Evaluating CMEMS products in the Western Mediterranean using multiplatform in situ data and an eddy tracker

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Introduction

The MedSub project aims to improve understanding of ocean circulation associated with meso- and submesoscale features (e.g., eddies, fronts, and filaments). Focus region is the western Mediterranean (WMED). Observational (in situ and satellite) and numerical data from the Copernicus Marine Envrionmental Monitoring Service (CMEMS). Desired MedSub outcome is improvement of CMEMS products based on new understanding of fine-scale ocean processes.

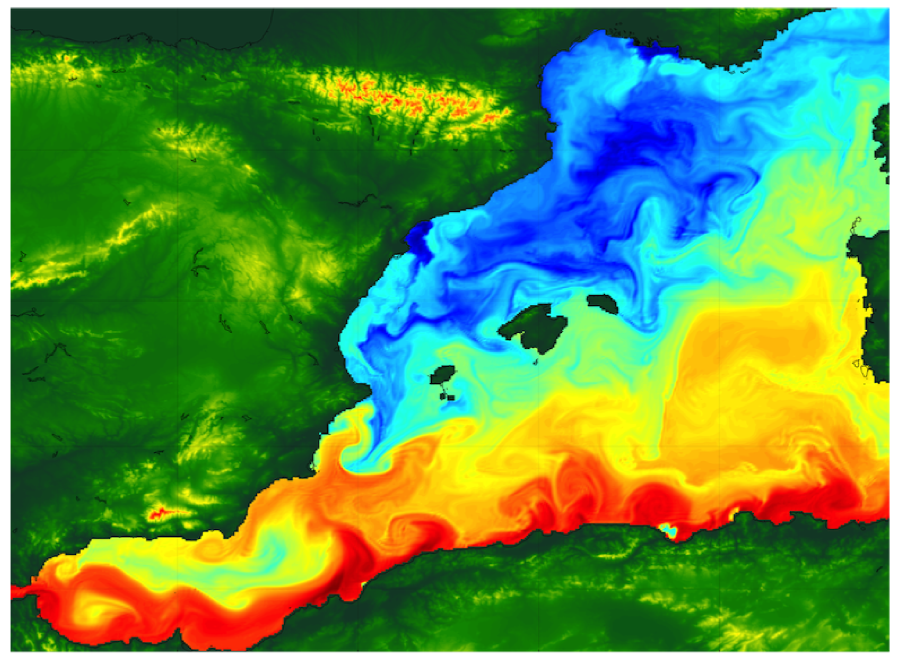

Figure 1: The western Mediterranean study region. SST patterns illustrate the intense mesoscale variability that is characteristic of the region.

MedSub methodology

We use **in situ data** from recent multisensor experiments (gliders and satellites) carried out in the WMED. Project *ABACUS* in 2014-2015 involved the collection of glider data and sea level anomalies from Saral-Altika between Mallorca and the Algerian shelf (e.g., Cotroneo et al., 2016). **Numerical data** come from three CMEMS operational models:

IBI Atlantic-Iberian Biscay Irish- Ocean Physics Analysis and Forecast (`IBI_ANALYSIS_FORECAST_PHYS_005_001_B`)

MFS Mediterranean Sea Physics Analysis and Forecast (`MEDSEA_ANALYSIS_FORECAST_PHYS_006_001`)

GLO Global Mercator 1/12° Physics Analysis and Forecast (`GLOBAL_ANALYSIS_FORECAST_PHY_001_024`)

