



2023 INTERNATIONAL OCEAN COLOUR SCIENCE MEETING

Ocean Colour Application & Research at CNES

Hubert Loisel/LOG

on behalf of Aurelien Carbonniere/CNES

- 1) Brief presentation of CNES EO program and activities;**
- 2) Focus on the SWOT mission, latest results and links with upcoming Trishna mission;**
- 3) Overview of CNES funded projects in the Ocean Color domain;**

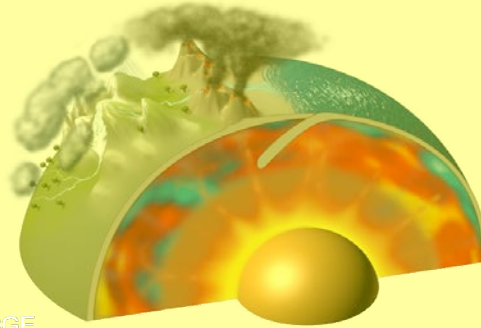
Phase 0 / Phase A

R&T actions

studies

Strategic in-situ
observations (buoys,
balloons, aircrafts, ...)

Development of
downstream applications



Support to
research

CNES EO missions

Strategie OT - Presentation DGE

Contributions to ESA / Copernicus /
EUMETSAT programmes

Data and services
centres

- ◆ A consistent set of actions aiming at covering all facets of the Earth System
- ◆ Collaborations / Partnerships
- ◆ Necessary combination of satellite + in-situ + model data
- ◆ From upstream (R&T) to downstream (applications)
- ◆ Guidance on strategy and level of support provided by scientific committees (CPS / TOSCA)

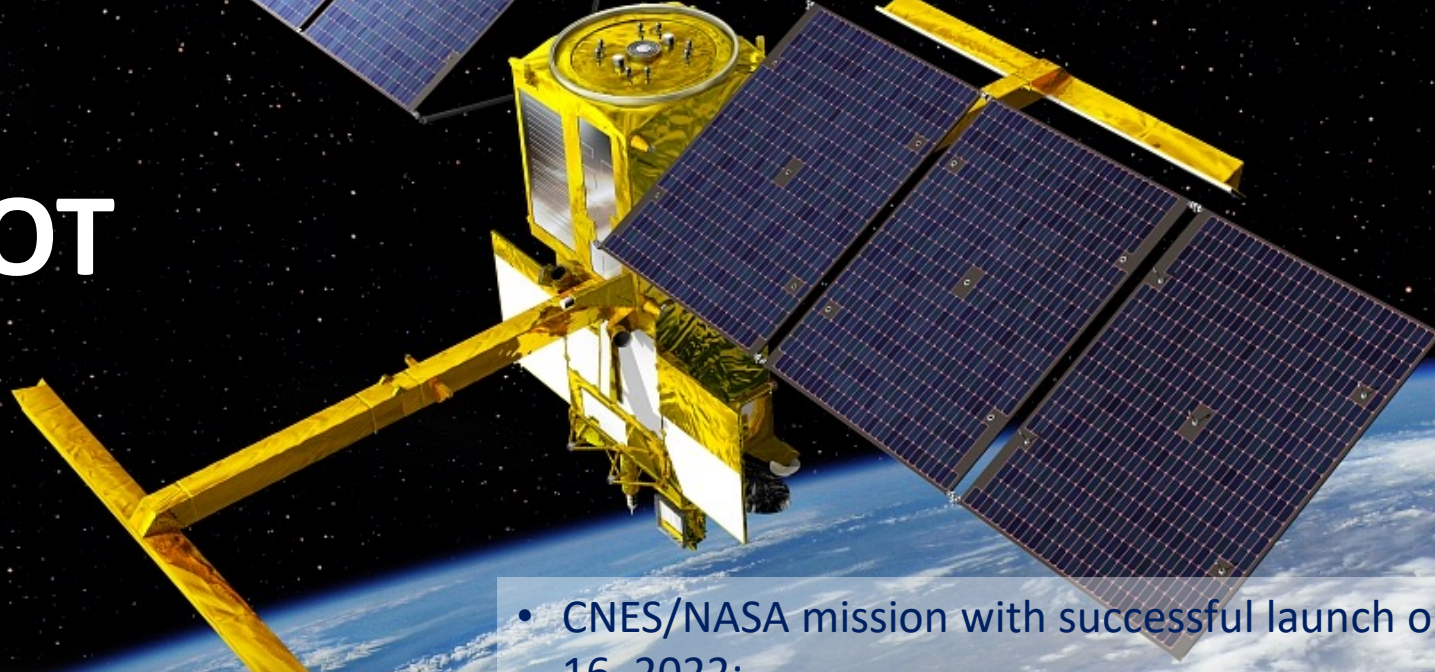
Missions in preparation:

- **AOS (Atmospheric Observatory with NASA, JAXA)**: moving to NASA Phase A;
- **ODYSEA (Ocean currents and winds, with JPL)**: Ph0/A CNES; Proposal to NASA Call June 2023
- **SMASH (water resources)** : Strategic subject, this is a French field of excellence, awaiting a programming framework, appraisal in progress;
- **NanoMagSat (terrestrial magnetism)**: ESA technical maturity activities
- **C3IEL (convective clouds)** with ISA (Israel); Transition to PhB0 March 2023.
- **Carioqa**: cold atom technology selected as part of Europe H2020 -> towards a new generation of gravimetric mission;

