meteoblue

Study of the Bora on the North Adriatic Coast

0 Introduction

The Bora is a well-known North East wind that blows on the North Adriatic coast. It is a cold and gusty wind that arises when a polar high-pressure system is located in the North-East of Europe and a low-pressure area lies on the warmer Adriatic. Its importance on the transport of nutrients and heat in the Adriatic makes its study of a great importance for the oceanographers.

The aim of this study is to verify the meteoblue wind simulation focusing on a specific wind that is the Bora. Its multiple surface wind jets due to its surrounding orography makes it an interesting phenomenon to specifically verify the skills of meteoblue wind simulation in a topographic influenced region. These jets patterns have been well studied by Signell et al. (2010).

We will present a wind map of the north Adriatic and analysed the wind speed of four important Bora events along the north Adriatic coast. Wind Roses for three cities along the north Adriatic coast will also be presented.

1 Data and methods

Four strong Bora events have been selected for our study. The first three are on February 7 2012 at 6, 10 and 15 UTC and the last one is on February 11 2012 at 15 UTC.

U and V wind vectors from the NEMS4 run of 0 UTC have been collected for these four events to draw a wind map of the North Adriatic.

Wind speed along the A-B transect have been selected to study the orographic effect along the coast.

Wind data of four ground stations along the Adriatic North coast have been collected and compared to the simulation data to assess their precision.

2 Results

2.1 Maps

Based on the four wind maps and the wind speed profile, we can identify similarities as well as differences for the four events.

One common pattern is the strong North-East winds descending down the slopes along the North Adriatic coast. This is a first evidence for a Bora event.

Different jets can be observed and correlated with the local topography. We can basically distinguish between three jets: the Trieste, the Senj and the Karlobag jet. These

Differences are, for example, that the 11 February event present stronger winds in the region of Trieste while the 7 February events have stronger winds in Senj and Karlobag.

Another particularity for the 11 February event is the low pressure area located at 44°N 14°E. This low can be observed on Figure 4 and is confirmed by Figure 5.

One can generally observe on Figure 5 that there is a high in the North East and a low in the South West. This is a typical situation for a Bora event.

It is interesting to observe the drastic change in the wind direction on Figure 3. North West wind is blowing along the Italian coast and meets the Bora off the coast causing a 90° change in the wind direction and lowering the wind speed to almost 0 m/s.

Looking at the 850mbar wind map, one can observe that the Bora is not present at this height. Although there is a North East wind along the slopes of the Croatian coast, the winds off the coast are coming from the South East.