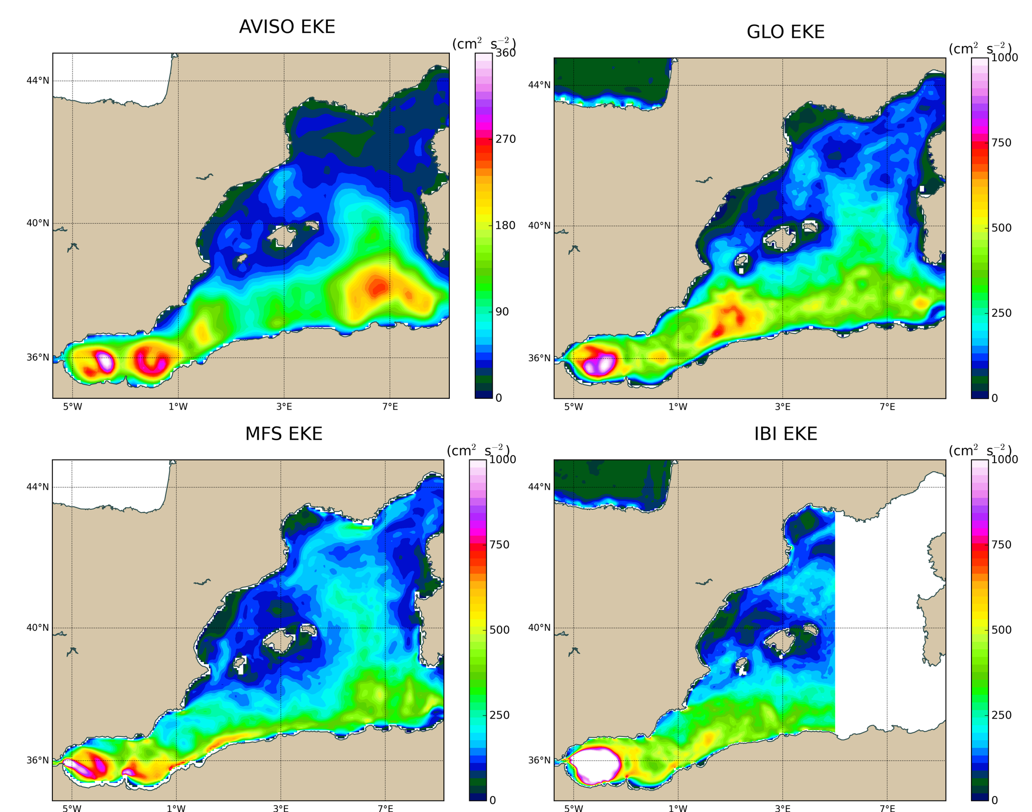

Figure 2: Maps of mean (2013-2016) WMED eddy kinetic energy from CMEMS altimetry and the three forecast models GLO, MFS and IBI. (The IBI domain ends at 5°E.)

Maps of eddy kinetic energy in figure 2 reveal the large and variable eddy energy distributions, especially in the southern WMED regions - motivation for a **subregional mesoscale eddy composite analysis intercomparison** (e.g., Mason et al., 2017).

Eddy identification and tracking: The *py-eddy-tracker* eddy tracking code provides four years of eddy tracks and properties using sea surface height (SSH) from daily Mediterranean CMEMS-AVISO altimetry, GLO, MFS and IBI (Mason et al., 2014).

MedSub results for the western Mediterranean

ABACUS multiplatform experiment: Model assessment based on particular events observed during the ABACUS multiplatform experiment. In situ data were collected during four glider missions carried out in 2014 and 2015 in the Algerian Basin along altimetry tracks (from Aulicino et al., 2017 in prep.).