Missions under development:

- **Merlin (CH4 monitoring)**: development frozen at CNES, but continued support for scientific activities.
- **Microcarb (CO2 from space)**: launch possible S1 2024
- **IASI NG (climatology, atm chemistry)**: launch 2024 tbc
- **Trishna (Agriculture + coastal/continental hydrology)**: launch 2026

SWOT



- CNES/NASA mission with successful launch on December 16, 2022;
- International Science Team meeting in Toulouse on September 19-22, 9 months after launch, 250+ participants
- After a 6-month Cal/Val phase in a dedicated orbit, the SWOT satellite is now in its scientific orbit (21-day revisit).



The SWOT programme – Challenges

❖ SWOT is a mission that will meet the needs and expectations of three communities

- **Oceanography:** First global determination of ocean circulation, interactions and circulation mechanisms at high resolution.
- **Hydrology:** First global inventory of surface water storage and its evolution. Observations on the quantity and variability of water stored in the world's lakes, reservoirs and wetlands, and access to river flows.
- **Coastal:** better understanding of phenomena in this exchange zone.

❖ Major cooperation France / USA

- With CSA and UKSA contribution
- Over 30 years of cooperation in altimetry (TOPEX/Poseidon, Jason-1/2/3/CS)



❖ Highly ambitious, innovative mission

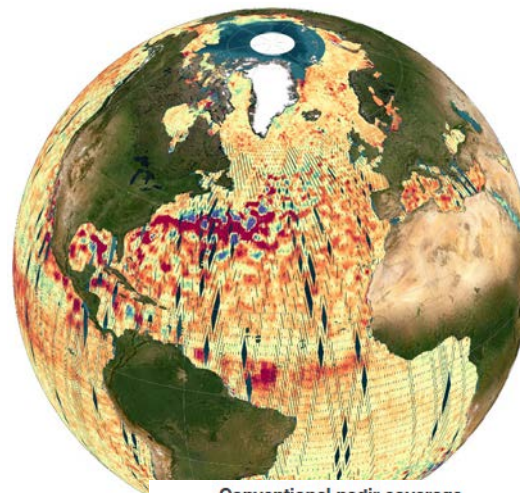
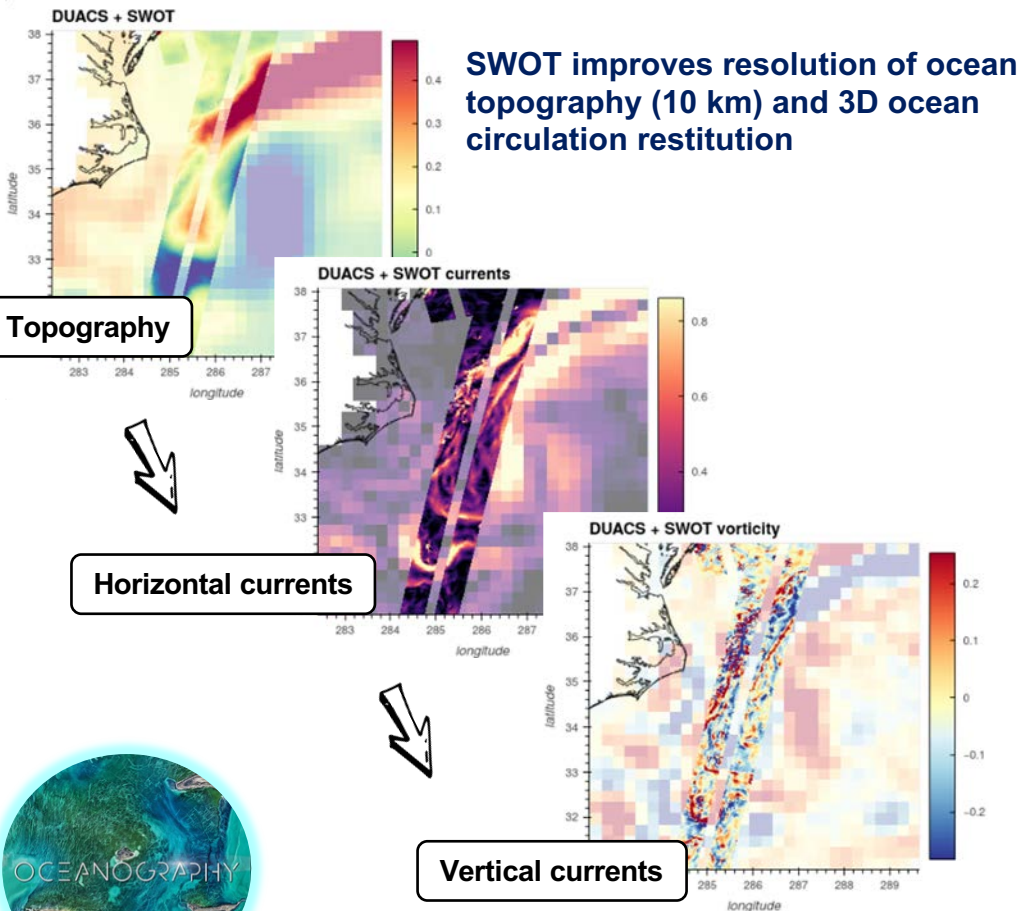
- Wide-swath interferometric altimetry (KaRIN instrument)
- Launch date: December 16, 2022
- Impressive results: watercourses of the order of 10 m in width (instead of the 100 m required)

