

ESA activities for Ocean-Atmosphere Interactions Studies and Applications

Marie-Helene RIO,
ESRIN-ESA

Remote Sensing for Ocean-Atmosphere Interactions
Studies and Applications Workshop

December 3rd 2021

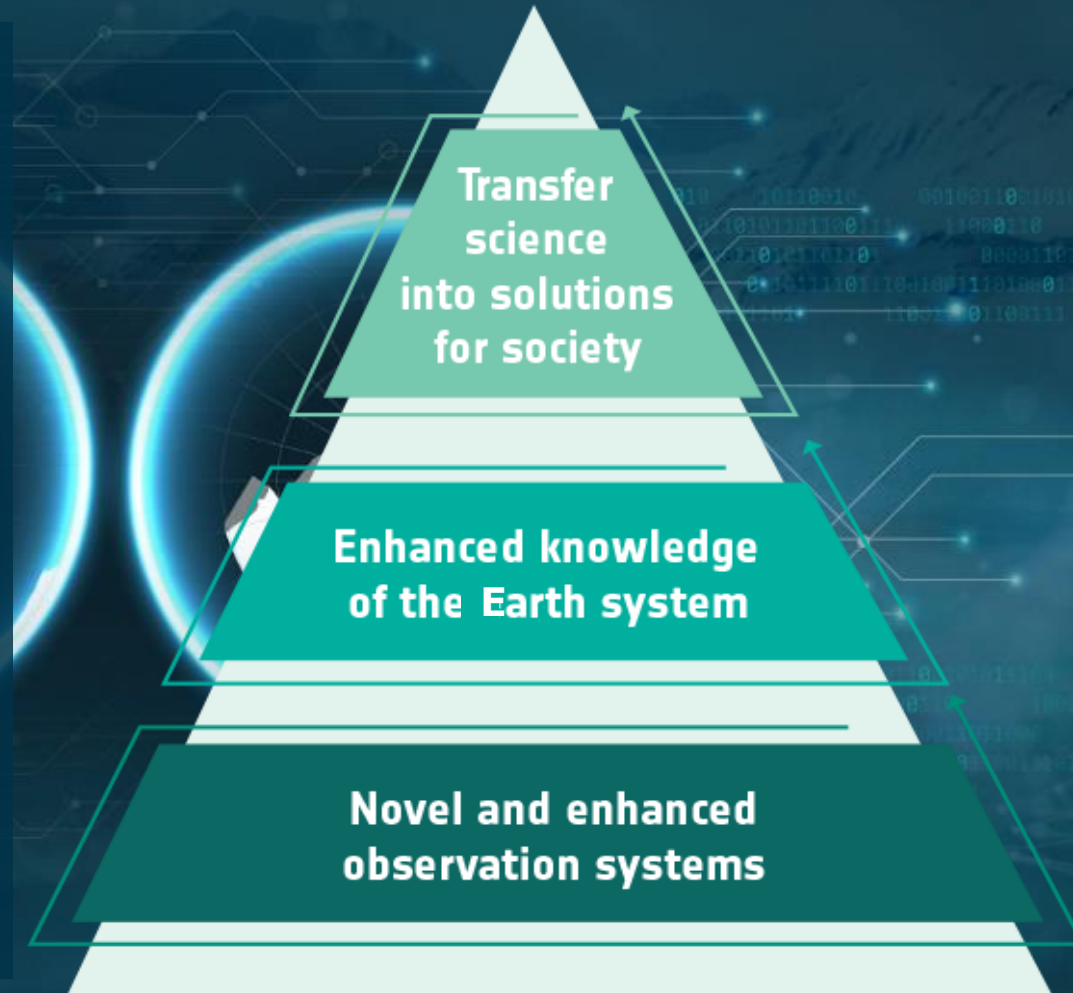
- ☐ Contribution from the Ocean Science cluster projects
- ☐ Contribution from the ESA-CCI dataset
- ☐ Relevant Future satellite missions

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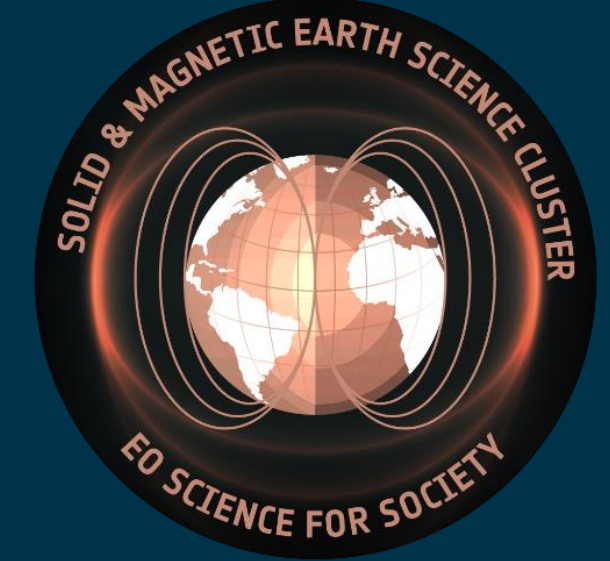
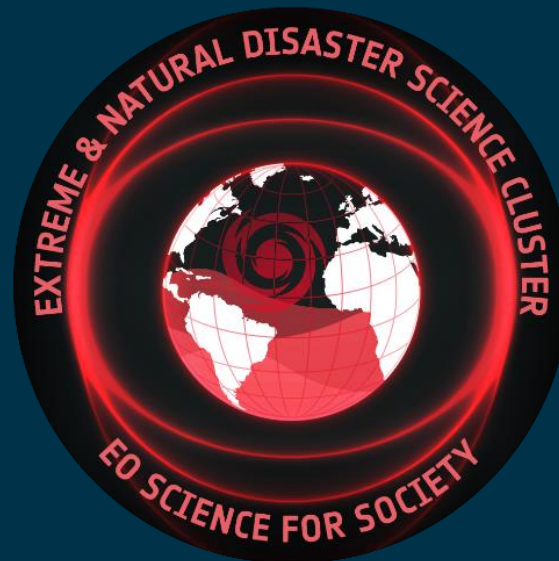
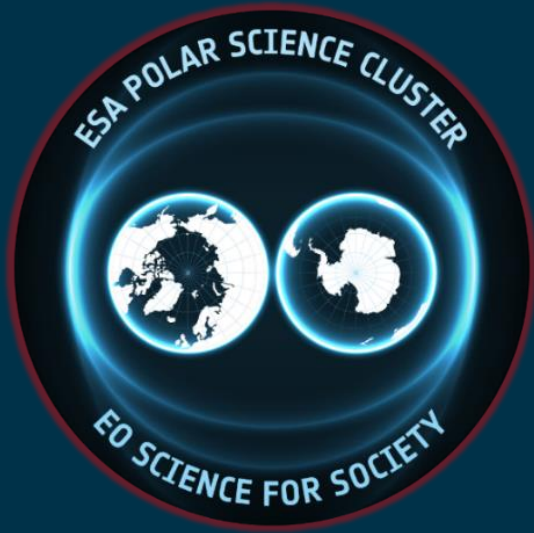
ESA Science Clusters: A community approach



- *Promote a coordinated approach to science, networking and partnerships;*
- *Promote collaborative research across projects and teams towards common ambitious goals;*
- *Maximise the scientific impact of ESA science activities by exploiting synergies across different domains;*
- *Based on a contiguous dialogue with the scientific community;*



ESA Science Clusters: A community approach



Ocean Science Cluster Projects (>35 on-going)



