

WATER QUALITY from Space

BROCKMANN CONSULT



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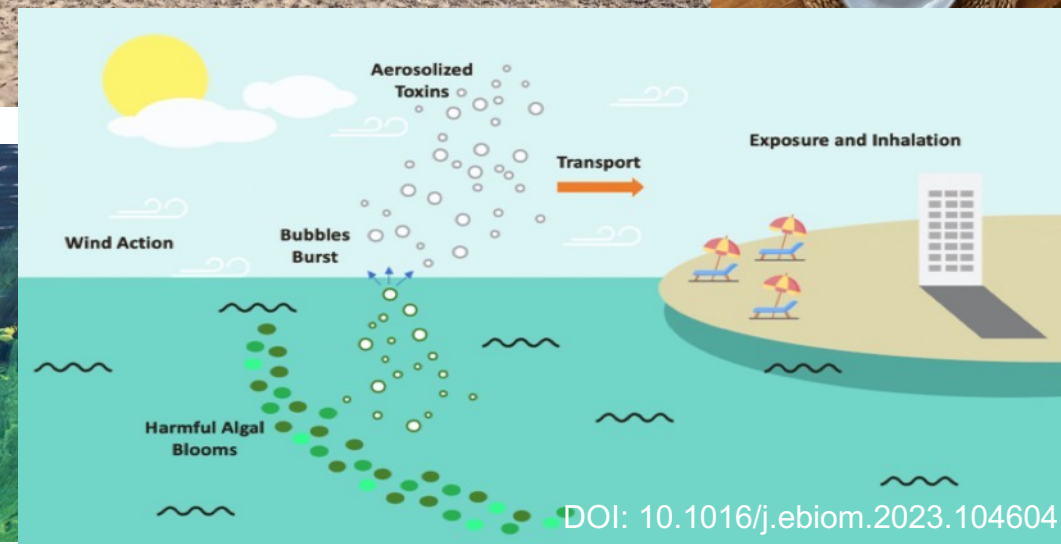
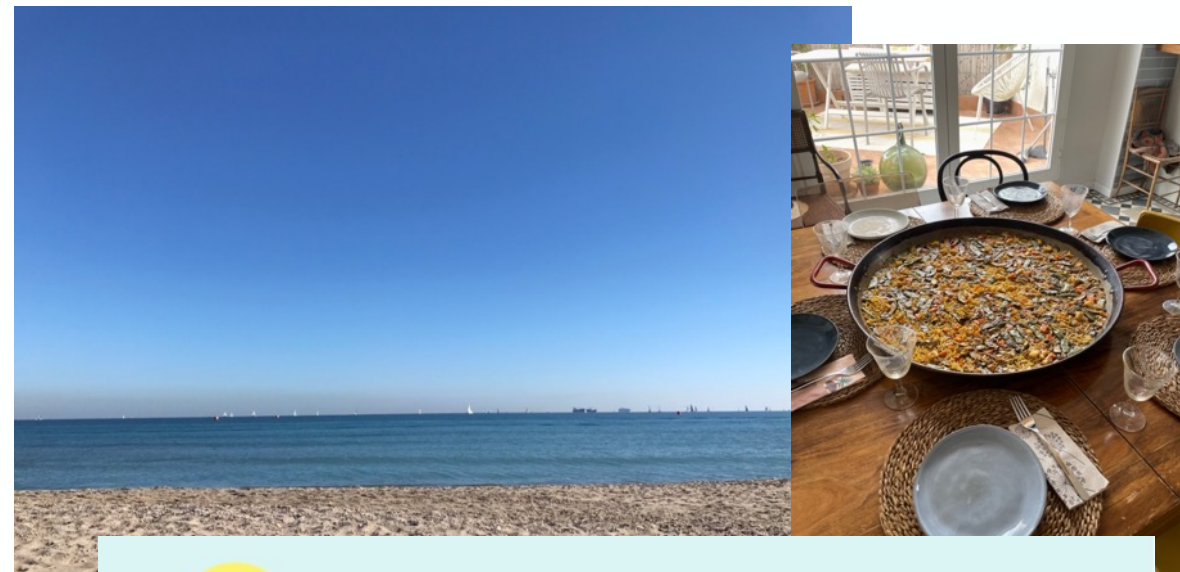
Water quality and human health

Why do we need good water quality:

- Health benefits of the environment
- High quality food

What happens when we do not have good water quality:

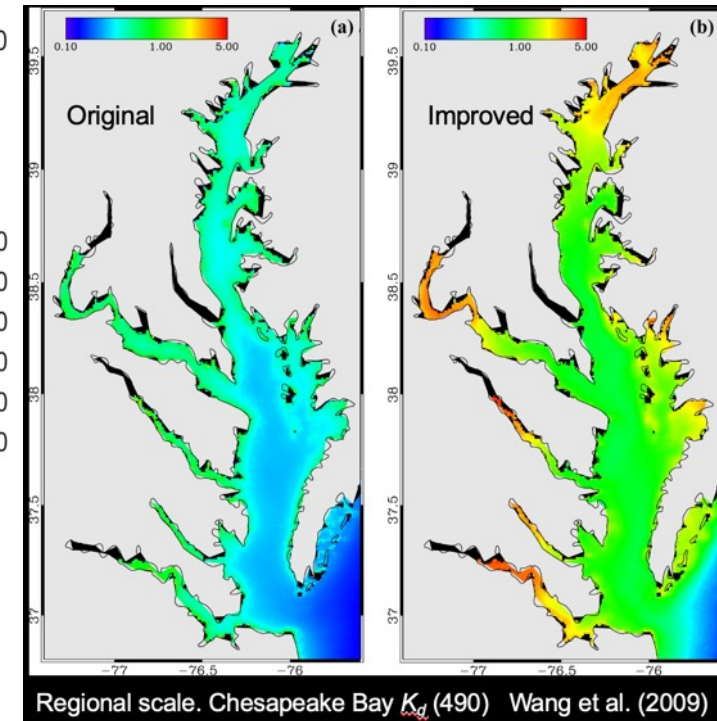
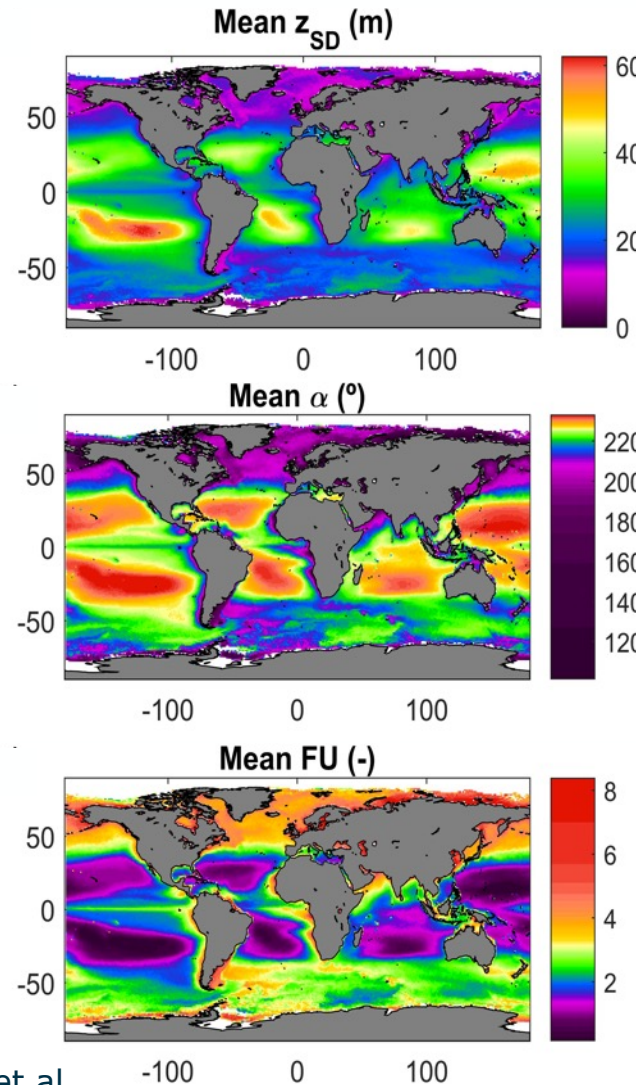
- Harmful algal blooms
- Infectious diseases



Water quality indicators from space



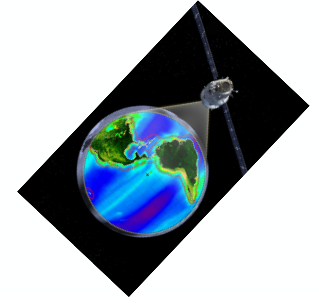
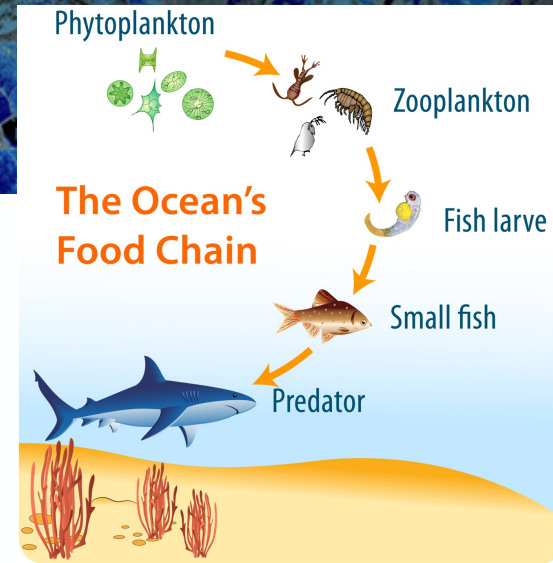
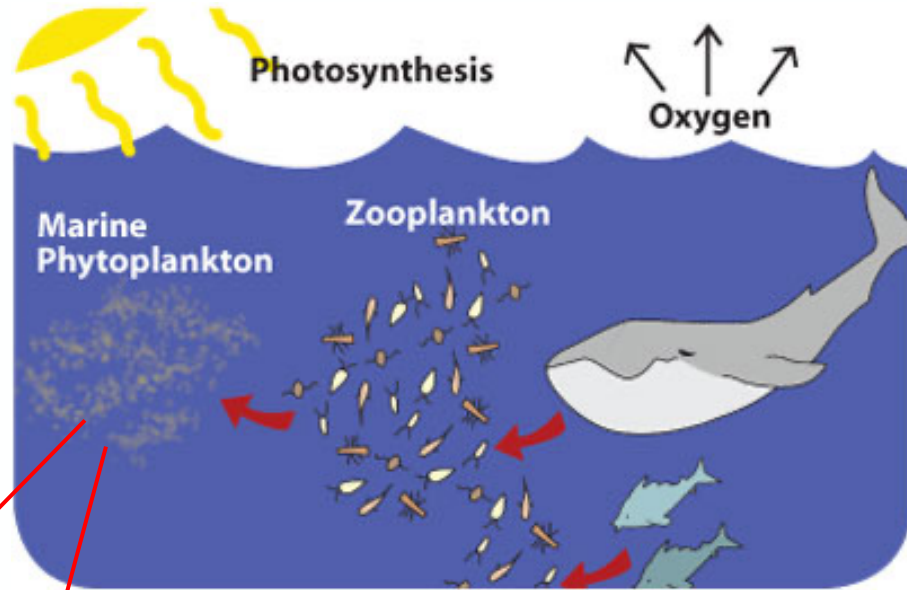
Indicators of water quality	Some References
Diffuse attenuation coefficient (K_d)	Lee et al. (2005), Wang et al. (2009)
Turbidity	Nechad et al. (2009), Son and Wang (2019), Dogliotti et al. (2015)
Water colour (Forel-Ule scale)	Woerd et al. (2015); Pitarch et al. (2021)
Water clarity (Secchi Depth)	Pitarch et al. (2021), Son and Wang (2020)
Suspended sediment load	Volpe et al. (2011), Son and Wang (2012)
Euphotic zone	Lee et al. (2007)



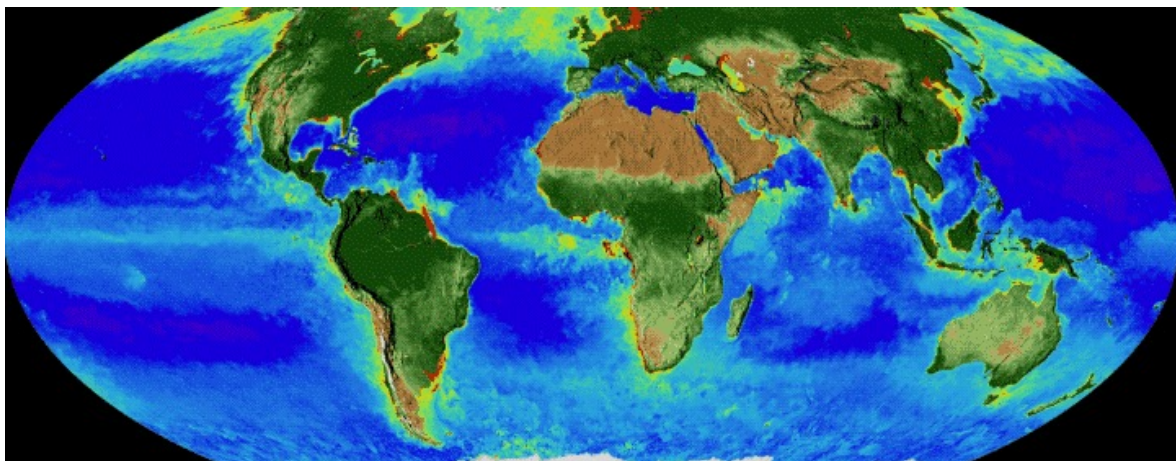
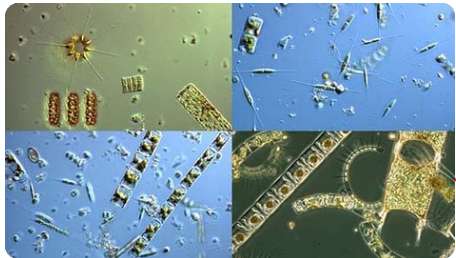
Global Scale. Pitarch et al. (2021)



Why phytoplankton?



- live in every aquatic environment
- integral part of the earth's ecosystem
- base of the marine food chain
 - Fish, Marine mammals
- global biogeochemical cycling & climate processes
 - Oxygen (~50% of earth's O₂)
 - Affects the Climate (CO₂, DMS)



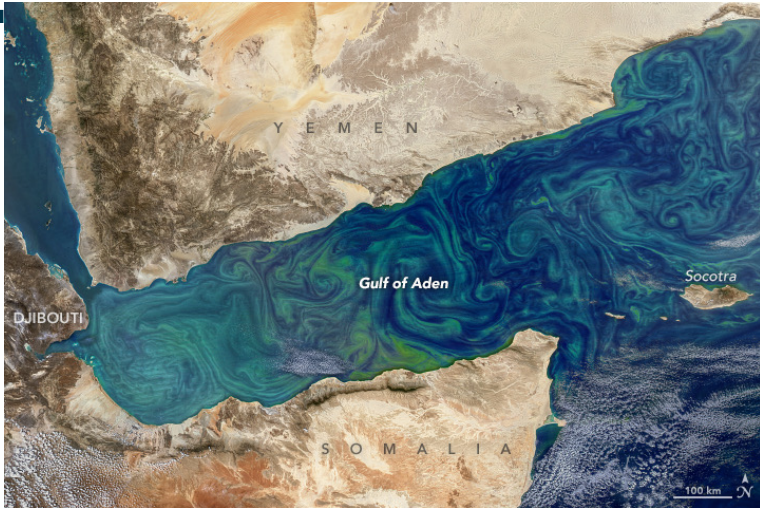
Quantifiable metrics that characterise ecosystem structure, composition or function

May serve as early-warning signals of ecological disturbances and gauges of long-term trends

Typically based on the presence of **phytoplankton**

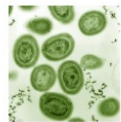


<https://www.uts.edu.au/research-and-teaching/our-research/climate-change-cluster/events/c3-colloquium-fu>



<https://earthobservatory.nasa.gov/images/91937/bloom-in-the-gulf-of-aden>

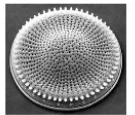
- Phytoplankton Biomass
- Primary production
- Phytoplankton Size/Community structure
- Phenology (timing of phytoplankton growth)



Pico
0.2 – 2 μm

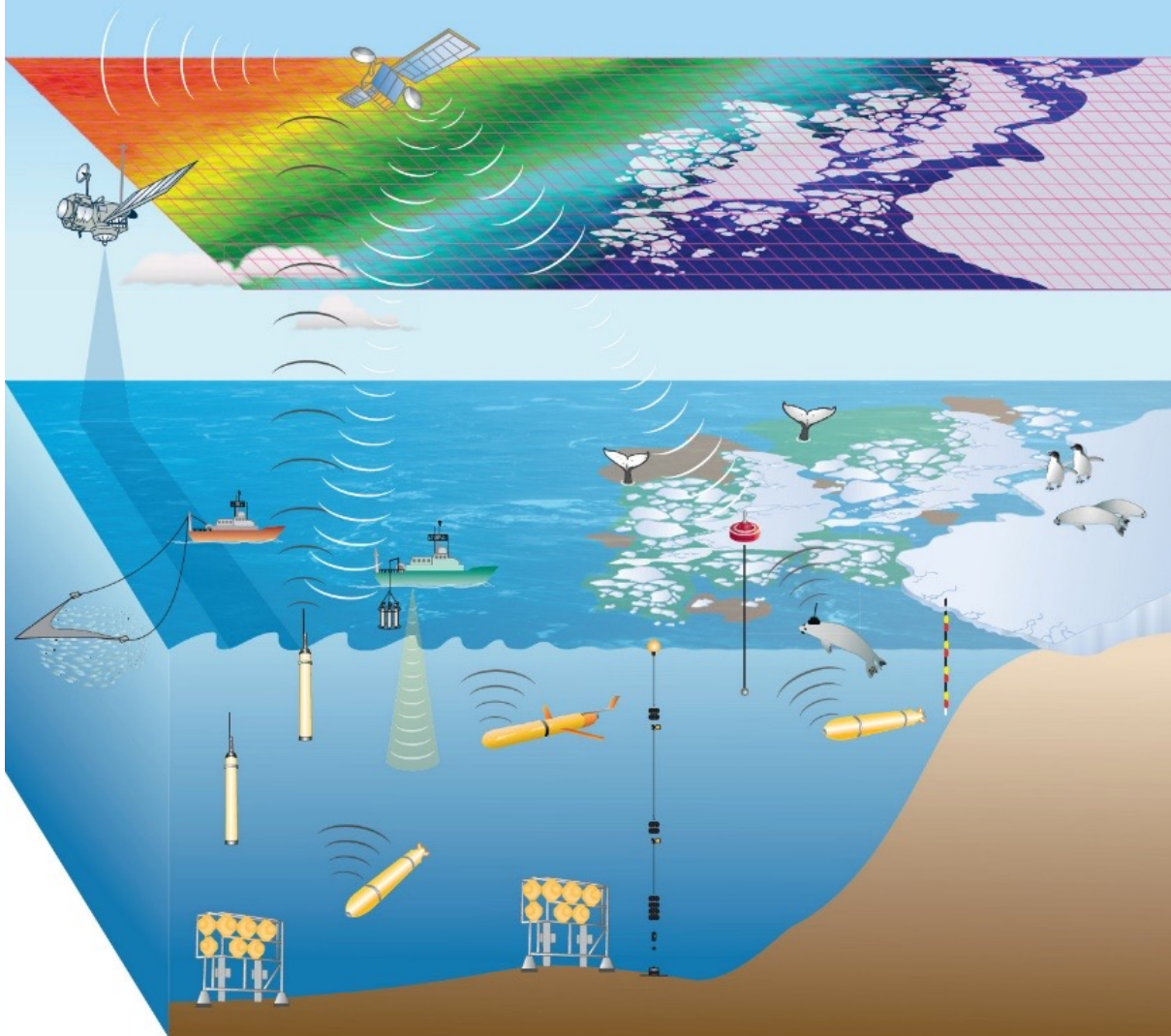


Nano
2 – 20 μm



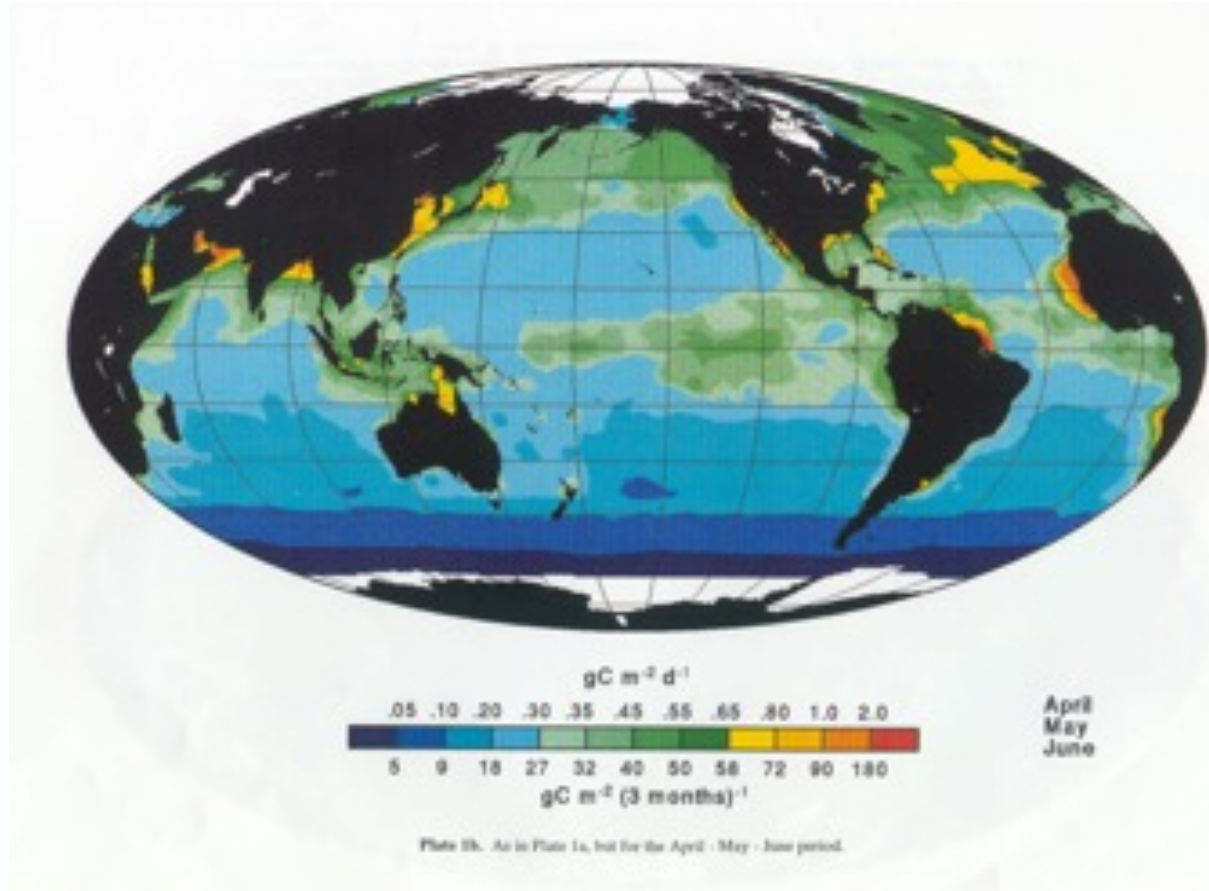
Micro
20 – 200 μm

How to measure phytoplankton



Long-term and large-scale biological dynamics in many marine ecosystems remain poorly understood, due to limited in-water measurements

Primary production of the global ocean



(Antoine et al. 1996)

ANTOINE ET AL.: OCEANIC PRIMARY PRODUCTION

65

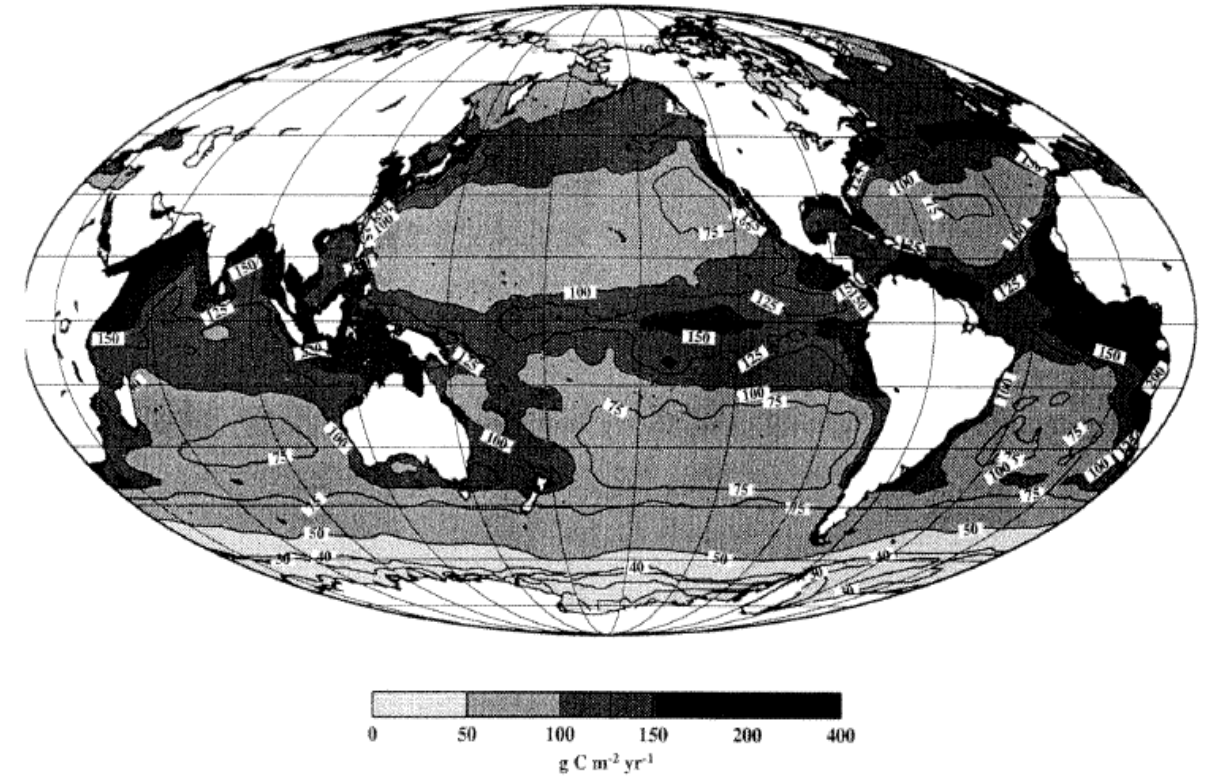
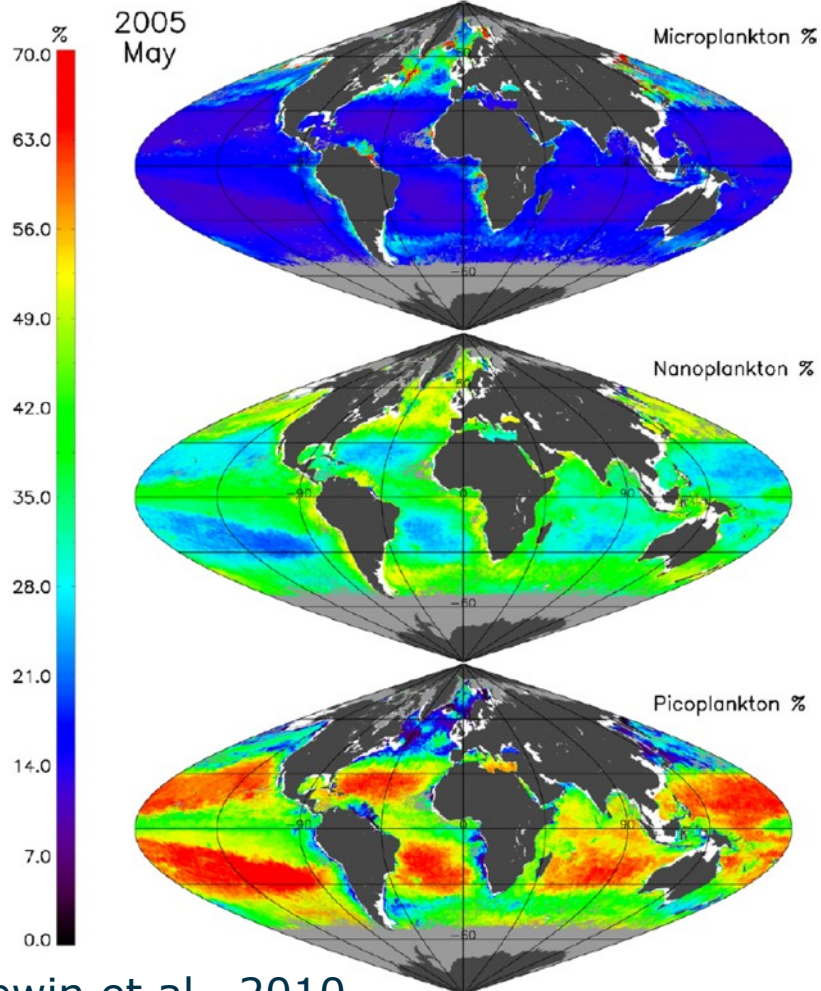


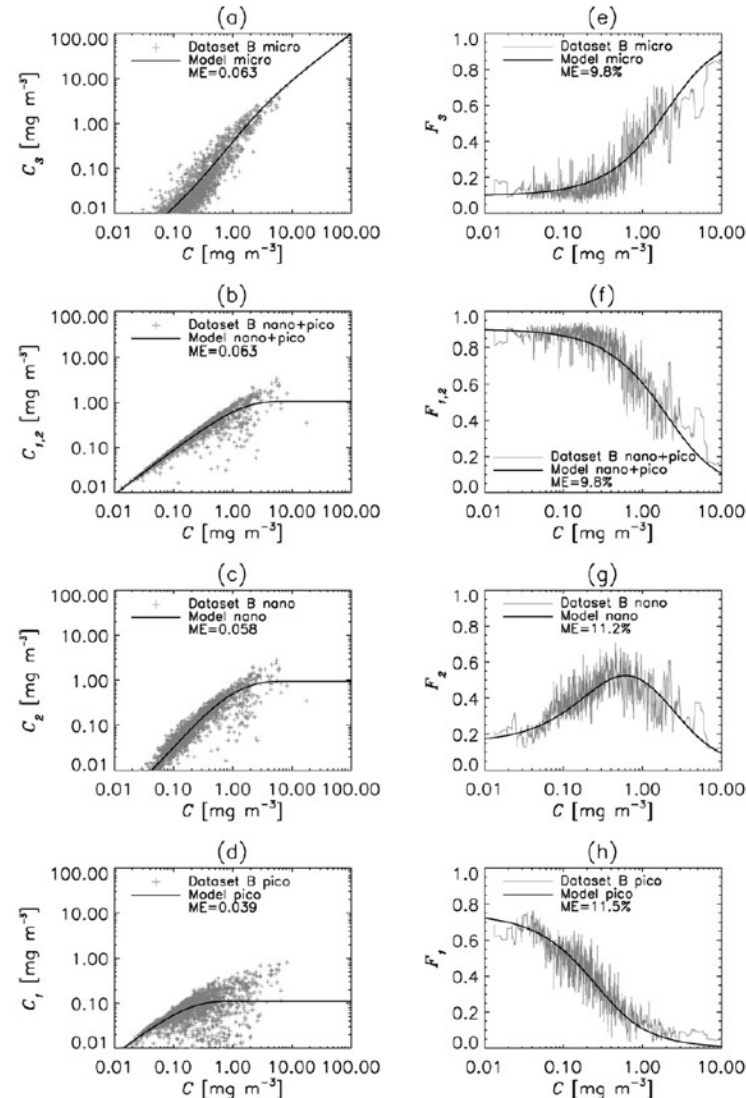
Figure 3. Annual primary production within the world ocean (equal surface “Mollweide” projection), obtained by summing the 12 monthly maps. This map shows the values obtained through the “standard” computation, which leads to a global annual carbon fixation of 36.5 Gt C yr⁻¹ (Table 1, line 1). This map can be compared to the historical primary production maps, as derived from compilations of in situ carbon fixation [e.g., *Koblentz-Mishke et al.*, 1970; *Berger et al.*, 1987].