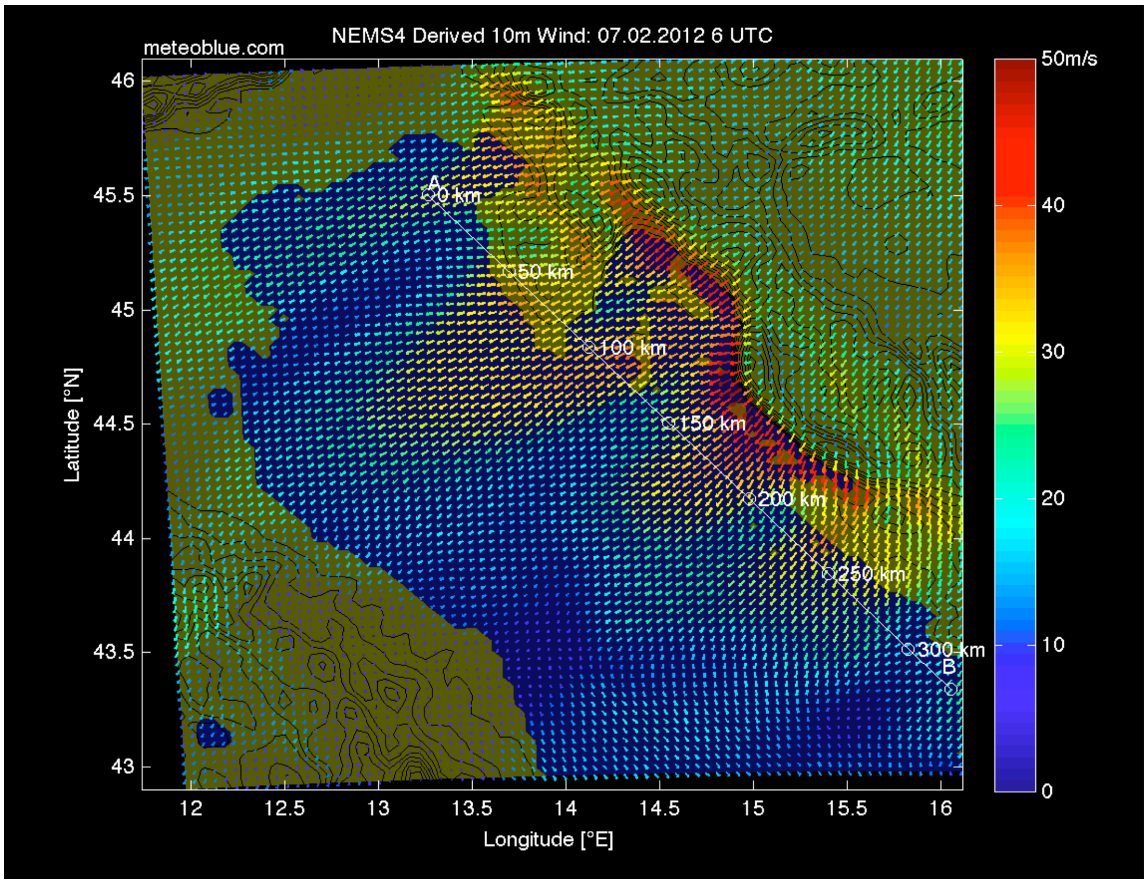

Figure 1: NEMS4-derived 10m wind at 0600 UTC on 7 February 2012. The topography is shown with black contour lines. The stronger winds are observed along the croating coast in the region of Karlobag. Areas with wind speeds close to 0 m/s are observed offshore when North Western winds meet the Bora.

