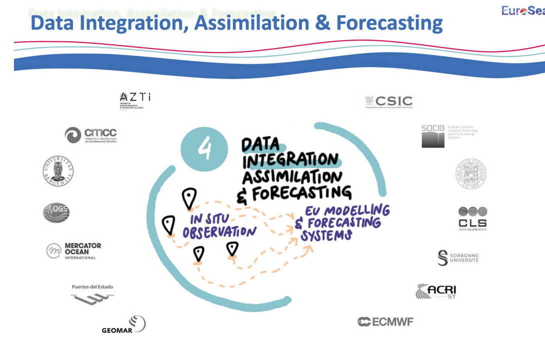
Glider observations in the Western Mediterranean Sea: their assimilation and impact assessment using four analysis and forecasting systems



EuroSea

MERCATOR OCEAN INTERNATIONAL

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

SOCIB Balearic Islands Coastal Observing and Forecasting System

OGS

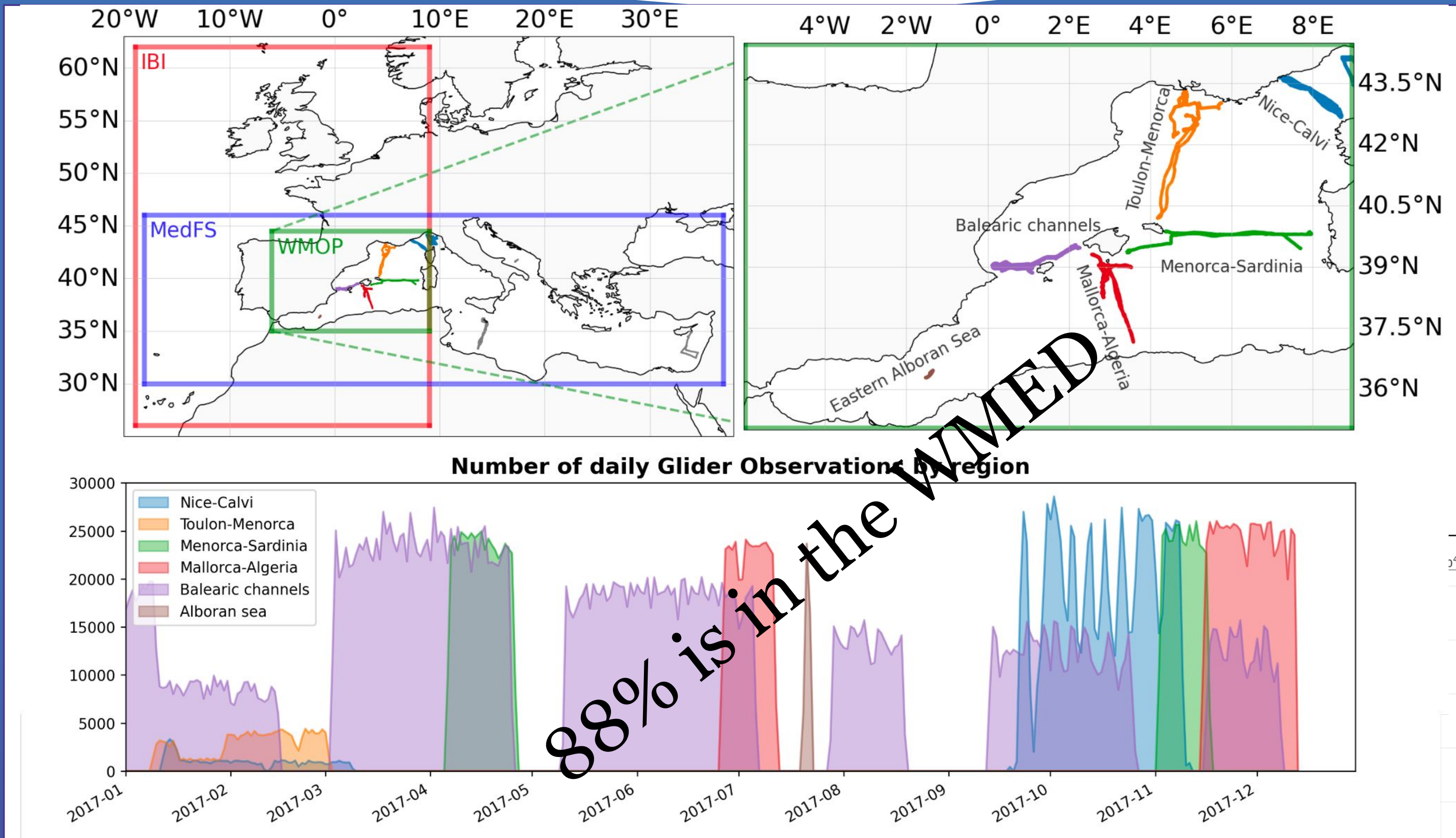
Ali Aydogdu, Romain Escudier, Jaime Hernandez-Lasheras, Carolina Amadio, Jenny Pistoia, Nikolaos Zarokanellos, Baptiste Mourre, Gianpiero Cossarini, Elisabeth Remy

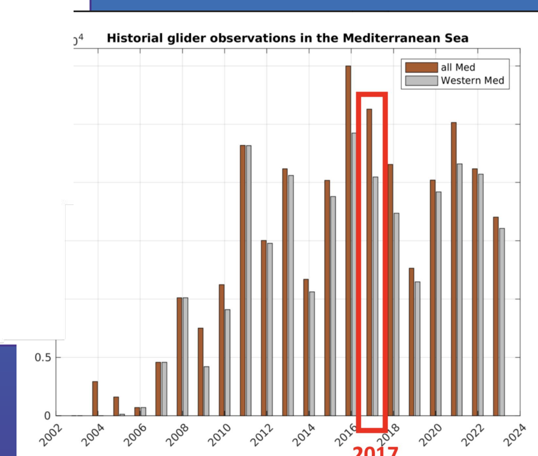
IUGC2024

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862626.

