



SWOT and the drifter's odyssey in the NW Mediterranean Sea: riding current meanders and escaping eddies

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Understanding, monitoring and predicting the sea level changes and currents from regional to local scales are critical issues for coastal populations and ecosystems. The 30-year record of satellite nadir altimetry observations is an outstanding tool to address them. Yet, interpreting small-scale, rapidly varying nearshore coastal ocean dynamics remains a challenge with 1-D altimetry measurements. The 2-D SWOT measurements provide unprecedented insights on small-scale ocean dynamics, that will enable us to revisit the physical content of 1-D altimetry and how it captures such processes. This presupposes a clear understanding of the signals captured by SWOT. Here, we explore SWOT L3 geostrophic currents in the Northwestern Mediterranean Sea, at regional and local scales.

Starting from the one-year odyssey of a drifter throughout the Northwestern Mediterranean Sea basin, we explore the coherency of its velocity and trajectory with the geostrophic currents derived from SWOT observations. As the drifter was launched during the SWOT fast-sampling phase, and ended its journey during the SWOT Science phase, it offers the opportunity to explore different aspects of SWOT (accuracy, sampling, physical content) for regional and coastal applications.

One of the most striking ocean dynamics features encountered by the drifter during its journey is an anticyclonic eddy located around the Capraia Island in the Corsica Channel, where it remains stuck for more than a month. This eddy, with a diameter of about 50 km, is known to have seasonal characteristics, appearing during Summer and lasting until Fall. It has been sampled by SWOT at the beginning of the Science Phase, which provides an opportunity to investigate the quality of SWOT derived currents in a more coastal and local domain. Two tracks of Sentinel-6 nadir altimeter also pass over the Capraia Island. This configuration is thus a very nice opportunity to analyze nadir altimetry at the light of SWOT, and how the various datasets capture the Capraia Island eddy.

1. A one-year journey in the Northwestern Mediterranean Sea

Datasets:

- **Drifter data:** hourly positions and velocities of a 15-m drogued drifter, provided by CMEMS (ref. GL_TS_DC_1801763), launched on 04/05/2023 under SWOT track 003 (CalVal phase) in the frame of the BioSWOT campaign (Fig. 1).
- **SWOT data:** Level-3 LR SSH product, version 2.0.1 at 2 km, filtered geostrophic currents
- **Nadir altimetry:** X-TRACK-L2P 1Hz along-track coastal altimetry sea level anomalies (here we use Sentinel-6 data)
- **Model:** total currents at 15-m depth extracted from a Symphonie simulation of the Mediterranean Sea (2 km resolution, 60 vertical levels) along the drifter trajectory

Data processing:

Period: 04/05/2023 to 04/06/2024

- Editing applied on the drifter velocities to remove outliers
- 48-h low-pass Lowess filter applied to drifter and Symphonie data to remove high frequency signals, including near-inertial oscillations