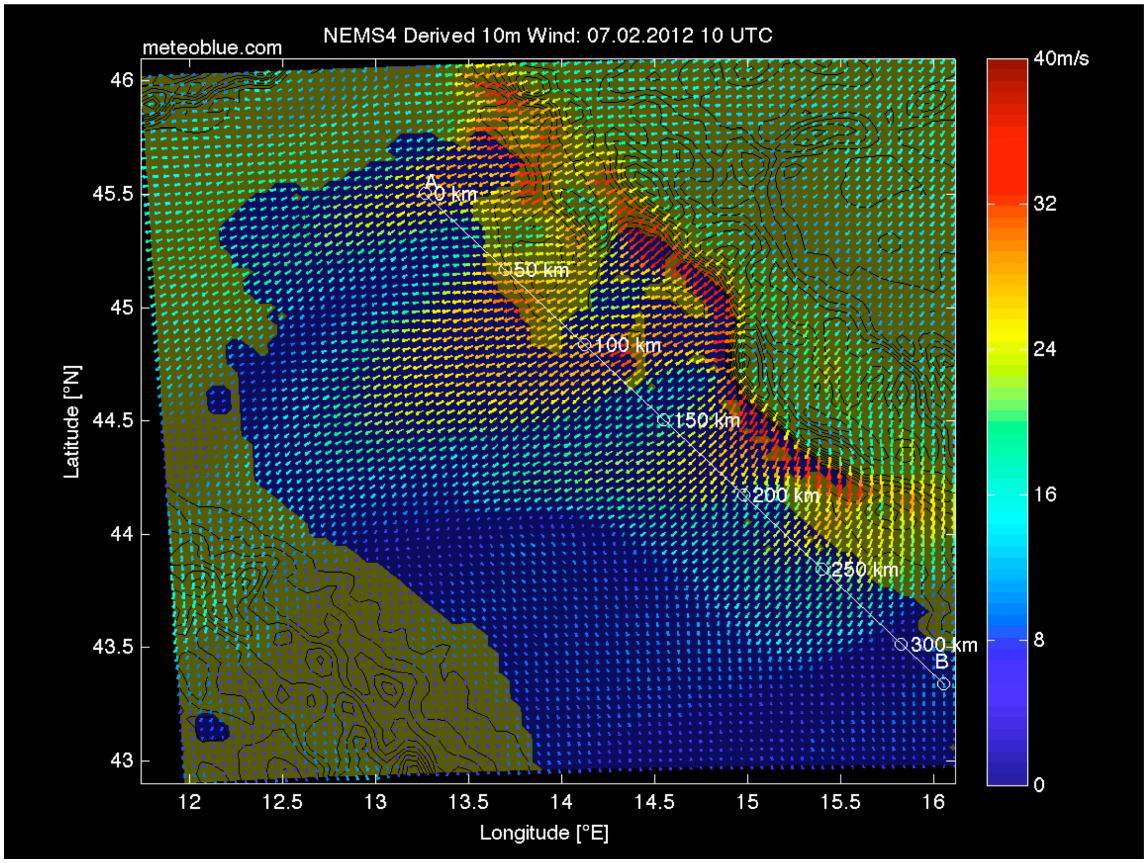

Figure 2: NEMS4-derived 10m wind at 1000 UTC on 7 February 2012. Same observations as Figure 1, except that North West winds are even more present off the Italian Coast.

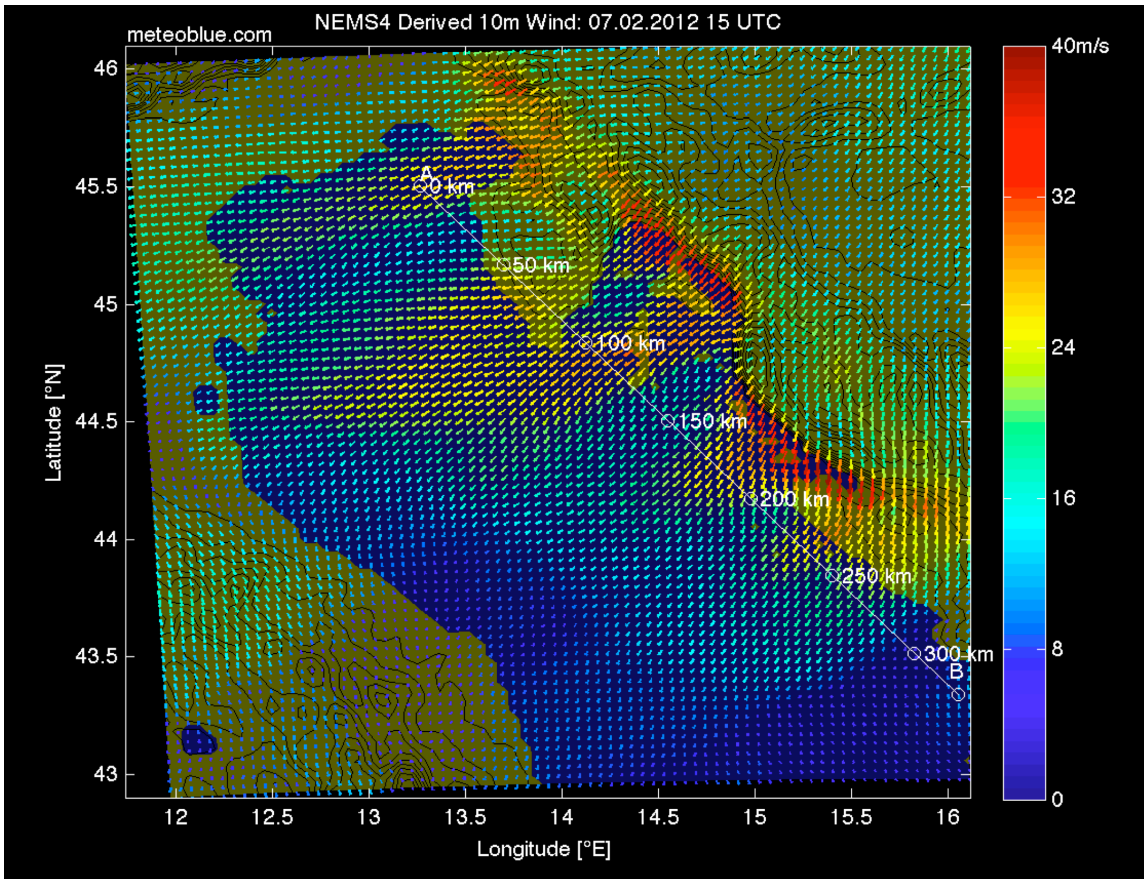

Figure 3: NEMS4-derived 10m wind at 1500 UTC on 7 February 2012. Relatively strong North West winds are observed in the Apennines mountain chain, creating this abrupt change in the wind direction and lowering the wind speed close to 0 m/s.

