

# Validation of Sentinel-3A altimetry data by using in-situ multi-platform observations near Mallorca Island (western Mediterranean)

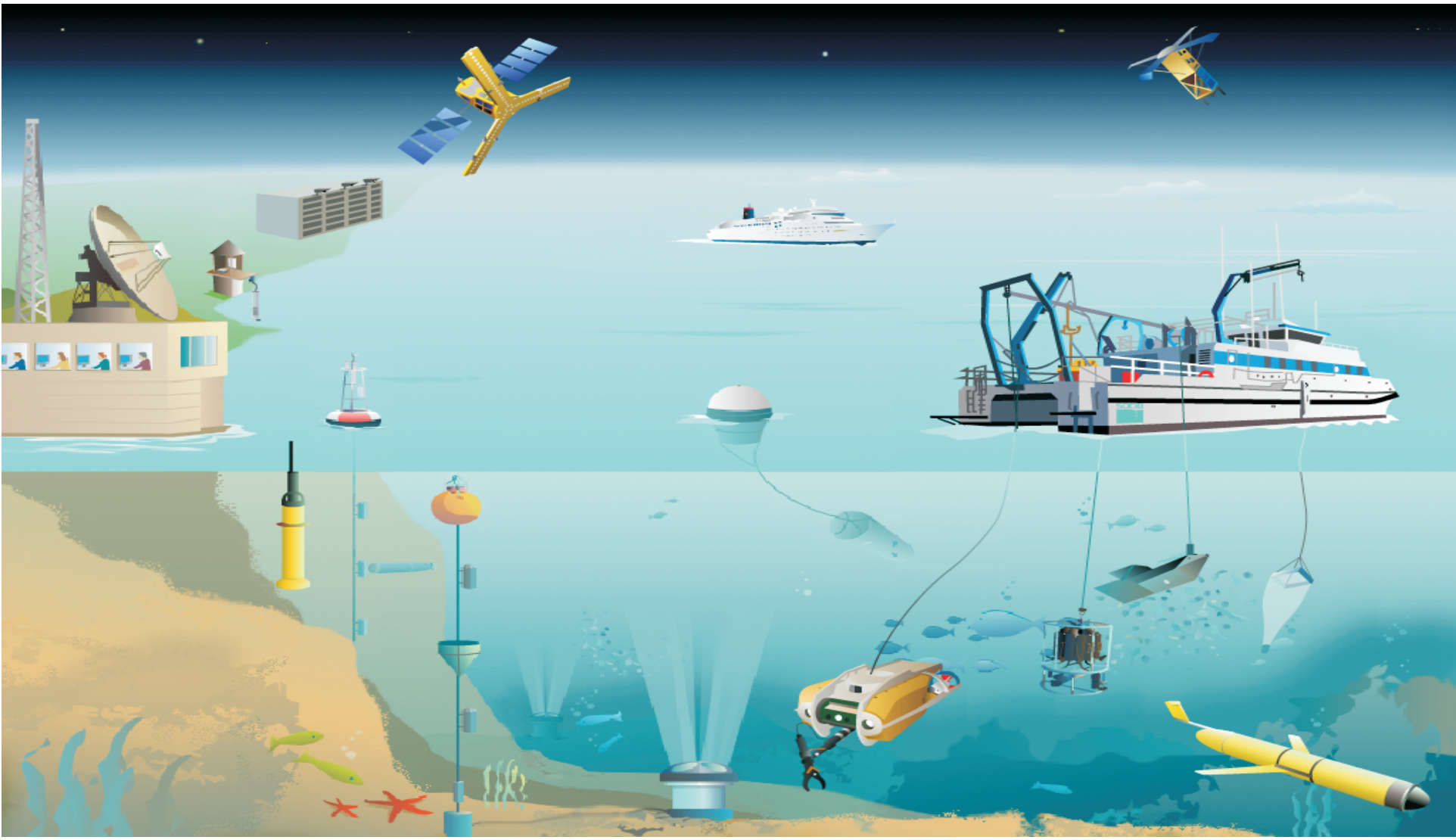
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## ABSTRACT

In the frame of the Copernicus Marine Environment Monitoring Service (CMEMS) Sea Level Thematic Assembly Center (SL-TAC), a glider mission was undertaken between May and June 2016 contemporaneous with and along the same track as the overpass of the Sentinel-3A satellite in the Southern Mallorca region. In addition a one-day ship mission on May 30, synchronous with the overpass of the satellite, captured two transects of moving vessel ADCP.