❖ Unprecedented funding

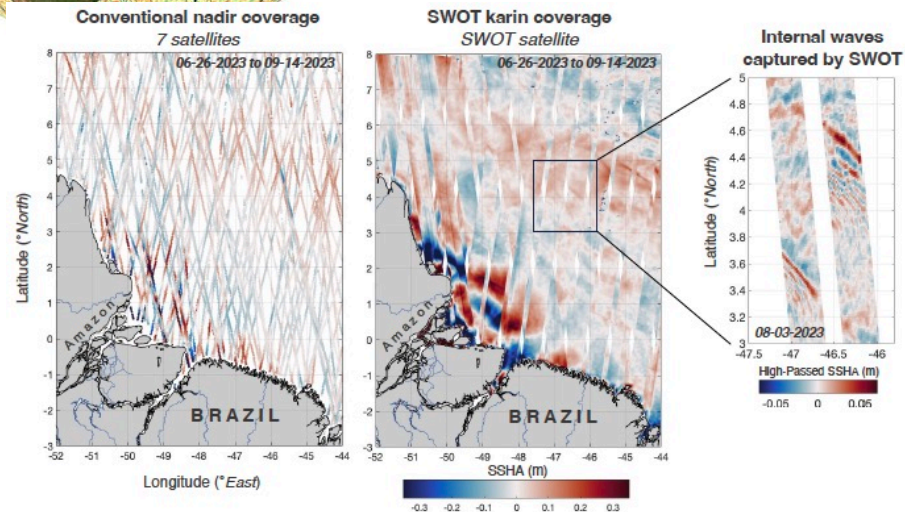
- SWOT has received funding from the PIA, the French government's innovation agency, recognition of its significant application potential.



Stunning first results!

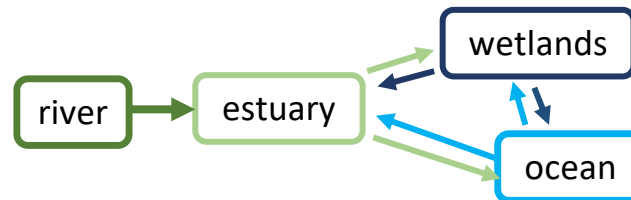


The spatial coverage offered by SWOT is 7 times better than that obtained with the nadir altimeter constellation (7 altimeters).



Stunning first results!

SWOT quantifies exchanges in coastal zones, estuaries, deltas and wetlands. KaRIn provides water level data up to 250 m offshore



Measurements backed up by numerous Cal/Val campaigns

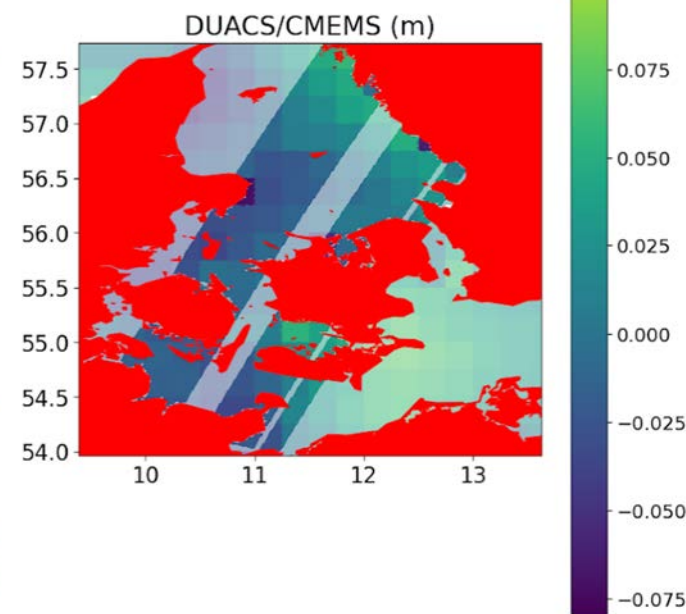
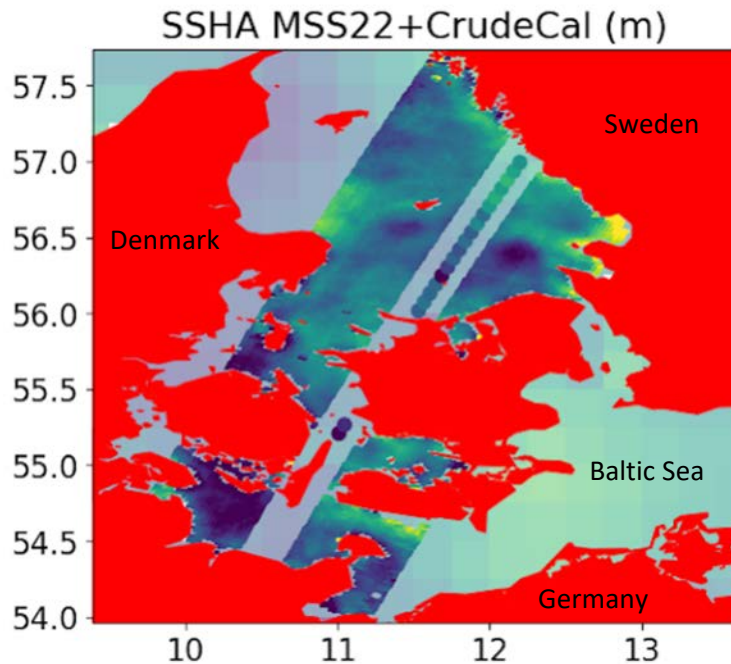
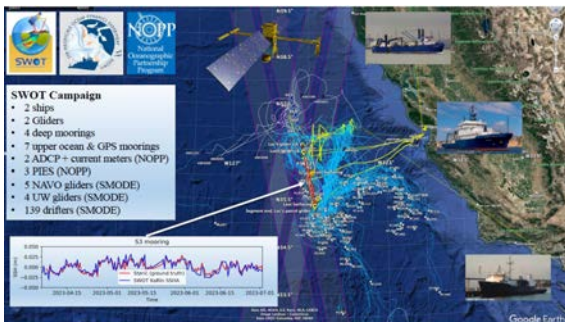


