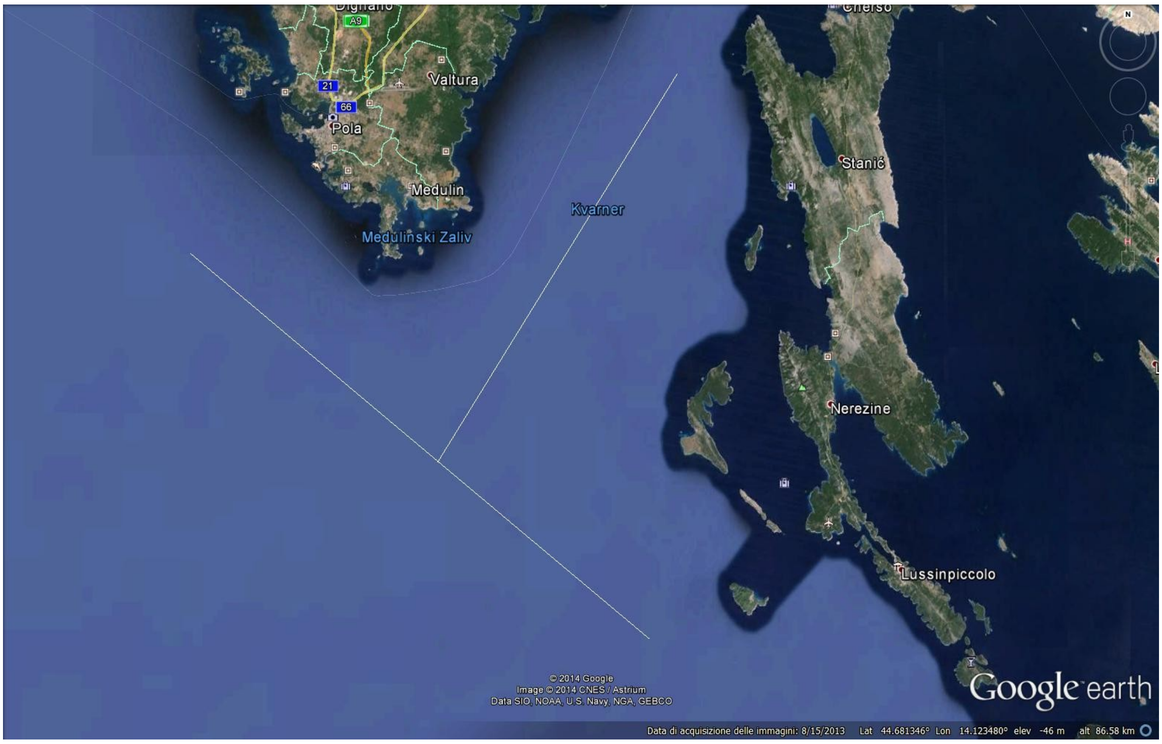
Analysis of the circulation from the Regional Ocean Modelling System (ROMS) output data in Kvarner during Bora and Sirocco events



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Introduction

A study of the circulation under the prevailing atmospheric conditions of the area was performed, to better planing the glider mission in the Kvarner area within the 'North Adriatic Experiment 2015'.

The main idea was to examine how a case of a strong East North East wind (Bora) can affect the surface and the deeper circulation and how the circulation can change in the case of a South wind (Sirocco).

February 2012 was a month characterized by strong Bora events, thus model data from that month where analyzed while a period of 3 days in November 2012 was chosen for the Sirocco wind.

Model data

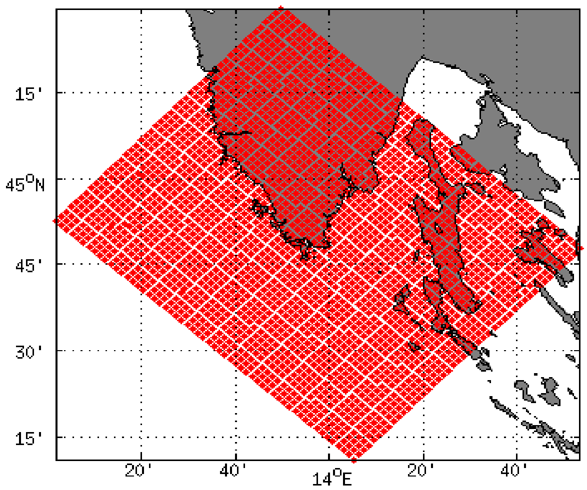

Fig. 1: Model selected sub-grid.