The aim was to compare the along track altimeter product and multi-platform in-situ observations, and in particular to explore the potential of the Synthetic Aperture Radar Mode (SARM) instrumentation of Sentinel-3. The ultimate goal is to contribute to a more complete understanding of physical ocean processes and biogeochemical impacts.



## GLIDER mission

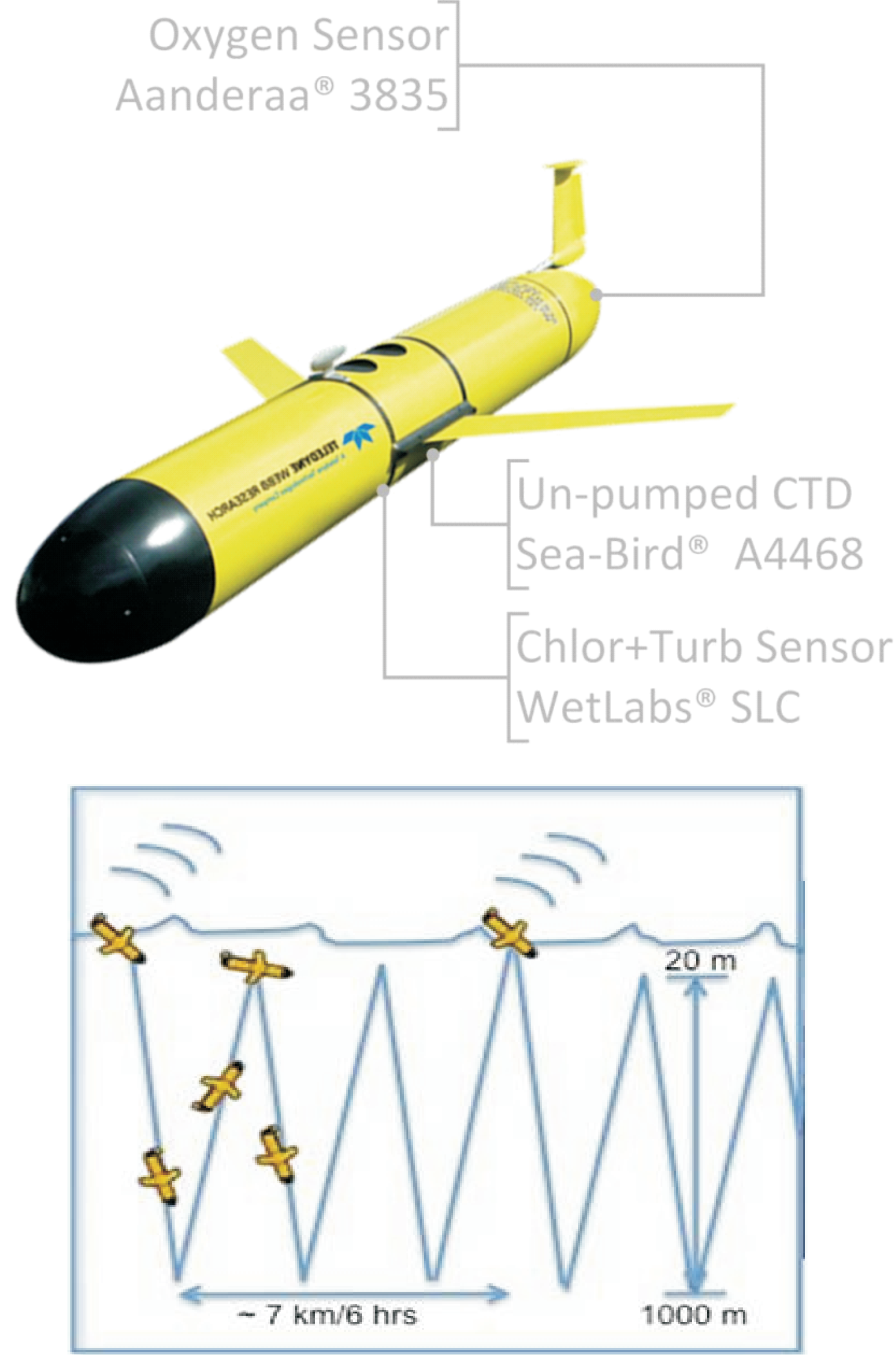


Figure 4. Glider SLOCUM-G1 used in the experiment (upper panel) and operating scheme (lower panel).

