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Documentation and results of the SODAR measurement at the Vlasina site in Serbia

Measurement Campaign from August 19th to October 23th 2009

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1. Introduction

The South East Europe Wind Energy Exploitation (SEEWIND) project[1], embedded in the 6th framework program of the European Commission, aims to gain experience in wind measurements, site development and operation of wind turbines in complex terrain.

AD Masurica is planning the installation of a wind farm at the Vlasina site in Serbia. Therefore a 30-m-mast has been installed by the Austrian company Energie-werkstatt. In order to gain information about the vertical profile of wind speed at this site, a SODAR measurement campaign has been carried out.

This report outlines the SODAR measurement campaign at Vlasina which has been carried out between August 19th and October 23th 2009.

[1] http://www.seewind.org/

2. The measurement site

The measurement site is located near the city of Surdurlica, 8 km south of the mountain lake Vlasinsko in the Psinja administrative district in the Southeast of Serbia. The instrument was mounted on Vardenik mountain, more specific on the Stolovi ridge southeast from Veliki Streser (1'875 m asl), the highest peak of the area. The 30-m-mast was located approximately 100 m away from the SODAR to the northeast. All coordinates are listed in Tab. 1. Fig. 1 shows a map of the area with the locations of the SODAR and the 30-m-mast. The photos on Fig. 2 show panoramic pictures taken from the measurement position towards east and west.

Tab. 1: Coordinates of SODAR and 30 m mast at Vlasina.

Vlasina	Coordinates (Geographic, WGS 84)	Altitude
SODAR	E 22°20'08" / N 42°36'20"	1'640 masl
30-m-mast	E 22°20'04" / N 42°36'16"	1'640 masl

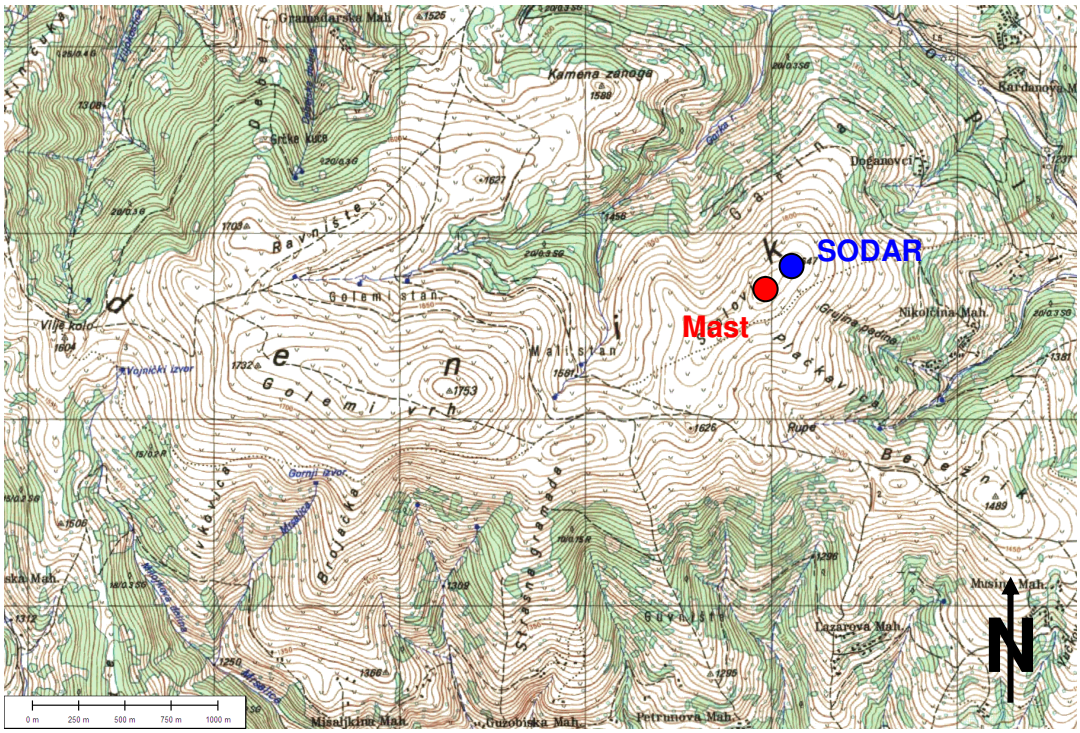

Fig. 1: Location of the SODAR (blue) and 30 m mast (red) at the Vlasina site.