Phytoplankton communities

R.J.W. Brewin et al. / Ecological Modelling 221 (2010) 1472–1483



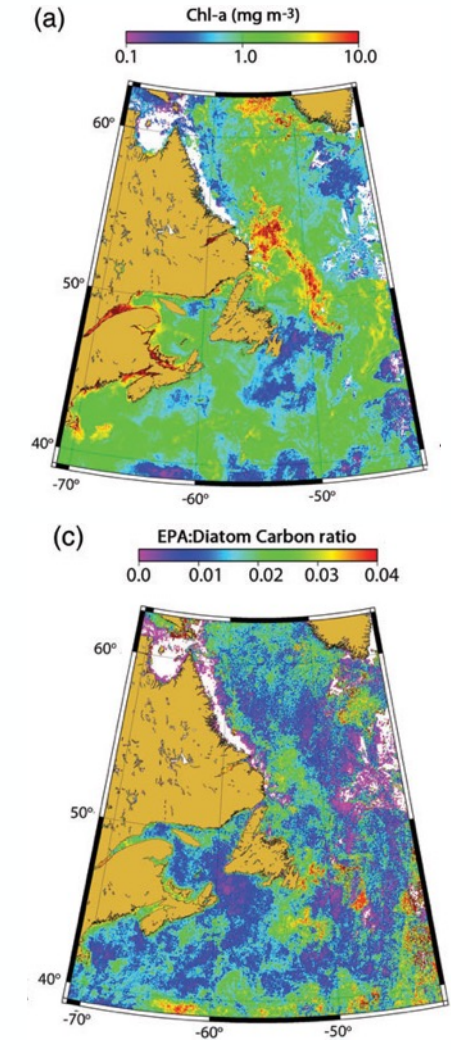
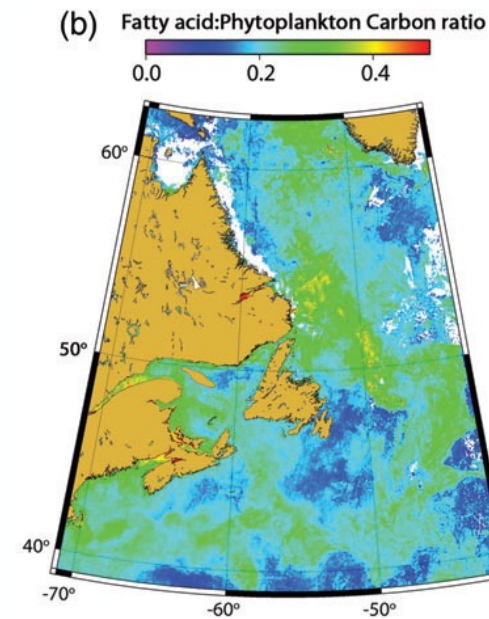
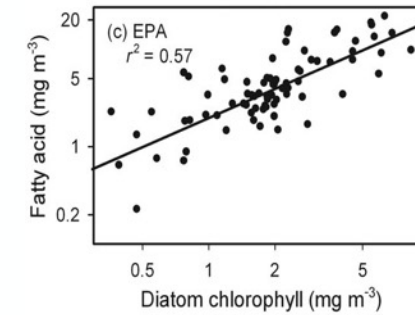
Brewin et al., 2010



- Phytoplankton: basis of trophic chain
- Shifts in community will have effects on trophic chain
- Increase in SST will increase stratification and reduce mixing at the surface (less nutrients)
- The meridional overturning circulation slows and shallows, which means less macronutrients from depth (reduction of chl).
- Sea ice retreats, which increase productivity in polar regions
- Other high latitudes will see productivity decreasing (less nutrients), but higher growth rates (+ and - responses)

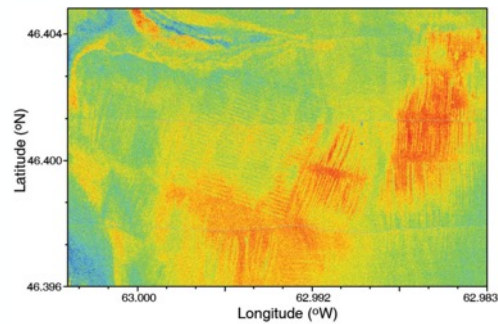
Phytoplankton are a source of Essential Fatty Acids

- Essential for health and survival of vertebrates.
- Different classes of phytoplankton produce FAs with differing structures
- For example, 16:4n-1 is synthesized almost exclusively by diatoms
- Diatoms also produce EPA (Eicosapentaenoic Acid), an essential omega-3 FA
- Climate-induced fish community transitions could be linked to availability of essential FAs in the ocean (Litzow et al., 2006).

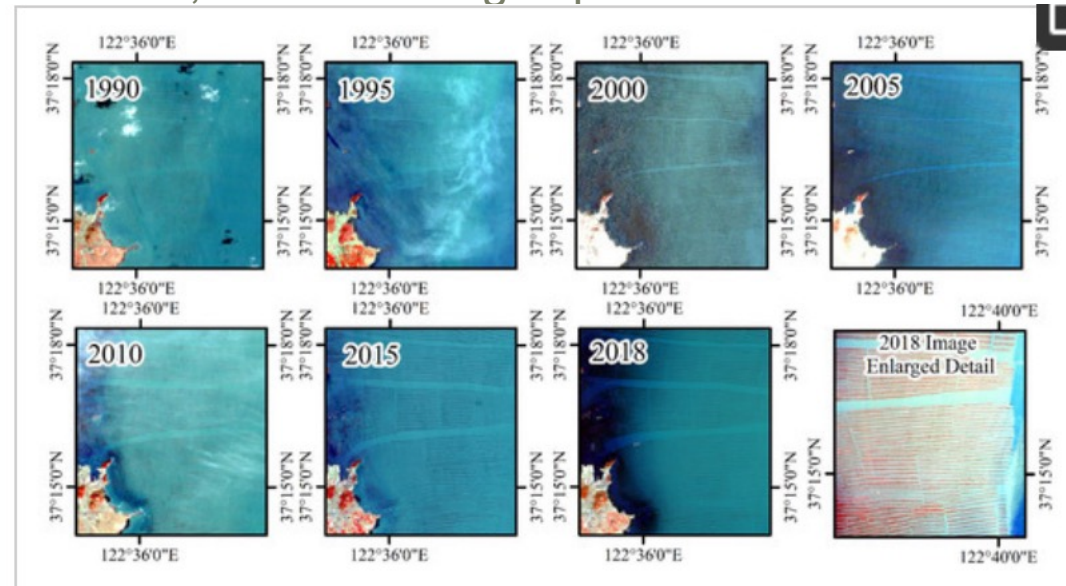


Fisheries and aquaculture industries

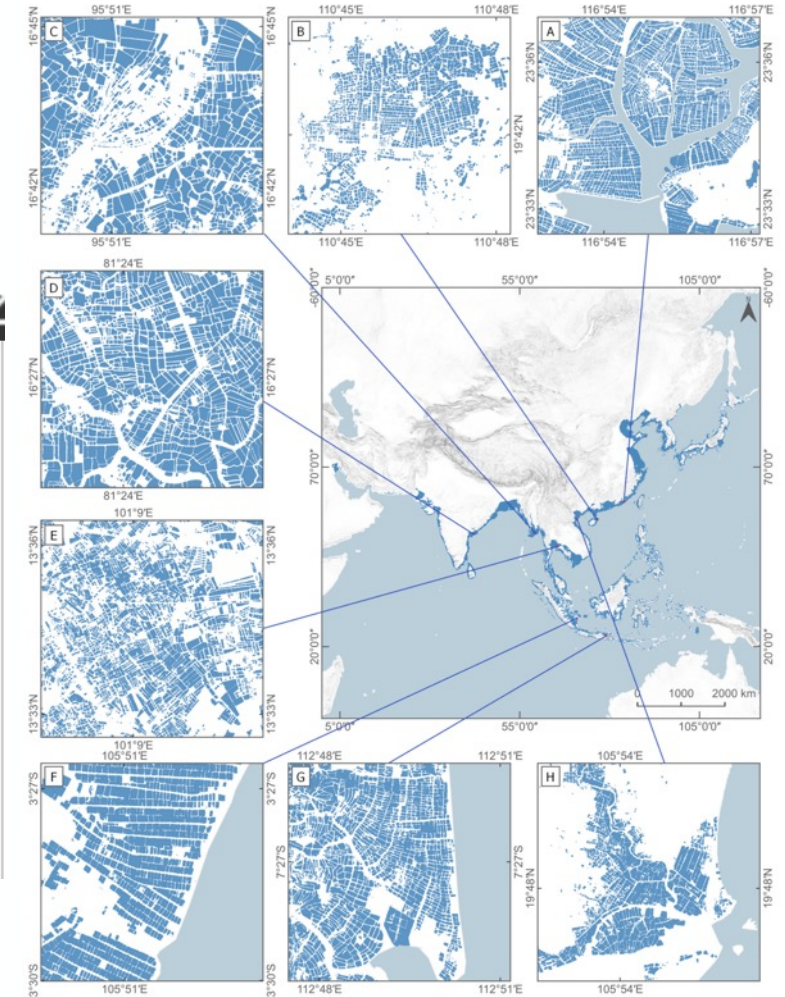
- Harmful algal bloom detection and warning
- Hypoxic events
- Carrying capacity of habitat for shellfish culture
- Water quality (for site selection, for monitoring impact)



Local depletion of chlorophyll by cultured mussels
Mussel Rafts in Tracadie Bay, Prince Edward Island



Zoomed Landsat satellite images showing detail of marine aquaculture areas from 1990–2018 (data source: <https://glovis.usgs.gov/>, *Remote Sens.* 2022, 14(3), 732; <https://doi.org/10.3390/rs14030732>)



Remote Sens. 2022, 14(1), 153; <https://doi.org/10.3390/rs14010153>

S. Sathyendranath

Water quality in urban waters - Hamburg



← Alster →



← Harbour / Elbe River →



NRT Service for Water quality in urban waters - Hamburg



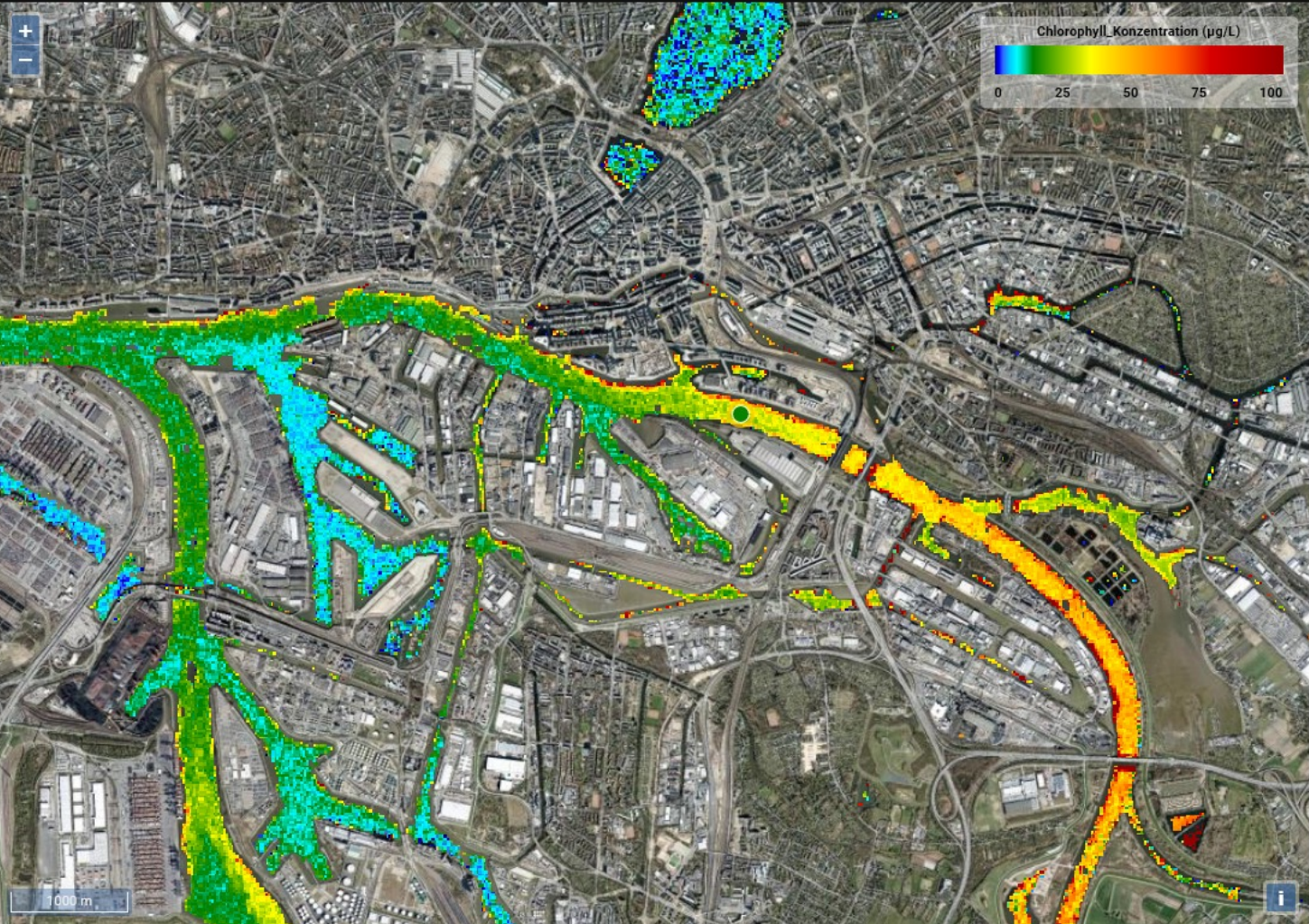
CyanoAlert



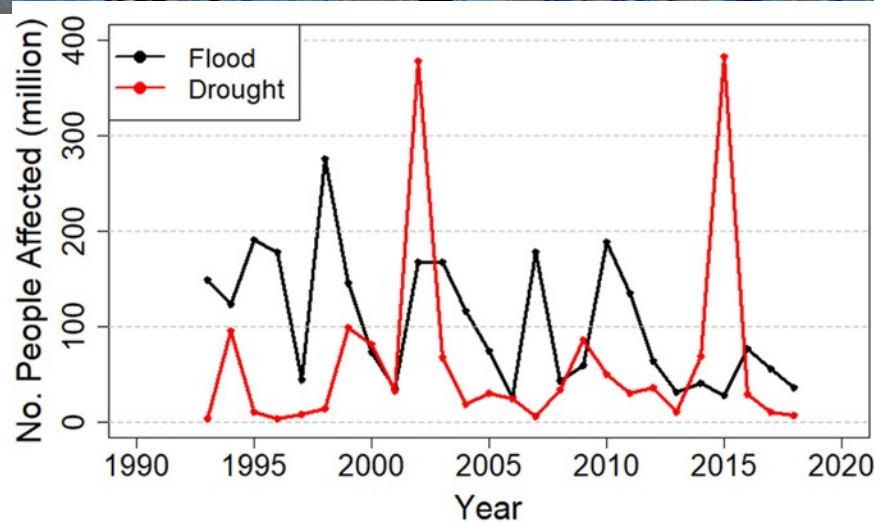
Datensatz Hamburg Variable Chlorophyll Konzentration RGB Meine Orte Punkt 5 Zeit (UTC) 2023-09-16 10:26:51

2017-10-29 2023-09-19

Chlorophyll Concentration



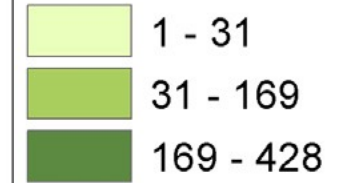
Water-Related Disasters 2001–2018



Europe

Occurrence: 655
 Total Deaths: 2,910
 The Affected: 9.3 million
 Total Damage (US\$):
 147.4 billion

Number of WRDs



North America

Occurrence: 938
 Total Deaths: 20,222
 The Affected: 168.7 million
 Total Damage (US\$):
 952 billion

United States (343)

South America

Occurrence: 384
 Total Deaths: 8,325
 The Affected: 64.9 million
 Total Damage (US\$):
 34.6 billion

Africa

Occurrence: 990
 Total Deaths: 38,880
 The Affected: 276.8 million
 Total Damage (US\$):
 12.6 billion

Oceania

Occurrence: 195
 Total Deaths: 739
 The Affected: 5 million
 Total Damage (US\$):
 35.2 billion

Asia

Occurrence: 2,206
 Total Deaths: 255,438
 The Affected: 2.9 billion
 Total Damage (US\$):
 557.5 billion

India (254)

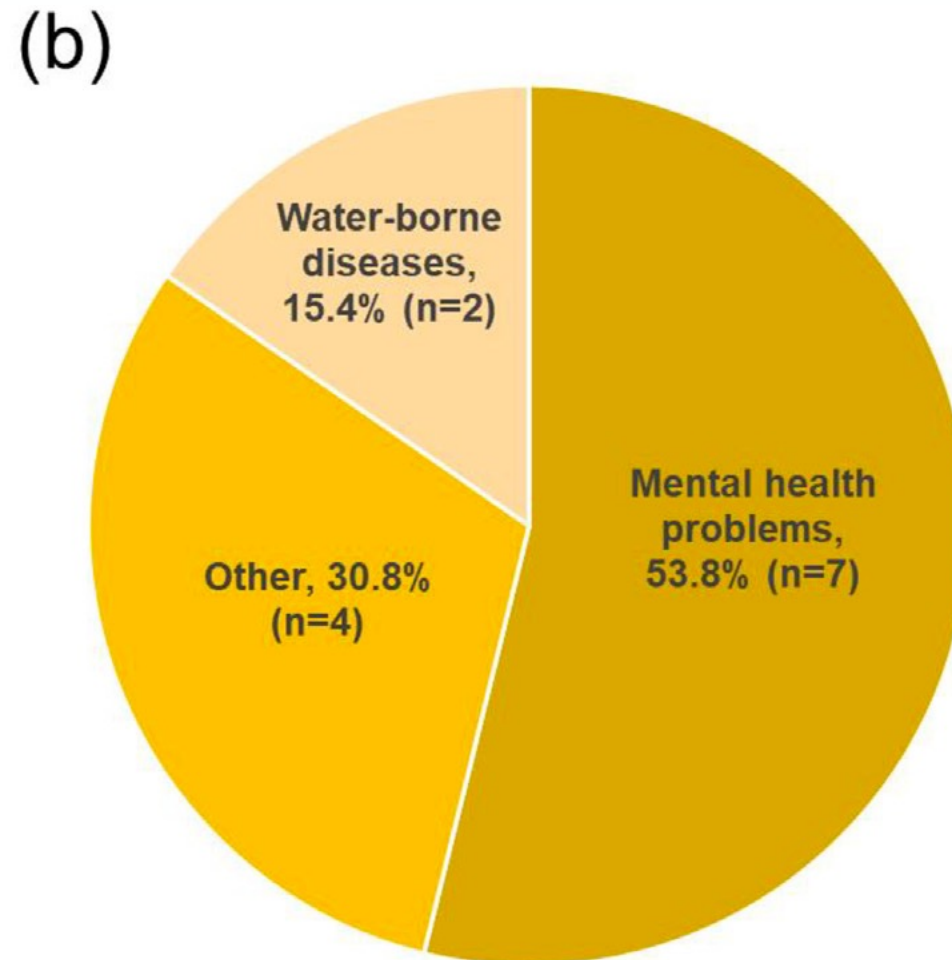
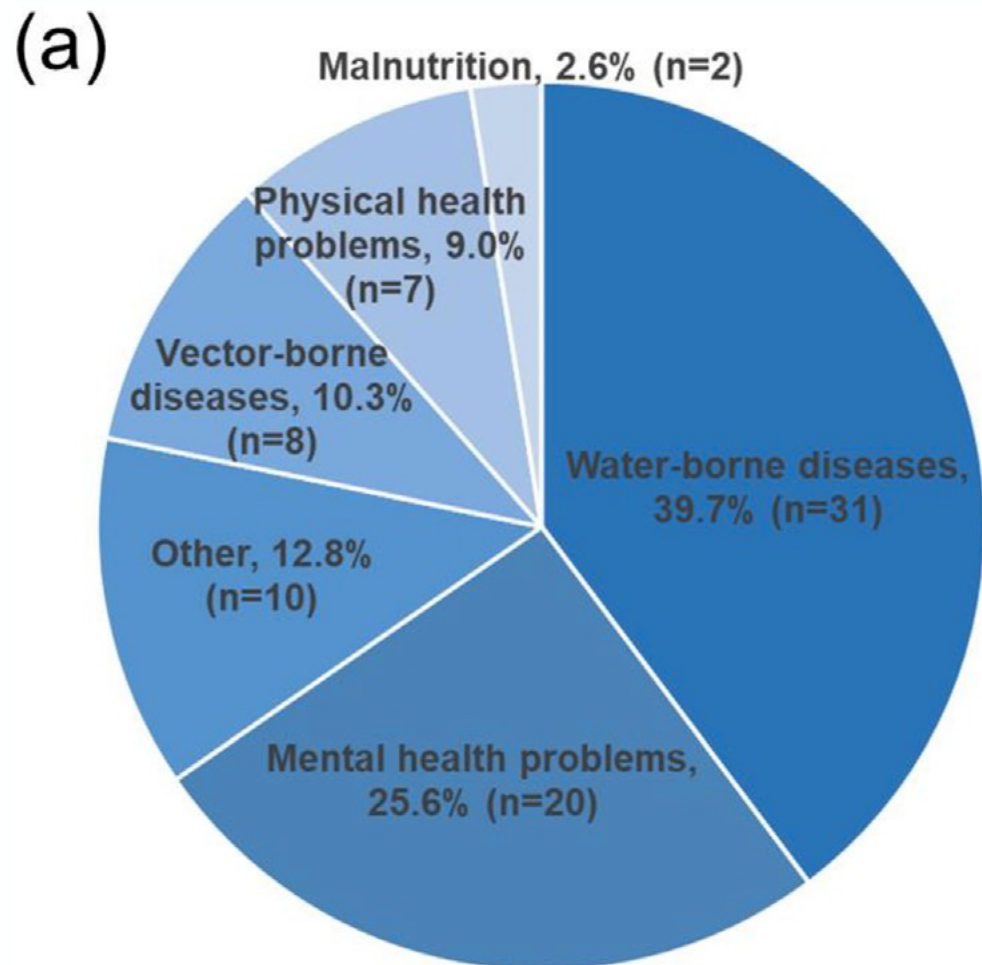
Philippines (255)

Indonesia (169)

China (428)



Health Impacts of Water-Related Disasters



Number of case studies for each health category following
 (a) floods
 (b) droughts

A case study: phytoplankton and cholera

One hypothesis: Indirect link *via* zooplankton

- Explains why there is often a lag of several weeks between chlorophyll blooms and cholera outbreaks (Huq et al. 2005)
- Chitin contained in the carapace of zooplankton serve as food to *V. cholerae*.
- Many lab experiments provide evidence that *V. cholerae* can grow successfully on copepods.

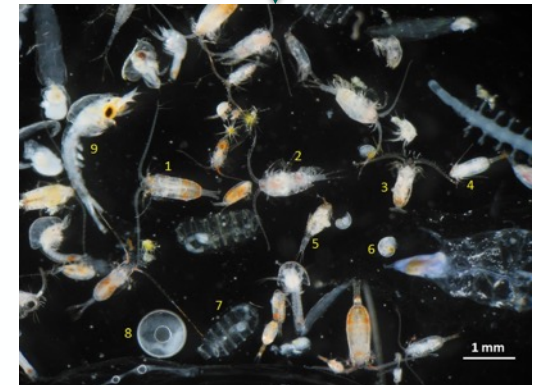


Images courtesy:
NASA
Wikipedia
Huq et al. 1984
Colwell and Huq

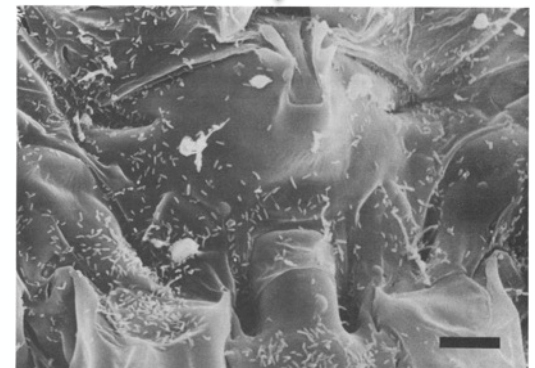
First step:
Phytoplankton
bloom



Second step:
Zooplankton follow
(delay 1-2 months)



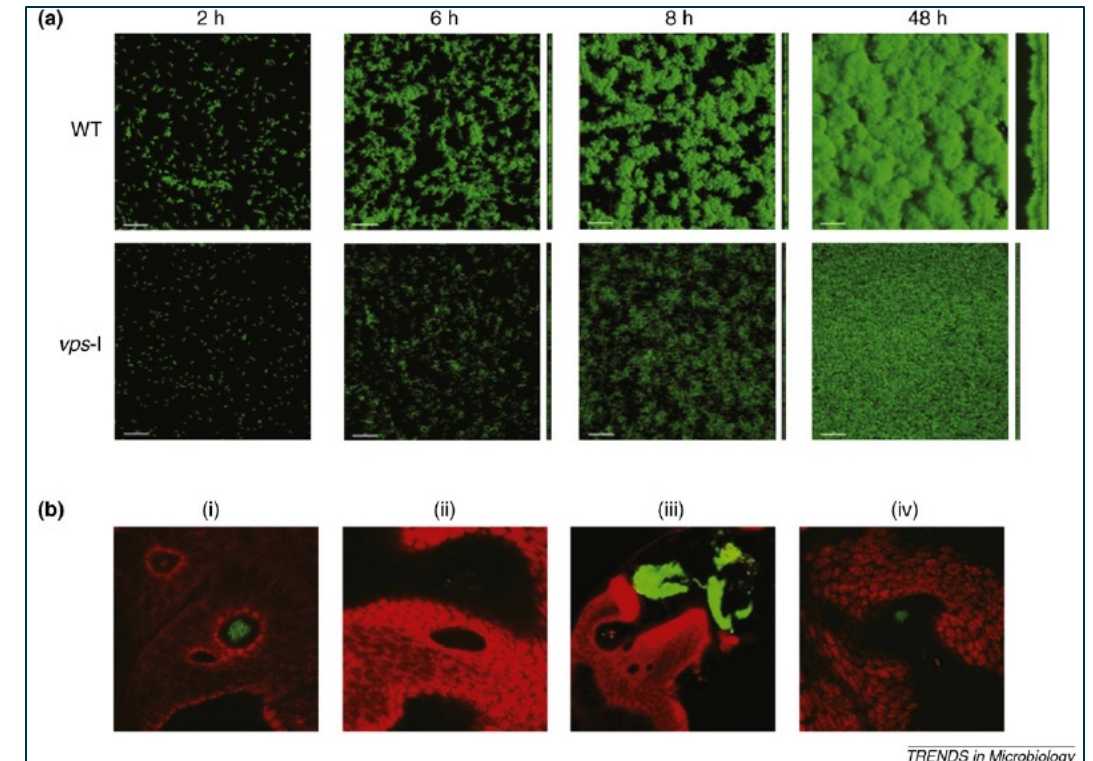
Vibrio cholerae
attach themselves
to zooplankton in
high densities



A case study: phytoplankton and cholera

Another hypothesis: Link *via* biofilms formed by *V. cholerae* around phytoplankton

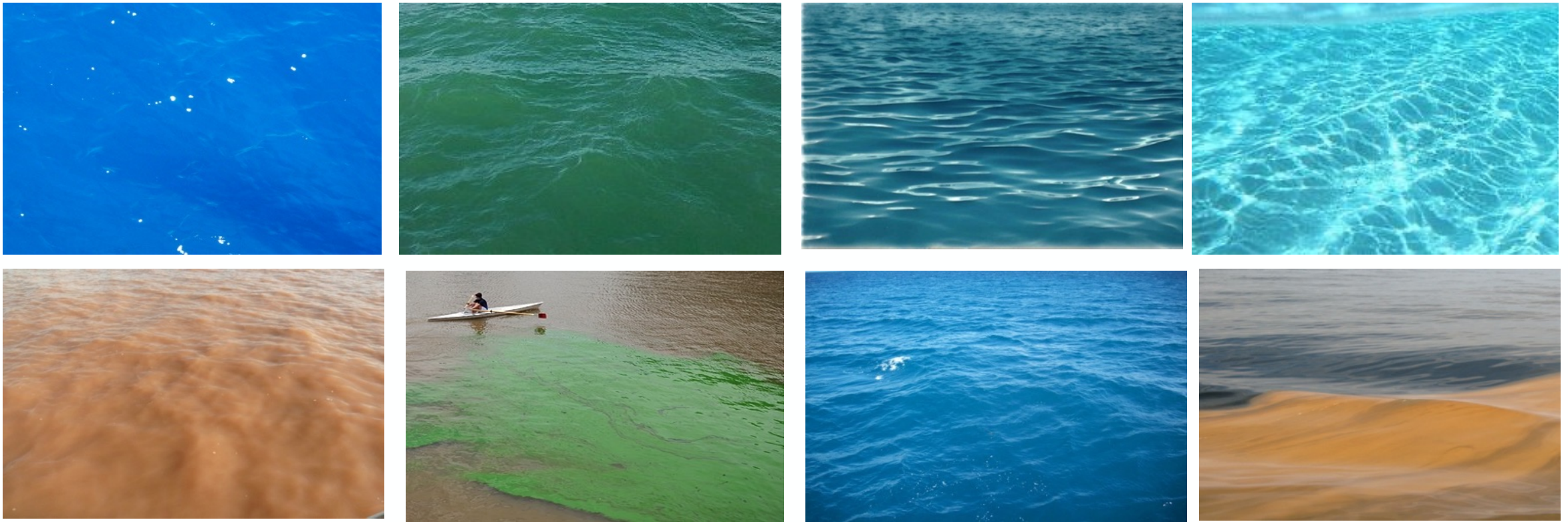
- *Vibrio cholerae* have the ability to form biofilms around many biotic and abiotic surfaces to access nutrients and avoid predators.
- Formation of biofilms (Yildiz and Visick 2009) or many other direct interactions could underpin strong association between *V. cholerae* and phytoplankton (Asplund *et al.* 2011, Anas *et al.* 2021).