The current data are output of the Regional Ocean Modelling System (ROMS), provided by Ruwedjer Boskovic Institute (Zagreb, Croatia). The model covers all the Adriatic Sea, thus we selected a smaller grid in the area of interest. The sub-grid is shown in Figure 1.

In order to analyse the current and wind data we have to correct the data because the model grid is not vertical orientated. It is rotated by an angle 'theta', which is the angle between x-axis and the East. To applied this angle correction to all the vector data, we used the follow equations:

$$u_{comp} = u_{orig} * \cos(theta) - v_{orig} * \sin(theta) \tag{1}$$

$$v_{comp} = v_{orig} * \cos(theta) + u_{orig} * \sin(theta) \tag{2}$$

u_{comp} and v_{comp} are the final u,v vector components that we want to use, while u_{orig} and v_{orig} are the original vector components as we find them in the netCDF files of ROMS.

The wind data after the correction are ready to be used, but in the case of the sea currents the data need also a second level treatment. Each current speed and direction are referred to the middle of the side of each grid cell and not to the center of the grid cell as for every other variable. For that reason, the current grid is not identical to the wind grid and a correction should be applied by using the matlab scripts v2rho_2d.m and u2rho_2d.m (provided by Romstools, http://www.brest.ird.fr/Roms_tools/). In our case a rough analysis of data is adequate and this last correction was not applied. As a result, the current vectors are a bit 'shifted'.

Bora case - February 2012

The model provides current data every 3 hours or daily averaged, while the wind is provided only as daily average. In Figure 2 daily averaged maps of the wind in the area of interest for 9 days are shown. The color index is in km/h and it is the same for all the plots. The mean wind speed in this area reached about 110km/h in almost all the plots.

The 3-h current maps were analyzed and selected images of the main response of the sea to a strong Bora event, at the surface and at the 10th model layer are depicted respectively in Figures 3 to 5.