Comparison SWOT/drifter at co-locations

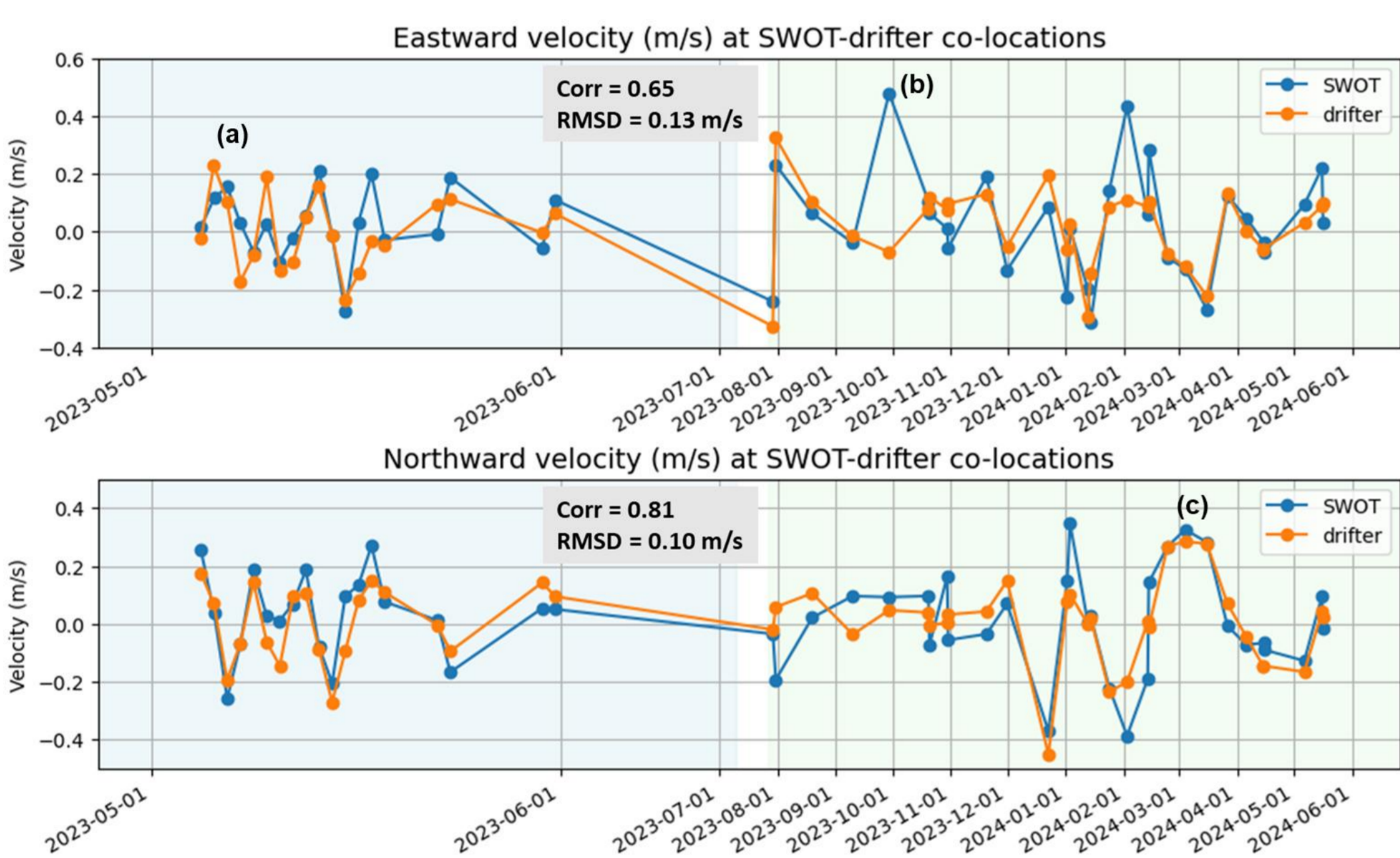


Figure 2: SWOT and drifter eastward (top) and northward (bottom) velocities at time-space co-locations along the drifter's journey. The time axis is stretched during the SWOT Calval phase (showed with light blue shading). The Science phase is showed with light green shading. Letters (a, b, c) refer to the events showed in Fig. 3.

Embark for the full odyssey!

