

# #MarineData4Asia

## The MULTI OBSERVATION THEMATIC ASSEMBLY products

H. Etienne , N. Verbrugge, B. Buongiorno Nardelli, Daniele Ciani, Michela Sammartino, T. Chau, F. Chevallier, H. Claustre, M. Gehlen, E. Greiner, S. Mulet, R. Sauzède, Stéphane Tarot, Nicolas Kolodziejczyk, Jacqueline Boutin, Gerald Dibarboure, Ana Parracho, Renosh Pannimpullath Remanan

## What is MULTIOBS (MOB TAC)

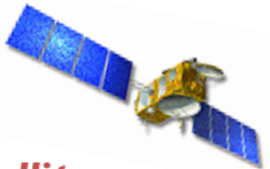
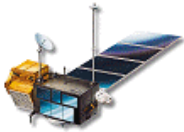
The Ocean **Multi Observations** are:

- **Global qualified** Products
  - Products based on **Observations** (satellite & in-situ) and **data fusion techniques**
  - Products covering the **blue** and **green** ocean
  - **Near-Real-Time** & **Multi-Year** products (annual updates) & **Ocean Monitoring Indicators**
  - Gridded for the most part.
- 
- ✓ Taking advantage of the **strength of the GOOS**
  - ✓ Staying **close** to the observations, providing **stable** long timeseries
  - ✓ Providing a **complementary approach** to model/assimilation (MFCs)

# MULTIOBS organisation & products

- 6 physical products (with 3 NRT)
- 2 products with carbon variables
- 2 BGC products
- 3 Carbon OMI

contact: [hetienne@groupcls.com](mailto:hetienne@groupcls.com)



Ocean geostrophic-current  
 fCO<sub>2</sub> nitrate  
 sea-surface-salinity  
 salinity 4D phosphate satellite  
 Bbp POC surface-current AI  
**Multi-Observations**  
 neural-network MLD sea-surface-density  
 in-situ silicate Chl-a Global  
 data-fusion-technique vertical-current  
 pH temperature  
 pCO<sub>2</sub>



# Sea Surface Salinity & Sea Surface Density

MULTIOBS\_GLO\_PHY\_S\_SURFACE\_MYNRT\_015\_013

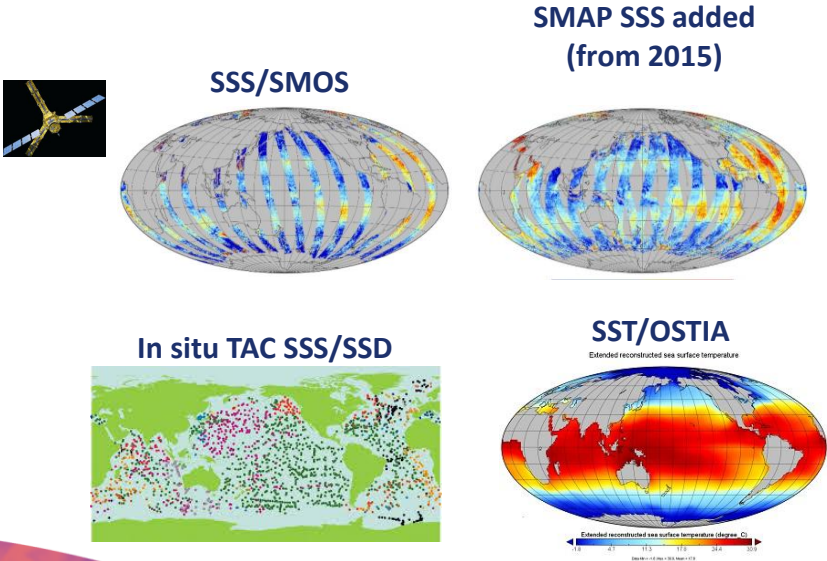
## → SSS & SSD NRT & REP time series

- Based on a **Multivariate Optimal Interpolation** algorithm
- Taking advantage of concurrent SST observations to increase effective space-time resolution up to mesoscale\*
- Hypothesis: **SST** and **SSS** variations are correlated at scales smaller than the ones dominating atmospheric variability (in the open ocean)



Michela Sammartino  
Bruno Buongiorno Nardelli

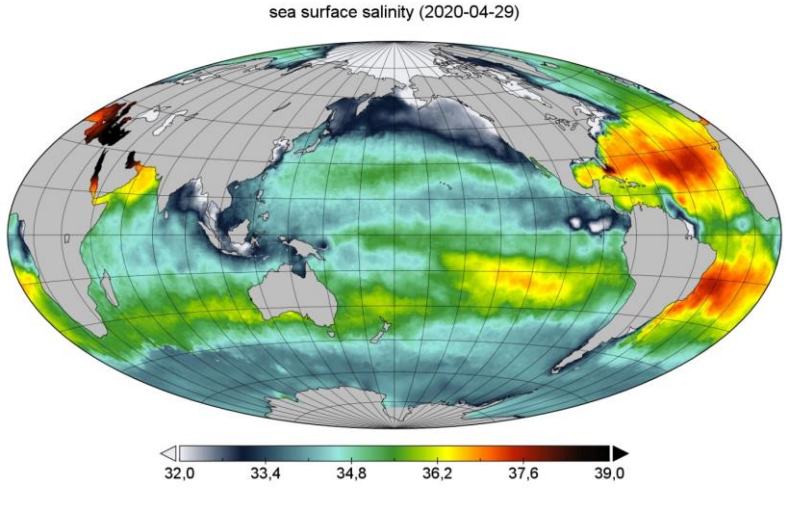
**GLOBAL**  
1/8° resolution  
daily  
1993-present



**Warning:** From August 8 to October 8, 2022, the NASA Soil Moisture Active Passive (SMAP) observatory has entered a safe-mode with no new data acquisitions.