Images courtesy:
NASA
Yildiz and Visick, 2009

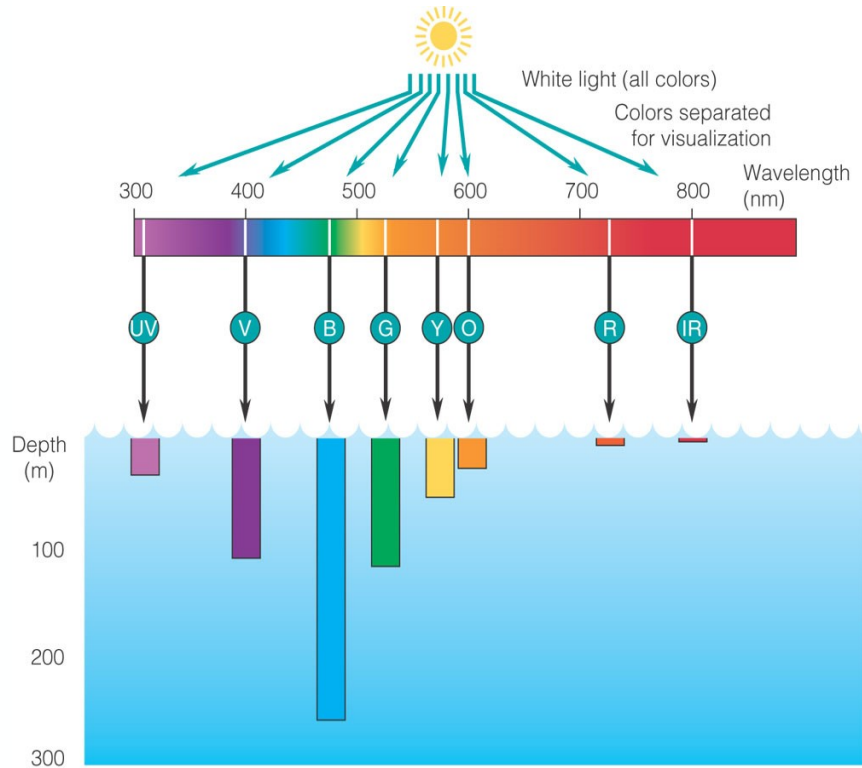
Ocean colour from space

What is the colour of the water?

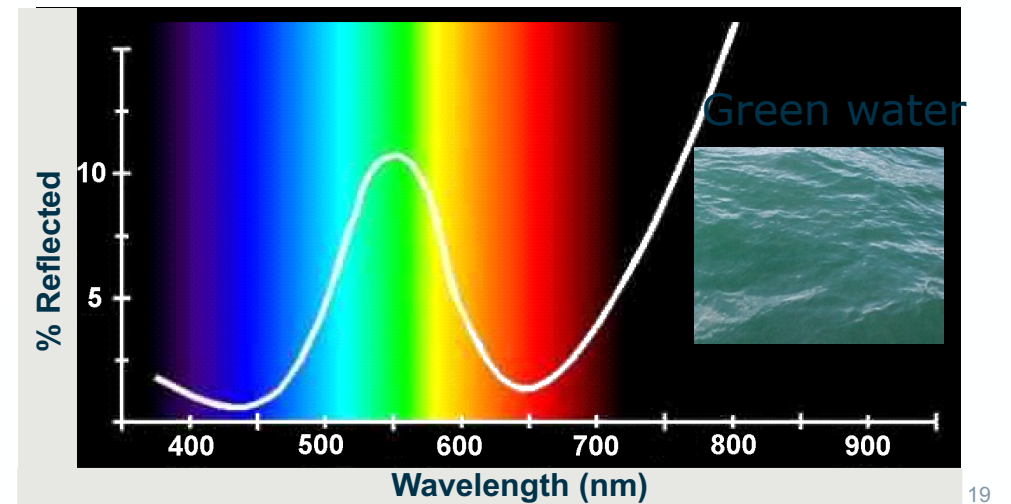
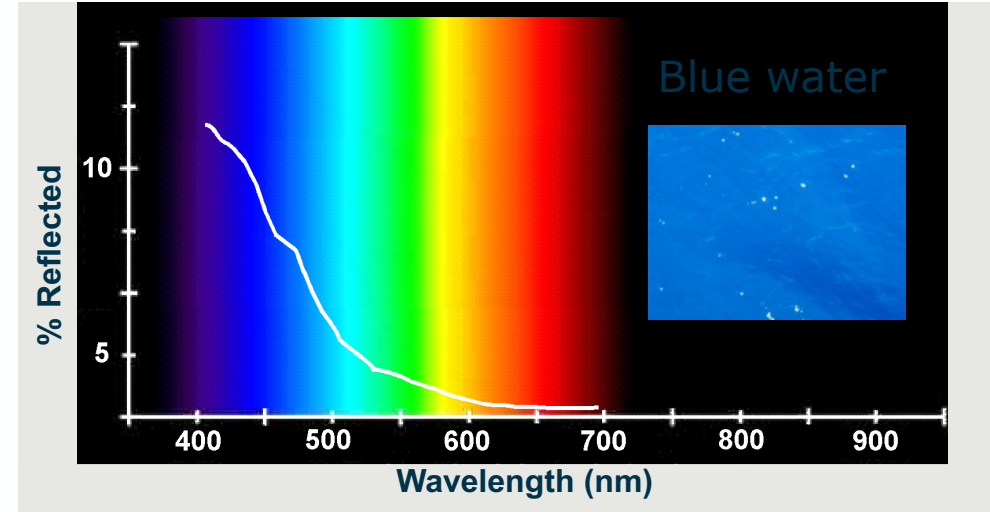


Ana Dogliotti

What is the colour of the water?

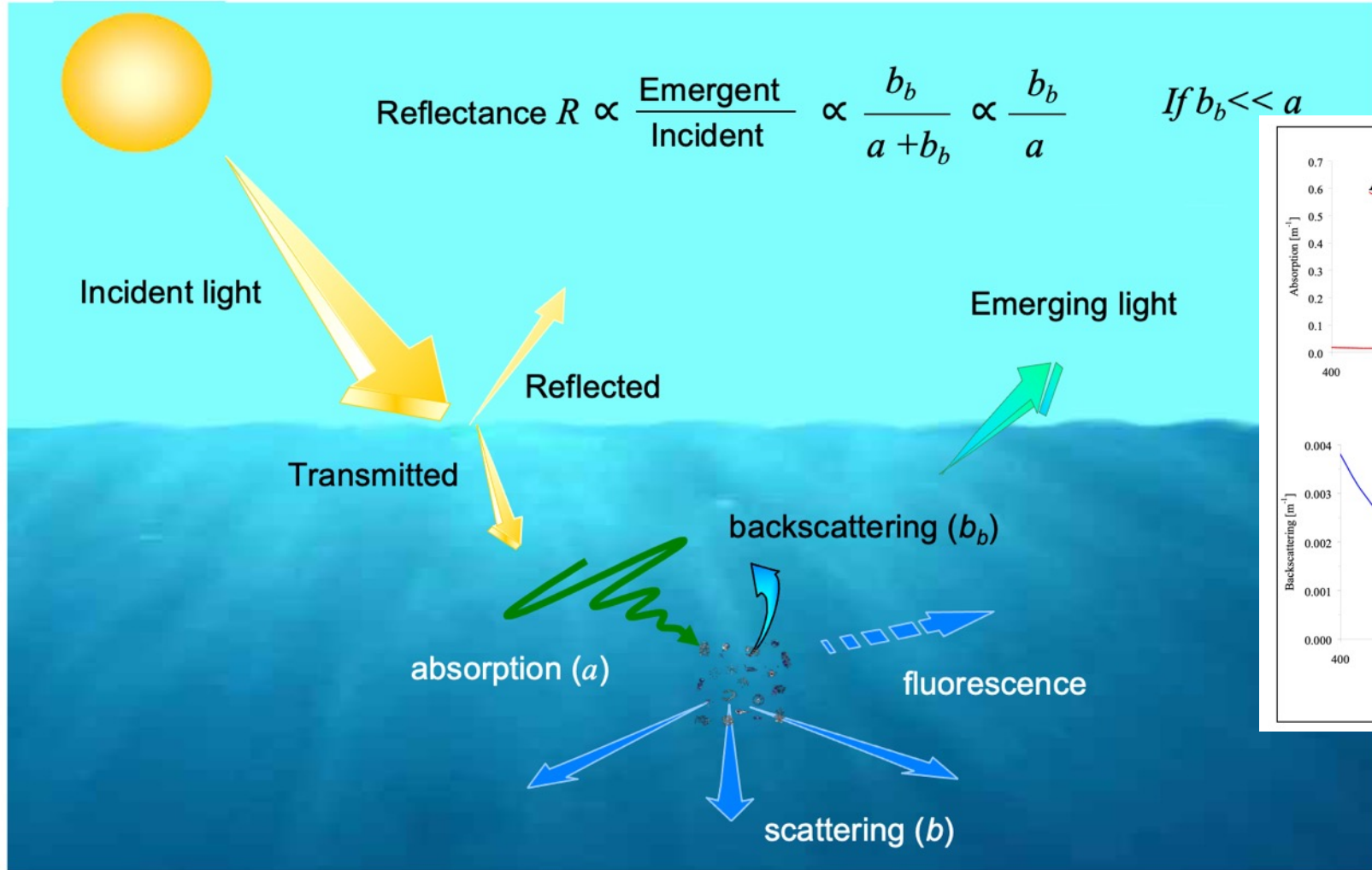


- When sunlight hits the ocean, some is reflected back, but most penetrates the surface and interacts with water molecules.
- Longer wavelengths of light (green → NIR) are absorbed
- The remaining light we see is composed of the shorter wavelengths (**blue**).

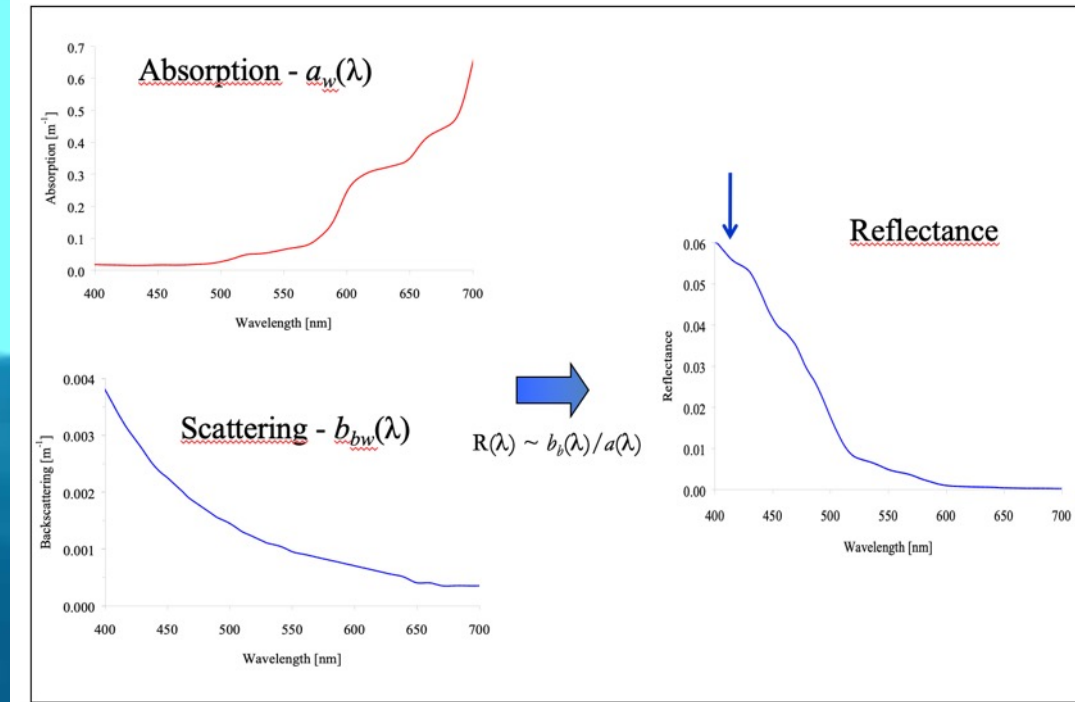


© 2005 Brooks/Cole - Thomson

What does the colour of water depend on?



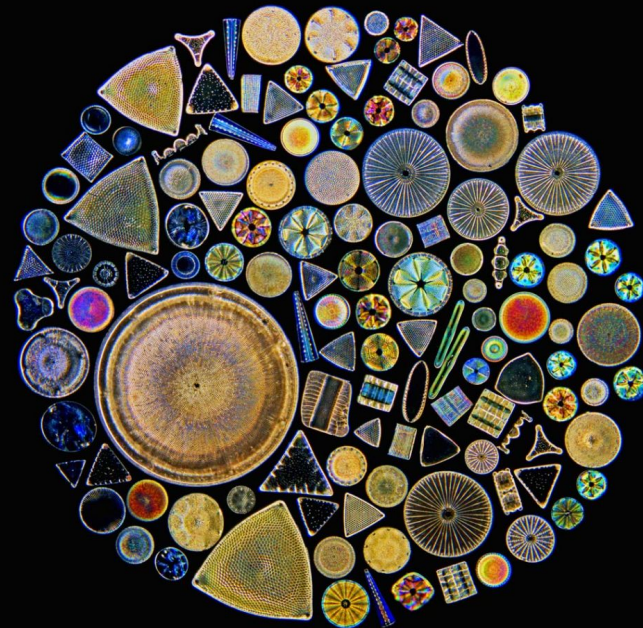
$$\text{Reflectance } R \propto \frac{\text{Emergent}}{\text{Incident}} \propto \frac{b_b}{a + b_b} \propto \frac{b_b}{a} \quad \text{If } b_b \ll a$$



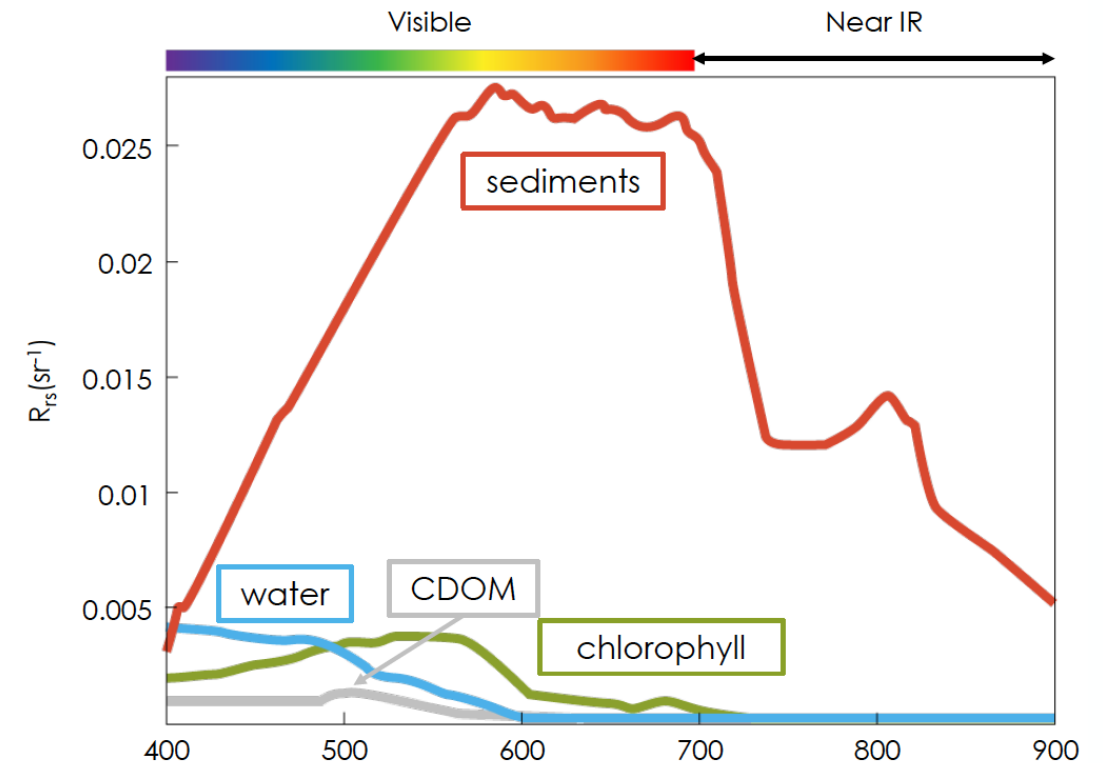
Ana Dogliotti

- Particles suspended in water increases scattering of incoming sunlight.

- Runoff from land / rivers.
- Coloured Dissolved Organic Matter (CDOM) aka Gelbstoff.
- Resuspended sediment.
- **Phytoplankton!**



Microscopic, unicellular drifting plants



IOP (Inherent Optical Properties)

Medium properties that depend only on the composition of this medium, regardless of light conditions.

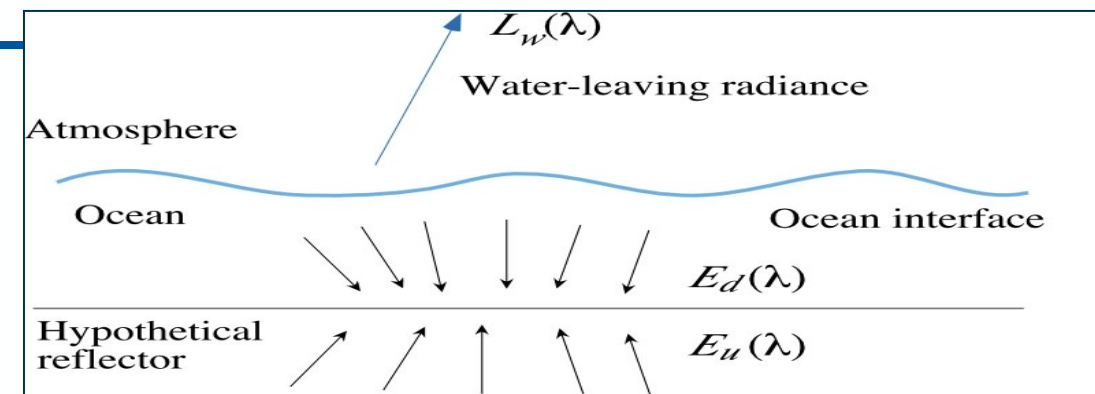
Examples are scattering (b), absorption (a), and fluorescence.

In a multi-component medium, the total inherent optical properties can be obtained by a simple addition of the individual contribution.

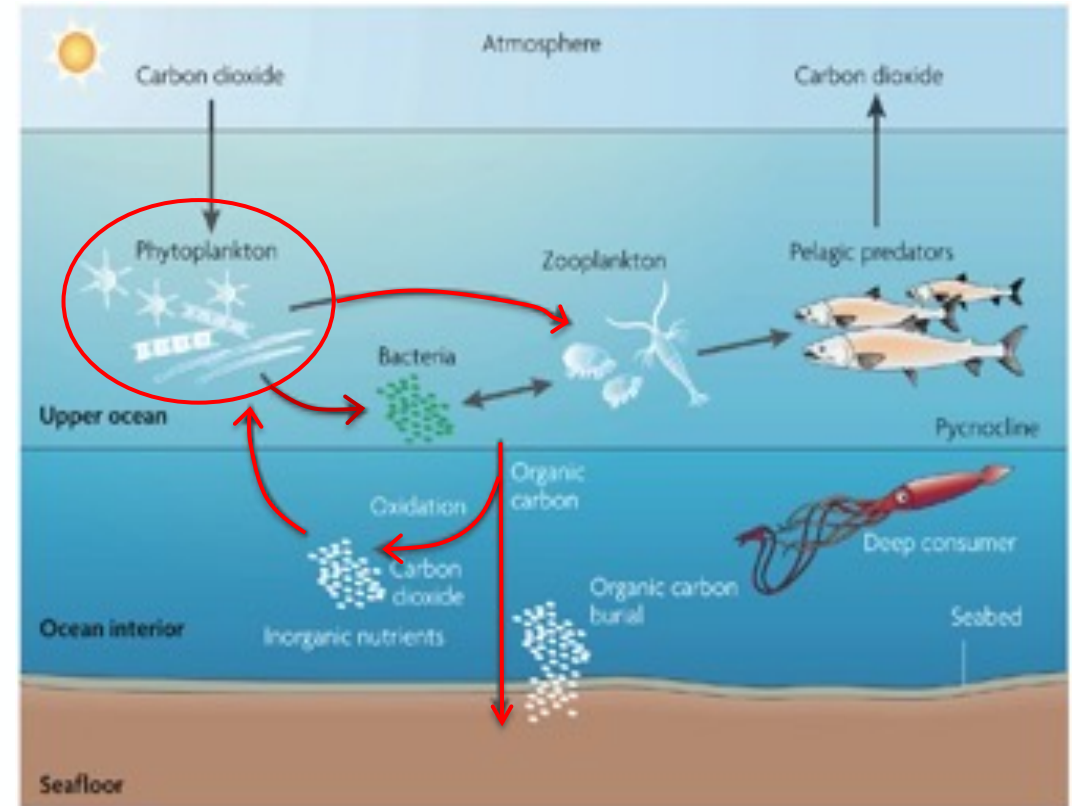
AOP (Apparent Optical Properties)

Characteristics of the medium dependent on geometric distribution of the light field and on the medium IOPs. They change with varying illumination conditions, such as solar zenith and azimuth angles.

Examples are irradiance (E), radiance (L), reflectance (R), diffuse attenuation coefficient (K), which depend on the surface boundary conditions.



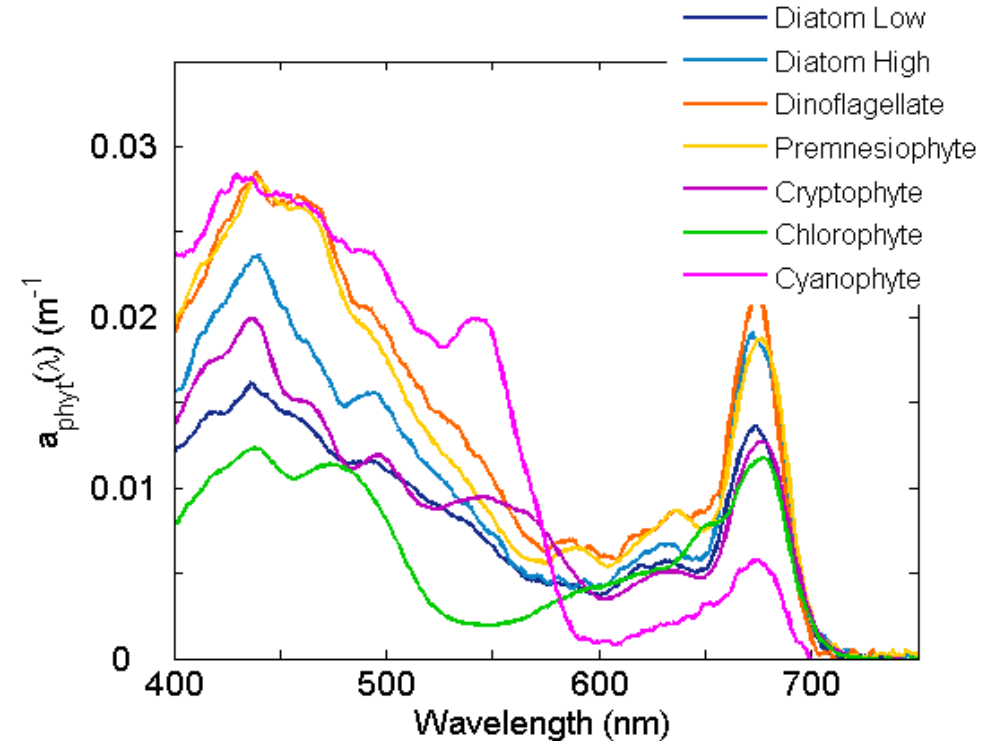
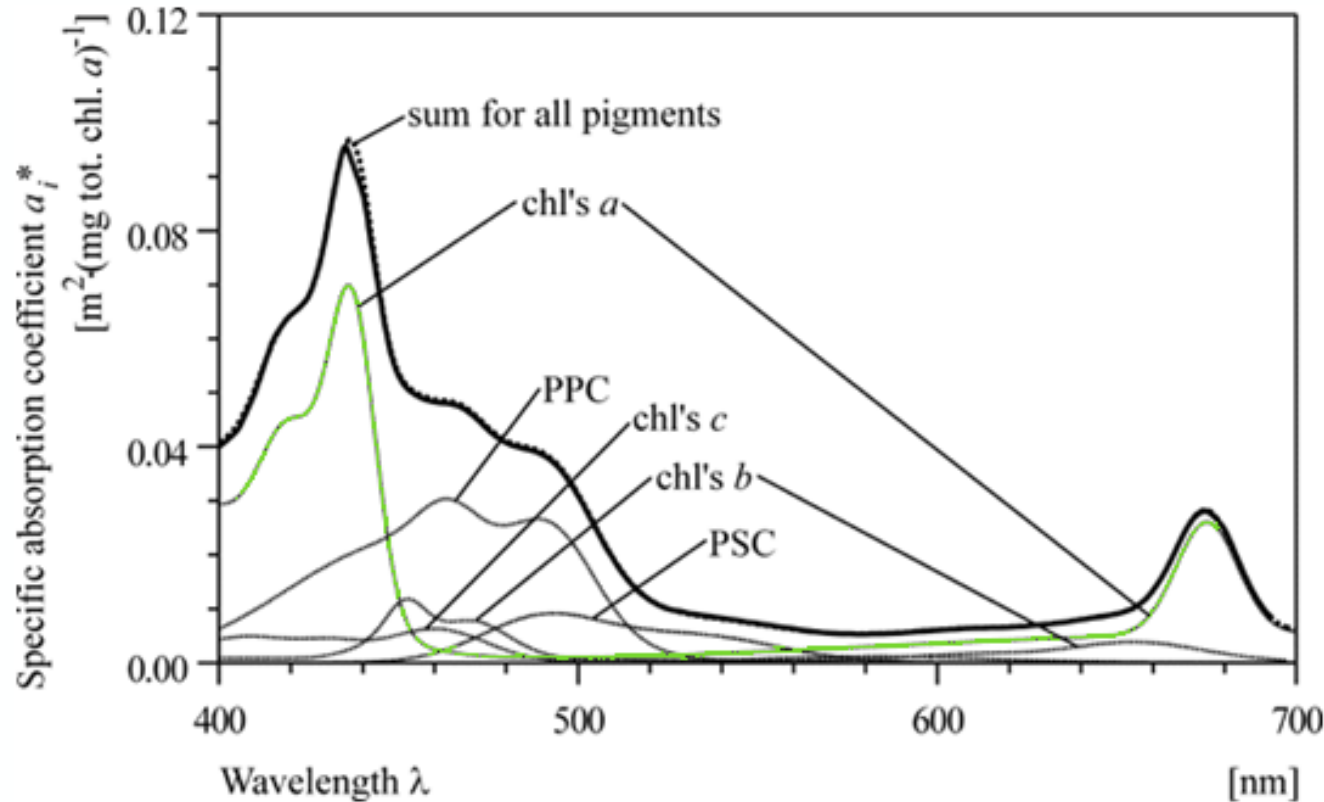
- + Phytoplankton are key players in the ocean's carbon pump
- + Phytoplankton diversity is an important factor that affects carbon cycling
- + What's the role of phytoplankton in today's oceans?
- + How will phytoplankton respond to future climate changes with interactions between climate and biogeochemistry?
- + We need observations of phytoplankton and associated processes on appropriate spatial and temporal scales



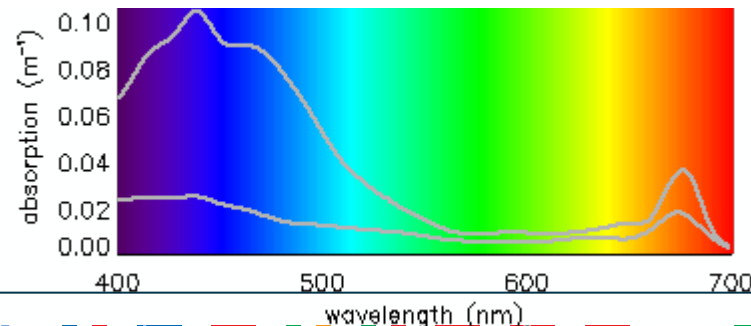
Falkowski et Oliver (2007) - The carbon biological pump