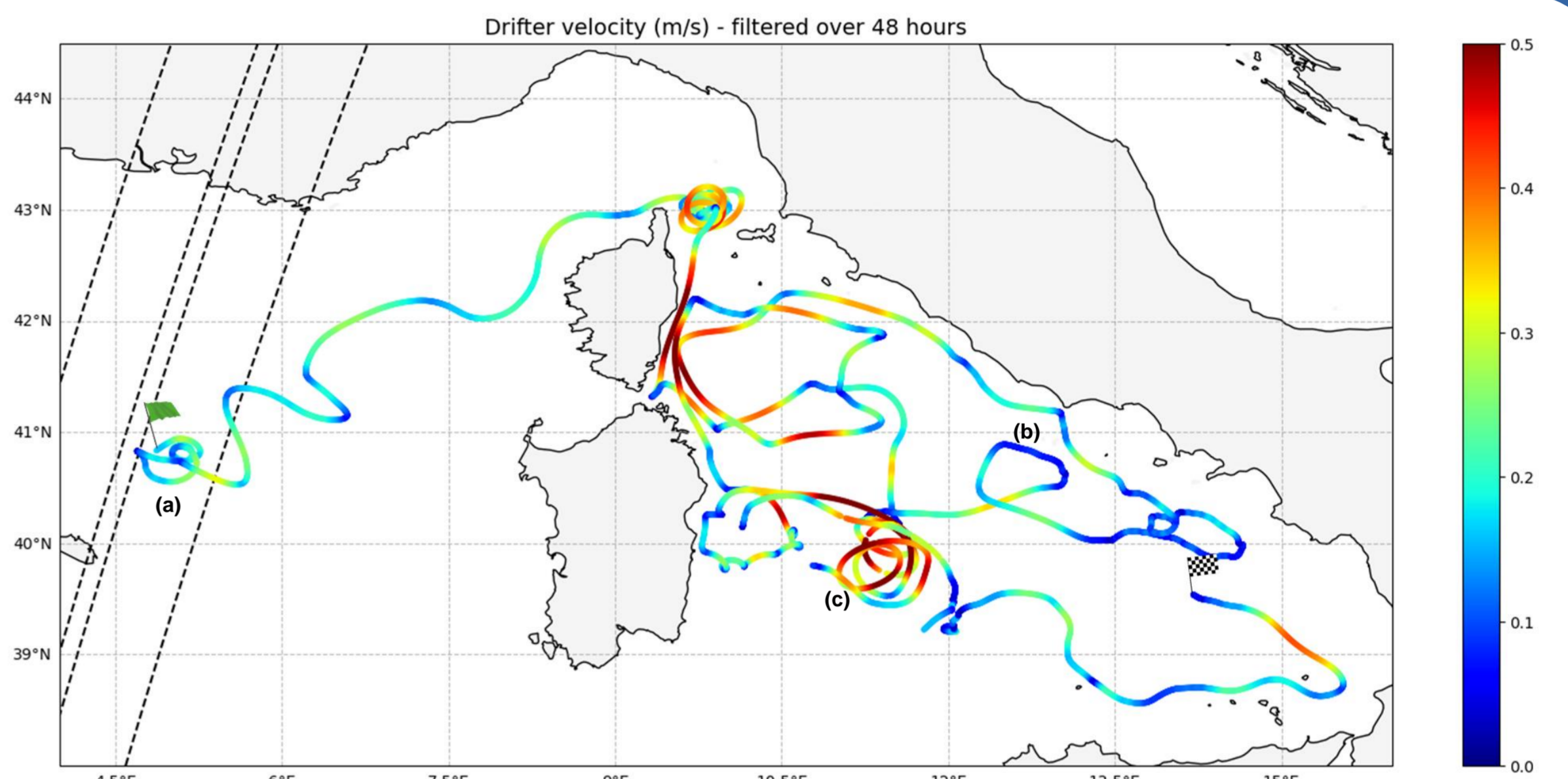


Figure 1: Drifter velocity (m/s) along its path from its launch under the SWOT CalVal phase track 003 (swath shown with black dashed lines) until early June 2024. The data have been 48-h low-pass filtered to remove near-inertial oscillations and other high frequency signals. Letters (a, b, c) refer to the specific events showed in Fig. 2 and Fig. 3.