Ocean Science Cluster Projects relevant for air-sea interactions studies

Ocean Health - Open
Ocean Biodiversity

BiCOME

Ocean Health -
Marine Heatwaves



Ocean Health - OceanSODA
Acidification

MAXSS CYMS

Polar Lows Prediction

DTEp - MHW

MedEOS Sargassum

SOON

POSEIDON

BICEP

Physioglob

Coastal Erosion

Aeolus+COLOR

Sentinel Coastal Charting

Aeolus+AOC

ARI - PRIMUS

Hydrocoastal

Baltic+Salinity

S5P+OC

OceanFlux - GHG

Baltic+SEAL

AMT4OceanSatFlux

Coastal Hazards

EO4SIBS

ARI - DUST

Baltic+SeaLaBio

Space4SafeSea

World Ocean Circulation

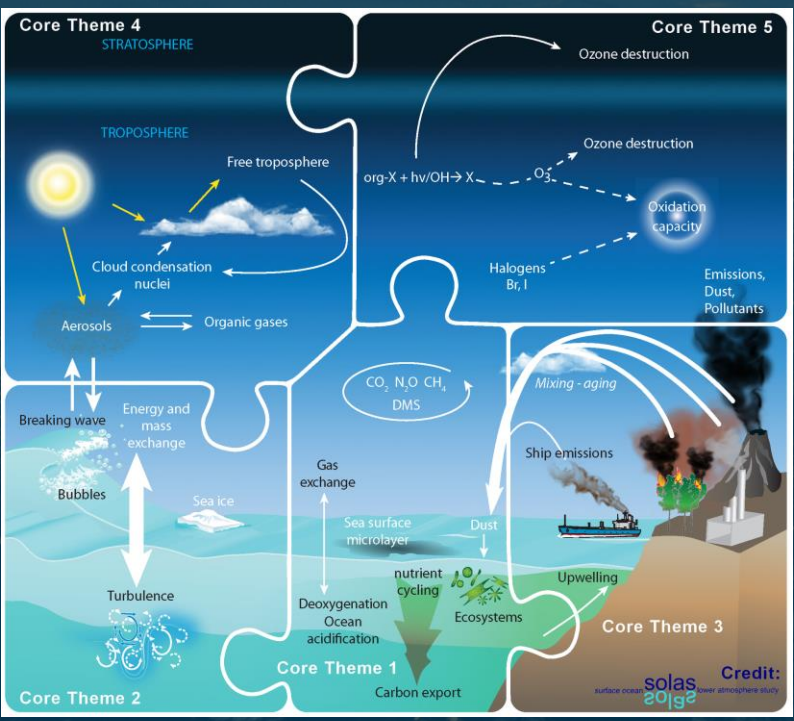
ARI-OHC

PYROPLANKTON

S-6 JTEX

S-1 Doppler

CIRCOL



OceanFlux Greenhouse Gases Evolution



oceanflux evolution
support to science element



www.oceanflux-ghg.org

Project endorsed by

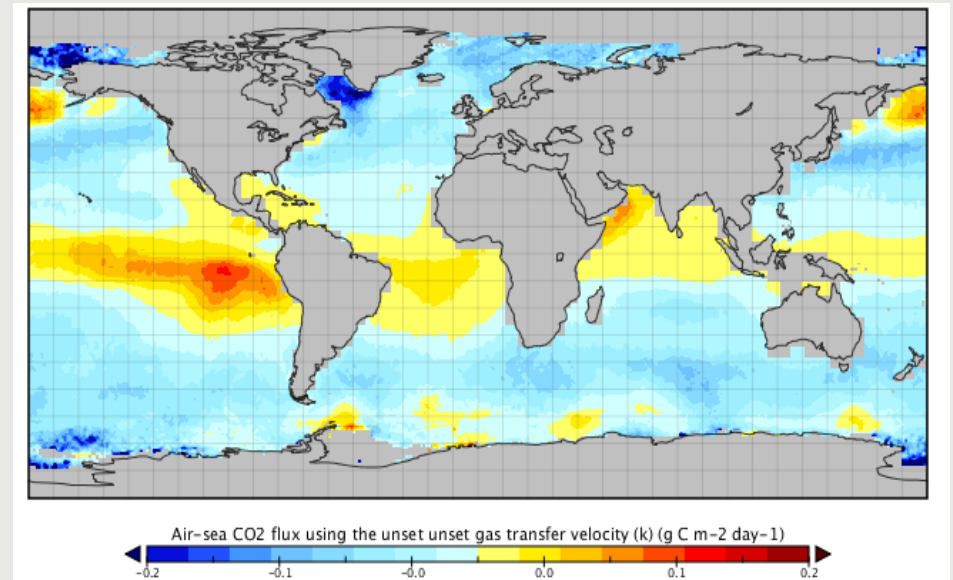


The objective was to improve the quantification of air-sea exchanges of greenhouse gases by developing and validating new and innovative products combining field data, satellite observation, and models.

Two OceanFlux GHG projects resulted in a global climatology of $f\text{CO}_2$ and >14 journal papers, and the development of the **FluxEngine – air-sea gas flux toolbox**

- Toolbox developed for community use:
- Open source license (python library).
- Standard NetCDF data input and output.
- Net flux tool with traceable land/ocean/basin templates.
- User configurable gas flux calculation.
- Extensively verified using published data.

Example mean daily Air-Sea CO_2 flux output



Shutler, J. D., Piolle, J-F., Land, P., Woolf, D. K., Goddijn-Murphy L., Paul, F., Girard-Ardhuin, F., Chapron, B., Donlon, C. J., (2016) Flux Engine: A flexible processing system for calculating air-sea carbon dioxide gas fluxes and climatologies, *Journal of Atmospheric and Oceanic Technology*.



OceanSODA project (Satellite Oceanographic Dataset for Acidification)