Nature Reviews | Microbiology

Phytoplankton optical properties: absorption



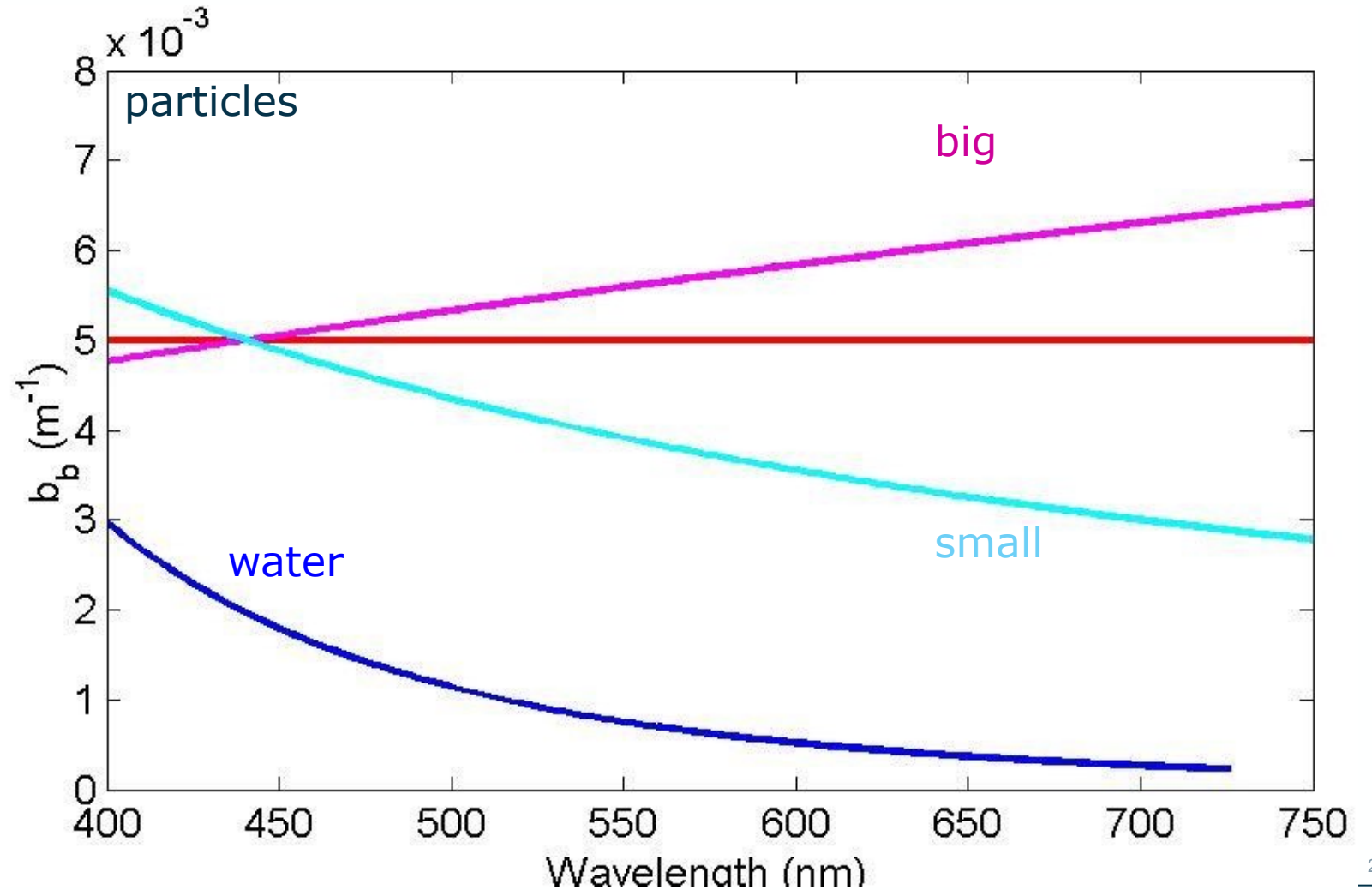
http://www.oceanopticsbook.info/view/absorption/absorption_by_oceanic_constituents



Phytoplankton optical properties: backscatter

$$b_{b\phi} = 0.3 \left(\frac{550}{\lambda} \right) [Cla]^{0.62}$$

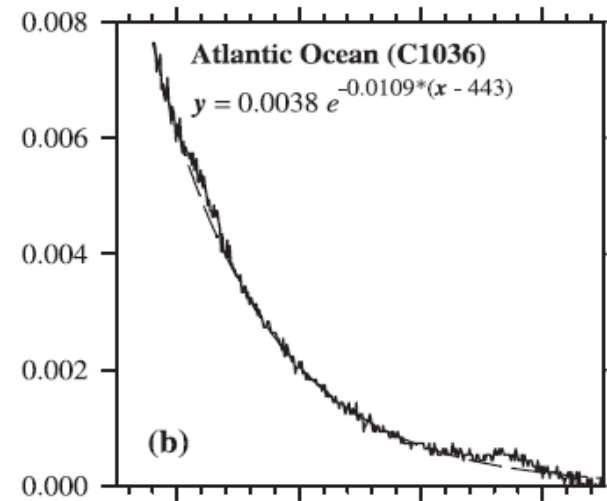
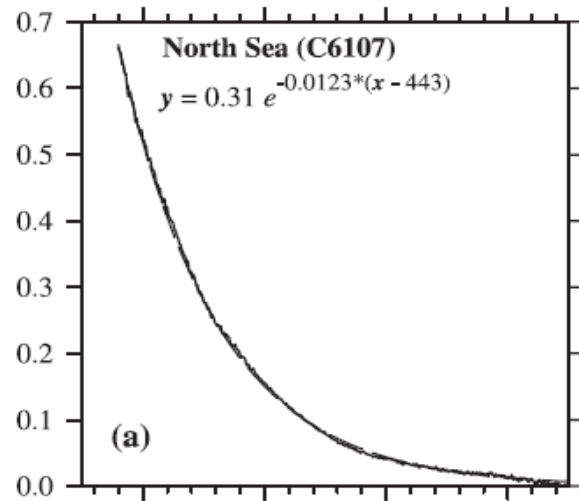
(Gordon & Morel, 1982)



Ana Dogliotti

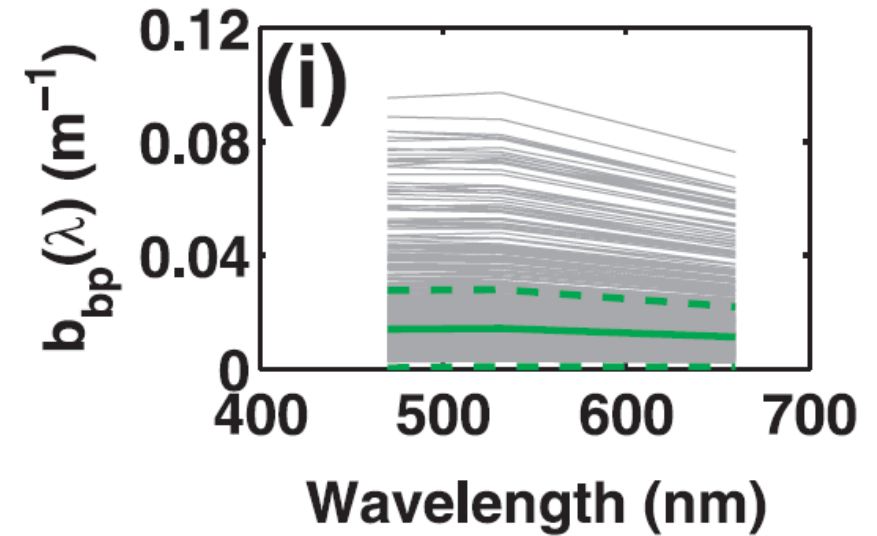
Absorption

$$a_{NAP}(\lambda) = a_{NAP}(443)e^{-S_{NAP}(\lambda-443)}$$



Backscatter

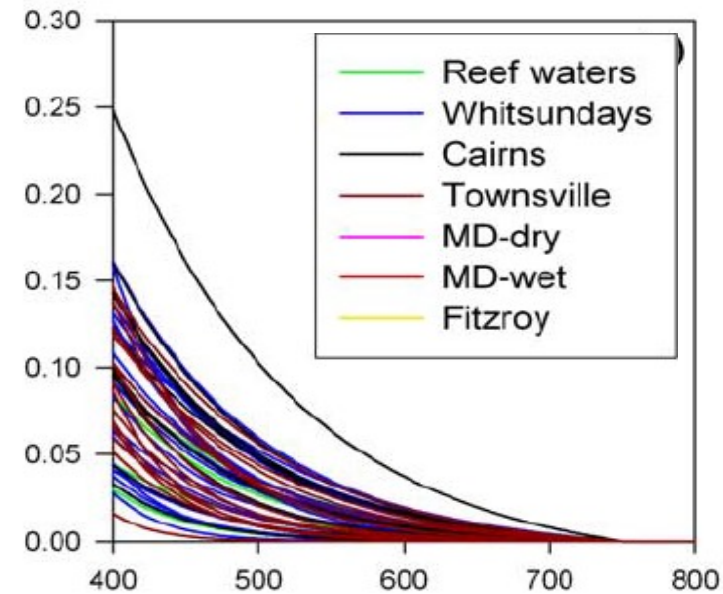
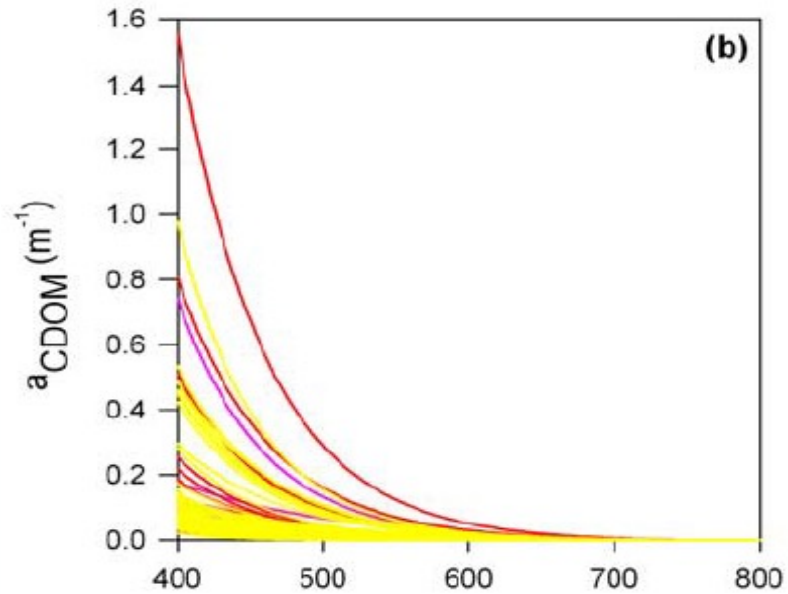
$$b_{bNAP}(\lambda) = b_{bNAP}(555) \left(\frac{\lambda}{555} \right)^{\gamma_{bb}}$$



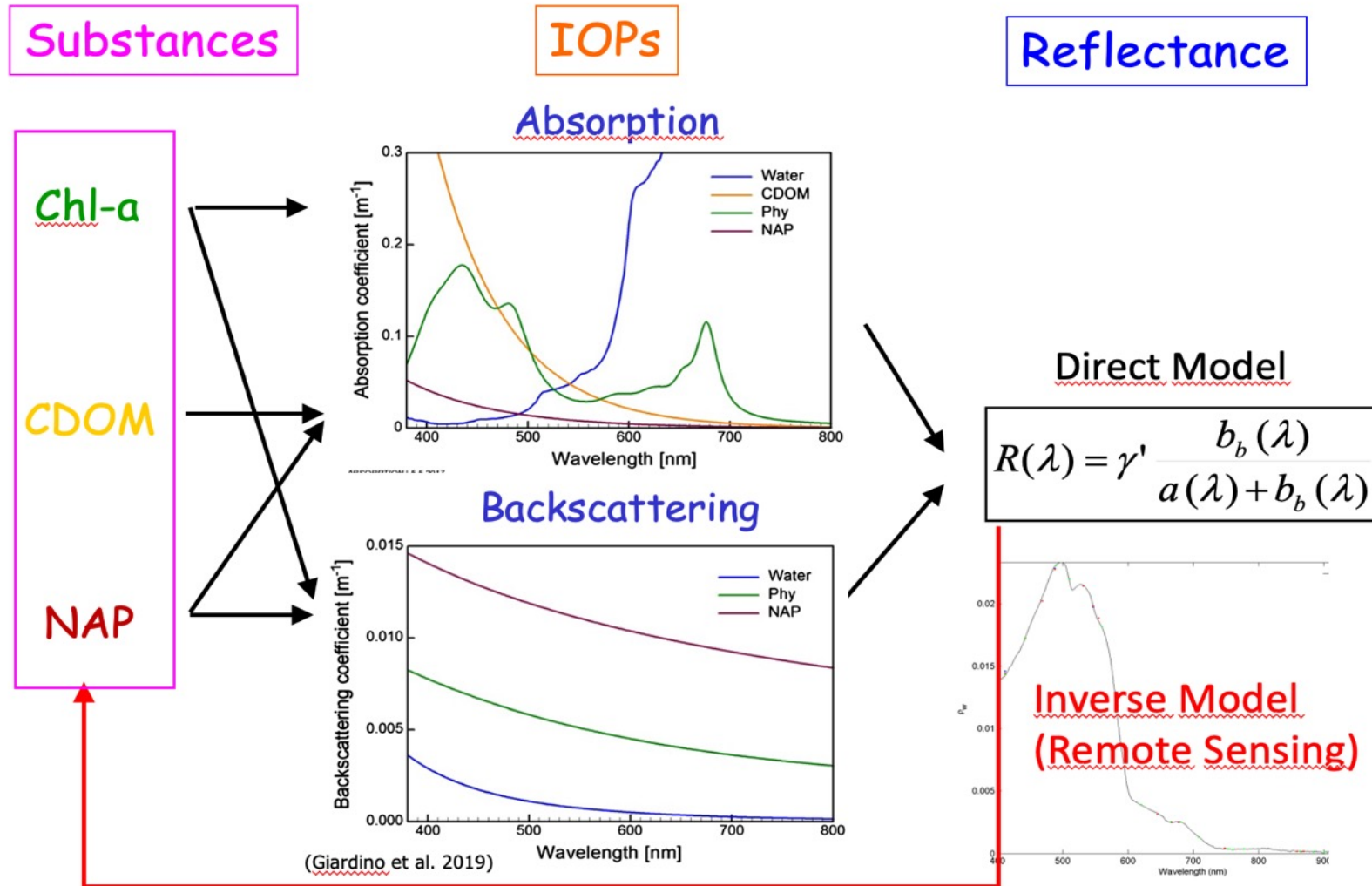
Absorption

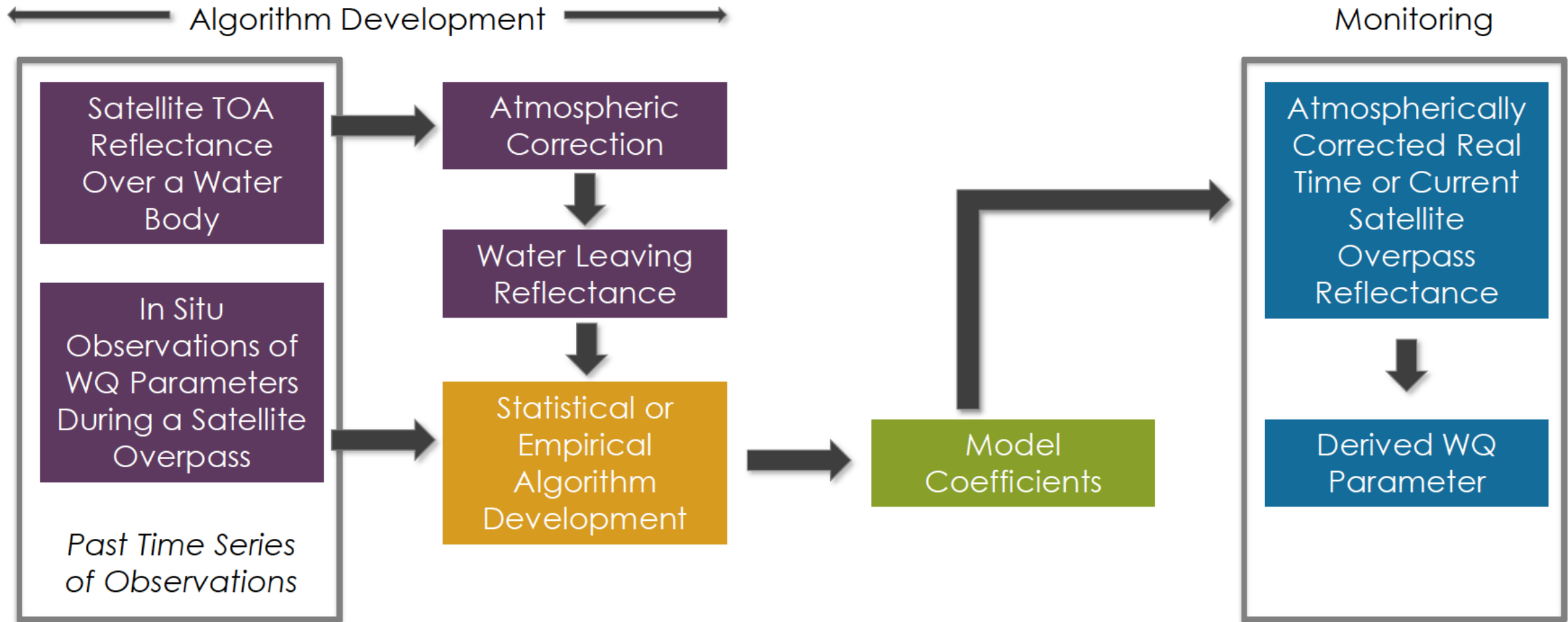
$$a_{CDOM}(\lambda) = a_{CDOM}(\lambda_0) e^{(-S_{CDOM}(\lambda_0 - \lambda))}$$

S_{CDOM} : slope (0.0114 – 0.0251 nm⁻¹)



(Blondeau-Patissier et al. 2009)





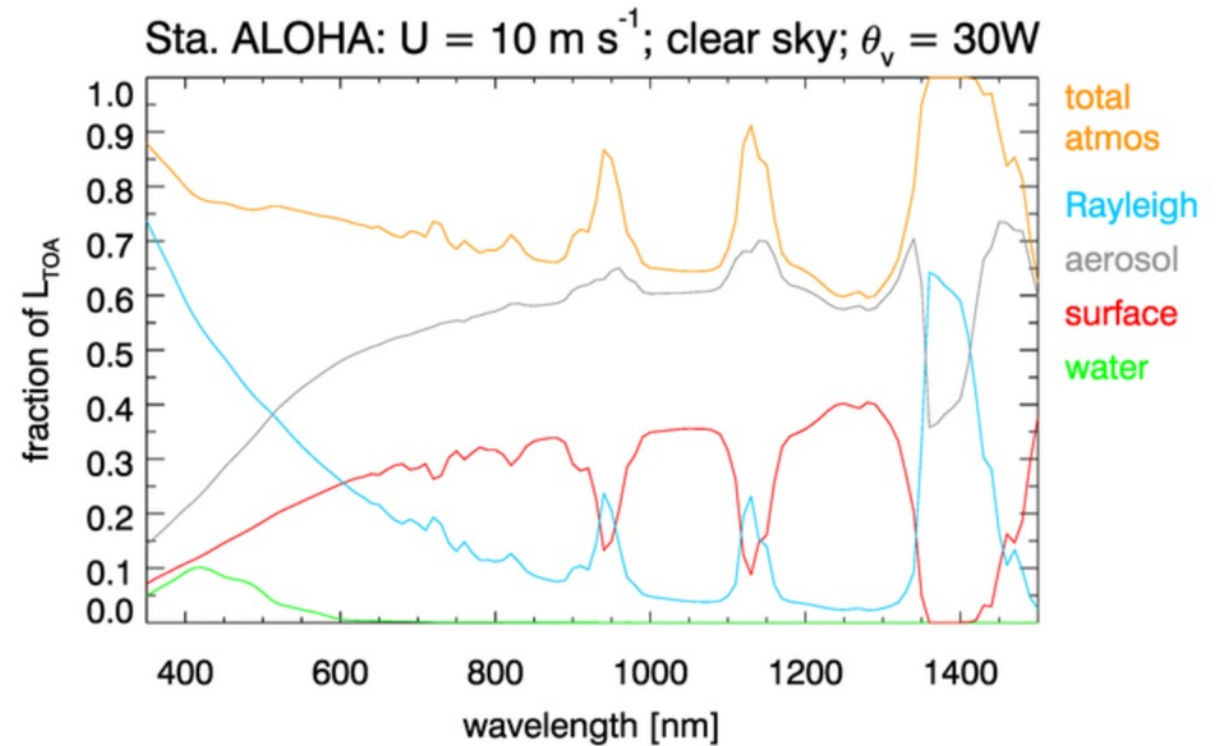
NASA's Applied Remote Sensing Training Program

Ocean Colour sensors measure the upwelling radiances at the Top Of Atmosphere (L_u).

L_u comes from the water leaving radiance (L_w), the radiance reflected by the atmosphere (L_r) and the radiance scattered into the viewing direction by the atmosphere (L_a).

To obtain L_w is necessary to remove the contributions from

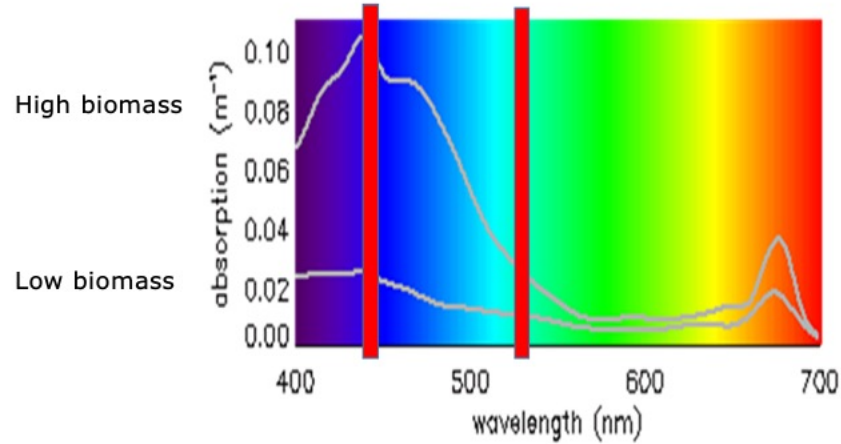
L_a and L_r = atmospheric correction.



Ocean Optics Web Book

Phytoplankton using Chl-a as proxy

Empirical algorithms



Remote-sensing reflectance maximum band ratio ([443,490,510]/555) as a function of chlorophyll-a concentration.

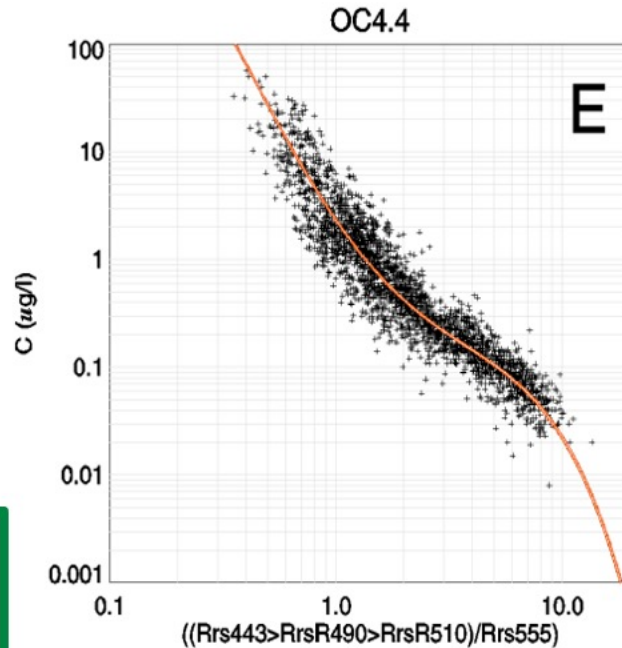


Figure from Valente et al 2016, Earth Syst. Sci. Data, 8, 235-252, doi:10.5194/essd-8-235-2016.

OC4 version 4

$$C = 10.0^{(a(0) + a(1)*R + a(2)*R^2 + a(3)*R^3 + a(4)*R^4)}$$

$$R = \text{ALOG10}((Rrs443>Rrs490>Rrs510)/Rrs555)$$

$$a = [0.366, -3.067, 1.930, 0.649, -1.532]$$

NASA OC4 and OC4E v64 operational standard algorithms,
http://oceancolor.gsfc.nasa.gov/cms/atbd/chlor_a

AOPS then IOPS

1. Atmospheric corrections & directional effects



2. Semi-analytical relationships:

$$R_{rs} = g_0 \left(\frac{b_b}{a + b_b} \right) + g_1 \left(\frac{b_b}{a + b_b} \right)^2$$

$$a(\lambda) = a_w(\lambda) + a_{dg}(443) e^{-S(\lambda - 443)} + a_\phi^*(\lambda) \text{ Chl}$$

$$b_b(\lambda) = b_{bw}(\lambda) + b_{bp}(443) \left(\frac{443}{\lambda} \right)^\eta$$

$R_{rs}(\lambda)$ from satellite(s)

$S, \eta, g_0, g_1,$ & $a_\phi^*(\lambda)$ are constants

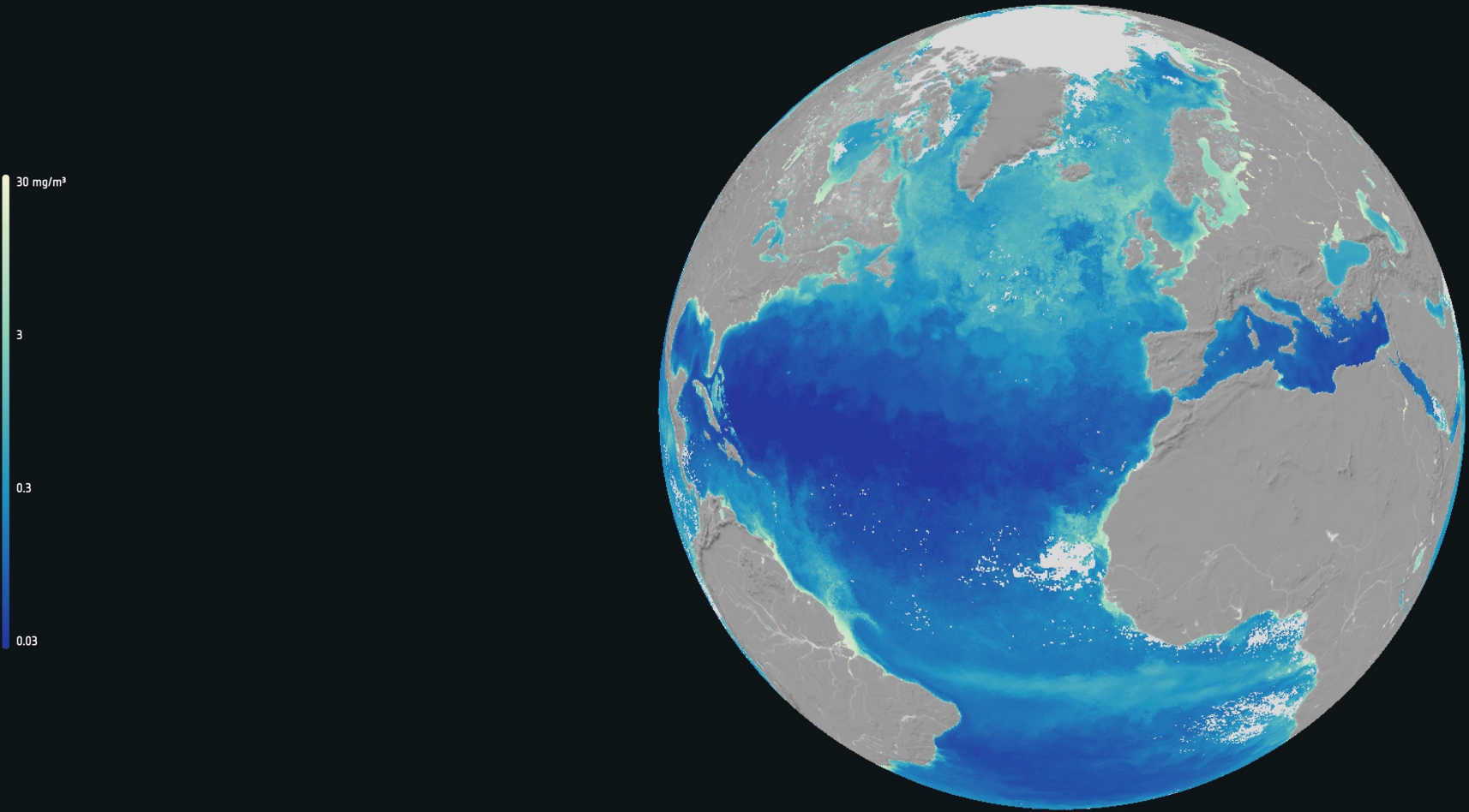
$a_{dg}(443), b_{bp}(443),$ & Chl are unknown

Ocean Colour Remote Sensing: why is key?