Glider observations in the Mediterranean Sea

EuroSea

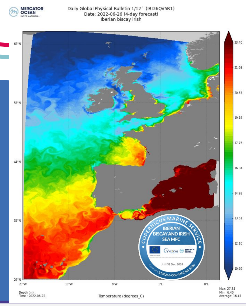


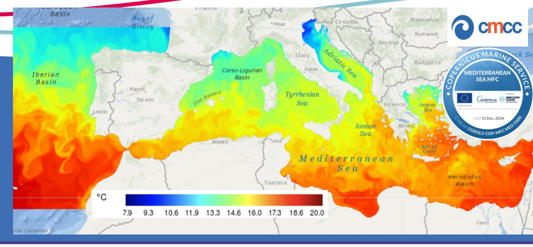


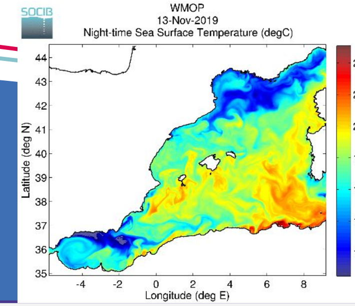
2017 is one of the years with most glider observations

From Copernicus Marine Database

Forecasting systems in the WMED





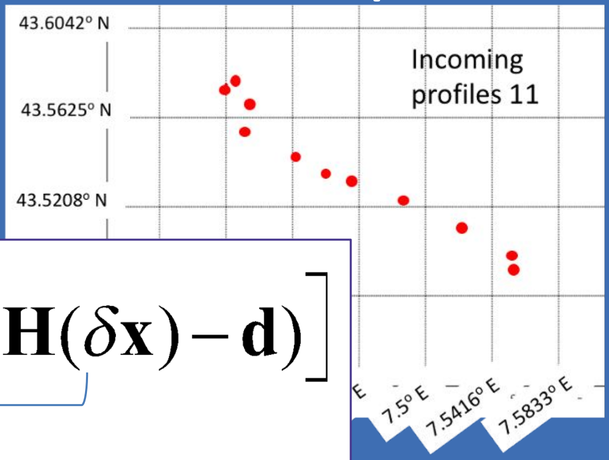


	IBI (MOi)	MedFS (CMCC)	WMOP (SOCIB)
Domain	Iberia Biscay Irish + Western Mediterranean (reaching Sicily)	Mediterranean Sea (+ Atlantic box)	Western Med. Gibraltar to Corsica- Sardinia
Resolution	1/36^{o} degree 50 z* vertical levels	1/24^{o} degree (~4.5km) 141 z* vertical levels	~1/50^{o} degree (2km) 32 vertical sigma-levels
Numerical model	NEMO v3.6	NEMO v3.6	ROMS v3.4
Time step	150 sec (Barotropic step 5sec)	120 sec (Barotropic step 2.4sec)	120 sec (Barotropic step 6sec)
Parameterizations	Tides, atmospheric pressure	Tides, atmospheric pressure	No tides, No atm. pressure
	33 rivers climatology	climatological inputs from 39 rivers.	climatological inputs from 6 major rivers.
	GLS k-epsilon - Internal waves parametrization	Richardson number-dependent vertical diffusion	Generic model of two-equations GLS turbulent closure.
	Flather for barotropic Prescribed + relaxation area for baroclinic	Flather for barotropic currents and SSH. Orlanski for baroclinic currents	Flather for 2-D momentum. Chapman for surface elevation. Mixed radiation-nudging for 3-D equations.
Atmospheric forcing	ECMWF IFS (3h)	ECMWF HR 10km, 6h	AEMET (Spanish meteorological agency) HARMONIE 2.5km 1hr
Lateral open boundary condition	Copernicus Marine GLO-MFC	Copernicus Marine GLO-MFC	Copernicus Marine MED-MFC
Data Assimilation	SAM2 (SEEK Filter): can assimilate SLA AT, SST L3s, ARGO profiles	OceanVar: can assimilate SLA along tracks, ARGO vertical T/S profiles. SST relaxation to gridded product in NEMO	Multimodel Local EnOI: can assimilate SLA along-track, ARGO vertical T/S profiles, SST L4 satellite product, HF-Radar (Ibiza Channel)

Data assimilation problem

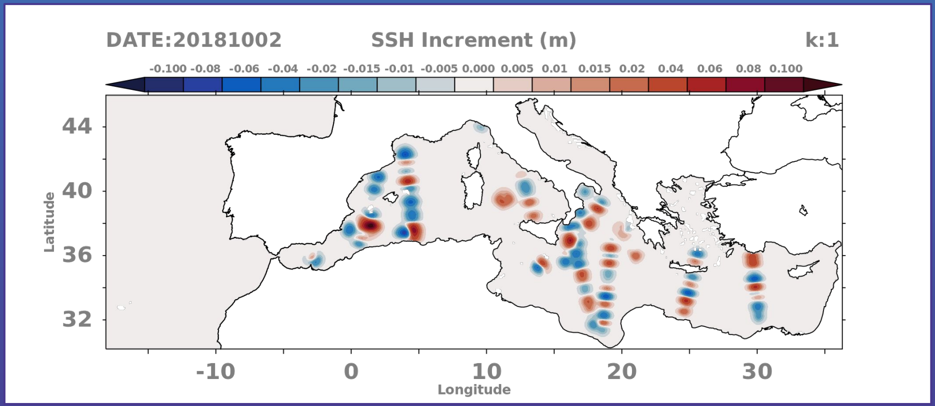
blend a model and observations
e.g. minimize 3DVar cost function

