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

EuroSea

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SYMPOSIUM OP'24

In partnership with

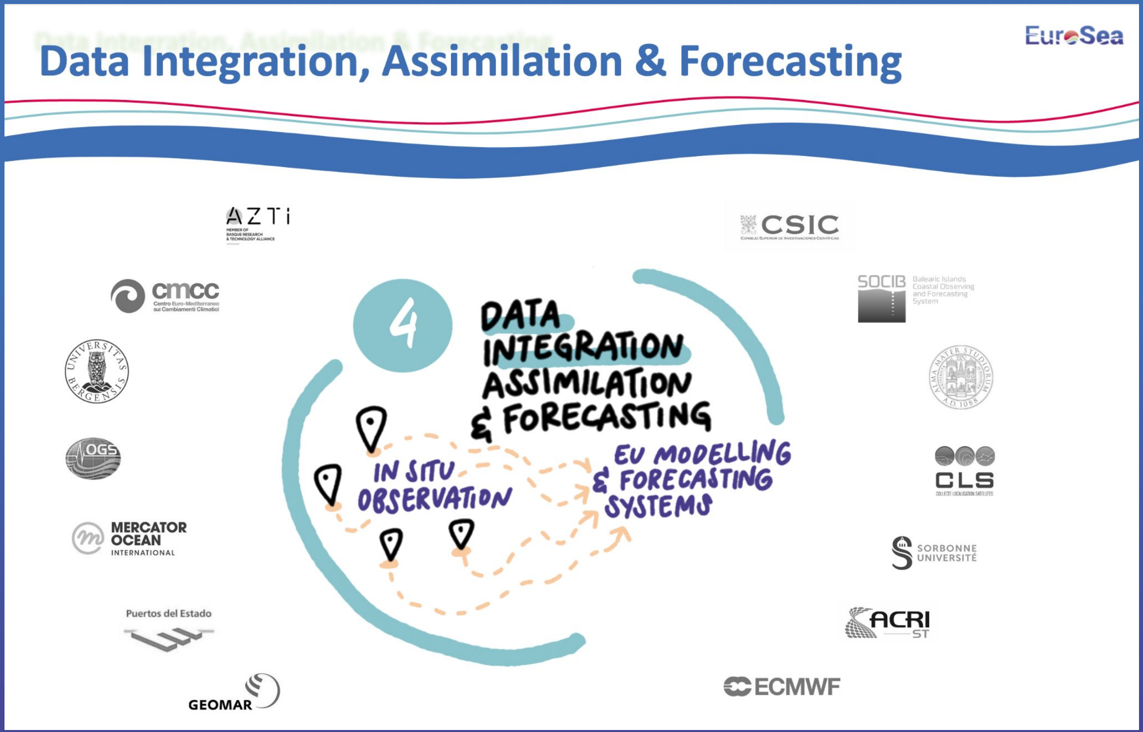
unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

OceanPredict Advancing the science of ocean prediction

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

Scope of the tasks



Task 4.1 / 4.2
Novel sensors (gliders and floats) for assimilation and validation

