NCEP/NCAR REANALYSIS DATA FOR THE PORTUGUESE MAINLAND

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ABSTRACT: Local measurement periods, typically ranging from 1 to 5 years, are short when compared with the standard period for average climate definition of 20 to 30 years. The annual variability of the wind regime, if not accounted for, adds to the uncertainty of the site's resource assessment and can lead to serious misevaluations.

Not surprisingly, the use of Long Term wind data is an old issue in wind resource assessment. The typical methods of eliminating the annual variations of the wind regime from the average are correlations like the MCP technique. However, the availability of such long periods of wind data is not as frequent as desired.

The NCEP/NCAR Reanalysis project gives access to more than 50 years of climate data, including the geostrophic and surface wind intensity and vectors. This data is the result of global scale climate models, based on surface, radiosondes and satellite measurements. The spatial resolution of the data is of around 260x260 km and the time resolution is 4 time daily data. Necessarily, the applicability of such data to Portuguese sites needs to be evaluated.

The Reanalysis data has been compared with local measurements from 20 wind measurement stations spread throughout the territory. Comparisons were made in terms of correlation quality for different sampling periods. In general, results show that the geostrophic data can provide a good approach on the annual variations of the wind intensity. Some limitations were found and these should be accounted for.

The variability of the wind regimes, namely wind intensity, was also assessed.

Keywords: NCEP/NCAR Reanalysis, Long Term wind data, Annual variability

INTRODUCTION

The annual variability of the wind regime adds a degree of uncertainty to the wind resource assessment of analysed sites. Determining this variability is essential for an efficient evaluation of a windfarm's wind potential for the expected duration of its operational life.

The denoted "Reanalysis" project resulted from the joint collaboration of the National Centers for Environmental Prediction (NCEP) and of the National Center for Atmospheric Research (NCAR) with the intention of performing a global analysis of atmospheric fields and making this data available to climate monitoring and research communities.

The model used in the Reanalysis is the NCEP global spectral model with a horizontal triangular truncation of 62 waves (T62), equivalent to 209 km. The climate data used in the Reanalysis results from observations of classic meteorological stations, radiosondes, satellites, among others. The data is subjected to a thorough quality control in order to eliminate possible errors and is then run in the model, producing a number of climate variables such as wind speed for surface and for different pressure levels. The length of available data is extensive, lasting from 1948 to the present date. The data is presented with a frequency of six-hour samples and a worldwide spatial resolution of 2.5 degrees latitude and longitude (approximately 280x280 km). [1]

This study compares the quality of the correlation between the Reanalysis data taken at the grid point (7.5º W, 40º N), approximately located in the centre of Portugal, and the measurements from local met stations. The intent was to evaluate the technical feasibility on the use of the climate information available from the Reanalysis project and its representativity for wind resource assessment.

WIND DATA SETS

The climate data sets used in the evaluation of the correlation are obtained from the NCEP/NCAR Reanalysis cell centred at the grid point (7.5º W, 40º N) and 20 wind measurement stations.

For the Reanalysis data, the variables used were the horizontal vector of wind speed (u, v) of the surface and pressure level data. For the surface level data, these variables are forecast at 10 meters a.g.l and are valid for six-hour periods from the reference time. The u and v variables at 10 m are classified as “B“ variables, meaning that although these values are directly affected by observations, the model used in the Reanalysis also has a strong influence in the results. For the pressure level data these variables are instantaneous values, only valid at the time listed. The pressure levels used in this analysis were the 850, 925 and 1000 hPa. [1]

For correlation purposes 20 wind measurement stations in mainland Portugal were chosen. A large proportion of met stations in the Reanalysis cell area was used. It was also possible to access climate data of some stations located in the north, costal and south of Portugal. Their locations is shown in figure 1.

The period selected for this analysis was from December 2001 to November 2005 in order to coincide with the period in which the measurement campaigns for the met stations have been conducted. Only stations with a monthly speed data availability greater than 80 % were chosen.

The data of the stations was available in ten-minute averages. These records were later converted to six-hour averages centred at the simultaneous Reanalysis data record.