Fig. 2: Panoramic pictures taken at the measurement site facing west (left) and east (right).

3. The measurement campaign

3.1. SODAR configuration

The installed SODAR was of type Aerovironment miniSODAR 4000F. Tab. 2 shows the configuration of the SODAR and Fig. 3 the installed SODAR at the Vlasina site.

Tab. 2: Configuration of the Aerovironment miniSODAR 4000F.

Parameter	Value
Minimum measuring height	20 m
Maximum measuring height	150 m
Measuring interval	10 m
Averaging interval	10 min
Alignment of the antenna	210°

3.2. SODAR measurement protocol

The measurement campaign started on August 19th 2009 and ended on October 23th 2009. Tab. 3 shows the measurement protocol of the campaign.

A battery pack, charged by a diesel generator was used as power supply. The diesel generator was operated manually by the local guards. As the instrument was not under surveillance during night time and as the capacity of the battery pack was not dimensioned for autonomous SODAR operation during a whole night, there were periods with bad data quality or interruptions in data collection during almost every night. These interruptions are not mentioned in the SODAR measurement protocol in Tab. 3.

Tab. 3: SODAR measurement protocol for Vlasina.

Event	Date / Time (CET)
Start of SODAR measurements	August 19th 2009, 17:10
Technical Problems with power supply	August 22th 2009, 23:50
Technical Problems resolved	August 31st 2009, 09:45
Blizzard – site inaccessible – no power supply	October 12th 2008, 23:50
Site accessible again – operation of SODAR resumed	October 16th 2008, 09:37
End of SODAR measurements	October 23th 2008, 19:50

Fig. 3: Picture with the SODAR (right) and the 30 m mast (left) facing west.

4. Data availability

SODAR measurements do not produce complete time series, because factors like surrounding noises, clouds, atmospheric stabilities or precipitation lead to gaps in the data sets. These effects are filtered from the data sets considering the surrounding noise or the signal-to-noise ratio. Fig. 4 shows the time series of the data availability at each measurement level for the entire measurement campaign at Vlasina, Fig. 5 shows the amount of available data at each level after cleaning the data.

As the instrument was not under surveillance during night time and as the capacity of the battery pack was not dimensioned for autonomous SODAR operation during a whole night, there were periods with bad data quality or interruptions in data collection during almost every night.

In order in increase the number of valid vertical profiles for further analysis, the maximum height was reduced to 100 m agl.

