



Report on typical patterns in the temporal evolution of the vertical wind profile during Bora events (D-4.3)

Comparison of SODAR and LIDAR profiles (D-4.4)

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1. Temporal evolution of the vertical wind profile during Bora

The LIDAR data during the first reporting period at the Maligrad and Rudine sites was analysed with respect to the temporal evolution of the vertical wind profile during Bora events. For further documentation and results of the individual measurement campaigns, see deliverables D-4.1 and D-4.2.

The analysis showed that the ZephIR LIDAR system used within this project was in many cases not capable to record wind speeds below 4 m/s. Therefore, data availability at the beginning of Bora events was in general low. Furthermore, at the Maligrad site, Bora events often occurred in combination with heavy rainfall or in-cloud conditions at the site (Fig. 1). These circumstances again reduced the data availability of the LIDAR. Thus the data availability at the beginning of Bora events was too poor to get reliable findings at the Maligrad site.



Figure 1: Typical in-cloud situations during Bora events at the Maligrad site.

1.1. Bora at Maligrad

Figure 2 shows a typical Bora event measured at the Maligrad site. The colors represent the wind speed at different heights while the dots show the wind direction. Grey areas mark periods with no data availability. Between December 3 and 4, 2008 the wind direction changes from south to north-east. However, no data could be recorded for approximately 6 hours. When the data availability increased again, wind speed was already at around 15 m/s i.e. no data was available during the build-up of the Bora event.

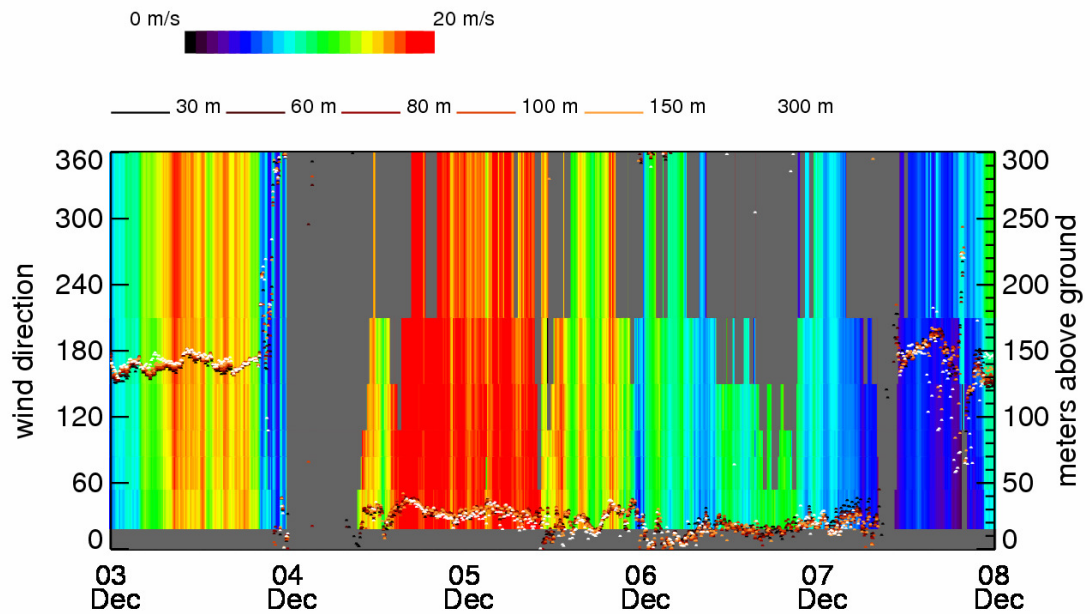


Figure 2: Evolution of vertical wind profile during a Bora event at the Maligrad site.

Figure 3 and 4 show two different visualisations of the development of the vertical profile starting on December 4 when Bora has already built up and reached a wind speed of approximately 15 m/s. In figure 3, the vertical profile was normalised at 30 m above ground. The different colors mark the temporal evolution, i.e. the brighter the later in time (from purple to blue, green yellow and red). It can be seen that there is only very little variation within the vertical profile. Figure 4 shows the time series of the ratio between the wind speed at the different height levels and the wind speed at 30 m. Again, hardly any variation over time is visible. These results indicate that there seems to be no significant temporal pattern during Bora events but that the vertical profile is mainly driven by the local topography.

