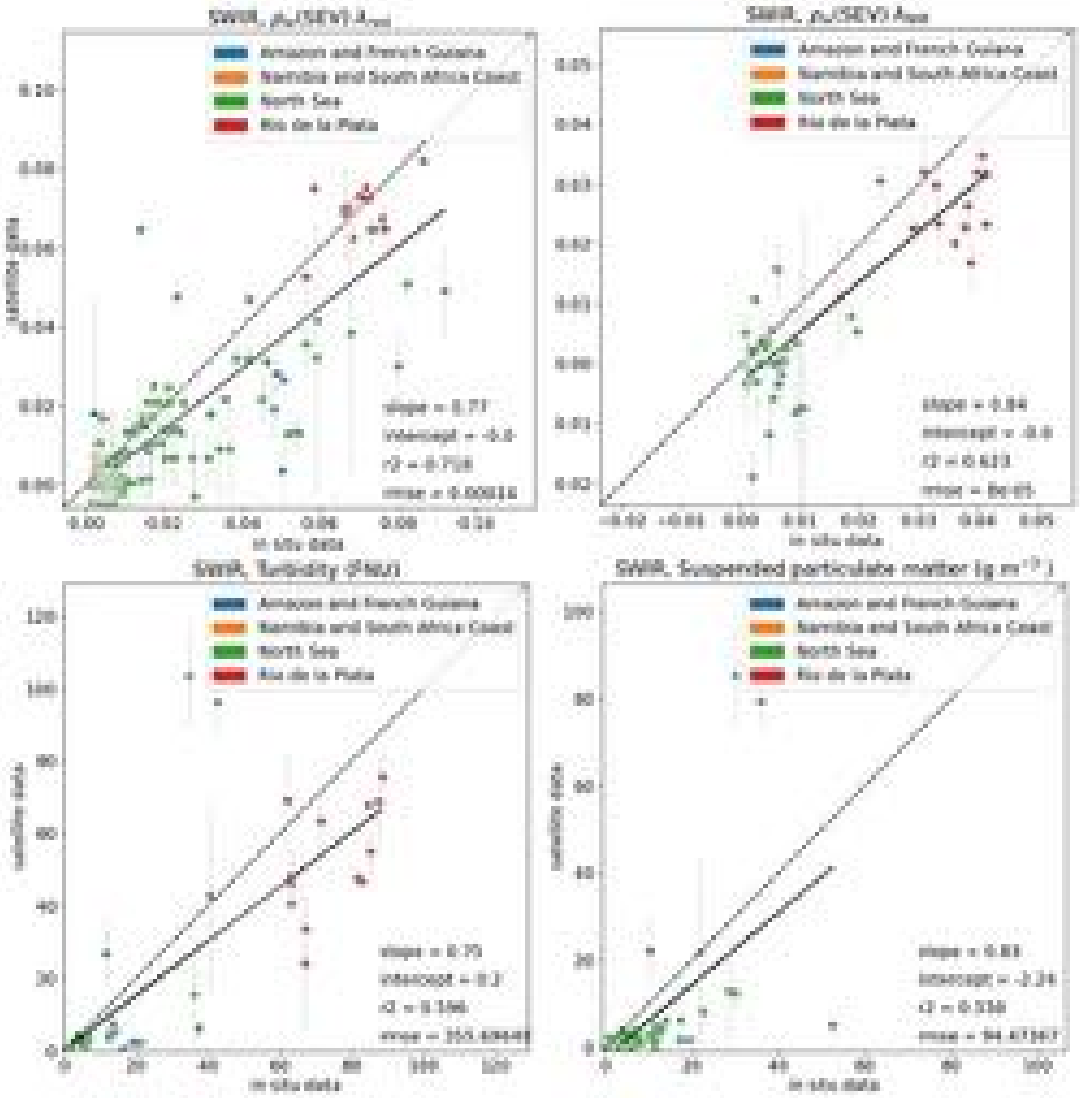
G. Neukermans, K.G. Ruddick, N. Greenwood