observation space



$$J(\delta x) = \underbrace{\frac{1}{2}\delta\mathbf{x}^{T}\mathbf{B}^{-1}\delta\mathbf{x}}_{\text{Error Background}} + \frac{1}{2}\left[\mathbf{H}(\delta\mathbf{x}) - \mathbf{d})\right]^{T}\mathbf{R}^{-1}\left[\underbrace{\mathbf{H}(\delta\mathbf{x}) - \mathbf{d})}_{\text{Error Observations}}\right]$$

model space

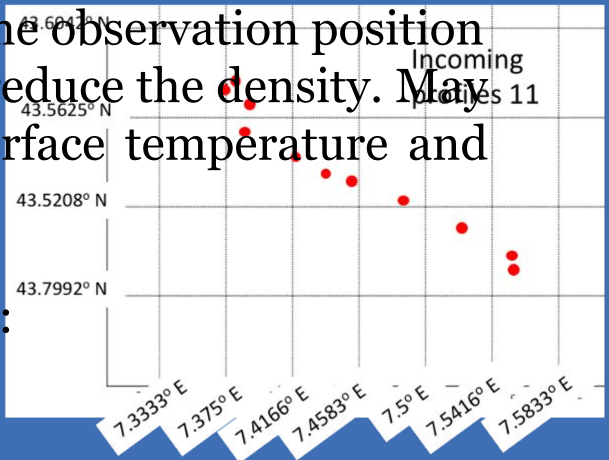


B	background error covariance matrix
R	observation error covariance matrix

Correlated observation error issue

Pre-processing to handle horizontal correlations in glider observations:

- **Sub-sampling**: Removing profiles in the inference radius of the observation position
- **Superobing**: Averaging profiles falling into the same area to reduce the density. May not be appropriate due to the diurnal cycle in surface/subsurface temperature and salinity.



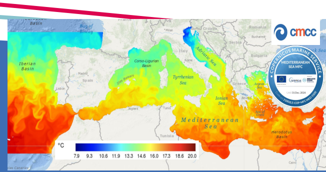
Pre-processing to handle vertical correlations in glider observations:

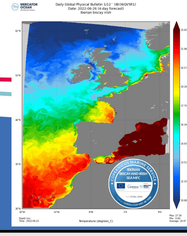
- **Binning** in vertical grid levels (Dobricic et al., 2010)
- Discarding observations with large variance in vertical levels
- Estimating **representativity error** from observation variance in vertical levels (Mourre and Chiggiato, 2014)

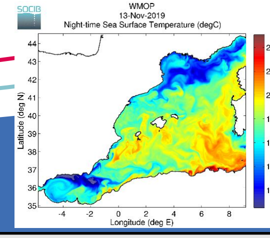
Other treatments of profiles may include:

- Using only **up-casts** (climb phase). The higher vertical speeds (up to 0.2 ms^{-1}) during the start of the dive phase near the surface may cause some spurious salinity values as the glider passed through the thermocline (thermal lag issue).
- Discarding profiles with vertical gaps larger than a certain threshold.
- Discarding profiles with low number of measurements.

Experiment setup and observation coverage







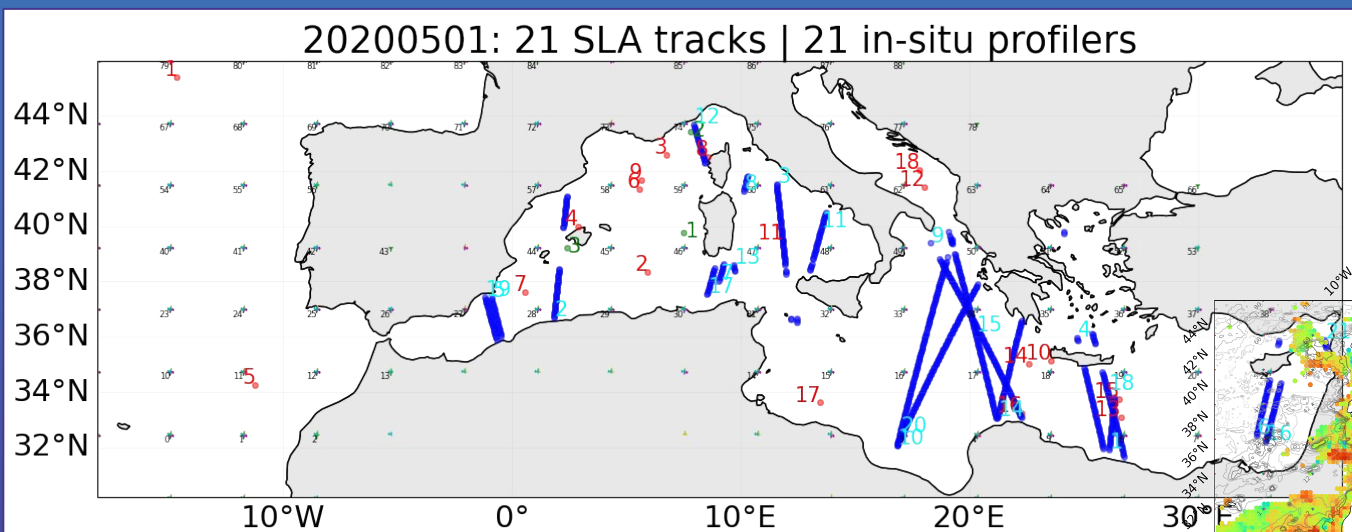
2017	MedFS	IBI	WMOP
FREERUN	No assimilation	No assimilation	No assimilation
NOGLIDS	SLA, ARGO, relaxation to Copernicus Marine SST L4 product	SLA, ARGO, SST ODYSSEA	SLA, ARGO, SST CMEMS MED HR
GLIDERS	GLIDER, SLA, ARGO, relaxation to Copernicus Marine SST L4 product	GLIDER, SLA, ARGO, SST ODYSSEA	GLIDER, SLA, ARGO, SST Copernicus Marine MED HR product