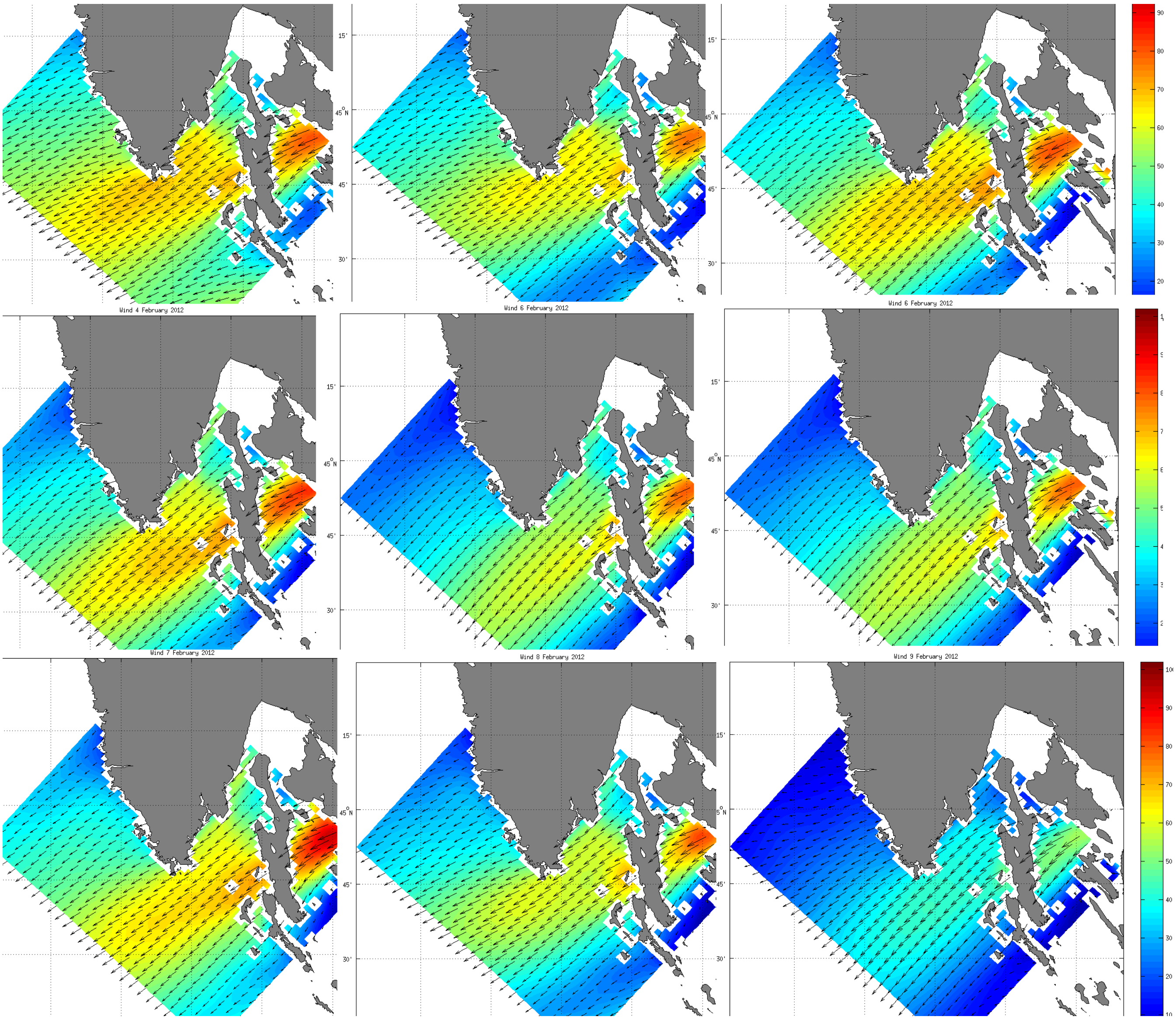

Fig. 2: Daily averaged wind for the first 9 days of February 2012, when a strong Bora event occurred. The colorbar indicates the wind speed and in km/h