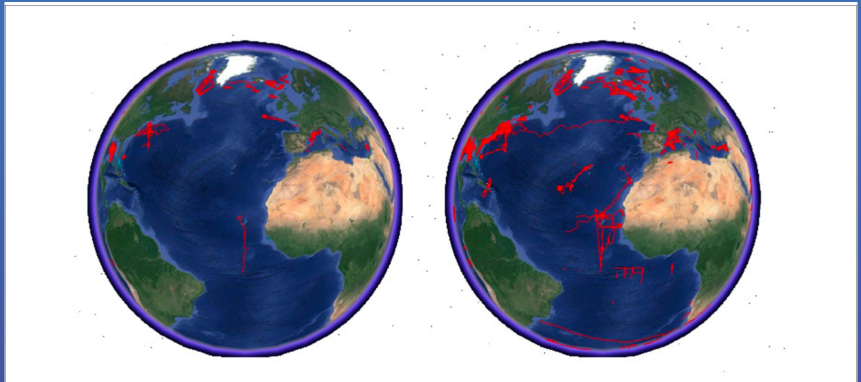
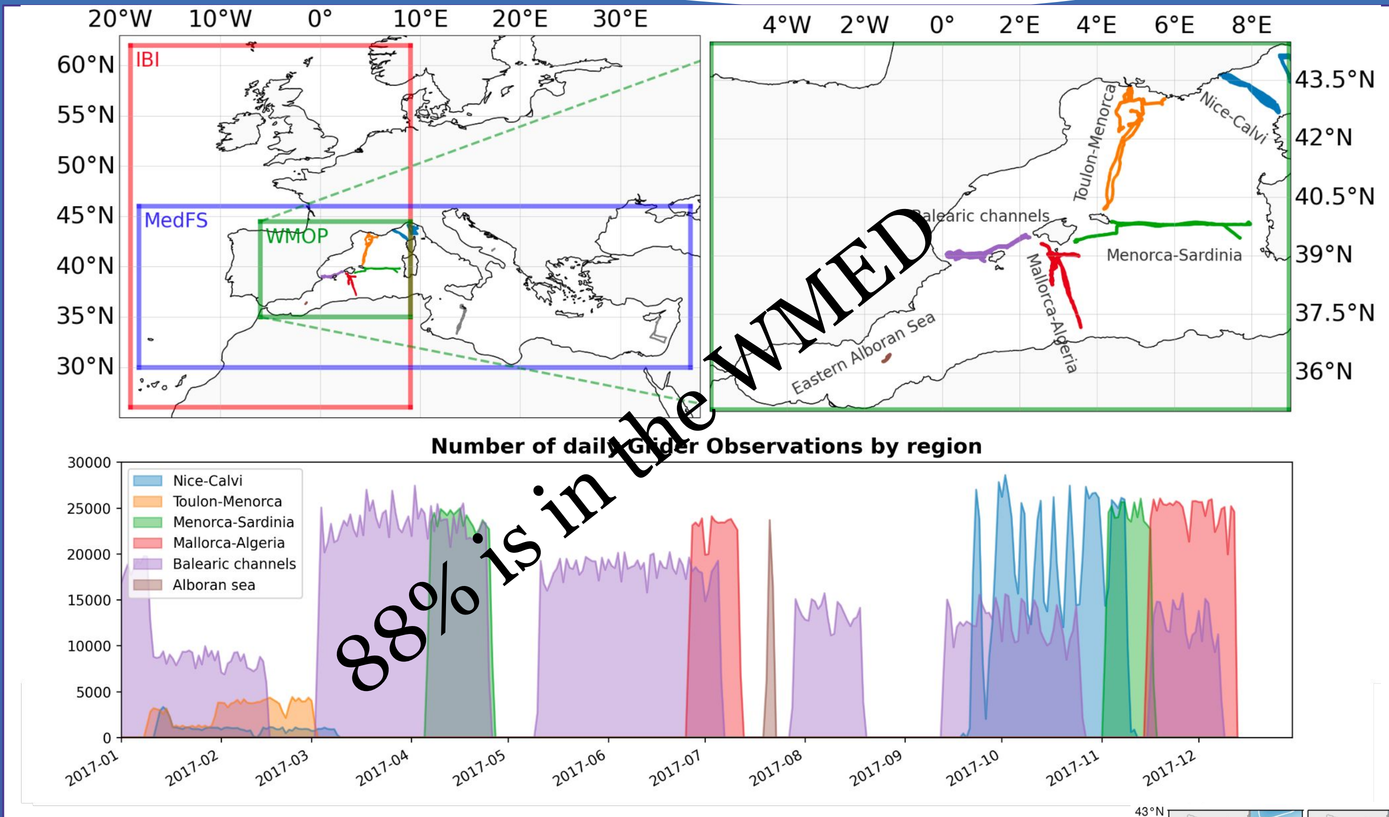


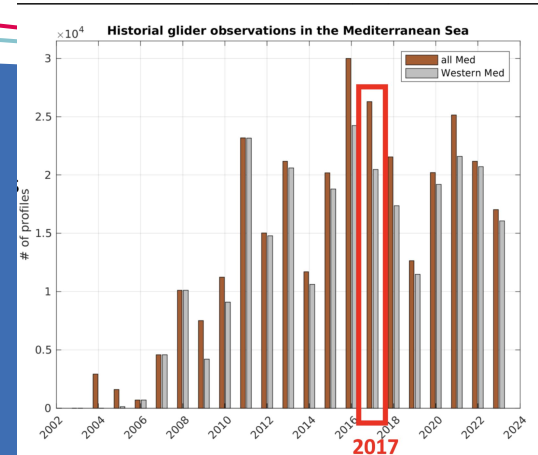
FIGURE 1 | Development of the glider activity over the past decade. Gliders tracks of past deployments **(left)** until December 2009 (OceanObs'09) and **(right)** until October 2018 (OceanObs'19 submissions), as can be viewed using google-earth.