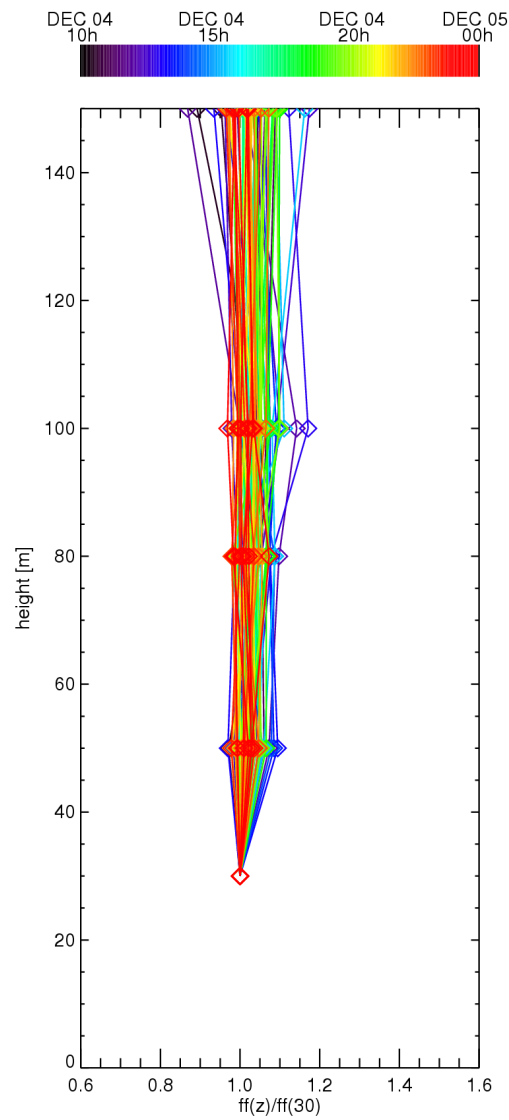


Figure 3: Vertical wind profile during a Bora event at the Maligrad site.

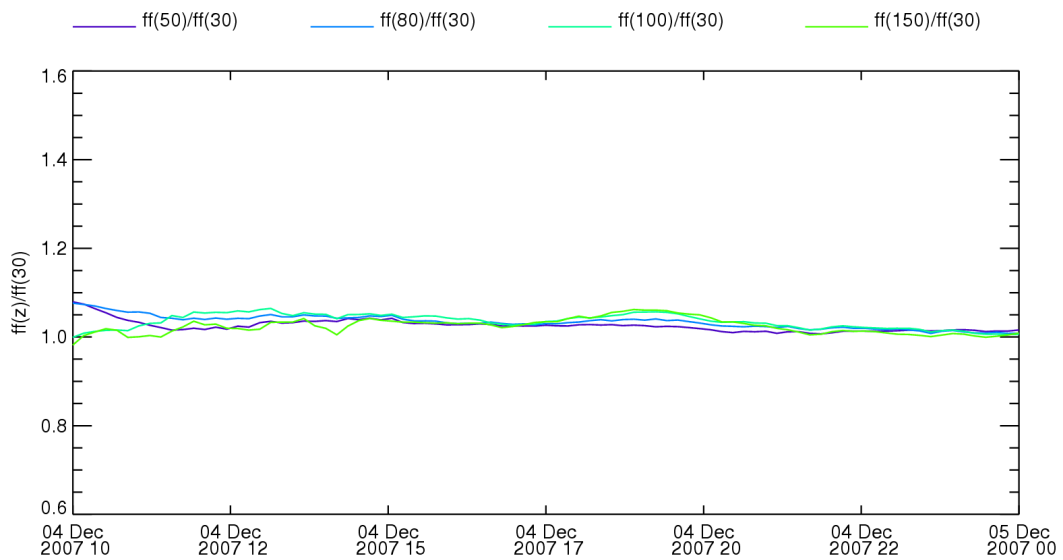


Figure 4: Time series of the ratio between the wind speed at the different height levels and the wind speed at 30 m during a Bora event at the Maligrad site.

1.2. Bora at Rudine

At the Rudine site, data availability during the build-up of Bora was higher than at the Maligrad site. Therefore, tentative results could be obtained. Figure 5 shows a typical Bora event measured at the Rudine site. The colors represent the wind speed at different heights while the dots show the wind direction. Grey areas mark periods with no data availability.

