

# Surface circulation in the Ligurian Sea: an assessment of satellite radar altimeter-derived geostrophic currents.

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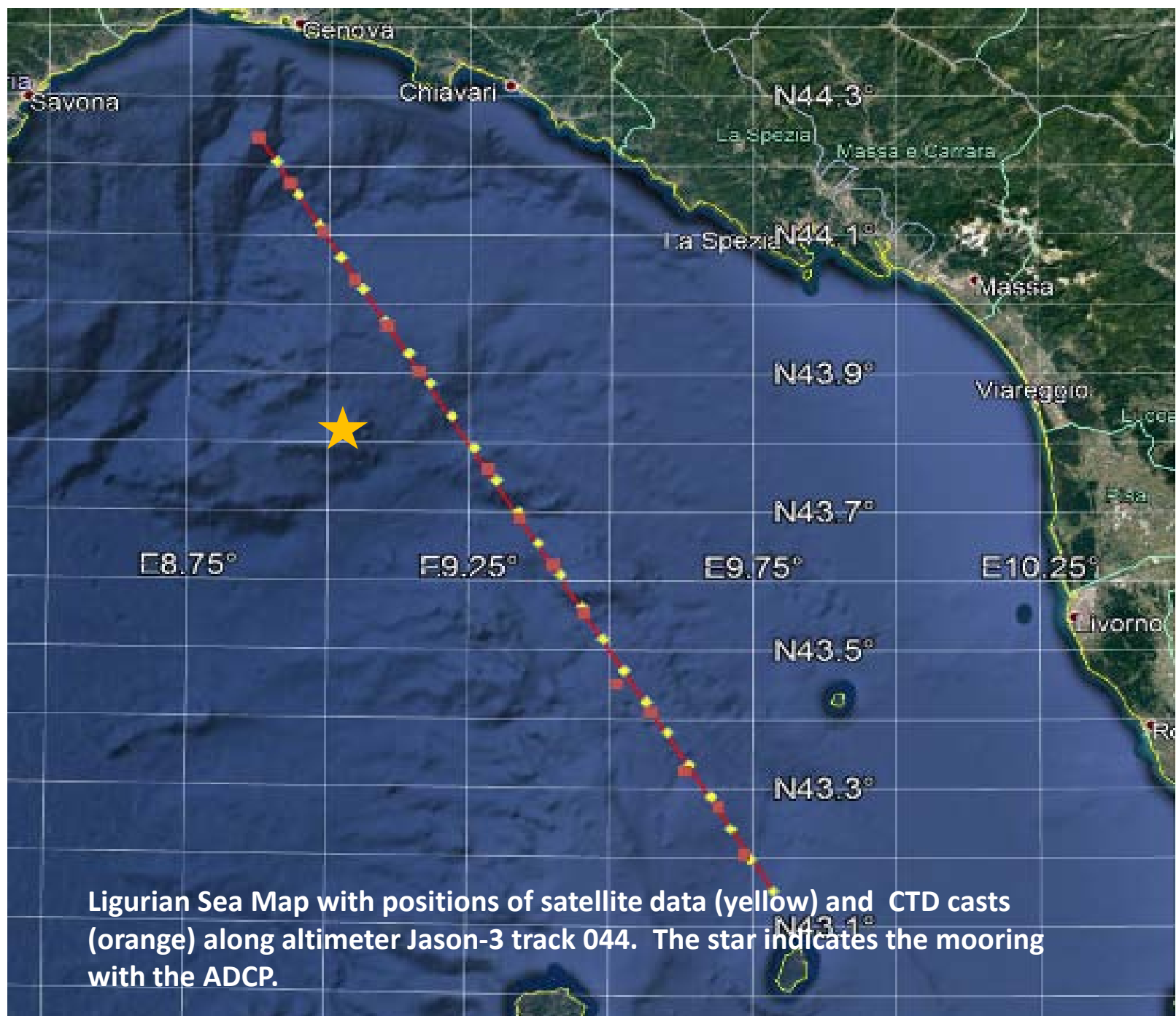
Sea surface topography from satellite radar altimetry can represent a powerful tool for a better understanding of the sea surface circulation.

Investigations of the Ligurian Sea using this remote sensing tool date back to the late 90' when observations from Topex/Poseidon satellite allowed to estimate sea surface level differences between Tyrrhenian and Ligurian Seas. These satellite-based estimates correlated well with climatological steric level differences and water transport across the Corsica Channel (Vignudelli et al., JGR 2000) .

Recent field campaigns at sea in the Northeastern Ligurian Sea, aiming at combining in-situ data from gliders and satellite-based observations, provided a comprehensive view of the regional ocean circulation dynamics (Borrione et al., Deep-Sea Res.,2019).

One of the open questions is how surface geostrophic circulation derived from satellite radar altimetry observations can be compared / integrated with in situ surface currents.

