TNA PROJECT REPORT

1. Project Information

Proposal reference number	JN_CALL_2_8
Project Acronym (ID)	BB-TRANS
Title of the project	Three-dimensional circulation and transport within the south-eastern Bay of Biscay from a multi-platform approximation
Host Research Infrastructure	COSYNA Glider (COSYNA_GL).
Starting date - End date	17 May 2018 - 14 June 2018
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2. Project objectives

Recent studies focused on the evaluation of the capabilities of altimetry using HF radar (HFR) data, and with the combined use of HFR and glider measurements, conclude that both approximations offer useful data that can help to improve the processing of altimetry data for coastal studies. Providing information of the circulation and transport of the water column, from the expansion of the surface information of HFR to deeper levels can extend the applications of these data for biological and environmental purposes. Several approaches, based on the combination of HFR data with information on the water column (from in-situ moored instruments, remote sensing or numerical models), have proven promising for understanding the three-dimensional coastal circulation. The combination of glider and HF radar data will offer a unique opportunity to describe local ocean processes at high spatial and temporal resolution and to investigate their role in the coastal transport.

Summarizing, the purpose of this project is to recover measurements of the water column, within the area covered by the coastal HFR system of the SE-BoB, in order to evaluate on the one hand, the accuracy of coastal altimetry along-track data within the HFR footprint area, and on the other hand, the performance of different methodologies for deriving transport in the water column, by means of HFR and glider data blending.

3. Main achievements and difficulties encountered

Several achievements have been reached during this project, but we highlight here three of them:

- HZG team has provided to the project a second glider. This shallow-shallow-glider (surface-100 m depth) was equipped with the same sensors as the deep-glider (CTD, fluorescence-turbidity and MicroRider sensors) with the exception of the ADCP. The data obtained by this glider (from 16 to 29 May 2018) will afford a larger spatial coverage and sampling frequency of the sea

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surface.

- The deep-glider carried out an almost one-month mission (17 May-14 June), the period planned for this mission. It collected water-column data in the area covered by the HFR and some tracks were concomitant with 2 altimeter tracks. More concretely it followed one track of the S3A and another from Jason-3.
- During the mission, besides glider tracking that allowed monitoring of the position and data measured by the glider, surface current fields and derived Lagrangian Residual Currents and satellite images, were used to change, when necessary, the next positions and settings of the glider, in near real time. According to this set of data (glider-HFR-satellite) both gliders crossed at least one mesoscale eddy.

The main difficulties encountered during this mission were, on the one hand, the leak of the deep-glider during the deployment. The glider was recovered and brought back to the port, where the HZG team replaced a piece of the glider. The day after the glider was successfully deployed. On the other hand, the shallow-glider required early recovery for a leak.

4. Dissemination of the results

The results of the project will be shown in the final JERICO-NEXT scientific results workshop (2019). The team plans to send at least one peer-reviewed publication and one contribution to a congress, e.g. the EGU General Assembly. So far, the team has participated in the following dissemination actions:

- Caballero, A., Rubio, A., Rio, M-H, Ayoub, N., Mader, J., Larnicol, G., Manso-Narvarte, I. and Dufau, C, 2018. Combining coastal altimetry data with in-situ and land-based remote data for improving the monitoring of the dynamics in the southeastern Bay of Biscay. Oral presentation in the "11th Coastal Altimetry Workshop", 12-15 June, Frascati (Italy).
- Manso-Narvarte, I., Caballero, A., Rubio, A., Dufau, C, Birol, F, 2018. Synergy between HF Radar and Altimetry in the SE Bay of Biscay. Abstract accepted for a poster presentation in the "25 Years of Progress in Radar Altimetry Symposium" that will be hold in 24-29 September 2018, Azores Archipelago (Portugal).

The data (and metadata) resulting from the experiment will be collected in the COSYNA data centre (http://codm.hzg.de/codm/), which is one of the JERICO-NEXT data centres.

5. Technical and Scientific preliminary Outcomes

First of all, the deep-glider followed 2 tracks of two different altimeters (Table 1 and Fig. 1). More specifically Jason 3's 248 track (two cycles) and Sentinel 3A's 257 track (1 cycle). These data will be compared with coastal altimetry along-track data.

Altimeter	Track	Date	Time
Jason 3	248	2018-05-20	04:04
Jason 3	248	2018-05-30	20:37

Table 1. Number of the tracks of the two altimeters that crossed the area covered by the coastal HFR system of the SE-BoB, during the mission and the estimated passing date/time.