At the end of May 2, 2009 the wind direction changes from south to north-east and wind speed starts to increase to up to 15 m/s. It can be seen that wind speed first increases at higher levels while the wind direction gradually turns from south over North to Northeast i.e. to Bora wind direction. Only when the wind direction has reached Northeast wind speed also increases at the lower levels.

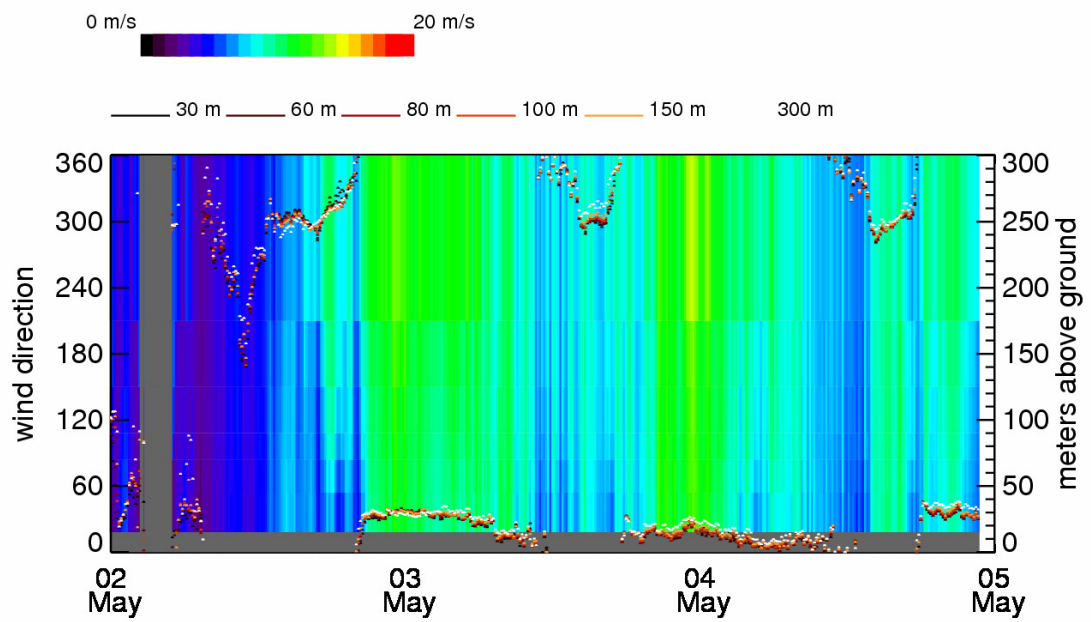


Figure 5: Evolution of vertical wind profile during a Bora event at the Rudine site.

This development is confirmed by figures 6 and 7. In figure 6, the vertical profile was normalised at 30 m above ground. The different colors mark the temporal evolution, i.e. the brighter the later in time (from purple to blue, green yellow and red). It can be seen that in the beginning (blue profiles), the vertical profile doesn't show an increase of wind speed with height. Then, the green profiles show how wind speed first increases at higher levels. Finally (yellow and red profiles), the initial vertical profile is reached again i.e. more or less the same wind speed at all levels.