- 2 transects in the Algerian Basin along S-3A track 713
  - Time Period: 25 May 2016 to 17 June 2016
  - Navigated Km/NM: 600/324
  - Profiles: 876 (CTD), 439 (OXY), 439 (CHL-TURB)
- Free Public Data available at [www.socib.es](http://www.socib.es)**
- TECHNICAL SPECIFICATIONS**
- AUV(Autonomous Underwater Vehicle): electric Glider
  - Manufacturer/Model: SLOCUM-G1
  - Max. Operative Depth : 1000 meters
  - Scientific Sensors: CTD, Oxygen, Chlor/Turb

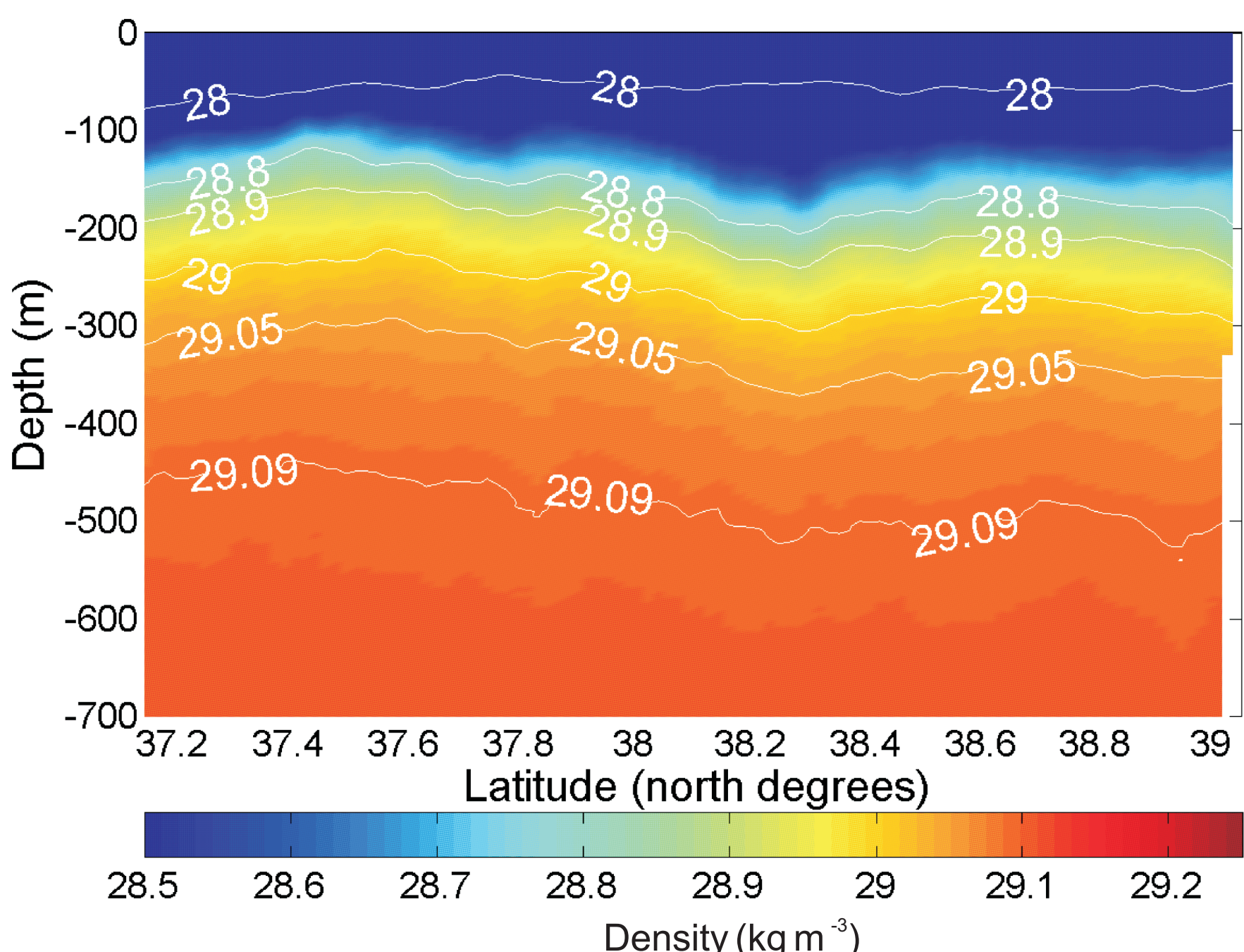


Figure 5. Density field computed from the glider data.

## RESULTS

### Dynamic Height and Absolute Dynamic Topography

Temperature and salinity fields from glider data are used to estimate the Dynamic Height (DH) at 30 m depth with respect to a reference level of 950 m. This data is compared with the Absolute Dynamic topography (ADT) computed from altimetry. Synthetic Aperture Radar mode (SARM) and Pseudo Low Resolution mode (PLRM) data (spatial resolution of 0.33 km) with the official ESA processing have been used. A low-pass Loess filter with a 30 km cut-off window was previously applied to remove the measurement noise (see Figure 6). Moreover, the reference level used to compute DH does not match with the reference used in the altimetry data (geoid), so the mean value of ADT and DH datasets were removed before the comparison.