Illustration of SWOT in the Baltic Sea



Bilateral programs devoted WATER

Land, coastal, Ocean waters

Satellite precursors S3 NG TOPO, LSTM

Downstream Programs

Thermal infraRed Imaging Satellite for High resolution Natural resource Assessment



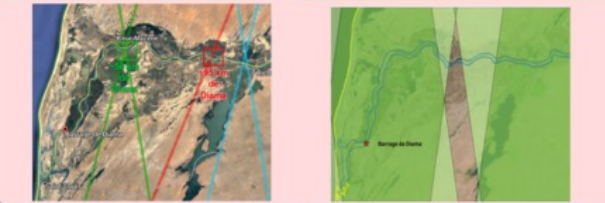
Blue water

Green and Blue waters

Ecosystem stress + coastal & inland hydrology

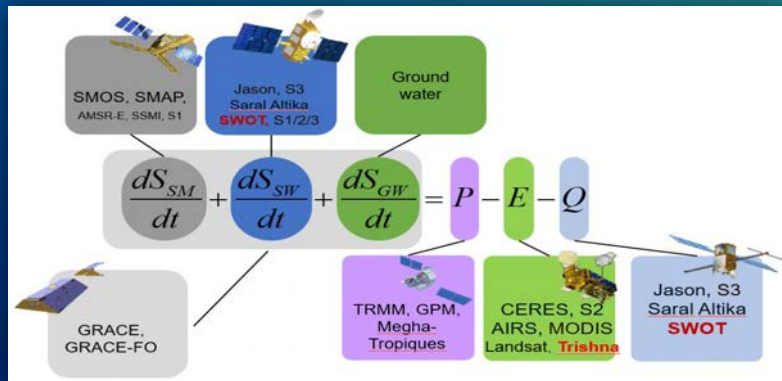
Design Drivers

In Senegal with Jason3 & S3 A/B with SWOT 2 obs or 1 obs in 21 days

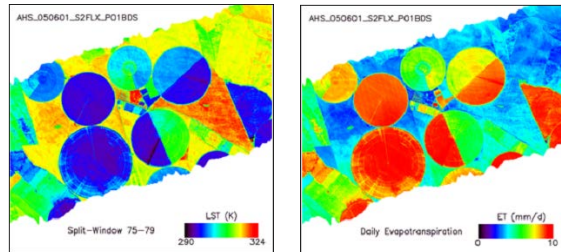
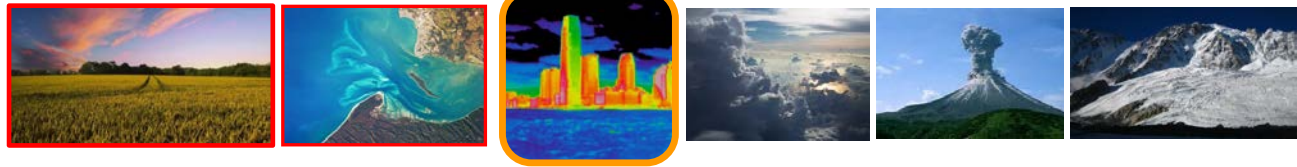
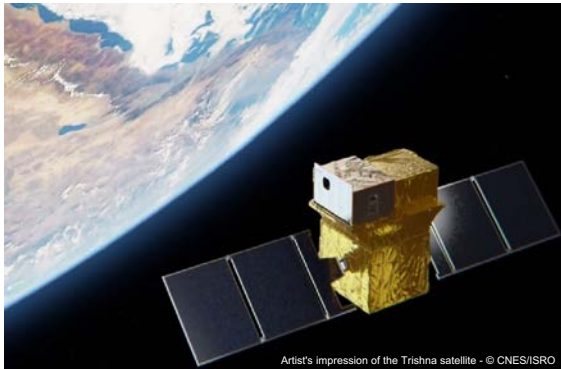


