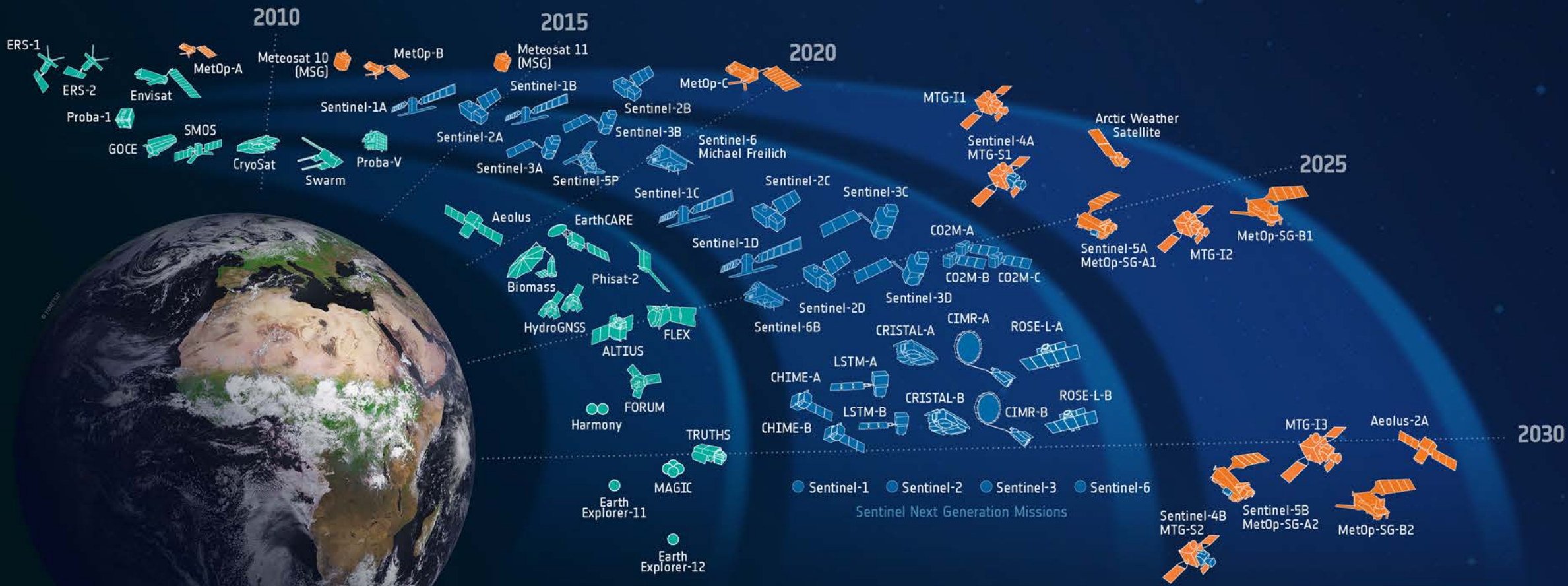


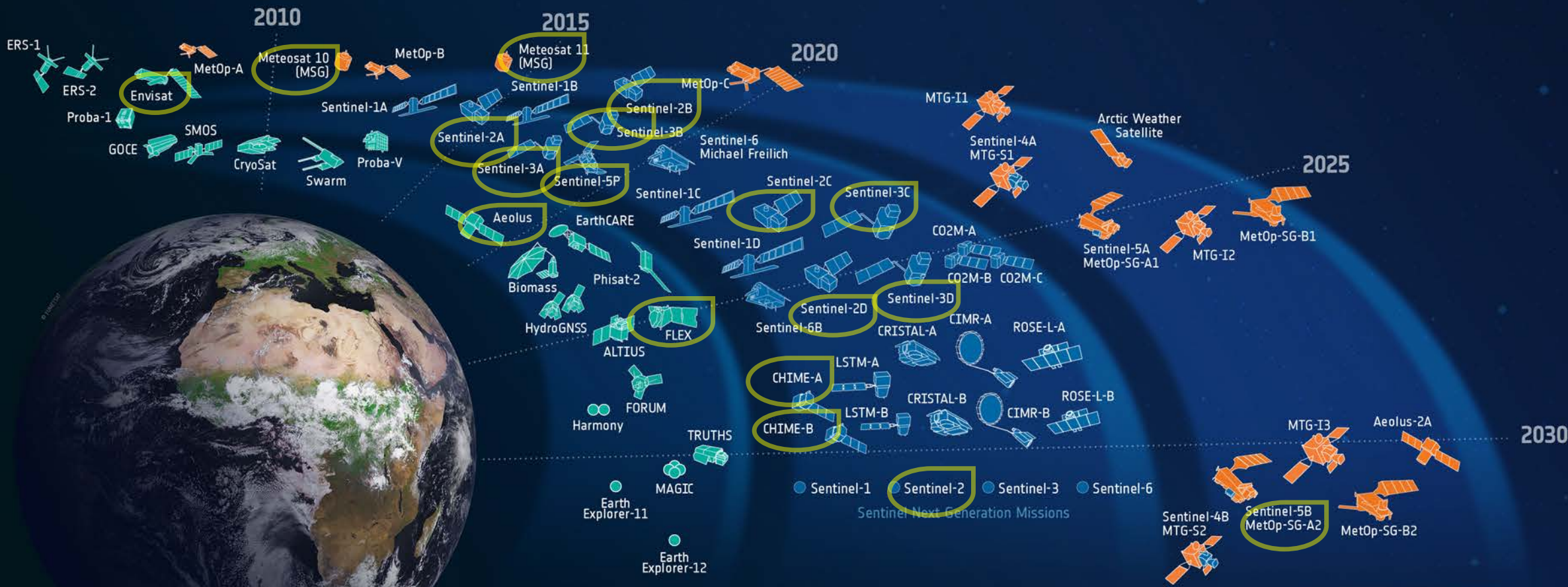
Ocean Colour Remote Sensing Science and Applications at the European Space Agency

Marie-Helene RIO, ESA-ESRIN

ESA-DEVELOPED EARTH OBSERVATION MISSIONS



ESA-DEVELOPED EARTH OBSERVATION MISSIONS



Ocean Science and Applications Projects (>35 on-going)

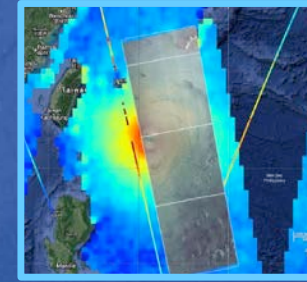


Ocean Health and Biodiversity



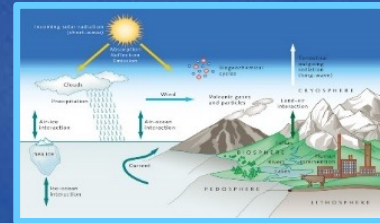
- WQ-FC
- MedEOS
- BiCOME
- Eu-Mon
- Sargassum
- MedEOS
- POSEIDON
- Ocean Health - Open Ocean Biodiversity
- Ocean Health - Acidification

Ocean Extremes



- CAREHeat
- MAXSS
- CYMS
- Polar Lows Prediction
- MITHO

Ocean's role in Earth and Climate System



Coastal Ocean incl. Land-Sea interactions



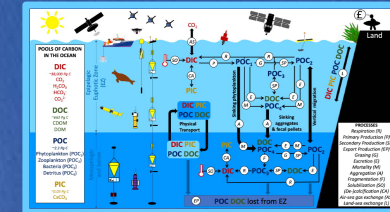
- Coastal Hazards
- Coastal Erosion
- Baltic+Salinity
- Baltic+SEAL
- SOON
- Hydrocoastal

Sentinel Coastal Charting

- ARI - DUST
- ARI-OHC

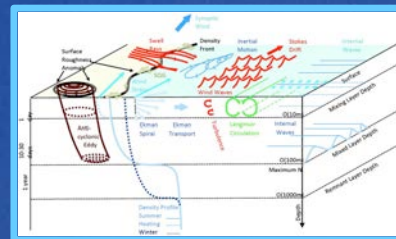
PYROPLANKTON

Ocean Carbon



- BICEP
- S5P+OC
- Physioglob
- Aeolus+AOC
- AMT4OceanSatFlux
- Aeolus+COLOR
- SCOPE
- ARI - PRIMUS
- Baltic+SeaLaBio