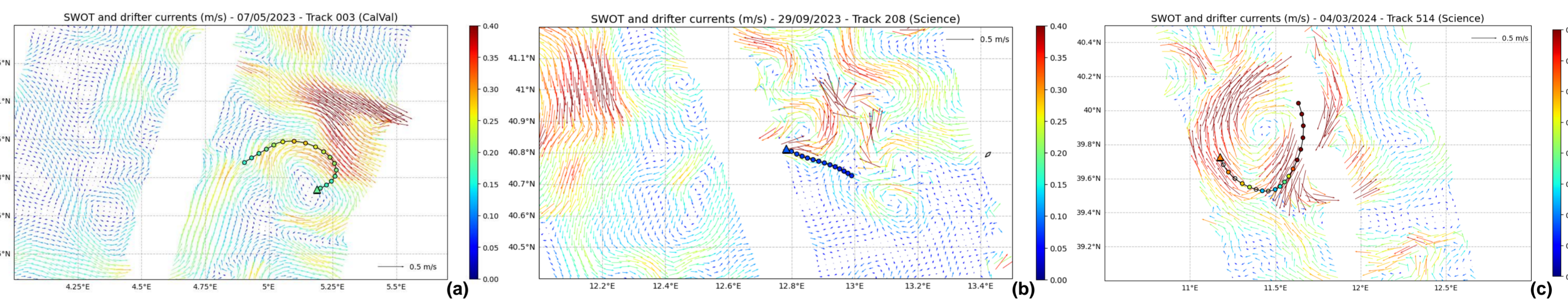


Figure 3: Maps of SWOT geostrophic currents for the events (a, b, c) showed in Fig. 1 and Fig. 2. The coloured triangle corresponds to the drifter velocity at the co-location with SWOT. The coloured dots show the drifter velocities and positions (under-sampled at 4 hours for (a) and (c), 6 hours for (b)) during the three days before the co-location.

- Very good agreement between the SWOT geostrophic currents and the drifter total currents at 15 m, both during the Calval phase and the Science phase (Fig. 2).
- Most patterns are very coherent in the drifter's trajectory and SWOT (see for example Fig. 3a and Fig. 3c, and also Fig. 4).
- Lower correlation on eastward currents due to one specific event (Fig. 3b), where SWOT highlights an eddy or meander while the drifter shows very low speed during several days. This may be due to strong southeastward wind that blew on the 24-25/09/2023 (as given by 10-m wind model data in the drifter dataset), but it needs to be further analyzed.