Future: Geostationary OCR

proofs of concept with MTG/FCI

Sensor	Spectral bands							
MSG/SEVIRI Spectral interval (µm) SNR @ specified albedo			635 0.56-0.71 10.1@1%	HRV 0.4-0.9 4.3@1% 810 0.74-0.88 7.28@1%			1640 1.50-1.78 3@1%	
MTG/FCI Bandwidth (nm) SNR @ specified albedo	444 60 25@1%	510 40 25@1%	640 50 30@1%	865 50 21@1%	914 20 12@1%	1380 30 40@1%	1610 50 30@1%	2250 50 25@1%
Himawari/AHI Bandwidth (nm) SNR @ specified albedo	455 50 300@100%	510 20 300@100%	645 30 300@100%	860 20 300@100%			1610 20 300@100%	2260 20 300@100%
GOES/ABI Bandwidth (nm) SNR @ specified albedo	470 40 300@100%		640 100 300@100%	860 40 300@100%		1380 30 300@100%	1610 60 300@100%	2260 50 300@100%

https://www.eumetsat.int/OC-GEO



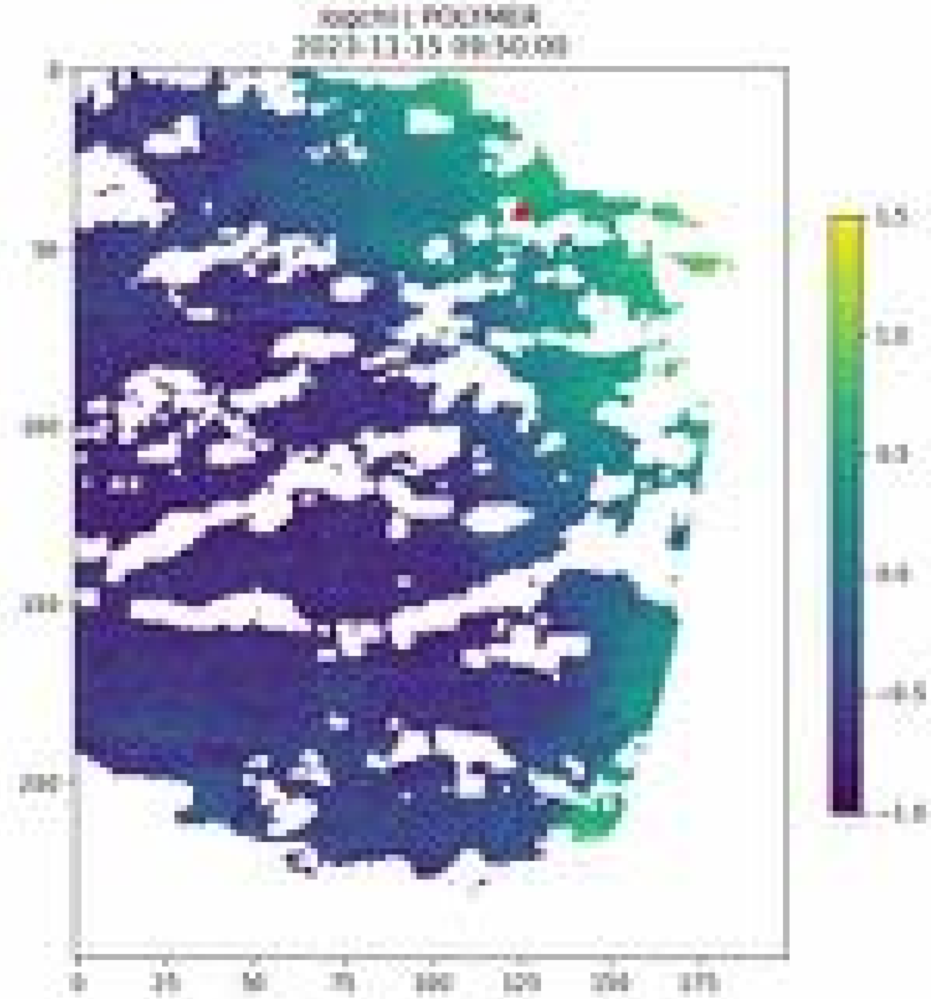