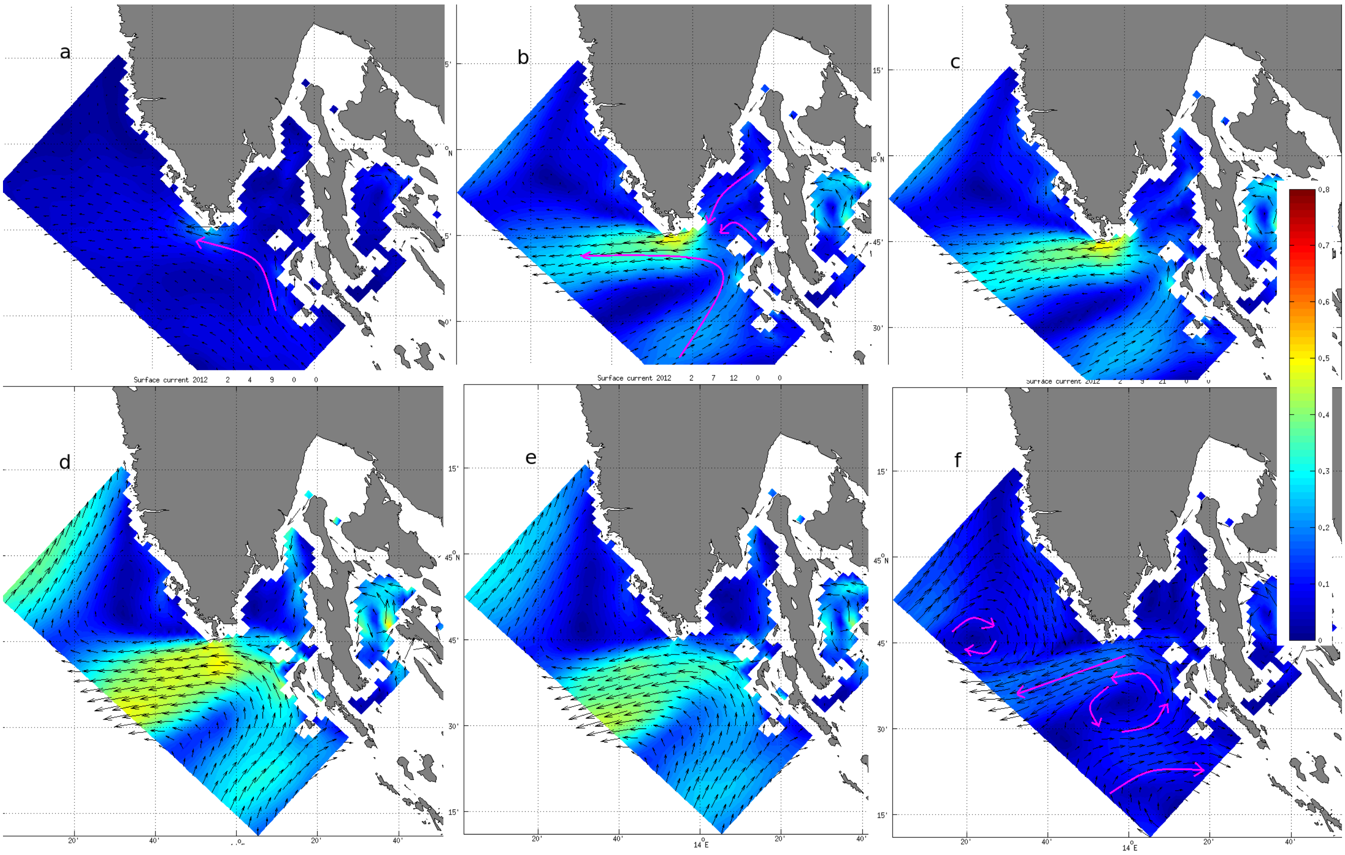

Fig. 3: Surface circulation at a) 29/1/2012, b) 1/2/2012, c) 2/2/2012, d) 4/2/2012, e) 7/2/2012 and f) 9/2/2012. The speed is in m/sec.

The surface circulation of specific days is depicted in Figure 3. The purple lines indicate the main circulation in front of Kvarner Bay, before the strong Bora starts to blow (Figure 3a), while the Bora blows (Figure 3 b – e) and when the wind speed slows down at the end of the strong Bora event (Figure 3f). When the strong Bora wind starts the north surface current turns eastward and generate a strong cyclonic circulation. The surface velocities vary from 0.1 m/s before the Bora starts to blow, to more than 0.6 m/s, when the wind speeds up as shown in Figure 4.

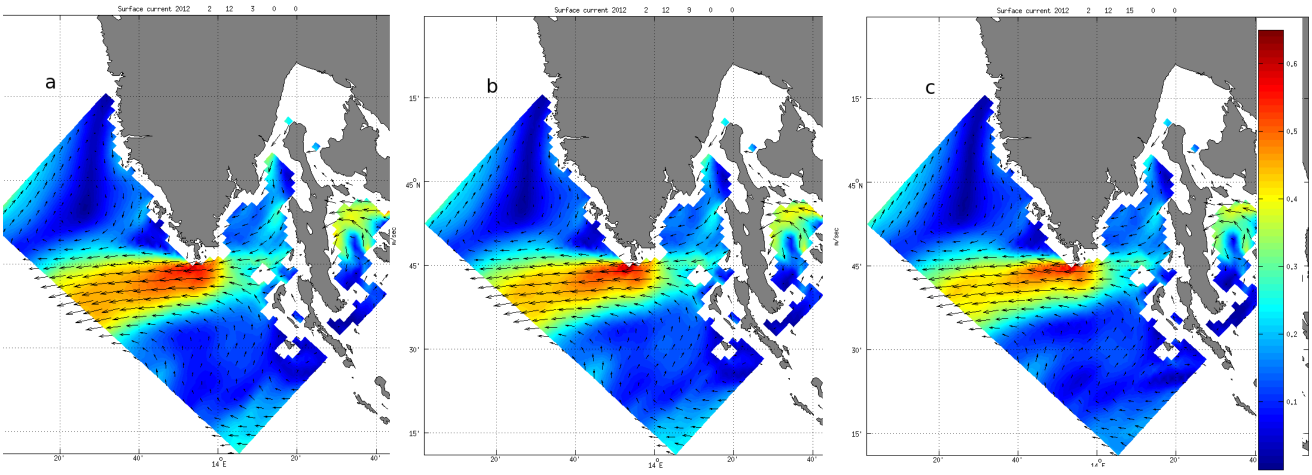

Fig. 4: Strong surface currents due to the strong Bora wind at a) 12/2/2012 03:00 UTC, b) 12/2/2012 09:00 UTC and c) 12/2/2012 15:00 UTC. The speeds are in m/sec.