Multivariate Optimal Interpolation algorithm



\* R. Droghei, B. Buongiorno Nardelli, and R. Santoleri (2018), A new Global Sea Surface Salinity and Density Dataset from Multivariate Observations (1993-2016), Front. Mar. Sci., 5(March), 1-13, doi:10.3389/fmars.2018.00084.

# Sea Surface Salinity L3

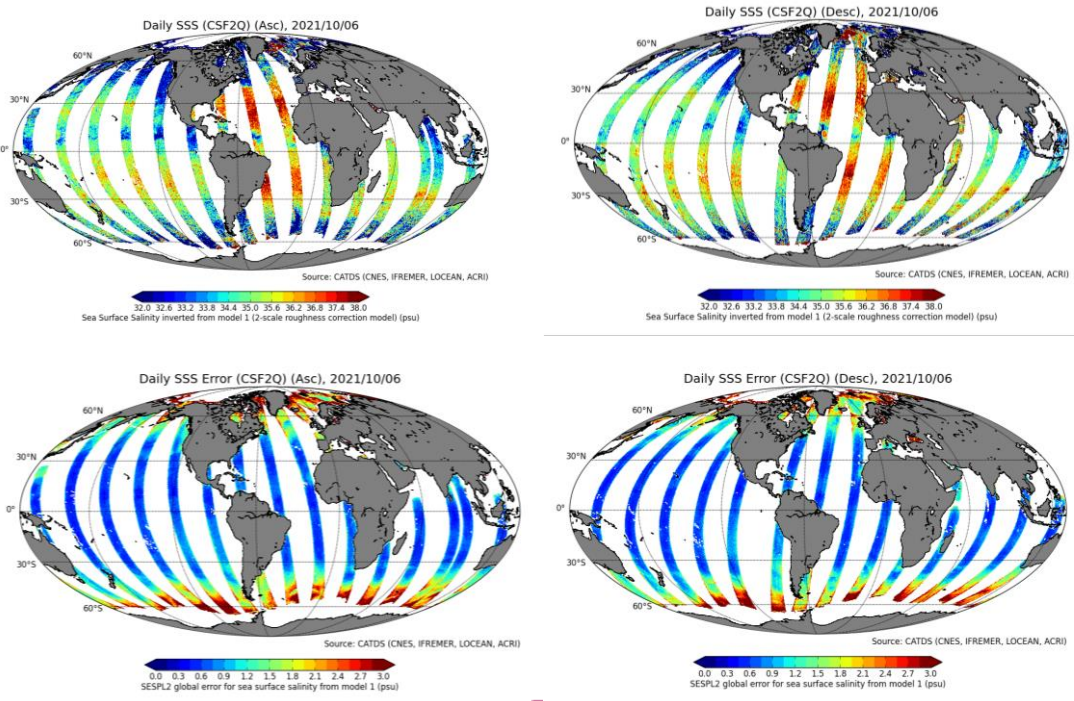
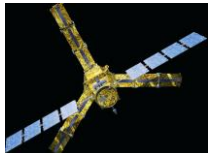
MULTIOBS\_GLO\_PHY\_SSS\_L3\_MYNRT\_015\_014

## → SSS L3 NRT & REP time series

- SSS from Soil Moisture Ocean **Salinity (SMOS) Level-3** daily data (ascending and descending passes separately)
- SSS corrected from land-sea contamination, latitudinal bias and with and without rain freshening correction
- NRT: First generated at D+1 (temporally uncentered calibration)
- NRT: Updated at D+5 (temporally centered calibration)



Stéphane Tarot  
 Jacqueline Boutin  
 Nicolas Kolodziejczyk



**GLOBAL**

- Along-track, 25km spatial resolution
- Data in each pixel correspond to spatially integrated SSS over the native resolution of SMOS observations
- daily
- 05/2010 to present