An assessment based on the comparison of satellite-derived surface geostrophic currents with those obtained from concurrent, co-localized CTD measurements as well as with time series of ADCP measurements in the Ligurian Sea is here presented.



## Available data

### **Satellite radar altimeter data from the X-TRACK product**

Track 044 points 225-248; 24 points 6 km apart

Cycles: #905 16-Sep-2017 05:33:21; #906 26-Sep-2017 03:31:53

Revisiting of the same place every 10 days

Analysed data are Sea Level Anomalies (SLA) which do not include tidal (TIDE) and atmospheric correction (DAC) for a better comparison with the steric level

### **CTD casts**

14 profiles along the track 044

21- 22 September 2017

On board Nave ARETUSA, Istituto Idrografico della Marina

Analyzed data were cut at a common depth of 250 m

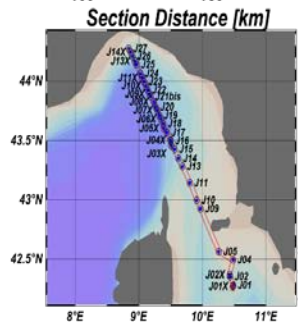
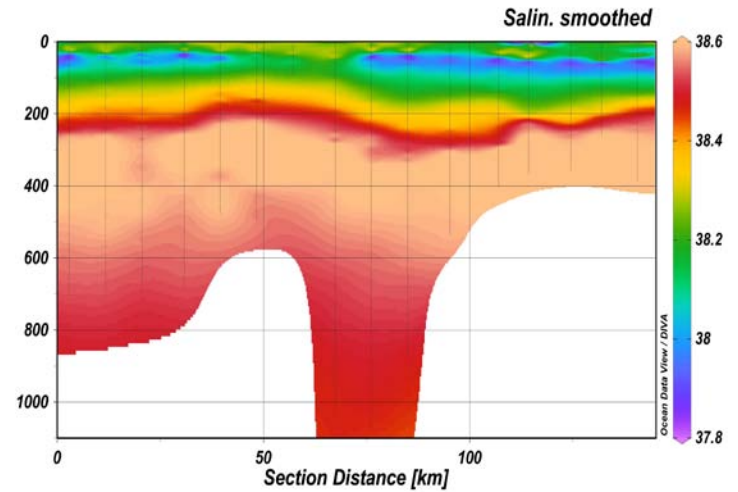
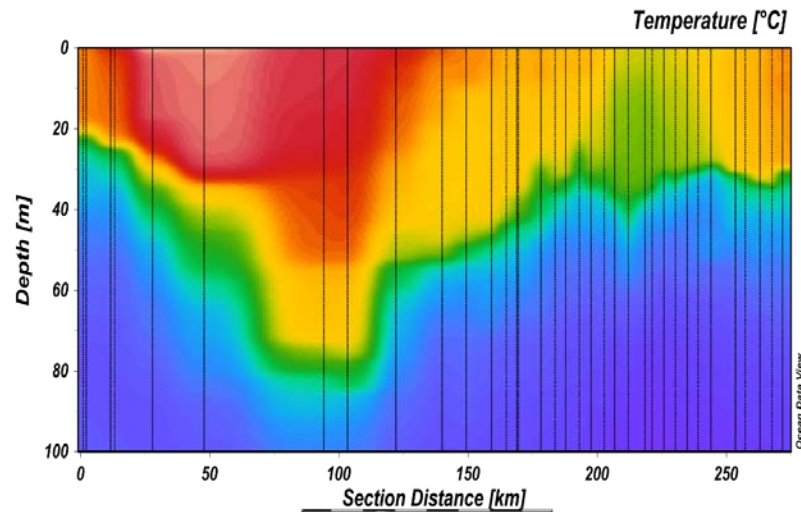
### **ADCP RD&I 300 kHz**