On the other hand, both gliders crossed mesoscale-like eddies. For example, the shallow-glider appears to have crossed an anticyclonic structure around 26 May. For monitoring the presence of structures, we have computed the Lagrangian Residual Currents (LRC). To obtain the LRCs, the Lagrangian trajectories for particles evenly located in the HF radar grid are computed over 3 days; then, the initial and final positions of each particle are used to compute a Lagrangian residual vector (we call this "residual", because the contribution of the tidal component is filtered out by the time integration used). The LRC maps provide an estimation of the surface transport during the integration period. According to the LRC map (Fig. 2 Left), the glider flew near the core of an eddy, while the deep-glider passed close to the periphery during the same days.

Around this date, a down-lifting of the seasonal thermocline is observed in the vertical profiles of the shallow-glider (Fig. 3a, black square). The down-lifting is more evident in the salinity and density profiles (Figs. 3bc) and has a clear impact in the fluorescence, whose Deep Chlorophyll Maximum reaches deeper waters. Some days after, around 2-3 June, the deep-glider arrived at the periphery of a cyclone (Fig. 2 Right). In this occasion, an up-lifting of the shallower isotherms (from surface to around 100 m depth) and a down-lifting of the intermediate isotherms (from around 100 to 400 m depth) is observed (Fig. 4, black square). The core of this cyclone was close to the position of the anticyclone mentioned before. Therefore, two hypotheses could be obtained from this inverse polarity of these mesoscale structures. First, both signals (in different dates) correspond to the same eddy but due to the interaction of the surface waters with the wind, it is not observed the same polarity of the eddy in the sea surface, not the same behaviour in deeper waters (0-100 m). And second, these signals correspond to two different eddies that occupied the same place, in a time-difference of a week.

As an initial approximation to the first hypothesis, the wind regime estimated from the WRF regional meteorological model (source: MeteoGalicia) in the location indicated with a blue (pink) point in Figure 2 and covering the period of both LRC maps (26 May-4 June) is showed in Figure 5 up (bottom). Over the northern point, from 26 to 28 May the wind flowed mainly to the NE, this forcing agrees with the eastward flow of the currents in the area. While during 2-4 June the wind flowed mainly to the SW; this forcing could produce the westward currents. The wind regime in the southern point was similar to the previous one, but the currents seem to be less correlated with it. This could be due to the rectification of the wind driven circulation by the local topography.

In order to test these last hypotheses, more analyses must be done for obtaining more conclusive results. These analyses will be also complemented with high resolution model data from the Atlantic-Iberian Biscay Irish - Ocean Physics Reanalysis, available in the Copernicus Marine environment monitoring service (http://marine.copernicus.eu).