# Sea Surface Salinity L4

MULTIOBS\_GLO\_PHY\_SSS\_L4\_MY\_015\_015

## → SSS L4 REP time series

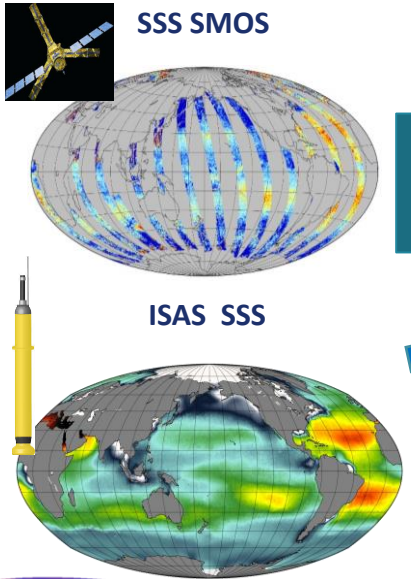
- L4 Based on a **Optimal Interpolation** algorithm combining ISAS SSS from In Situ TAC and SMOS SSS to reduce large scale and temporally varying bias
- From **SSS L4 + AMSR2 SST + TEOS-10\* algorithm** => Sea Surface Density (SSD), Sea Surface Spiciness (SSSp) + Sea Surface Absolute Salinity (SSA), Conservative Temperature (SCT), surface thermal expansion coefficient (alpha) and haline contraction coefficient (beta)



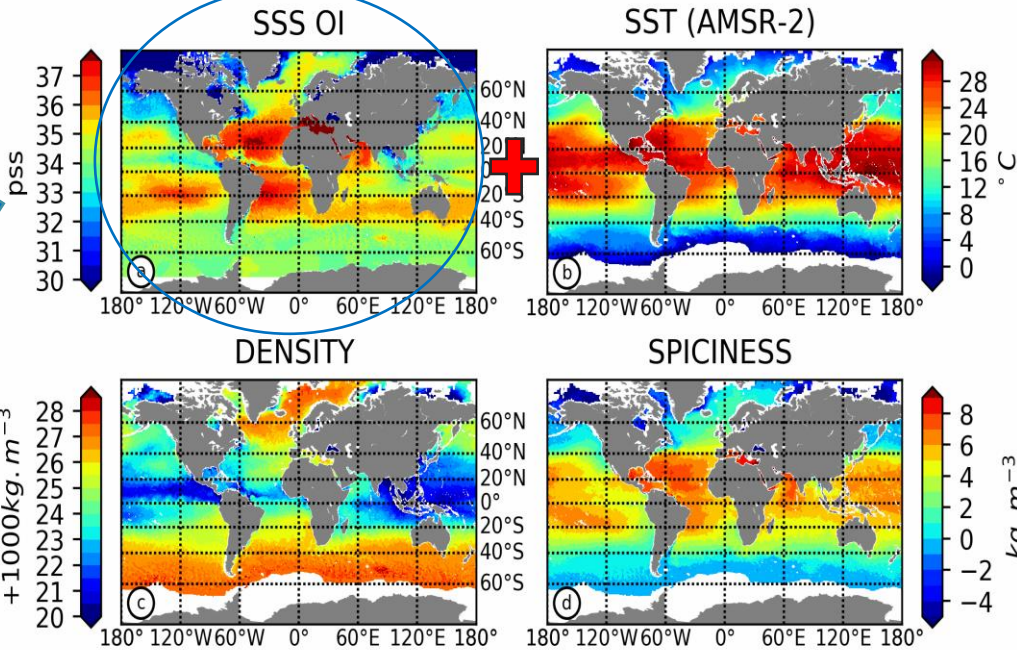
Stéphane Tarot  
 Jacqueline Boutin  
 Nicolas Kolodziejczyk

**GLOBAL**  
 1/4° resolution  
 Weekly  
 1993-2021

**June 2024**  
 Add SMAP SSS from 2015



Optimal Interpolation



TEOS-10

\*Kolodziejczyk et al., 2021

# 3D T/S/Uvg/MLD – ARMOR3D

MULTIOBS\_GLO\_PHY\_TSUV\_3D\_MYNRT\_015\_015

## → 3D temperature, salinity, geostrophic currents and MLD NRT & REP time series

- Based on a **3 steps method** starting from a first guess climatology
  - (1) Satellite data (SLA + SST + SSS) are projected onto the vertical using a **multiple linear regression** method
  - (2) Combination between step 1 fields with T/S in situ profiles using an **optimal interpolation** method
  - (3) Use of the **thermal wind equation** to combine the 3D T/S fields with surface geostrophic current fields to generate 3D geostrophic current