esa Climate from Space

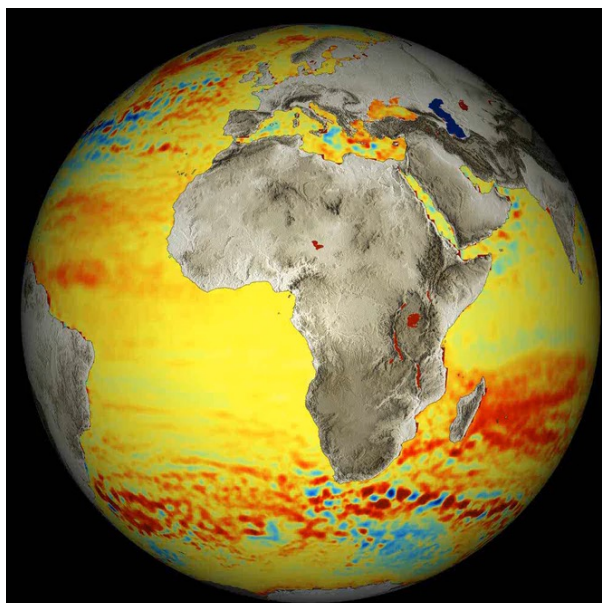
Stories Data Layers



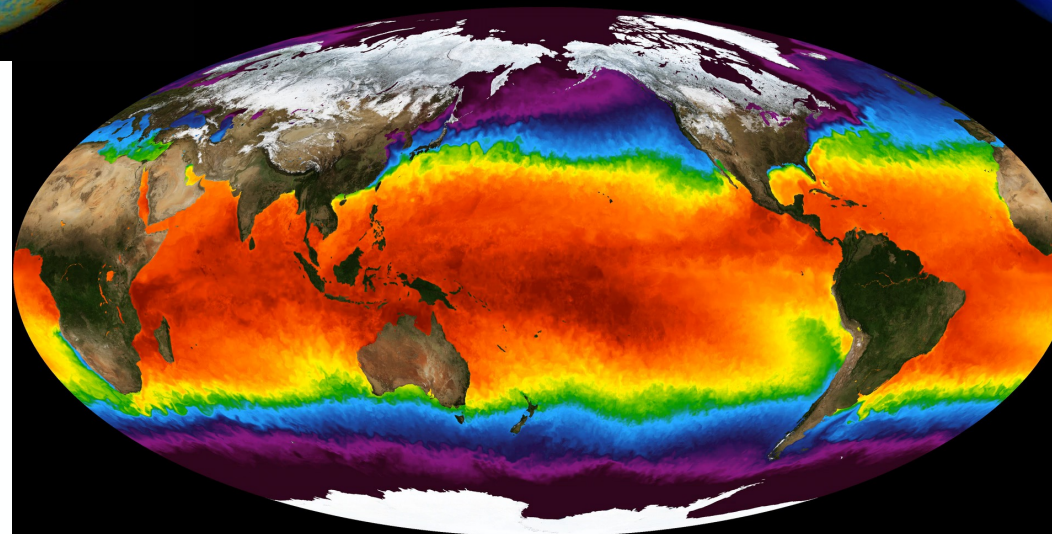
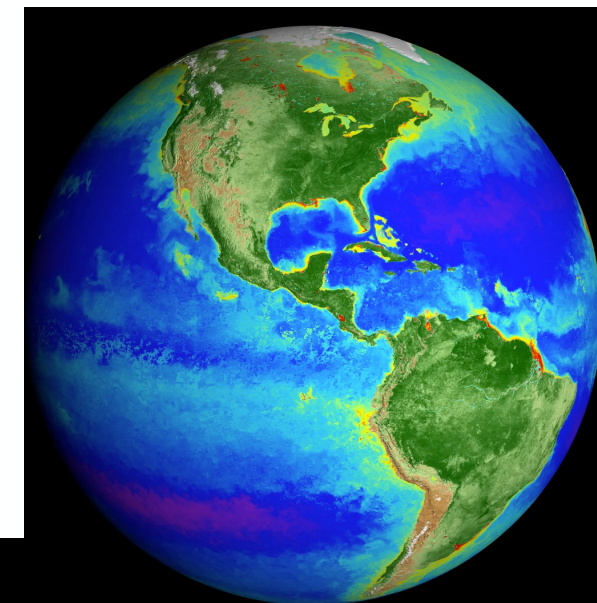
30 mg/m³
3
0.3
0.03

Ocean Colour – Chlorophyll-a Concentration ⓘ

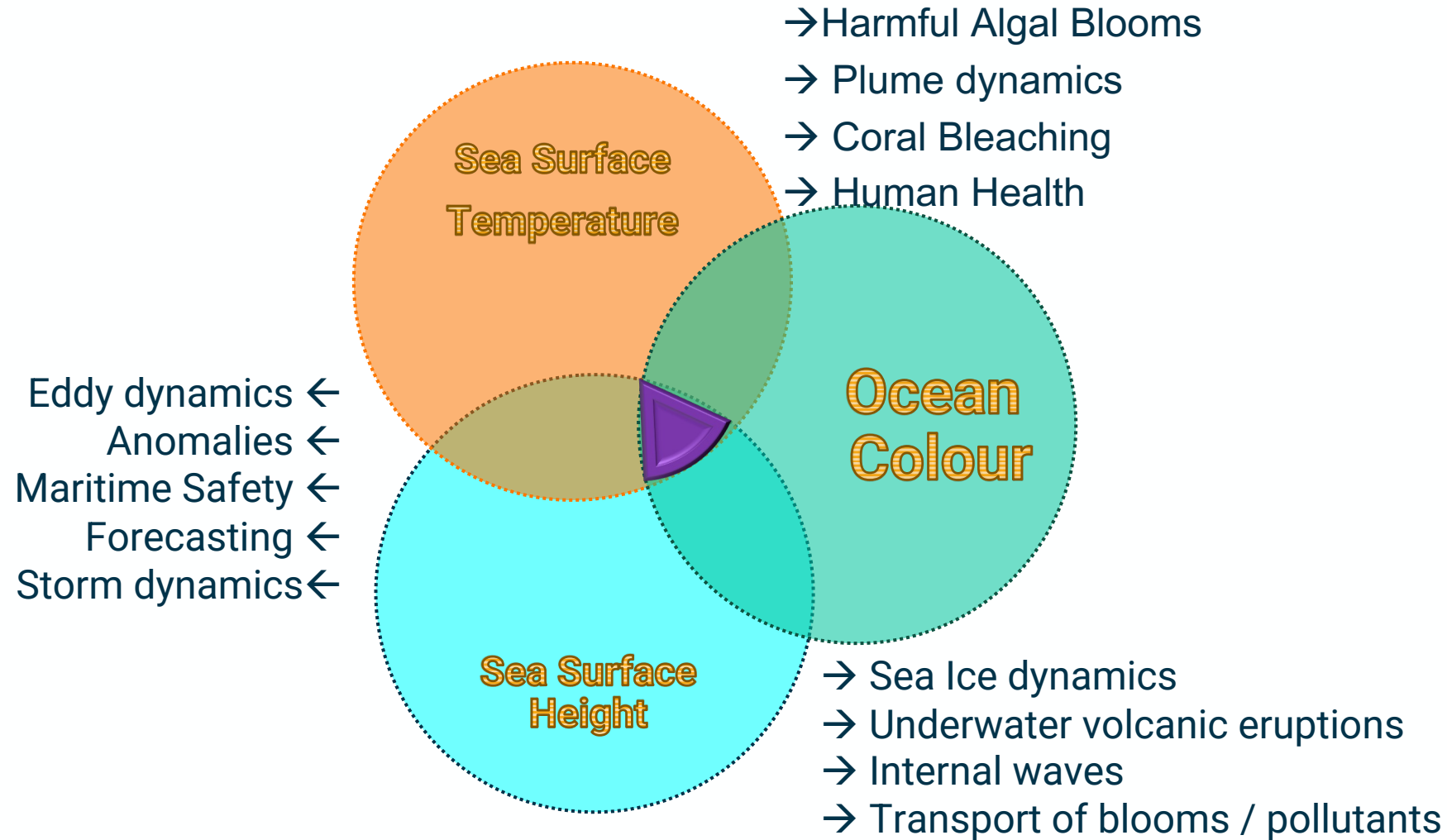
July 2002



Ecosystem Monitoring



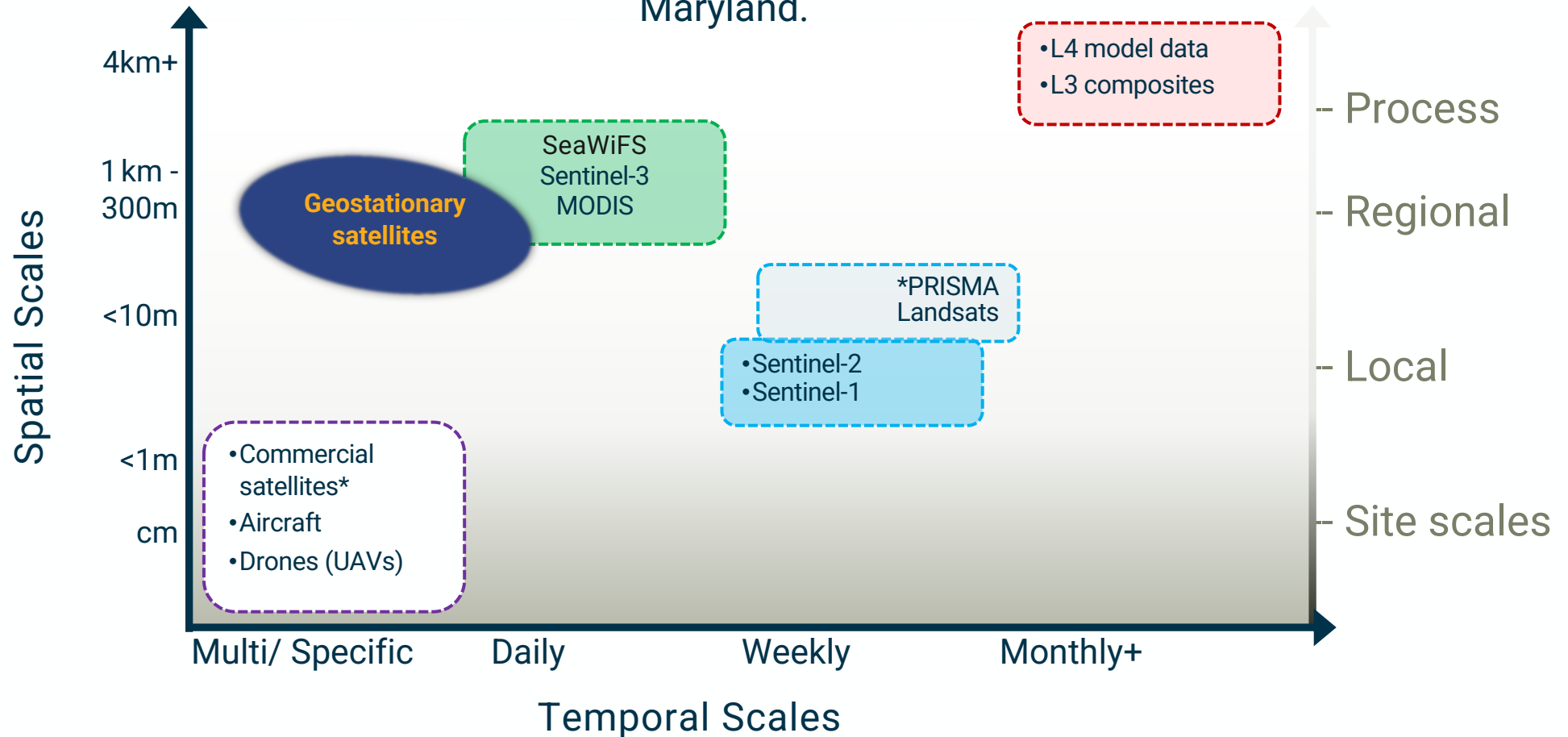
Why to combine with other variables



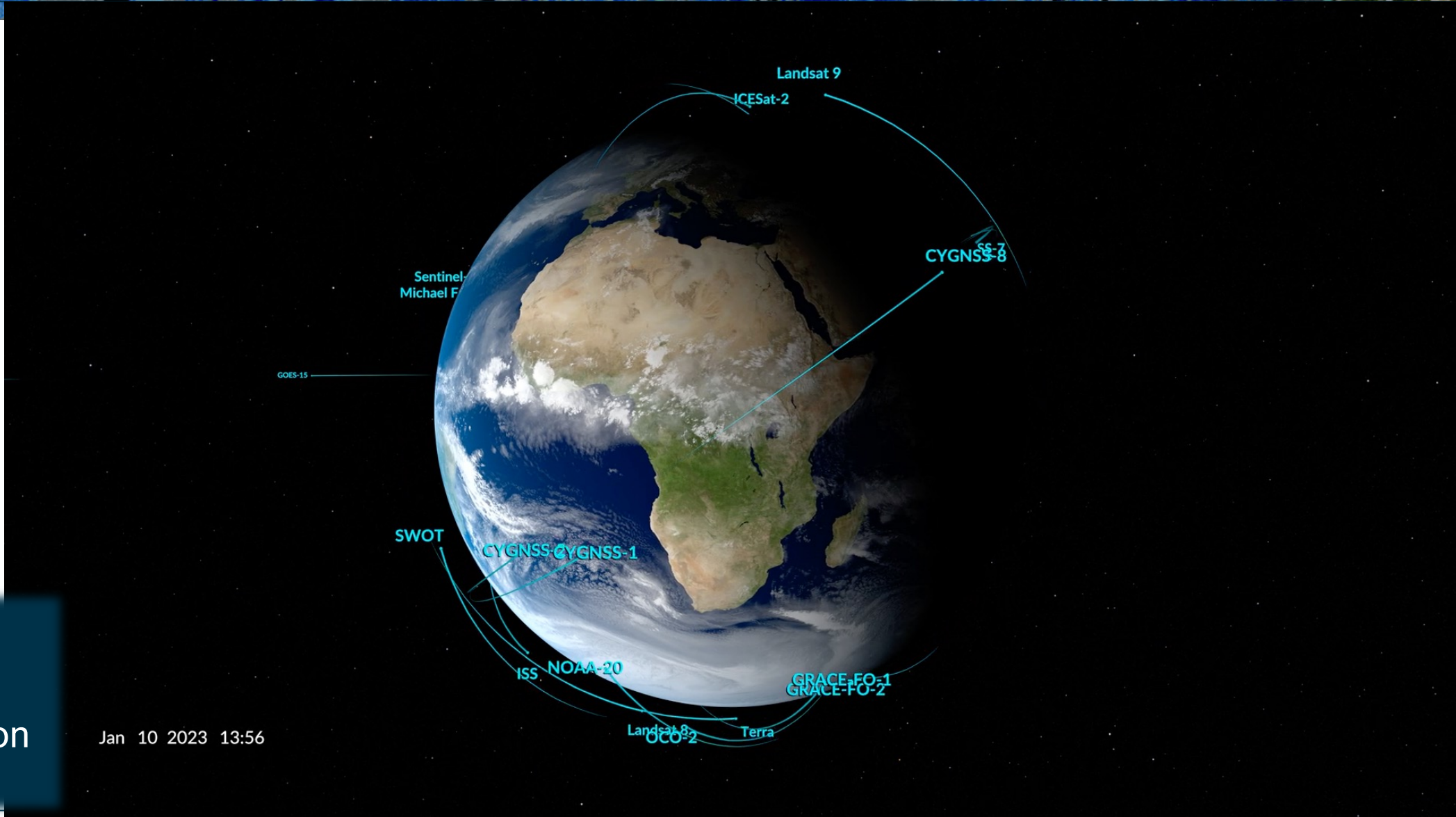
You cannot have everything

Define temporal and spatial scale

Phinn, S.R, Roelfsema, C.M. and Stumpf, R. (2010). Remote sensing: the promise and the reality. In: Dennison, W., (Ed.) Coastal Assessment Handbook, Chapter 15, University of Maryland.



Swarm of satellites



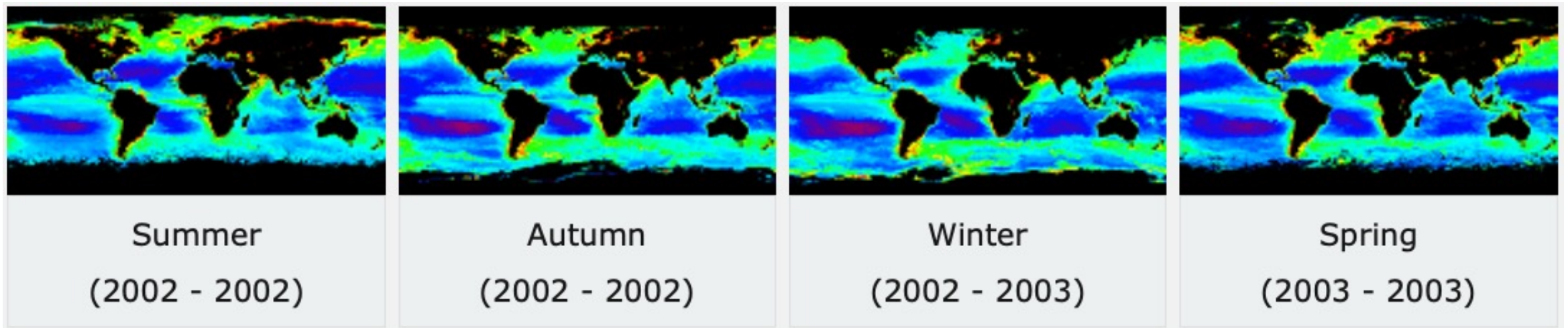
Animation:
NASA
Visualisation
Studio

Jan 10 2023 13:56

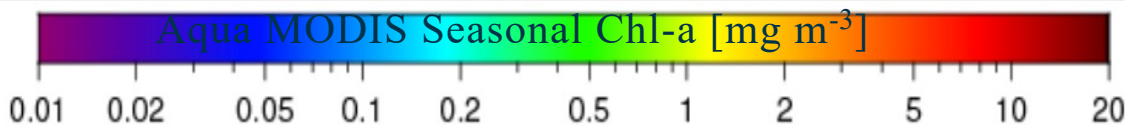
NASA's MODIS (MODerate resolution Imaging Spectroradiometer) sensors aboard Terra & Aqua satellites.

Coverage of Earth's surface every 2 days with data acquired in 36 bands at 300 m resolution.

Launched in July 2002 to present day – over 20 years!



L. Biermann



EARTH DATA Other DAACs

OCEAN COLOR
OB.DAAC | OBPG

ABOUT DATA RESOURCES TOOLS COMMUNITY GALLERY FORUM Quick Links

Ocean Color Feature

Bikini Atoll Under Threat

The **Bikini Atoll** in the Marshall Islands was used as a testing ground for **24 nuclear bombs** between 1946 and 1958. Craters from the violent explosions are still evident, notably in the Northeastern part of the atoll where the **Castle Bravo** (equivalent to 15 MT of TNT) and **Romeo** (11 Mt) tests were conducted.

[See this in the Gallery](#)

- October 2023
- September 2023
- August 2023
- July 2023
- June 2023
- April 2023

Ocean Color Web

NASA deploys a number of Earth observing instruments that measure the spectral nature, or color, of water. Specifically, NASA acquires, archives, and publicly distributes such data from a variety of sources, including remote sensing ocean color instruments on satellite and airborne platforms, as well as similar measurements made on shipborne field campaigns, by long-duration autonomous in situ platforms, and derived as Earth system model outputs.

The Ocean Biology Processing Group (OBPG) at NASA's Goddard Space Flight Center has been operating and supporting the Ocean Color Web since 1996. As a Science Investigator-led Processing System (SIPS), our responsibilities include the collection, processing, calibration, validation of ocean-related products from a large number of operational, satellite-based remote-sensing missions providing ocean color, sea surface temperature and sea surface salinity data to the international research community. As a Distributed Active Archive Center (DAAC), known as the Ocean Biology DAAC (OB.DAAC), we are responsible for the archive and distribution of satellite ocean biology data produced or collected under NASA EOSDIS, including those from historical missions and partner space organizations.

- Get Started >
- Find Data >
- Use Data >

What is Ocean Color?

Ocean Color is the apparent hue, shade, or tone of water that results from the interactions of sunlight with the microscopic composition of the water column and water itself. Typical relevant water constituents include phytoplankton, mineral particles, and dissolved organic matter. The color of the ocean varies with how these materials in seawater absorb and scatter photons of different wavelengths, which varies with their concentrations. For example, highly productive waters where phytoplankton are abundant appear green, whereas less productive waters with

Ocean Color Social Media

Twitter Facebook Instagram

nasaocean
156K followers [View profile](#)

[View more on Instagram](#)

2,084 likes

Add a comment...

PACE Plankton, Aerosol, Cloud, ocean Ecosystem

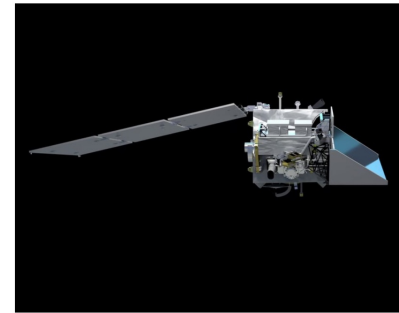
- HOME
- ABOUT
- MISSION
- SCIENCE
- APPLICATIONS
- DATA
- LEARN MORE
- NEWS
- EVENTS
- GALLERY
- DOCUMENTS

Mission

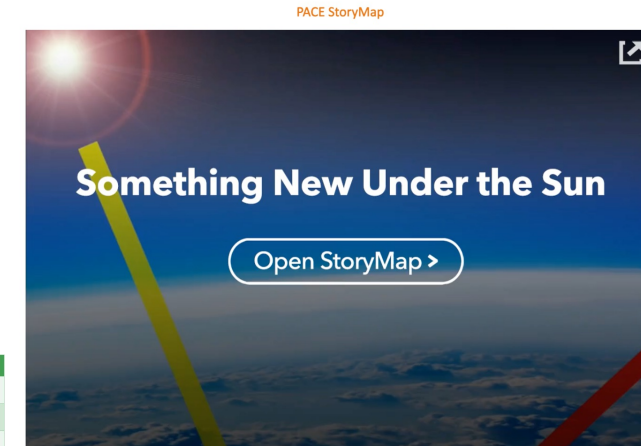
Building on lessons learned from previous ocean color studies, a team of dedicated people is bringing PACE to life. PACE will face a series of important milestones during its mission development. The Development Team at Goddard Space Flight Center (GSFC) will guide PACE through each phase as the instruments, spacecraft, and observatory are built, tested, and flown.

Observatory

GSFC is responsible for the principal mission elements, including the design and fabrication of the spacecraft, development of scientific instrumentation.

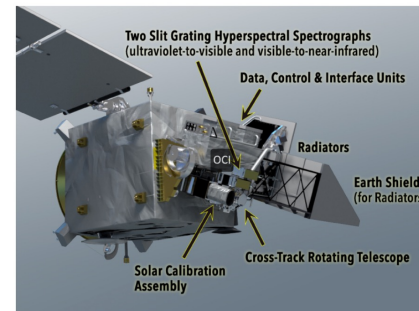


Build your own PACE!

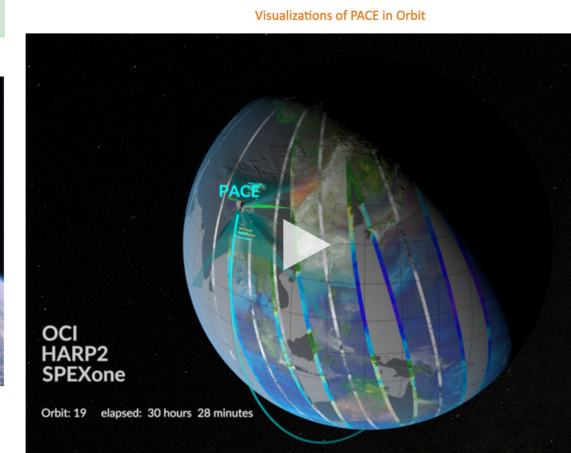
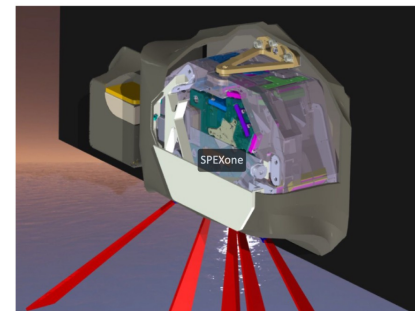


Observatory Overview	
Mass with fuel	Not to exceed 1700 kg (3748 lb)
Dimensions	1.5 m x 1.5 m x 3.2 m (4.9 ft x 4.9 ft x 10.5 ft)
Power	1000 Watts
Communications	S-Band - Command & Telemetry Ka-Band - Science Data

Instruments



Click on any image for a closer view.



Click image to view movie. Credit: NASA Scientific Visualization Studio.

The primary science instrument planned for PACE is the Ocean Color Instrument (OCI) which will be capable of measuring the color of the ocean from ultraviolet to shortwave infrared. [Learn more about the OCI >](#)

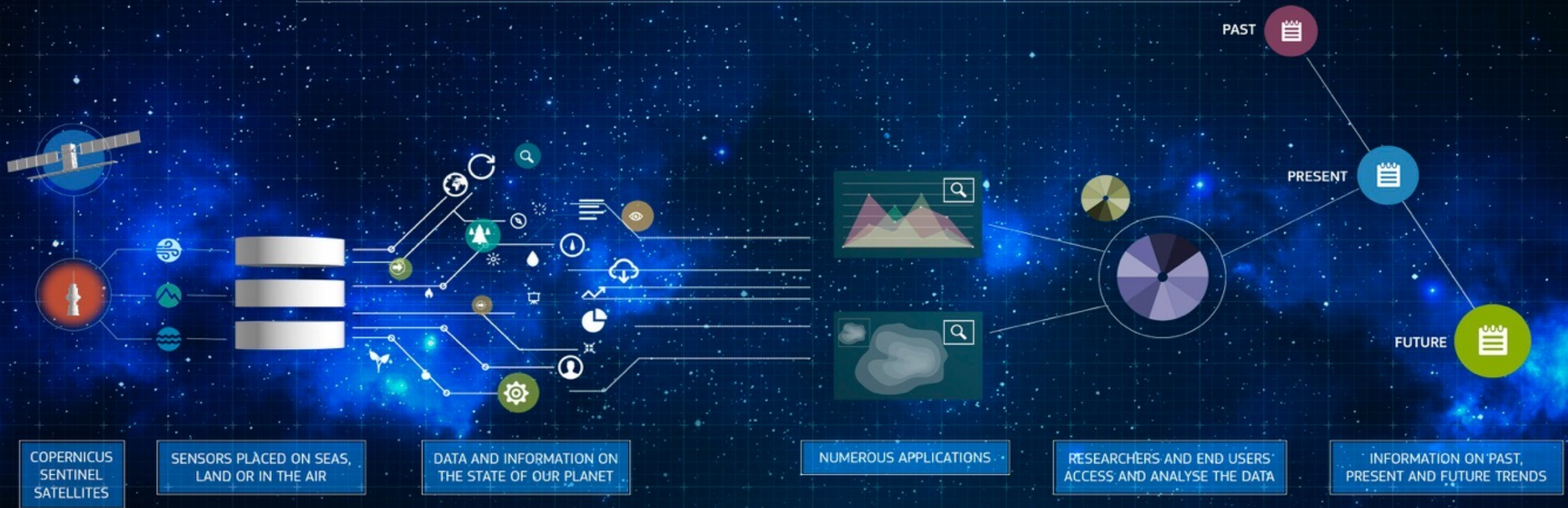
PACE will also include two polarimeters. Such instruments are used to measure how the oscillation of sunlight within a geometric plane - known as its polarization - is changed by passing through clouds, aerosols, and the ocean.

- European Commission funds and manages the Copernicus Programme – **all** EO data are freely available to **any users**.
- Satellite operation & data services shared between:

1. European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
2. European Space Agency (ESA)



COPERNICUS DATA AND APPLICATIONS



DATA IS COLLECTED BY COPERNICUS SENTINEL SATELLITES THAT SOMETIMES OPERATE ALONE AND SOMETIMES COMBINED WITH SENSORS PLACED ON THE SEAS, LAND OR IN THE AIR. THIS DATA HELPS TO PROVIDE A LARGE AMOUNT OF RELIABLE AND UP-TO-DATE INFORMATION ON THE STATUS OF OUR PLANET AND CAN BE USED TO CREATE DIFFERENT KIND OF PRODUCTS SUCH AS STATISTICS AND TOPOGRAPHIC MAPS. THE DATA IS ANALYSED IN A WAY THAT GENERATES INDICATORS USEFUL FOR RESEARCHERS AND END USERS, PROVIDING INFORMATION ON PAST, PRESENT AND FUTURE TRENDS.

Sentinel-3A was launched in Feb 2016 and Sentinel-3B followed in April 2018

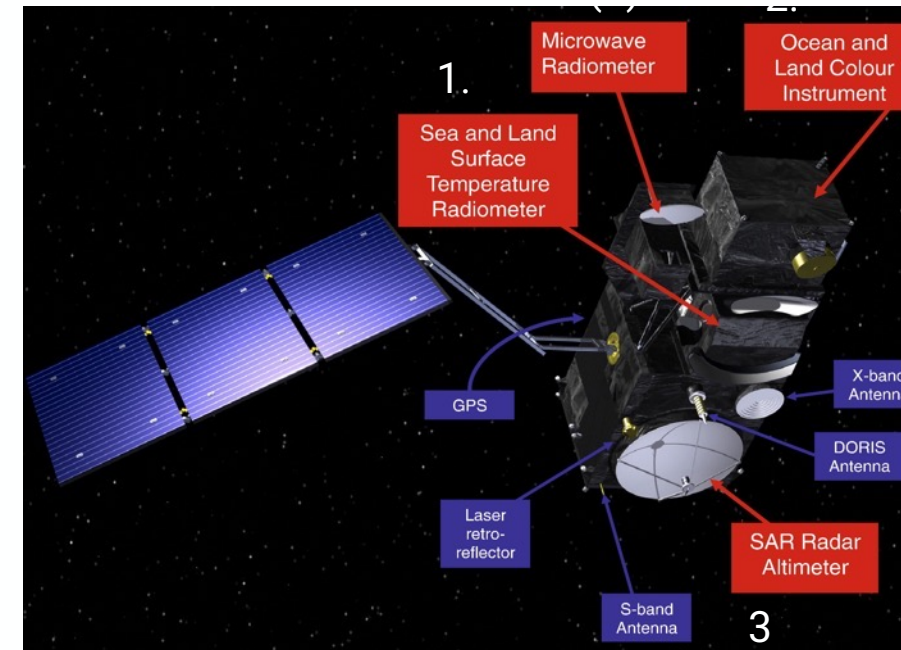
Sentinel-3 (and all Sentinels) fly in pairs (constellations).

Two-day global coverage of optical data.

Mission's main objective is to deliver measurements of sea-surface height, surface temperature, and chlorophyll.

Fondly known as the 'Blue Sentinel' thanks to its suite of ocean observing instruments.

- Sentinel-3 carries 3 sensors:
 1. SLSTR (Temperature)
 2. OLCI (Chlorophyll)
 3. SRAL (Surface Height)
- EUMETSAT operates Sentinel-3 satellites.
- Copernicus Marine Data Service conducts marine data processing and dissemination.