43.7962 N; 9.0467 E

Dz 0-8 m dt 1 h time series A) 13/9/2003 – 24/5/2004 B) 19/4/2005 – 22/2/2006

Time average and EOF decomposition is also applied

## Oceanographic campaign ARET 17, 21-22 september 2017

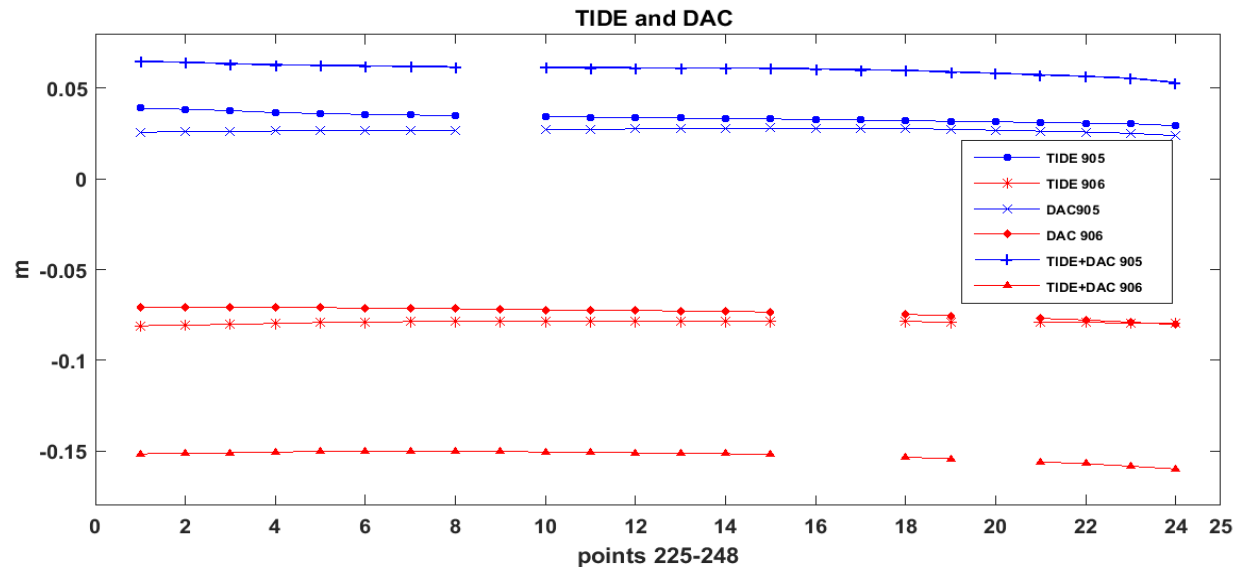
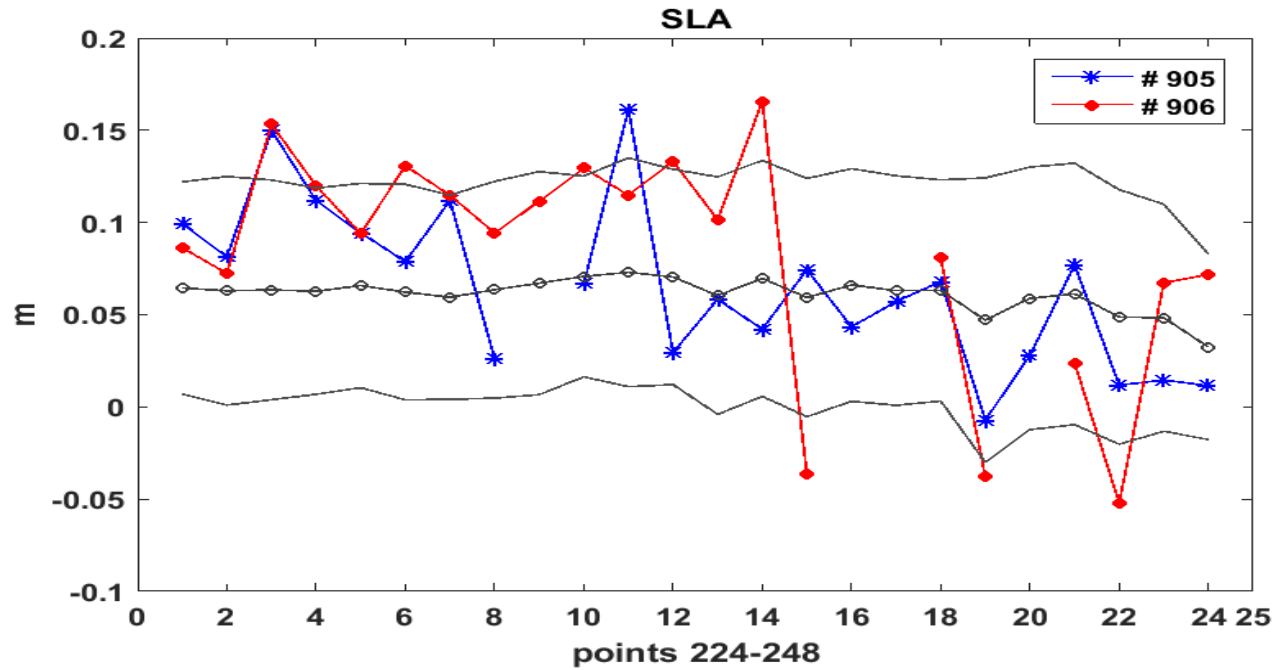


*Temperature and salinity distribution along the track. The presence of the Ligurian Front separating the warmer waters coming from the Tyrrhenian Seas from those of the North Western Mediterranean is well evident*