Launched Dec 16, 2022

hydroweb.next



Launch scheduled 2026



Ground surface temperature and daily evapotranspiration

Launch scheduled
2026

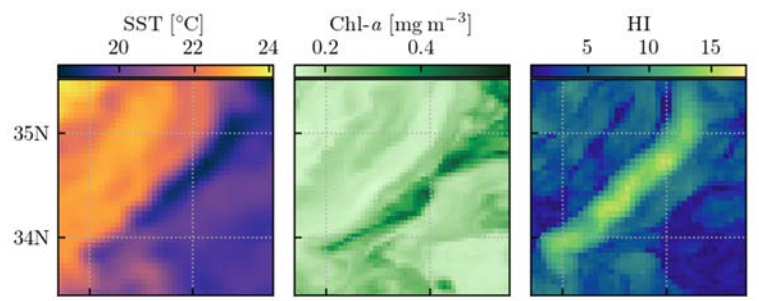
- 2 principal thematic issues:

Agriculture + Coastal & Inland Hydrology
+ **Urban, Cryosphere, Atmosphere, Solid Earth**

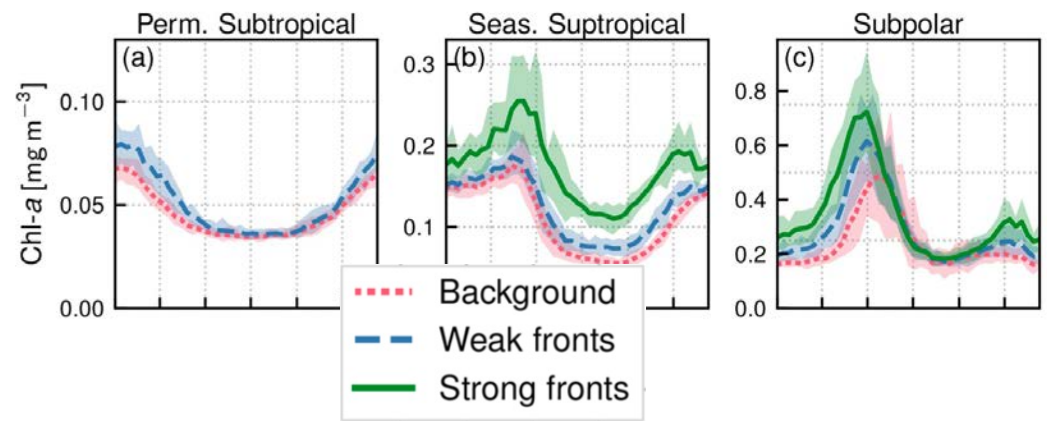
- **Global coverage @ 57 m resolution for continental and coastal areas**, binned at 1 km over open ocean.
- 4 TIR bands (**NeDT 0.2K**)+ 4 VNIR bands + 3 SWIR bands
- **3 Global acquisitions per 8 days period**
- 761km-8day orbit reducing hot spot constraints in intertropical zone
- $\pm 34^\circ$ scan angle, 1030km swath, Overpass time : 1 PM \pm 15 mn
- Indo-French(*) science mission group, synergies Under development with ECOSTRESS, SBG, **LSTM** science & application teams, + other European contributors



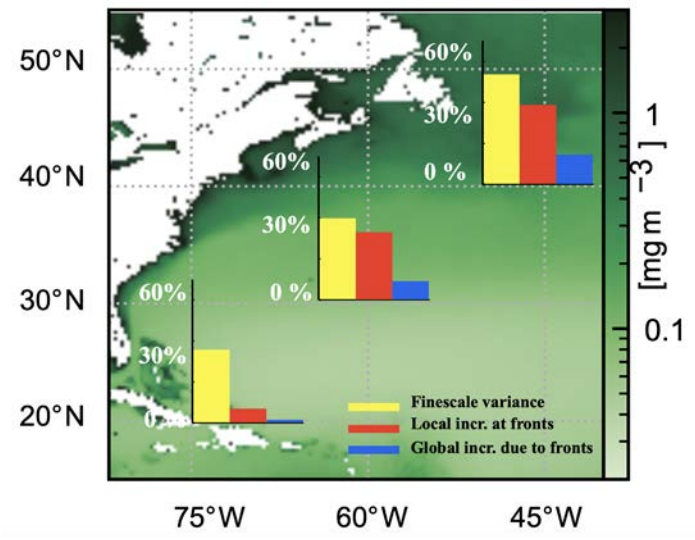
Front detection from SST



Chl-a seasonal cycle over fronts and outside



Impact of fine-scales on phytoplankton



up to + 60% more Chl-a over fronts
But contributes to less than 10% of regional budget

nature geoscience

Article <https://doi.org/10.1038/s41561-022-01057-3>
Annual variations in phytoplankton biomass driven by small-scale physical processes

Received: 14 September 2021 M. G. Keerthi¹, C. J. Prend², O. Aumont¹ & M. Lévy¹
Accepted: 22 September 2022

<https://doi.org/10.5194/egusphere-2022-1489>
Preprint. Discussion started: 6 January 2023
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Satellite data reveal earlier and stronger phytoplankton blooms over fronts in the Gulf Stream region