Upper-ocean dynamics including air-sea interactions



- S-6 JTEX
- Space4SafeSea
- CIRCOL
- World Ocean Circulation
- SARWAVE



Ocean Science and Applications Projects (>35 on-going)



Ocean Health and Biodiversity

WQ-FC



Sargassum

MedEOS

MedEOS

BiCOME

POSEIDON

Eu-Mon Ocean Health - Open Ocean Biodiversity

Ocean Health - Acidification

Coastal Ocean incl. Land-Sea interactions

Coastal Hazards



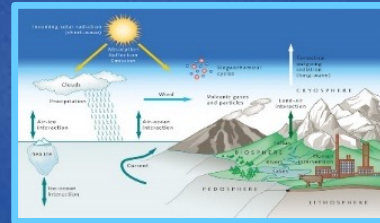
Coastal Erosion SOON

Baltic+Salinity Hydrocoastal

Baltic+SEALabio

Sentinel Coastal Charting

Ocean's role in Earth and Climate System



ARI - DUST

ARI-OHC

PYROPLANKTON

S-6 JTEX

Space4SafeSea

World Ocean Circulation

CIRCOL

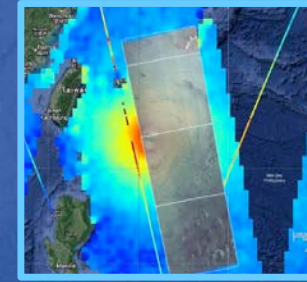
SARWAVE

Ocean Extremes

CAREHeat

MAXSS

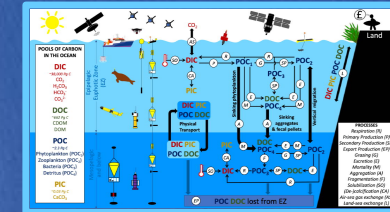
CYMS



MITHO

Polar Lows Prediction

Ocean Carbon



BICEP

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Physioglob

Aeolus+COLOR

Aeolus+AOC

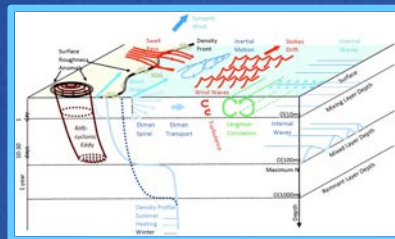
SCOPE

AMT4OceanSatFlux

ARI - PRIMUS

Baltic+SeaLaBio

Upper-ocean dynamics including air-sea interactions



Ocean Health and Biodiversity

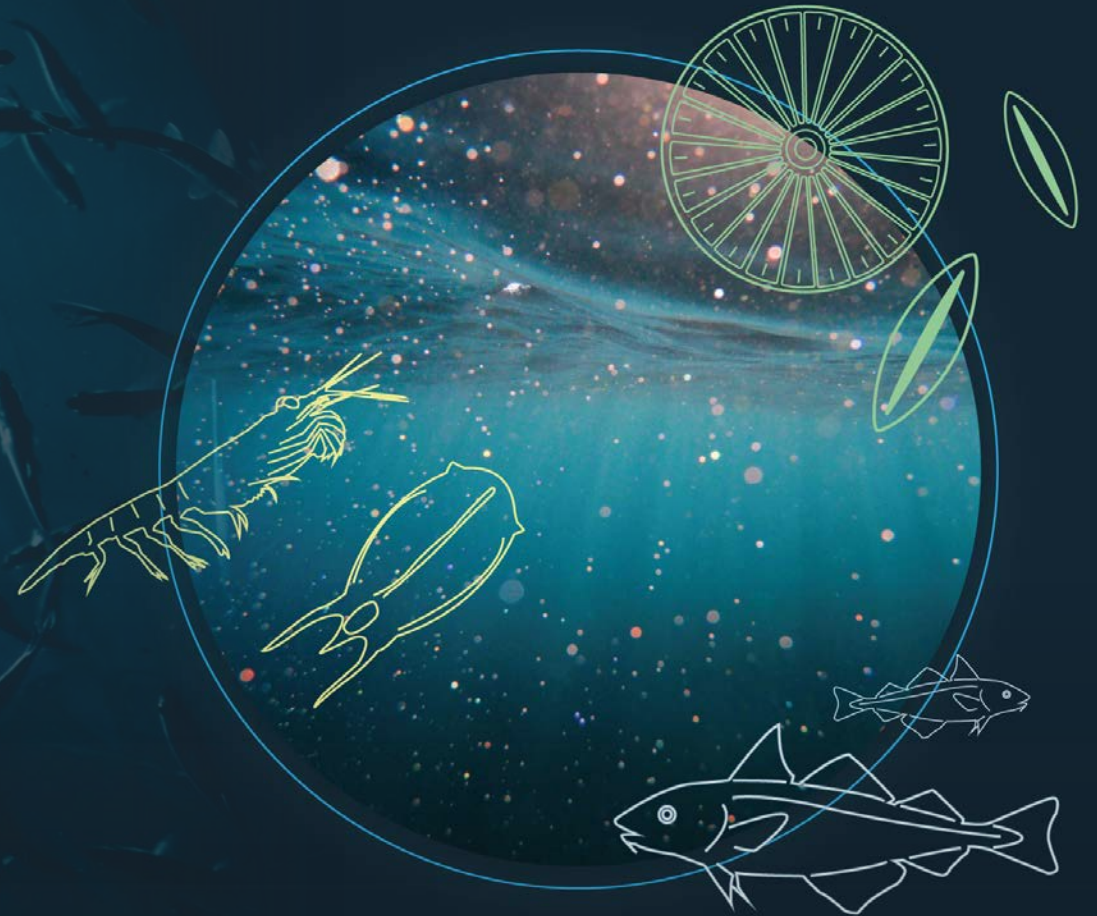


OCEAN HEALTH

BOOMS - Biodiversity in the Open Ocean: Mapping, Monitoring and Modelling

Aims:

- Develop dynamic seascapes from multi-sensor algorithms
- Demonstrate impact in scientific and societal applications



www.booms-project.org



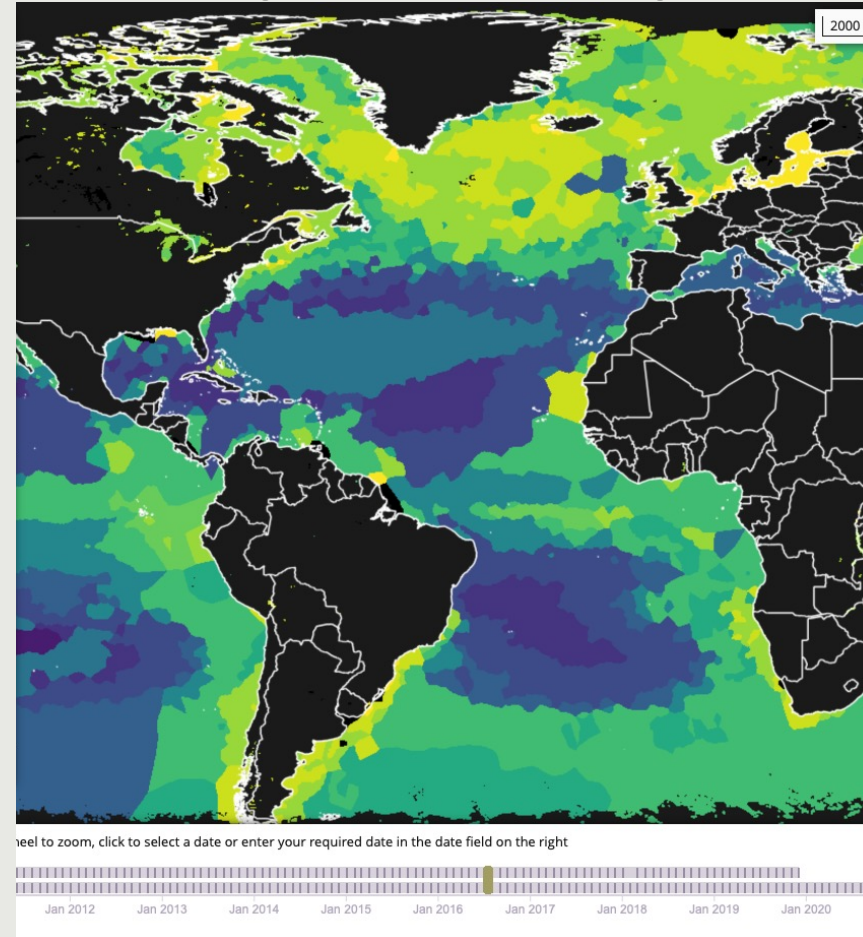
The BOOMS project is funded by the European Space Agency (ESA)
ESA contract no. 4000137125/22/I-DT