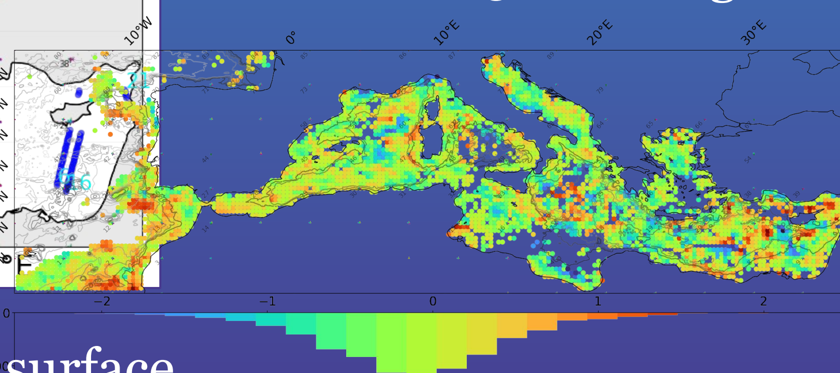
Where do we ingest gliders?

Example:

Left: Altimeter and in-situ observations

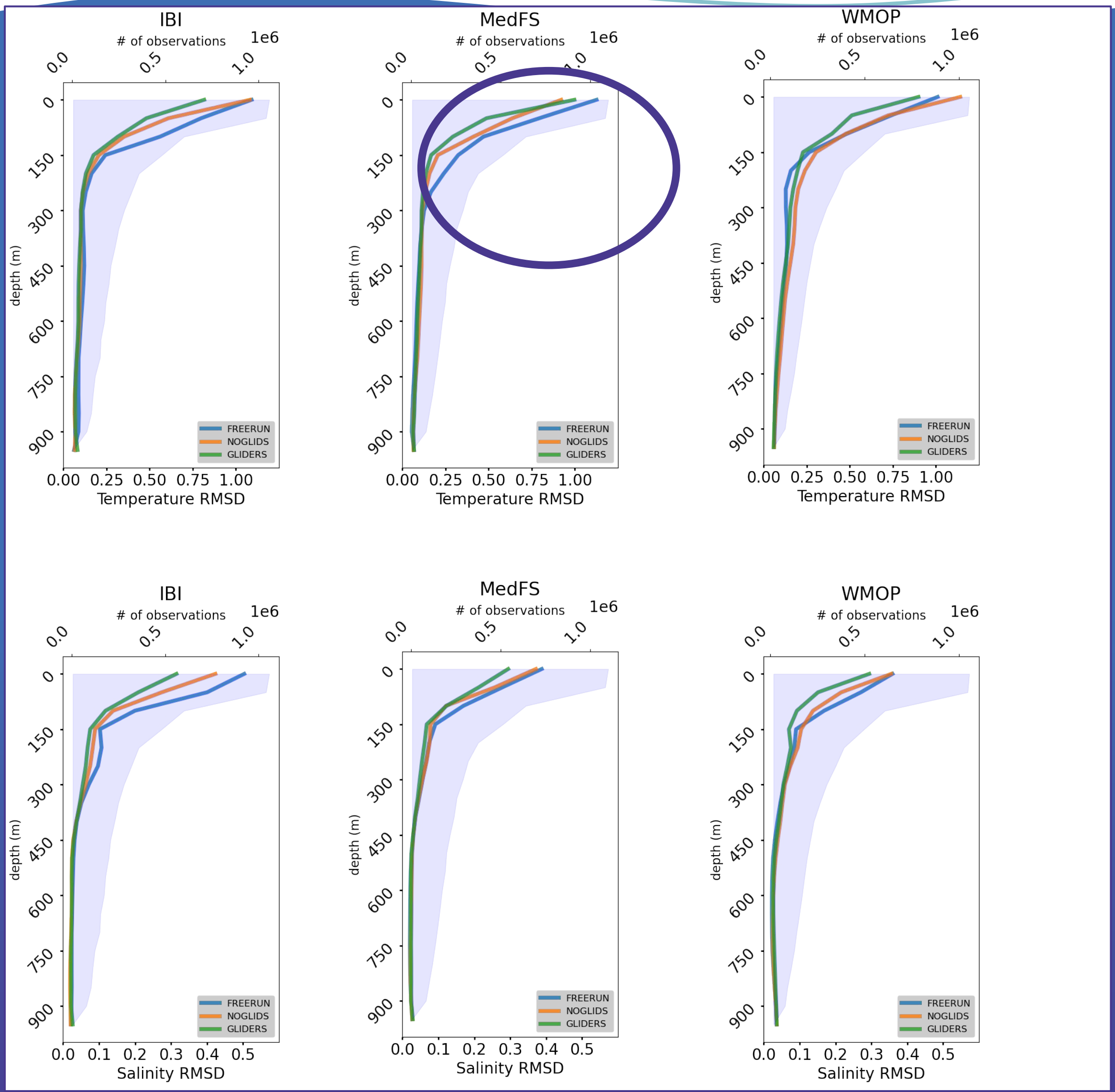
Below: SST L3S coverage

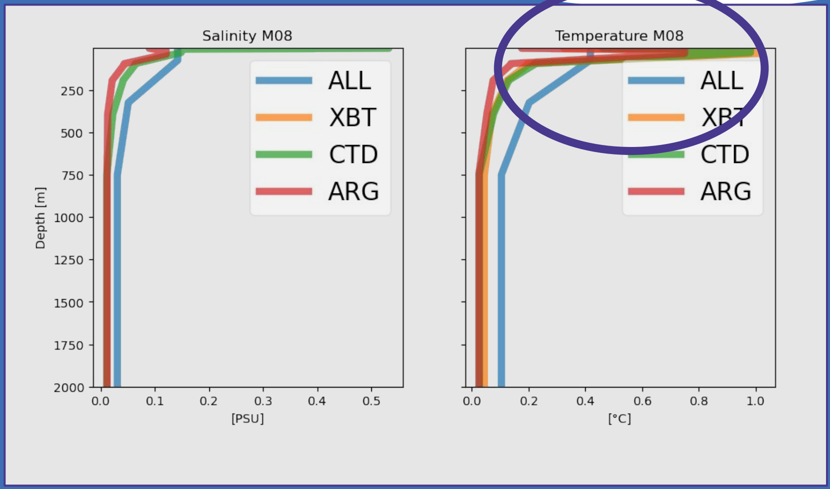




Domain is covered by observations but only at the surface

Temperature & Salinity skills





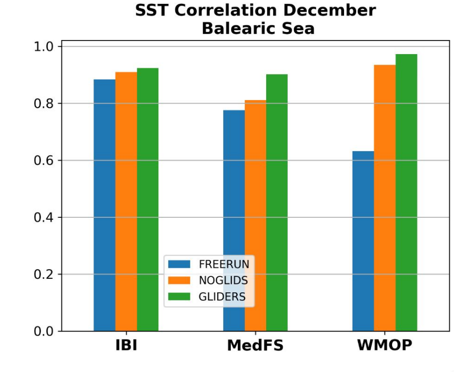
Some issues where the observation errors are kept small.

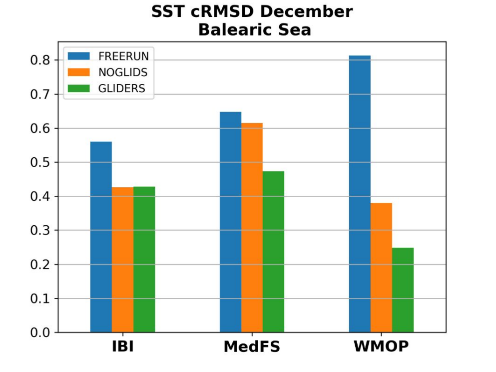
Mostly improved RMSD, up to 20% in some layers.