OLCI sensor – Algal Pigment Chlorophyll-a Concentrations:

Full Resolution (FR) 300m

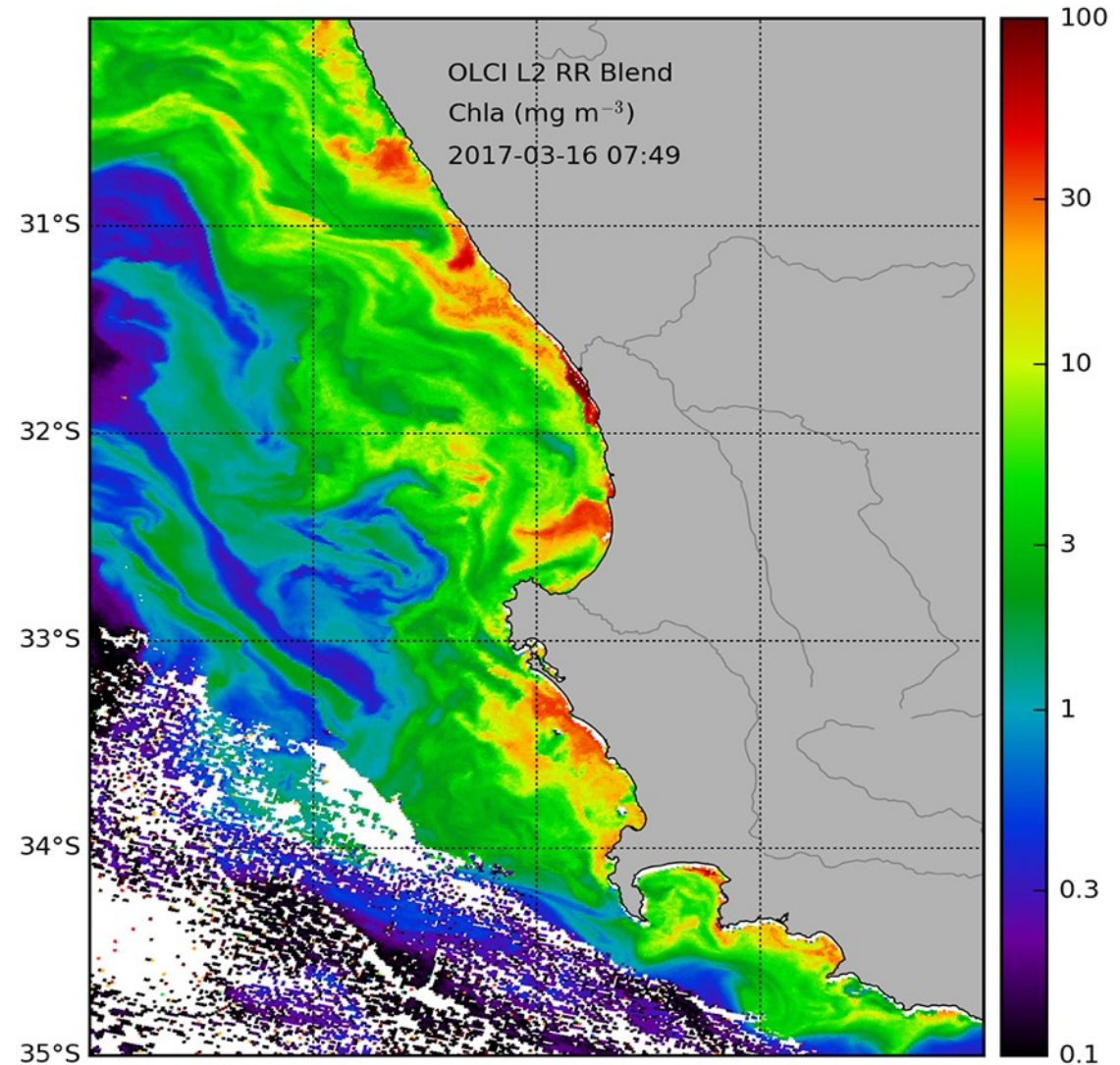
21 spectral bands (RGB - SWIR)

Excellent Signal to Noise Ratio.

Measures to 1 optical depth; determines what is suspended in surface waters (how much).

OLCI:

- Swath width: 1 270 km.
- Spatial resolution: 300m full resolution (FR) granules, 1km reduced resolution (RR).





- Terrestrial mission with **some marine applications**.
- Passive Optical sensor.
- Max 10 m spatial resolution.
- **Derived Ocean Colour**.
- Level 1C and Level 2 data.



Brown hills speckle the eastern part of Australia's Lake MacKay (ESA)

Thanks to the high spatial resolution (10m) of its VIS & NIR bands, Sentinel-2 is still useful for:

- ✓ Observing surface blooms.
- ✓ Monitoring water quality, including inland waters.
- ✓ Monitoring aquaculture farms.
- ✓ Validating radar applications.
- ✓ Marine Spatial Planning.
- ✓ Detecting floating debris.

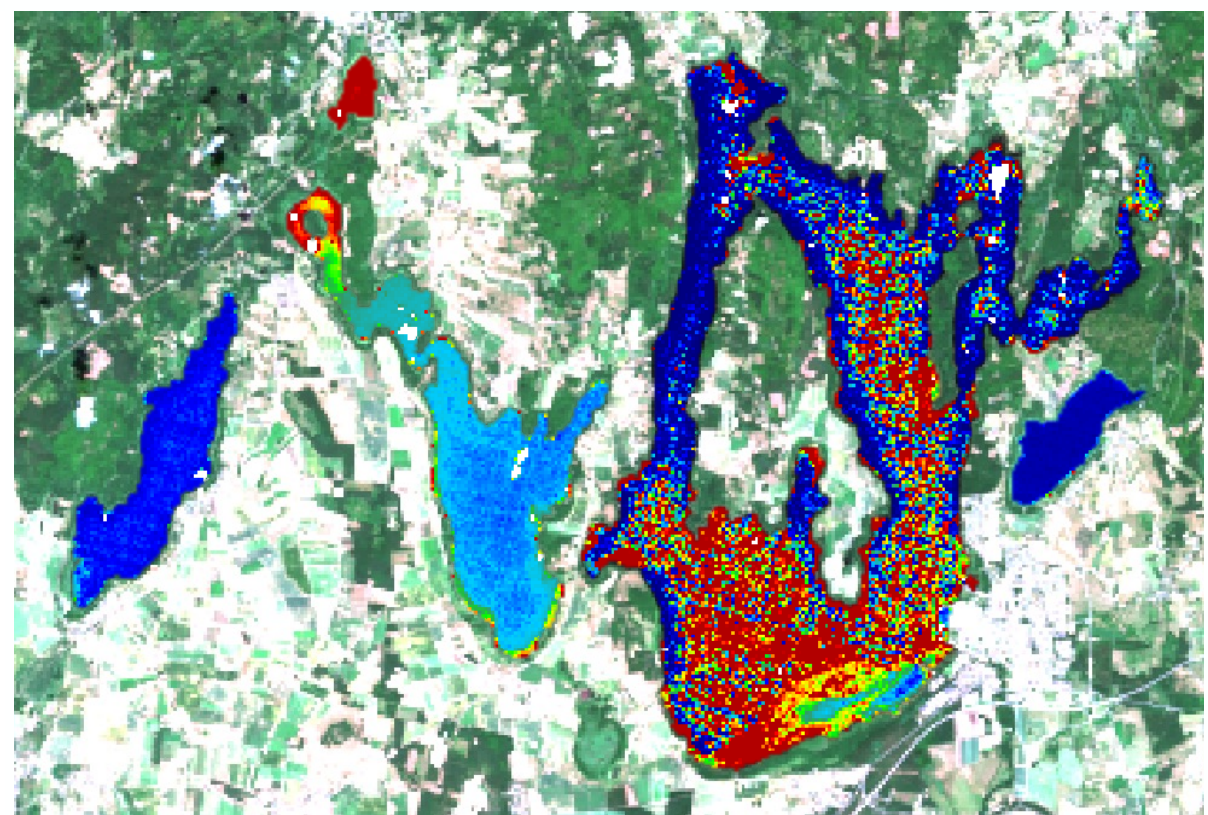
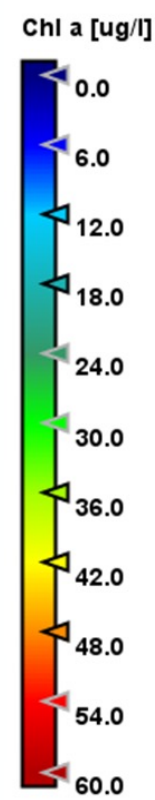


Florida: Floods Oct 2022

CyanoAlert Service - Sweden

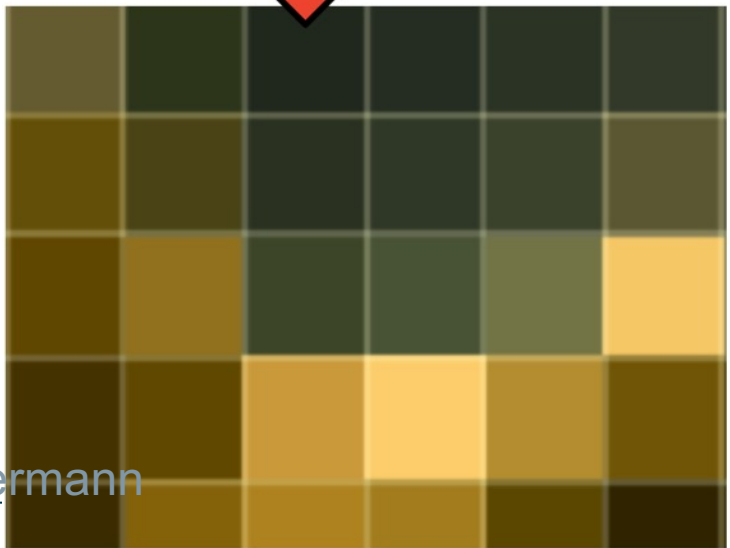
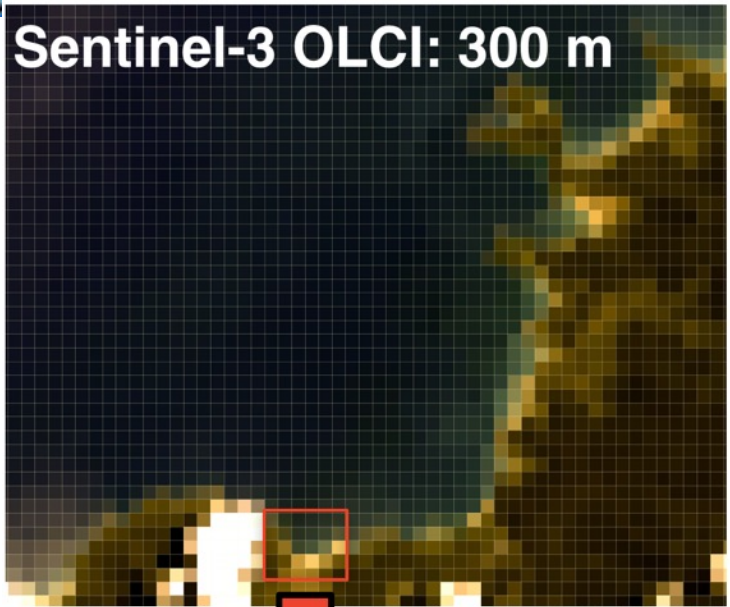


Vattenriket - a UNESCO biosphere reserve area monitored with Sentinel-2. Reflectance and Chl a retrieval fails over dark humic

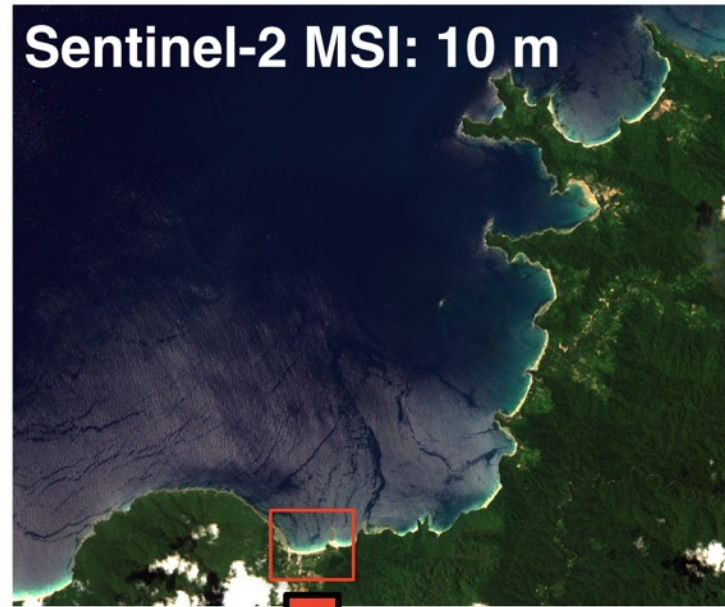


Spatial vs. Spectral

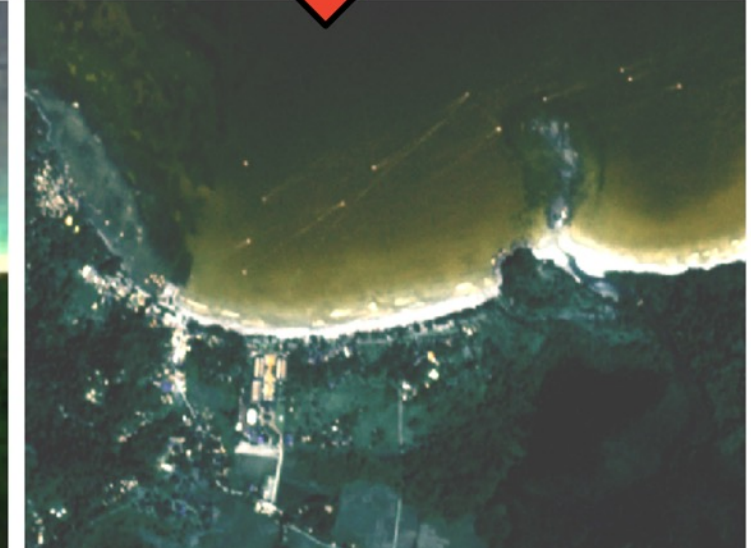
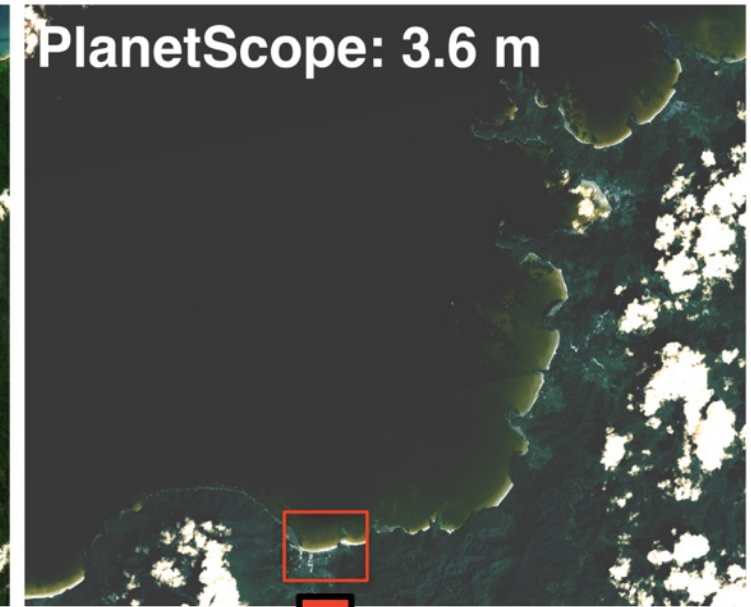
Sentinel-3 OLCI: 300 m



Sentinel-2 MSI: 10 m

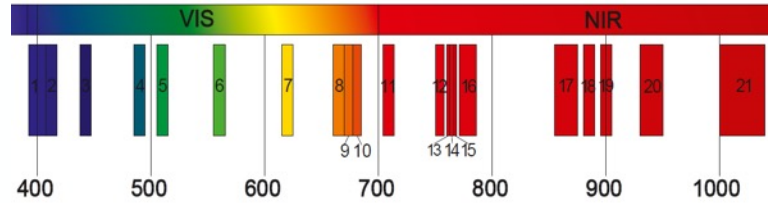


PlanetScope: 3.6 m

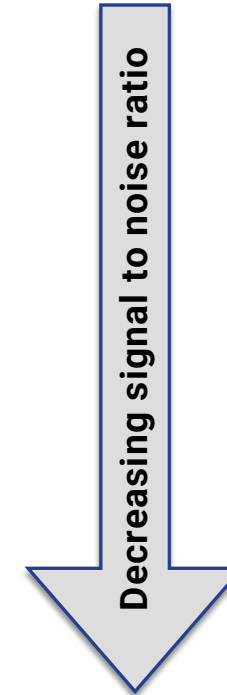
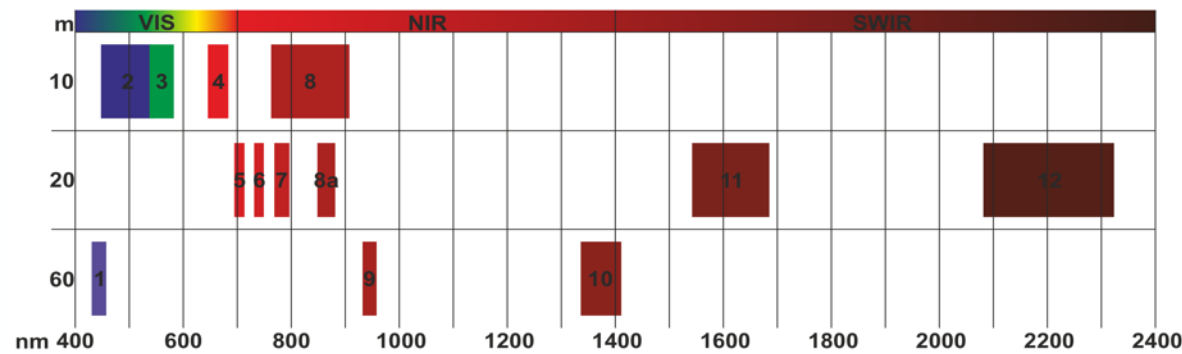


Spatial vs. Spectral

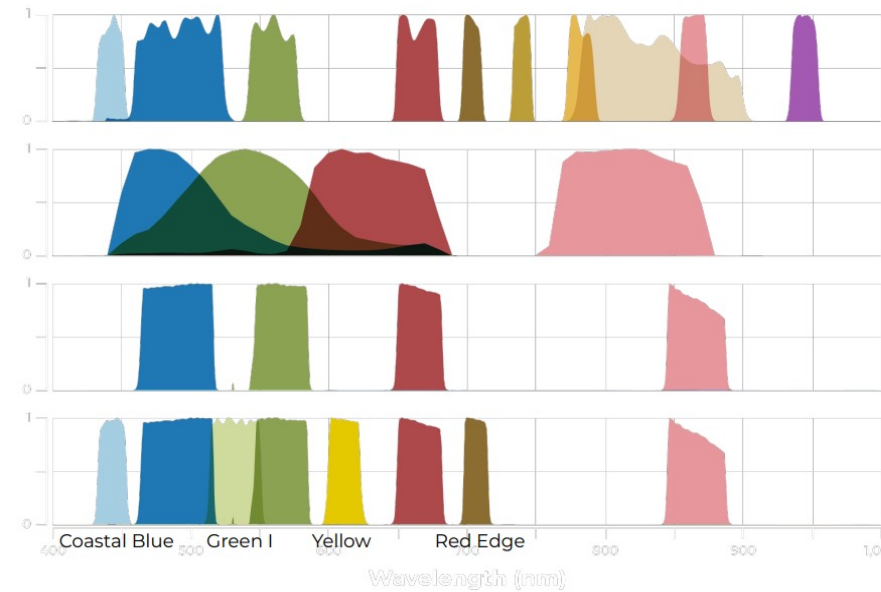
Sentinel-3
OLCI:



Sentinel-2
MSI:



Commercial satellites



Sentinel-2

Dove Classic

Dove-R

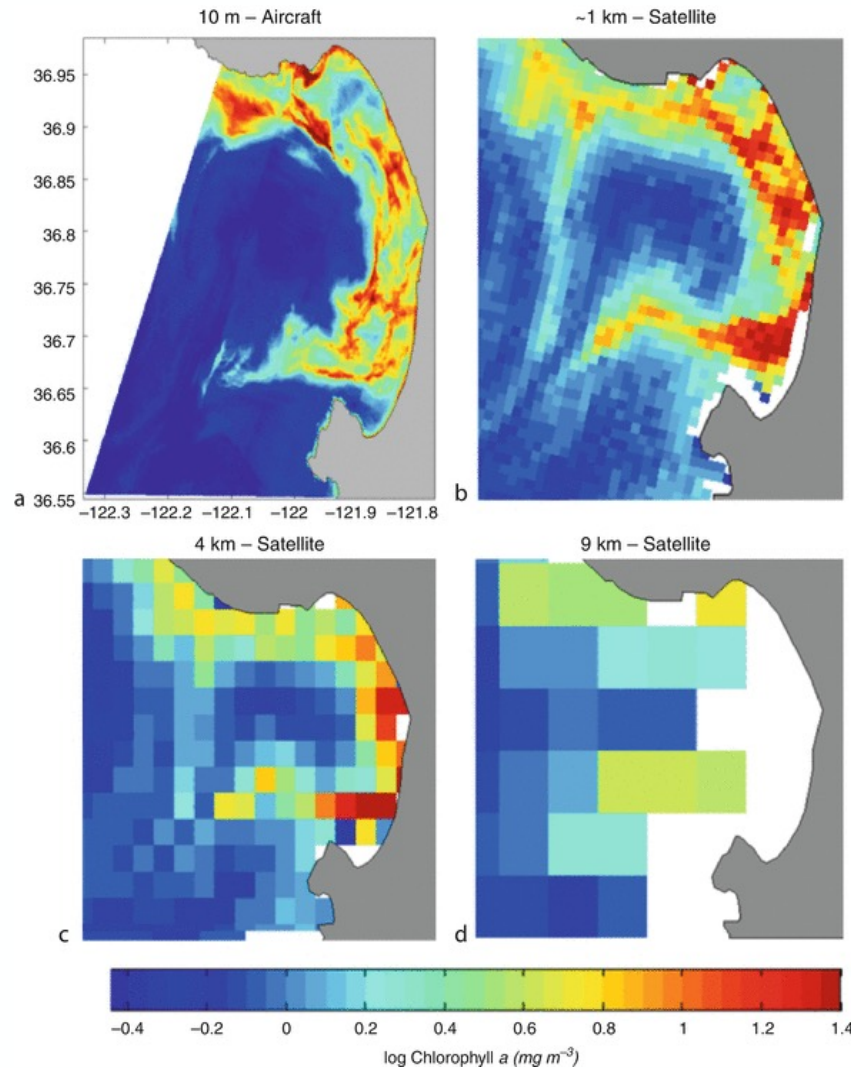
SuperDove

Blue: 455 - 515 nm
Green: 500 - 590 nm
Red: 590 - 670 nm
NIR: 780 - 860 nm

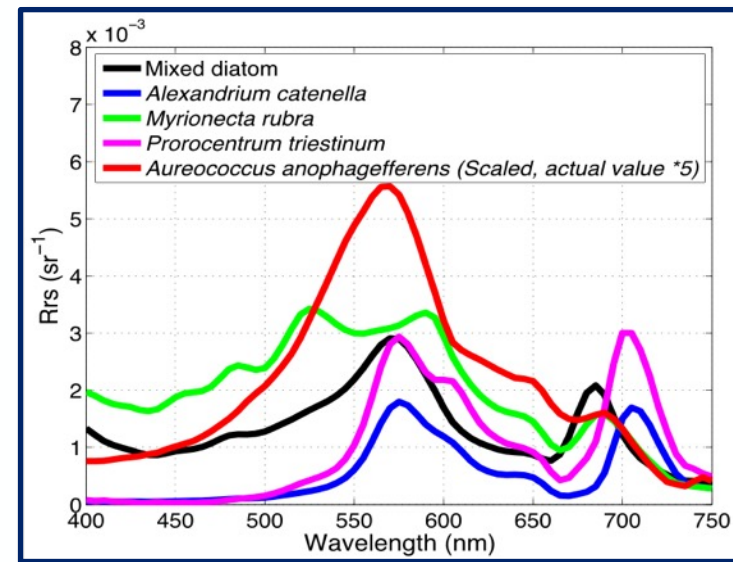
Blue: 464 - 517 nm
Green: 547 - 585 nm
Red: 650 - 682 nm
NIR: 846 - 888 nm

Coastal Blue 431-452 nm*
Blue: 465-515 nm
Green I: 513 - 549 nm
Green II: 547 - 583 nm*
Yellow: 600-620 nm*
Red: 650 - 680 nm
Red-Edge: 697 - 713 nm
NIR: 845 - 885 nm
(* avail. after 8-band release)





Important characteristics for Ocean Colour sensors



1. Spectral Resolution
2. Spatial Resolution...
3. SENSITIVITY!

What data are relevant to us?

Things we usually know when we ask this;

- What variables (we think!) we want
- What area and time period we want to cover

But, with satellite data, there many other things we should also take into consideration. We need to be specific about our “ask” before we start.

Because;

- Data is massive....really massive!
- Data is usually in different places
- Acquisition/download can be time consuming, so good to get it right!

What data are relevant to us?

Some additional considerations before you go looking for data (not exhaustive!);

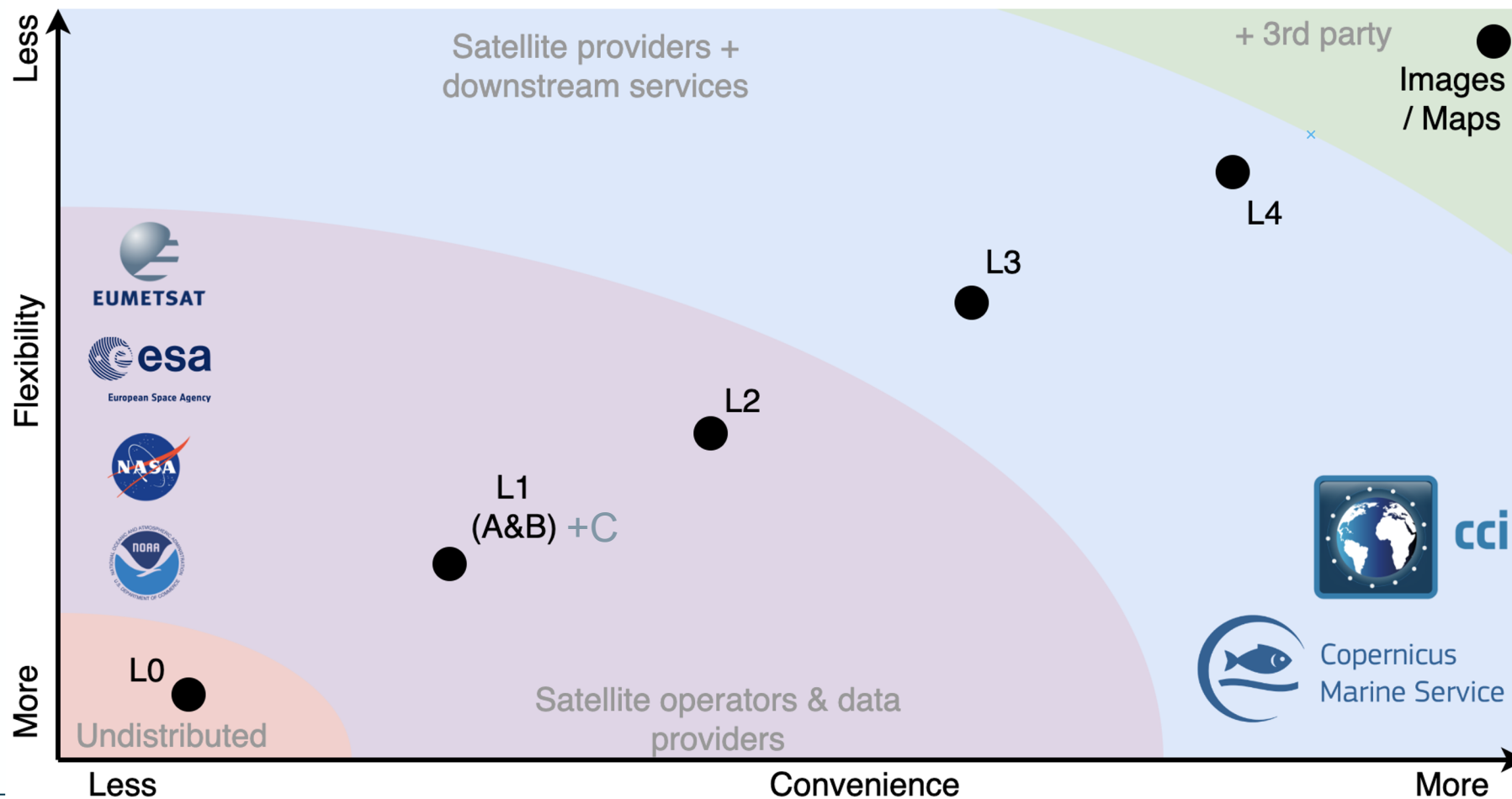
- Spatial coverage; does a satellite cover your area
- Spatial resolution; does a satellite give you the spatial detail we need (not always simple with S:N!)
- Spectral resolution; does a satellite have the radiometric channels you need?
- [CHL1] ≠ [CHL2] ≠ [CHL3]; are standard algorithms suitable for your needs?
- Temporal revisit; how often is your region sampled?
- Temporal resolution; is a time-average suitable or do you need a specific time?
- Quality vs availability; Reprocessings? Operational? Near real-time?
- Flagging; how much data is “lost” in your region? Is it really lost?
- Synergy; is a single-sensor or a multi-sensor product more appropriate?
- Format; can you “easily” work with the data?
- License; can you get the data?

Answers to these questions will determine where you should look for your data or interest!

Much depends on the “level” of data you can or need to use

Processing Level	Description
Level 0	Reconstructed, unprocessed instrument and payload data at full resolution, with communications artefacts removed. Not distributed.
Level 1 (a+b)	Reconstructed, unprocessed, top-of-atmosphere instrument data at full resolution, time-referenced, and annotated with ancillary information.
Level 2 (+p)	Derived geophysical variables at the same resolution and location as Level 1 source data. Usually atmospherically corrected.
Level 3	Variables mapped on uniform space-time grid scales , usually with some completeness and consistency. Except topography (L4)
Level 4	Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements, gap filled, temporally aggregated)

- Convenience: how easy is the data for you to use?
- Flexibility: how many decisions have already been made in processing the data?