Contact point: V. Martinez Vicente
(vmv@pml.ac.uk)

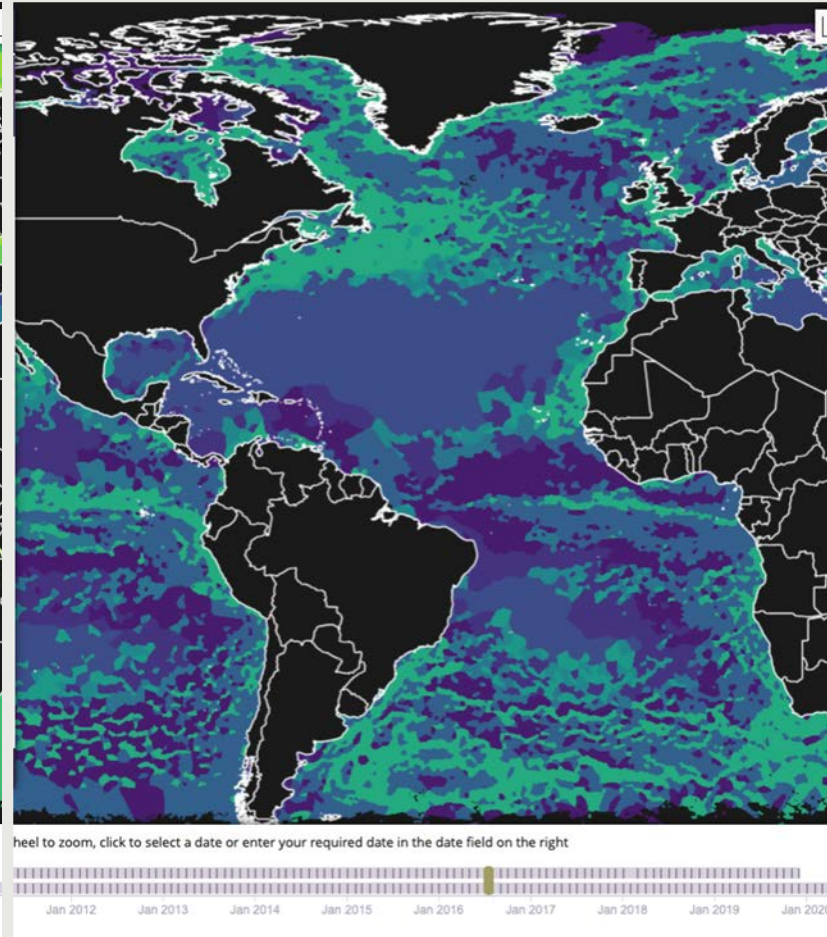
Open Ocean Biodiversity (BOOMS)

Three dynamical seascape types developed at 4 km resolution, from January 1998 – December 2021
(monthly and weekly composites)

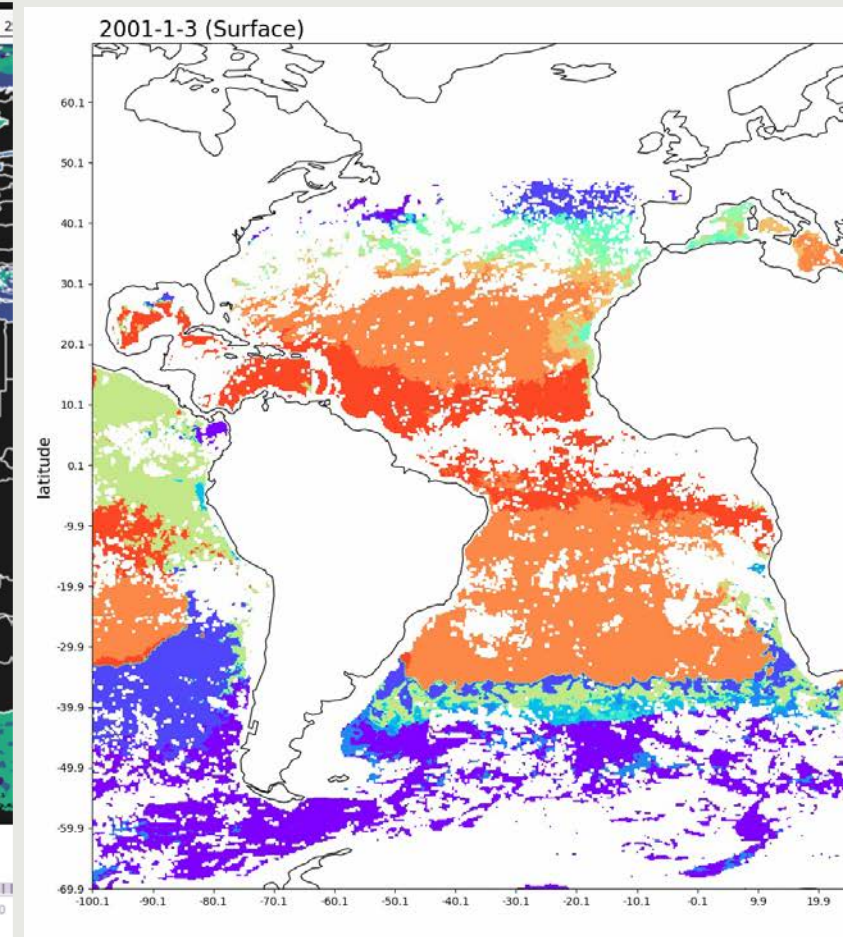
Bio-Optical Seascapes



Bio-physical Seascape



4D seascapes



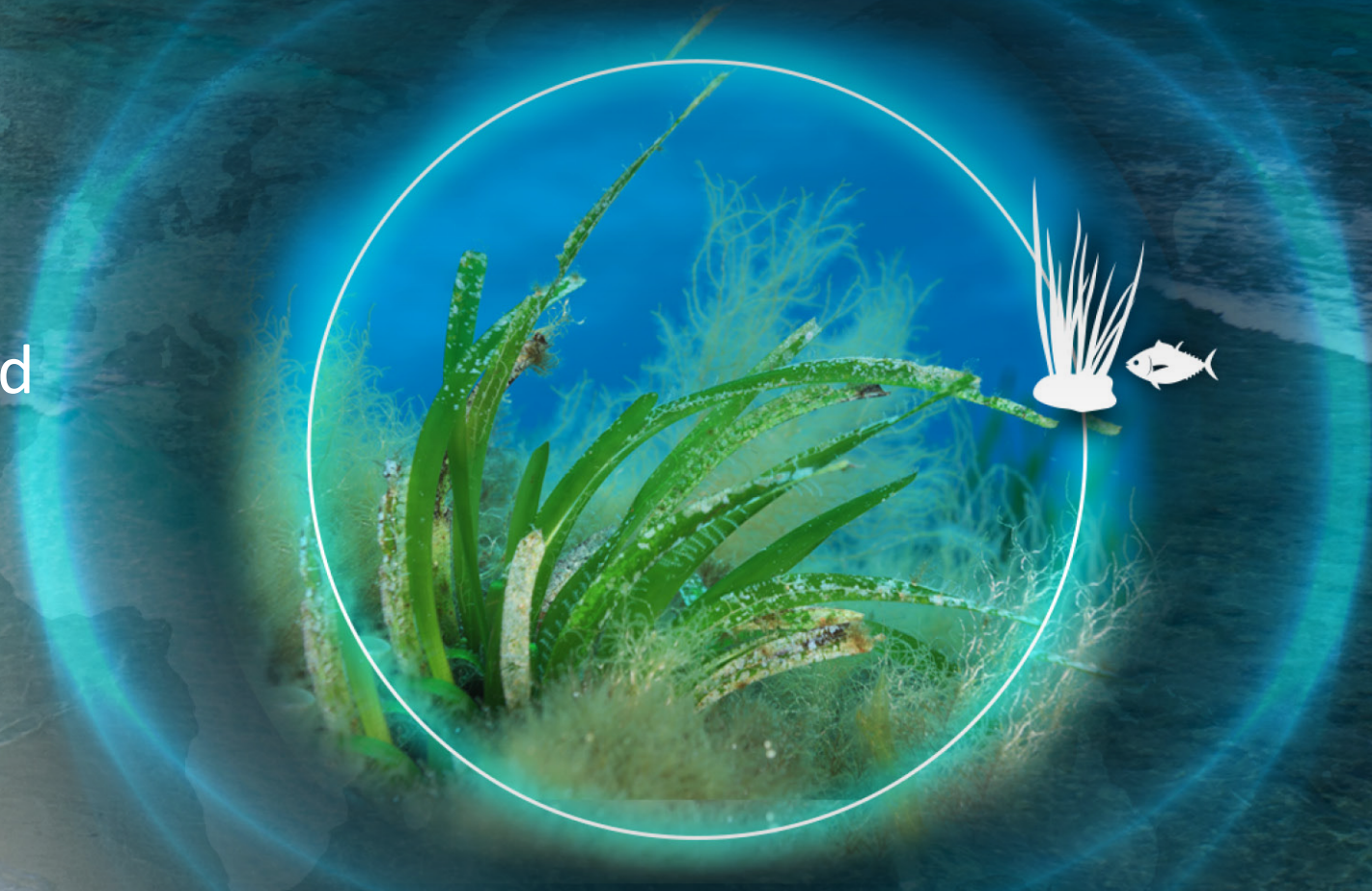
All dataset available via THREDDS and viewable in PML portal