before: Ocean Acidification and starting soon: Ocean Health - Acidification

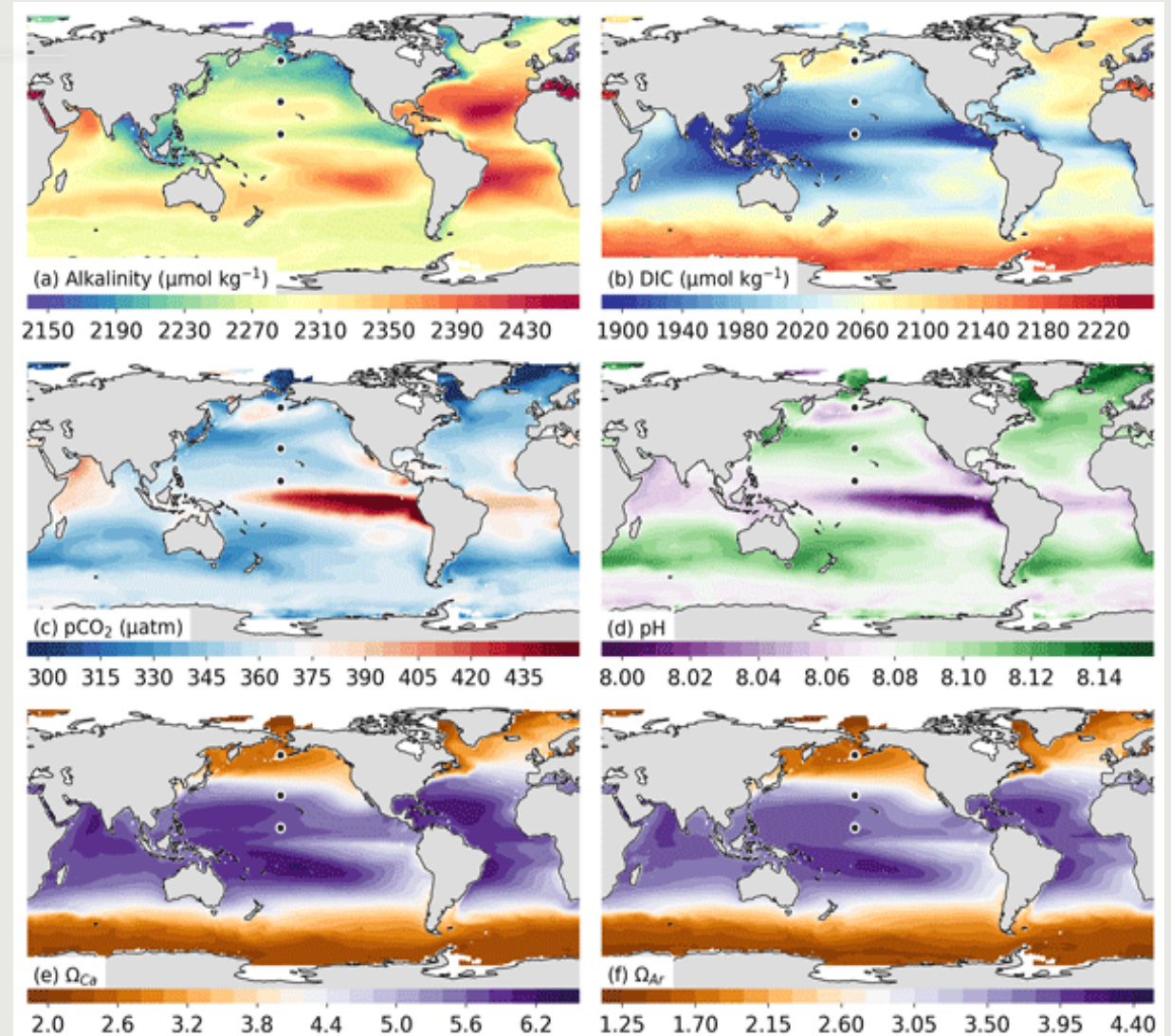
Objectives:

- further develop and validate algorithms linking satellite variables with marine carbonate system parameters
- characterise and analyse how upwelling (of low pH waters) and compound events impact the carbonate system, and characterise the flow and impact on marine ecosystems of low pH waters from large river systems

Gregor and Gruber, 2021: OceanSODA-ETHZ: a global gridded data set of the surface ocean carbonate system for seasonal to decadal studies of ocean acidification

-> monthly, $1^\circ \times 1^\circ$ maps of **all the marine carbonate parameters** in surface waters have been produced over the time period **1985-2018**:

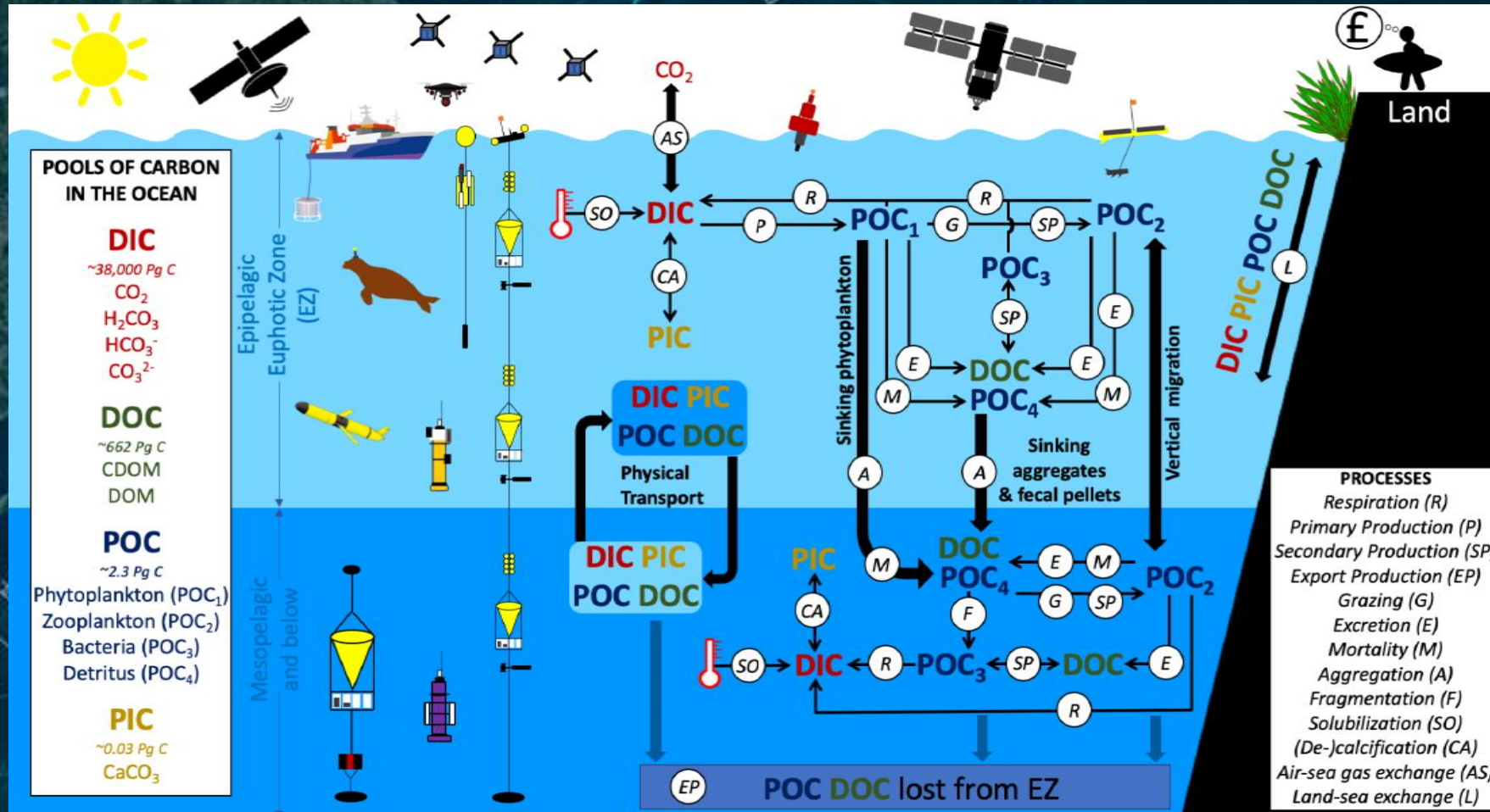
- surface ocean pH,
- total alkalinity (AT),
- total dissolved inorganic carbon (DIC or CT),
- aragonite saturation state (Ω_{ar}),
- partial pressure of CO₂ - pCO₂



The Ocean Carbon From Space Workshop

2nd Workshop in the CLEO (Colour and Light in the Ocean from Earth Observation) Series

<https://oceancarbonfromspace2022.esa.int/>



From Brewin et al, 2021. This figure has been inspired by, and builds on, two earlier figures, one from the CEOS carbon from space report (CEOS, 2014) and the other from the NASA EXPORTS plan (Siegel et al., 2016).

The Ocean Carbon From Space Workshop

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Abstract submission open until December 8th

Sessions

The workshop is being organised as a series of sessions targeting specific themes. Each session will consist of invited talks, contributed oral and poster presentations, and a group discussion. The workshop will conclude with a synthesis and recommendation session.

