Global Windmapping Service (GWS)

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Abstract

In order to obtain a general understanding of the wind potential for planning wind energy projects, AL- PRO GmbH & Co. KG provides high- resolution wind maps. The accuracy of the GWS® Meso Maps is verified by comparing the calculated wind speed and wind rose with weather stations worldwide. This paper summarizes the result of the validation.

1 Introduction

The company AL- PRO GmbH Co. KG provides GWS® Meso wind speed maps. The simulation of the wind maps is based on a mesocale model with the NCAR/NCEP reanalysis dataset [1] as an input. The dataset contains data for 43 years, from 1958 until 2000. The GWS® Meso maps cover an area of 2.5 degrees x 2.5 degrees (approximately 200 x 300 km in the temperate zone) and are available for areas between 60°S and 60°N. The resolution of the maps is 2 x 2 km and the reference height is 60 m or 120 m above ground level. The maps are available as hard copy maps and as digital maps for Google Earth and the GWS® Viewer.

2 Validation method

To ensure the quality of the calculated GWS® wind speed maps, the results were compared with a reference dataset at a height of 10 m above ground level. The reference dataset is based on the data of the *Deutscher Wetterdienst* [2], *European Wind Atlas* [3] as well as the *Wind Atlas of the European Central Countries* [4]. Additionally, it is based on data from *Wetteronline GmbH* [5]. Currently, the validation database includes data from approximately 400 weather stations worldwide.

2.1 General aspects of the reference data

Wind statistics are usually referred to a long-term period in order to consider annual variation of the wind speed. In this study the reference dataset covers a ten year period in the majority of cases whereas the GWS® wind speeds base on a dataset of 43 years. Here and there the fact might influence the mean annual wind speed of the reference data and therefore the deviation. Since the aim of the GWS® dataset is a general understanding of the wind potential and is not meant to replace measurements those short- term data were used. Excluding short-term data would set the reference dataset to a minimum.

Another aspect of the validation is the low reference height of 10 m. At this height there is a strong influence of the surrounding area. Since there are no well documented publicly reference data available at 60 m above ground level this study compares the data at 10 m above ground level. Although some observation data are lower or higher than 10 m, those data were excluded from the validation in order to analysis just one reference height.

2.2 Description of datasets

The *European Wind Atlas* contains comprehensive wind statistics for more than two hundred stations covering the western European countries. For each station data of over 10 years are recorded. Besides the station description each station resumes a raw data summary, calculated regional Weibull parameters and calculated regional mean wins speeds and energies. Furthermore, the European Wind Atlas is a handbook for regional wind resource assessment and local siting of wind turbines, including computational procedures for the effects of shelter, roughness and orography on power production.

The dataset of the *Deutscher Wetterdienst* is an appendix of the *European Wind Atlas* and provides wind data of 107 stations in Germany. The dataset contains data from 1976-1995. Whereby the period for each station differs and some stations contain data for only 5 years. For each station a station description, a raw data summary, the calculated Weibull parameters as well as the calculated regional mean wind speed is summarized.

About 40 stations are listed in the *Wind Atlas of the European Central Countries.* The stations are located in Austria, Croatia, Czech Republic, Hungary, Slovakia and Slovenia. The content of the data is similar to the dataset of the European Wind Atlas. The period of the dataset varies between 1975 and 1995. As with the period of the *Deutscher Wetterdienst*, the period of each station differ. The time series varies between 3 years and 14 years.

The company *Wetteronline GmbH* provides weather observations worldwide via the internet. The mean annual wind speeds as well as the wind distribution are presented. The period of the observations varies between several years and several decades. There is no supply of a detailed description of the location.

2.3 Determination of met mast location

With the help of the detailed station description provided by the three atlases, the positions of each station were located in Google Earth. If required, the position of the station was corrected manually. In some cases the detailed description was missing. Therefore, the location was positioned via the city name and if existing via the remark of an airport position. The weather stations with an inconclusive location were excluded from the validation.

2.4 Proceeding the validation

For each calculated GWS® map at least three stations were analyzed. Besides the annual mean wind speeds, the wind roses were compared qualitatively.

At first, the weather stations from the atlases were used. In case of no data from the three atlases, the calculated wind maps were compared with the data from Wetteronline GmbH.

3 Results

3.1 Comparison GWS® wind speed data with validation data

The comparison of GWS® data and validation data indicates that 54 % of the data are within +/- 0.5 [m/s]. As shown in Figure 1, 82 % of the data are within +/- 1 [m/s]. Less than 9 % of the GWS® data deviate more than 1.5 [m/s] from the weather stations.

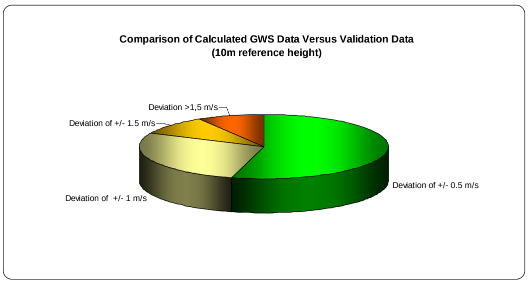


Figure 1: Comparison of Calculated GWS® Data and Validation Data

Considering the model resolution of 2 x 2 km on the one hand and the strong influence of local effects in the low reference height of 10 m on the other hand, these results show that the GWS® data can be regarded as very good.

A histogram of the deviation of the GWS® dataset minus the validation data is displayed in Figure 2. The histogram shows that the majority of the data deviate within +/- 0.5 [m/s]. Regarding the distribution of the positive and negative deviation one can see that there is no tendency to over- or underestimation of the measured data by the GWS® data.