Figure 6. SARM ADT (green line) and PLRM ADT (blue line) from altimetry; and DH (brown line) derived from glider data. Notice that the mean value of the DH and ADT has been removed for comparison purposes. Units are in cm.

### Surface geostrophic velocity

The 30 km filtered SARM ADT and PLRM ADT was used to compute absolute geostrophic velocities along the satellite track. We computed the component of the geostrophic current perpendicular to the track by applying central finite differences in the interior and first differences at the boundaries of the ADT data (Troupin et al., 2015). This geostrophic velocity was compared with velocities recovered from the glider and ADCP.

Glider velocity collected along the transect 1 (30 May to 6 June 2016) was used to compute geostrophic currents at 30 m depth perpendicular to the glider track (Figure 7). The glider geostrophic velocity uses a reference velocity for the geostrophic calculation derived from the Depth Average Velocity (DAV) variable, which is calculated by the glider for each dive segment (see Bouffard et al., 2010).

DAV is an estimation of the average current speed for each segment of the glider trajectory and is corrected post mission for errors in the internal compass heading. This variable was not filtered out because it is estimated from the filtered T/S data.

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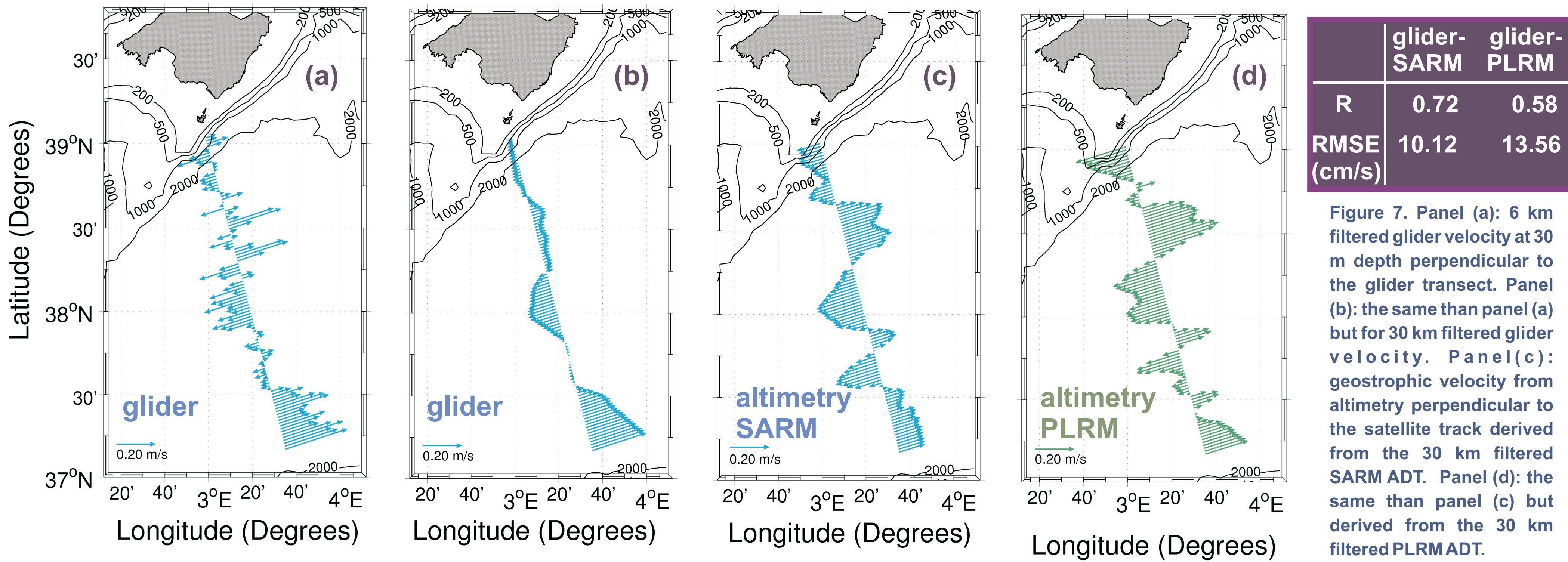