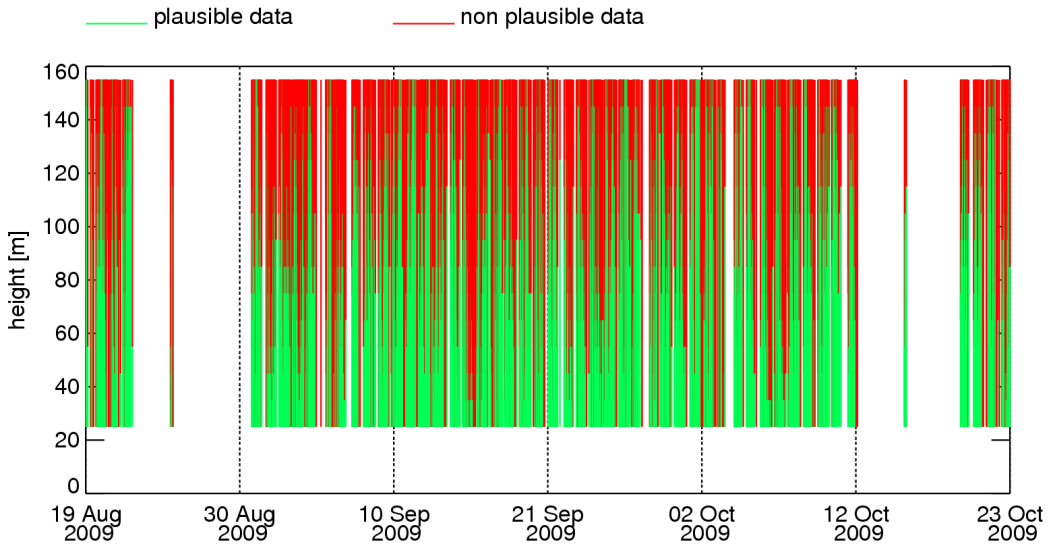

Fig. 4: Time series of the data availability of the SODAR measurements at Vlasina for each measurement level. Plausible data are displayed in green, rejected values in red. During white period, the SODAR was not operating.

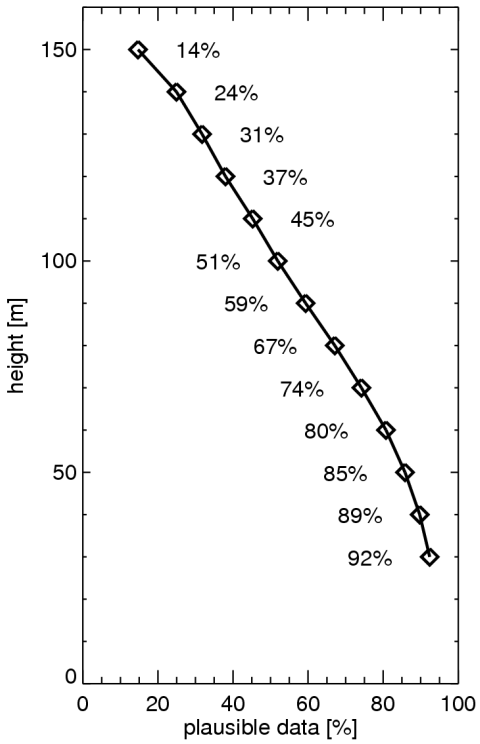

Fig. 5: Amount of available data of the SODAR measurements at each level at Vlasina.

5. Results

5.1. Wind speed / wind direction

Fig. 6 shows the 10 minute wind speed values of the SODAR measurements at Vlasina for four different height levels, Fig. 7 the 10 minute wind direction values for four different height levels.

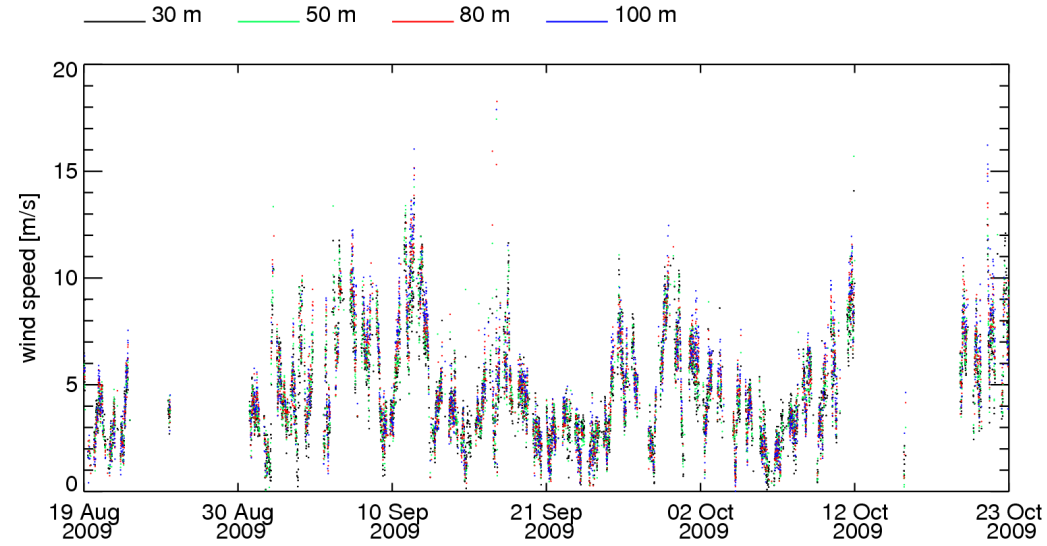

Fig. 6: The 10 minute wind speed averages of the SODAR measurements at Vlasina at 30, 50, 80 and 100 m above ground.