The 10th layer does not correspond to the same depth in all the grid cells. The depth of the 10th model layer is presented in Figure 6 and corresponds to 4 m in the northern part of the grid and 20 m in the eastern part of the grid. Figure 5 depicts the circulation maps at the 10th model layer at the same time step of the surface current maps, presented in Figure 3.

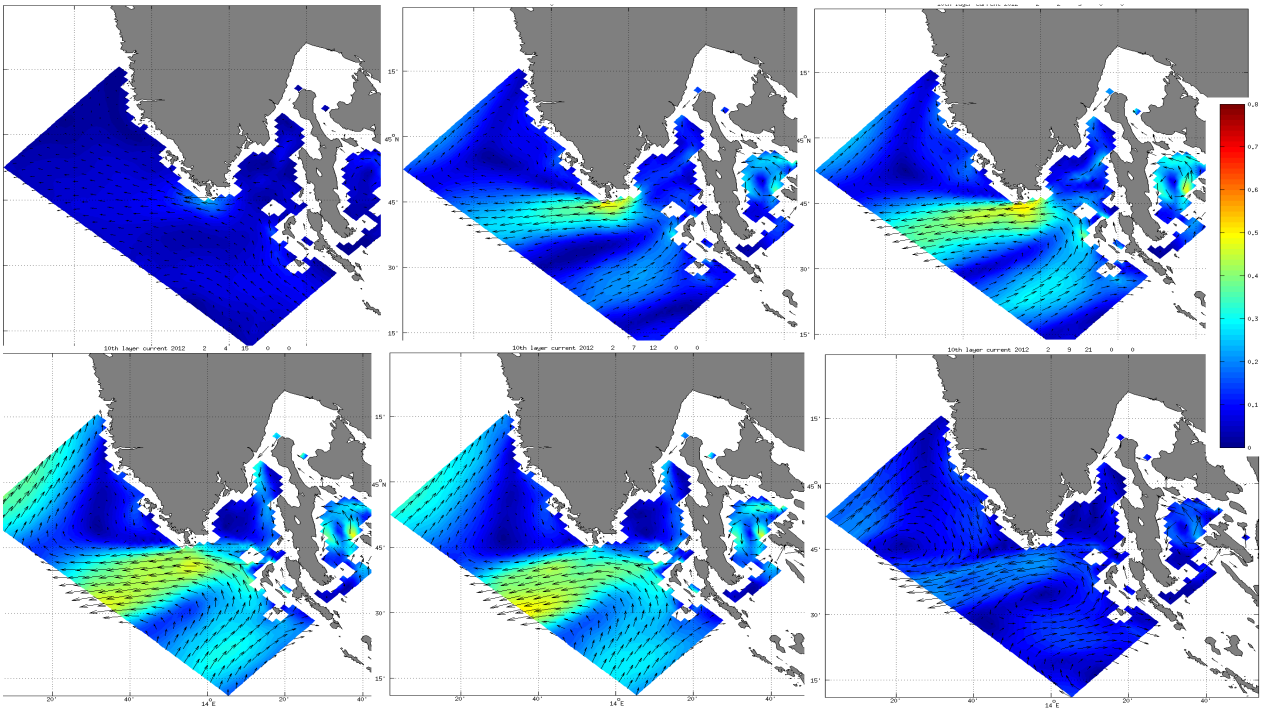

Fig. 5: Circulation at the 10th layer at a) 29/1/2012, b) 1/2/2012, c) 2/2/201, d) 4/2/2012, e) 7/2/2012 and f) 9/2/2012. The speed is in m/sec.

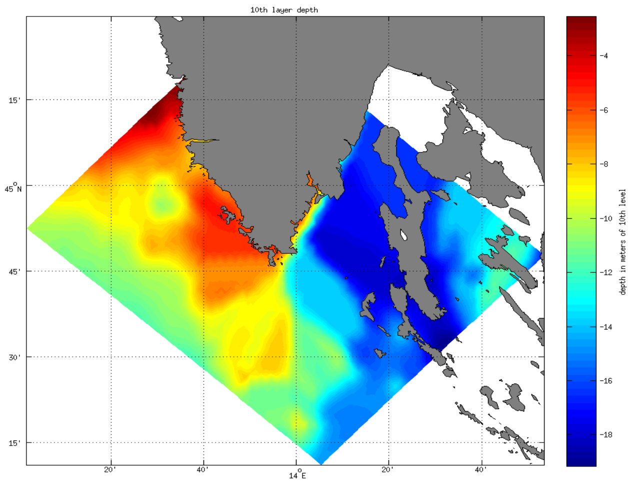

Fig. 6: Depth of the 10th model layer.