Testor et al. (2019)

Glider observations in the Mediterranean Sea



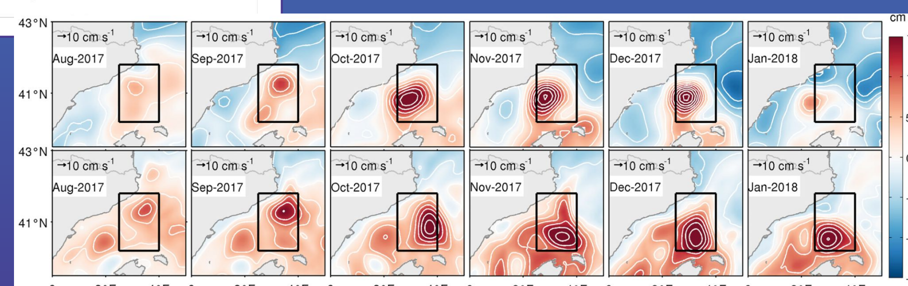
88% is in the WMED



From Copernicus Marine Data Store

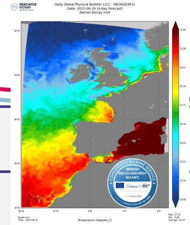
2017 is one of the years with most glider observations.

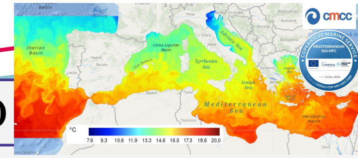
Long-living mesoscale activity throughout the year. →

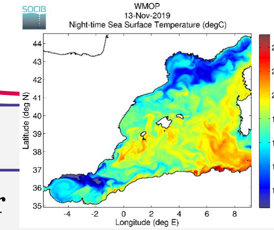


Aguiar et al. (2022)

Forecasting systems in the WMED





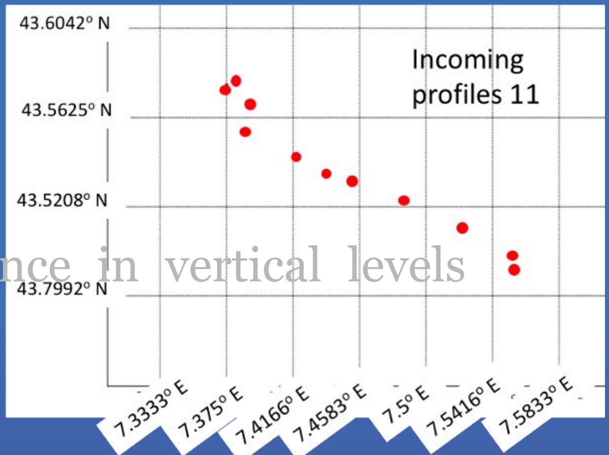


	IBI (MOi)	MedFS (CMCC)	WMOP (SOCIB)
Domain	Iberia Biscay Irish + Western Med(reaching Sicily)	Mediterranean Sea (+ Atlantic box)	Western Med. Gibraltar to Corsica- Sardinia
Resolution	1/36° degree 50 z* vertical levels	1/24° degree (~4.5km) 141 z* vertical levels	1/50° degree (~2km) 32 vertical sigma-levels
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
LOBC	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)

Observation curation / processing

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:

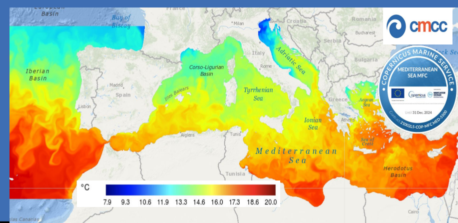
- **Binning** in vertical grid levels (Dobricic et al., 2010)
- Discarding observations with large variance in vertical levels
- Estimating **representativity error** from observation variance in vertical levels (Mourre and Chiggiato, 2014)

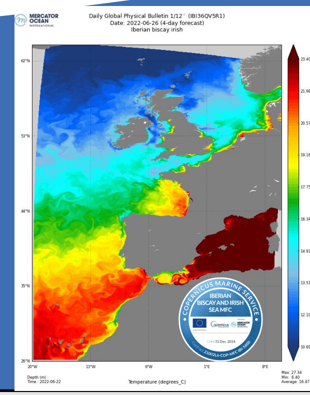
Other treatments of profiles may include:

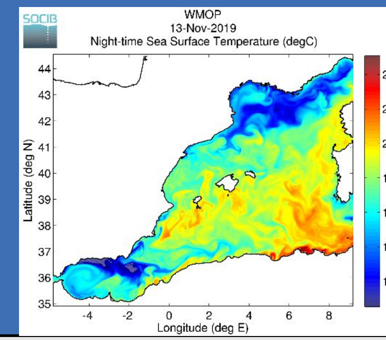
- Using only **up-casts** (climb phase). The higher vertical speeds (up to 0.2 ms^{-1}) during the start of the dive phase near the surface may cause some spurious salinity spikes as the glider passed through the thermocline (thermal lag issue).
- Discarding profiles with vertical gaps larger than a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