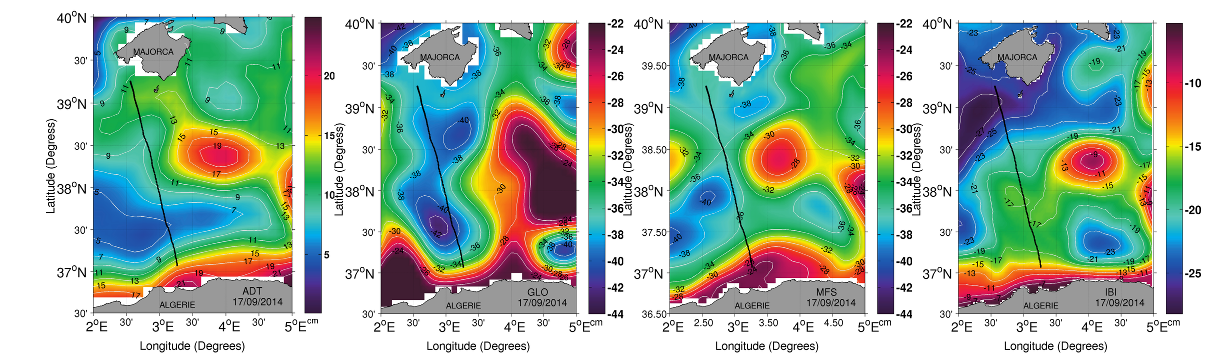

Figure 3: Maps of ADT on 17/09/2014 from (a) CMEMS-AVISO (altimetry), (b) GLO, (c) MFS and (d) IBI. Black lines shows a contemporaneous glider track.

- MFS gives generally best fitting results compared to altimetry
- Anticyclonic eddy at 38.5°N identified by MFS and IBI

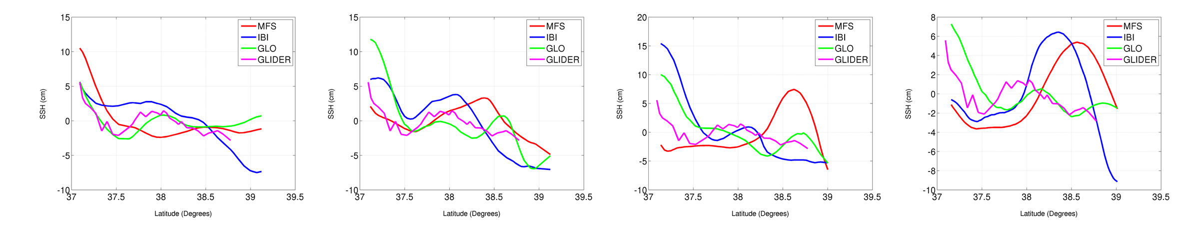

Figure 4: SSH from MFS, IBI and GLO and four contemporaneous glider missions along the track in figure 3. (a) 17/09/2014, (b) 26/11/2014, (c) 12/12/2014, (d) 23/10/2015. Units in cm.

- MFS RMS averaged over the four missions in figure 4 are smallest (table 1)
- For individual missions however MFS RMS smallest only in Nov and Dec 2014
- During Sep 2014 and Oct 2015 both GLO (1.06 and 2.61 cm) and IBI (1.97 and 3.15 cm) better fit the glider derived information than MFS (2.95 and 4.33 cm)

Table 1: CMEMS model products used in the ABACUS experiment. RMS of the differences between SSH from CMEMS models and dynamic height (reference level 900 m) computed from independent (not assimilated) CTD glider data from figure 4.

Model	Spatial resolution [deg]	Assimilation	RMS of SSH (model-glider) [cm]			
			Sep 2014	Nov 2014	Dec 2014	Oct 2015
MFS	1/16	Yes	2.95	2.52	2.19	4.33
IBI	1/36	No	1.97	3.02	4.11	3.15
GLO	1/12	Yes	106	2.56	3.34	2.61

Eddy tracks: Clear regions of eddy dominance of both signs visible in cyclone and anticyclone eddy tracks from altimetry and the three models are evident across the WMED in figure 5.