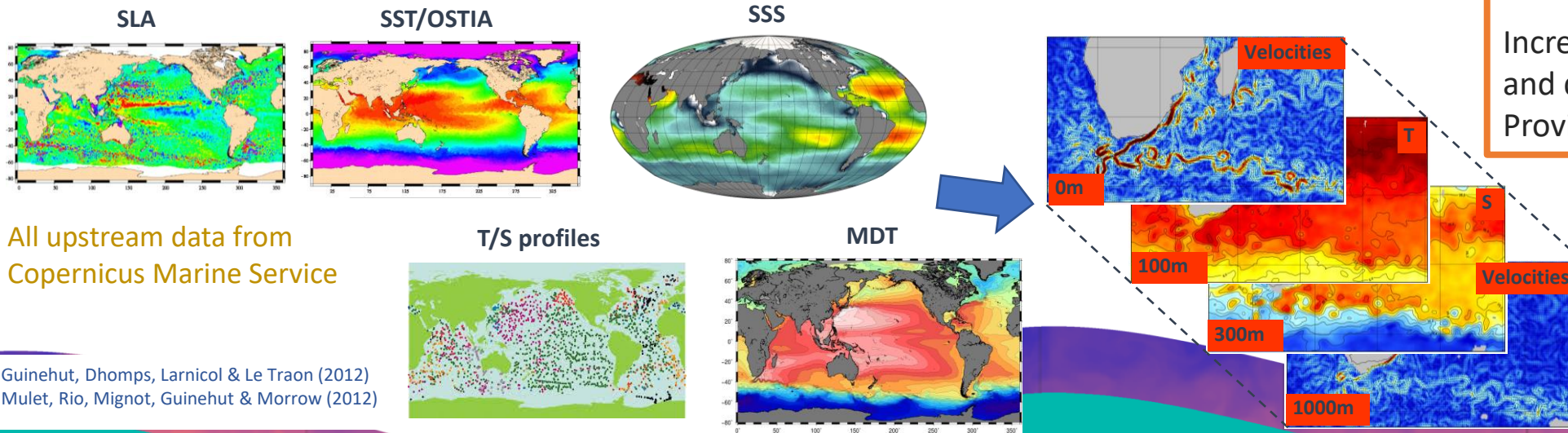
## → Mesoscale structures at the right place thanks to satellite input & Stable climate signal



Nathalie Verbrugge  
Sandrine Mulet  
Eric Greiner

**GLOBAL**  
1/4° resolution  
50 levels, weekly  
1993-present

**December 2024**  
Increase resolution to 1/8°  
and daily.  
Provide uncertainty



- Guinehut, Dhomp, Larnicol & Le Traon (2012)
- Mulet, Rio, Mignot, Guinehut & Morrow (2012)

# 3D Quasi-geostrophic currents – OMEGA3D

MULTIOBS\_GLO\_PHY\_W\_3D\_REP\_015\_007

→ **3D Quasi-geostrophic currents (Vertical & Horizontal) REP** based on the application of the **diabatic QG Omega equation** to ARMOR3D observation-based fields & ERA-interim fluxes



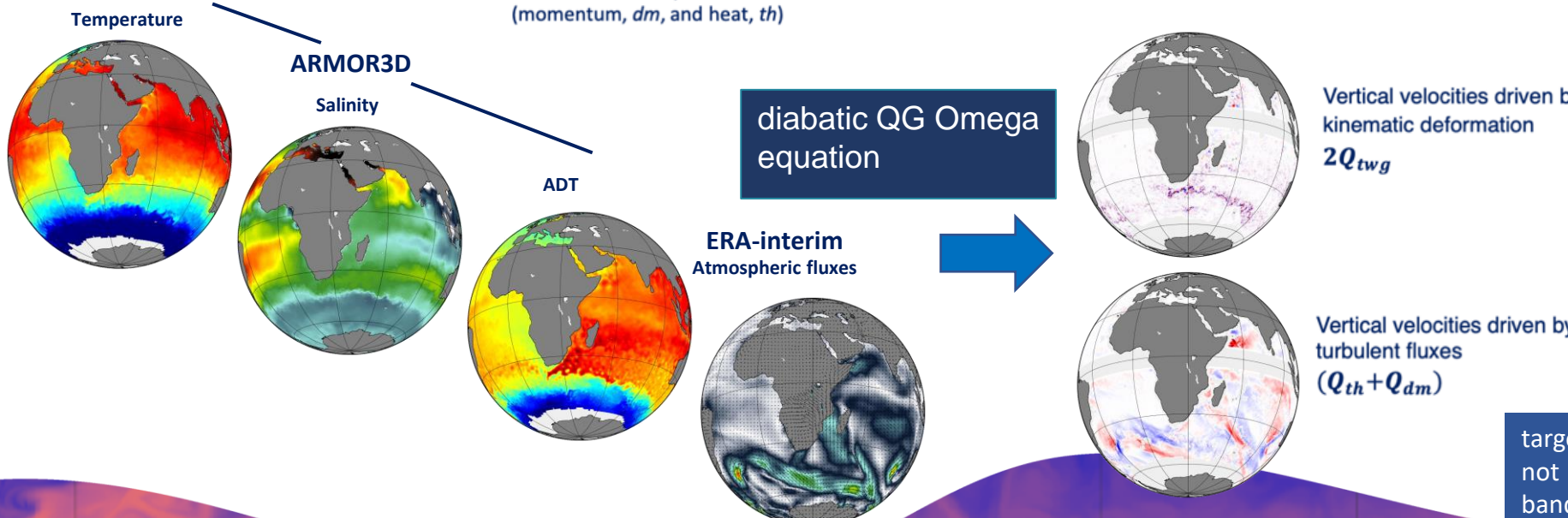
BrunoBuongiorno Nardelli  
Sarah Asdar

$$\nabla^2_h(N^2w) + f^2 \frac{\partial^2 w}{\partial z^2} = \nabla_h \cdot Q$$

$$Q = 2Q_{twg} + (Q_{th} + Q_{dm}) \rightarrow$$

forcing ( $Q$ ) and solution ( $w$ ) include adiabatic ( $twg$ ) and turbulent flux components (momentum,  $dm$ , and heat,  $th$ )