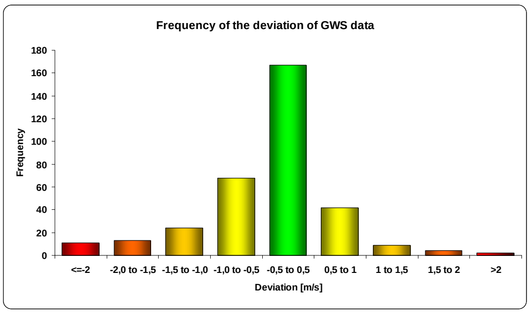


Figure 2: Frequency of the deviation of GWS® Data

The analysis shows no significant correlation between the GWS® wind speed data and the absolute value of the deviation (see Figure 3). Therefore, the error of the GWS® data is independent of the calculated wind speeds. Particularly, there is no tendency to larger errors at higher wind speeds. In addition, there is no tendency towards under- or overestimation of the calculated GWS® dataset.

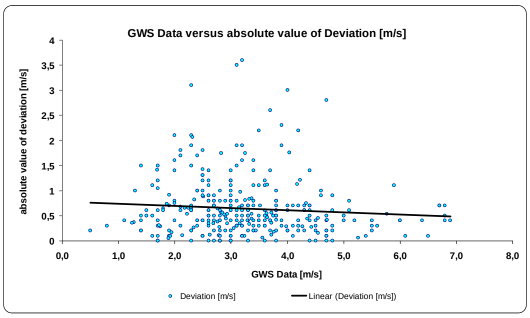


Figure 3: Correlation between GWS® data and deviation data [m/s]

3.1.1 Analyzing regional distinctions

The map in Figure 4 illustrates on the one side the geographical location of the meteorological stations and on the other side the deviation of the GWS® data and the validation data of Europe. As one can see there is no particular region of minor or maximum differences. Besides that there are variations in the differences of the GWS® data and the reference data from region to region. For example, in the United Kingdom and in the Central European Countries the deviation is between + 0.5 [m/s] and – 0.5 [m/s] whereas in the eastern part of Europe the values differ between -2 [m/s] and + 2 [m/s]. It is not clear if this higher deviations in eastern Europe are caused by the model results or maybe lower quality of the reference data (shorter time periods of measurement, lower quality of measurements).

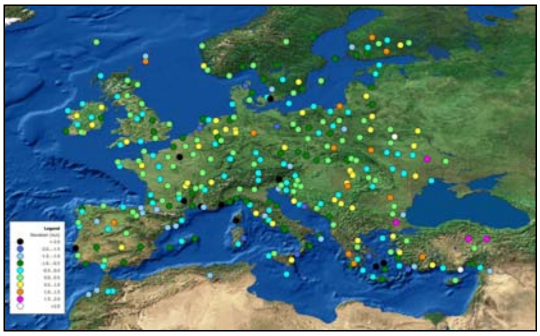


Figure 4: Geographical location of the meteorological stations with the deviation [m/s]

3.1.2 Analyzing type of stations

A check of the deviation depending on the topography of the GWS® model at several data point in France and Poland shows that the stations which are located close to cities are underestimated (e.g. Paris and Poznan). This is an expected result due to the fact that the GWS® wind speeds always represent the average of a 2x2 km square, based on topographic information in the same resolution. In urban areas therefore the model delivers low wind speeds while wind measurements are usually located at sites with more open direct environment and therefore measure wind speeds above the average of a 2x2 km surrounding area.

Furthermore, in many cases stations nearby coastlines are underestimated as well (e.g. Istres, France), more or less for the same reason. The model delivers the average result for the first 2x2 km onshore square. As wind speed decreases significantly with the distance from the shoreline in the first several 100 m, especially in a height of 10 m a.g.l. stations close to the shore will measure higher wind speeds.

Especially in flat terrain areas mainly low deviations are observed.

3.1.3 Analyzing wind rose

Figure 5 depicts several comparisons of the wind roses of the reference data and the simulation data. The majority of the cases show a match (e.g. Toulouse). Furthermore, in some cases the wind roses differ (e.g. Capo Palinuro).

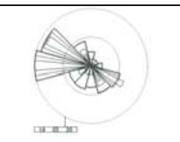
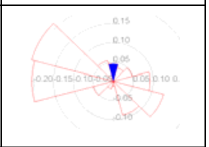
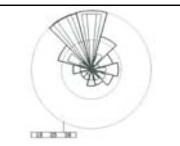
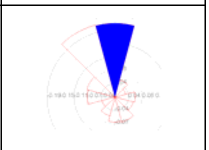
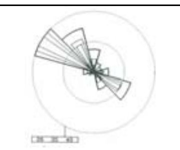
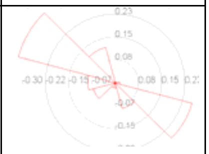
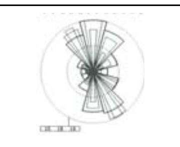
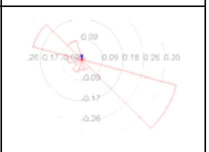
	Reference data	Simulation data
Toulouse, France		
Istres, France		
Uras, Italy		
Capo Palinuro, Italy		

Figure 5: Samples of wind roses of reference data and simulation data.

This study contains no classification of the deviation of the wind roses and therefore no statistical analysis.

4 Conclusion

AL- PRO GmbH & Co. KG provides GWS® Meso maps with a resolution of 2 x 2 km at a reference height of 60m and 120m worldwide to get a first impression of the wind resource. The accuracy of the GWS® data is verified by comparing the wind maps with weather stations worldwide. The validation shows a deviation of +/- 0.5 [m/s] for the majority of the GWS® data. Considering the aim of the GWS® maps this result can be regarded as very good.

References

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[5] www.wetteronline.de (02.03.2009)