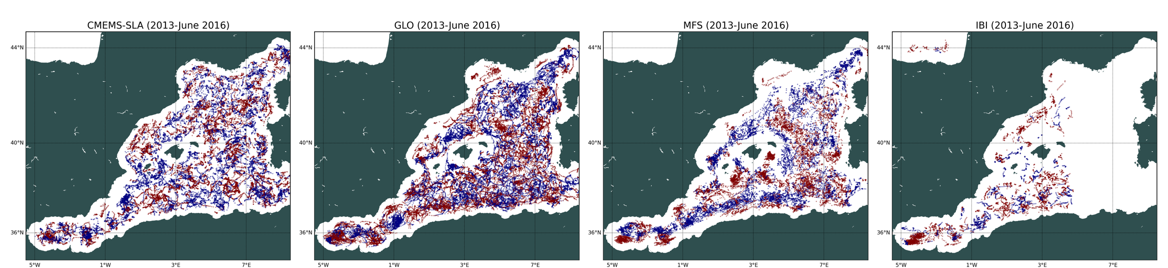

Figure 5: Eddy tracks for cyclones (blue) and anticyclones (red) between 2013 and June 2016 from (a) CMEMS-SLA, (b) GLO, (c) MFS, and (d) IBI.

- Asymmetry explained by preferential formation of eddies of both signs, dominance in eddy longevity, and/or conditions favoring preferred propagation pathways

Eddy properties: Hotspots in eddy properties associated with the anticyclonic Algerian eddies, and cyclones in the region between the central and eastern Alboran gyres are visible in maps of WMED mean eddy radii and amplitudes for cyclones and anticyclones in figures 6 and 7.

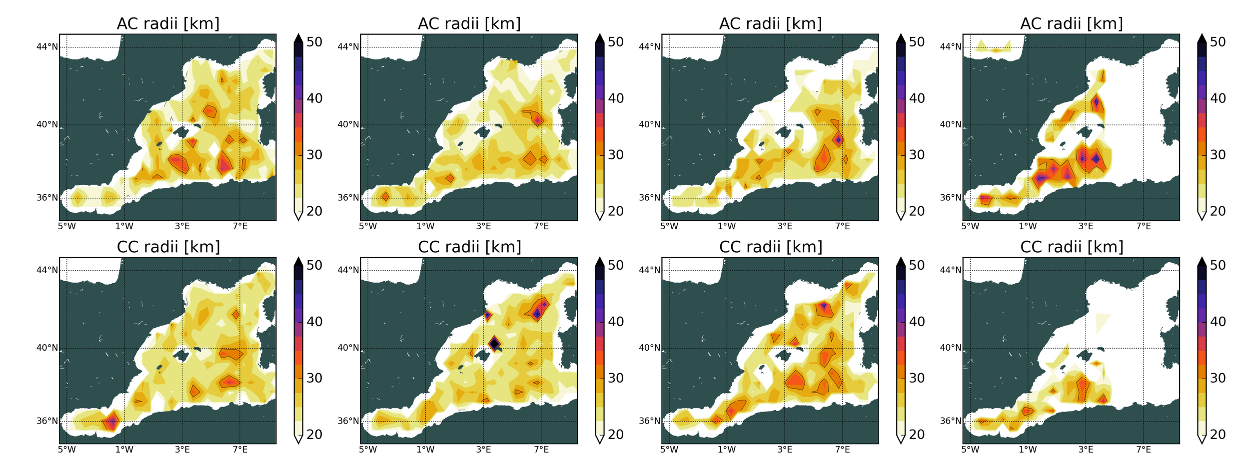

Figure 6: Maps of WMED mean eddy radii for (left to right) CMEMS-SLA, GLO, MFS and IBI from the eddy tracker on a 0.5°×0.5° grid for anticyclones (top row) and cyclones (bottom row).