$$\begin{cases} Q_{twg} = \frac{g}{\rho_0} \left( \frac{\partial u_g \partial \rho}{\partial x \partial x} + \frac{\partial v_g \partial \rho}{\partial x \partial y} + \frac{\partial u_g \partial \rho}{\partial y \partial x} + \frac{\partial v_g \partial \rho}{\partial y \partial y} \right) \\ Q_{dm} = \frac{f}{\rho_0} \left( -\frac{\partial^2}{\partial z^2} \left[ \rho K_m \left( \frac{\partial u}{\partial z} - \gamma_u \right) \right], \frac{\partial^2}{\partial z^2} \rho \left[ K_m \left( \frac{\partial v}{\partial z} - \gamma_v \right) \right] \right) \\ Q_{th} = -\frac{g}{\rho_0} \nabla_h \left( \frac{\partial}{\partial z} \left[ K_\rho \left( \frac{\partial \rho}{\partial z} - \gamma_\rho \right) \right] \right) = \nabla_h \left( \frac{\partial}{\partial z} \left[ K_\rho \left( N^2 + \frac{g}{\rho_0} \gamma_\rho \right) \right] \right) \end{cases}$$



**GLOBAL**  
1/4° resolution  
75 levels, weekly  
REP: 1993-2018

**December 2024**  
Use ERA5 flux  
Use empirical correction to the KPP viscosity from MOB product MYNRT\_015\_003)

targeted for Open ocean  
not applicable in equatorial band/coastal areas

Buongiorno Nardelli, B., Earth Syst. Sci. Data 2020, No. 12, 1711–1723.  
<https://doi.org/10.5194/essd-12-1711-2020>.

# Surface and near-surface currents

MULTIOBS\_GLO\_PHY\_MYNRT\_015\_003

## → 2D surface and near-surface currents NRT & REP time series (Copernicus-Globcurrent)

- Altimetry derived **Geostrophic** Currents + **Ekman** Currents
- Wind driven Ekman model constructed using **in situ observations** of **Argo** surface drift and 15 m depth **SVP drifters** together with **wind stress** from ERA5 & ERA5\*
- Related uncertainties (daily and monthly)



GLOBAL  
 surface/15m  
 1/4° resolution  
 NRT: 1-hourly  
 (1993-present)

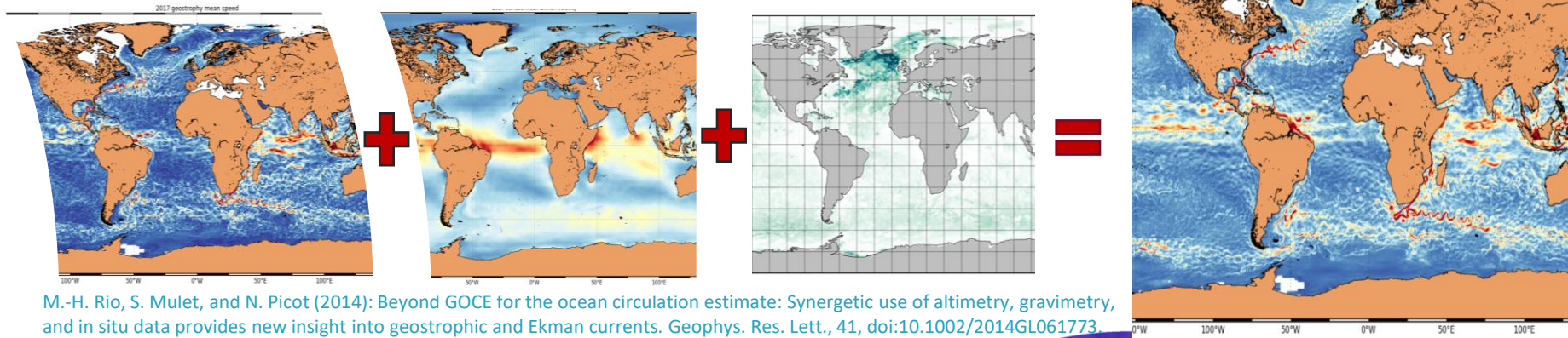
December 2024  
 Add tide signal

Geostrophy  
 CNES-CLS18 MDT + DUACS21  
 SLA (SL TAC)

Wind driven  
 Empirical model (0,  
 15m) + ERA5

ARMOR3D MLD

Total current  
 (0, 15m)



M.-H. Rio, S. Mulet, and N. Picot (2014): Beyond GOCE for the ocean circulation estimate: Synergetic use of altimetry, gravimetry, and in situ data provides new insight into geostrophic and Ekman currents. Geophys. Res. Lett., 41, doi:10.1002/2014GL061773.

