# SEVERE BORA STORM 14 – 15 NOVEMBER 2004.

The bora wind of extreme severity, which blew along the entire Adriatic coast on 14/15 November (*Figure 1*), caused a lot of damage to the power-line network and a complete road, air, railway and sea traffic disruption with at least 2 persons died and over 50 persons injured. The violent storm also caused a considerable damage to houses, harbours and trees (many olive trees were uprooted). Sheep-farming on the northern Adriatic islands also suffered a lot, due to settled sea-salt on the vegetation.

A moderate to strong bora started already on Saturday, 13th November 2004 as a cosequence of a strenghtening cyclone over the southern Adriatic. Further synoptic development (deepening of the cyclone and a simultaneous strenghtening of a middle Europe anticyclone, *Figure 2*) led to a strenghtening of the bora. During the night from Saturday to Sunday, the mean wind speed gained the gale to storm force (wind speed greater than 17 m/s) with severe gusts exceeding 33 m/s (*Figure 3*).

This bora case was exceptional primarily due to longlasting winds with the gale to hurricane – like wind speeds (*Figure 4*). However, such bora windstorms are rather infrequent.

The **bora** wind is a strong, gusty, north-easterly downslope wind along the eastern Adriatic coast (Tutiš, 2002).

Although a recent investigation showed important differences in the behaviour of the bora wind between the northern and the southern Adriatic, investigation of severe bora cases reveals its multiscale nature. The bora onset, its longevity and severity are all closely related to larger mesoscale features, in particular to those resulting from the interaction processes of synoptic scale flow with the Alpine massif. In addition, the speed and direction of bora are greatly influenced by local topographic shape. Thus, when discussing severe bora, we have to bear in mind that such windstorms are mostly of subsynoptic dimensions, strongly influenced by local processes and orography and, therefore, very difficult to study by a regular synoptic network.

There are generally three classical synoptic weather patterns leading to severe bora flow:

- **anticyclonic bora type** – when there is a strong anticyclone north or northeast of the Alps, producing strong pressure gradients over the Dinaric Alps (thus pushing the air from the inland to the Adriatic area)
- **frontal bora type** – rather brief episodes of bora, following the cold front movement (duration and intensity of bora is directly dependent on the amount of cold air following the cold front)
- **cyclonic bora type** – when there is a Mediterranean cyclone close to the Dinaric Alps, exerting strong pressure gradients over the Dinaric Alps (thus drawing the air out from the inland to the Adriatic area)

On the mesoscale, severe bora is related to the cold airflow in the lower troposphere, upstream blocking, splitting and crossing over an orographic obstacle (*Figure 5*).

In conclusion, the severe bora windstorm on the 14/15 November 2004 is an example of a combination of anticyclonic and cyclonic bora type (*Figure 6*). In such a case, there are strong surface pressure gradients of more than 10 hPa over horizontal distance of 50km (like e.g. Ogulin-Senj), causing strong wind not only along the coastal area but also in the inland of Croatia (*Figure* 7). Similar weather situation was reported on 6 to 9 November 1999.

Figure 1. Severe bora, Senj, 14 November 2004, photo Damir Šenčar (HINA)