We invite submission of abstracts contributing to the following themes:

Pools of Carbon in the Ocean

1. Particulate Organic Carbon
2. Phytoplankton Carbon
3. Particulate Inorganic Carbon
4. Dissolved Organic Carbon
5. Carbon Chemistry, including Dissolved Inorganic Carbon

Main processes

6. Marine Primary Production
7. Export Production
8. Underwater Light Field
9. Air-Sea Exchanges
10. Land-Sea Exchanges

Crosscutting themes

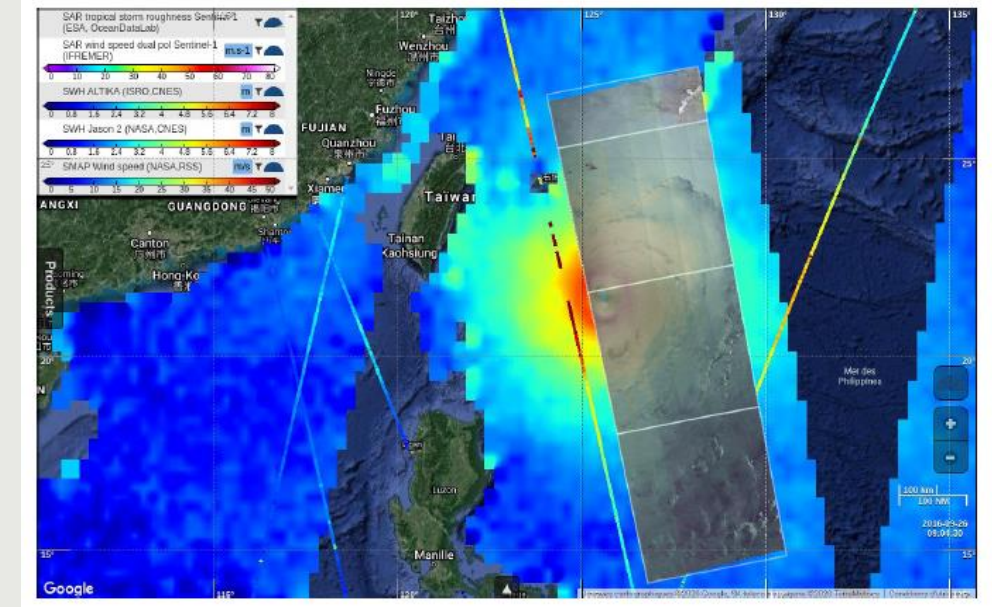
11. Uncertainty Estimates
12. Freshwater Carbon
13. Blue Carbon
14. Extreme Events, Tipping Points and Impacts on Carbon
15. Climate Variability and Change
16. Ocean Carbon Budget: How Close to Closure?

Extreme Winds: The MAXSS project <https://www.maxss.org/> (Marine Atmosphere eXtreme Satellite Synergy)

Objectives: Optimize the use of EO data to improve the observation, understanding and prediction of extreme wind events and their interaction with the ocean and the earth system.

In particular, the required activities include:

- the development and validation of a long time series (at least 10 years) of **global multi-mission synergy wind products in high to extreme wind conditions (>35 m/s)**, from different spaceborne sensors, mainly SMOS and S-1 but also other mission data (e.g., Radarsat-2, AMSR-2, Aquarius, SMAP, CYGNSS, radar altimeters...)
- the production of **an atlas of extreme wind events collocated with measurements of the underlying ocean environment** as measured from satellite sensors (Sea Surface Height, Sea Surface Temperature, Ocean Colour, Sea Surface Salinity, Wave height) or from auxiliary datasets from in-situ and/or models (ex. Mixed Layer Depth),
- the implementation of Science Case Studies to investigate: 1) Decadal Extreme Wind changes, 2) **Turbulent air-sea fluxes under Extreme conditions and 3) Storm impact on ocean biogeochemistry and gas fluxes.**
In particular, the objective is to characterize:
 - ⇒ the combined impact of all polar lows and cyclones **on air-sea CO₂ gas transfer, the resultant air-sea gas fluxes and the net integrated oceanic sink of CO₂.**
 - ⇒ correlations between **the storm induced variations in momentum and air-sea gas fluxes and net CO₂ sink**, and optimal Earth observation derived inorganic and organic carbon data (eg surface total alkalinity, pCO₂ and dissolved inorganic carbon, primary production).



4D-Atlantic Dust&Ocean Modelling and Observing Study

<https://www.ecmwf.int/en/research/projects/domos>

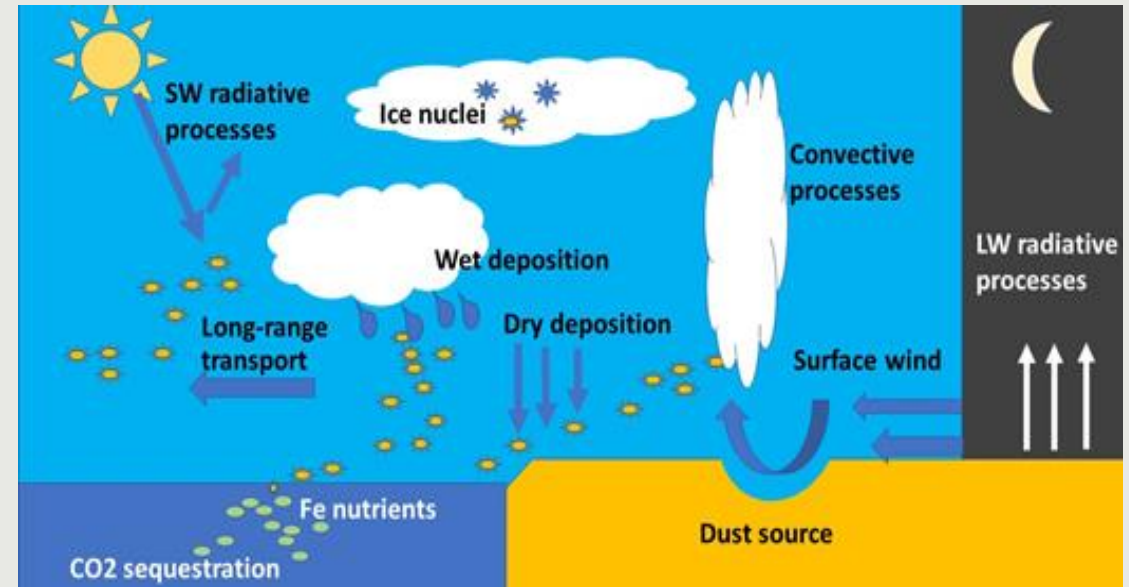
Dust is a key player in the Earth System through its impacts on radiation, clouds and the ocean biogeochemical cycles.

DOMOS will address the dust interactions with the ocean using an **integrated modelling and observing approach**

Scientific questions:

1- To what extent dust deposition over the Atlantic has changed over the last 20 years? Can we identify robust trends in the reanalysis and model datasets and if yes, how can we verify them?

2- What is the contribution of anthropogenic and natural sources of dust compared to biomass burning and anthropogenic aerosols to soluble iron deposition over the Atlantic?



3- What are the impacts of changes in dust deposition on marine biogeochemistry and their potential effects on ecosystems?