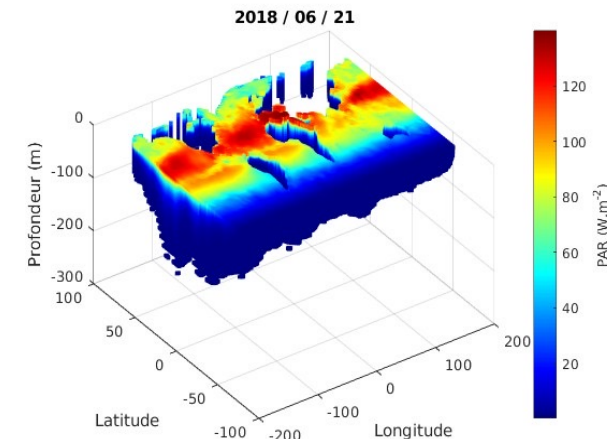
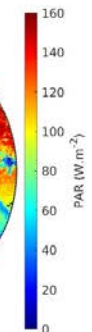
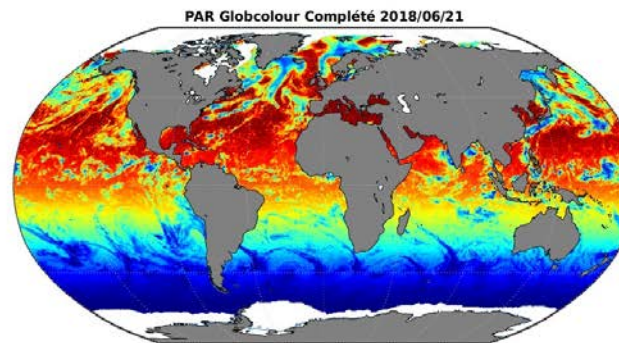
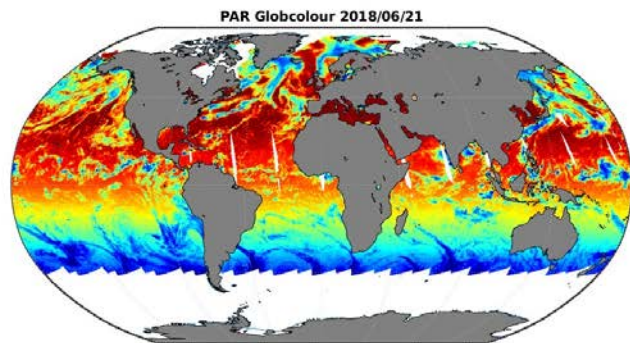
Clément Haëck¹, Marina Lévy¹, Inès Mangolte¹, and Laurent Bopp²
¹LOCEAN-IPSL, Sorbonne Université, CNRS, IRD, MNHN, Paris, France
²LMD-IPSL, École Normale Supérieure / Université PSL, CNRS, École Polytechnique, Paris, France



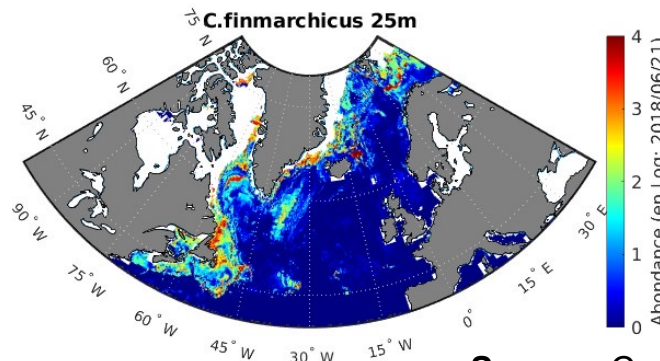
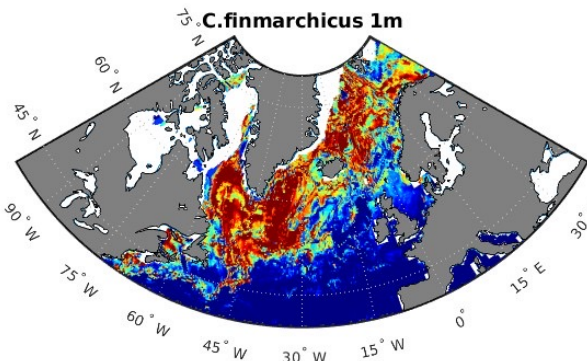
Objective 1: to provide a gap-free 4D PAR dataset (latitude x longitude x days x depth) for 1958-onwards

Original PAR dataset (Globcolour)

New PAR dataset (Globcolour)



Objective 2: to use the PAR dataset and other environmental data to model spatial and temporal changes in plankton distribution in the North Atlantic



Source: Castant et al (submitted)