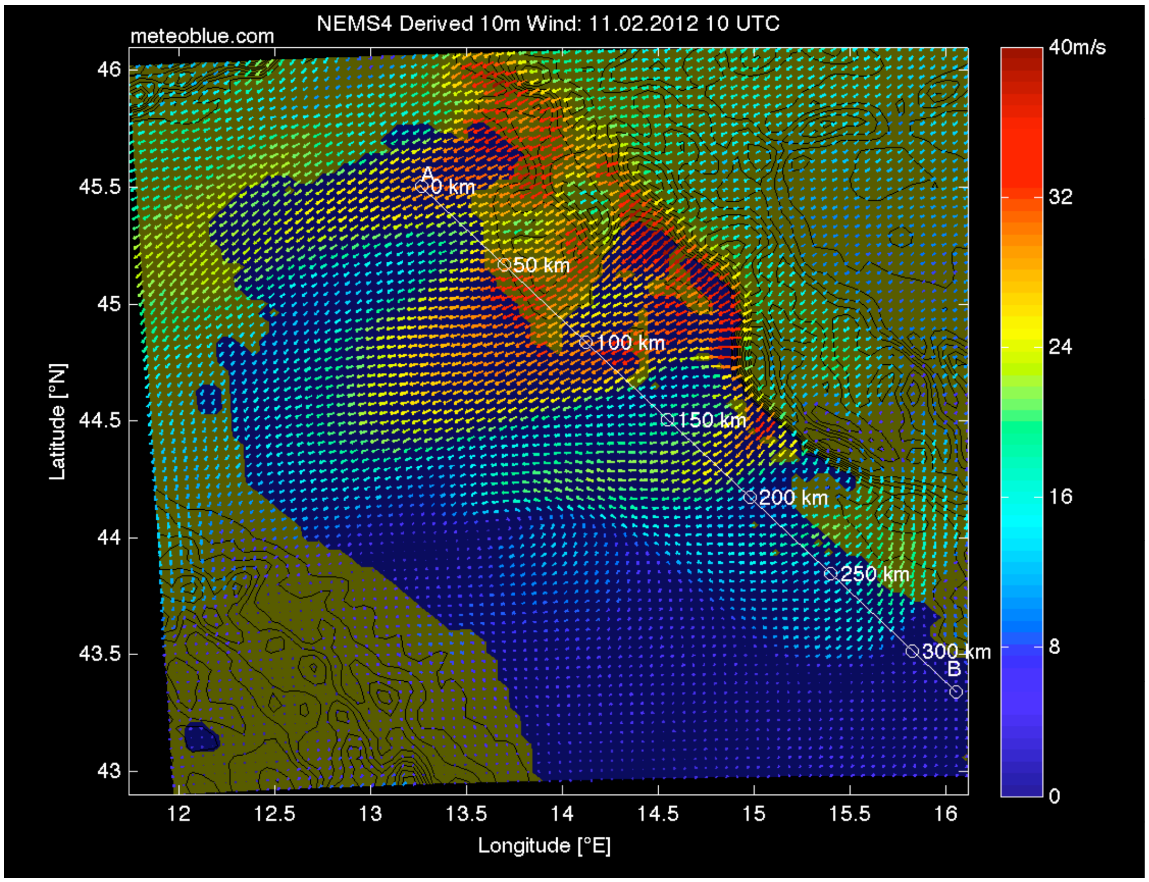

Figure 4: NEMS4-derived 10m wind at 1000 UTC on 11 February 2012. Stronger winds are observed in the region of Trieste compared to the 7 February events. We can assume a low-pressure area off the Italian coast. It will be confirmed with the mean sea level pressure maps