The PYROPLANKTON project

New Living Planet Fellowship

Joan Llort Jordi, Barcelona Supercomputing Center

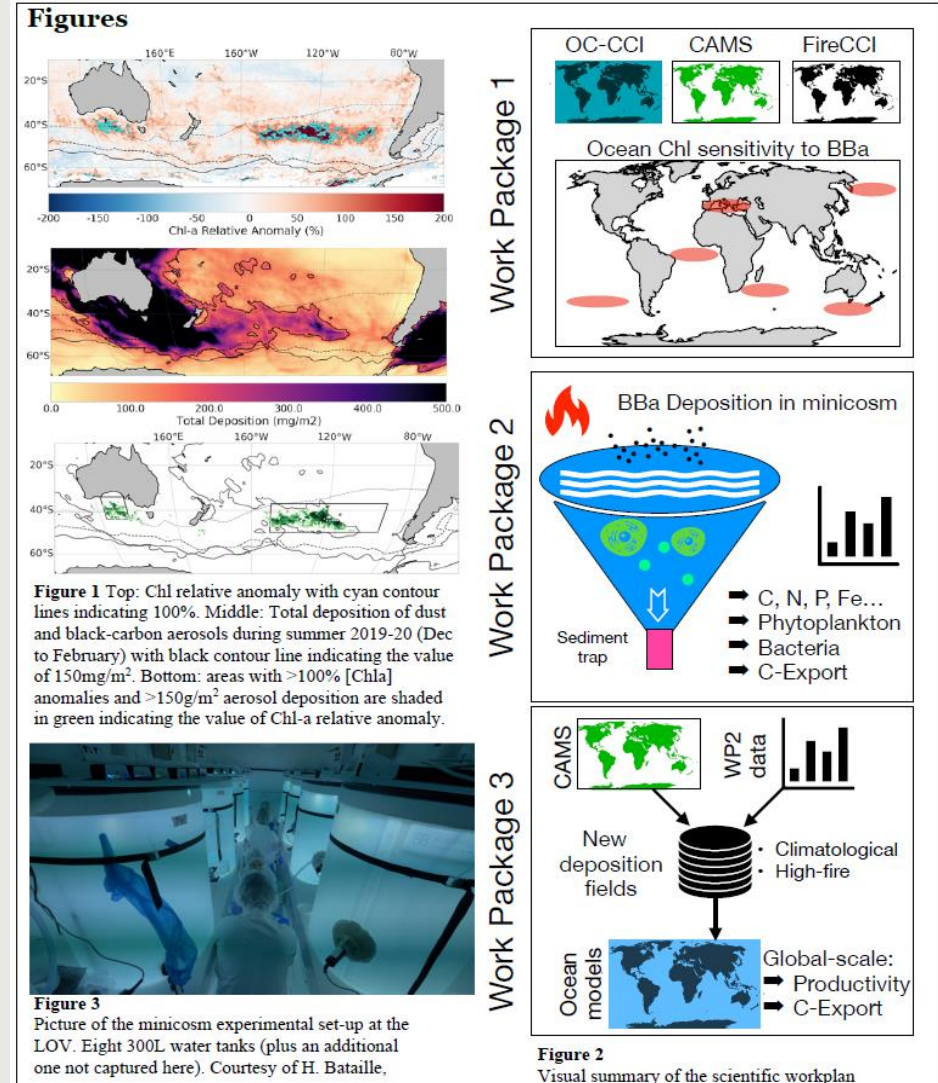
OVERARCHING GOAL Provide a comprehensive evaluation of how wildfire, by releasing biomass burning aerosols (BBa) such as carbon, organic matter, and iron into the atmosphere, affect marine ecosystems, productivity, and geochemistry.

MAIN OUTPUTS:

A new methodology to attribute Chl-a anomalies to aerosols deposition using ESA data (WP1).

Exhaustive experimental results of the impact of ash on marine biogeochemistry (WP2)

The first estimate of BBa impact on global marine productivity and carbon export (WP3).



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Realising the benefits of satellite-based Essential Climate Variables (ECVs) supported through ESA's Climate Change Initiative



