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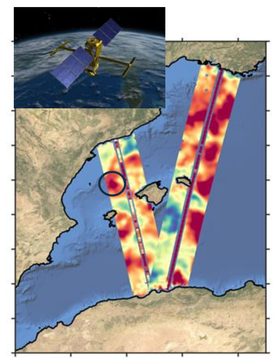
Assessment of SWOT satellite observations and integration with high-resolution regional simulations in the Western Mediterranean Sea



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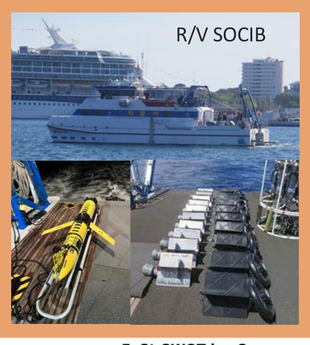
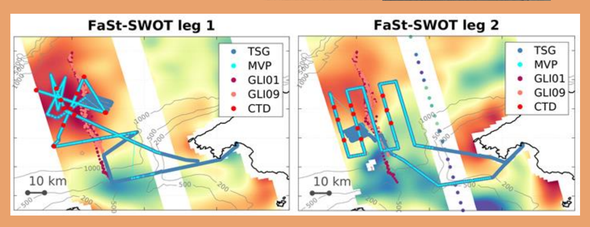
Introduction

- We observed a small-scale intrathermocline anticyclonic eddy in the Western Mediterranean Sea during SWOT fast-sampling phase in April–May 2023 (FaSt-SWOT experiment).
- This eddy had a ~20-25 km radius, extended from 50 to 450 m depth, and produced ~3 cm sea surface height (SSH) anomalies.
- In this study, we 1) provide an assessment of SWOT capability to observe the sea surface signature of the eddy, and 2) evaluate the impact of assimilating both SWOT and in-situ observations into a high-resolution modelling system.

FaSt-SWOT experiment

- 2 legs (25-28 April and 7-10 May 2023)
- Monitoring of water column T-S and horizontal velocities through multi-platform instrumentation: Research Vessel, CTDs, Moving Vessel Profiler, ADCP, 2 gliders, 45 surface drifters

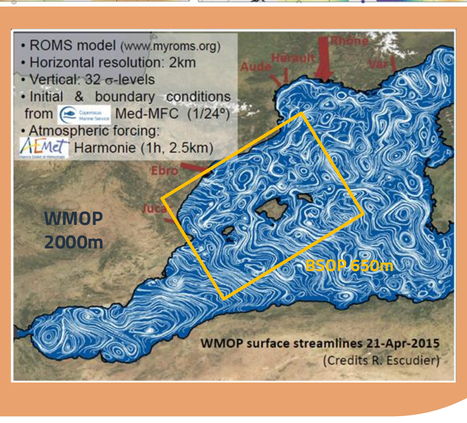




<u>& high-resolution simulations including data assimilation (local multimodel EnOI)</u>:

SOCIB WMOP (2km res.)
BSOP (650m res.)

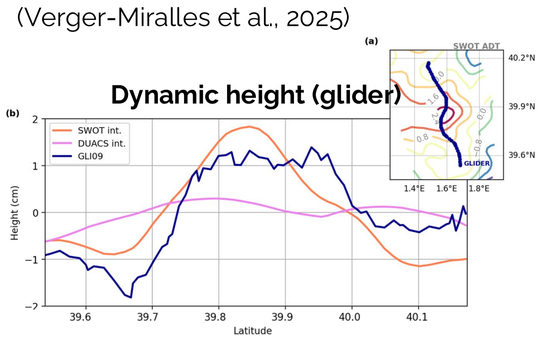
Forecasts, free-runs and reanalysis.

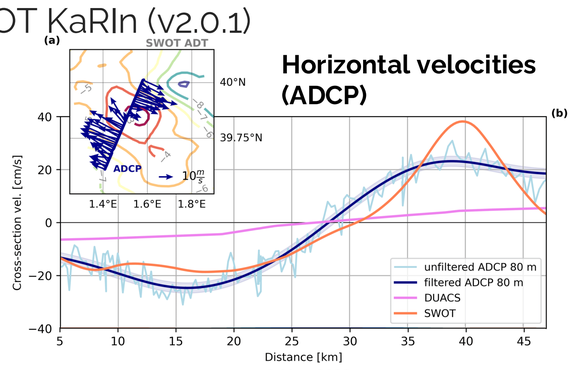


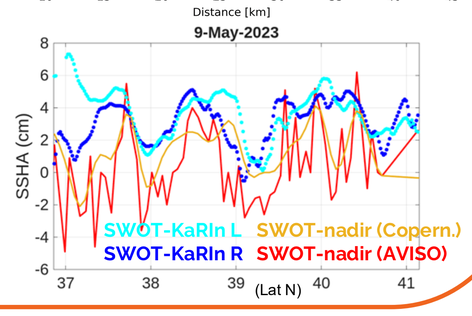
Assessment of SWOT observations

→ Very good performance of SWOT KaRIn (v2.0.1)

(Verger-Miralles et al., 2025)





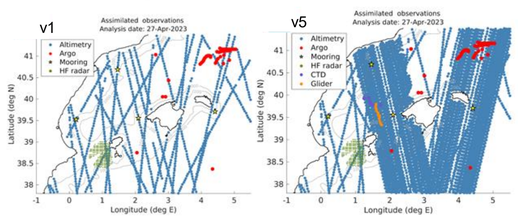


→ Some issues with SWOT nadir

Discrepancies between AVISO and Copernicus products.