<https://rsg.pml.ac.uk/thredds/catalog-booms.html>

BiCOME - Biodiversity of the Coastal Ocean: Monitoring with Earth Observation

Aims:

- Develop biodiversity relevant products from remotely sensed reflectance
- Demonstrate in scientific and societal applications



www.bicome.info



@BicomeProject



BiCOME is funded by the European Space Agency (ESA)

Contact point: V. Martinez Vicente
(vmv@pml.ac.uk)



EOV in Coastal Environments

Intertidal: Seagrass



Subtidal: Seagrass

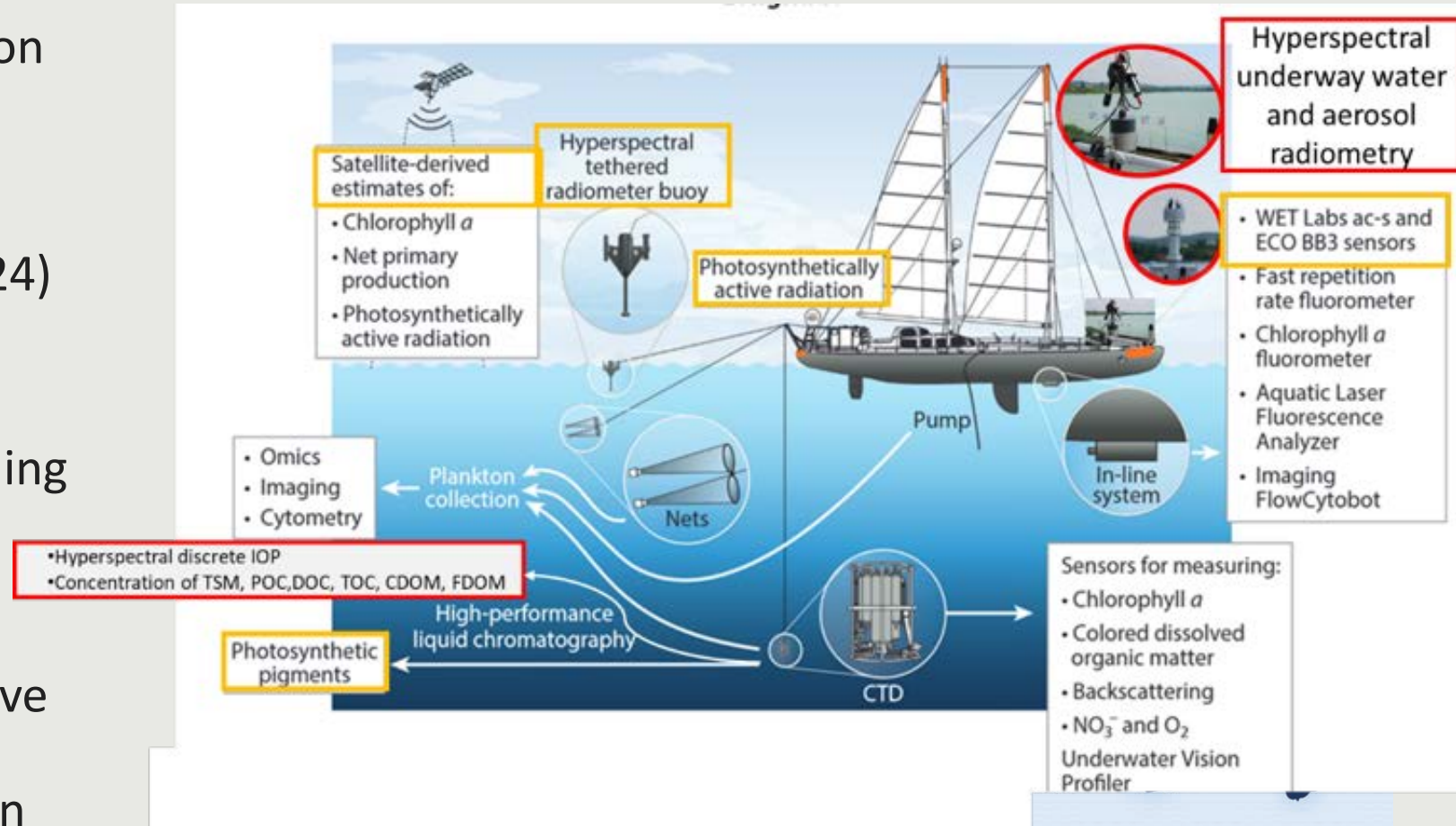


Pelagic: phytoplankton and floating macroalgae



HyperBOOST – Preparing for Hyperspectral mission

- TREC (Traversing European Coastlines) is a scientific expedition to understand biodiversity and ecosystems along Europe's coastlines. Two year campaign (April-Oct 2023 and April-July 2024)
- Objective of HyperBOOST is to extend the variables collected during the TREC integrated sampling by **including bio-optical measurements** (hyperspectral radiometry, optical properties, biogeochemical and optically active components) relevant to present and future (CHIME) satellite ocean colour missions.



Multiple THreats on Ocean health (MITHO)



PML Plymouth Marine Laboratory



MERCATOR OCEAN

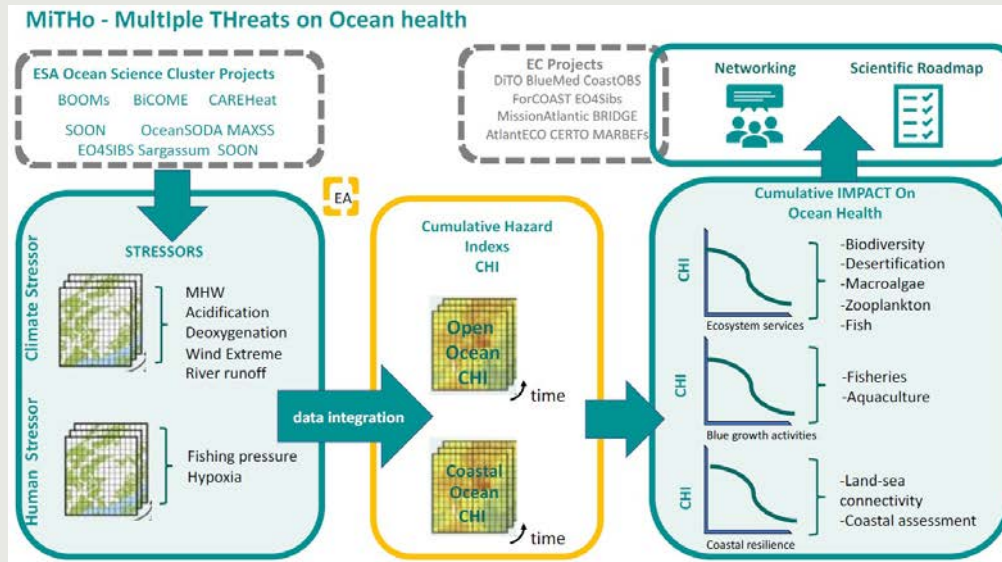


Objective: developing new methods and new EO-based products allowing to advance our observational capability and scientific understanding of the **impact of multi stressors events (mainly compounds) on Ocean Health**, intended as the capacity of marine ecosystems to provide their services.