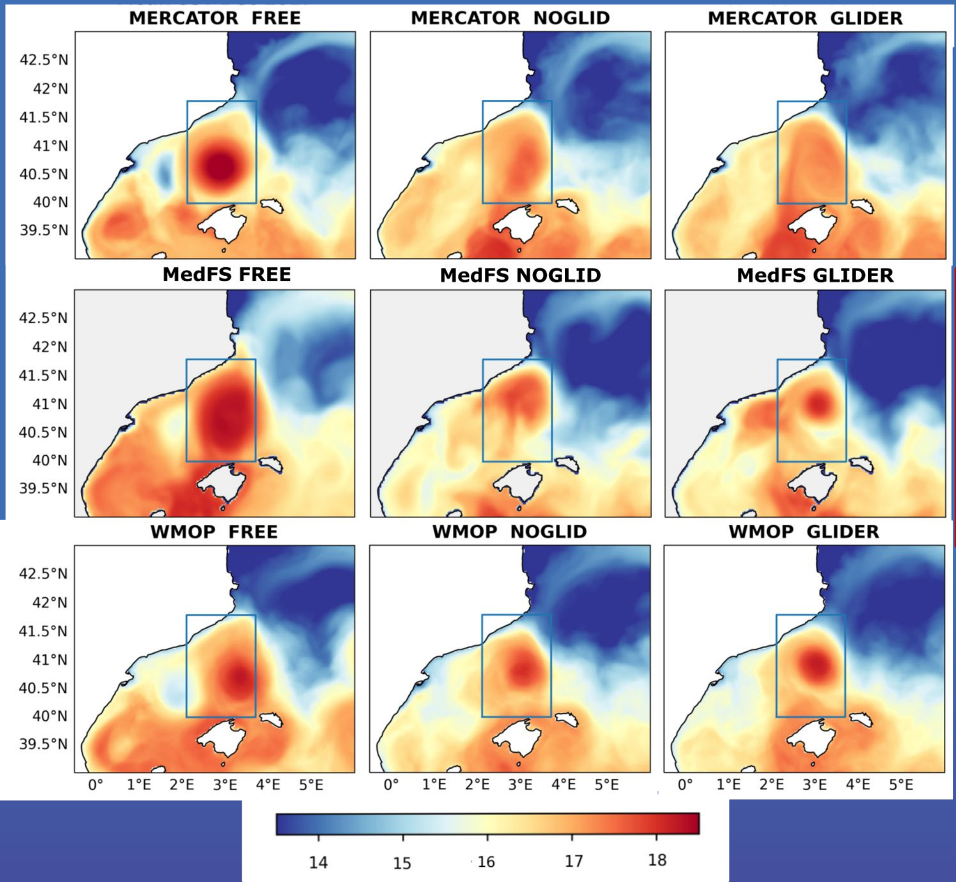
Eddy in the Balearic Sea

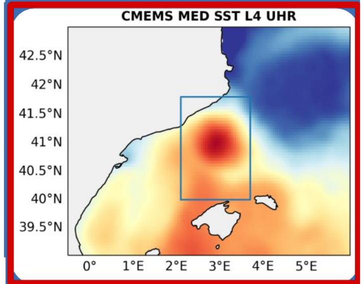
EuroSea

Correlation increases RMSD decreases →

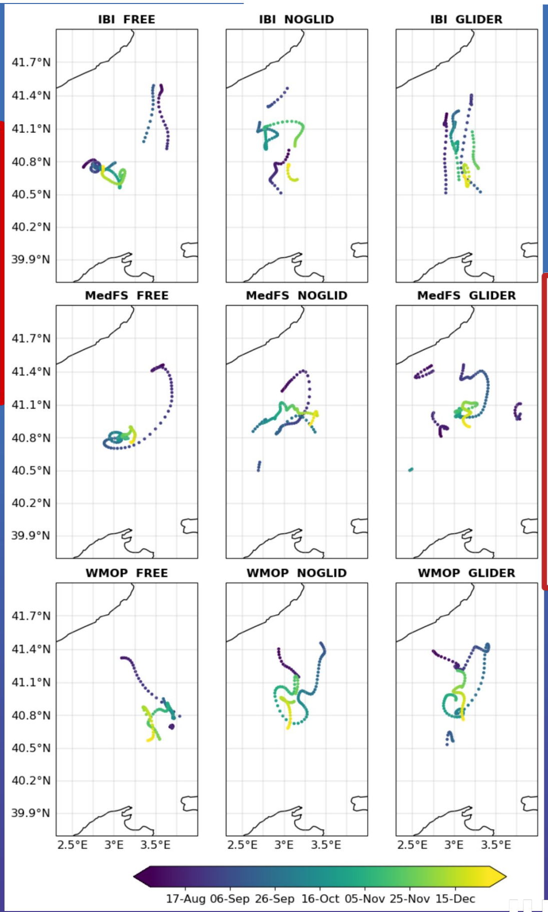


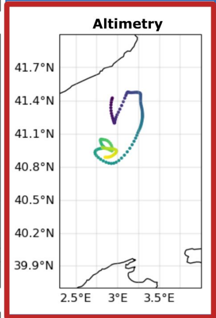