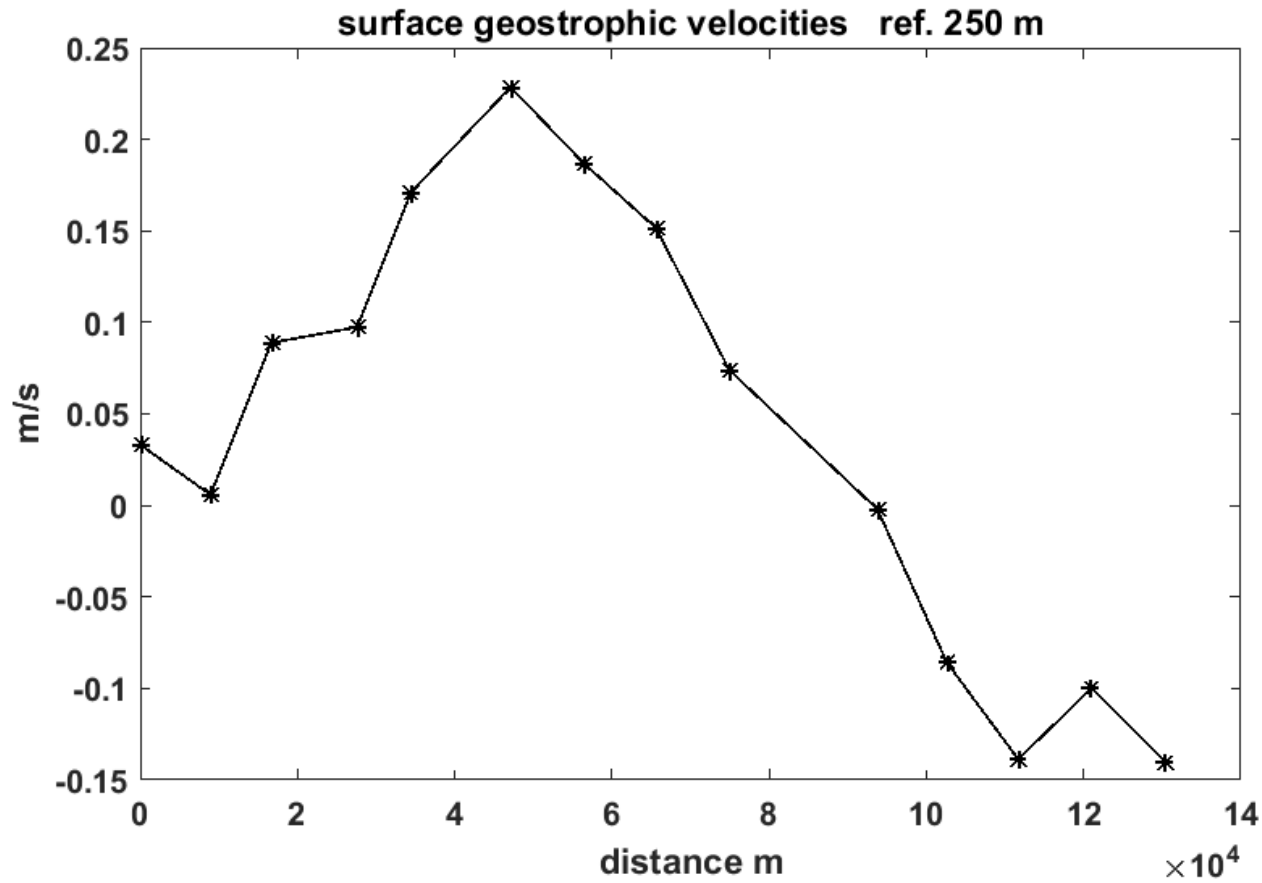
## Altimeter data

SLA raw data from  
Track 044 passages  
#905 #906  
Points 224-248  
Grey lines indicate  
“climatological”  
september data with  
std.  
Below, tidal and  
atmospheric  
corrections that  
were not considered  
in this analysis. DAC  
is mainly related to  
atm.pressure  
variations, while tide  
are negligible in the  
region. (M2 in Genoa  
is 8.5 cm)