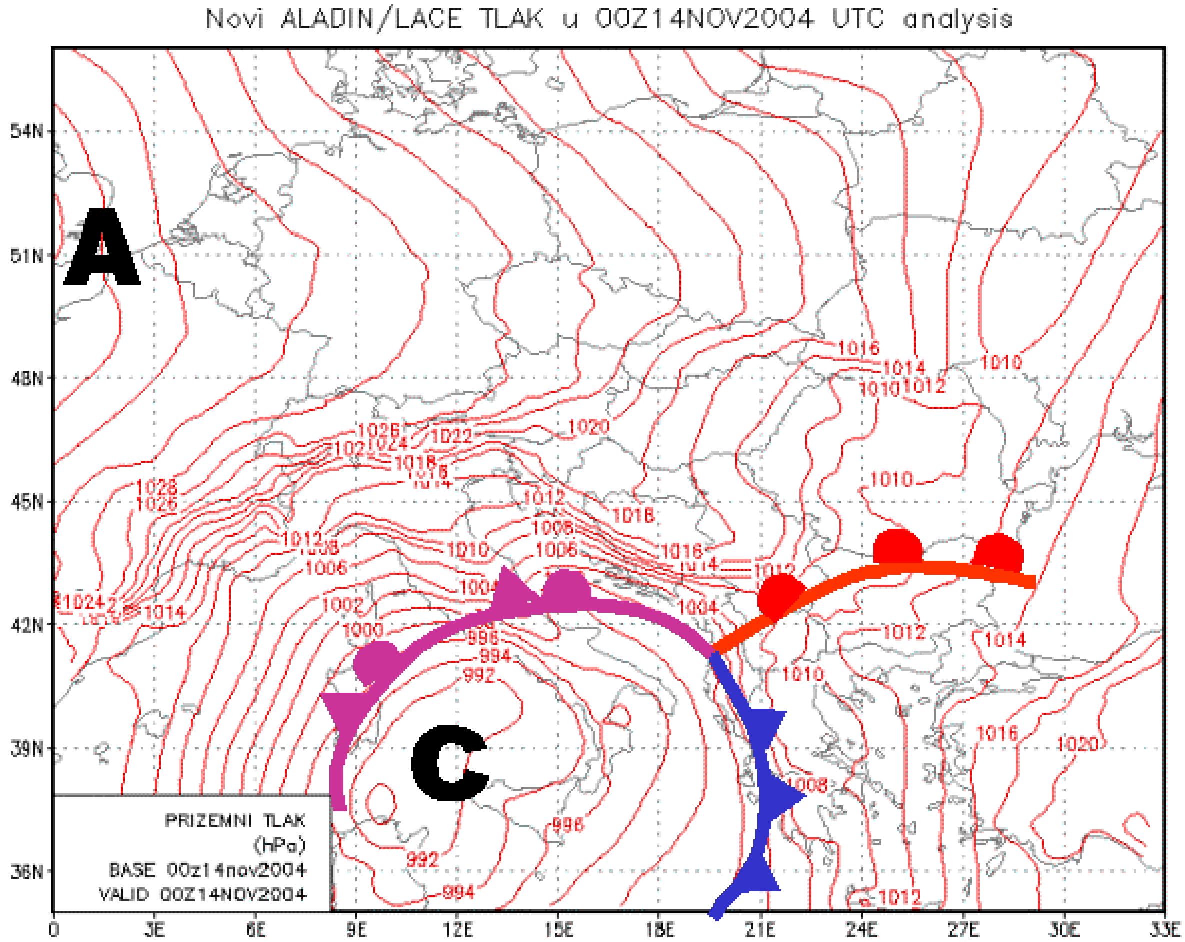


Figure 2. Surface pressure, 14 November 2004 at 00 UTC (ALADIN analysis); cold front (blue), warm front (red), occluded front (purple)