Dec. 2017 model vs. satellite SST

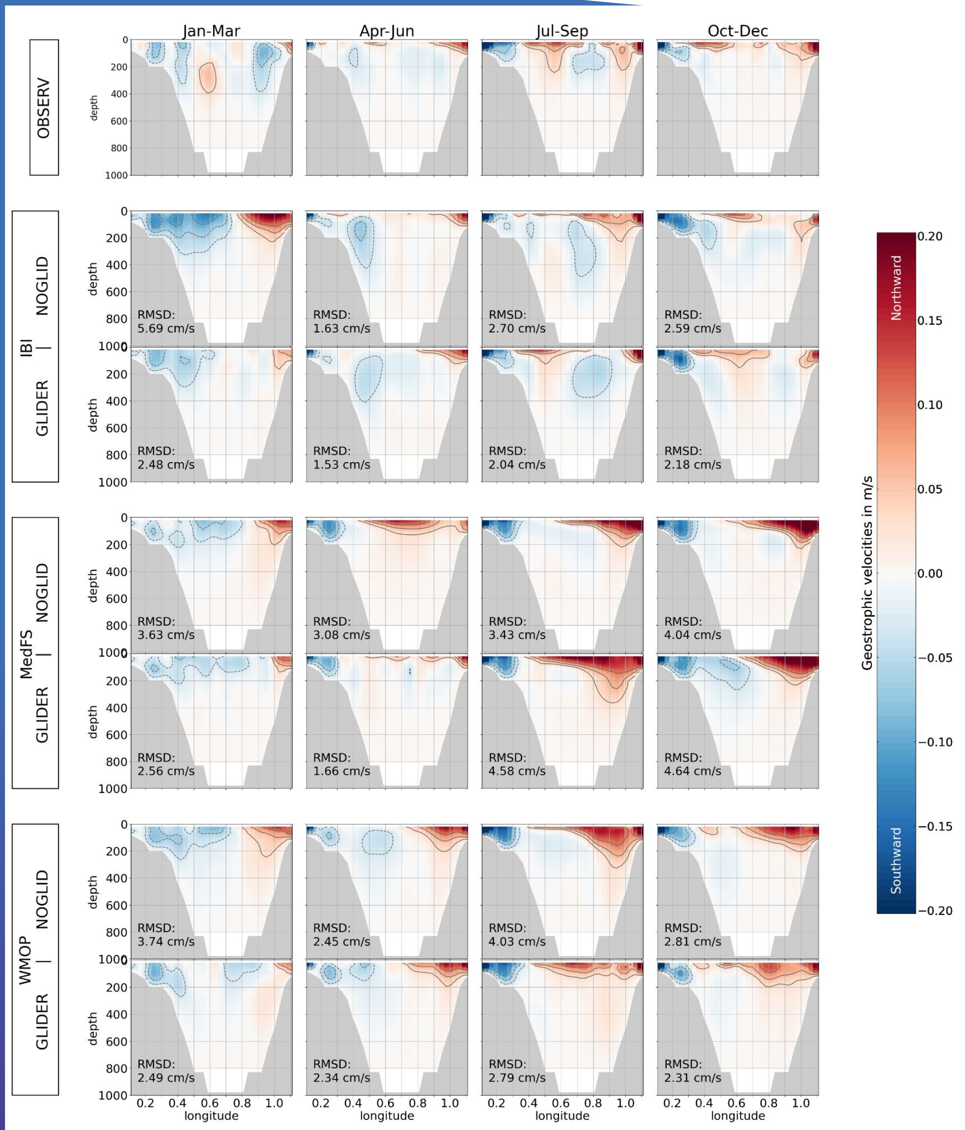




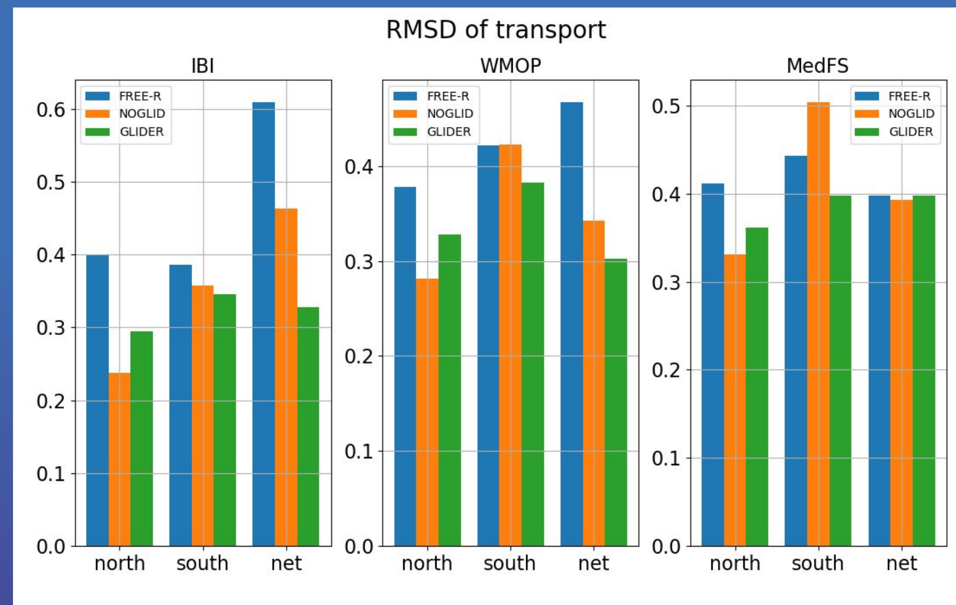
model vs. altimeter eddy trajectories

Assimilation of glider observations enhances the representation of the eddy structure