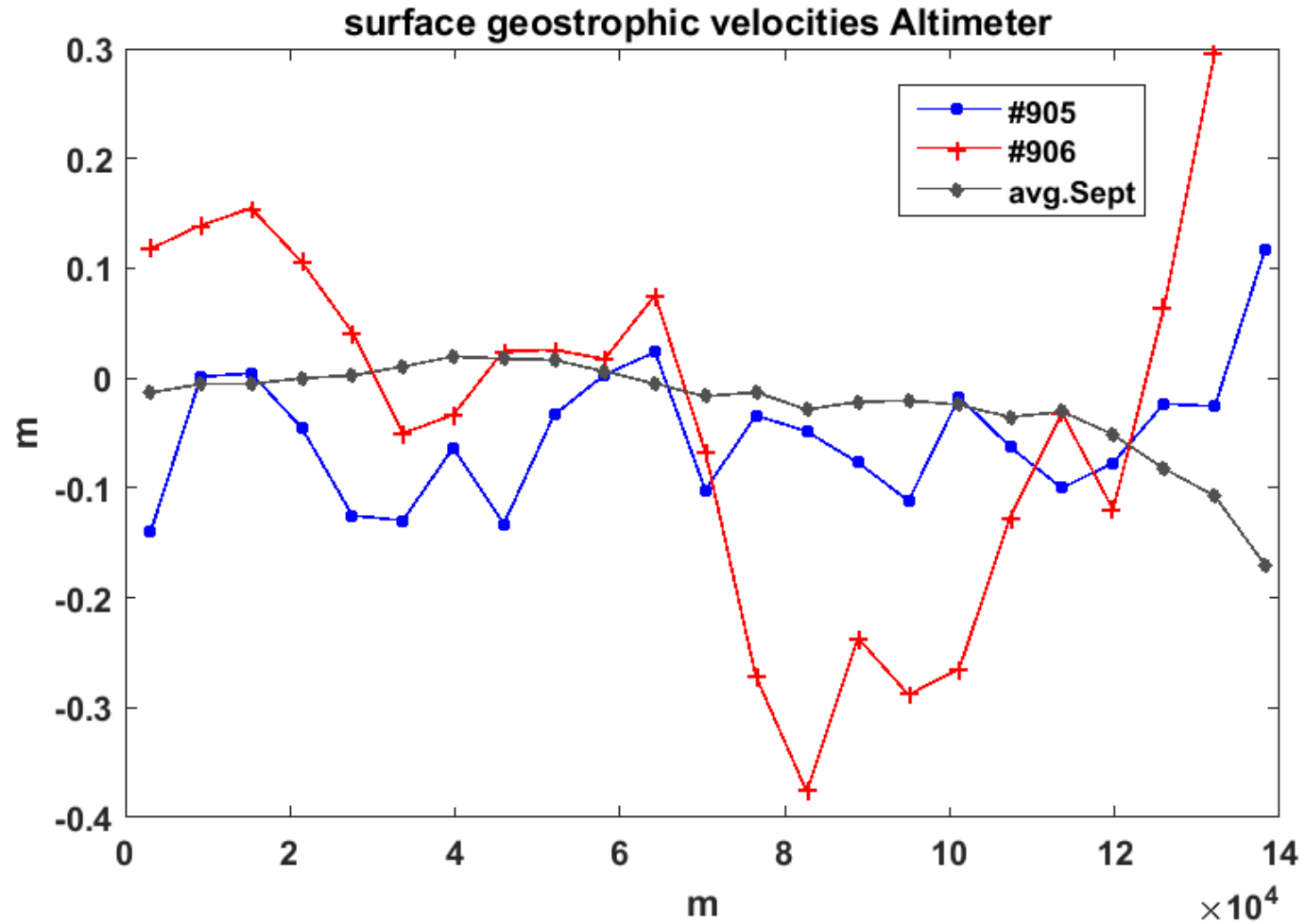


### Geostrophic currents from CTD casts

Surface (0-50 cm) geostrophic currents were computed from dynamic height using 250 m as reference level. The obtained values are the component directed 240°N, (orthogonal to the altimetry track direction 330° N with positive values to the N/E)