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ANNEX: FIGURES

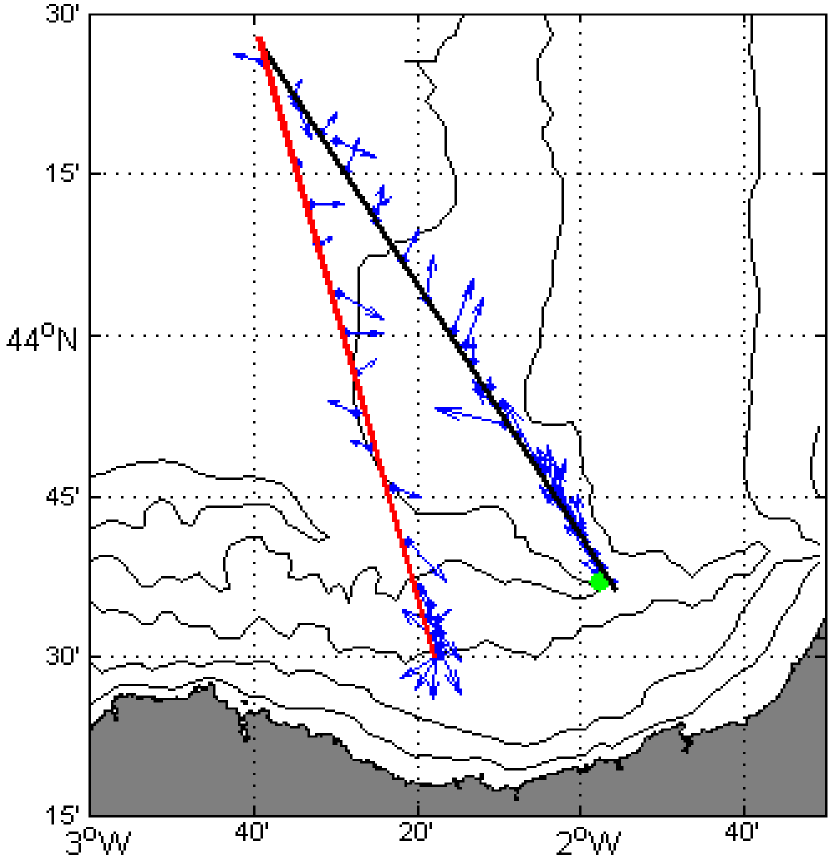

Figure 1. Tracks of the two altimeters crossing the area during the mission (the black/red line represents the track of Jason 3/Sentinel 3A) and vertically integrated currents corresponding to the deep glider (blue arrows). Isobaths (m): 50, 100, 200, 1000, 2000, 3000 and 4000.

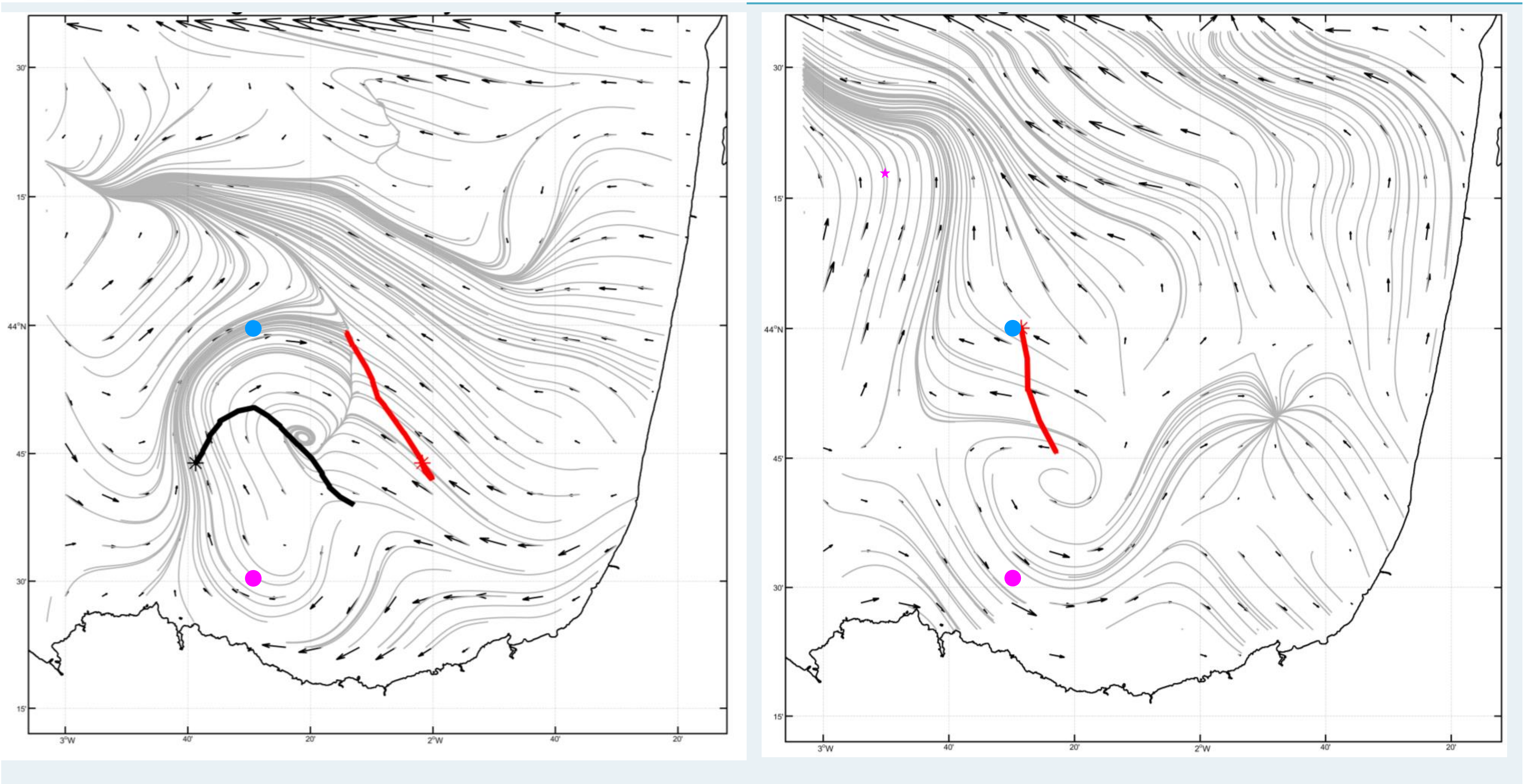

Figure 2. LRC maps estimated from the HFR data and corresponding to 26 to 28 May (Left) and from 2 to 4 June (Right). The trajectories followed by the deep-glider (red line) and shallow-glider (black line) during this period are also shown. Note: the asterisks indicate the beginning of the trajectory. The blue and pink points indicate the positions for which the wind evolution has been analyzed.