MTG/FCI NTU &SPM

Future: Geostationary OCR

proofs of concept with MTG/FCI

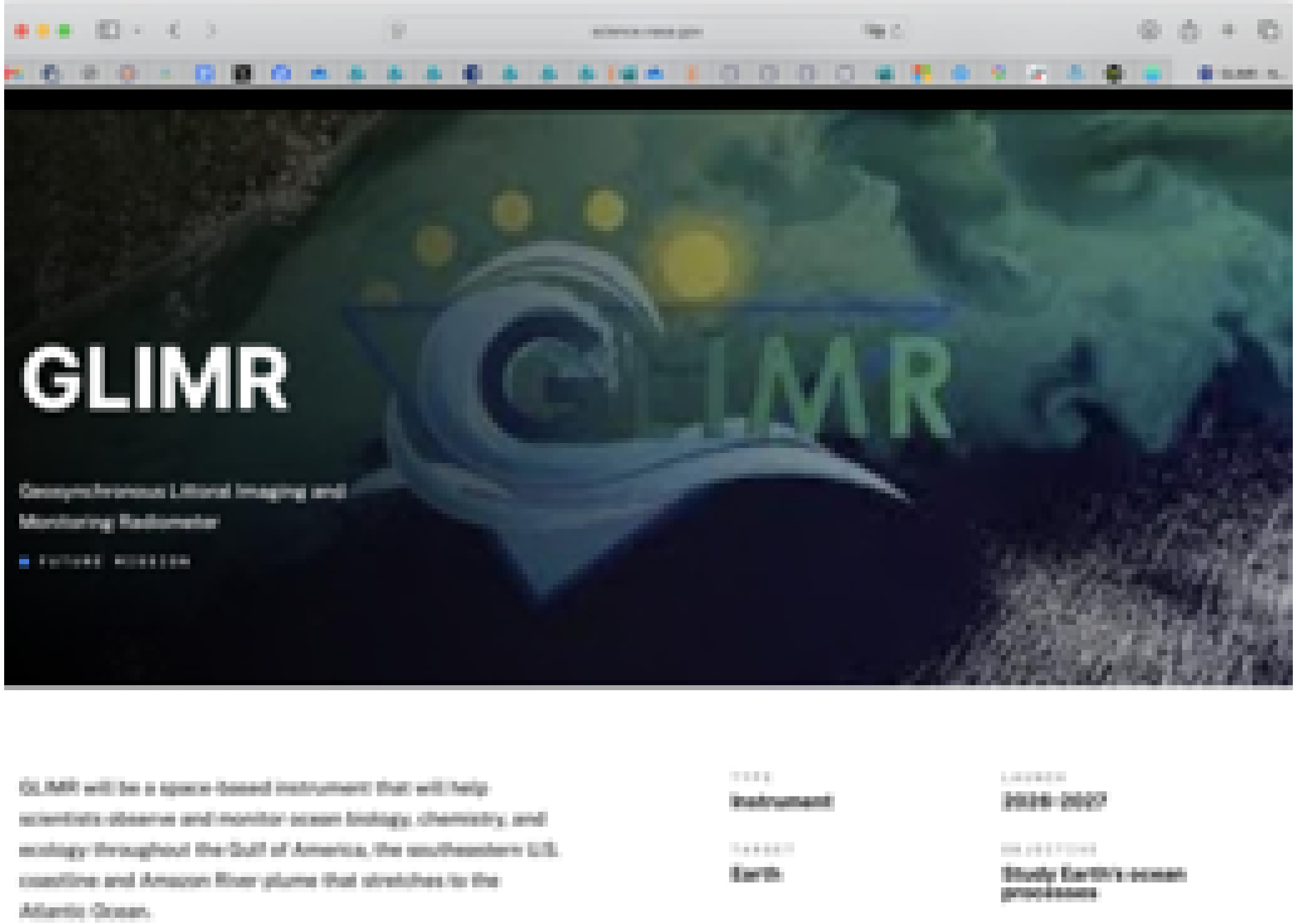
Sensor	Spectral bands							
MSG/SEVIRI Spectral interval (µm) SNR @ specified albedo			635 0.56-0.71 10.1@1%	HRV 0.4-0.9 4.3@0% 810 0.74-0.88 7.28@1%			1640 1.50-1.78 3@1%	
MTG/FCI Bandwidth (nm) SNR @ specified albedo	444 60 25@1%	510 40 25@1%	640 50 30@1%	865 50 21@1%	914 20 12@1%	1380 30 40@1%	1610 50 30@1%	2250 50 25@1%
Himawari/AHI Bandwidth (nm) SNR @ specified albedo	455 50 300@100%	510 20 300@100%	645 30 300@100%	860 20 300@100%			1610 20 300@100%	2260 20 300@100%
GOES/ABI Bandwidth (nm) SNR @ specified albedo	470 40 300@100%		640 100 300@100%	850 40 300@100%		1380 30 300@100%	1610 60 300@100%	2260 50 300@100%