Figure 7. Panel (a): 6 km filtered glider velocity at 30 m depth perpendicular to the glider transect. Panel (b): the same than panel (a) but for 30 km filtered glider velocity. Panel (c): geostrophic velocity from altimetry perpendicular to the satellite track derived from the 30 km filtered SARM ADT. Panel (d): the same than panel (c) but derived from the 30 km filtered PLRM ADT.

ADCP velocity at 32 m depth recovered along the ADCP return transect (conducted on 30 May between 13:16h - 17:37h) were also used to compare with geostrophic velocities derived from altimetry and glider data (Figure 8). Here, however, the Loess filter was not applied due to the high quality of this dataset.

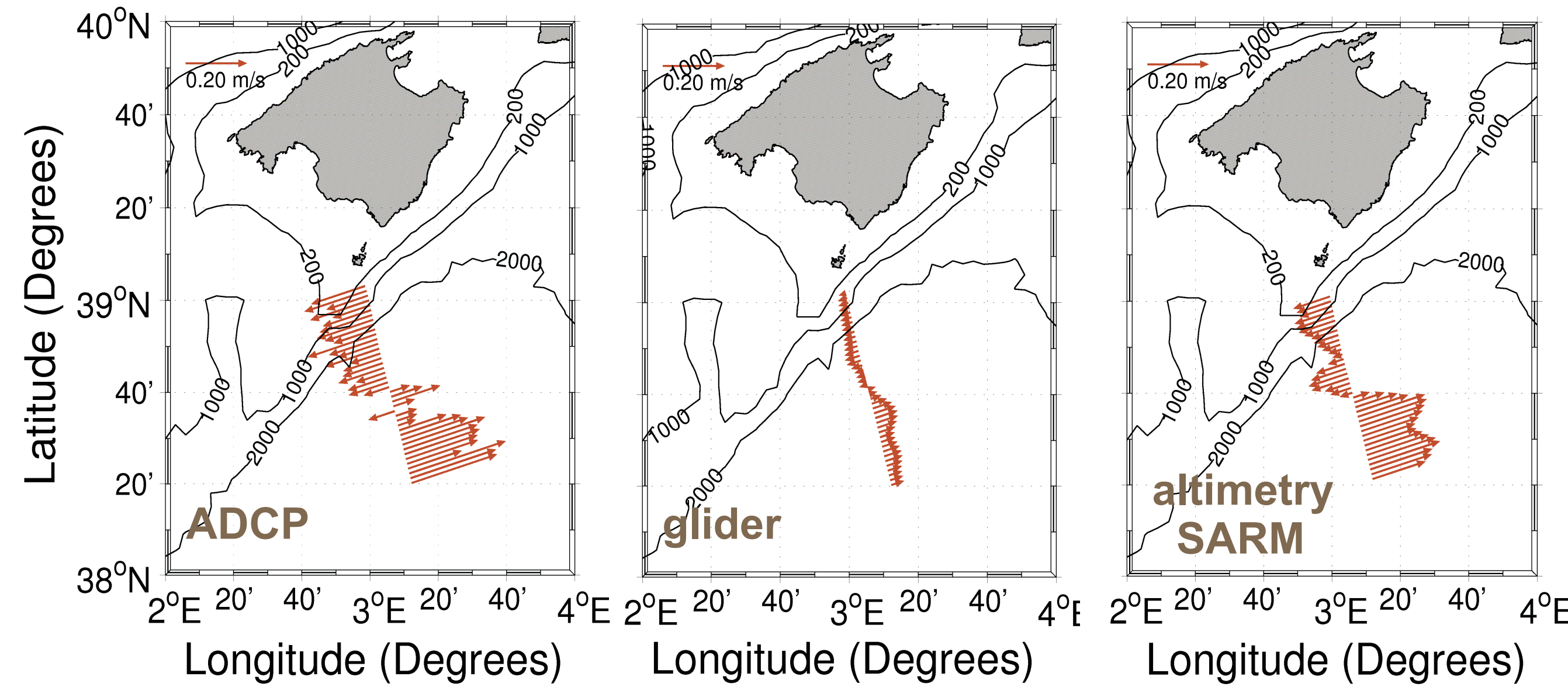


Figure 8. Left panel: ADCP total velocities at 32 m depth perpendicular to the ADCP return transect. Panel in the middle: 30 km filtered glider velocity at 30 m depth perpendicular to the glider transect. Right panel: geostrophic velocity from altimetry perpendicular to the satellite track derived from the 30 km filtered SARM ADT.

## SUMMARY AND CONCLUSIONS

1- A multi-platform experiment was successfully conducted in summer 2016 in the Western Mediterranean Sea to compare the along-track Sentinel-3A altimeter product and in-situ glider and ADCP observations. PLRM and new SARM altimetry data with the official ESA processing have been used.

2-SARM ADT and DH exhibit a quite similar spatial pattern with a correlation coefficient of 0.79 and a RMSE of 1.23 cm. Coarser results ( $R = 0.67$  and  $RMSE = 1.52$  cm) are obtained when comparing PLRM ADT and DH. As a consequence, geostrophic velocities computed from PLRM altimetry and glider velocities exhibit a correlation coefficient of 0.58 and a RMSE close to 14 cm/s (see Pascual et al, 2015 and Troupin et al., 2015). These results improve 34 % when using SARM data ( $R = 0.72$  and  $RMSE = 10$  cm/s).