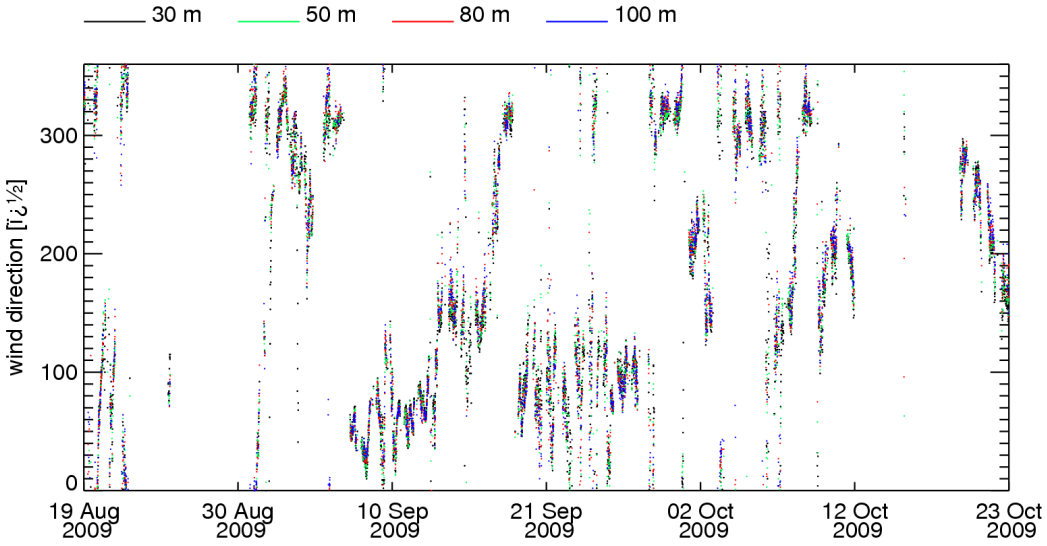

Fig. 7: The 10 minute wind direction averages of the SODAR measurements at Vlasina at 30, 50, 80 and 100 m above ground.

5.2. Wind roses / turbulence roses

Fig. 8 shows wind roses and turbulence roses for five levels. During the measurement campaign winds from southwest and from east were prevailing.