https://www.eumetsat.int/OC-GEO



MTG/FCI CHL

Future: Geostationary OCR



https://science.nasa.gov/mission/glimr/

The Geostationary Littoral Imaging and Monitoring Radiometer (GLIMR) instrument is a hyperspectral ocean color sensor launching after 2026 that targets the Gulf of Mexico and other coastal and ocean waters of North and South America.

With its vantage point from geostationary orbit, GLIMR will be the first hyperspectral ocean color sensor in the Western Hemisphere to study ocean processes at the diurnal timescales required to observe the dynamic ecological, biogeochemical and physical processes typical of coastal and ocean waters.

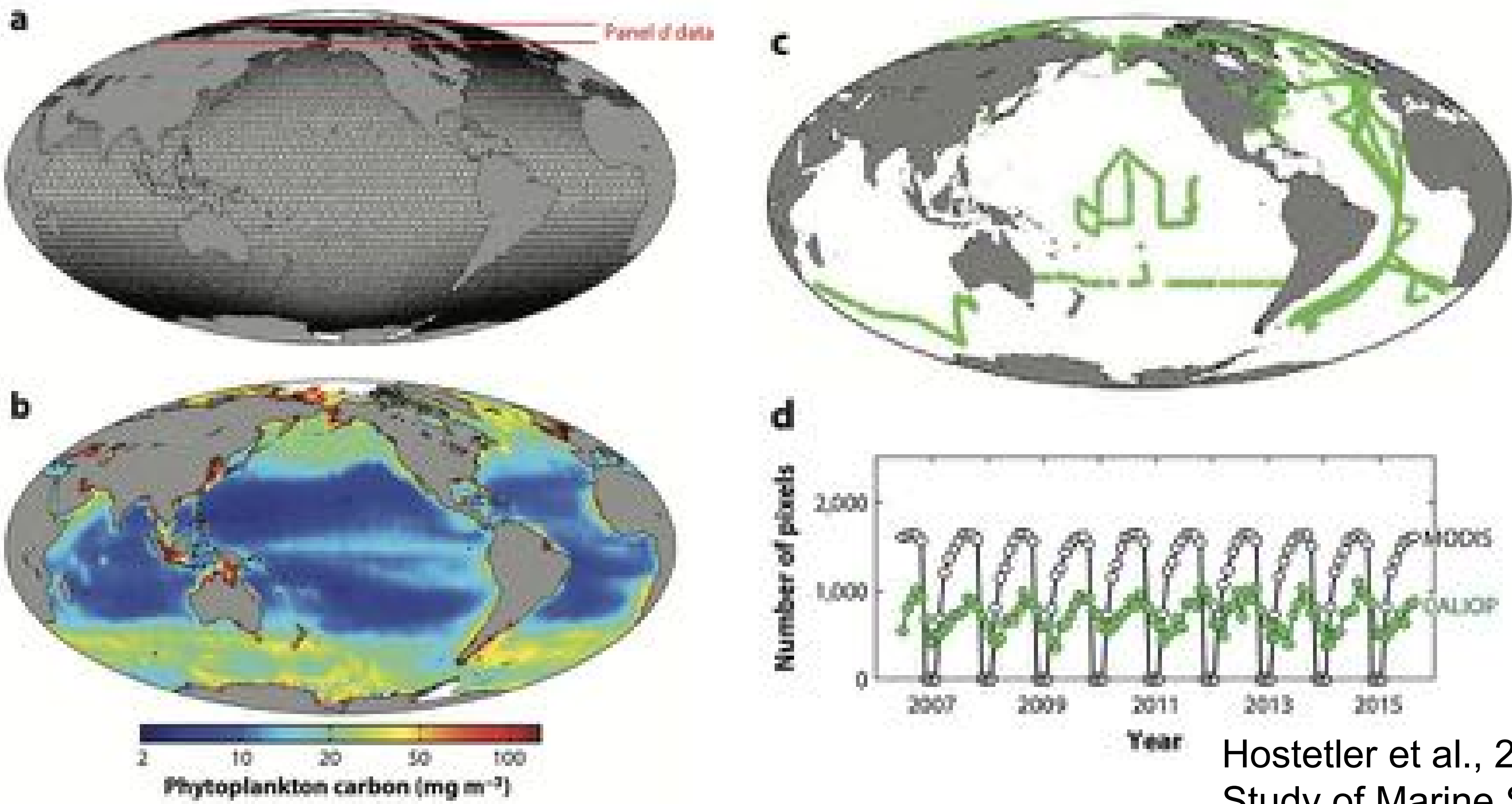
Future: Satellite-borne ocean LIDARs

- Passive ocean colour allows accessing a signal whose 90% comes from depths < ~1/Kd (Gordon and McLuney, 1975, Applied Opitcs 14(2)).
- In the clearest waters, this is about 20 m in the blue; otherwise, just a few meters
- The vertical structure in the upper layers is important and not necessarily uniform
- Hence the idea that LIDARs could help, because they are precisely designed to resolve vertical structures
- Satellite LIDARs have been essentially used for atmospheric purposes, however ocean LIDARs have been deployed from ships or aircrafts as proofs of concept.

- The Cloud-Aerosol LIDAR with Orthogonal Polarization (CALIOP) on CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) was used as a proof of concept for satellte-borne ocean LIDARs:
  - two-wavelength (532 and 1064 nm) elastic backscattered signals with polarization channel
  - Measurements are taken 3° off-nadir