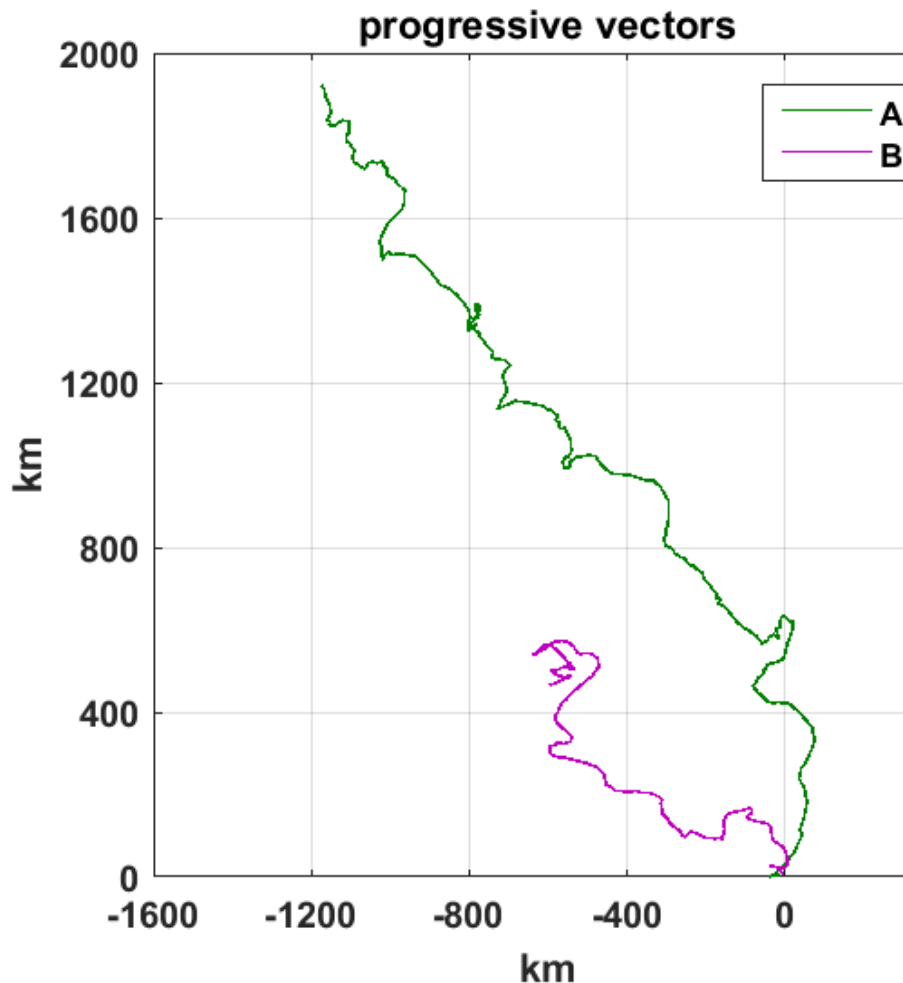


Altimeter derived geostrophic currents on 16 and 26 september 2017 and comparison with those obtained from the climatological september 1993-2020