Time Period: September 2023 – September 2025

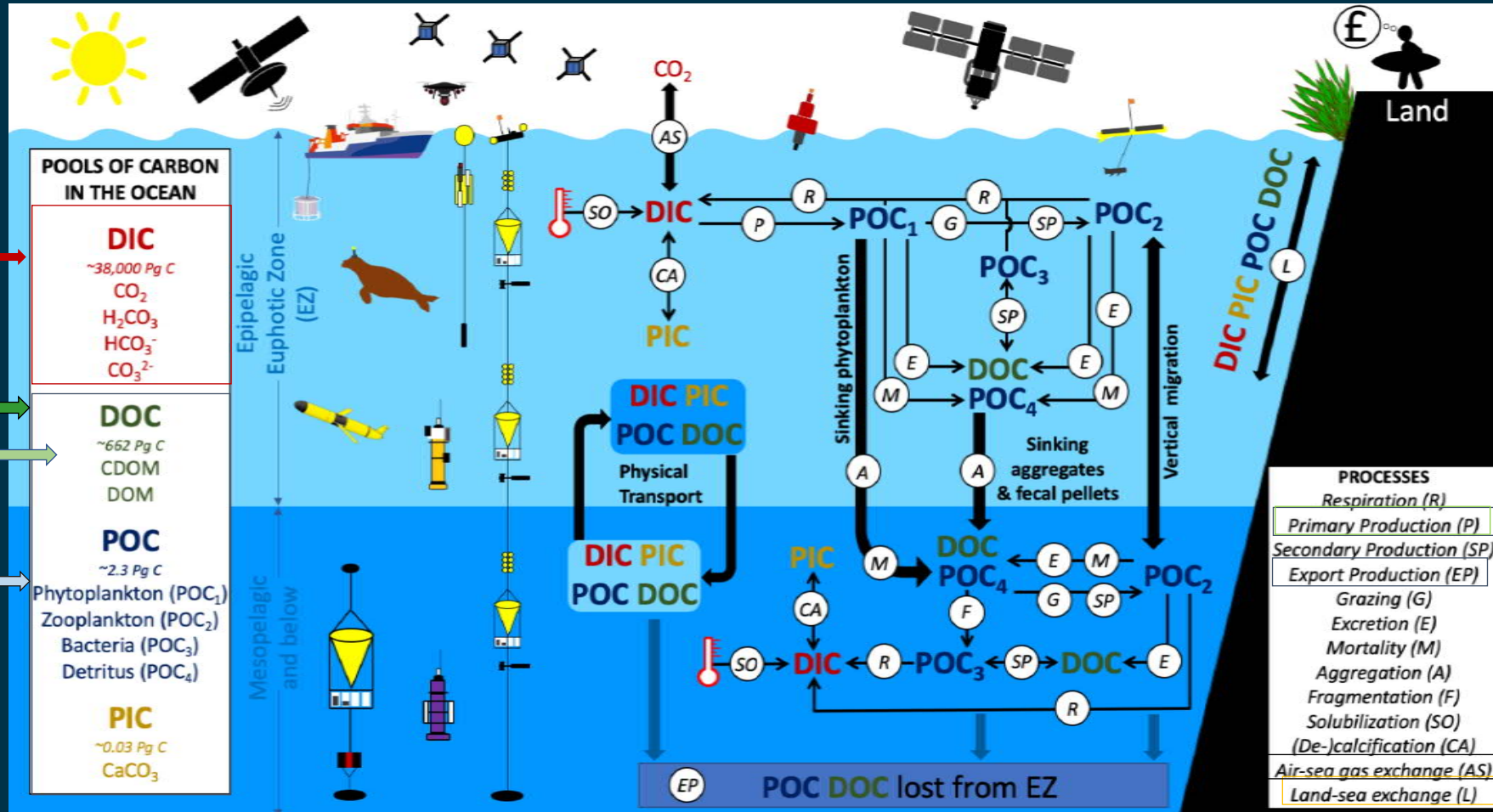
Main activities include:

- Development of two **multistressor cumulative hazard indexes (CHIs)**, specific for coastal and open ocean waters,
- Feasibility analysis to exploit EO data in combination with different levels of model and in-situ data, and the use of Artificial Intelligence to **observe and monitor O2 changes in the ocean** at different scales.
- Analysis of the **impact of multistressors on fundamental ecosystem levels** (including primary producers, secondary producers, final Producers and apex predators), **and land-ocean processes** (inland-marine waters connectivity).
- Transfer the novel EO-product and multistressors scientific knowledge to aid the **impact assessment on key ocean-based activities and services**, including Water quality monitoring, fisheries, aquaculture and coastal protection.



Contact point: Federico Falcini (federico.falcini@cnr.it)

Ocean Carbon



Ocean Carbon Projects: Pools, fluxes and processes that form the ocean solubility and biological carbon pump. From Brewin et al, 2021. Sensing the ocean biological carbon pump from space: A review of capabilities, concepts, research gaps and future developments, Earth-Science Reviews 217 (2021) 103604.

*BICEP= Biological Pump and Carbon Exchange Processes

The BICEP project

Project timeline January 2020- September 2023

The Biological Pump and Carbon Exchange Processes (BICEP) project

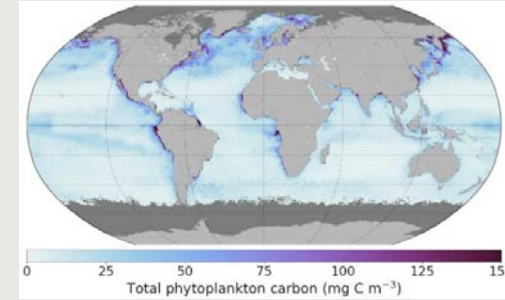
Objective: better characterise the different components of the biological carbon pump and compute its budget (carbon pools and fluxes) from space.

BICEP datasets available!

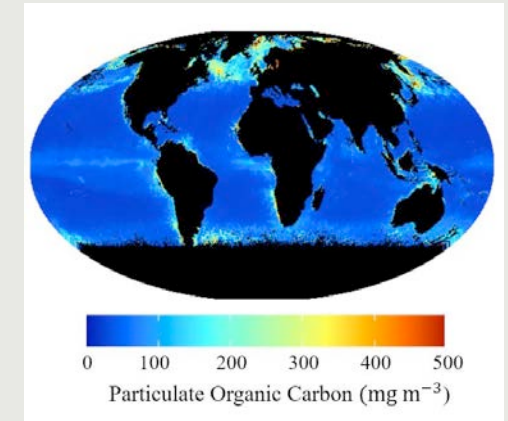
Overview of archived datasets of the Biological Pump and Carbon Exchange Processes (BICEP) project.

Dataset	OC-CCI	Coverage	Range	Archive
Particulate Organic Carbon (POC)	v5	Global, 4km	1997-2020	https://catalogue.ceda.ac.uk/uuid/5006f2c553cd4f26a6af0af2ee6d7c94
	v5	Global, 9km	1997-2020	https://catalogue.ceda.ac.uk/uuid/6a6ccbb8ef2645308a60dc47e9b8b5fb
Phytoplankton Carbon	v5	Global, 9km	1998-2020	https://catalogue.ceda.ac.uk/uuid/6a6ccbb8ef2645308a60dc47e9b8b5fb
Microphytoplankton Carbon	v5	Global, 9km	1998-2020	https://catalogue.ceda.ac.uk/uuid/6a6ccbb8ef2645308a60dc47e9b8b5fb
Nanophytoplankton Carbon	v5	Global, 9km	1998-2020	https://catalogue.ceda.ac.uk/uuid/6a6ccbb8ef2645308a60dc47e9b8b5fb
Picophytoplankton Carbon	v5	Global, 9km	1998-2020	https://catalogue.ceda.ac.uk/uuid/6a6ccbb8ef2645308a60dc47e9b8b5fb
Dissolved Organic Carbon (DOC)	v4.2	Global, 9km	2010-2018	https://rsg.pml.ac.uk/shared_files/gku/ESA_animation/DOC_1-month_9km/
Primary Production (PP)	v4.2	Global, 9km	1998-2020	https://catalogue.ceda.ac.uk/uuid/69b2c9c6c4714517ba10dab3515e4ee6
Export Production (EP)	v4.2	Global, 9km	1998-2019	https://catalogue.ceda.ac.uk/uuid/a6fc730d88fd4935b59d64903715d891
Particulate Inorganic Carbon (PIC)	V4.2	Global, 9km	1997-2020	https://rsg.pml.ac.uk/shared_files/gku/ESA_animation/PIC_1-month_9km/