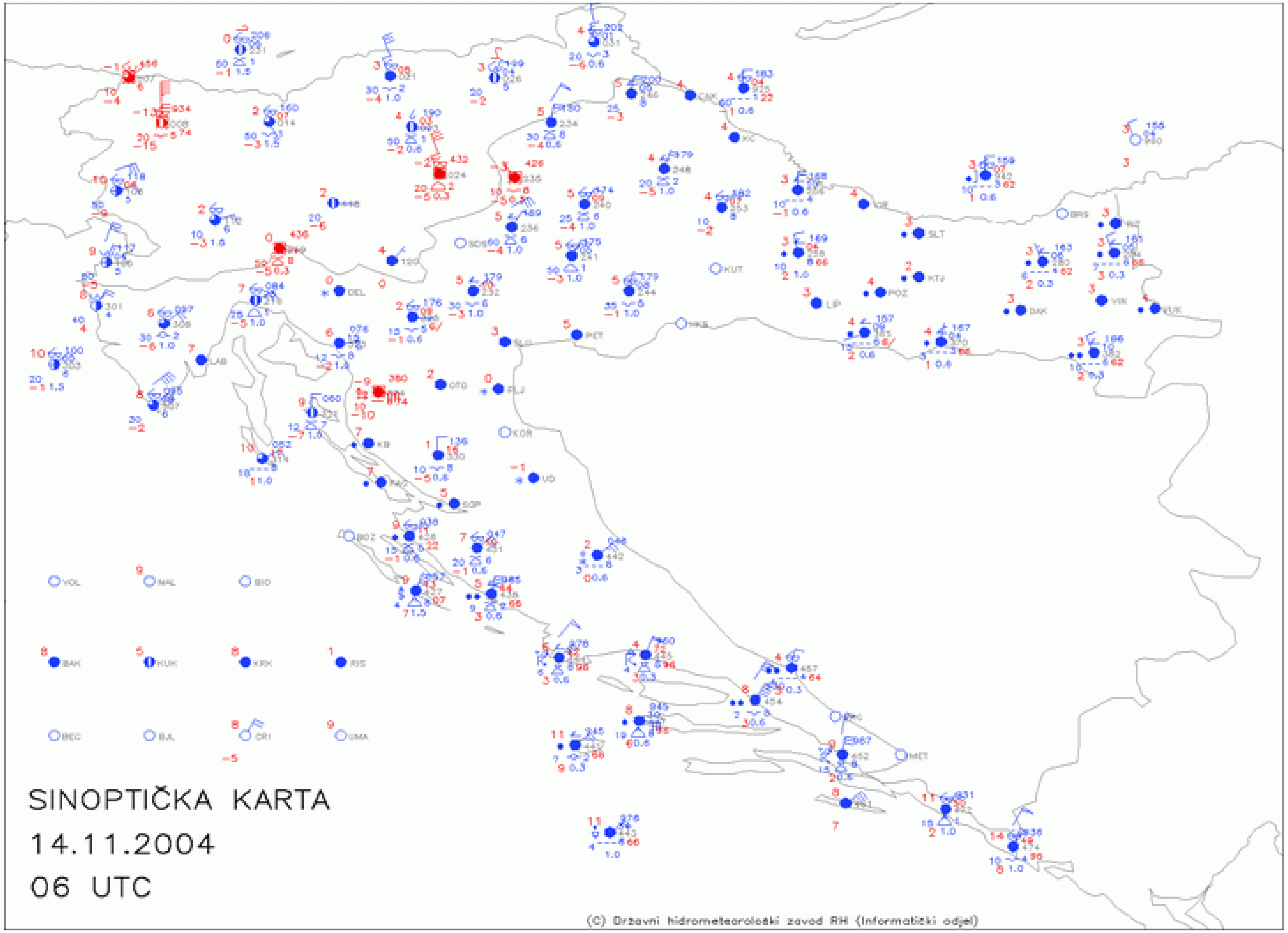


Figure 3. Surface synoptic chart, 14 November 2004 at 06 UTC

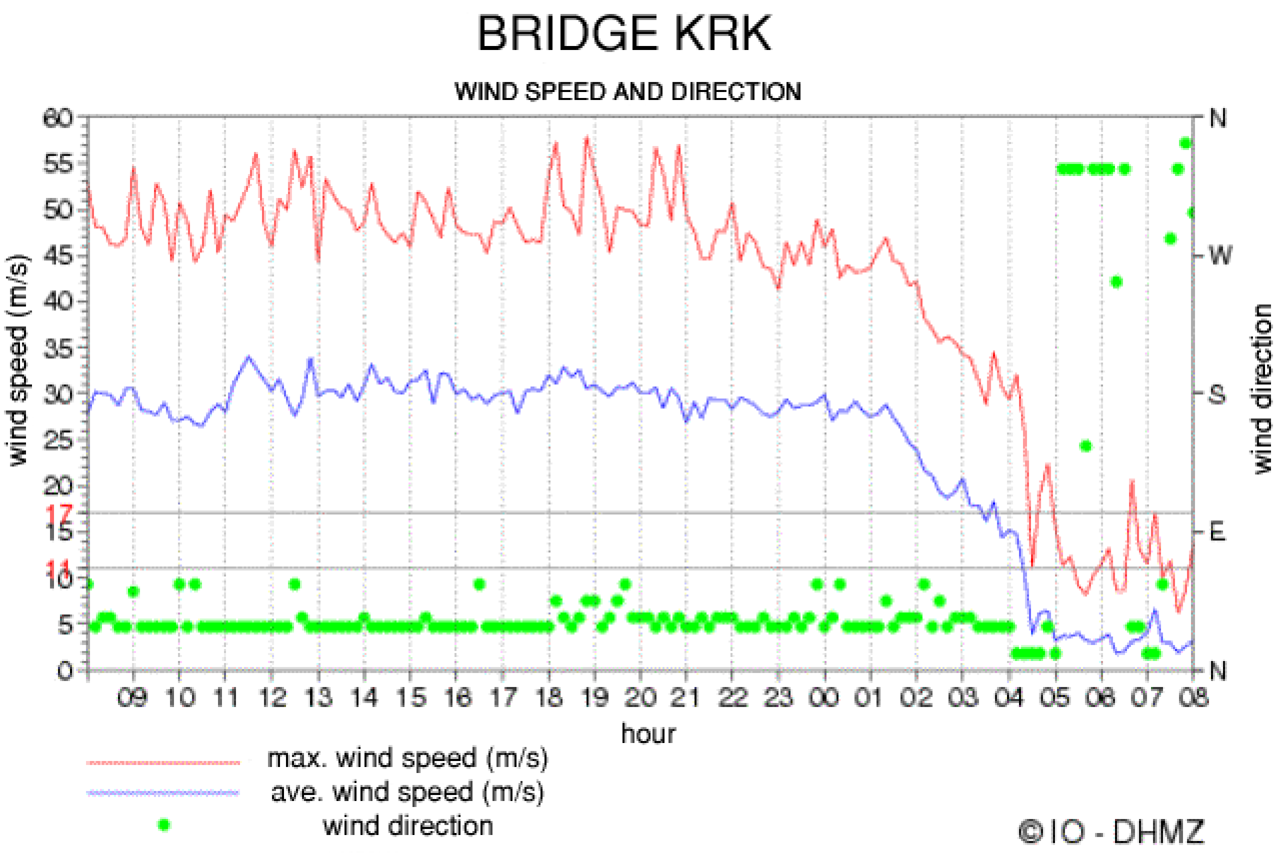


Figure 4. Automatic meteorological station data, Bridge Krk, 14 November at 08 h till 15 November 2004 at 08 h (local time)