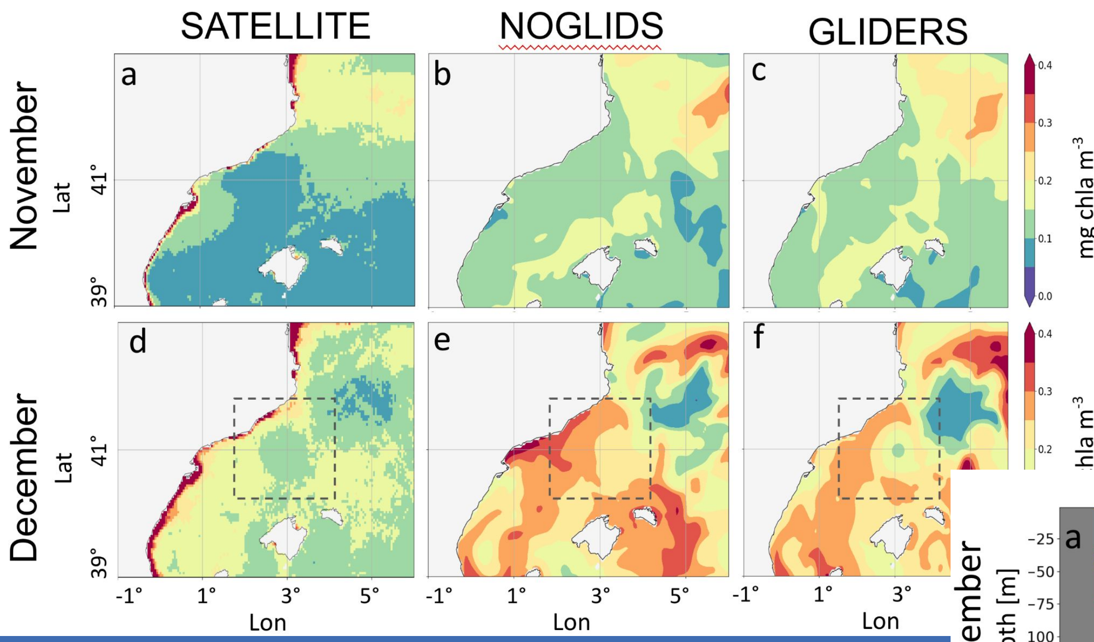
Transport in the Ibiza Channel



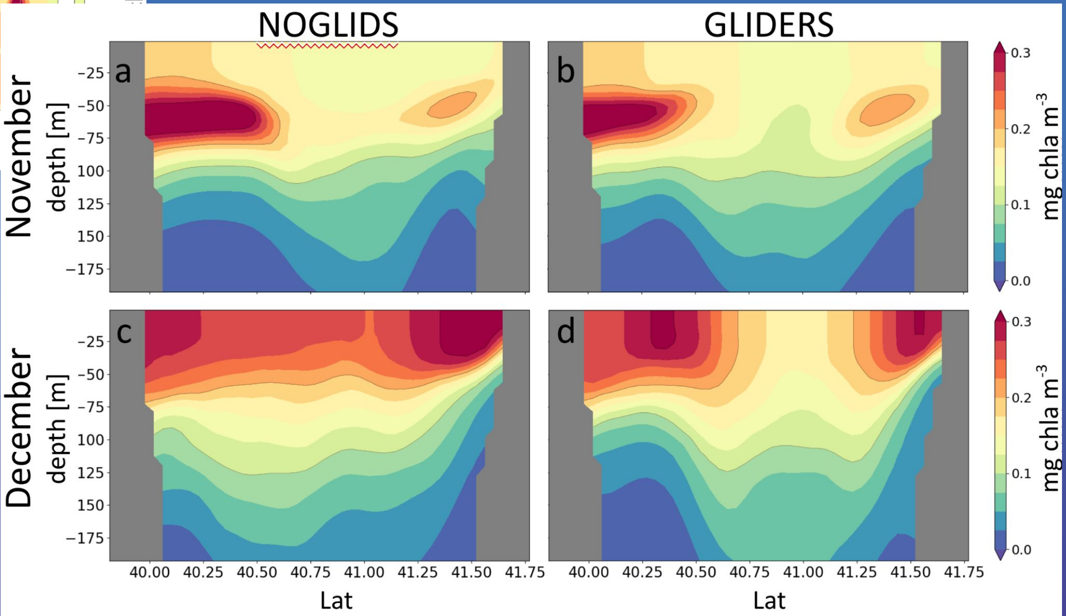
Net transport through the Ibiza Channel is improved
Northward transport worsens southward improves.



Impact on BioGeoChemistry



Improved representation of the eddy fields wrt to satellite chlorophyll



Enhanced outcropping of eddy following glider assimilation.

Manuscript will be submitted soon.

Workshop with observation scientists/providers

EuroSea

- the best practices in use of glider and floats i
- On the accessibility to the glider / Argo floats o
- On the quality control (QC) in the assimilation

Leveraging the multi-system glider data assimilation experiments within EuroSea to the international level

Victor Turpin[1], Elisabeth Remy[2], Ali Aydogdu[3], Baptiste Mourre[4], Romain Escudier[2], Pierre Testor[5], Jaime Hernández-Lasheras[4], Nikos Zarokanellos[4], Brad deYoung[6]

[1] OceanOPS, World Meteorological Organization / Intergovernmental Oceanographic Commission, Brest, France, [2] Mercator Ocean International, Toulouse, France, [3] Ocean Modeling and Data Assimilation Division, Centro Euro-Mediterraneo Sui Cambiamenti Climatici, Bologna, Italy, [4] SOCIB, Spain, [5] LOCEAN / CNRS, Sorbonne University, Paris, France, [6] Memorial University of Newfoundland, Halifax, Canada

29 JUNE – 1 JULY 2022
EuroSea/OceanPredict
Workshop on Ocean Prediction and Observing

EuroSea

Internal Milestone #28

Joint workshop between CMCC SOCIB Task 4.2, Task 4.3, Task 4.4 partners and WP3 on sharing best practices on how to use novel sensors (glider, floats) data for assimilation and validation in the CMEMS (global and MED) and SOCIB operational systems (physical and biogeochemical)

Date: *24 June 2021 10:00-12:00 CET*

Goal: EuroSea Task 4.2 aims at evaluating the impact of the glider and BGC Argo observations on marine forecasting systems in the Mediterranean Sea. The question of where and how to access the data in both near-real-time (NRT) and delayed-time (DT) is critical for this task. Several issues have been identified concerning the glider data availability, especially for NRT systems. The objective of this workshop is to bring together European experts on glider data collection, processing and management with the data assimilation experts to open a discussion on this issues and propose solutions to use glider and float observations in operational forecasting systems in the best possible way.