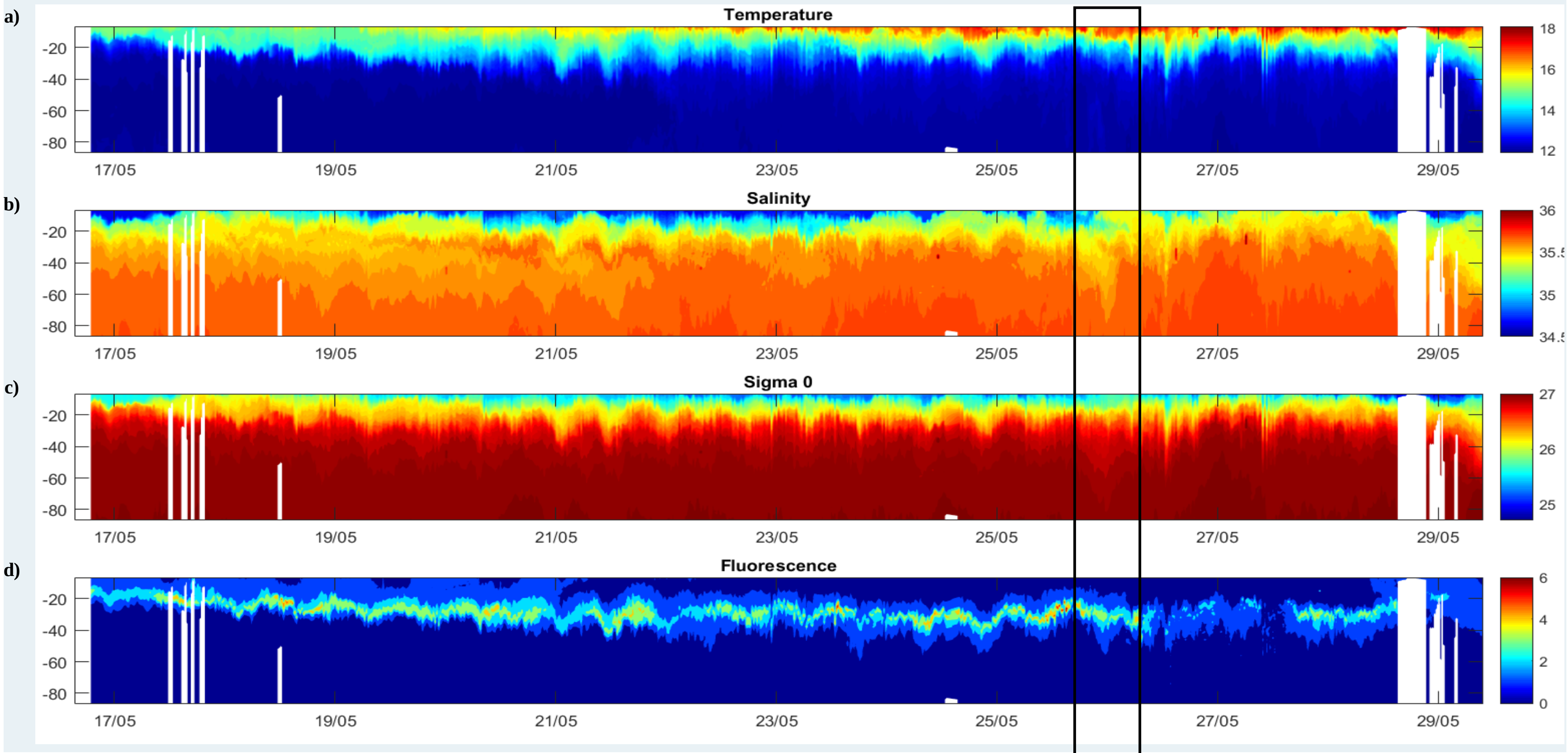

Figure 3. Vertical potential temperature (a), salinity (b), density (c) and fluorescence (d) distribution along the shallow-glider tracks from the surface to 100 m depth. The black square delimits the signal of the eddy.