# 2D Surface Carbon

MULTIOBS\_GLO\_BIO\_CARBON\_SURFACE\_REP\_015\_008

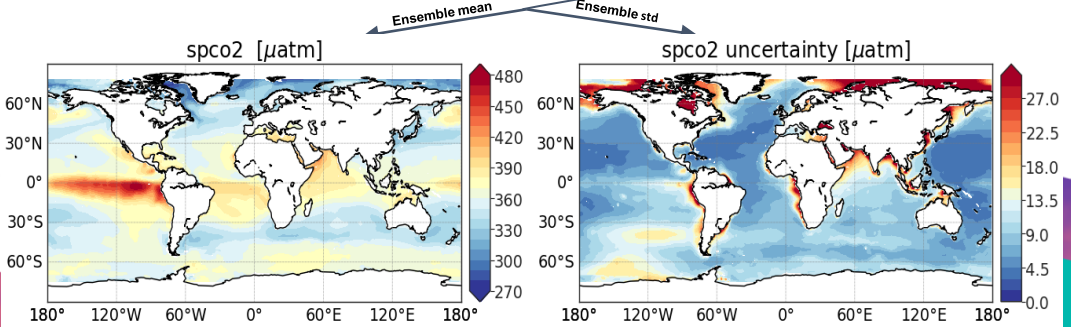
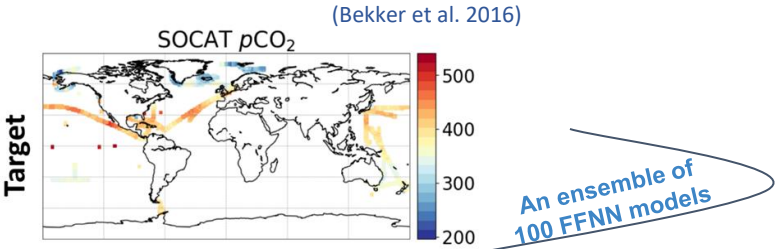
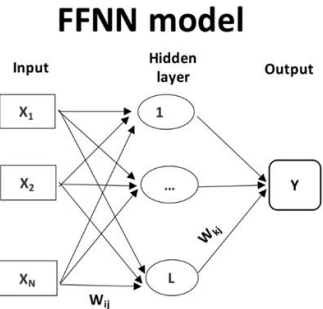
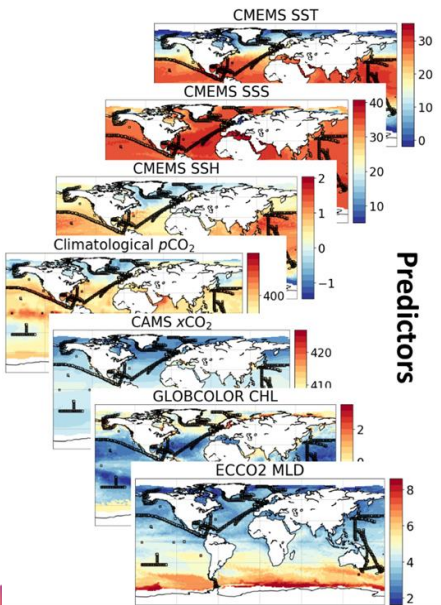
- Global surface pCO<sub>2</sub>, FCO<sub>2</sub>, pH, talk, tCO<sub>2</sub>, omega\_ca, omega\_ar monthly mean fields (1985-2021)
  - Surface ocean pCO<sub>2</sub> (spco2)
    - Based on an ensemble of 100 feed forward neural-network models (an improvement of LSCE-FFNN, Denvil-Sommer et al., 2019), trained on in situ observations of pCO<sub>2</sub><sup>oc</sup> from the SOCATv2020 Atlas (Bakker et al., 2016)
  - Air-sea flux of CO<sub>2</sub> (fgco2)
  - alkalinity, DIC, pH, calcite carbonate saturation states



Trang Chau  
Frédéric Chevallier  
Marion Gehlen

**GLOBAL**  
1/4° resolution  
monthly  
REP: 1985-2022

**December 2024**  
New low latency dataset (M-1)



Temporal mean of spco2 best estimate and uncertainty over 1985-2021

Denvil-Sommer, A., Gehlen, M., et al. (2019) LSCE-FFNN  
Chau et al. (2022)

# Nutrient vertical profiles

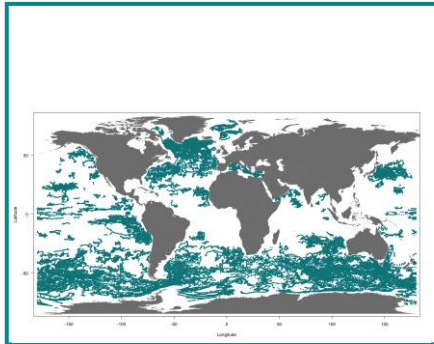
MULTIOBS\_GLO\_BIO\_NUTRIENTS\_PROFILES\_REP\_015\_009

→ **Nutrient (nitrate, phosphate and silicate) and Carbonate system variables (pH, total alkalinity (AT), dissolved inorganic carbon (CT), and partial pressure of CO2 (pCO2)) vertical profiles derived from BGC-Argo P/T/S/O<sub>2</sub> profiles**