AGENDA

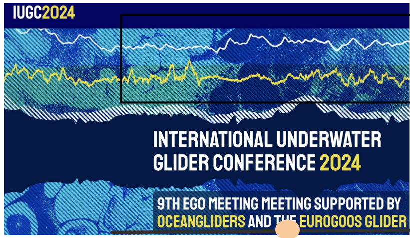
10:00-10:15 Objectives and overview of the status (Ali Aydogdu)
10:15-10:25 Update on SOCIB experience (Jaime Hernandez)
10:25-10:35 NRT and delayed mode data exchange strategy and further opportunities (Victor Turpin / Daniel Hayes)
10:35-10:45 The status of glider observations in the CMEMS (Thierry Carval)
10:45-12:00 Discussion

Best practices on how to use novel sensors (gliders and floats) for assimilation and validation

A need…

- for more time to assimilate the high-quality glider and BGC-Argo observations in the NRT systems however, DM observations are already high-quality and synchronized to the required repositories.
- to come up with a universal solution. CMEMS (European) and SOCIB (Balearic) systems involved in EuroSea can be taken as a base to detect the need for improvements and propose solutions for every step of the data flow and usage.
- for communication between the communities, e.g., Argo vs. Glider communities to converge on coherent procedure and avoid inconsistencies, Argo + Glider vs. modelling + assimilation communities for the best practices on the use of observations in forecasting and reanalysis systems, e.g., on QC standards.

Engagement with OceanGliders community



OGDA TT core scientific objectives

Cooperation with OGDM TT
Best Practices TT

Cooperation with: Event base TT
BOON TT

OceanGlider Data Assimilation Task Team

R — ***Improve observation error covariances***
- Subsampling/Superobing
- Correlations

H — ***Develop/improve observation operators***
- Mapping the modelled observation

QC — ***Better online quality control***
- Blacklisting
- Timeliness for the NRT systems

Process — ***Identify processes / improve representation***
- transports
- eddy
- deep water formation
- biogeochemistry

Links OceanGliders to OceanPredict

Involves early career researchers putting hands on glider assimilation

Search for funding for better use of glider observations

Possible coordinated experiments using analysis/forecasting systems

OceanPredict
Advancing the science of ocean prediction

Ocean Gliders