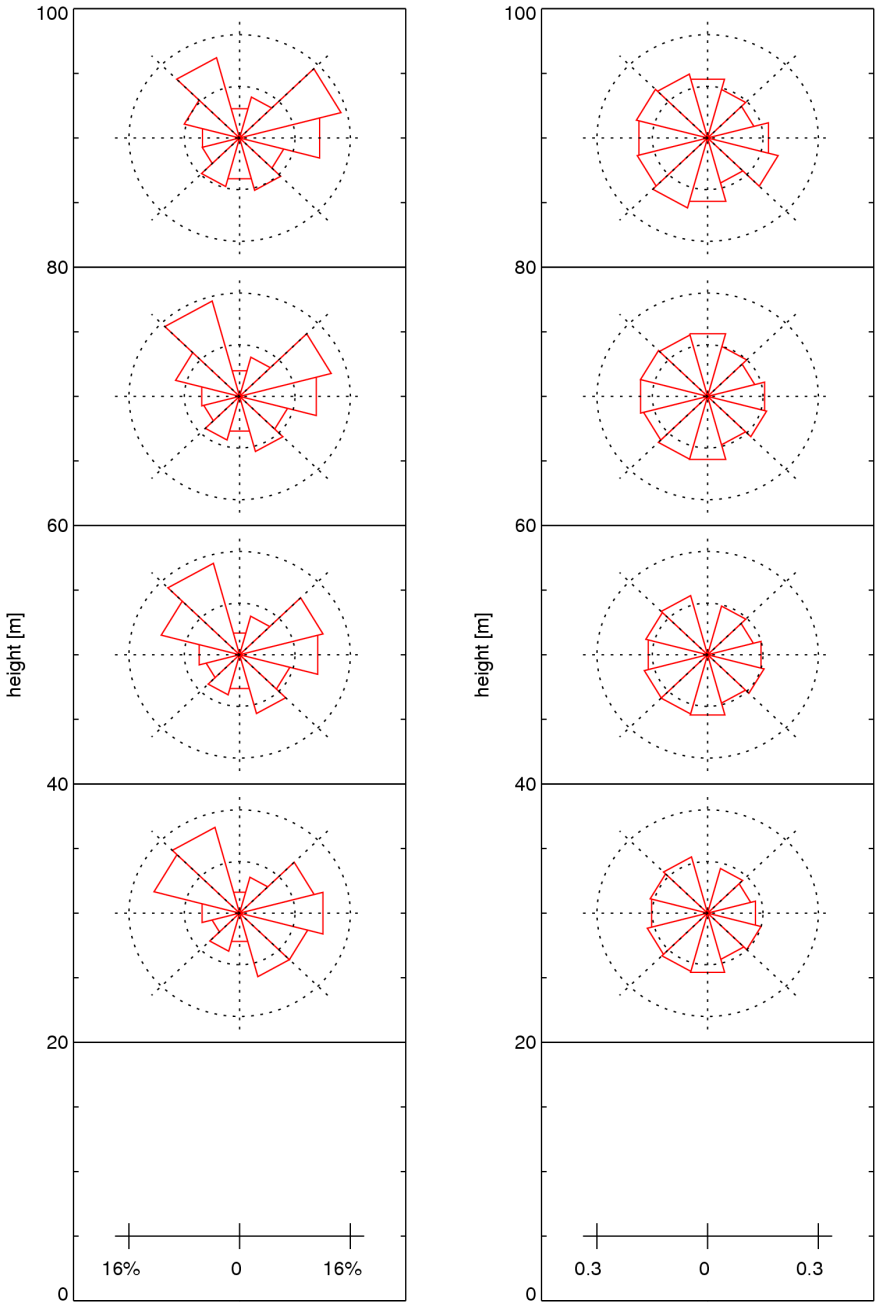

Fig. 8: Left: Wind roses of the SODAR measurement at Vlasina at 30, 50, 70 and 90 m above ground. Right: Turbulence roses at 30, 50, 70 and 90 m above ground. The calculation of the turbulence intensity has only been carried out for wind speeds greater than 4 m/s.

5.3. Vertical profiles of wind speed

Fig. 9 shows the vertical profiles of wind speed scaled to 30 m height in 30° wind direction sectors.