Data assimilation experiments [26 Apr – 2 May 2023]

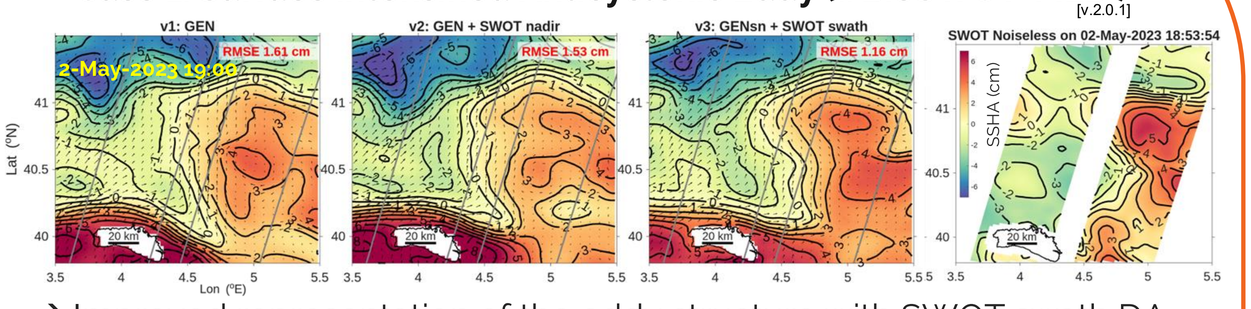
v1: GEN (along-track SLA, SST, Argo T-S, Moorings, HF radar)
v2: GEN + SWOT Nadir (GENsn)
v3: GENsn + SWOT swath
v4: GENsn + in-situ glider and CTD
v5: GENsn + SWOT swath + in-situ glider and CTD



SWOT data treatment: assimilation of SSHA v2.0.1 with spatial subsampling (1 every 4 pts), prescribed obs error std : 2cm (instrumental) + 3cm (representativity) [same as alongtrack altimetry], errors assumed uncorrelated.

Impact of SWOT observations: SSH

Case 1: Surface intensified Anticyclonic Eddy (#BioSWOT-MED) [v.2.0.1]

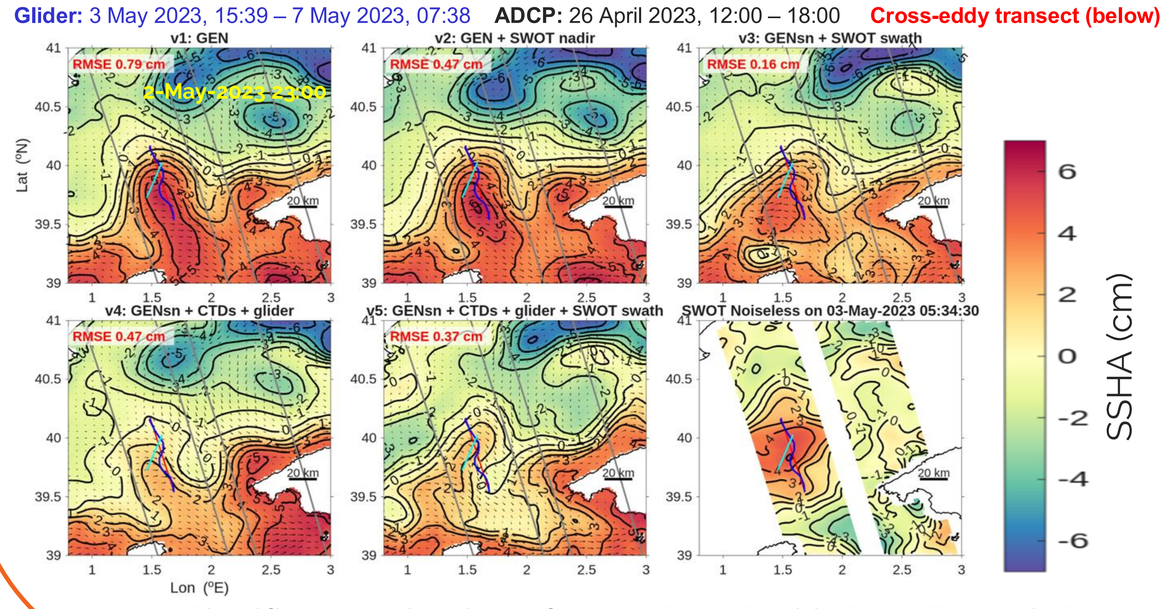


→ Improved representation of the eddy structure with SWOT swath DA

→ 27% RMSE reduction

Case 2: Intrathermocline Anticyclonic Eddy (#FaSt-SWOT)