B. Loveday

Data providers



copernicus.eumetsat.int



Completely non-exhaustive!... Lots of organisation – agencies (development, launch, operations, data processing and provision)...



B. Loveday





cci

Completely non-exhaustive!... Lots of organisation – agencies (development, launch, operations, data processing and provision), strategic programmes, downstream providers, scientific organisations, data & cloud services...

copernicus.eu/metadata



B. Loveday

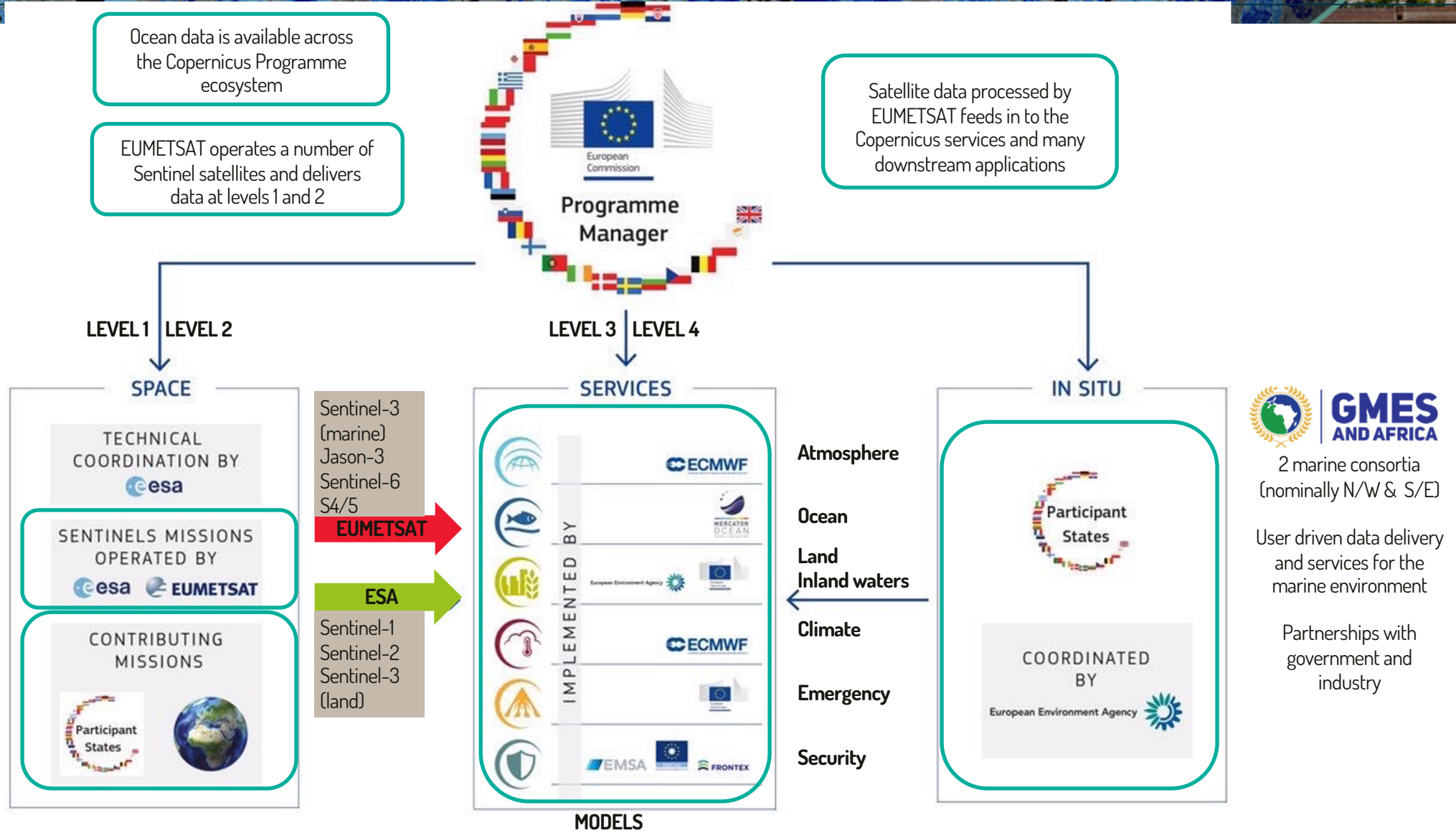
The Copernicus Programme



Ocean data is available across the Copernicus Programme ecosystem

EUMETSAT operates a number of Sentinel satellites and delivers data at levels 1 and 2

Satellite data processed by EUMETSAT feeds in to the Copernicus services and many downstream applications



B. Loveday



Data repositories



EUMETSAT

[Data Store \(GUI, API\)](#)

[Data Centre \(GUI, offline\)](#)

[EUMETCast \(Push\)](#)

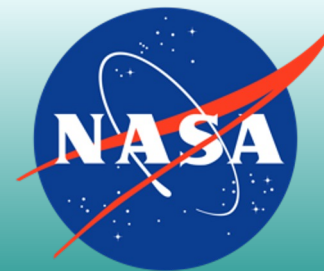
[EUMETView \(WebGIS\)](#)



**Copernicus
Marine Service**

[CMEMS Marine Data Store \(GUI, API\)](#)

[MyOcean Viewer \(WebGIS\)](#)



NASA

[EarthData \(GUI, API\)](#)

[DAAC network \(Browsers, GUI, API\)](#)

[EOSDIS WorldView \(WebGIS\)](#)



[Climate Data Store \(WebGIS, Toolbox, API\)](#)

[Atmospheric Data Store \(WebGIS, API\)](#)



European Space Agency

[Copernicus Data Space Ecosystem \(GUI, API\)](#)

[CCI Open Data Portal \(links\)](#)

[Ocean Virtual Laboratory](#)

New cloud data service mechanisms coming soon...

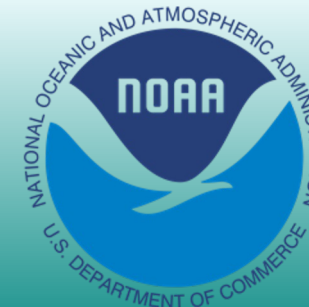


WEkEO

[WEkEO viewer \(GUI\)](#)

[Harmonised data access API](#)

[Cloud services](#)



NOAA

[CoastWatch Data Portal \(WebGIS, API\)](#)



[Various \(API, FTP\)](#)



[SentinelHub EO Browser](#)



Who has it?

- Here are some of the most likely sources for most of what you need (but probably nowhere near all!)

Processing Level	Stream				
	Ocean colour	Sea surface temperature	Surface topography	Radar	Ice
Level 1	<ul style="list-style-type: none"> EUMETSAT Data Store (OLCI) WEkEO (OLCI, MSD) NASA EarthData portal (MODIS+) ESA COAH (MSI) 	<ul style="list-style-type: none"> EUMETSAT Data Store (SLSTR, AVHRR) WEkEO (SLSTR) 	<ul style="list-style-type: none"> EUMETSAT Data Store (SRAL, S6) WEkEO (SRAL, S6) 	<ul style="list-style-type: none"> ESA COAH (S1) WEkEO (S1) 	
Level 2 (+p)	<ul style="list-style-type: none"> EUMETSAT Data Store (OLCI) WEkEO (OLCI) NASA EarthData portal (MODIS+) NOAA CoastWatch (VIIRS+) 	<ul style="list-style-type: none"> EUMETSAT Data Store (SLSTR, AVHRR) WEkEO (SLSTR) 	<ul style="list-style-type: none"> EUMETSAT Data Store (SRAL, S6) WEkEO (SRAL, S6) 	<ul style="list-style-type: none"> ESA COAH (S1) WEkEO (S1) 	<ul style="list-style-type: none"> EUMETSAT OSI SAF
Level 3	<ul style="list-style-type: none"> CMEMS Marine Data Store WEkEO ESA CCI Open Data Portal 	<ul style="list-style-type: none"> CMEMS Marine Data Store WEkEO ESA CCI Open Data Portal 	<ul style="list-style-type: none"> CMEMS Marine Data Store WEkEO 	<ul style="list-style-type: none"> CMEMS Marine Data Store WEkEO 	<ul style="list-style-type: none"> EUMETSAT OSI SAF CMEMS Marine Data Store WEkEO
Level 4	<ul style="list-style-type: none"> CMEMS Marine Data Store WEkEO ESA CCI Open Data Portal NOAA CoastWatch (VIIRS+) 	<ul style="list-style-type: none"> CMEMS Marine Data Store WEkEO ESA CCI Open Data Portal NASA EarthData Hub NOAA CoastWatch 	<ul style="list-style-type: none"> CMEMS Marine Data Store WEkEO ESA CCI portal 	<ul style="list-style-type: none"> CMEMS Marine Data Store WEkEO 	<ul style="list-style-type: none"> EUMETSAT OSI SAF CMEMS Marine Data Store WEkEO ESA CCI portal

B. Loveday

Where to obtain images?

Some things to be aware of when “data shopping”;

- Who has what is not always well advertised (but getting better!)
- Collections and products are not always 100% described (test first!)
- There is replication, and it is not always transparent (cloud services are particularly bad at this; ask questions of the provider!)

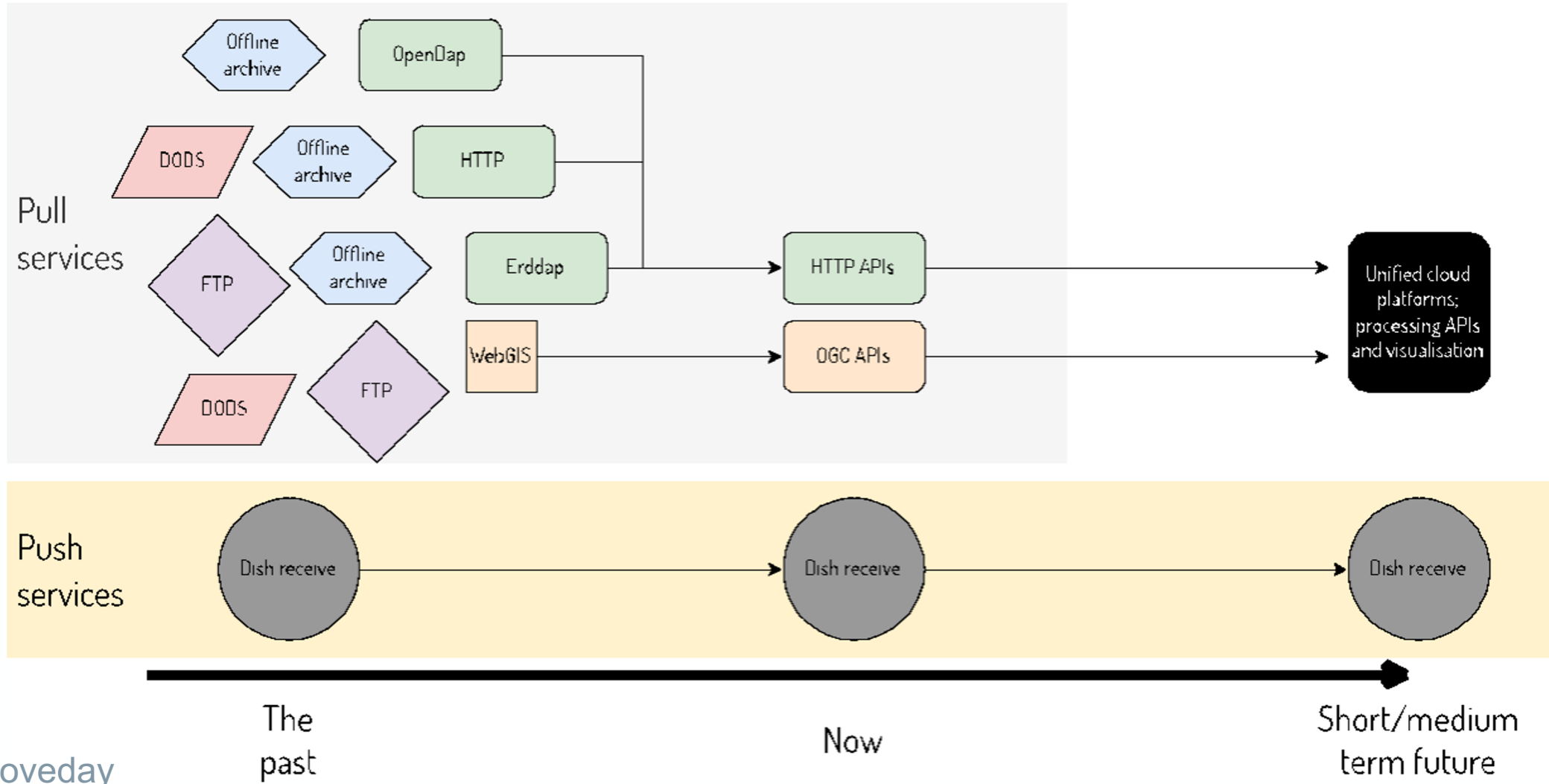
Formats are starting to change:

- For now, mostly netCDF (including Sentinel SAFE format)
- Future moves to CoG or ZARR for better cloud optimisation and new access methods.

Storage architecture is starting to change:

- Object storage (e.g. S3 buckets)
- New ways to catalogue data (e.g. STAC)

How the data delivery landscape is changing



B. Loveday

How to get the data



WebUI: machine to human

The screenshot shows the EUMETSAT Data Services WebUI. The top navigation bar includes 'Data Access / Advanced search results', 'API Access', 'Cart', '4 Items', and 'Login'. The main content area displays search results for 'OLCI'. A search box contains 'OLCI' and a 'We've found 10 results' message. Below this, there are two main product listings:

- OLCI Level 1B Full Resolution - Sentinel-3**: Description: OLCI (Ocean and Land Colour Instrument) Full resolution, 300m at nadir. Level 1 products are calibrated Top Of Atmosphere radiances values at OLCI 21 spectral bands. Radiances are computed from the instrument digital counts by applying geo-referencing, radiometric processing from binary correction, smear correction, dark offset correction, absolute gain.
- OLCI Level 1B Reduced Resolution - Sentinel-3**: Description: OLCI (Ocean and Land Colour Instrument) Reduced resolution, 600m at nadir. Level 1 products are calibrated Top Of Atmosphere radiances values at OLCI 21 spectral bands. Radiances are computed from the instrument digital counts by applying geo-referencing, radiometric processing from binary correction, smear correction, dark offset correction, absolute gain.

The interface includes various filters and options on the left side, such as Platform (EARTHDATA), Sensor Type (EARTHDATA SEARCH), Sensor (GHRSSST-MUR), and Data Policy (Granule Search). A table of search results is visible, showing columns for Date, Product, Platform, and Size. The bottom of the page has 'CONTACT' and 'LEGAL INFORMATION' links.

API: machine to machine

The screenshot shows the EUMETSAT Data Services API interface. The top navigation bar includes 'SERVICES', 'DATA', 'COMPUTING', 'USE CASES', and 'SUPPORT'. The main content area displays an XML response for a search request. The XML is truncated, showing the beginning of the response structure. Below the XML, there is an 'OPeNDAP Dataset Access Form' with the following details:

- Action:** Get ADCI | Get Binary | Show Help
- Data URL:** https://www.oceancolour.org/feeds/iodc/OLCI_w43-DAILY
- Global Attributes:** Content-Type: CP-1.7, Start_Date: 20-DEC-2019 00:00:00, Stop_Date: 30-DEC-2019 23:59:00, Metadata_Convention: OPeNDAP Dataset Discovery v1.0, Data_Type: Grid
- Variables:** Array of 32 Bit Reals (bit = 0.4319)

The bottom of the page shows a map interface with a 'Sea water velocity' layer selected. An 'API request' dialog box is open, showing the request details and the resulting XML response. The XML response is truncated, showing the beginning of the response structure. The bottom of the page has 'CONTACT' and 'LEGAL INFORMATION' links.

B. Loveday



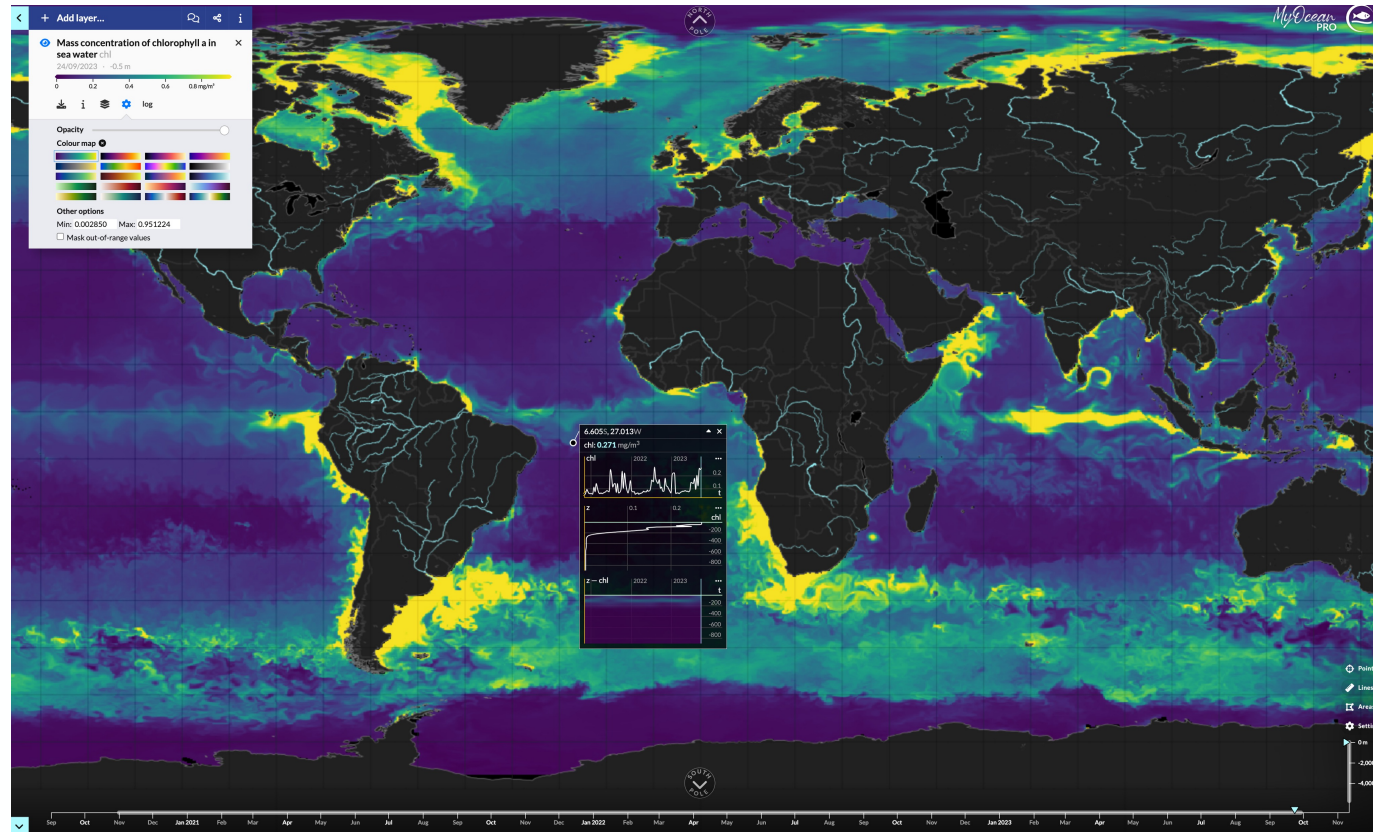
Copernicus Products: ocean in CMEMS



Copernicus Marine Data Store



Home > Marine Data Store



Filters

- FREE-TEXT SEARCH
Free text
- FAVOURITES ★ 0
- TIME RANGE
dd/mm/yyyy - dd/mm/yyyy
Covering full interval
- WITH DEPTH 39
- DEPTH RANGE
- UNIVERSE
Blue Ocean 189
White Ocean 39
Green Ocean 78
- MAIN VARIABLES
Carbonate system 19
Mixed layer thickness 17
Nutrients 16
Optics 45
Organic carbon 2
Oxygen 25
Plankton 75
Salinity 37
Sea ice 35
Sea surface height 47
Surface density 17
Temperature 85
Velocity 58
Wave 14
Wind 8
- AREA
Global Ocean 301
Arctic Ocean 3
Atlantic: Iberia-Biscay-Ireland 44
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Global Ocean Physics Analysis and Forecast
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Models
Global, 0.083° × 0.083° × 50 levels
1 Nov 2020 to 2 Oct 2023, hourly, daily...
Mixed layer thickness, salinity, sea ice, sea surface height, temperature, velocity, wave...

Global Ocean Biogeochemistry Analysis and Forecast
GLOBAL_ANALYSIS_FORECAST_B_..._001_028
Models
Global, 0.25° × 0.25° × 50 levels
1 Nov 2020 to 29 Sep 2023, daily, monthly
Carbonate system, nutrients, oxygen, plankton

Global Ocean Physics Reanalysis
GLOBAL_MULTYEAR_PHY_001_030
Models
Global, 0.083° × 0.083° × 50 levels
1 Jan 1993 to 31 Dec 2020, daily, monthly
Mixed layer thickness, salinity, sea ice, sea surface height, temperature, velocity

Global O Surface
SEALEVEL_1
Satellite L4
Global, 0.25° × 0.25° × 50 levels
1 Jan 1993
Sea surface

NEW IN COPERNICUS MARINE

Mediterranean Meridional Overturning Circulation
MOC_CIRCULATION_MOC_MEIS_..._ed_m...
Med Sea
1 Jan 1987 to 31 Dec 2020, yearly

Nutrient and carbon profiles vertical distribution
MUTIS_GLO_BGC_NUTRIENT_..._015_009
In-situ
Global
1 Sep 2002 to 31 Aug 2022, instantaneous
Carbonate system, nutrients, oxygen, salinity, temperature

Antarctic Ocean - High Resolution Sea Ice Information
SEANCE_ANT_PHY_AUTO_L3_NRT_01_012
Satellite L4
Global, 1° × 1 km
1 Jan 2021
Temperature

ODYSSEY Temper
SST_04_2P
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Global, 0.1° × 0.1° × 1 km
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BLUE OCEAN

Global Ocean Physics Analysis and Forecast
GLOBAL_ANALYSISFORECAST_P_..._001_024
Models
Global, 0.083° × 0.083° × 50 levels
1 Nov 2020 to 2 Oct 2023, hourly, daily...
Mixed layer thickness, salinity, sea ice, sea surface height, temperature, velocity, wave...

Global Ocean Waves Analysis and Forecast
GLOBAL_ANALYSISFORECAST_W_..._001_027
Models
Global, 0.083° × 0.083° × 50 levels
1 Jan 2021 to 2 Oct 2023, hourly
Velocity, wave

Global Ocean Physics Reanalysis
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Models
Global, 0.083° × 0.083° × 50 levels
1 Jan 1993 to 31 Dec 2020, daily, monthly
Mixed layer thickness, salinity, sea ice, sea surface height, temperature, velocity

Global O Reanalysis
GLOBAL_RE
Models
Global, 0.25° × 0.25° × 50 levels
1 Jan 1993
Mixed layer height, tem

WHITE OCEAN

Global Arctic - Arctic and Antarctic - Sea Ice...
SEANCE_GLO_SEANCE_I4_NRT_08_..._011_001
Satellite L4
Global, 10 × 10 km
Since 4 May 2019, daily
Sea ice

Global Ocean - High Resolution SAR Sea Ice Drift
SEANCE_GLO_SEANCE_I4_NRT_08_..._011_006
Satellite L4
Global, 10 × 10 km
Since 4 May 2019, irregular
Sea ice

Arctic Ocean - Sea Ice Concentration Charts - Svalbar...
SEANCE_ARC_SEANCE_I4_NRT_08_..._011_002
Satellite L4
Arctic, 1° × 1 km
Since 4 May 2019, daily, irregular
Sea ice

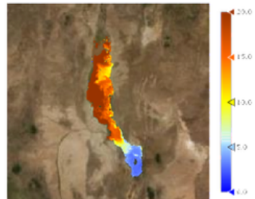
SAR Sea Ice and Indiv
SEANCE_I4N
Satellite L4
Arctic, 10 × 10 km
Since 4 May 2019, irregular
Sea ice



Lake Water Quality 2016-present (raster 300 m), global, 10-daily - version 1

General Info

Download



Provides semi-continuous observations for a large number of medium and large-sized lakes, according to the Global Lakes and Wetlands Database (GLWD) or otherwise of specific environmental monitoring interest. 10-daily observations are available in near real time in the spatial resolution of 300 m and with the temporal extent from 2016 to present.

Validation status

Validated

See the Quality section for detailed information.

Dataset citation

You can find instructions on how to cite CLMS data in our [Data policy](#) section.

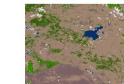
Characteristics

Spatial coverage: Global	Temporal extent: 2016-present	Type: Satellite observations
Spatial resolution: 300 m	Temporal usability: Archive with regular updates	Sensor: Sentinel-3 OLCI
Spatial representation: Grid	Update frequency: AsNeeded	
	Timeliness: Within 3 days after the end of the synthesis period	

Access full metadata here

- [Lake Water Quality: global 10-daily Near-Real Time \(raster 300m\) - version 1, May 2018 - PDF - XML](#)

Water Bodies



- Main
- Applications & use cases
- User outreach
- Roadmap

Water is fundamental to life on Earth. Water quality, including aspects like turbidity and trophic state, is vital for assessing a water body's ecological well-being and its suitability for drinking. Understanding the water's surface temperature is key for monitoring climate change and can influence weather patterns. Tracking water levels in lakes and rivers helps in flood prediction, irrigation planning, and hydroelectric power generation. The presence and extent of ice on lakes and rivers can have significant implications for regional climates, ecosystems, and human activities. Moreover, the surface extent of water bodies, whether permanent or ephemeral, informs land management across various sectors. In an era marked by environmental change, these metrics offer insights into sustainable water resource management.

The Water Bodies product group aims to address these critical issues by providing tailored datasets to users which are applicable across a wide array of sectors. It includes Lake Surface Water Temperature, providing real-time and historical data; Lake Water Quality in various resolutions; Water Bodies datasets for surface extent; Lake and River Water Level Information; the River and Lake Ice Extent product for ice presence; and the Aggregated River and Lake Ice Extent product, showing percent ice coverage. These products support applications like food security, public health safeguarding, climate studies, and responsible water management practices.

Technical summary

Datasets

Water Bodies

River and Lake Water Level

Lake Water Quality

Lake Water Quality 2019-present (raster 100 m), global, 10-daily - version 1
Provides semi-continuous observations for a large number of medium and large-sized lakes, according to the Global Lakes and Wetlands Database (GLWD) or otherwise of specific environmental monitoring interest. 10-daily observations are available in near real time in the spatial resolution of 100 m and with the temporal extent from 2019 to present.

[View more](#) [Download](#)

Lake Water Quality 2016-present (raster 300 m), global, 10-daily - version 1
Provides semi-continuous observations for a large number of medium and large-sized lakes, according to the Global Lakes and Wetlands Database (GLWD) or otherwise of specific environmental monitoring interest. 10-daily observations are available in near real time in the spatial resolution of 300 m and with the temporal extent from 2016 to present.

[View more](#) [Download](#)

Lake Water Quality 2016-2018 (raster 1 km), global, 10-daily - version 1
Provides semi-continuous observations for a large number of medium and large-sized lakes, according to the Global Lakes and Wetlands Database (GLWD) or otherwise of specific environmental monitoring interest. 10-daily observations are available in the spatial resolution of 300 m and with the temporal extent from 2016 to 2018.

[View more](#) [Download](#)

Lake Water Quality 2002-2012 (raster 300 m), global, 10-daily - version 1
Provides semi-continuous observations for a large number of medium and large-sized lakes, according to the Global Lakes and Wetlands Database (GLWD) or otherwise of specific environmental monitoring interest. 10-daily observations are available in the spatial resolution of 300 m and with the temporal extent from 2002 to 2012.

[View more](#) [Download](#)

Lake Water Quality 2002-2012 (raster 1 km), global, 10-daily - version 1
Provides semi-continuous observations for a large number of medium and large-sized lakes, according to the Global Lakes and Wetlands Database (GLWD) or otherwise of specific environmental monitoring interest. 10-daily observations are available in the spatial resolution of 1 km and with the temporal extent from 2002 to 2012.

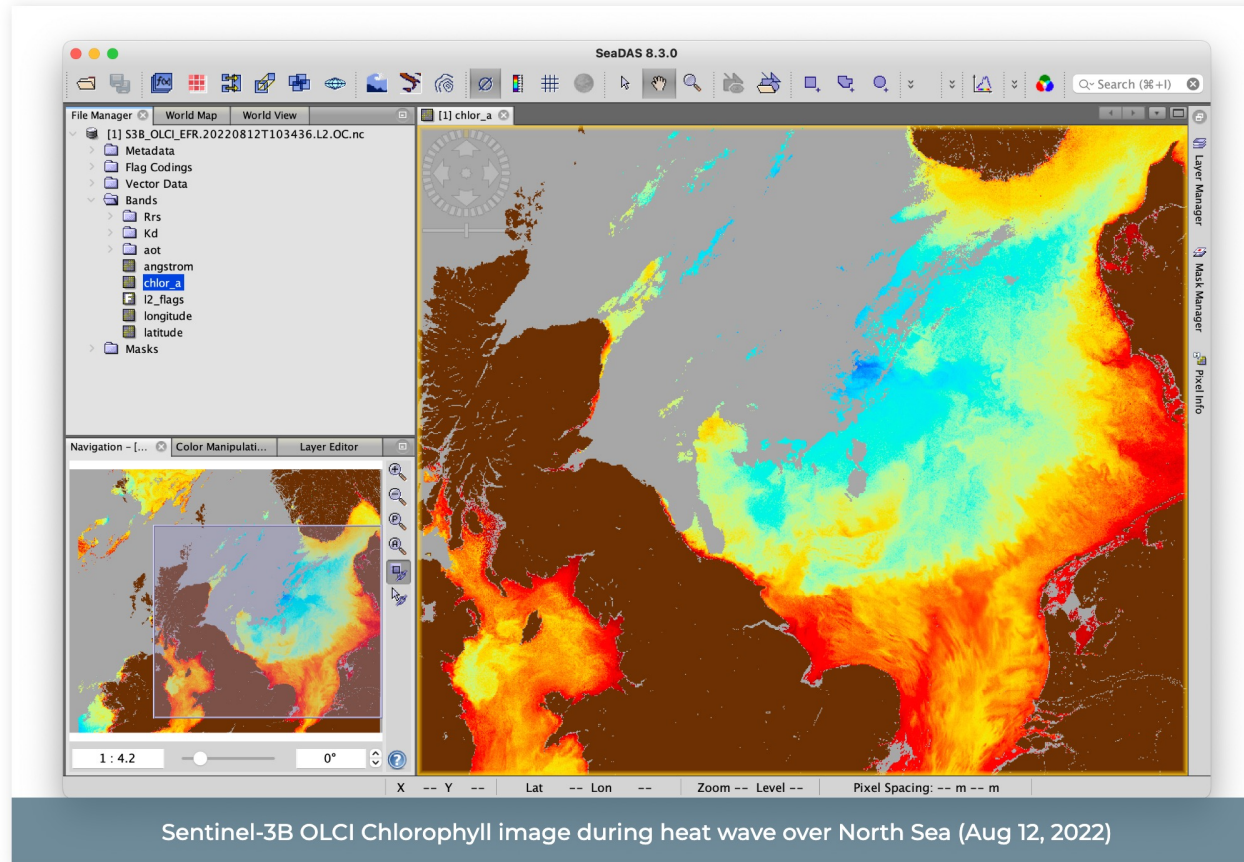
[View more](#) [Download](#)

River and Lake Ice Extent

Temporary Release Available: SeaDAS 8.3.10 (Mac OS only) release fixes incompatibility issue with MacOS 13 Ventura

The Official NASA/OB.DAAC Data Analysis Software

Last update: SeaDAS 8.3.0 (December 12, 2022), SeaDAS 8.3.10 (June 14, 2023)



Sentinel-3B OLCI Chlorophyll image during heat wave over North Sea (Aug 12, 2022)

Features

- » Visualization
- » Science Processing
- » Statistics

Requirements

Operating Systems

- » Linux: tested on Ubuntu (16.04 LTS)
- » Intel Mac: OS X 10.12
- » Windows: 10

View the [complete list](#) of suggested hardware & configuration requirements for supported systems.