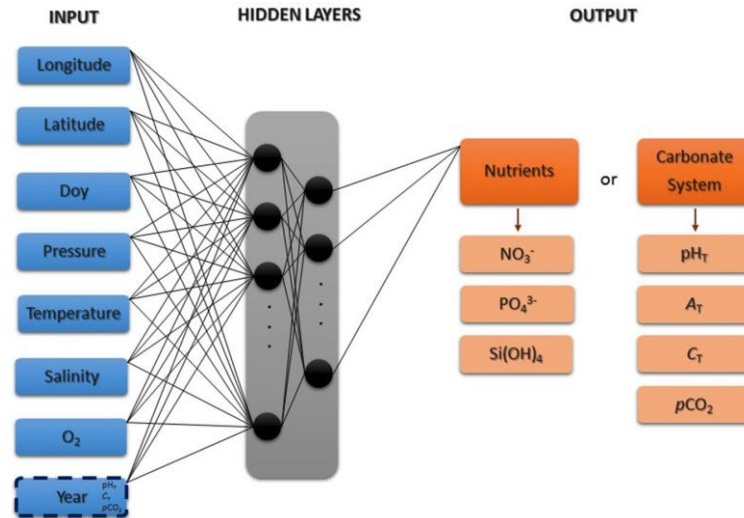


Raphaëlle Sauzède  
Hervé Claustre  
Ana Parracho,  
Renosh Pannimpullath Remanan

- Based on the **neural-network method CANYON** trained on high quality nutrient data collected over the last 30 years (**GLODAPv2** database)

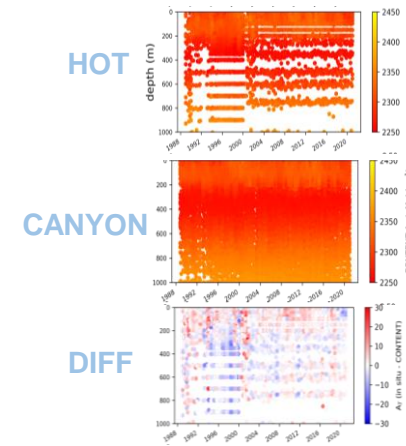


→ take advantage of fast growing number of **BGC-Argo profiling floats data** with the main objective to finally provide **useful and easy usable 3D end-users products**



**Carbonate system variables compared with observed HOT time series (ex: Total Alkalinity)**

**December 2024**  
New low latency dataset (M-1)



**CANYON-B:** Carbonate system and Nutrients concentration from hYdrological properties and Oxygen using a Neural-network. Sauzède et al., 2017, Front. Mar. Sci. 4:128.doi: 10.3389/fmars.2017.00128; Bittig et al., 2018. **CANYON-MED:** Fourrier et al., 2020

# 3D Chla/POC (+B<sub>bp</sub>)

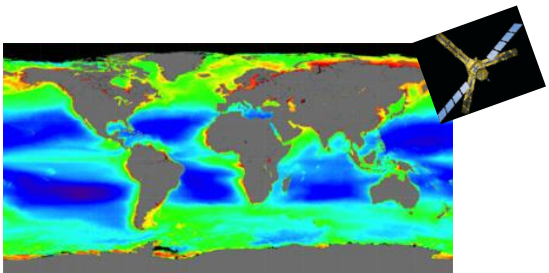
MULTIOBS\_GLO\_BIO\_BGC\_3D\_REP\_015\_010

## → Global 3D POC/b<sub>bp</sub> and Chla from satellite products

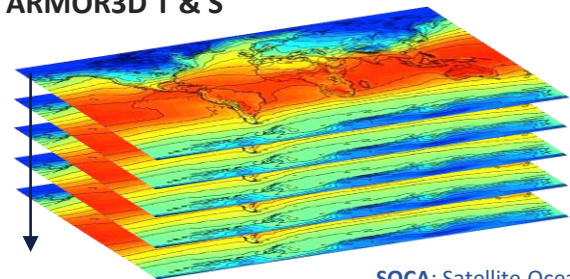
- Based on the **neural-network method SOCA** trained on BGC Argo b<sub>bp</sub> (bio-optical proxy of POC) and chla profiles - data collected from **BGC-Argo** floats and applied on satellite products - 2010 to 2020 – satellite matchups only



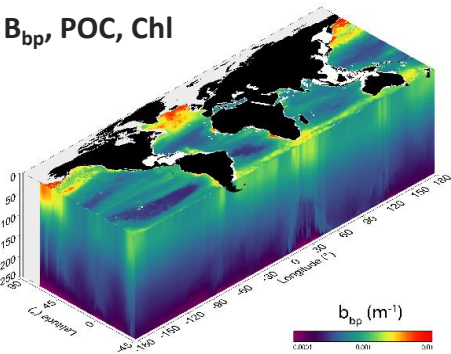
Raphaëlle Sauzède  
 Hervé Claustre  
 Ana Parracho,  
 Renosh Pannimpullath Remanan