3- Surface velocities from ADCP data exhibit a similar spatial pattern than geostrophic velocities computed from SARM altimetry and glider velocity in the northern part of the transect. Larger amplitudes in the ADCP data could be due to the fact that ADCP measures the total velocity, this including the inertial currents which are missed from altimetry and glider data. The RMSE between altimetry and ADCP data is lower than 10 cm/s; the correlation coefficient is 0.86.

4-This very good correlation between altimetry and the 2 in situ measurements (RMSE lower than 10 cm/s) demonstrates the high capacity of SAR instrument to retrieve the small scales of the Algerian current.

## ACKNOWLEDGMENTS

This work has been carried out in the frame of the Copernicus Marine Environment Monitoring Service (CMEMS) Sea Level Thematic Assembly Center (SL-TAC) Project. We specially thank to SOCIB Glider Facility, SOCIB Engineering and Technology Division; and SOCIB coastal R/V Facility for their support. The authors also thank ESA MPC project for implementing a dedicated reprocessing of pass 713 of Sentinel 3.

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## MULTI-PLATFORM EXPERIMENT

### SENTINEL-3A satellite mission

- Satellite Over-flight Date: 30 May 2016 at 21:00, utc
  - Orbital Context: Cycle 0004 – Pass 0713, SRAL operating in SAR mode
  - Exact Over-flight Glider Location : [38.6695°N, 3.1075°E] 30 May 2016 at 21:00 utc
  - Reprocessed Level 2 SRAL products in version 06.05 (PB 2.8) provided by European Space Agency (ESA)
- Two altimetric range processings were tested: the SAR mode (SARM) range, and the pseudo LRM mode (PLRM) which is an approximation of classic LRM processing

Figure 1. Sentinel-3A #713 track (blue line) overpassing the Mallorca Island and the Algerian coast. Red line shows the glider track along the same path.