Version History

View release notes and download historical versions of the SeaDAS software package.

- » Latest Release: [8.3.10 \(Mac only\)](#)
- » [Previous versions](#)

SeaDAS is a comprehensive software package for the processing, display, analysis, and quality control of ocean color data. While the primary focus of SeaDAS is

How to process data: programming languages

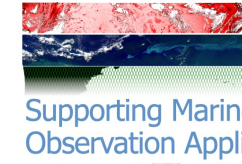


Some examples and demos can be found in the following links (among many others):

Python: <https://youtu.be/ZyCkVI7k3eo?si=I93ltnDNDQtjerV4>

Julia: https://youtu.be/BT0IA_59jAU?si=i3Gu4520ocQWnKCN

EUMETSAT Supporting Marine Earth Observation Applications (SMA) training course 2022

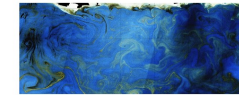


The EUMETSAT Supporting Marine Earth Observation Applications (SMA) training course, conducted in partnership with the Oceanography & Earth Observation Group of the National and Kapodistrian University of Athens, will share knowledge, skills, resources and code so attendees are able to independently access and process data from the EUMETSAT product catalogue for their marine work-flows and applications. The SMA course will support data streams from EUMETSATs Copernicus marine missions (Sentinel-3; Sentinel-6) and derived downstream products, those derived from Copernicus supporting missions, and those made available by the Ocean and Sea-Ice Satellite Application Facility (OSI-SAF).



Self-Paced phase: 31 Oct - 18 Nov 2022, online
Classroom phase: 21 - 25 November 2022, online

Using the Copernicus Marine Data Stream for Ocean Applications – Summer Course



CMDS Summer Course

31 May - 25 June 2021

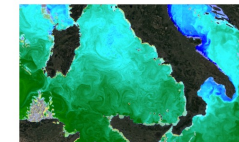
CMDS for Operational Services - Ocean Applications (2021)



The purpose of this EUMETSAT Copernicus Marine Data Stream (CMDS) training workshop is to share knowledge, skills, resources and code so that attendees are independently able to access and process Sentinel-3 data for their marine workflows and applications.

26 April - 7 May 2021

Operational Satellite Oceanography symposium 2021



This course will offer an overview of the operational aspects of the Copernicus Marine Data Stream (CMDS) and the NOAA CoastWatch program. Topics covered will include ocean satellite data products (SST, ocean colour, salinity, altimetry, winds, ...), how CMEMS assimilates data into operational models and Level 4 multi sensor products, Data download APIs and ways in which data retrieval and processing can be scripted, and an overview of the ERDDAP data platform and CoastWatch data portal.

28 May 2021

CMDS Essentials Pack for Ocean Applications | self-paced learning



SNAP

SeNtinel
Applications
Platform



SNAP is

an ecosystem to analyse, process and communicate Earth Observation data
an Open-Source Project - github.com/senbox-org
scalable to run on notebooks up to large production clusters
used for scientific analysis, operational production and training
easy to use

SNAP can

access many satellite-based Earth Observation data products as well as generic raster formats directly in the cloud
visualise the data in many ways
analyse data using statistical functions, mathematical operations, correlation, comparison with point and vector data
process satellite data with instrument specific as well as generic raster data operations
save sessions and export results in various raster and non-raster formats
be extended using Java and Python API

SNAP has

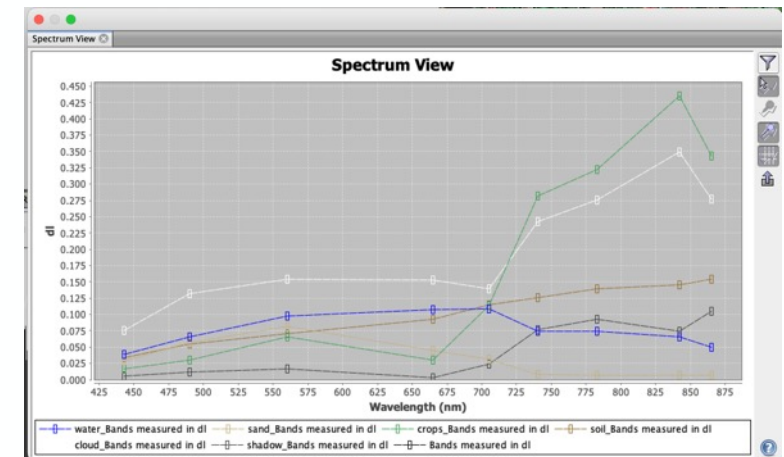
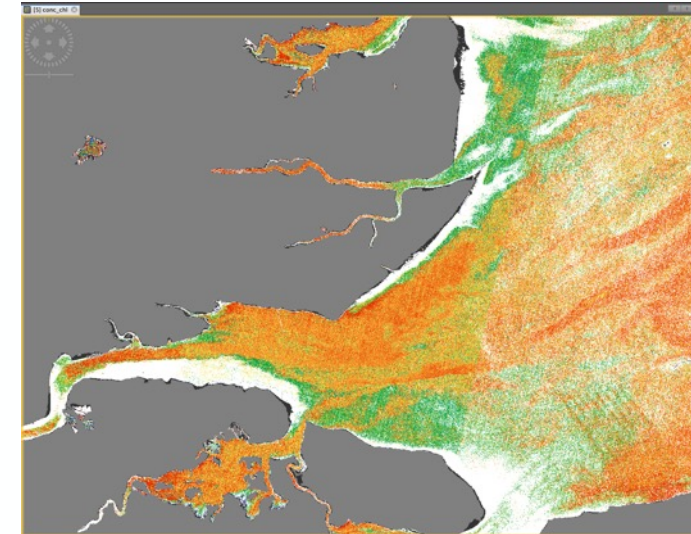
comprehensive documentation - step.esa.int
> 1 Million users and active community, > 10 000 forum users – forum.step.esa.int
a long-term commitment of the European Space Agency



SNAP Desktop is the GUI application which allows access to a large number of EO and generic raster data.

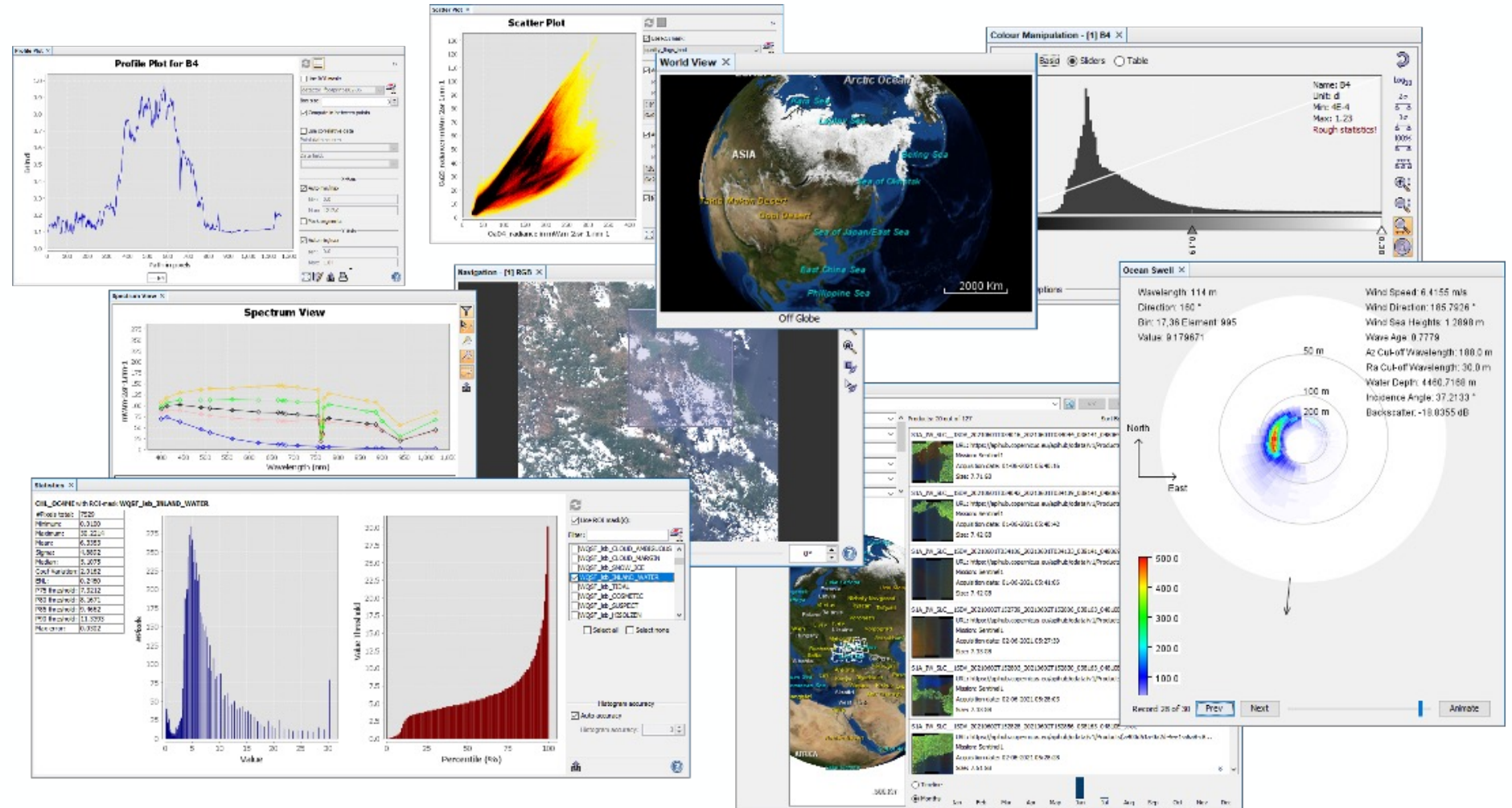
It provides various tools to display the data, and to visually analyse them.

The figure on the right shows an RGB of a Sentinel 2 product together with a visualisation of a water quality parameter (right panel). Bottom right show the spectral plots at places marked by PINs.



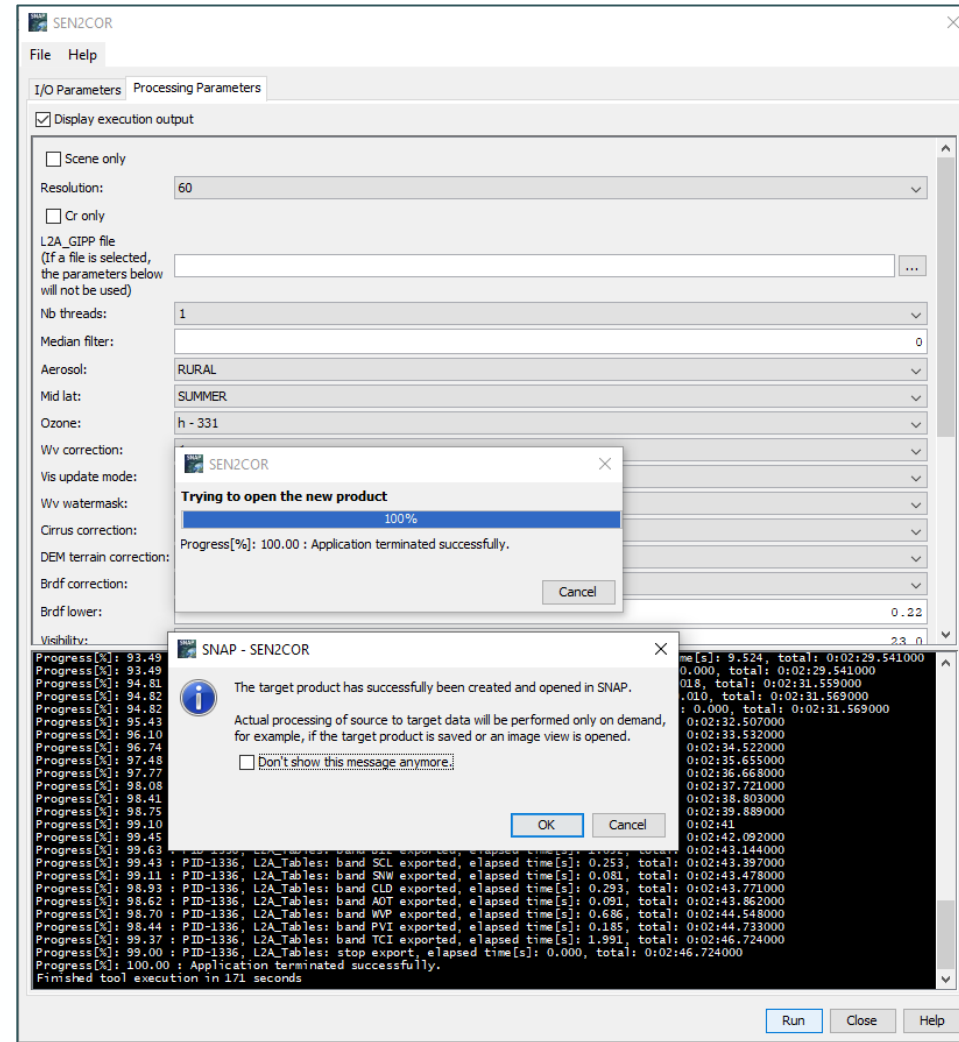
SNAP provides a rich suite of tools for data analysis, including profile and spectrum plots, statistical analysis, extraction of points through time series, and comparison with reference data (match-ups).

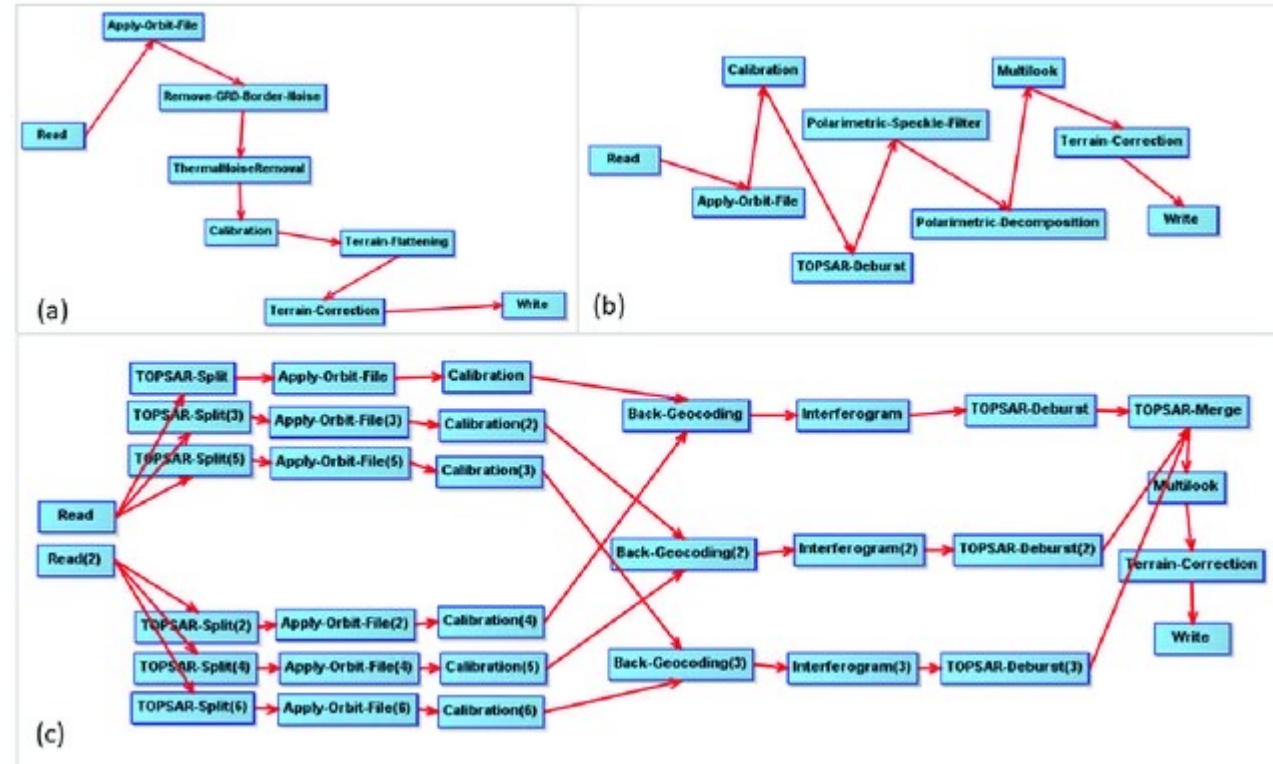
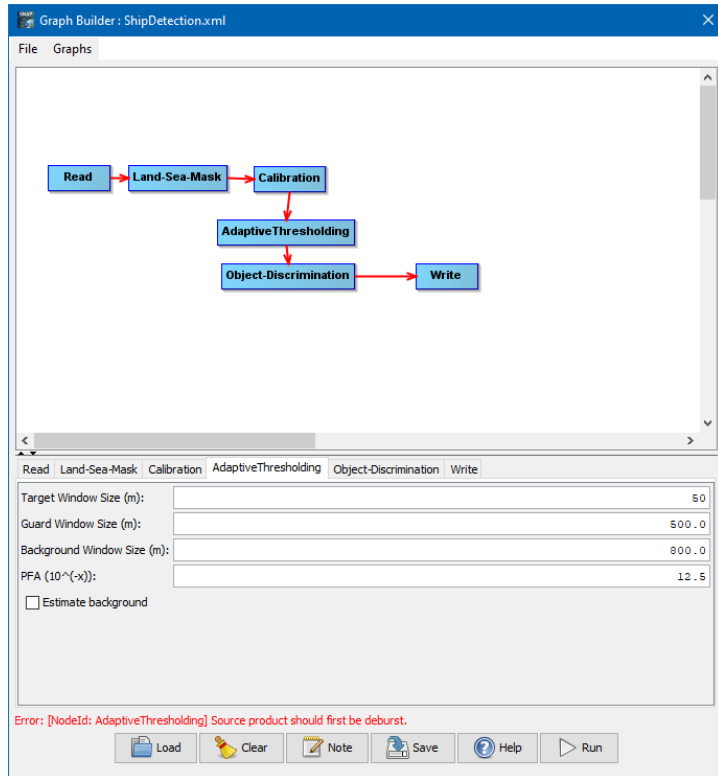
The figure shows some of the graphical analysis tools included in SNAP.



SNAP Data Processors analyse one or more input products and generate a new output product. Processors exist for generic operations such as band arithmetic, map projection or temporal aggregation. SNAP also provides a very large number of thematic processors, e.g. for atmospheric correction, biophysical indices calculation or retrieval of water quality. And SNAP supports special calibration of correction of satellite instruments with dedicated processors.

The figure shows the GUI for the Sentinel-2 Atmospheric Correction Processor `sen2cor`. The screenshot was taken when the processor was successfully executed. The black background shows the logging information during execution of the processor.





The SNAP graph builder allows to connect SNAP operators in processing graphs. These can be executed locally or in large clusters and cloud systems.

Example: Workflows in the SNAP graph builder tool for producing Synthetic Aperture Radar (SAR) analysis ready data (ARD) products. From Ticehurst, et al (2019). Building a SAR-Enabled Data Cube Capability in Australia Using SAR Analysis Ready Data. Data. 4. 100. 10.3390/data4030100.

User Forum

step forum

all categories ▾ Categories Latest Top

Category Topics

s1tbx 29 / month

The S1 Toolbox category regroups all threads about the Sentinel-1 Toolbox, as SAR readers or processors.

■ Problem Reports ■ Interferometry ■ Polarimetry ■ StaMPS
■ PyRate ■ snaphu

s2tbx 15 / month

The S2 Toolbox category regroups all threads about the Sentinel-2 Toolbox as Sentinel-2 product readers and product manipulation, Sentinel-2 processors as L2A processor for atmospheric correction, L3 processor for temporal synthesis, etc.

■ sen2cor ■ sen2three ■ Problem Reports ■ sen2like

s3tbx 2 / month

The S3 Toolbox category regroups all threads about the Sentinel-3 Toolbox as readers and processors for Sentinel-3 OLCI & SLSTR L1 & L2. Useful information about Sentinel-3 and the data can found at the [S3VT Documentation page](#).

■ Problem Reports

Issue Tracker

SNAP Ihre Aufgaben ▾ Projekte ▾ Filter ▾ Dashboard

Landing Page

Projekte

- CHRIS-Box (CHRIS)**
Leitung: Marco Peters
- Sentinel-1 Toolbox (SITBX)**
Leitung: Luis Veci
- Sentinel-2 Toolbox (SIITBX)**
Leitung: Florian Douzich
- Sentinel-3 Toolbox (SIITBX)**
Leitung: Marco Peters
- Sentinel Application Platform (SNAP)**
Leitung: Marco Peters
- SMOS Toolbox (SMOSTBX)**
Leitung: Tom Block
- SNAP Requirements Monitoring (SRM)**
Leitung: Marco Peters
- SNAP User Feedback (SUF)**
Leitung: Oana Hogoiu

Tutorials

DOCUMENTATION

Tutorials

Found 70 tutorials

- SNAP (GENERAL TOOLBOX USAGE)
- SENTINEL-1 TOOLBOX (SAR APPLICATIONS)
- SENTINEL-2 TOOLBOX (HIGH RESOLUTION OPTICAL APPLICATIONS)
- SENTINEL-3 TOOLBOX (MEDIUM RESOLUTION OPTICAL APPLICATIONS)
- ESA TRAINING COURSES (ESA TRAINING COURSES)
- EXTERNAL RESOURCES (EXTERNAL RESOURCES)
- OTHER (OTHER TUTORIALS)

ALL (ALL TUTORIALS)

For Developers

COMMUNITY

Developers

Source code

We are using Git to keep track of code changes, and the source code is available on [GitHub](#). We highly encourage fixes and new features made to the code be submitted to the [main branch](#).

SNAP API Documentation

For developers who want to extend or patch SNAP we provide the Javadoc here:

- [SNAP Engine API Documentation](#)
- [SNAP Desktop API Documentation](#)

License

The Sentinel Toolboxes and full source code is open-source software and is distributed under the [GNU GPL](#).

Wiki

The [Developers Wiki](#) contains valuable resources for getting familiar with the software.

Forum

There is a dedicated section in the [Forum](#) for development-oriented topics.

SNAP Community and Tutorials

<http://forum.step.esa.int/c/s3tbx>
<http://step.esa.int/main/doc/tutorials/>
<https://senbox.atlassian.net/wiki/spaces/SNAP/pages/1898053693/SNAP+FAQs>

SENTINEL-3 TOOLBOX (MEDIUM RESOLUTION OPTICAL APPLICATIONS)

ESA TRAINING COURSES (ESA TRAINING COURSES)

EXTERNAL RESOURCES (EXTERNAL RESOURCES)

OTHER (OTHER TUTORIALS)

ALL (ALL TUTORIALS)

Showing [1 ... 6] from 6 Sort By (Tutorial)

Search for specific tutorials...

<p>DOCUMENT Data conversion and export for Sentinel-3</p> <p>A short guide on converting and exporting Sentinel-3 data to GeoTIFF format for use in GIS software. This guide is kindly provided by our users Ankafropkova and hnl17 in the forum.</p> <p>MARCH 1, 2017 ADMIN</p> <p>JUNE 22, 2018 MARPET</p> <p>READ →</p>	<p>VIDEO Download & Visualise Sentinel-3 Data</p> <p>EUMETSAT shows how to download and visualise their provided Sentinel-3 data with the Sentinel-3 Toolbox.</p> <p>MARCH 1, 2017 ADMIN</p> <p>PLAY →</p>	<p>DOCUMENT Introduction to Sentinel-3 Toolbox</p> <p>This presentation gives a general introduction to the usage of the Sentinel-3 Toolbox.</p> <p>JUNE 1, 2015 ADMIN</p> <p>READ →</p>	<p>DOCUMENT Rayleigh Correction Tutorial (S3 OLCI, MERIS, S2 MSI)</p> <p>Introduction to the Rayleigh correction provided by the Sentinel-3 Toolbox. The document gives information on the correction.</p> <p>JUNE 16, 2021 ANA B. RUESCAS, DAGMAR MÖLLER</p> <p>READ →</p>	<p>DOCUMENT S3TBX Collocation Tutorial</p> <p>The tutorial explains how to collocate satellite data and which technical and scientific considerations need to be made. Even the examples focus on the collocation of Sentinel-3, Sentinel-2 and Sentinel-1.</p> <p>OCTOBER 7, 2022 ANA B. RUESCAS, MARCO PETERS</p> <p>READ →</p>
---	---	---	--	--



Dear SNAP users,

We would love to have your feedback on your SNAP experience. It would help us to know which are the things that should be improved and taken into consideration for the future, so that you will be satisfied when using SNAP.

Please take an anonymous survey in order to help us helping you:
[SNAP User Survey](#)

Many thanks from SNAP Team!

all categories ▾ **Categories** Latest New (2) Unread (275) Top + New Topic

Category	Topics	Latest
s1tbx The S1 Toolbox category regroupes all threads about the Sentinel-1 Toolbox, as SAR readers or processors. 5.6k 60 unread ■ Problem Reports 12 unread ■ Interferometry 2 unread ■ Polarimetry ■ StaMPS 3 unread ■ PyRate ■ snaphu 2 unread	<ul style="list-style-type: none"> Failure to import ICEYE H5 file and solution 0 10h ■ Problem Reports Error while running snaphu-unwrapping 0 11h ● snaphu COSMO-SkyMed Coreg_ifg_subset Error 10 20h ■ s1tbx 	
s2tbx The S2 Toolbox category regroupes all threads about the Sentinel-2 Toolbox as Sentinel-2 product readers and product manipulation, Sentinel-2 processors as L2A processor for atmospheric correction, L3 processor for temporal synthesis, etc. 2.5k 61 unread ■ sen2cor 16 unread ■ sen2three ■ Problem Reports 7 unread ■ sen2like	<ul style="list-style-type: none"> Snap2stamps error 239 20h ■ StaMPS Mosaicking of SAR SLC images 0 22h ■ Interferometry NESZ of Radarsat-2 0 22h ■ s1tbx Atmospheric Correction for InSAR 119 23h ■ s1tbx 	
s3tbx The S3 Toolbox category regroupes all threads about the Sentinel-3 Toolbox as readers and processors for Sentinel-3 OLCI & SLSTR L1 & L2. Useful information about Sentinel-3 and the data can found at the S3VT Documentation page. 579 21 unread 1 new ■ Problem Reports 3 unread	<ul style="list-style-type: none"> Uav_sar_snap 0 1d ● snap ps_plot velocity 12 1d ■ StaMPS Phase to displacement theory 0 1d ● Show Room SNAP software Back-Geocoding Error 0 1d ■ Problem Reports 	
snap This category contains all topic about the Sentinel Toolbox Application (SNAP) not related to a specific Sentinel Toolbox. 2.2k 114 unread 1 new	<ul style="list-style-type: none"> No_initial_PS_candidates (sentinel-1) 0 1d ■ Problem Reports UNITS of sentinel 3 0 1d ■ s3tbx 	

06/2023 – SNAP 10

- Optical and Microwave Toolboxes
- Large software renovation
- Documentation update
- Making it technologically future proof

12/2023 – SNAP 11

- Product Groups
- STAC support (Spatio-Temporal Asset Catalogue)
- Preparing for hyperspectral CHIME and microwave CIMR

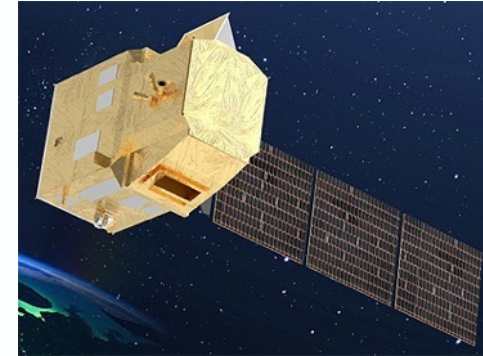
06/2024 – SNAP 12

- Change detection Toolbox

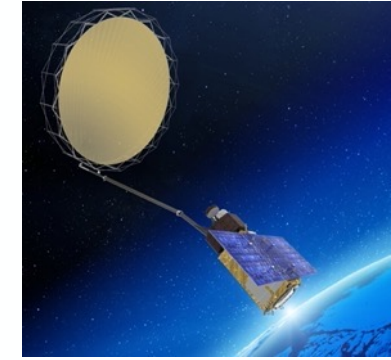
12/2024 – SNAP 13

- Support NISAR, BIOMASS
- Time series tools

Optical Toolbox
With future CHIME support



Microwave Toolbox
with future CIMR support



Thank you!

Questions are welcome.

Contact and further
information

ana.ruescas@brockmann-consult.de