Glider: 3 May 2023, 15:39 – 7 May 2023, 07:38 **ADCP:** 26 April 2023, 12:00 – 18:00 **Cross-eddy transect (below)**

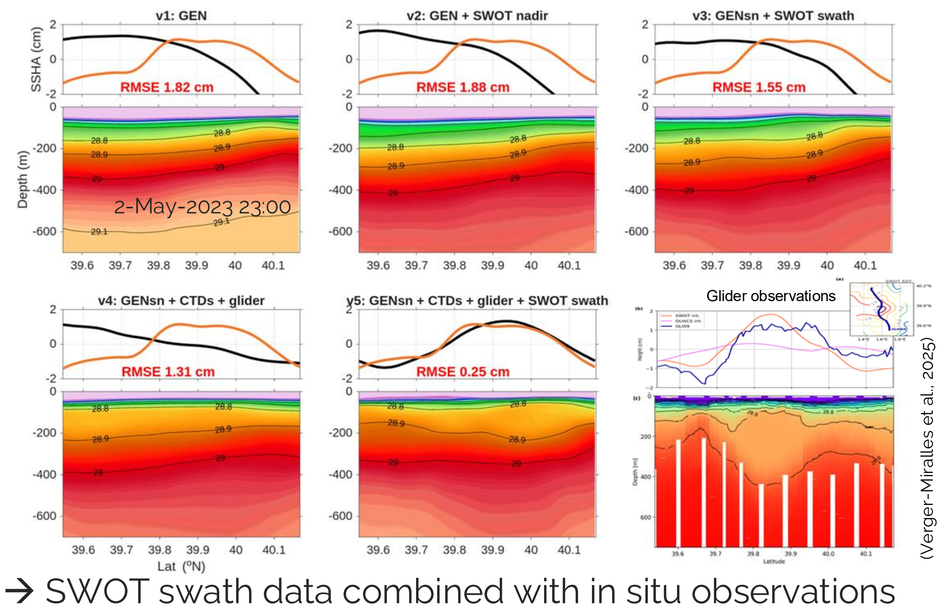


→ Significant reduction of SSHA RMSE with SWOT swath DA

Impact of SWOT observations: subsurface

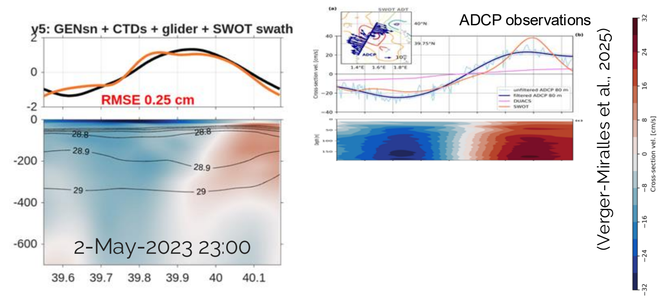
Glider cross-eddy transect

Potential density and SSHA



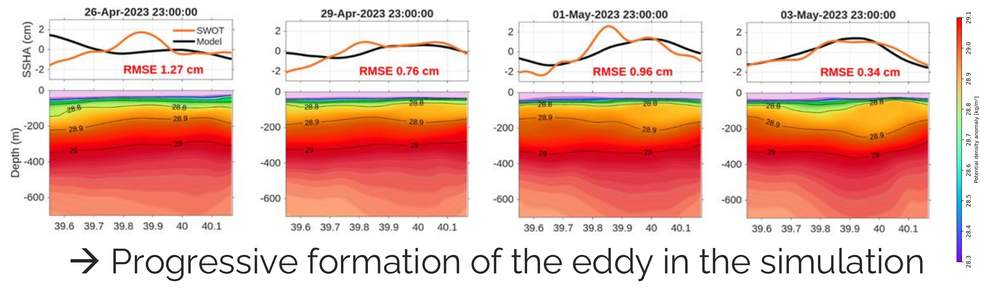
→ SWOT swath data combined with in situ observations needed to represent the intrathermocline nature of the eddy

Horizontal velocity and SSHA



→ Proper representation of anticyclonic velocities associated with the eddy

Temporal evolution



→ Progressive formation of the eddy in the simulation

→ High daily variability in SWOT observations

Conclusion and future plans

- SWOT data assimilation improves the representation of small scale eddies in the model.
  Subsurface observations are needed to represent the vertical structure.
- Future plans: (i) evaluation of the sensitivity of the results to observation error covariances, (ii) validation against CTDs, ADCP and drifters, (iii) investigation of eddy dynamics.

Acknowledgements

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Reference: Verger-Miralles E. et al. (2025). SWOT enhances small-scale eddy detection in the Mediterranean Sea. Geophysical Research Letters, 52, e2025GL116480. https://doi.org/10.1029/2025GL116480