climate change initiative

Oceanic



Terrestrial



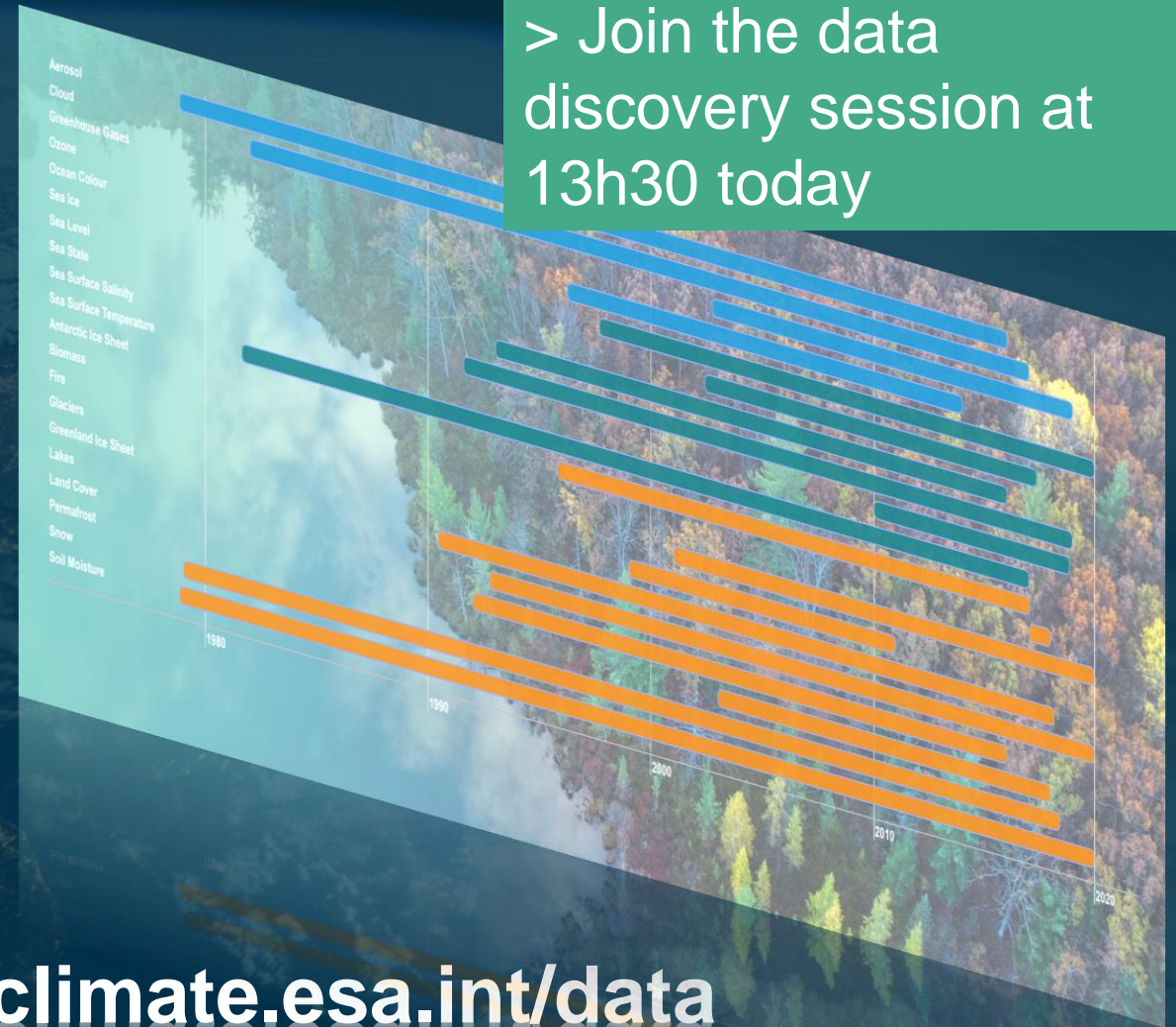
Atmospheric

23 ECV projects (covering 21 ECVs), 2 budget closure projects, a data support project & Climate Modelling project

Access ECV climate data – CCI Open Data Portal

- ✓ **Free and Open Access**
- ✓ **Global** coverage (where applicable)
- ✓ Long timeseries (20-30 years)
- ✓ **Gridded** (at a usable resolution e.g. $\frac{1}{4}$ degree)
- ✓ **Validated** (by in situ observations) and tested
- ✓ **Bias corrected** (e.g. between different satellites)
- ✓ **Uncertainty characterisation** (per pixel, correlated...)
- ✓ Useful temporal resolution (**daily, monthly...**)
- ✓ Can be sourced back to algorithm choice
- ✓ Level 1, 2 or 3
- ✓ **Consistency** between CCI_ECV datasets
- ✓ Full documentation & version control
- ✓ Peer reviewed publications
- ✓ Available on CCI Data Portal, and Copernicus Services
- ✓ Supporting information, e.g. cloud masks

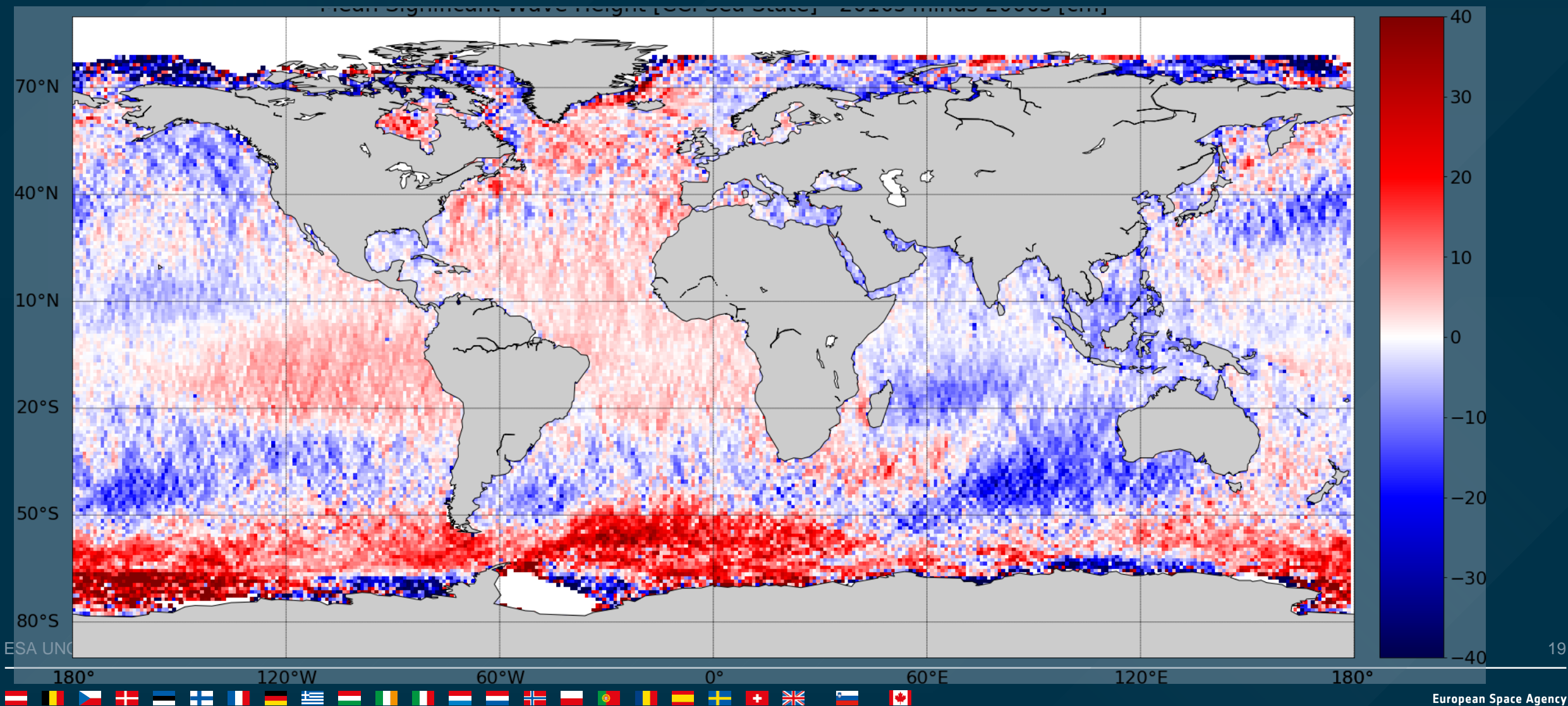
> Join the data discovery session at 13h30 today