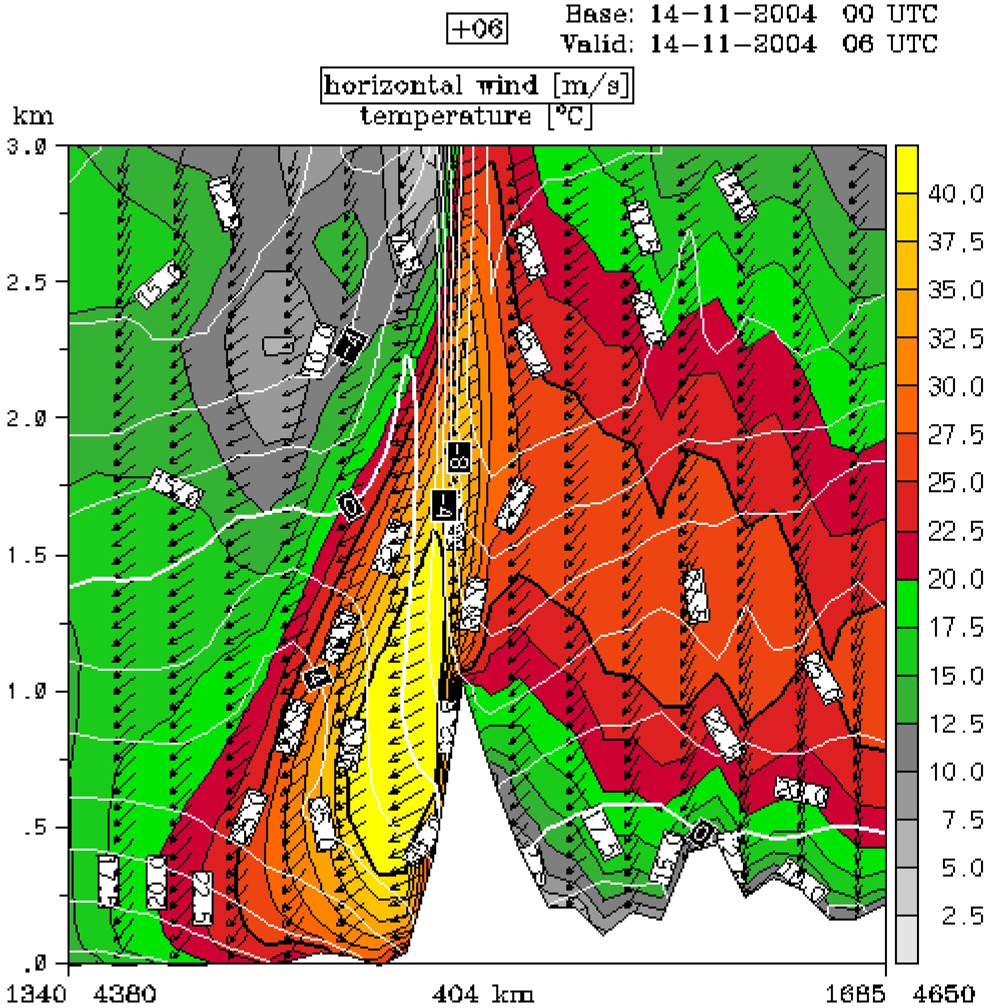


Figure 5. Vertical cross-section Mali Lošinj – Zagreb (up to 3 km), valid for 14 November 06 UTC (ALADIN forecast + 06h). The arrows represent the horizontal wind direction, the shaded areas and the black isolines (isotaches) correspond to wind speed (m/s) and the white curves are isotherms (°C).

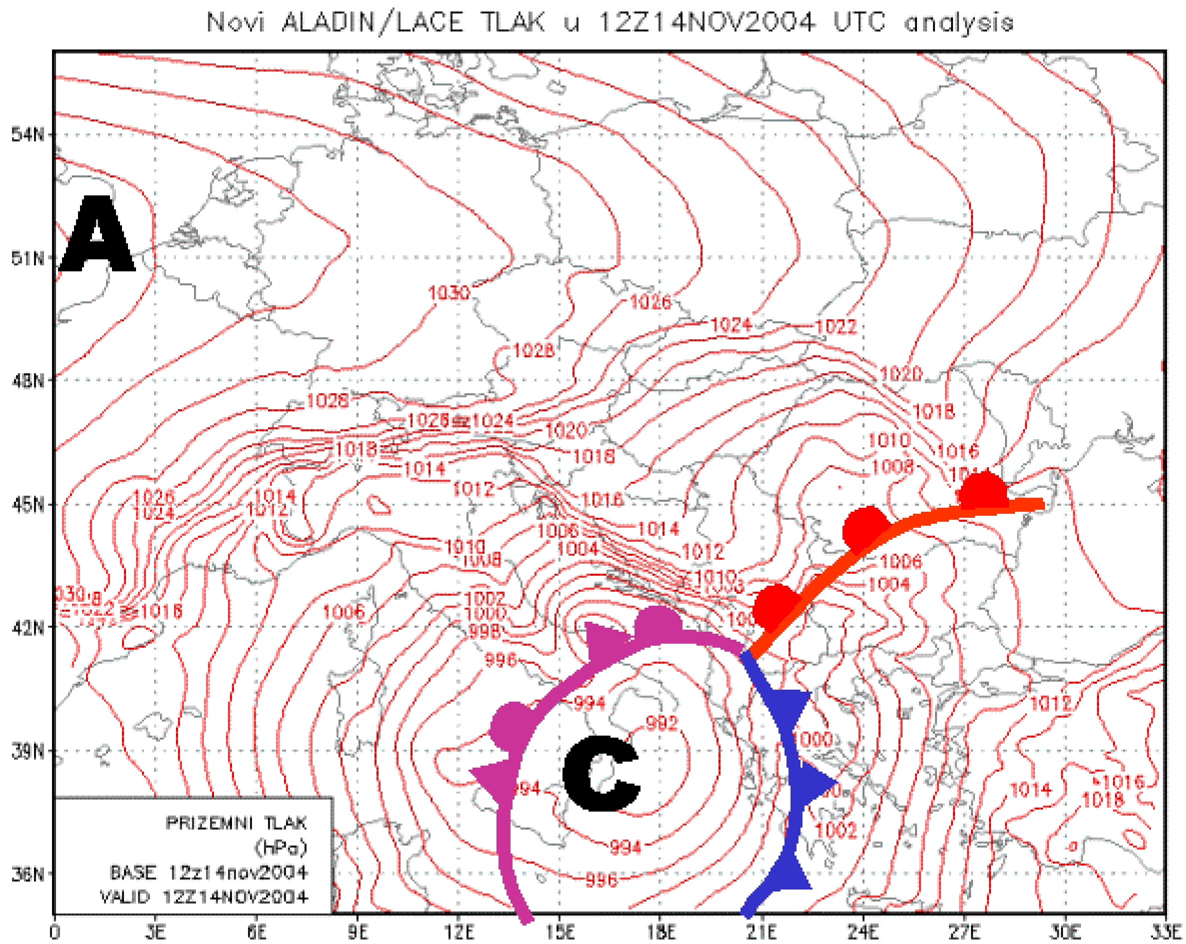


Figure 6. Surface pressure, 14 November 2004 at 12 UTC (ALADIN analysis);
cold front (blue), warm front (red), occluded front (purple)