Experiment setup / Assimilated observations

EuroSea



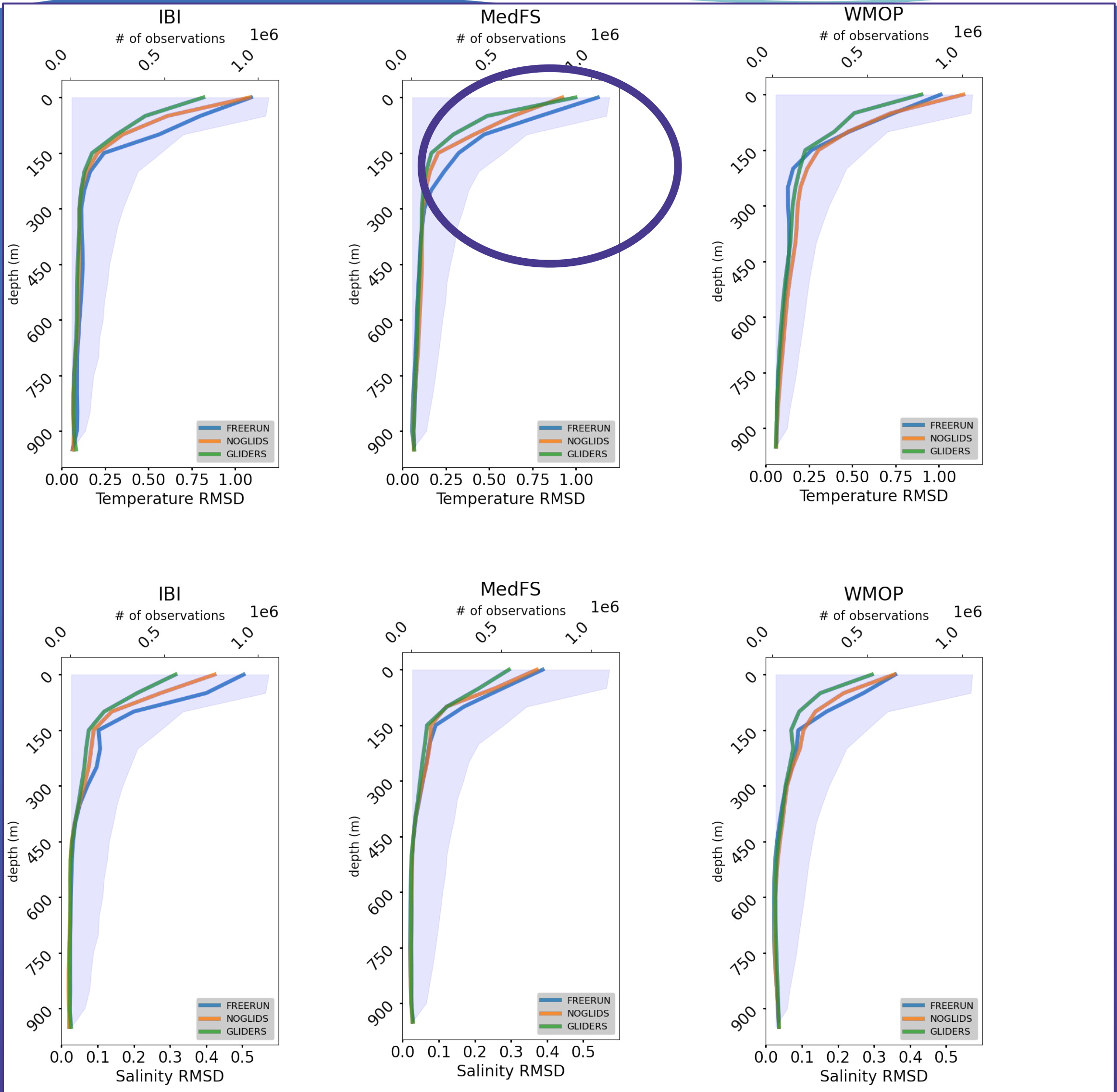




2017	MedFS	IBI	WMOP
FREERUN	No assimilation	No assimilation	No assimilation
NOGLIDS	SLA, ARGO, relaxation to Copernicus Marine SST L4 product	SLA, ARGO, SST ODYSSEA	SLA, ARGO, SST CMEMS MED HR
GLIDERS	GLIDER, SLA, ARGO, relaxation to Copernicus Marine SST L4 product	GLIDER, SLA, ARGO, SST ODYSSEA	GLIDER,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