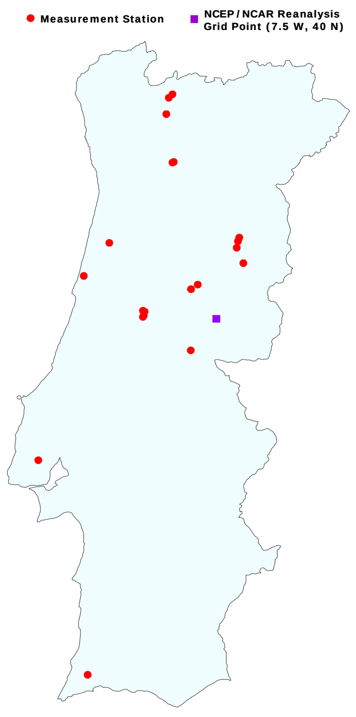

Figure 1: Met stations and NCEP/NCAR Reanalysis project cell centre grid point

CORRELATION BETWEEN DATA

The correlation coefficients R^2 of the linear regressions between the six-hour data, monthly averages and the annual moving averages are presented in tables 1, 2 and 3. Figure 2 summarises the results for the 925 hPa pressure level which resulted in best correlations. Notice that for determining the correlation of the annual moving averages, only stations 18 and 20 were used since they had the longer periods of available data.

Table 1: Correlation coefficient R^2 for the 6h Data

Station	10 m	Pressure Level [hPa]			Number of records
		1000	925	850	
1	0.38	0.29	0.29	0.24	1366
2	0.38	0.32	0.34	0.32	1270
3	0.39	0.32	0.39	0.37	1275
4	0.35	0.23	0.19	0.16	674
5	0.36	0.37	0.34	0.27	1241
6	0.32	0.26	0.27	0.20	1170
7	0.32	0.28	0.32	0.24	1166
8	0.26	0.24	0.37	0.37	1154
9	0.24	0.25	0.41	0.40	1166
10	0.39	0.41	0.51	0.55	1701
11	0.32	0.39	0.49	0.44	1313
12	0.38	0.40	0.48	0.50	1714
13	0.40	0.33	0.40	0.41	1117
14	0.42	0.43	0.39	0.27	1142
15	0.40	0.33	0.21	0.05	1085
16	0.18	0.11	0.08	0.02	1462
17	0.23	0.34	0.42	0.40	1386
18	0.16	0.16	0.24	0.24	3721
19	0.26	0.35	0.42	0.43	1288
20	0.25	0.18	0.19	0.16	4049
Average	0.32	0.30	0.34	0.30	

Table 2: Correlation coefficient R^2 for the Monthly Data

Station	10 m	Pressure Level [hPa]			Number of records
		1000	925	850	
1	0.21	0.64	0.67	0.71	11
2	0.52	0.80	0.66	0.53	10
3	0.42	0.81	0.83	0.72	10
4	0.44	0.42	0.35	0.35	5
5	0.39	0.69	0.43	0.40	10
6	0.45	0.52	0.46	0.42	9
7	0.52	0.58	0.56	0.49	9
8	0.34	0.71	0.83	0.78	9
9	0.29	0.69	0.84	0.79	9
10	0.40	0.72	0.84	0.89	14
11	0.58	0.83	0.90	0.85	11
12	0.57	0.54	0.67	0.71	14
13	0.16	0.78	0.85	0.78	8
14	0.42	0.58	0.47	0.43	9
15	0.42	0.58	0.47	0.43	8
16	0.05	0.47	0.49	0.43	12
17	0.01	0.56	0.85	0.79	12
18	0.16	0.36	0.55	0.63	32
19	0.04	0.59	0.87	0.87	12
20	0.36	0.11	0.08	0.09	36
Average	0.34	0.60	0.63	0.60	

Table 3: Correlation coefficient R^2 for the Annual Moving Averages

Station	10 m	Pressure Level [hPa]			Number of records
		1000	925	850	
1	-	-	-	-	-
2	-	-	-	-	-
.	-	-	-	-	-
.	-	-	-	-	-
.	-	-	-	-	-
.	-	-	-	-	-
.	-	-	-	-	-
.	-	-	-	-	-
.	-	-	-	-	-
17	-	-	-	-	-
18	0.60	0.46	0.68	0.72	16
19	-	-	-	-	-
20	0.71	0.38	0.62	0.71	25
Average	0.65	0.42	0.65	0.72	

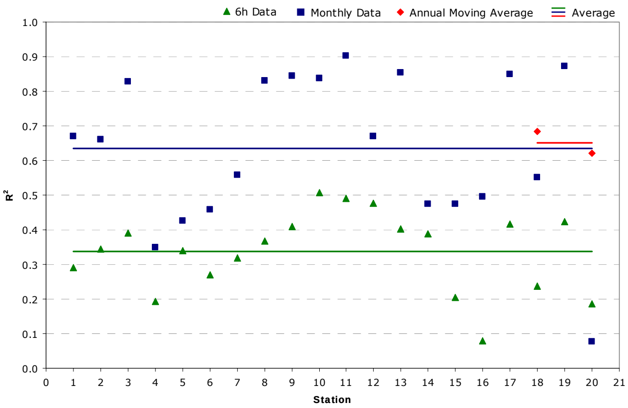

Figure2: Correlations quality for the 925 hPa pressure level

The correlations for the six-hour periods are poor for all data sets. In fact, the higher correlation coefficient values are around 0.5 and were found for station 10 at 925 and 850 hPa pressure levels.