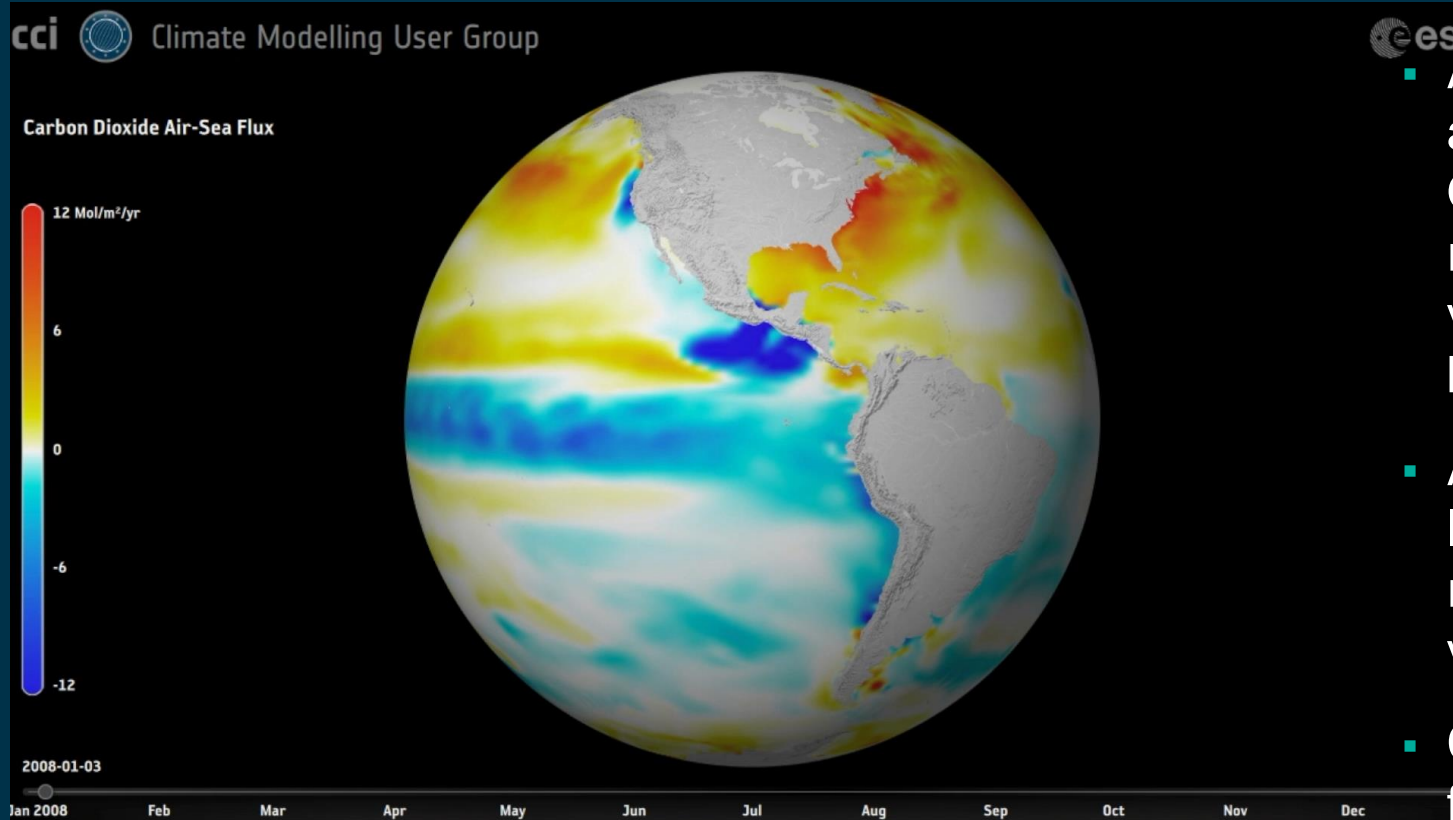
climate.esa.int/data

New ECV: Sea State CCI 1991-2018

Sea State CCI v1 dataset: difference 2010s – 2000s for changes in stormy seas



Marine ECVs used to improve reanalyses: CO₂ air-sea flux



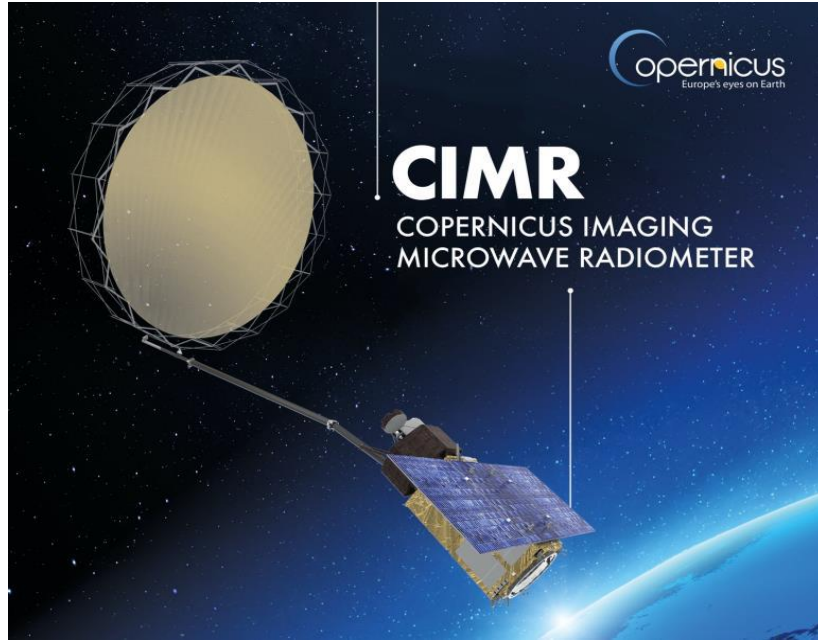
- Assimilation of CCI SST, sea level anomaly and ocean colour into Met Office FOAM-HADOCC improved representation of spatial features and variability in both physical and biogeochemical systems (CCI CMUG)
- Assimilating SST alone improves location and magnitude of gradients in reanalyses, best results when all variables assimilated together
- Chlorophyll bias reduced consistently for fisheries regions with previous sparse spatial coverage

New datasets published 2021 in the CCI Open Data Portal:
Ocean Colour CCI v5 (1997-2020)
SST CCI v3 in beta form for trailblazer users (autumn): contact
Nick Rayner nick.rayner@metoffice.gov.uk

Ford, D. A.: Assessing the role and consistency of satellite observation products in global physical–biogeochemical ocean reanalysis, Ocean Sci., 16, 875–893, 2020

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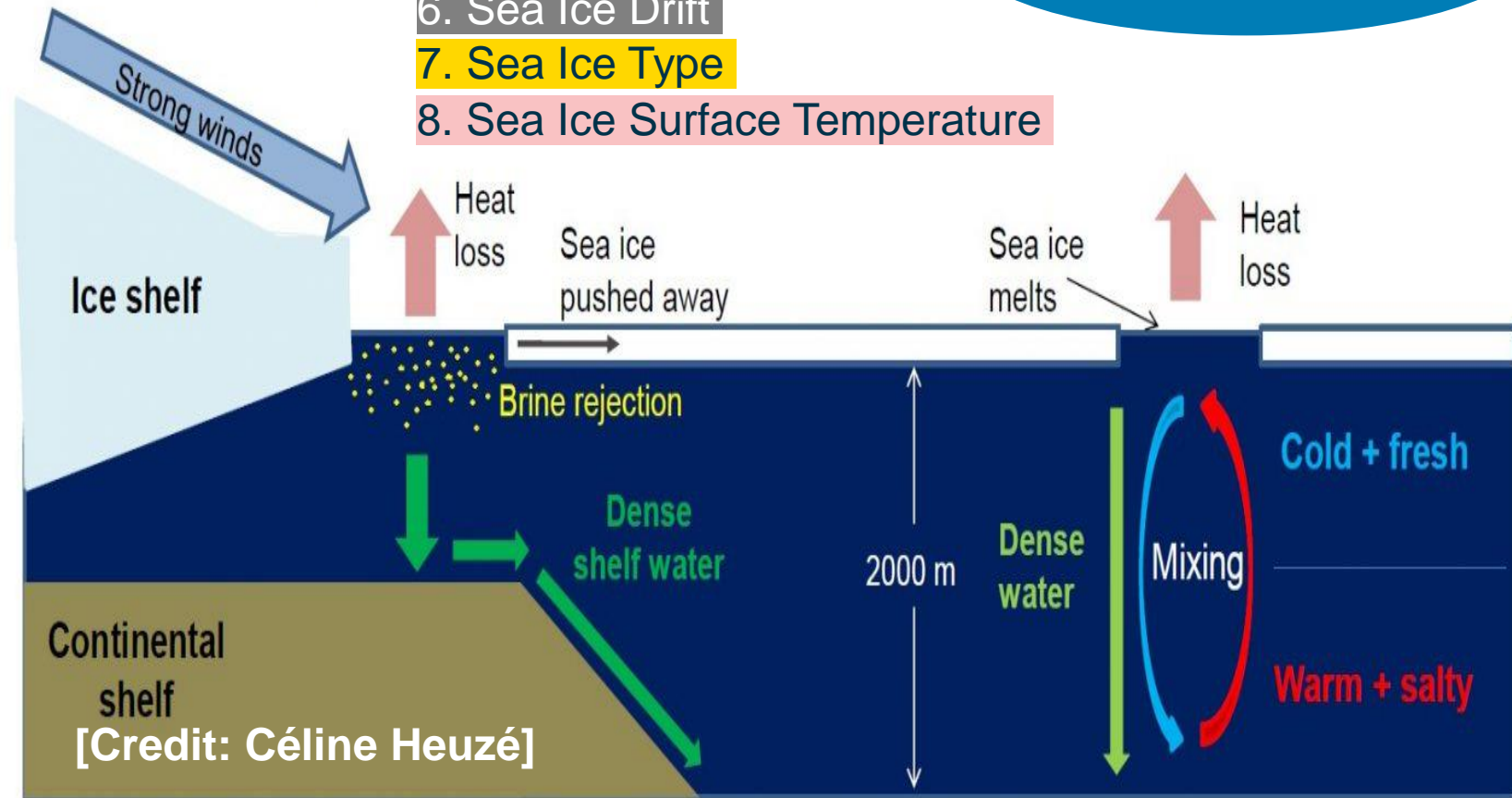
The Copernicus Imaging Microwave Radiometer (CIMR)



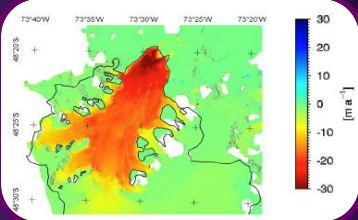
The CIMR mission will embark a conically scanning multi-frequency imaging microwave radiometer payload to measure the brightness temperature of the upwelling microwave radiation at different frequencies.