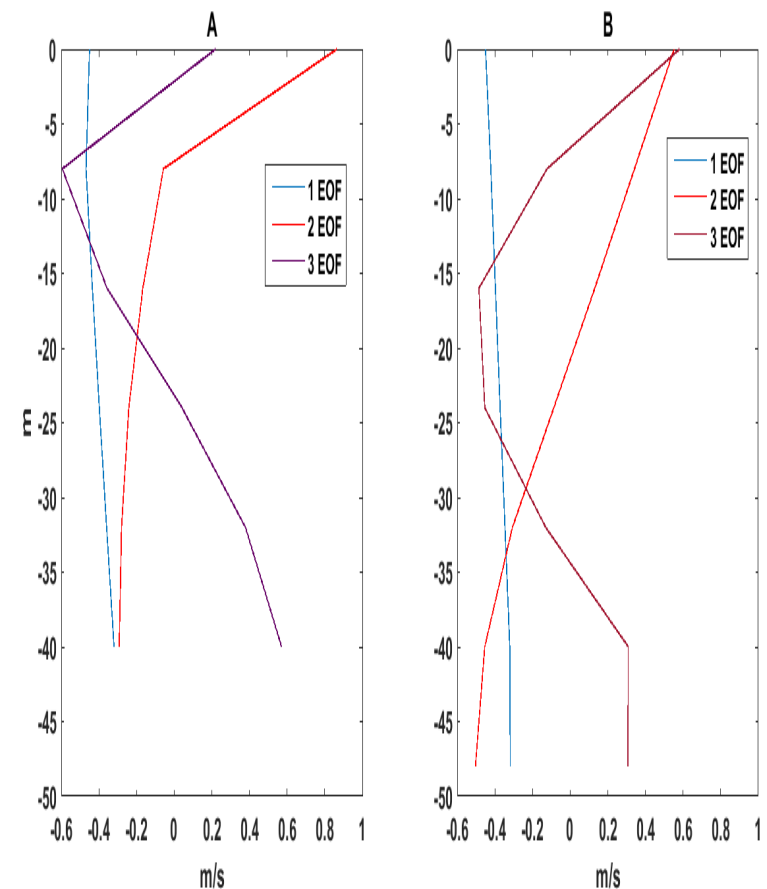


## ADCP surface data time series

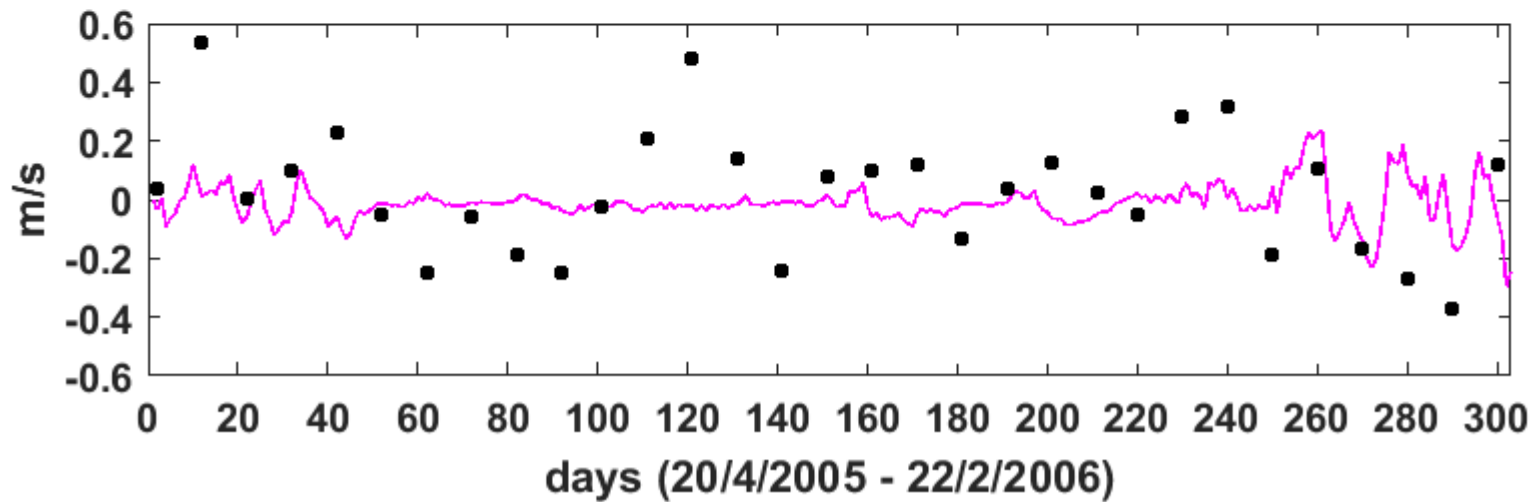
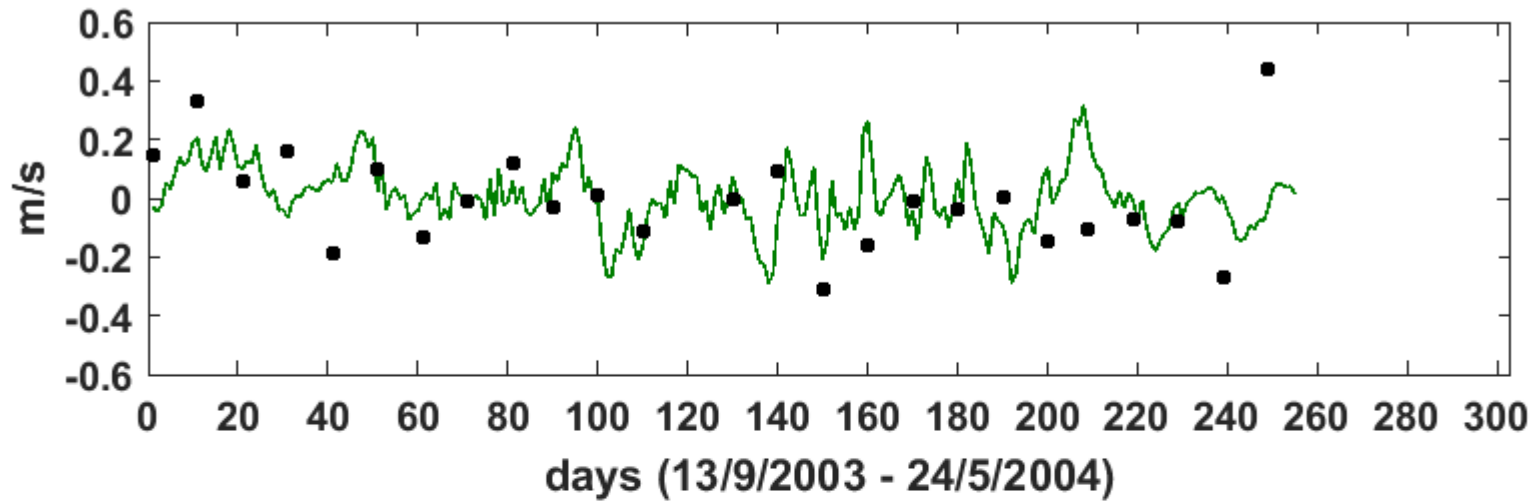
Data of available surface ADCP measurements collected in the periods **A** 13/9/2003–24/5/2004 and **B** 19/4/2005–22/2/2006 were recovered for this analysis. EOF mode decomposition was applied to daily mean averaged time series. First mode time series were reconstructed and analyzed. First EOF mode time averaged cross-track velocity over the two periods are respectively  $A = 0.0046$  m/s and  $B = -0.0156$  m/s