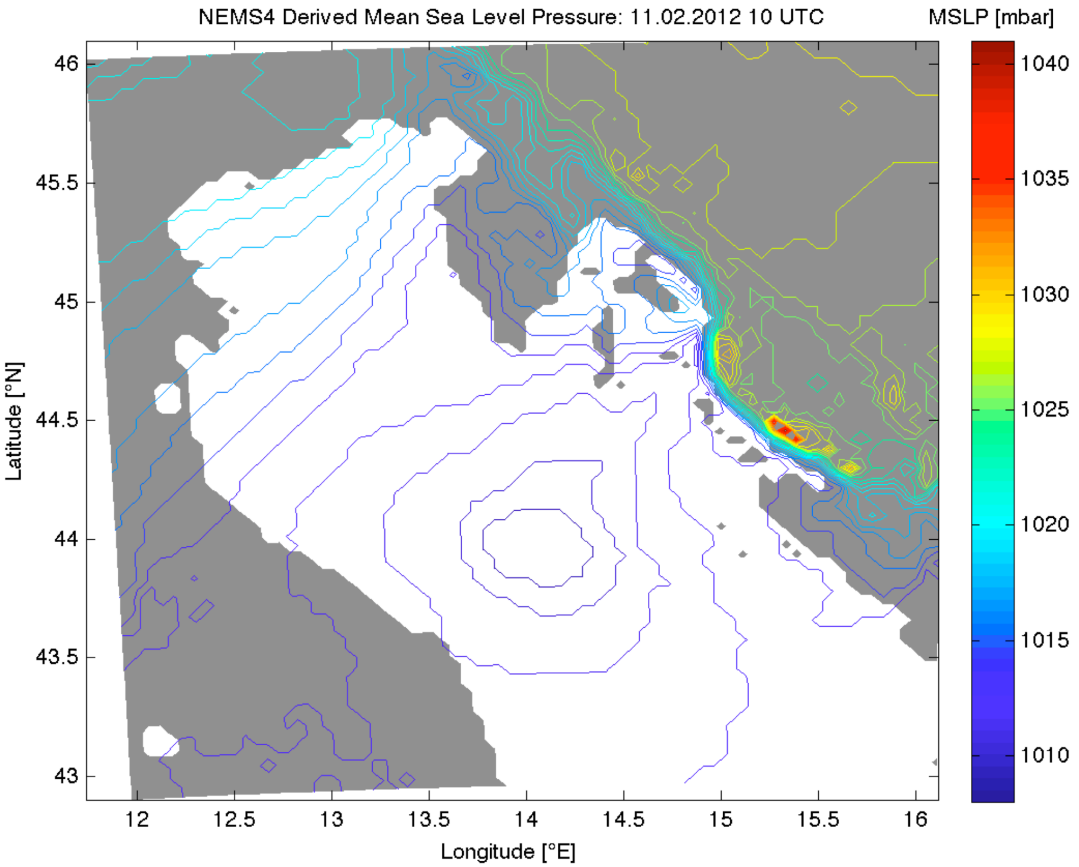

Figure 5: NEMS4-derived mean sea level pressure at 1000 UTC on 11 February 2012. A low can be observed at 44°N 14°E. Lower pressures on the Adriatic together with higher pressures in the North East direction is a necessary condition for a Bora event to happen.