The surface direction of the currents is similar to the one at the 10th layer. The speed of the currents decreases in the deeper layers varying from 0.1 to 0.4 m/sec .

Sirocco case

Since Sirocco events are difficult to be identified in the model data due to the daily averaged wind availability, we analysed the data from the MAMBO buoy, located in the Gulf of Trieste. We speculated that when Sirocco was blowing in Trieste it was also present in Kvarner Bay. The decision to use MAMBO data was driven by the fact that the wind data were easily accessible. We isolated days during November 2012 (Figure 7) with Sirocco wind (the days are 27, 28 and 29 of November) and we produced the current maps for Kvarner area, both at the surface and at the 10th layer.

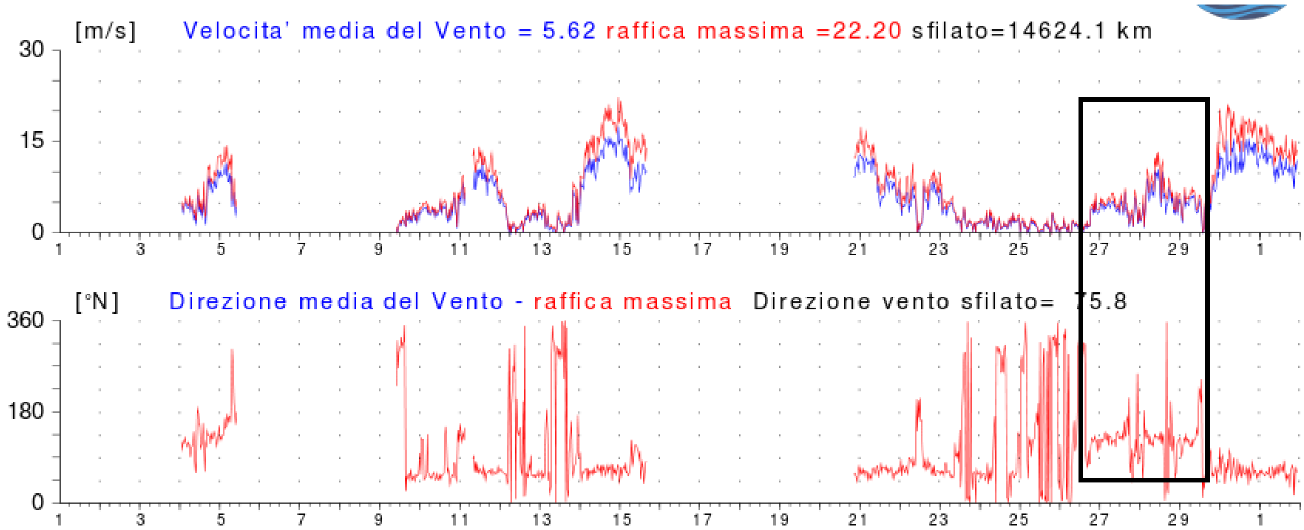

Fig. 7: Sirocco case in November 2012. The black box indicates the chosen period.