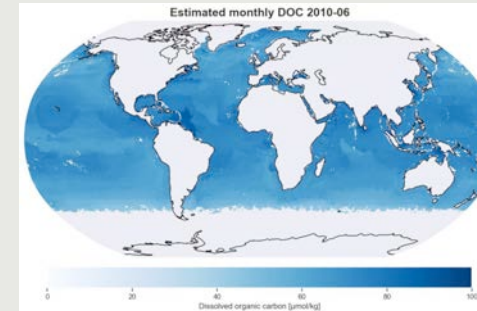
Total Phytoplankton Carbon



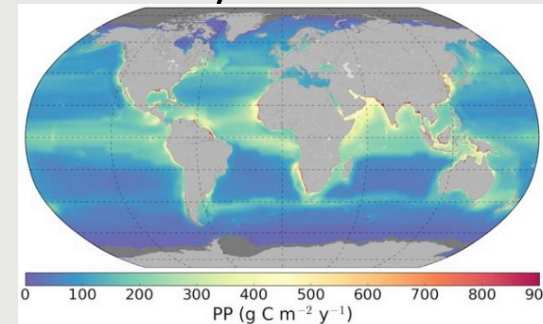
Particulate Organic Carbon



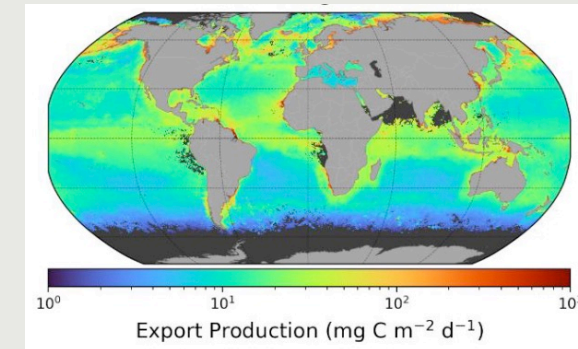
Dissolved Organic Carbon



Primary Production



Export Production



<https://bicep-project.org/>

Ocean Health - Acidification



Impact of Ocean Acidification on Marine Ecosystems

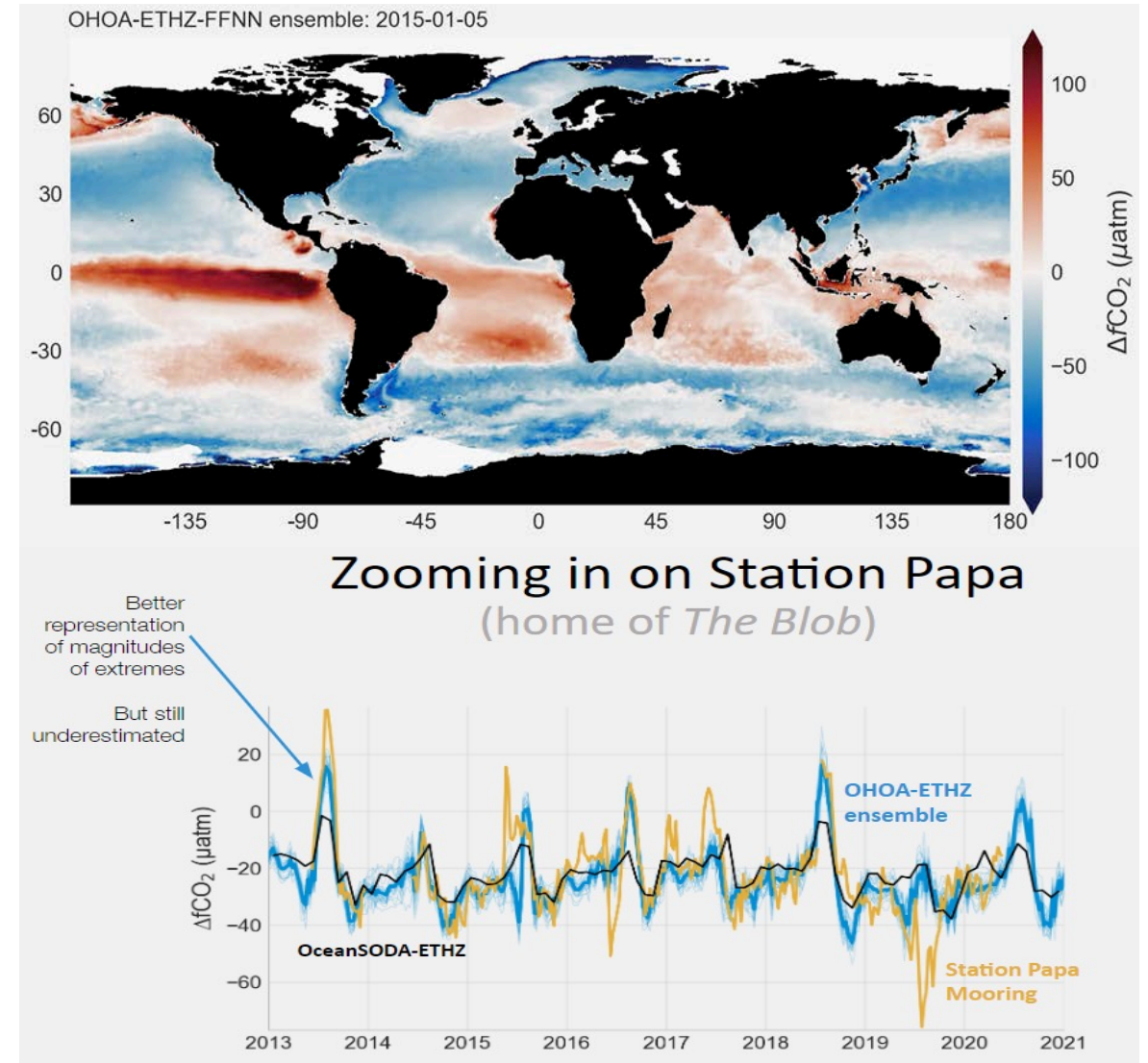
Time Period: March 2022 – March 2024

- Developing ocean acidification products from the use of satellite Earth Observation at enhanced spatio-temporal resolution (1/4 deg, 8 days) than existing products
- Characterizing global and regional variability of ocean acidification
- Characterizing the impacts of Ocean acidification on a selection of marine species.
- Characterizing where Ocean Acidification occurs with other stressors (eg warming, eutrophication, deoxygenation).