### ADCP mission

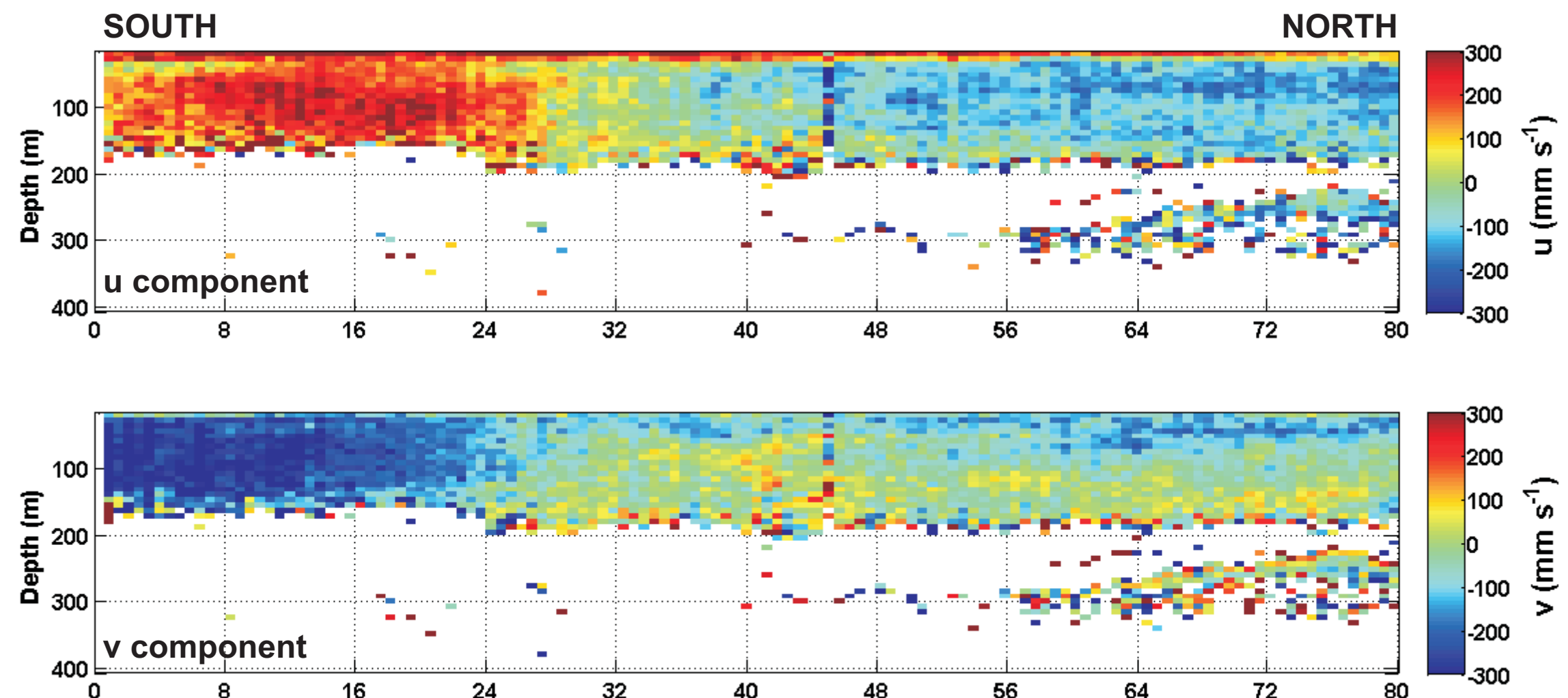


Figure 2. ADCP velocity field along the Sentinel-3A path.