Hostetler et al., 2018, Spaceborne Lidar in the Study of Marine Systems, Annual Review of Marine Science, 10:121–47. https://doi.org/10.1146/annurev-marine-121916-063335

Future: Satellite-borne ocean LIDARs



Convergence of CALIOP ground tracks yields the most dense spatial sampling at high latitudes (Figure 5a), providing 1◦ binned spatial coverage comparable to that of MODIS in both the north and south polar regions during late-spring to early autumn months and better coverage from the late-autumn to early-spring period (Figure 5d).

Hostetler et al., 2018, Spaceborne Lidar in the Study of Marine Systems, Annual Review of Marine Science, 10:121–47.
https://doi.org/10.1146/annurev-marine-121916-063335

Future: Satellite-borne ocean LIDARs

Terms of Reference

- To showcase the use of Lidar, an active remote sensing technique, for studying the ocean
- To explain and to train the ocean color community on the basics of lidar instrumentation and data processing
- To provide sample data and codes for visualizing and processing lidar data
- To provide examples of applications of lidar for oceanic studies
- To discuss the advantages and limitations of lidar to monitor the upper ocean layer
- To provide recommendations and actions for increasing the use of lidar in the ocean color community in term of training, instrumentation, algorithms and good practice
- To prepare a report on lidar for ocean applications for the IOCCG Report Series

More details in the lectures by Davide Dionisi next week

IOCCG Summer Lecture Series 2026

Frontiers in Ocean Optics and Ocean Colour Science

Past, present and future of satellite OCR

Vittorio E. Brando

CNR-ISMAR, Rome, Italy

with material by D. Antoine, B. Loveday, J. Concha, C. Giardino

Venice, Italy - 9 July 2026