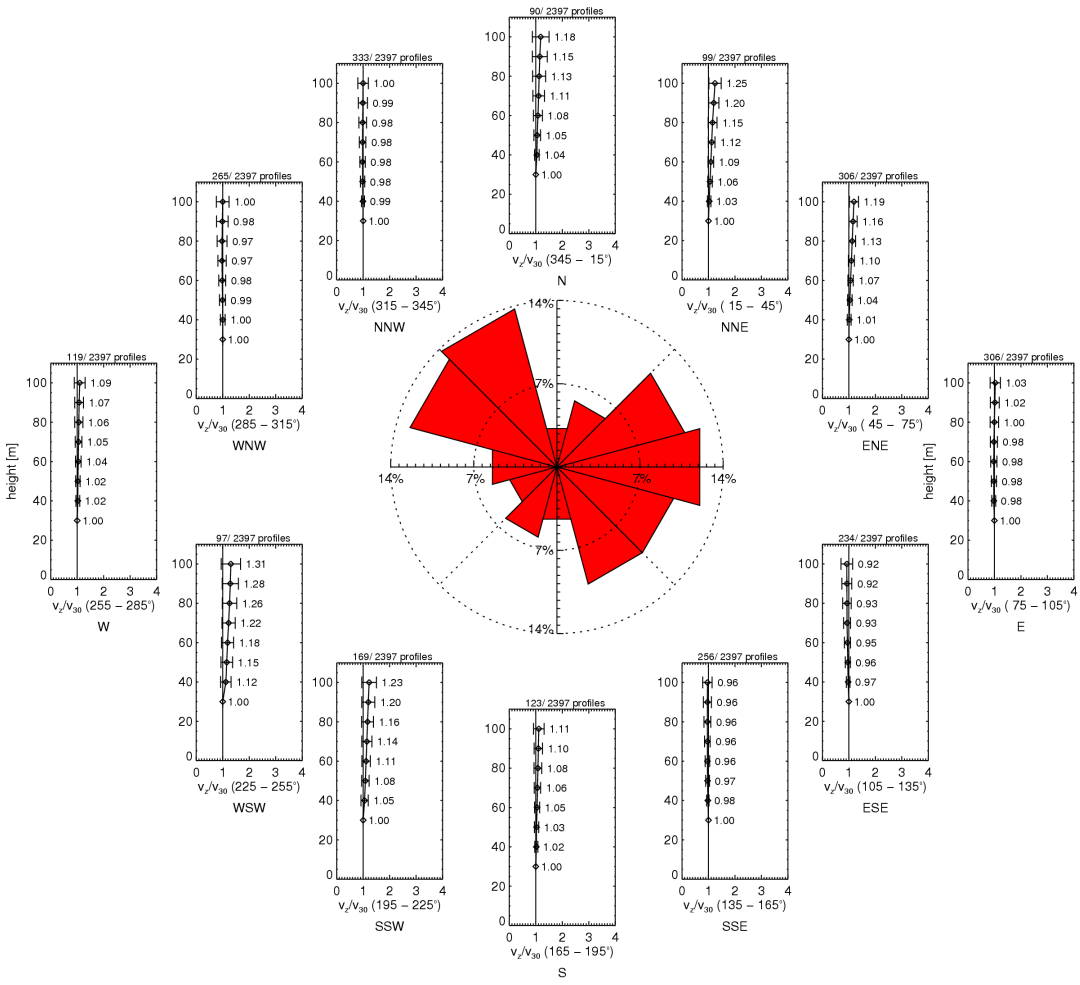

Fig. 9: Vertical profiles of wind speed for 30° wind direction sectors, scaled to 30 m height at the SODAR measurement site Vlasina. The bars indicate the standard deviation. No profiles are shown for sectors with less than fifty 10 minute averages. In the center the wind rose at 30 m is displayed.

Fig. 10 shows the vertical profiles of wind speed scaled to 30 m height for the main wind directions northwest and east for different wind speeds as well as the statistical mean errors of the profiles.