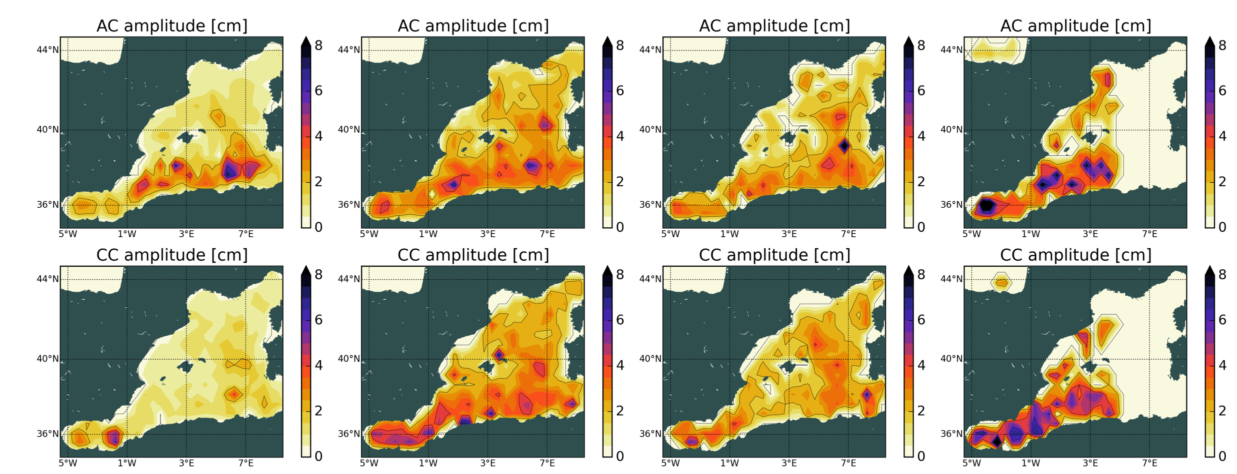

Figure 7: Maps of WMED mean eddy amplitudes for (left to right) CMEMS-SLA, GLO, MFS and IBI from the eddy tracker on a 0.5°×0.5° grid for anticyclones (top row) and cyclones (bottom row).

- GLO eddies have small radii and large amplitudes, contrary to expectations for a relatively coarse resolution model

Eddy compositing: For any desired variable ϕ, composites are made by matching with eddy observations in time and space. Radial dimensions of each eddy instance are normalized by the eddy radius, allowing interpolation to a Cartesian grid (limits ± 4 at intervals $\Delta x = 0.2$). The collocated observations are temporally averaged to produce composites of ϕ for specified subregions and periods.

Eddy composites of T', S' and ζ/f in the Alboran Sea: Two subregions for compositing in figures 8 and 9 distinguish the western Alboran (5.5°-2°W, 35°-37°N) and eastern Alboran (2°W-1°E, 35°-37°N) gyres.