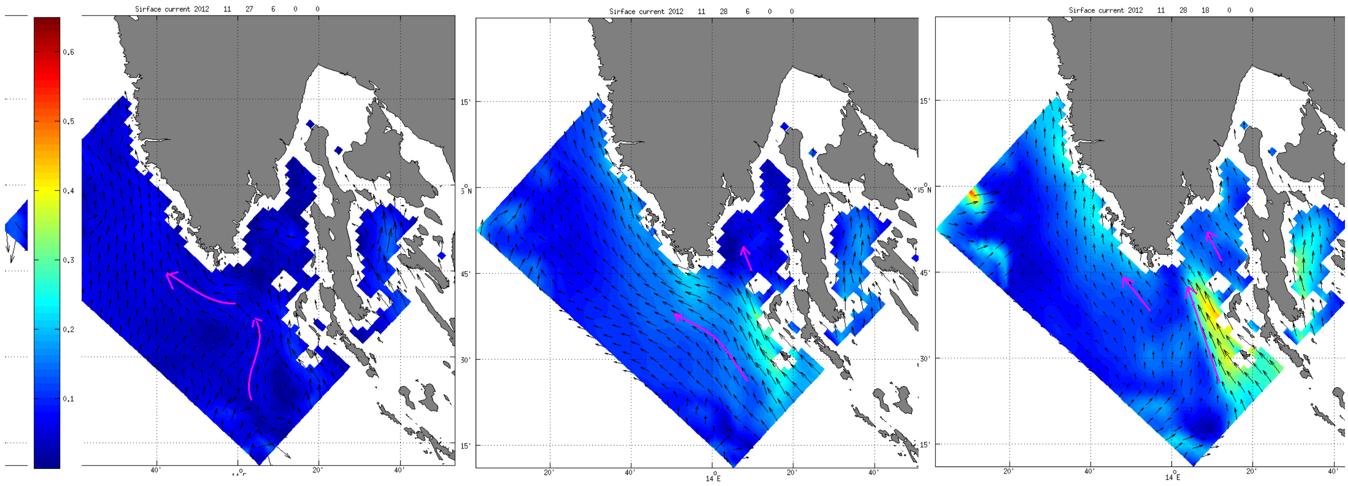

Fig. 8: Surface circulation in 27-29 of November 2012 with Sirocco wind. The speed is in m/s.

Under Sirocco wind, the surface currents are directed to the North (Figure 8). The purple lines depict the main circulation. With a light wind (~7 m/sec) we have surface velocities are of 0.1 m/sec. As the wind intensifies and reaches the 15 m/sec, the surface current velocities reach the 0.4 m/sec. The circulation at the 10th layer for the same period is depicted in Figure 9.

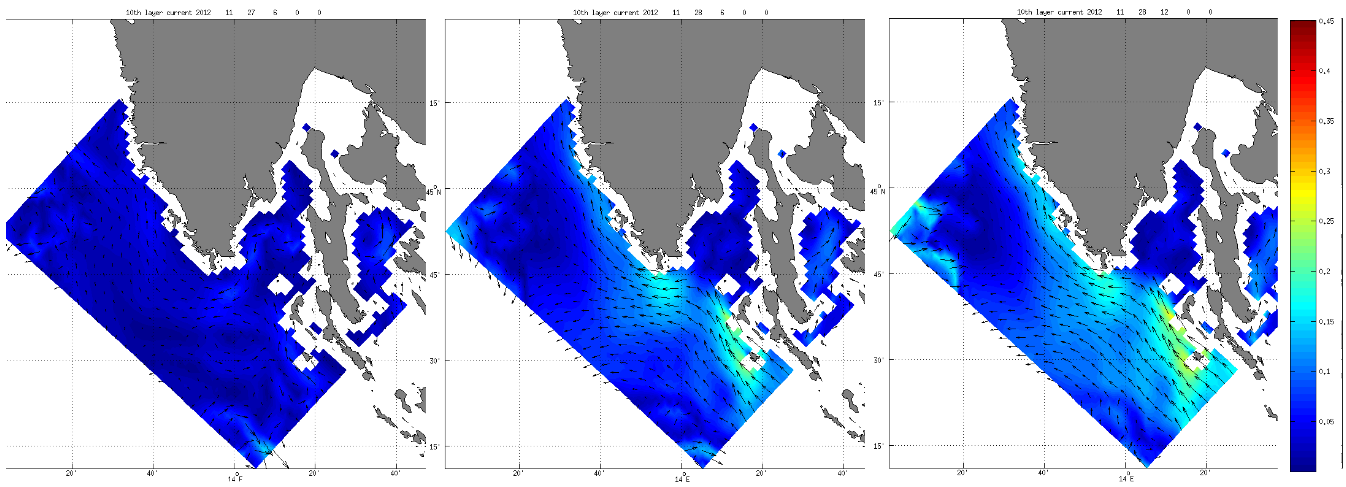

Fig. 9: 10th layer circulation during 27-29 of November 2012 with Sirocco wind. The speed is in m/s.

The deeper circulation there follows the surface circulation, but the current speed is slightly reduced. While at surface the current speed can reach 0.4 m/sec, in the deeper layer the maximum is about 0.25 m/sec.