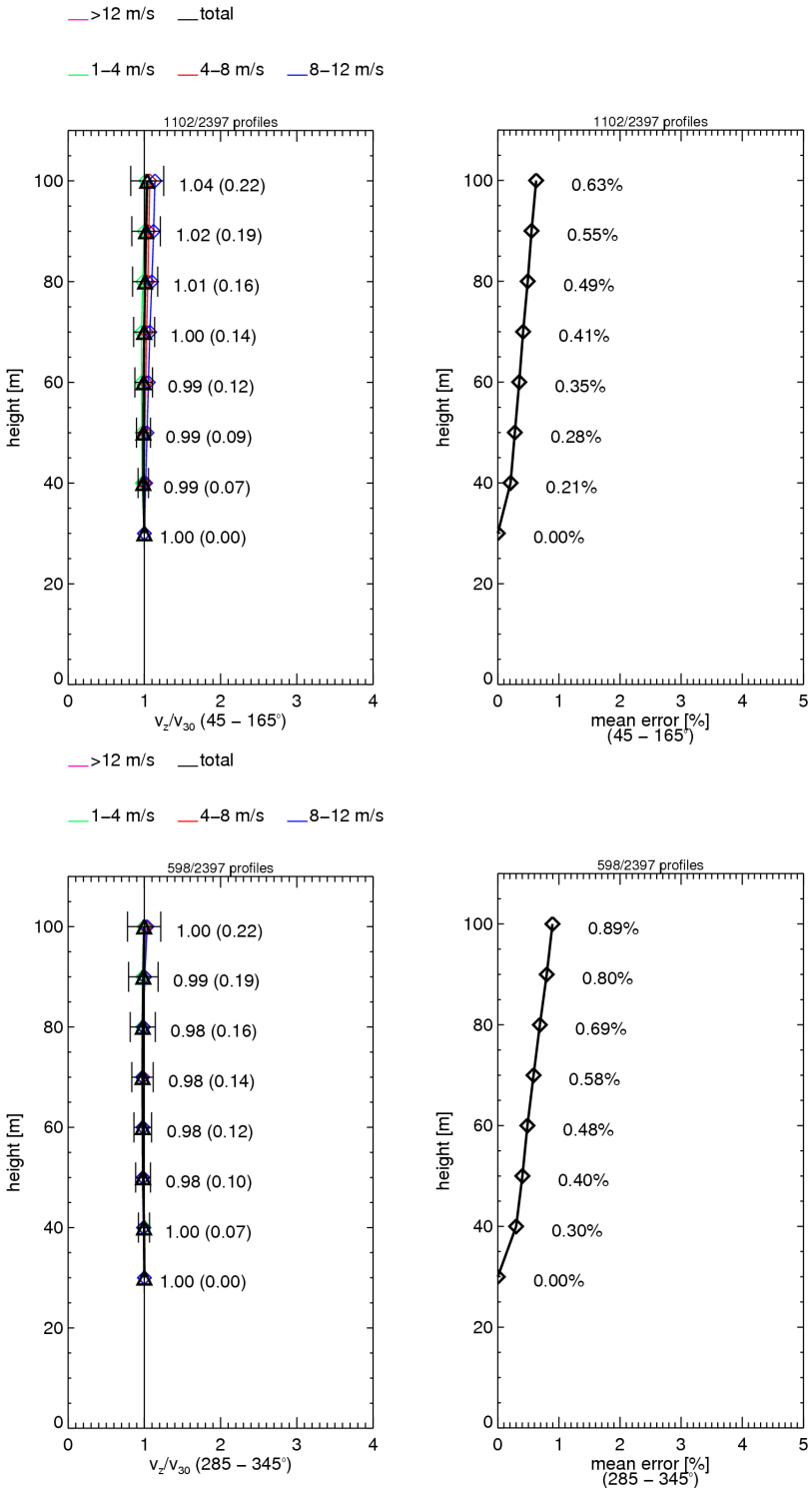

Fig. 10: Vertical profile of the wind speed for the main wind directions east (top) and northwest (bottom) for different wind speeds (left) and the mean error of the profile (right).

5.4. Vertical profiles of turbulence

Fig. 11 shows vertical profiles of the turbulence intensity at Vlasina. Turbulence intensity was calculated only for wind speeds above 4 m/s. No turbulence was calculated for sectors/levels with less than ten valid 10 minute averages.