2. Spinning in the Capraia Eddy

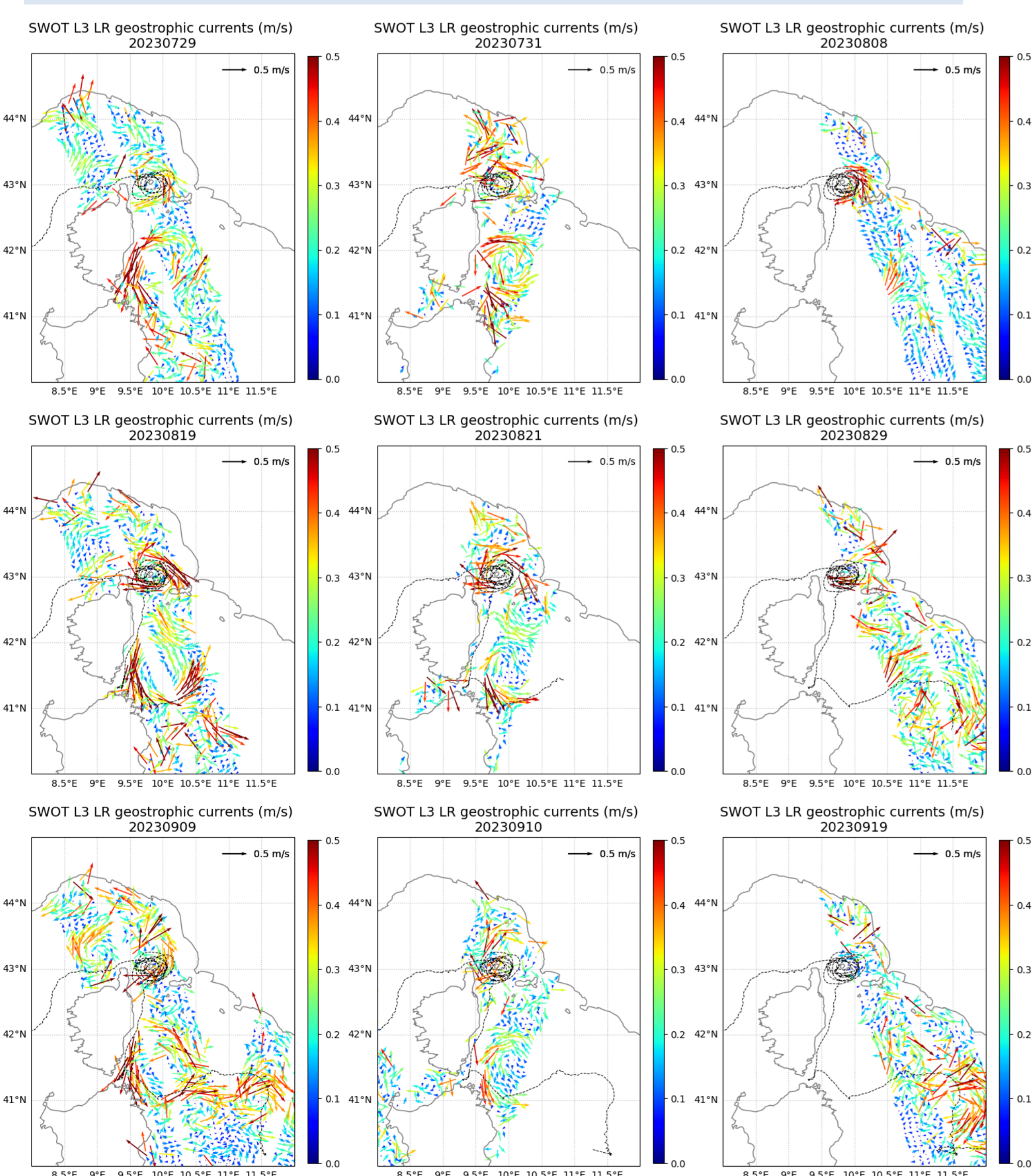


Figure 4: SWOT absolute geostrophic currents for all occurrences over Capraia between the start of the Science phase and 19/09/2023. The trajectory of the drifter is showed with black dots on each map for all the period until SWOT pass.