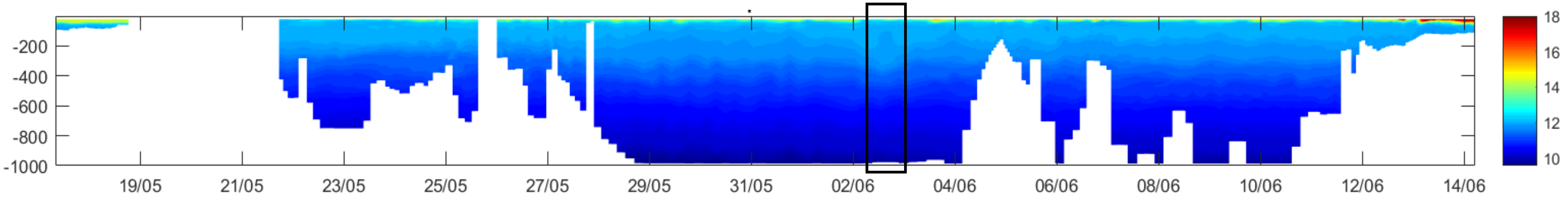

Figure 4. Vertical potential temperature distribution along the deep-glider tracks from the surface to 1000 m depth. The black square delimits the signal of the eddy.

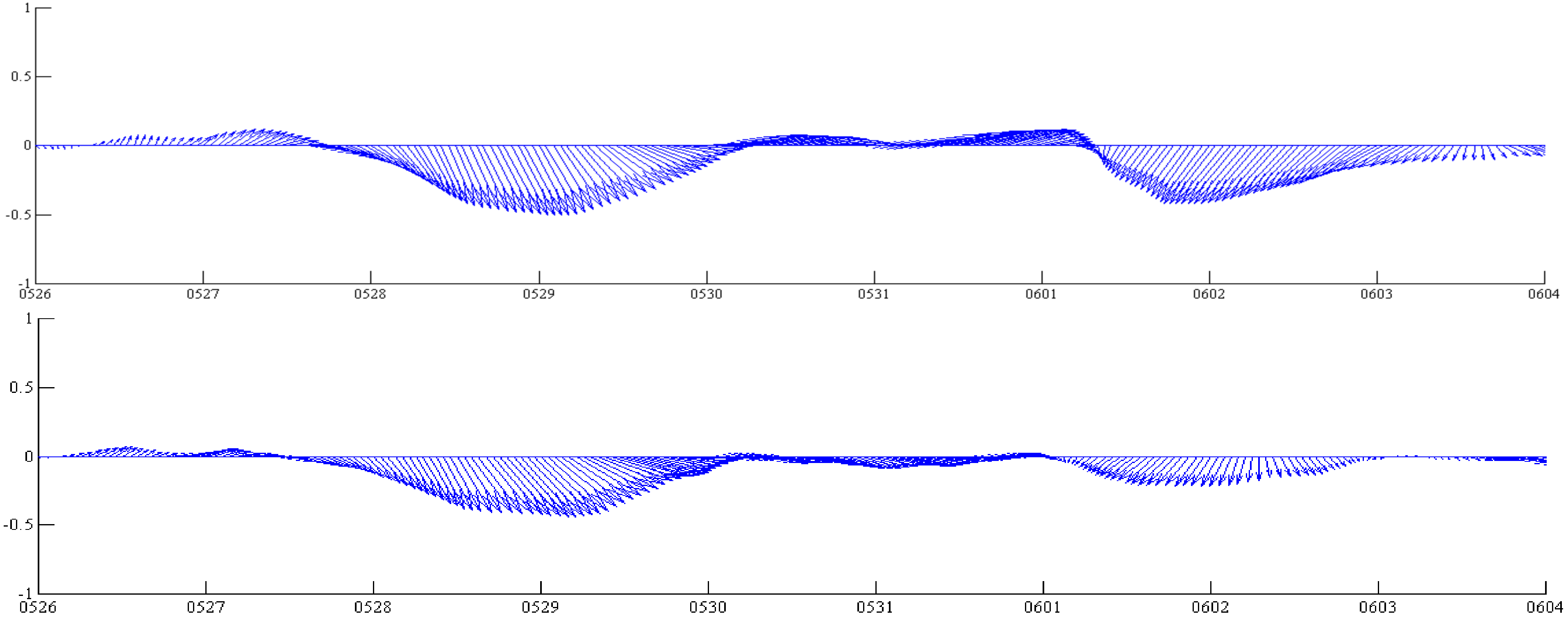

Figure 5. Evolution of the winds over the point indicated with a blue point (top) and over the point indicated with a pink point (bottom) in Figure 2.