Contact point: j.d.shutler@exeter.ac.uk

Website: <https://oceanhealth-acidification.org/>

8 days, 1/4° x 1/4° maps of $\Delta f\text{CO}_2$

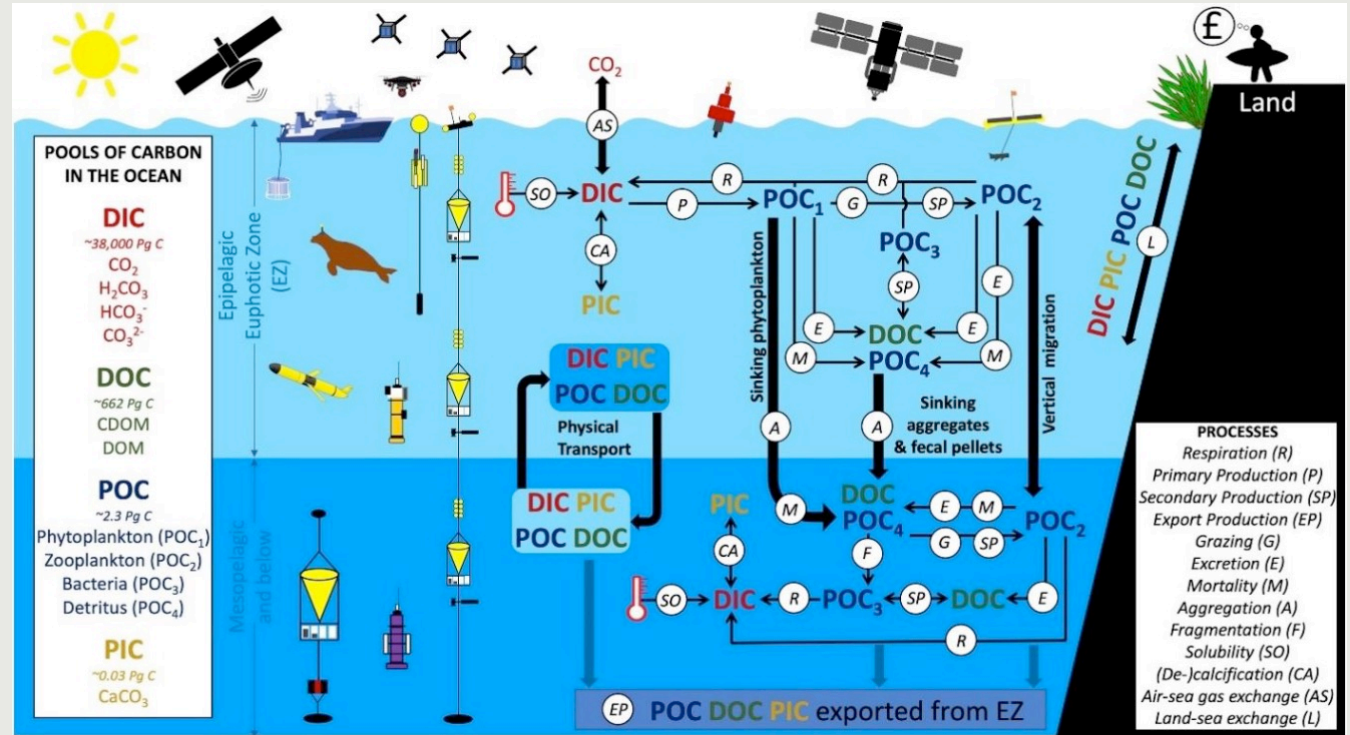


SCOPE: Satellite-based observations of Carbon in the Ocean: Pools, fluxes and Exchanges

Time Period: December 2023 – December 2025

Objective: this activity aims at bringing the present and past ESA and other European developments together with other relevant new results in the community (national fundings, EC projects) into a holistic exercise aiming at producing an **integrated budget of pools and fluxes of carbon in the ocean**, and further understanding its variability in space and time. This budget shall primarily be based on satellite data but also rely on in-situ measurements and models to reduce uncertainties and fill the gaps.

Contact point: Gemma Kulk (gku@pml.ac.uk)



Overview of the pools, fluxes and exchanges that form the ocean biological carbon pump (OBCP), and current methods used to monitor them. From Brewin et al, 2021

Coastal Blue Carbon project (to start early 2024)



This activity is linked to a number of key international and European policies (e.g., the EU Marine Strategy Framework Directive, Maritime Spatial Planning (MSP) Directive, Water Framework Directive (WFD)).

The project aims at developing new methods for innovative indicators to **improve the estimation and monitor the changes of the extent and carbon stock of major Blue Carbon Coastal ecosystems** specifically for: **mangroves, salt marshes, and seagrasses** in representative areas in the world.

The activity shall be implemented in close collaboration with key end-users: **government agencies, environmental organisations and also local communities**. The activity also aims at the provision of the necessary information products and tools to support countries integrating Blue Carbon into their national carbon accounts.

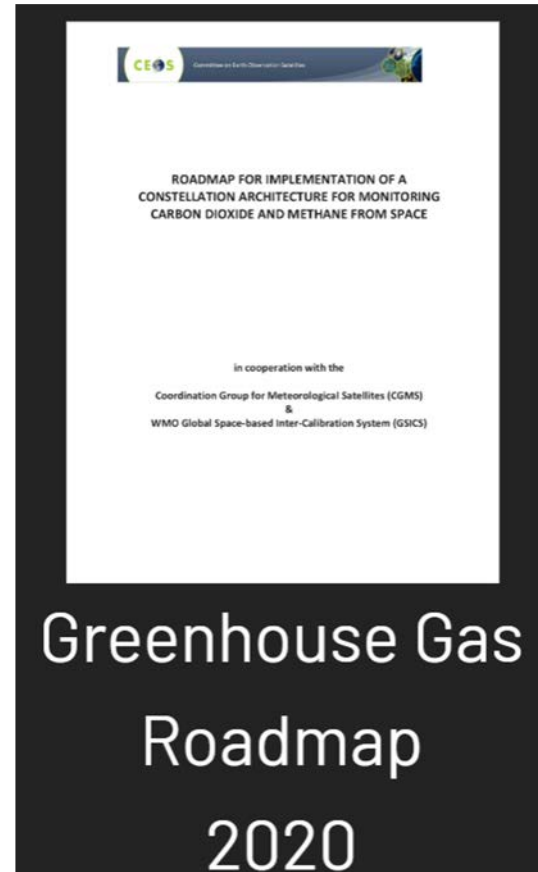
The project shall have a multi-sensor approach and leverage on state-of-the-art existing datasets (e.g., global mangrove watch) and integrate open non-EO data as necessary, in-situ measurements of both blue carbon extent and stock.



Contribution to CEOS Workplan: Toward an Aquatic Carbon Roadmap



CEOS Global Stocktake strategy paper
-> demonstrate the value of Earth
Observation satellite datasets to
support the Global Stocktake process



CEOS Aquatic Carbon Roadmap?

Coordination Team:

Marie-Helene Rio (ESA), Laura Lorenzoni (NASA), Hiroshi Murakami (JAXA)

Scientific leaders:

Jamie Shutler (University of Exeter), Robert Brewin (University of Exeter), Cecile Rousseaux (GSFC-NASA), Kelsey Bisson (NASA)

Endorsed on Wednesday 15th November at CEOS Plenary

ESA Climate Change Initiative



Maximizing the value of EO for Climate research, following the requirements by GCOS and the Climate Modelling community



climate modelling
user group
cci



climate change initiative

Oceanic



Terrestrial



Atmospheric

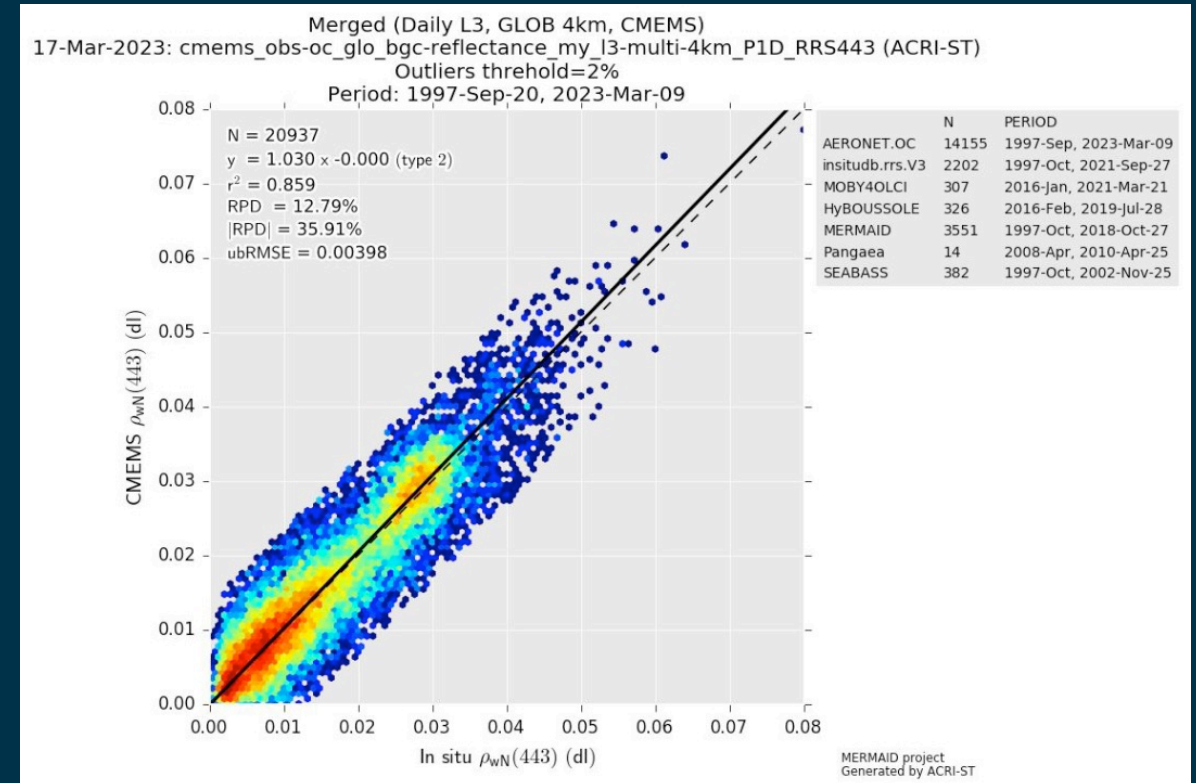
23 ECV projects (covering 21 ECVs), 2 budget closure projects, a data support project and a Climate Modelling project
<https://climate.esa.int/en/projects/ocean-colour/data/>

Sen2water: Toward a Sentinel-2 Aquatic Reflectance

Goal: to provide an aquatic reflectance product as part of the ESA S-2 Level 2A product.