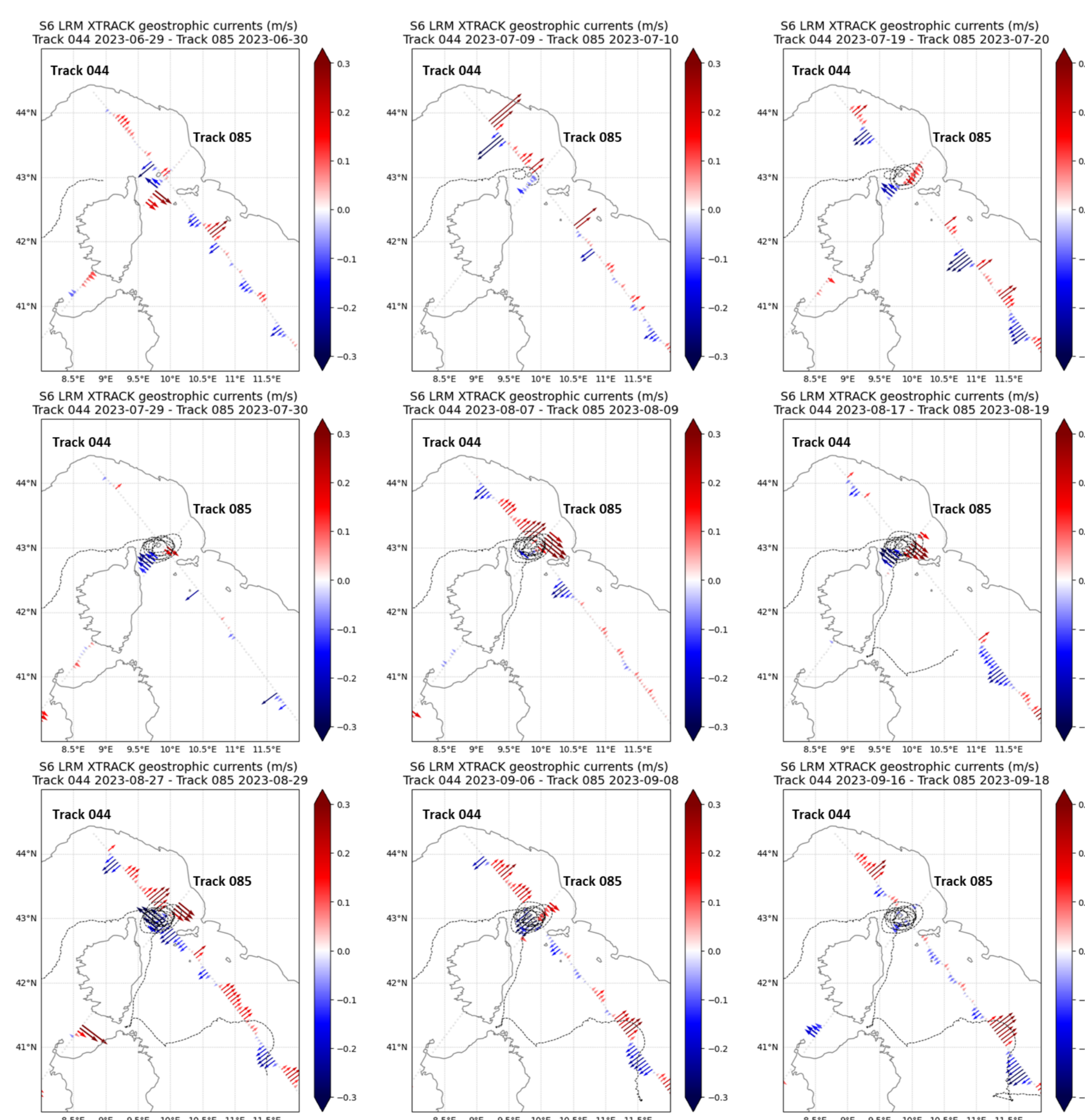


Figure 5: X-TRACK-L2P Sentinel-6 LRM cross-track absolute geostrophic currents, from 29/06/2023 to 18/09/2023. The altimeter ground tracks 044 and 085 are showed with light grey dots where there is no data. The trajectory of the drifter is showed with black dots.

A seasonal anticyclonic eddy appears in summer around the island of Capraia (Ligurian anticyclone, e.g., Iacono and Napolitano, 2020). Between early July and early August 2023 (mostly during SWOT transition to Science phase), the drifter has been spinning around the island, trapped in the eddy.

- This eddy is clearly visible in SWOT data from end of July until mid-September 2023 (Fig. 4).
- It was also sampled by Sentinel-6 1Hz coastal SLA processed with the X-TRACK-L2P approach (Fig. 5).
- Further analyses are required but, despite missing S6 nadir altimetry data in the area, both datasets show very good consistency in terms of eddy extension and period of presence, on this event.

3. What comes next?

- Redo the analyses with the version 3 of the L3 LR SWOT products, and further explore the differences between the datasets (geostrophy limit?).
- Further investigate the Capraia eddy and how SWOT and a numerical simulation (Fig. 6) can help revisit the 30-year long time series of coastal nadir altimetry data in the region.