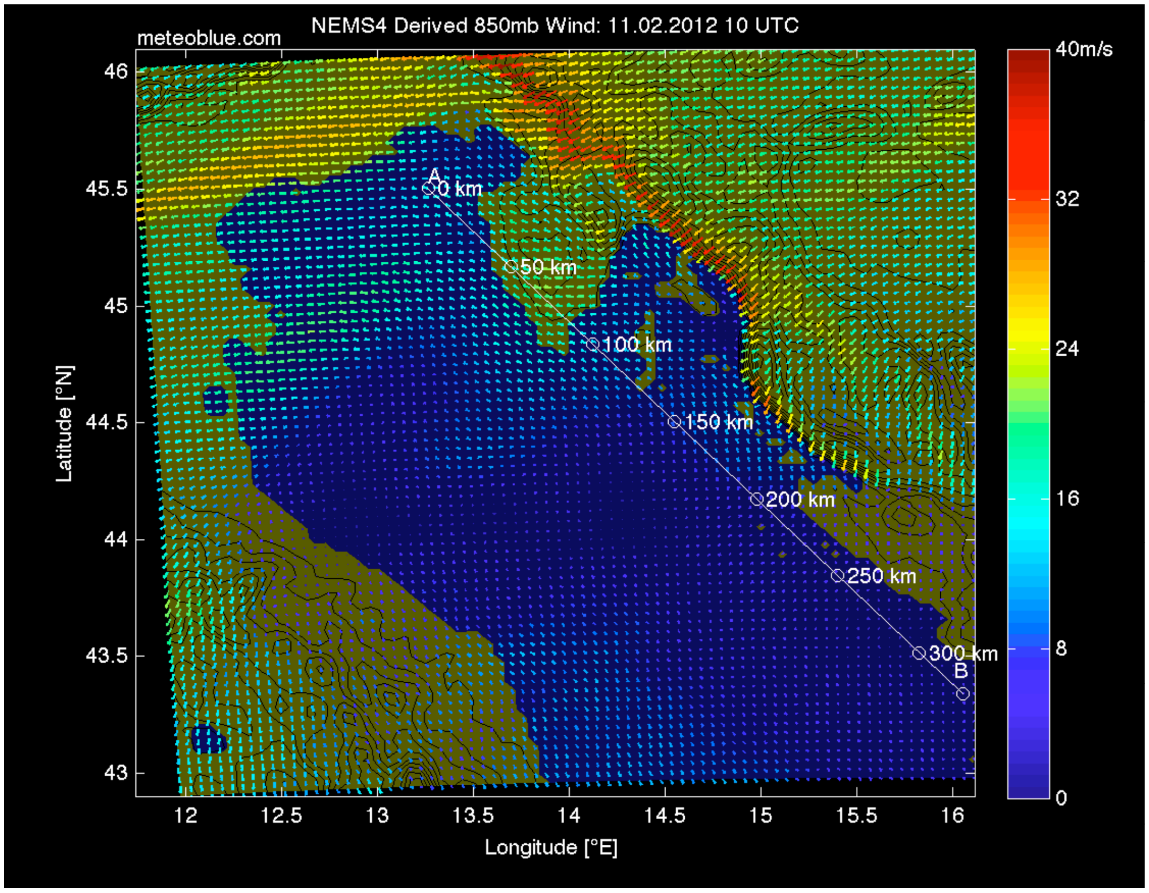

Figure 6: NEMS4-derived 850mb wind at 1000 UTC on 11 February 2012. The Bora cannot be observed at this height: the South East winds on the Adriatic confirm that the Bora has no influence at this level of pressure.

2.2 Transect Analysis

In this part, we will analyse the wind speed along the A-B transect. The boundaries of the three jets are represented with vertical lines. It is interesting to note that the four events have the same local minimums and maximums along the track. They represent the jet and wake alternating off the coast, which are well correlated with the coastal topography.

One can also observe that the wind speed on the 11 February is decreasing along the track while the others are increasing. This difference can also be observed on the wind maps, which shows that different Bora events hit the coast with different intensities and spatial distributions.