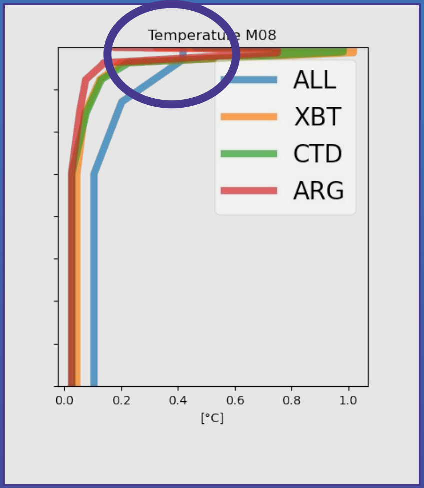
Temperature & Salinity skills

EuroSea

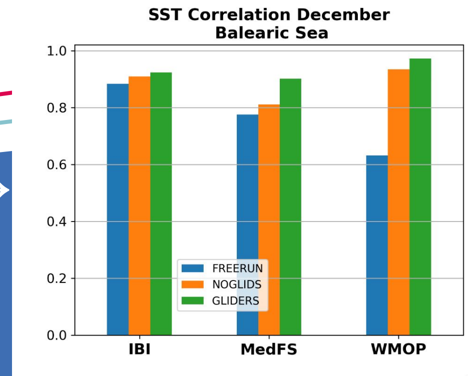


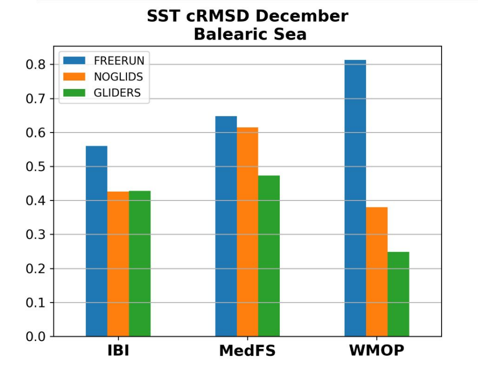
Mostly improved RMSD, up to 20%.

Issues where observation errors are kept small.