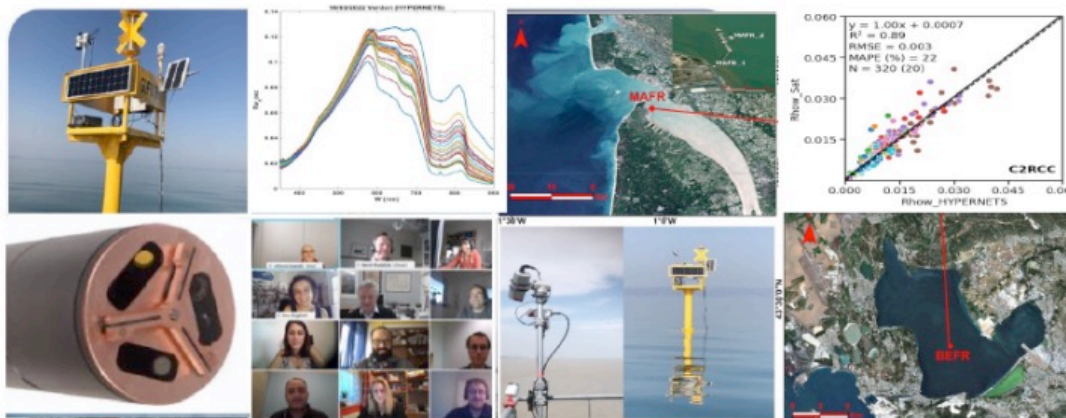
HYPERNETS

HYPERVAL



H2020-HYPERNETS : new international network of above-water hyperspectral radiometers for the validation of satellite-derived water-leaving reflectance in coastal and inland areas

HYPERVAL: Autonomous calibration and validation of satellite-derived products (turbidity, concentrations of algal and non-algal particles) on HYPERNETS water sites



In estuaries, river mouths and coastal lagoons, autonomous optical measurements for the validation of satellite-derived:

- water reflectance
- turbidity and Chla fluorescence

For accurate retrieval and monitoring of SPM and Chla concentrations

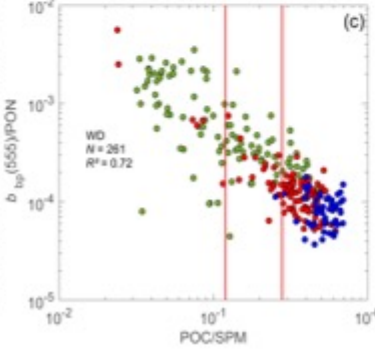
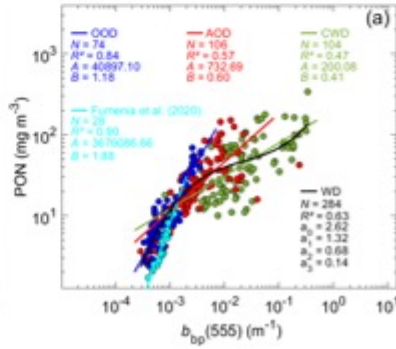
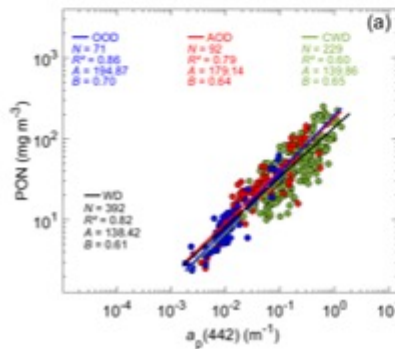
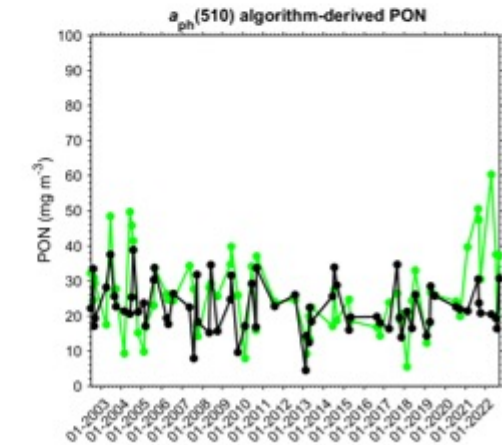
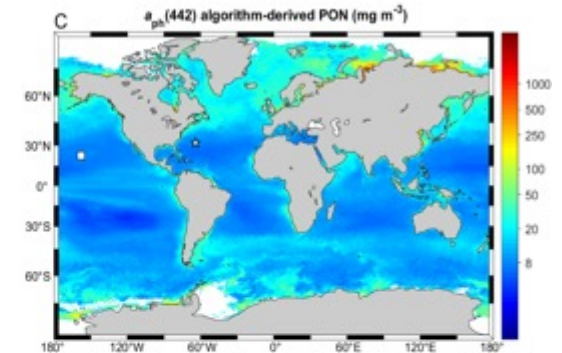
Optical Proxies of Particulate Organic Nitrogen and Phosphorus: application to ocean colour remote sensing (COUL-PNP)

PI: H. Loisel (LOG)

Collaborators: D. Stramski and R. Reynolds (Scripps)

Objectives

- Examine the relationships between the PON and particulate IOPs
- Development of PON and POP OCR algorithms
- Analysis of the PON and POP spatio-temporal variability over the global ocean, and pertinences of the remotely sensed POC/N/P ratios.