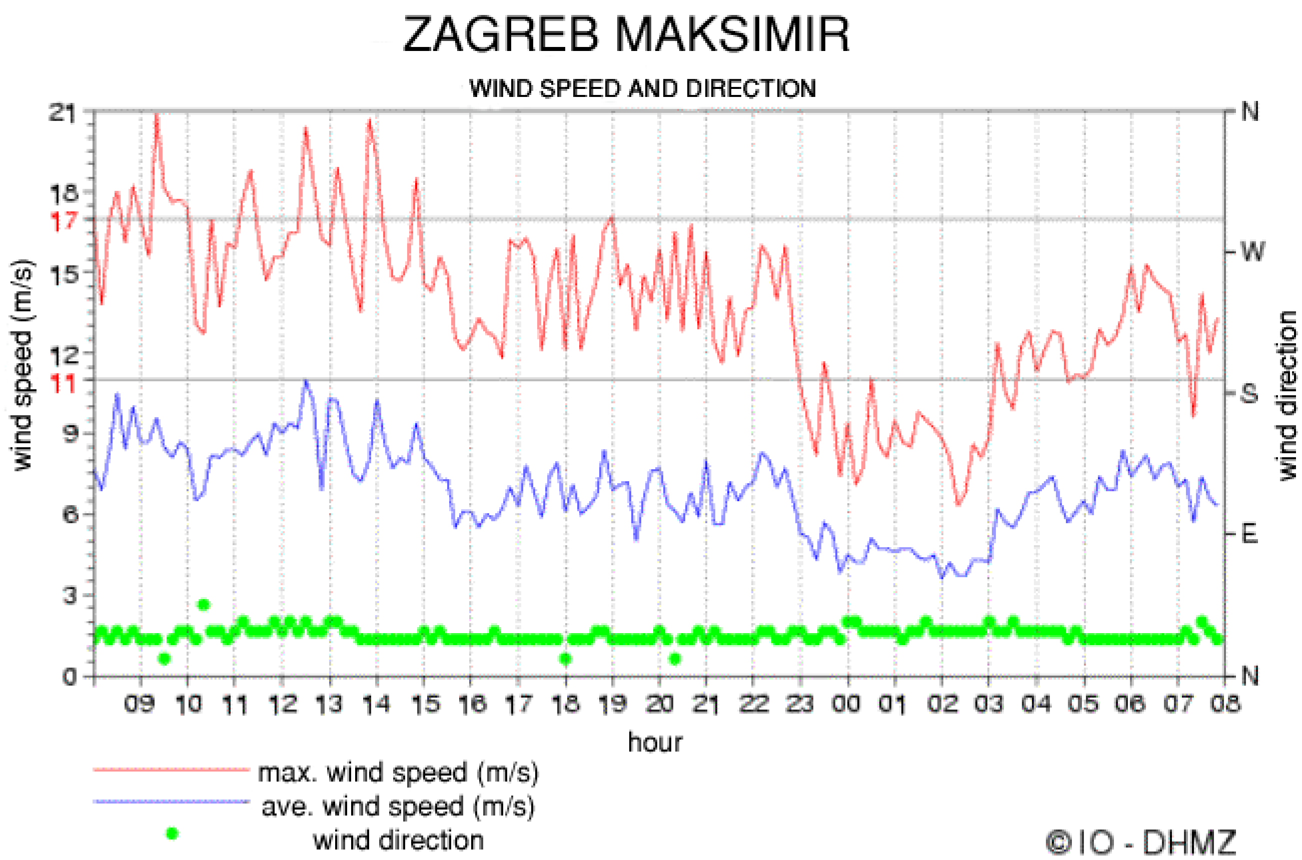


Figure 7. Automatic meteorological station data, Zagreb Maksimir, 14 November at 08 h till 15 November 2004 at 08 h (local time)