1. Sea Ice Concentration
2. Sea Surface Temperature
3. Sea Surface Salinity
4. Surface Winds
5. Sea Ice Thickness
6. Sea Ice Drift
7. Sea Ice Type
8. Sea Ice Surface Temperature

Cryosphere-ocean-atmosphere processes



Cryosphere



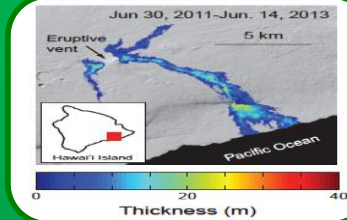
Glacier mass balance, dynamics of sea ice and marginal ice zone

Oceanography

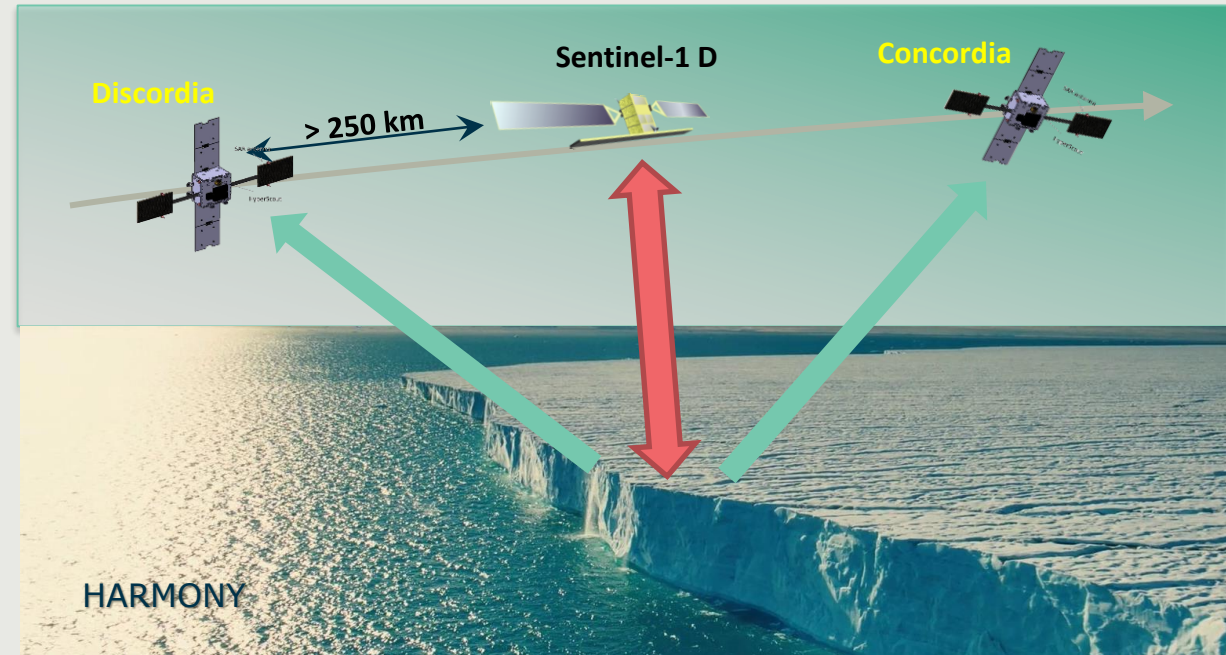


High resolution surface currents and wave data modelling, ocean small scale dynamics, extreme weather events

Geosphere



3-D deformation fields and topography changes relating to landslides, post-seismic deformation, volcanism



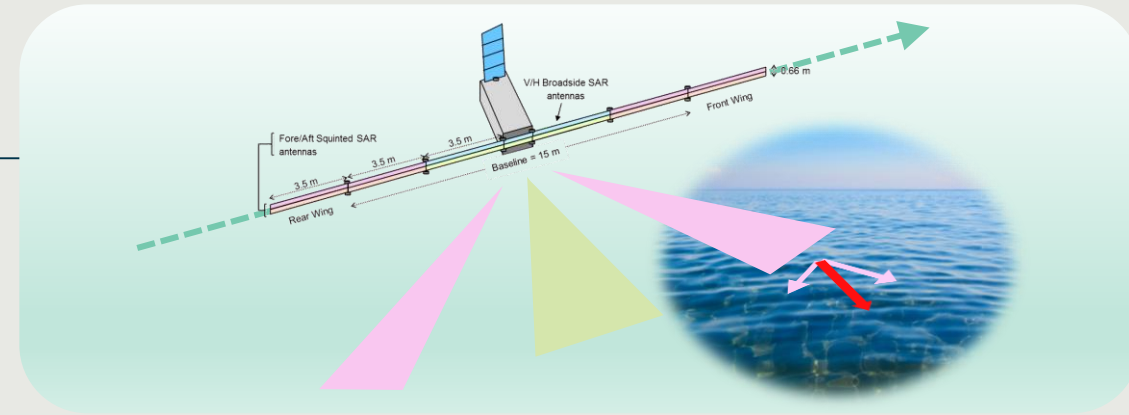
Primary Ocean Science goals:

- Quantify and characterize the impact of small-scale air-sea interactions and upper-ocean processes on the coupled ocean-atmosphere system.
- Fully characterize Tropical (like) Cyclones and polar lows in order to understand small-scale structure/processes and their interaction with the larger scales.

In particular, Harmony will for the first time provide **simultaneous measurements of wind, waves, currents**, that together with measurements of sea surface thermal differences and cloud motion will enable an unprecedented view of the **marine atmospheric boundary layer**.

Earth Explorer 11 Phase 0 mission candidate

Seastar has been selected as one of the four candidates for becoming ESA EE11.



Seastar would provide ocean surface current and surface wind vectors at 1 km resolution for all the coastal ocean, shelf seas and marginal ice zones. This information would further answer scientific questions concerning ocean dynamics and small-scale ocean process, **which are important for understanding air–sea interactions** that are linked to primary productivity supporting the marine food chain. These small-scale dynamics are also important for the dispersion of oil and plastic pollution. The satellite would carry a two-antenna along-track interferometry radar.

Pre-feasibility studies are being started, after which further down-selections will be made in 2023 and 2025, with a view to launching the successful Earth Explorer 11 mission in 2031–2032.

CALL FOR ABSTRACTS EXTENDED UNTIL 10 DECEMBER 2021

living planet symposium

BONN 23–27 May 2022

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- Observing small-scale ocean dynamics at the interfaces of the Earth System
- Ocean Doppler: Challenges and Opportunities for Future Missions of Global Ocean Surface Currents
- Colour and Light in the Ocean from Earth Observation
- Remote-sensing of Ocean Waves and their Applications
- ...