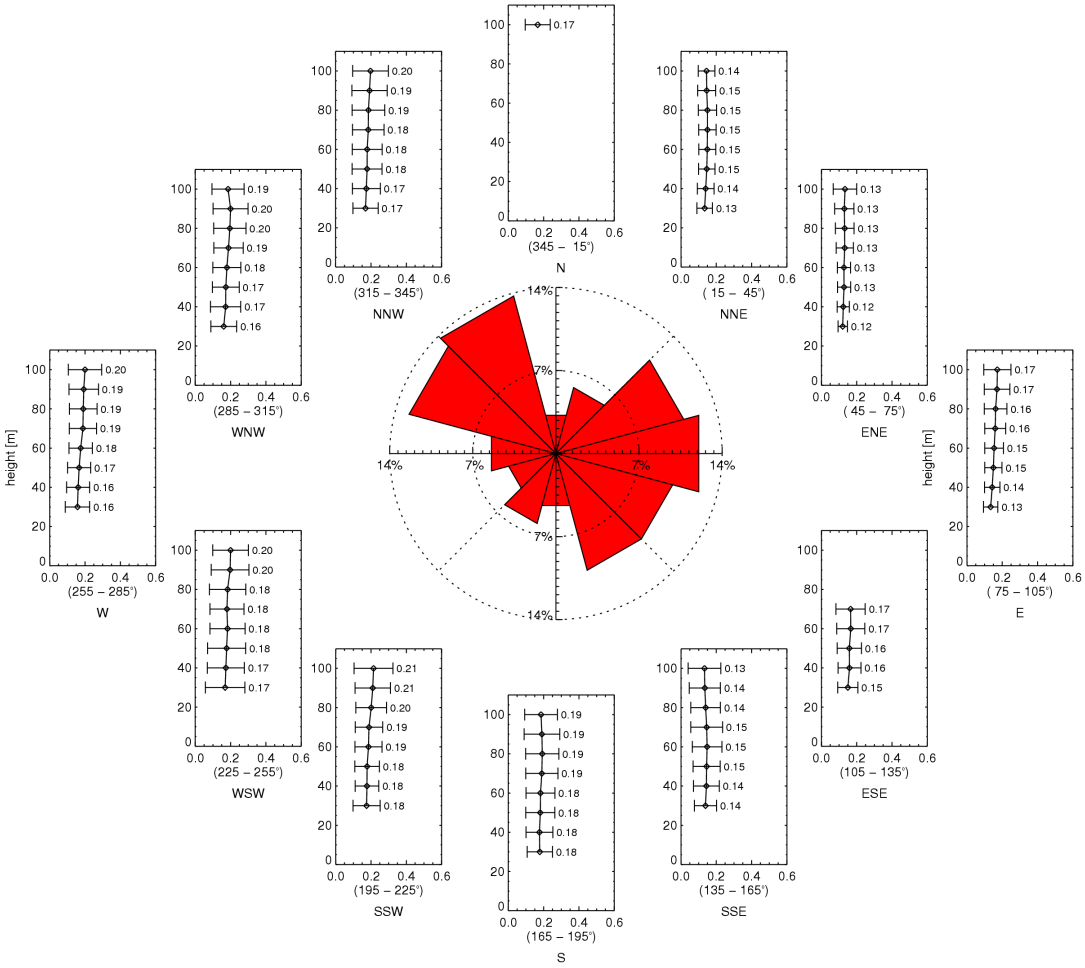

Fig. 11: Vertical profiles of turbulence intensity for 30° wind direction sectors at the SODAR measurement site Vlasina. The bars indicate the standard deviation. In the center the wind rose at 30 m is displayed. Turbulence intensity was calculated only for wind speed greater than 4 m/s. No turbulence was calculated for sectors/levels with less than ten valid 10 minute averages.

5.5. Vertical wind component

Fig. 12 shows the vertical component of the wind at Vlasina for the wind directions northwest (blue) and east (red).

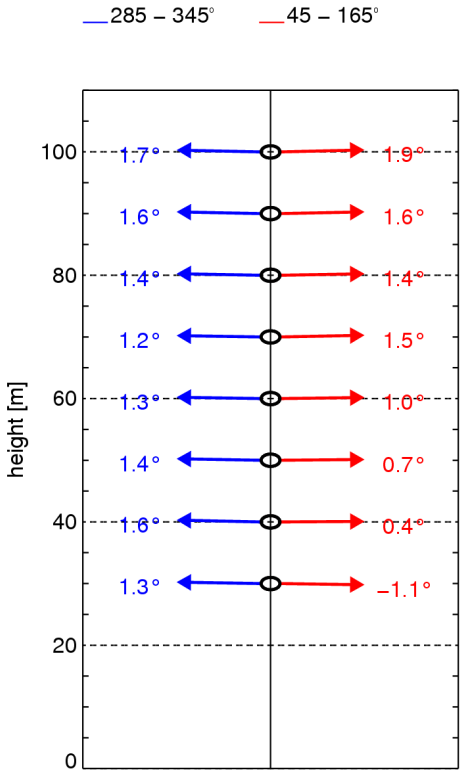

Fig. 12: Vertical component of the wind at Vlasina for the wind directions northwest (blue) and east (red).