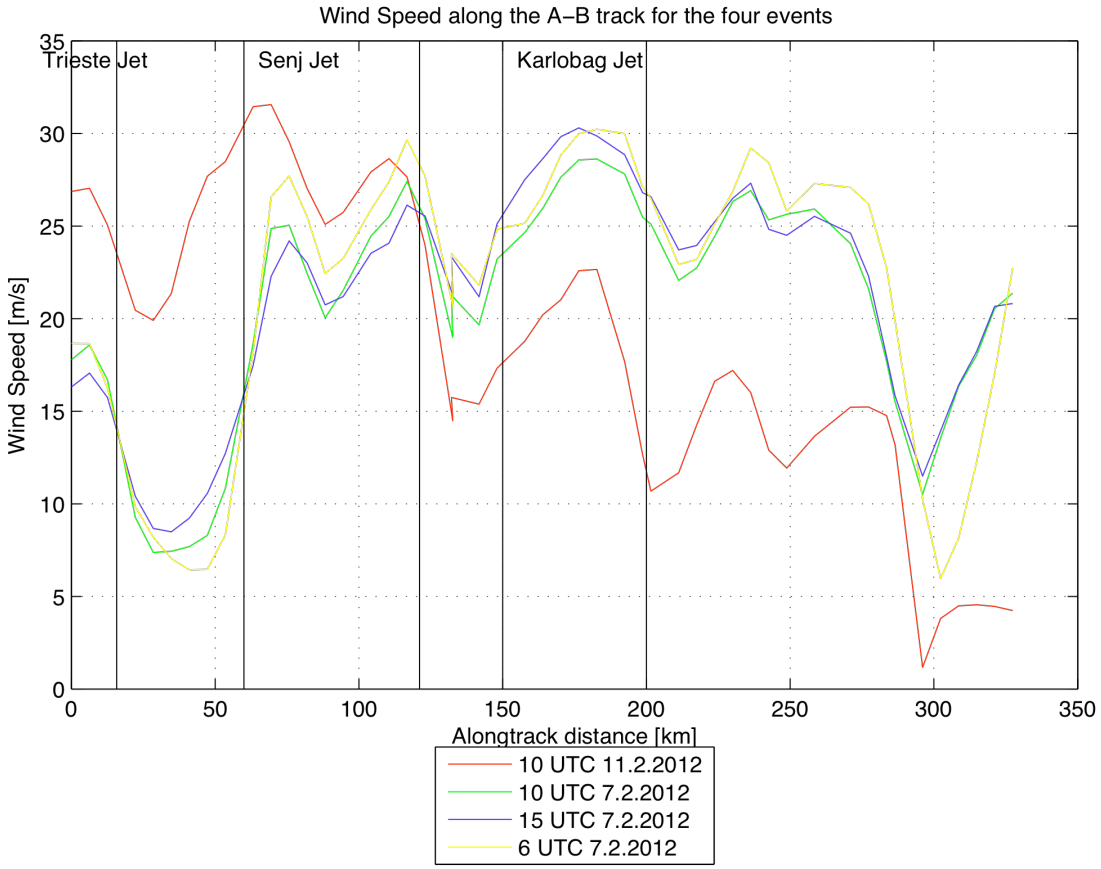

Figure 7: Wind Speed along the A-B transect. The boundaries of the three jets are represented with vertical lines.

2.3 Wind Roses

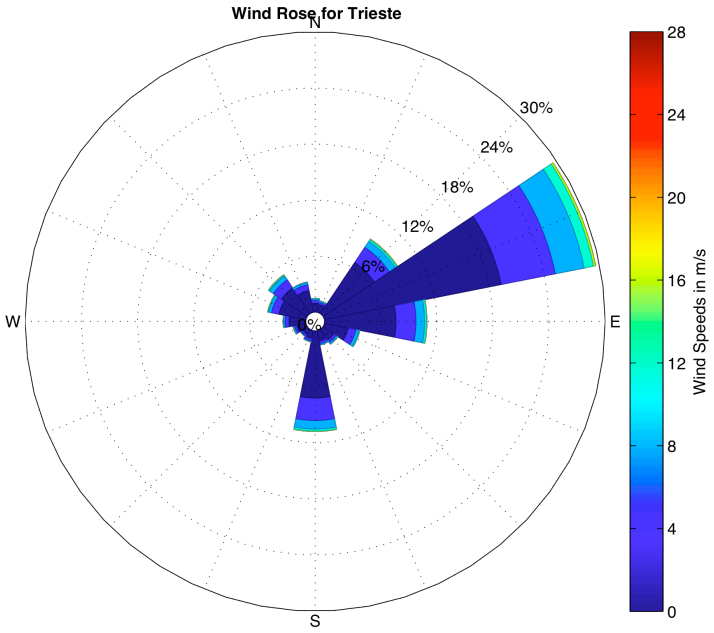

Figure 8: Wind Rose for Trieste. Hourly Station data from 1 October 2011 until 31 December 2013. It shows that Trieste is a strong Bora influenced region . A south wind component can also be observed

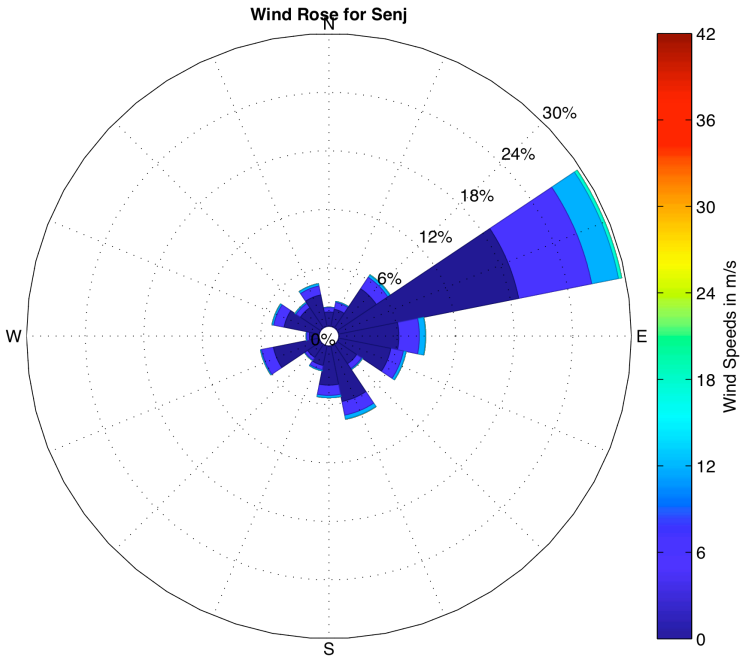

Figure 9: : Wind Rose for Senj. Hourly Station data from 1 October 2011 until 31 December 2013. Senj is also a strong Bora influenced region.