ARMOR3D T & S



SOCA Neural-  
Network



B<sub>bp</sub>, POC, Chl

b<sub>bp</sub> (m<sup>-1</sup>)

**GLOBAL**  
 1/4° resolution  
 B<sub>bp</sub>: 36 levels (0-1000m)  
 Chl: 50 levels up to 1,5 times ZNORM depth  
 weekly + clim  
 REP: 1998-2021

**December 2024**  
 Increase resolution to 1/8°

SOCA: Satellite Ocean-Color merged with Argo. Sauzède, R., H. Claustre, J. Uitz et al. (2016), A neural network-based method for merging ocean color and Argo data to extend surface bio-optical properties to depth: Retrieval of the particulate backscattering coefficient, J. Geophys. Res. Oceans, 121, doi:10.1002/2015JC011408.

# How to find MULTIOBS products: <https://data.marine.copernicus.eu/products>



Filters ×  
FREE-TEXT SEARCH  
MULTIOBS

FAVOURITES ★ 0  
TIME RANGE ▲  
jj/mm/aaaa 📅 jj/mm/aaaa 📅  
Covering full interval

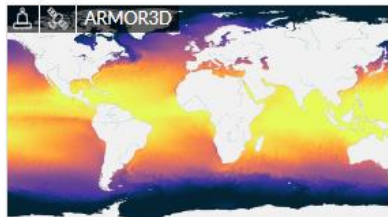
WITH DEPTH 4  
DEPTH RANGE ▲

UNIVERSE ▲  
Blue Ocean 13  
Green Ocean 3

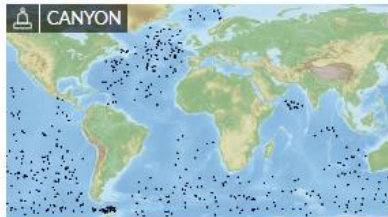
MAIN VARIABLES ▲  
Carbonate system 4  
Mixed layer thickness 1  
Nutrients 1  
Optics 1  
Organic carbon 1  
Oxygen 1  
Plankton 1  
Salinity 7  
Surface density 2  
Temperature 5  
Velocity 3

AREA ▲  
Global Ocean 11  
Atlantic: Iberia-Biscay-Ireland 2  
Atlantic: North 2

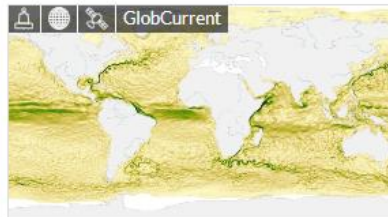
Products 15



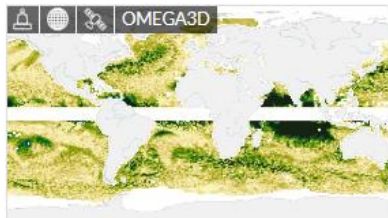
**Multi Observation Global Ocean 3D Temperature Salinity Height...**  
MULTIOBS\_GLO\_PHY\_TSUV\_3D\_MYN...\_015\_012  
In-situ, satellite (L4)  
Global, 0.25° × 0.25° × 50 levels  
1 Jan 1993 to 10 Jan 2024, weekly, monthly  
Mixed layer thickness, salinity, temperature, velocity



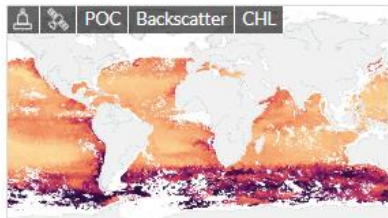
**Nutrient and carbon profiles vertical distribution**  
MULTIOBS\_GLO\_BGC\_NUTRIENTS\_C...\_015\_009  
In-situ  
Global  
1 Sep 2002 to 31 Aug 2022, instantaneous  
Carbonate system, nutrients, oxygen, salinity, temperature



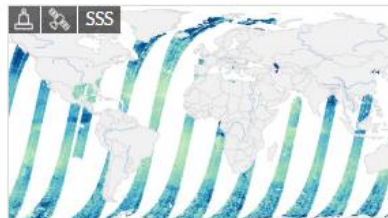
**Global Total (COPERNICUS-GLOBCURRENT), Ekman and...**  
MULTIOBS\_GLO\_PHY\_MYNRT\_015\_003  
In-situ, models, satellite (L4)  
Global, 0.25° × 0.25° × 2 levels  
1 Jan 1993 to 22 Jan 2024, hourly, daily, monthly  
Velocity



**Global Observed Ocean Physics 3D Quasi-Geostrophic Currents...**  
MULTIOBS\_GLO\_PHY\_W\_3D\_REP\_015\_007  
In-situ, models, satellite (L4)



**Global Ocean 3D Chlorophyll-a concentration, Particulate...**  
MULTIOBS\_GLO\_BIO\_BGC\_3D\_REP\_015\_010  
In-situ, satellite (L4)



**SMOS CATDS Qualified (L2Q) Sea Surface Salinity product**  
MULTIOBS\_GLO\_PHY\_SSS\_L3\_MYNRT\_015\_014  
In-situ, satellite (L3)