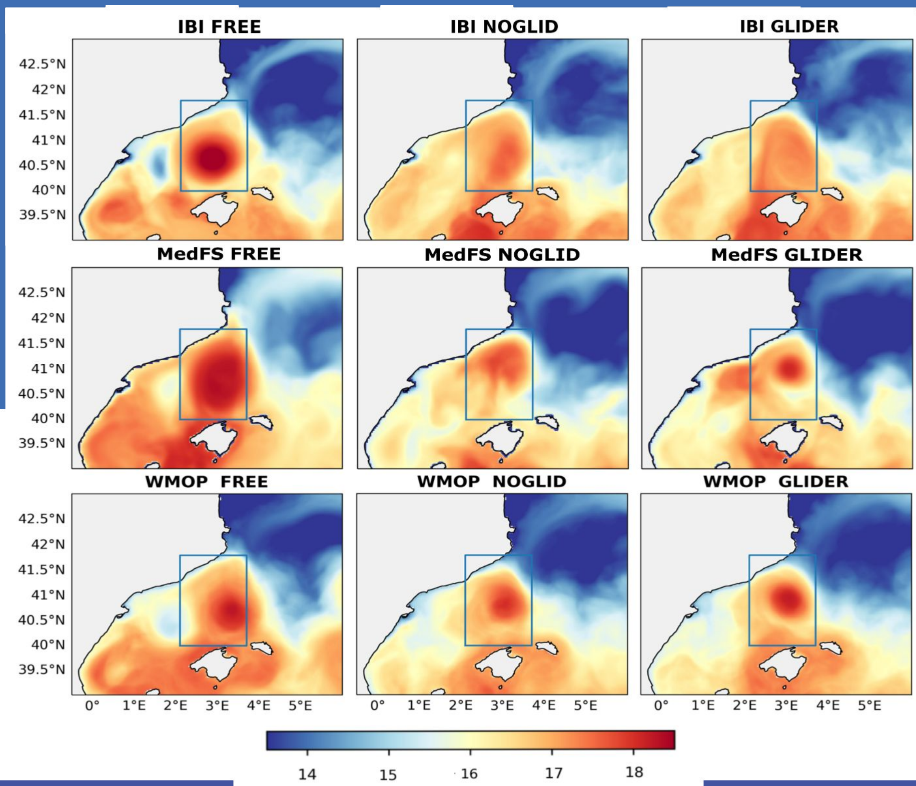


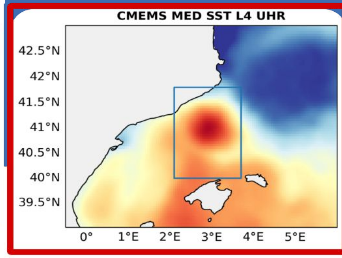
Eddy in the Balearic Sea



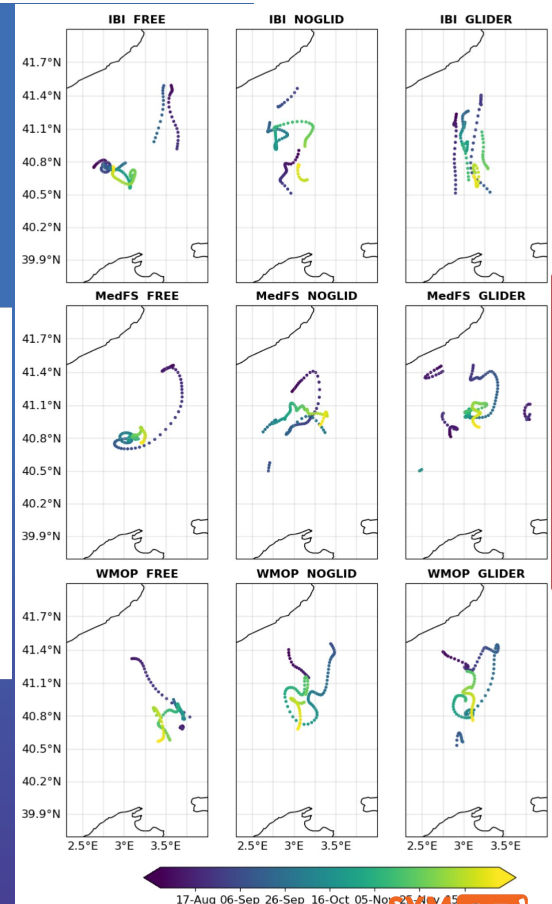


Correlation increases RMSD decreases →

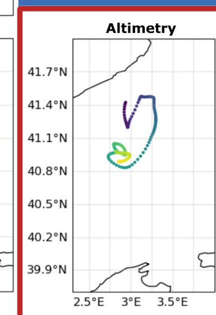




Dec. 2017 model vs. satellite SST

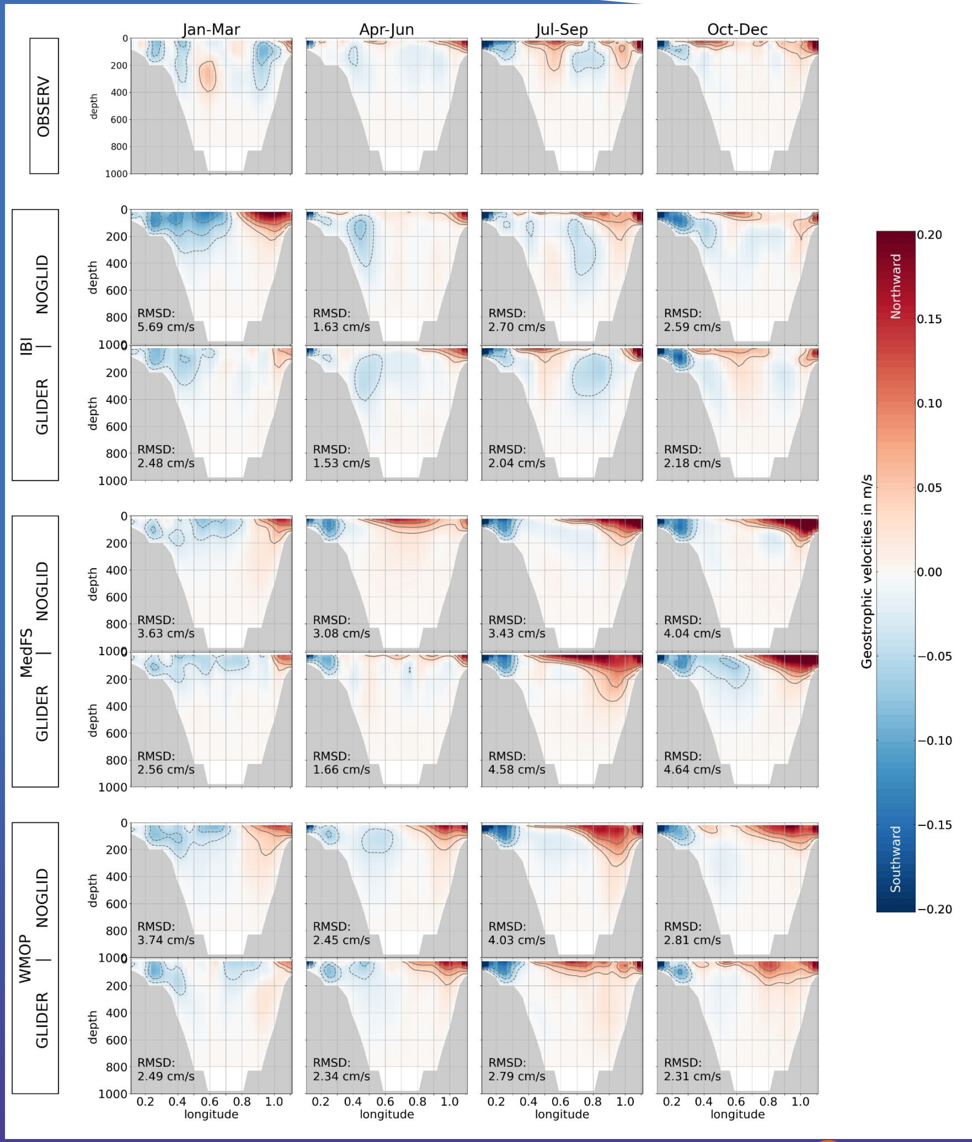