## Three EOF Mode decomposition



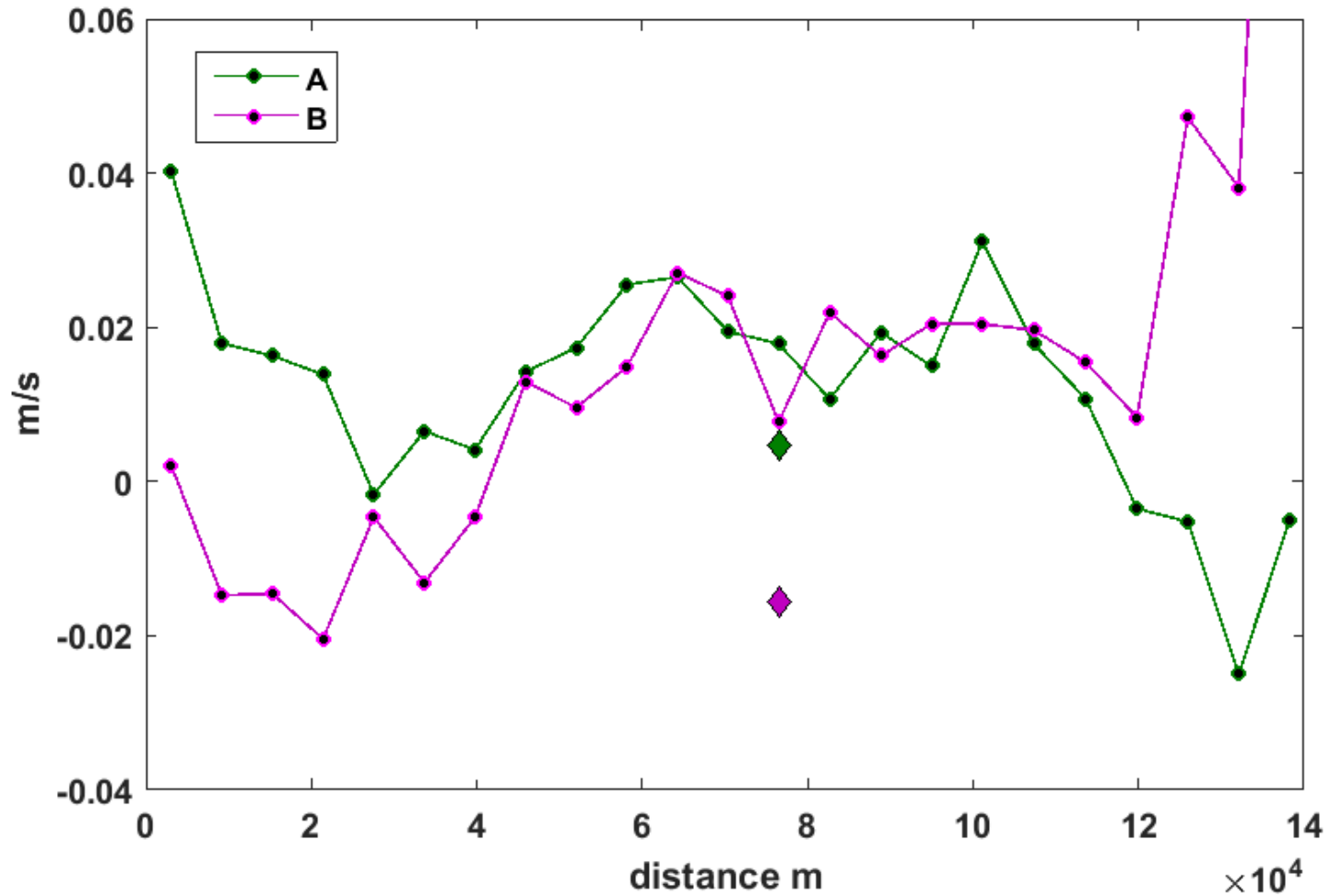
Point to point comparison between 1 EOF mode ADCP time series and geostrophic velocity from the altimeter (• )



rms diff A 0.19 m/s  
rms diff B 0.20 m/s

Altimeter data were temporal averaged over the whole correspondent periods of available surface ADCP measurements and then smoothed (passages: A #389- #415; B #448- #479).  
Geostrophic currents were computed along the two avraged tracks.

*Resulting time-averaged geostrophic currents along the track and correspondent ADCP values (diamonds) .*



## Discussion

Direct comparison of altimeter derived surface geostrophic currents with those obtained from CTD cast and ADCP measurements in the Central Ligurian Sea is hampered by a series of uncertainties, among which the accuracy of altimeter measurements (2 cm). This can lead to an error up to 0.3 m/s on the computed geostrophic currents between a pair of adjacent measurements.

Moreover, as currents are the results of a variety of processes occurring at a wide range of time scales, different observations and estimation methods might not properly account for each of the components. As an example, geostrophic currents obtained from CTD casts are computed relative to 250 m reference depth, where current speed are not available;

In the case A, the analyzed ADCP data shows currents mainly directed along the track with only a small cross-track component; in the case B the ADCP time series was characterized by an anomalous summer period of particular low speed currents.

Nevertheless, the obtained rmsd, despite high in respect of the average current speed of the region, are below the estimated uncertainties.

Results evidence the need to define a robust metrics to compare surface ADCP currents with geostrophic components. The first EOF decomposition mode, as it filters out the variability due to the atmospheric pressure and wind, can better describe the geostrophic contribution.