OCEAN COLOR PRODUCTS IN HIGH RESOLUTION (FUNDED THROUGH TOSCA PROJECT OBS2CO)



CNES inland Water Quality products: OBS2CO

Sentinel-2 and Landsat images



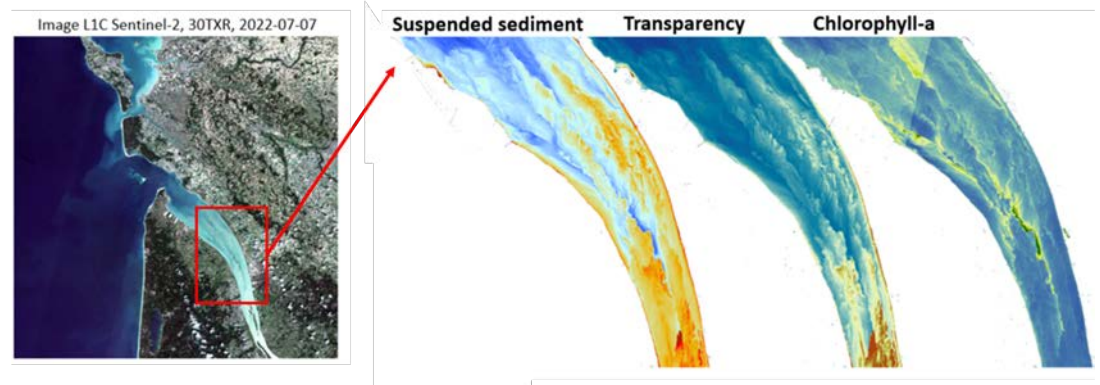
GRS [1] two-step Radiometric correction

Corrected reflectances



Model-based or empirical inversion

Water quality variables (20m resolution)



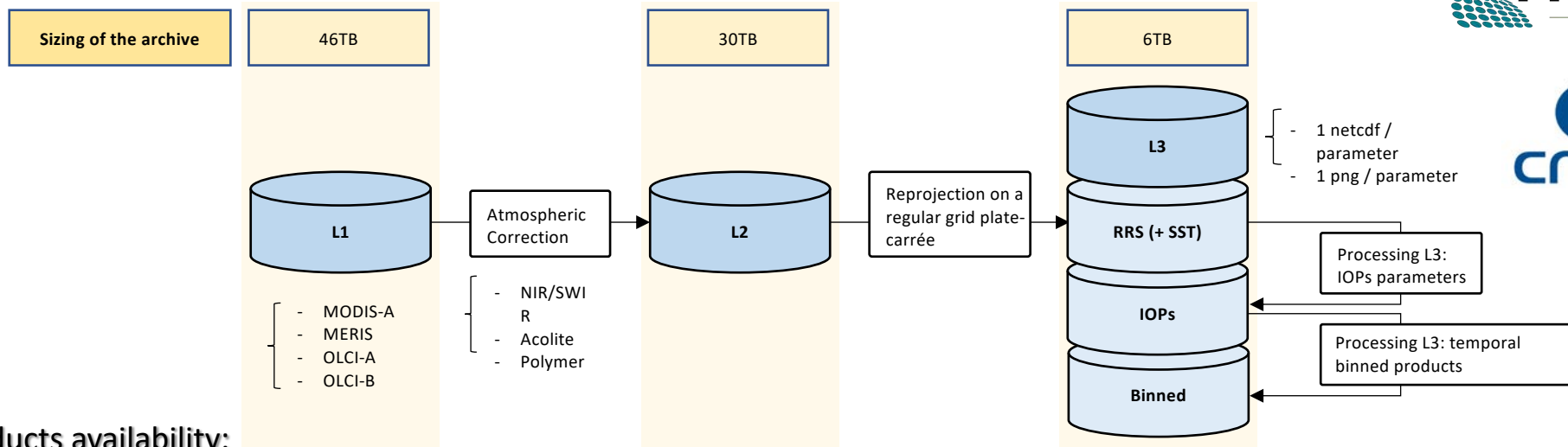
[1] Harmel et al., "Sunlint correction of the Multi-Spectral Instrument (MSI)-SENTINEL-2 imagery over inland and sea waters from SWIR bands" in Remote Sensing of Environment, 2018

Products available on hydroweb.next.theia-land.fr



Ocean Color products in Medium Resolution

Processing chain:



Products availability:

| | CHL-OC5 | CHL-GONS | BBP | SPM-G | SPM-R | T-FNU | CDOM | DOC | POC | |
|---------------|--------------------|--|---|------------------|--------------------|------------------------|---------------------|--------------------------|-------------------|--------------|
| Algorithm | Gohin et al., 2002 | Gons et al., 2005 Gernez et al., 2017 | Loisel et al., 2018 Jorge et al., 2021 | Han et al., 2016 | Novoa et al., 2017 | Dogliotti et al., 2015 | Loisel et al., 2014 | Vantrepotte et al., 2015 | Tran et al., 2019 | + RRS SST |
| Open Ocean | X | | X | X | | | X | X | X | |
| Coastal Ocean | X | X | X | X | X | X | X | X | X | |

All products are available at 300 m spatial resolution:

- For the French coastal areas (up to 200 km offshore)
- For the following archives:
 - MODIS 2002-2021
 - MERIS 2002-2012
 - OLCI-A 2016-2021
 - OLCI-B 2018-2021

A web tool offers to the end user the possibility of extracting matchups for the location of interest



MANY THANKS FOR YOUR ATTENTION

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