model vs. altimeter eddy trajectories

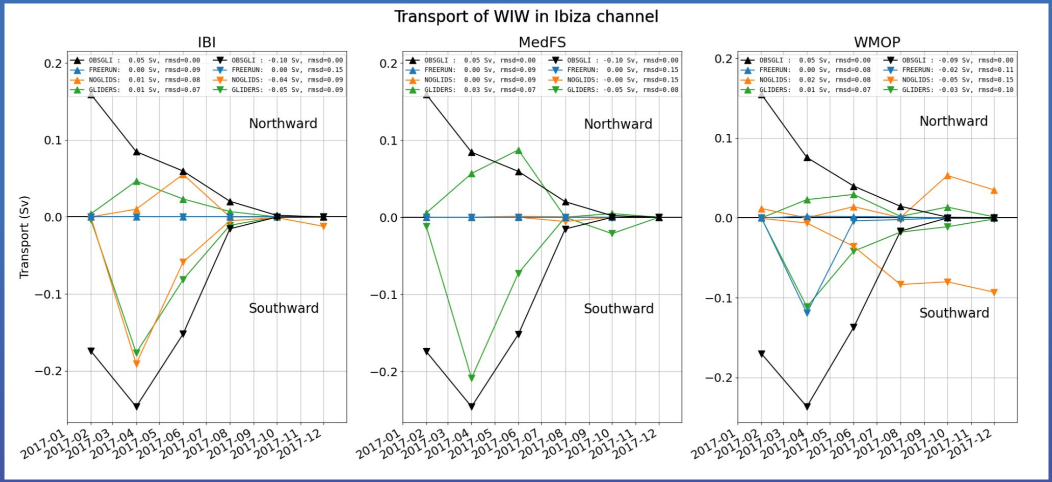


Assimilation of glider observations enhances the representation of the eddy structure

Transport in the Ibiza Channel



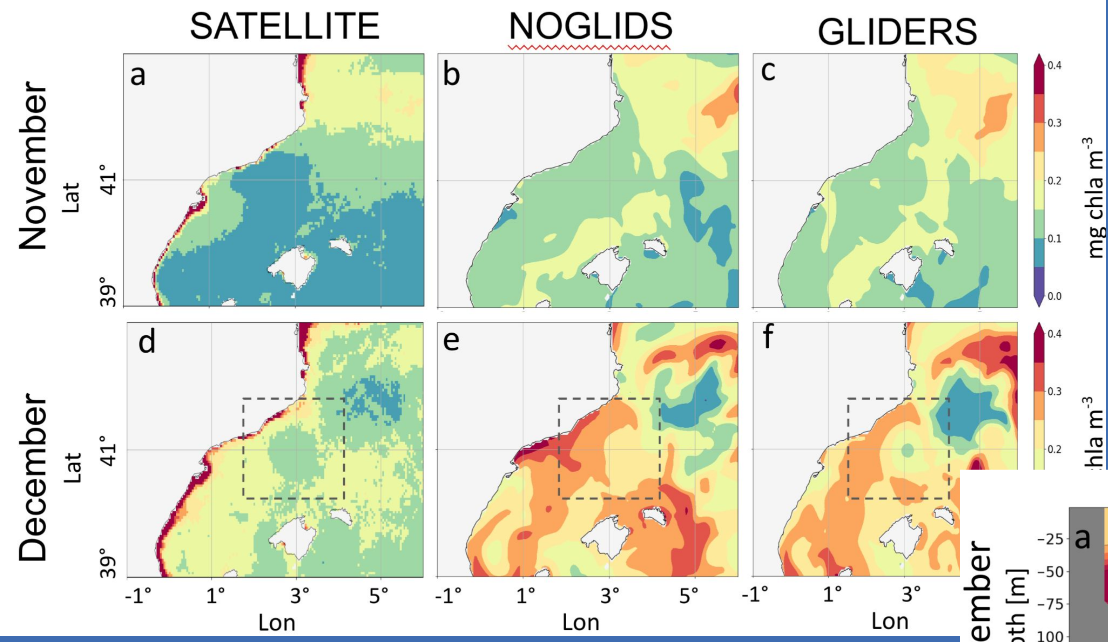
Net transport through the Ibiza Channel is improved
Especially, southward transport of WIW gets better.