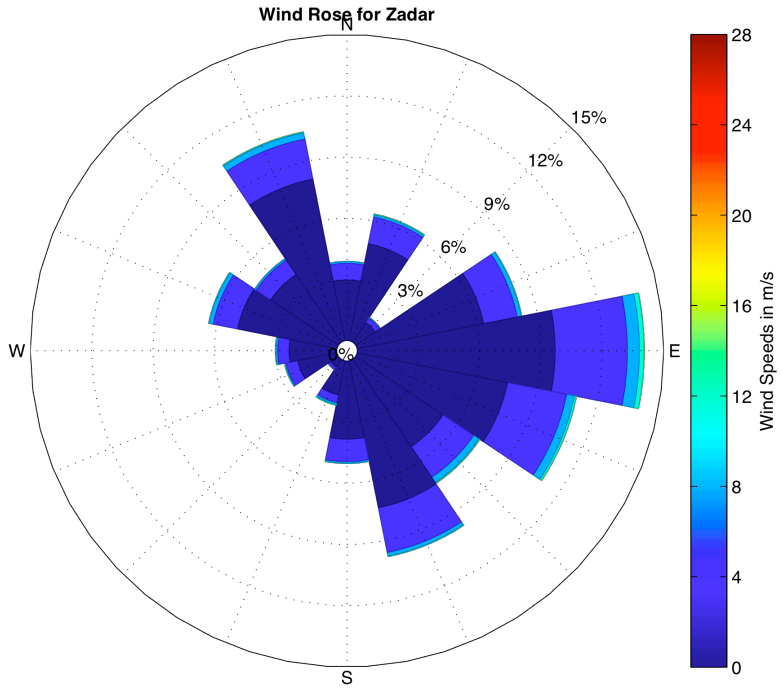

Figure 10: Wind Rose for Zadar. Hourly Station data from 1 October 2011 until 31 December 2013. Although Zadar is affected by the Bora during our selected events, it is mainly affected by other winds when we consider a longer period.

2.4 Verification

We performed a verification for four stations along the north eastern Adriatic coast. We compared the station wind speeds values with the ones from the grid points. RMSE, Bias and

Correlations are represented in Table 1. RMSE are in the range of 2.2 – 4.1 m/s which shows that de grid points wind speeds are reliable. A bias of 2.0 and 1.8 m/s for Trieste and Senj respectively show a slight overestimation of the wind speed compared to the stations data. These two stations present a fairly good correlation of 0.75 and 076, while Pazin and Zadar have a lower correlation of 0.53 and 0.50. When comparing the RMSE and Bias with the distance from grid point, one can conclude that the stations with the smallest distance are the one with the smallest RMSE, Bias and Correlation. We would have the tendency to affirm that the nearer the grid point the better they represent their corresponding stations. It is right when looking at the RMSE and the Bias but wrong when looking at the correlation.

Briefly, we can say that NEMS4 derived wind speeds are in agreement with the stations data.

Table 1: Verification parameters and distance from grid point

	RMSE [m/s]	Bias [m/s]	Correlation	Distance from grid point [km]
Trieste	3.6	2.0	0.75	3.4
Pazin	2.2	0.9	0.53	2.5
Senj	4.1	1.8	0.76	2.7
Zadar	2.5	0.7	0.50	0.8

3 Conclusion

These four kilometres resolution wind maps have provided interesting facts about the spatial distribution of the Bora in the North Adriatic. The alternating jet and wake patterns can be observed on all maps. Local differences between the four events show that each Bora event presents different characteristics.

The mean sea level pressure map showed us the corresponding pressure systems associated with Bora events.

Wind roses informed us on the wind distribution along the northern Adriatic coast. While some cities are nearly always hit by the Bora, others seem to be hit mostly during the winter and during strong Bora events.

4 Reference

Signell, R. P., J. Chiggiato, J. Horstmann, J.D. Doyle, J. Pullen and F. Askari (2010), High‐resolution mapping of Bora winds in the northern Adriatic Sea using synthetic aperture radar, Journal of Geophysical Research, 115, C04020, doi:10.1029/2009JC005524.