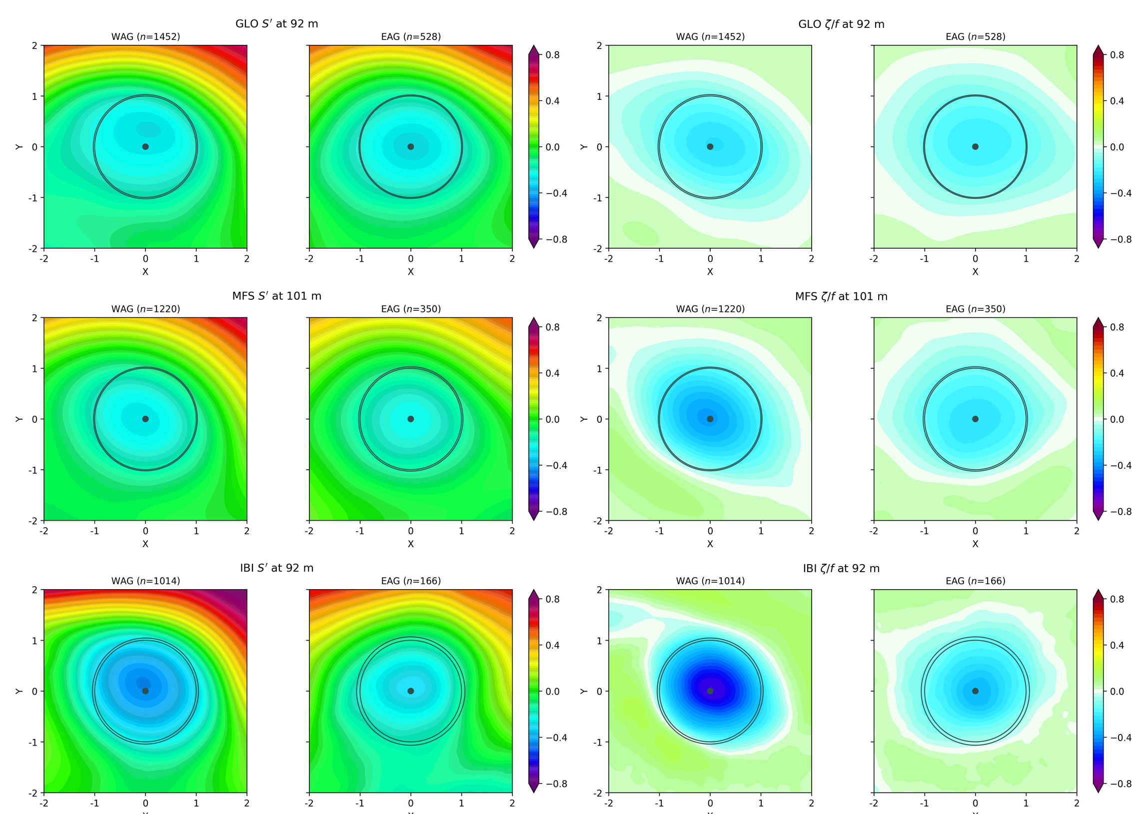

Figure 8: Mean eddy-centric composites of S' and ζ/f at 100 m for AC eddies in the western and eastern Alboran gyre subregions from GLO (top row), MFS (middle row), and IBI (bottom row). Inner (outer) grey circles correspond to the mean normalized eddy speed (effective) radius.

- Composites of S' in both the WAG and EAG at 100 m in figure 8 have similar intensity for GLO and MFS; S' in IBI is markedly fresher in the WAG
- Composites of ζ/f for the three models are comparable in the EAG; in the WAG ζ intensity increases in MFS and IBI