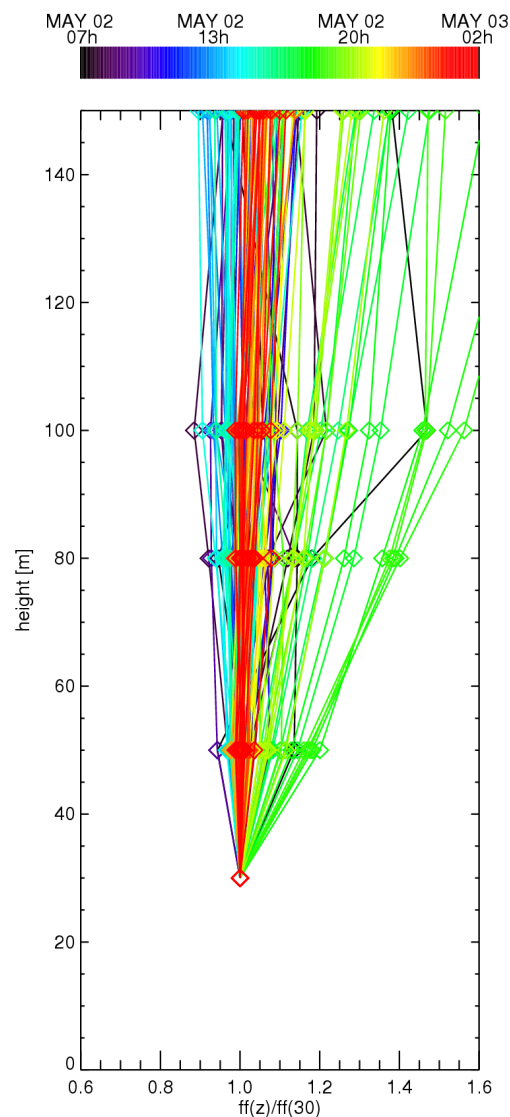


Figure 6: Vertical wind profile during a Bora event at the Rudine site.

Figure 7 shows the time series of the ratio between the wind speed at the different height levels and the wind speed at 30 m. Also in this graph, it is evident how the wind speed increases at higher levels first during May 2. However, it could not be evaluated if this effect is a Bora specific phenomenon or if it also driven by the local topography. In order to do this, the data availability was too scarce. Furthermore, the results show that the averaging interval of the LIDAR of 10 minutes was most probably not sufficient to capture patterns in the build-up of Bora events. In order to get suitable results, an averaging interval of 1 minute or even higher should have been chosen.

On the other hand it is evident that such a strong wind shear as it appeared in the analysed example can have a significant effect on a large wind turbine.

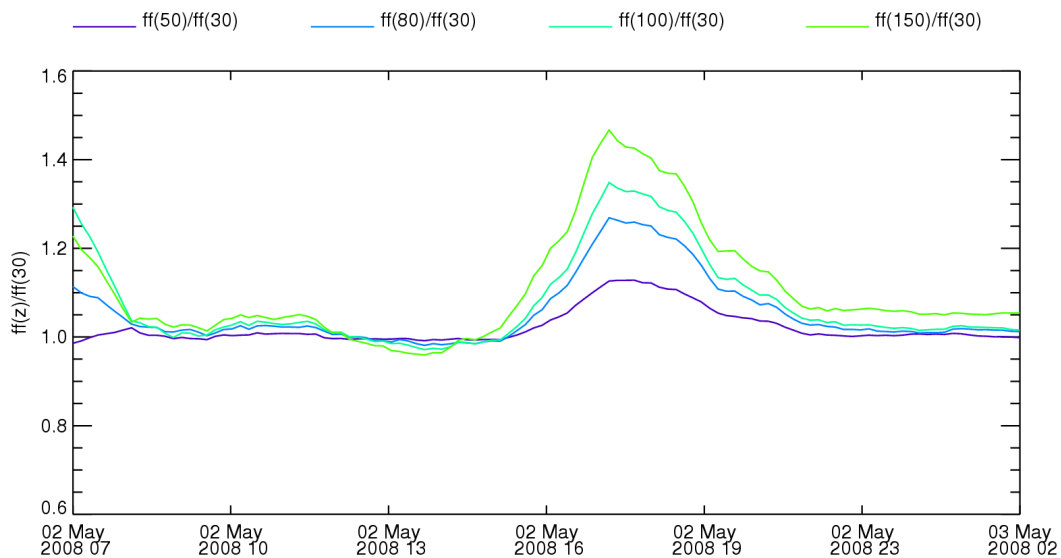


Figure 7: Time series of the ratio between the wind speed at the different height levels and the wind speed at 30 m during a Bora event at the Rudine site.

1.3. Summary

On the basis of the data collected with LIDAR, SODAR and mast measurements on two sites it was difficult to find clearly defined patterns on the temporal evolution of a Bora event which are universally valid. The reasons for that are manifold. First, the data availability at the beginning of Bora events was usually very low due to the inability of the ZephIR LIDAR to measure below 4 m/s and also due to the influence of rain and low clouds. Second, it was difficult to differentiate if the resulting vertical wind profile was stronger influenced by the complex terrain or the Bora event. Third, with the measuring interval of 10 minutes it was not possible to capture the fast evolution in the beginning of a Bora event.