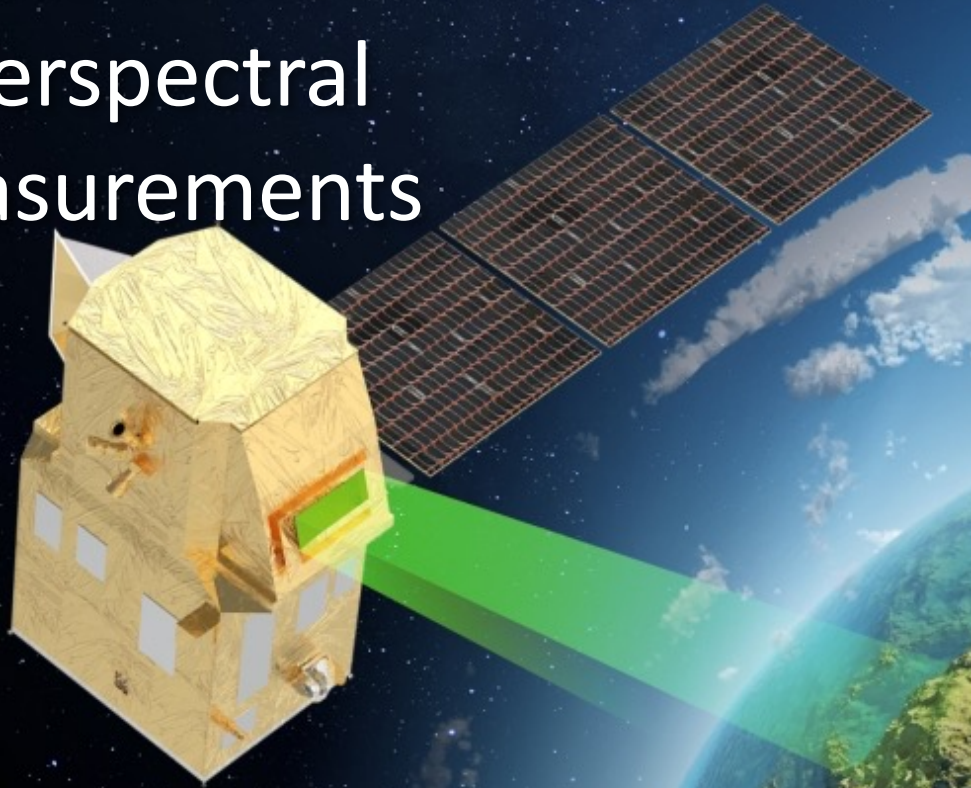
Validation will follow the methodology of the ACIX AQUA benchmark (Pahlevan et al. 2021)

Timeline: ~ end 2024



CHIME

Visible to Near Infrared
hyperspectral
measurements

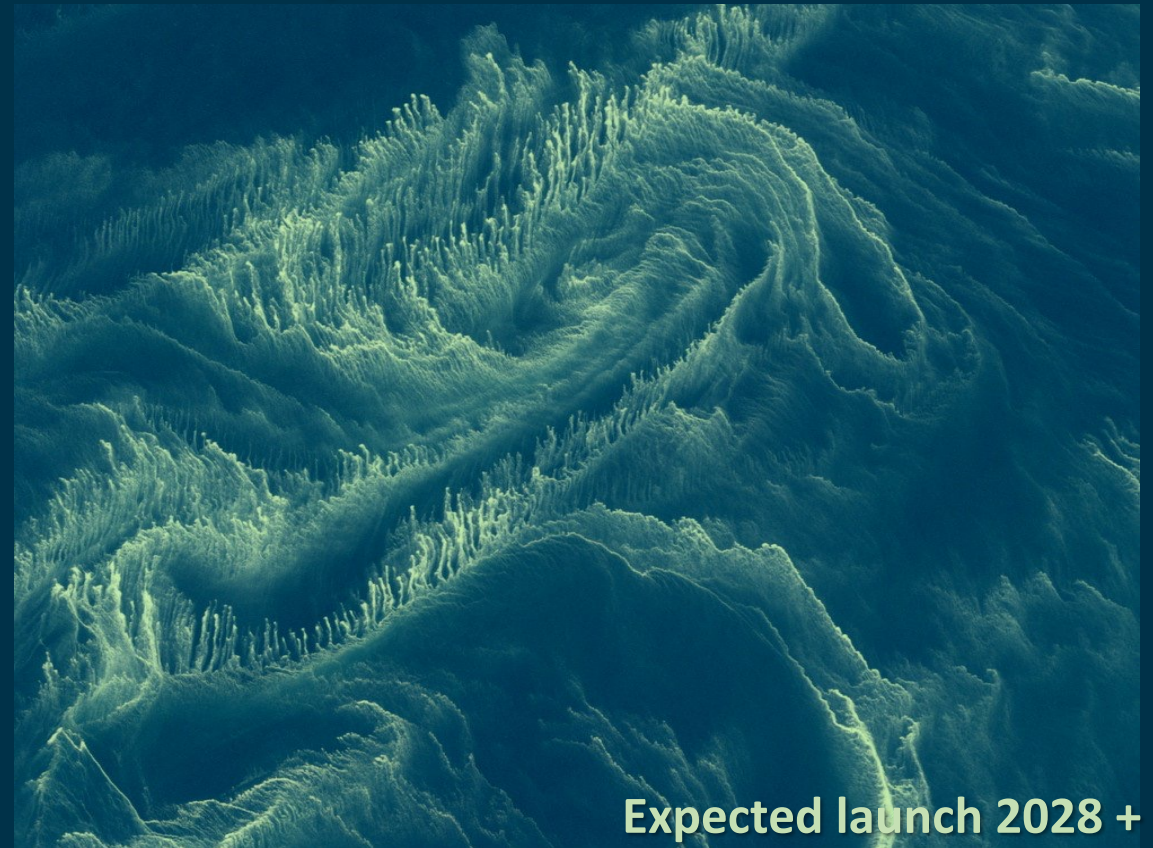


Expected launch 2028 +

Future missions

S2-NG

Multi-spectral mission
ensuring enhanced
continuity of service for S-2
products



Expected launch 2028 +

Upcoming relevant calls (non exhaustive):

WorldCoast **Time frame: 2024 – 2026 (ITT Q1 2024)**

Objective: On the experience of Coastal Erosion projects and the recommendation of the Climate Modelling User Group, this activity will scale-up the algorithms and methods for coastline mapping at global level.

The final product and related analytics tools should take into consideration tidal changes and erosion/accretion processes.

Primary data source will be Sentinel-2 complemented with Sentinel-1.

The activity will be developed in close collaboration with Member States hydrographic offices and international partners.

Sustainable Blue Economy **Time frame: 2024 – 2026 (ITT Q1 2024)**

Objective: The objective of the Blue Economy project is to fully exploit and optimize the use of satellite data, in synergy with in-situ and/or model outputs, **to support Blue Economy activities and monitor their impact on the marine environment.** Innovative products and high-level indicators shall be specified, developed, validated, and their benefit demonstrated, in close link with Early Adopters, for four different Blue Economy activities: **Fisheries, Aquaculture, Renewable Energy, Tourism (4 contracts) .**

Ocean Health and Biodiversity **Time frame: 2024 – 2026 (ITT Q1 2024)**

Objective: Call for collaborative projects aimed at advancing towards novel EO-based ocean biodiversity datasets for enhanced observation and understanding of Open Ocean and coastal biodiversity and foster collaborative efforts to undertake a joint interdisciplinary assessment on the health of ecosystems including on-set and drivers of change, vulnerability and responses to natural and anthropogenic pressures, specially under extreme conditions

Sentinel User Preparation Activities **Objective:** Prepare for the exploitation of future missions (S2-NG, CHIME)

STAY TUNED

Ocean Science Cluster mailing list

If you want to be kept updated, you can subscribe to this list by clicking on the following link:

<https://esacontact.esa.int/ocean-science-cluster-newsletter-subscribe/>

Thanks!