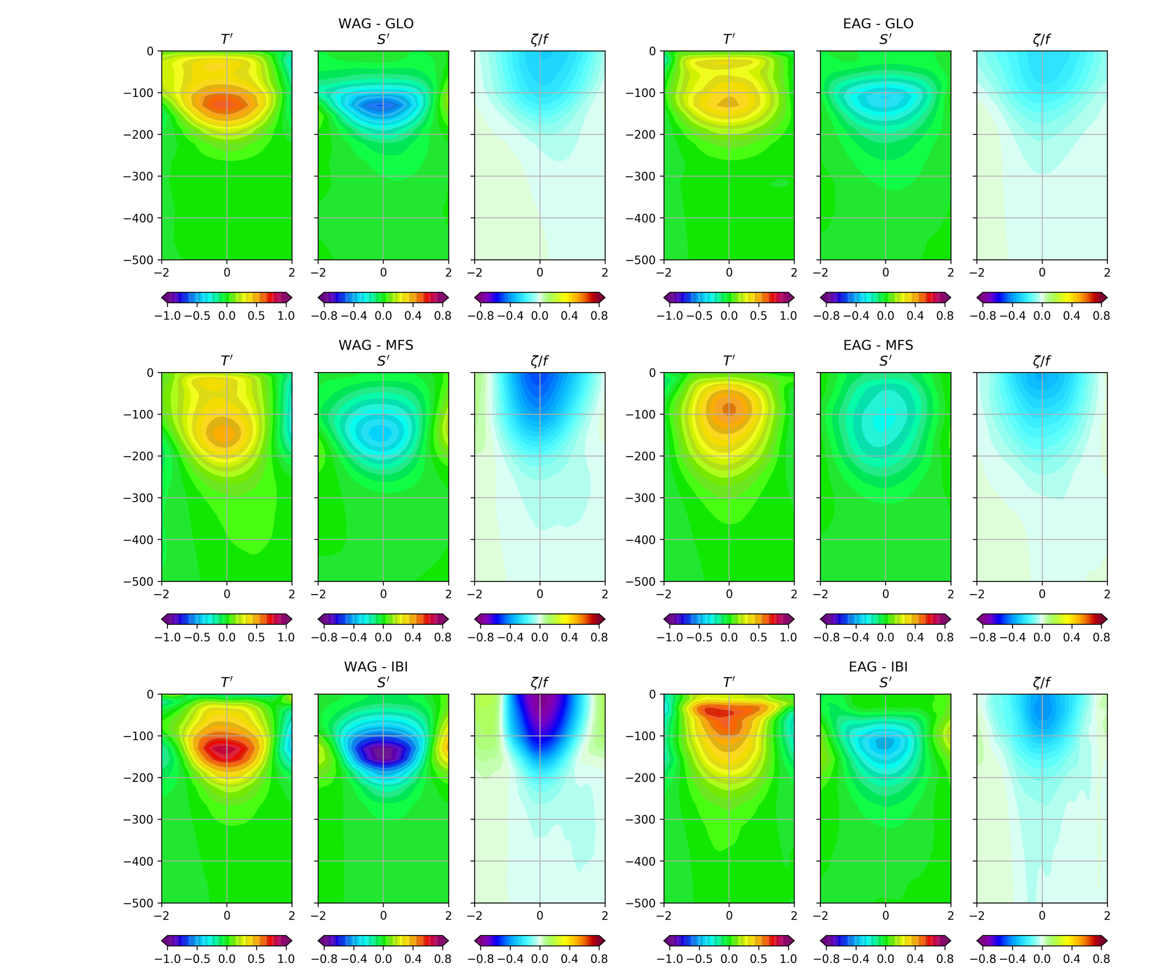

Figure 9: Vertical sections of mean eddy-centric composites of AC T', S' and ζ/f in the western and eastern Alboran gyres from GLO (top row), MFS (middle row), and IBI (bottom row).

Eddy composite vertical sections of T' (°C), S' and ζ/f in the WAG and EAG in figure 9 reveal further differences between the models for GLO and MFS.

- T' and S' extrema are located at $\sim$ 125 m in the WAG; MFS (IBI) anomalies are the weakest (strongest)
- ζ is surface intensified, with significant signals down to $\sim$ 200-300 m

Conclusions

- Through MedSub we are exploring new approaches to assessment of the mesoscale content of CMEMS operational models
- The automated eddy tracker is one example of a promising analysis tool
- Eddy tracking and compositing will benefit CMEMS operational services by enriching the CMEMS product menu with additional properties associated with the 2D circulation
- Multiplatform experiments also provide complementary approaches to model assessment

References

- Cotroneo, Y., G. Aulicino, S. Ruiz, A. Pascual, G. Budillon, G. Fusco, and J. Tintoré, 2016: Glider and satellite high resolution monitoring of a mesoscale eddy in the Algerian basin: Effects on the mixed layer depth and biochemistry. *J. Mar. Syst.*, **162**, 73–88, doi:10.1016/j.jmarsys.2015.12.004.
- Mason, E., A. Pascual, and J. C. McWilliams, 2014: A new sea surface height based code for mesoscale oceanic eddy tracking. *J. Atmos. Oceanic Technol.*, **31 (5)**, 1181–1188, doi:10.1175/JTECH-D-14-00019.1.
- Mason, E., A. Pascual, P. Gaube, S. Ruiz, J.-L. Pelegrí, and A. Delepoulle, 2017: Subregional characterization of mesoscale eddies across the Brazil-Malvinas Confluence. *J. Geophys. Res. Oceans.*, Accepted, doi:10.1002/2016JC012611.

Acknowledgments

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