Impact on BioGeoChemistry

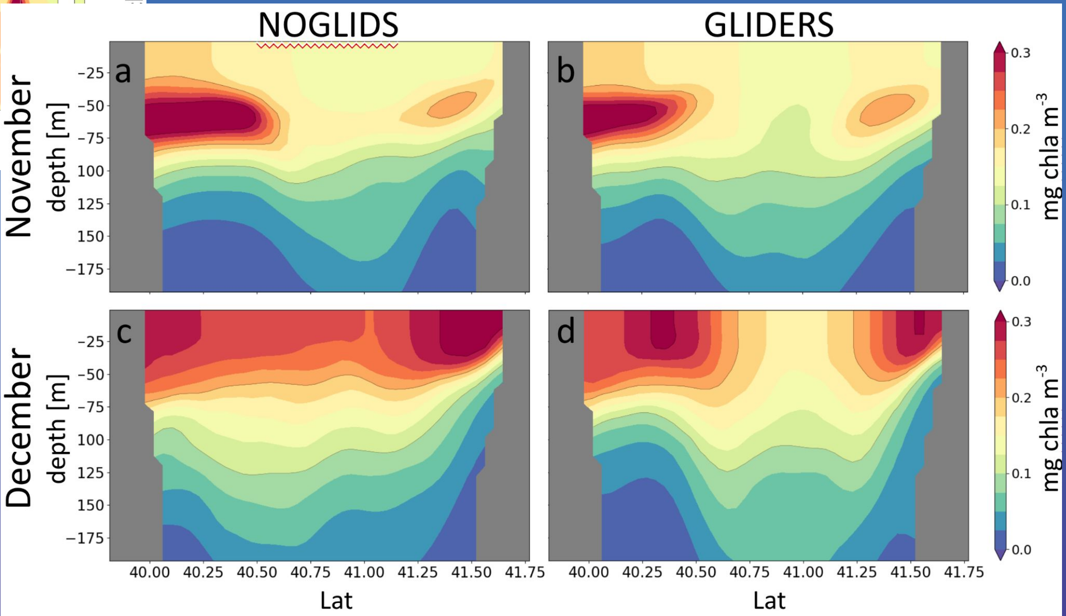
	MedFS (CMCC)	MedBFM (OGS)
Domain	Mediterranean Sea (+ Atlantic box)	Mediterranean Sea
Resolution	1/24° degree (~4.5km) 141 z* vertical levels	1/24° degree (~4.5km) 125 vertical levels
Model	NEMO v3.6	MedBFM (OGSTM-BFM)
Time step	120 sec (Barotropic step 2.4sec)	
Parameterizations	Tides, atmospheric pressure	plankton functional types: 4 phytoplankton groups, 4 zooplankton groups, 1 bacteria group Describes the biogeochemical cycle of N, P, C, Si and O. It includes the carbonate system dynamics
	climatological inputs from 39 rivers.	climatological inputs from 39 rivers.
	Richardson number-dependent vertical diffusion	
	Flather for barotropic currents and SSH. Orlanski for baroclinic currents	
Atmospheric forcing	ECMWF HR 10km, 6h	
LOBC	Copernicus Marine GLO-MFC	MED-MFC PHY
Data Assimilation	OceanVar: can assimilate SLA along tracks, ARGO vertical T/S profiles. SST relaxation to gridded product in NEMO	

Impact on BioGeoChemistry



Improved representation of the eddy fields wrt to satellite chlorophyll

Enhanced outcropping of eddy following glider assimilation.



In Interactive Review
Original Research

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Frontiers in Marine Science
Ocean Observation

Submitted on 28/06/2024 | Interactive Review on 31/10/2024

Under revision

18-22 Nov. 2024

OceanPredict
Advancing the science of ocean prediction

Workshop with observation scientists/providers

EuroSea

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

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

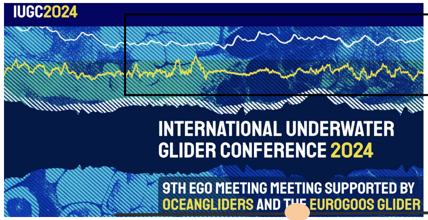
10:00-10:15 Objectives and overview of the status (Ali Aydogdu)
10:15-10:25 Update on SOCIB experience (Jaime Hernandez)
10:25-10:35 NRT and delayed mode data exchange strategy and further opportunities (Victor Turpin / Daniel Hayes)
10:35-10:45 The status of glider observations in the CMEMS (Thierry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

Shared outcomes at IUGC (Goteborg June 2024) and IQuOD/SOOPIP/GTSPP/XBT Science (Bologna November 2024)

Concluding Remarks

- A coordinated set of experiments is performed in the Western Mediterranean Sea to assess the impact of glider observations
- Aim is
  - to develop capacity of assimilating glider observations in the operational systems covering Western Mediterranean
  - set the scene for intercomparison in the overlapping areas
  - develop diagnostics to analyse the results
- Assimilation of gliders
  - improve consistently the analysis in all systems
  - provides a better representation of eddy structure
  - helps to ameliorate transport of water masses
- EuroSea provided an opportunity to interact and collaborate with in-situ observation community