- A 16 hour mission on 30 May 2016
  - 2 ADCP transects along the same track and contemporaneous with the overpass of the satellite
  - At the same time as the glider mission
- TECHNICAL SPECIFICATIONS**
- 150 kHz, RDI Ocean Surveyor, VM-ADCP
  - Transducer depth = 2 m / Blank distance = 8 m
  - Bin thickness = 8 m / Number of Bins = 50
  - Max range for bottom tracking = 400 m

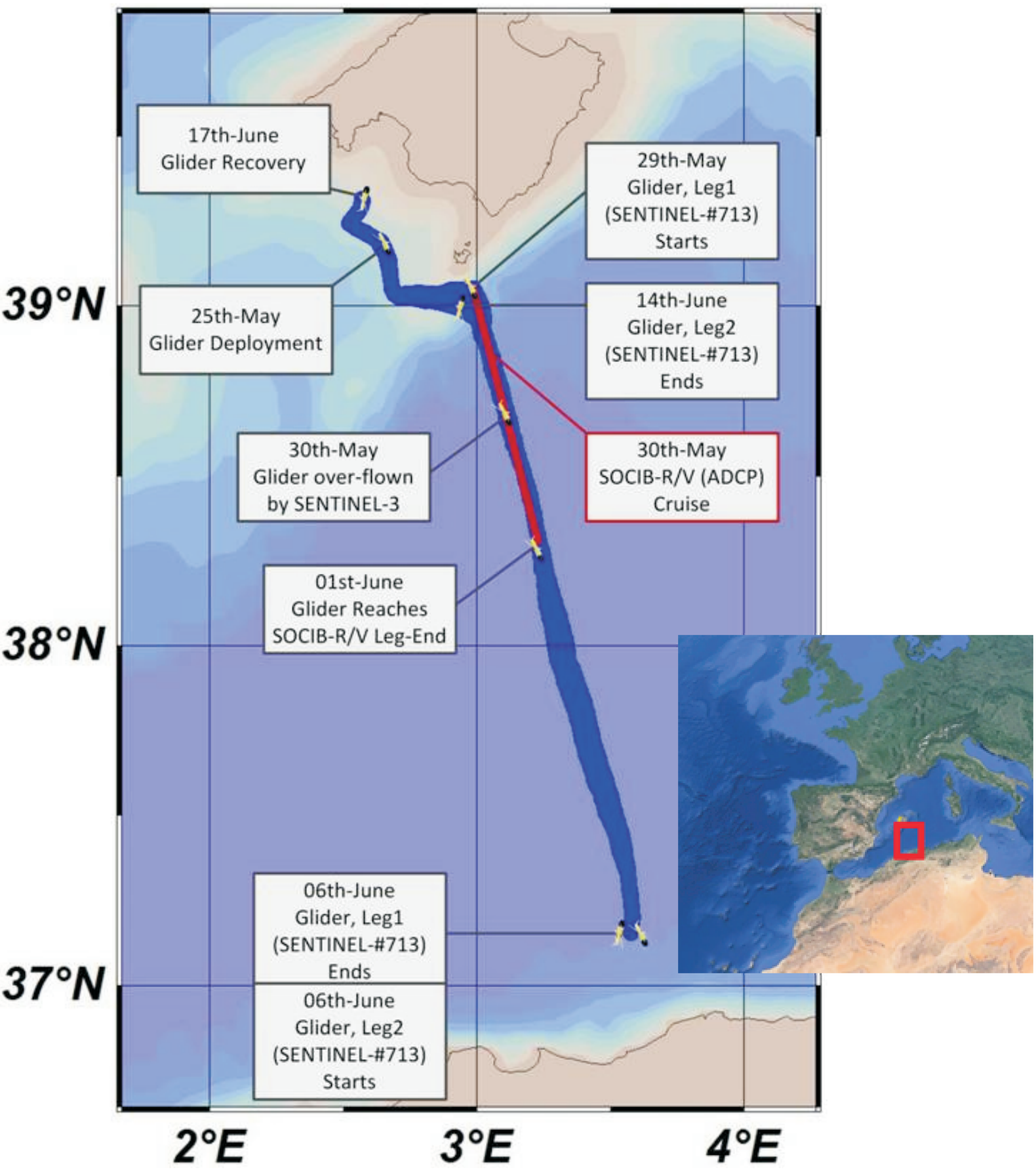


Figure 3. Glider path (blue line) between Mallorca Island and the Algerian coast. Red line shows the ADCP track contemporaneous with the overpass of the satellite.