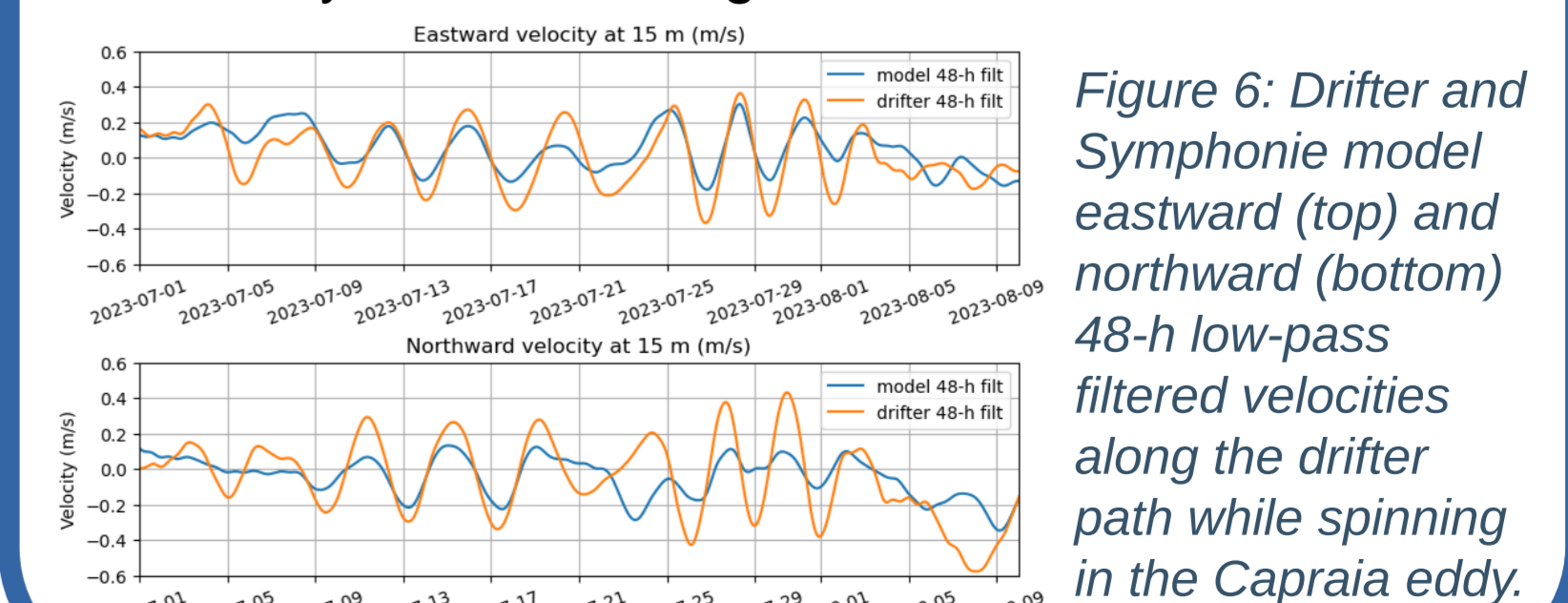


Figure 6: Drifter and Symphonie model eastward (top) and northward (bottom) 48-h low-pass filtered velocities along the drifter path while spinning in the Capraia eddy.

References

- Iacono, R. and Napolitano, E.: Aspects of the summer circulation in the eastern Ligurian Sea, Deep-Sea Res., 166, 103407, <https://doi.org/10.1016/j.dsr.2020.103407>, 2020
 Global Ocean in-situ Near real time observations of ocean currents, E.U. Copernicus Marine Service Information (CMEMS). Marine Data Store (MDS). DOI: <https://doi.org/10.48670/moi-00041> (Accessed on 17/12/2024)
 CTOH. (2023). X-TRACK-L2P Coastal along-track sea level anomalies (Version v2.2) [Data set]. CNES. <https://doi.org/10.24400/527896/A01-2022.020>