In the monthly data the correlation quality improves considerably being the best results found for stations 11 and 19 at 925 hPa pressure level.

The use of annual moving averages leads to better correlation factors for the two cases in which this technique was experimented. Particularly relevant is the improvement of the correlation coefficients for station 20.

The correlations for station 20 are very different from the average of the other stations, showing a very low correlation for the 6h and monthly data. For the 925 hPa pressure level, the average result of R^2 is 0.63 and varies between 0.08 and 0.9, although the lowest value corresponds to station 20. If this station was not considered, the average result of R^2 would be 0.66 and the lowest and highest values, 0.35 and 0.9.

Figures 3, 4 and 5 compare the evolution of both the Reanalysis and the met station 18 data for the different analysed integration periods. Figure 6 shows the correlation of the same data sets, for the analysed period.

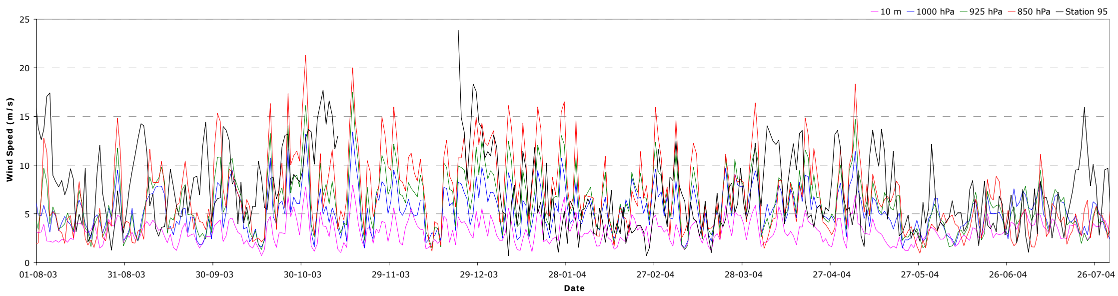

Figure 3: Overlay of a station 18 sample data on the 6h data from the Reanalysis

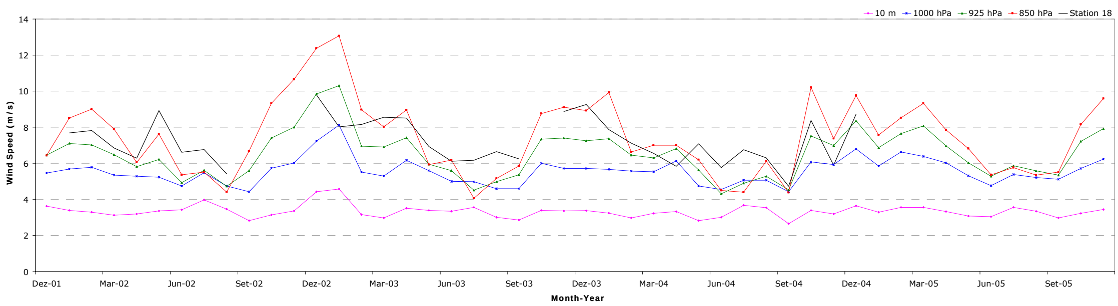

Figure 4: Overlay of the station 18 data on the monthly data from the Reanalysis

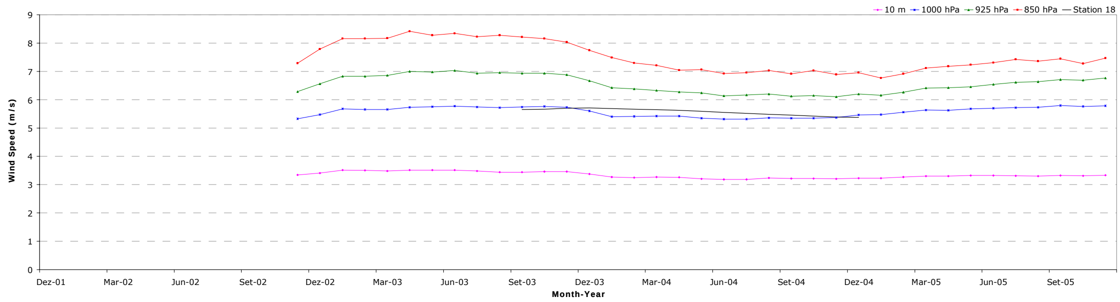

Figure 5: Overlay of the station 18 data on the annual moving average from the Reanalysis

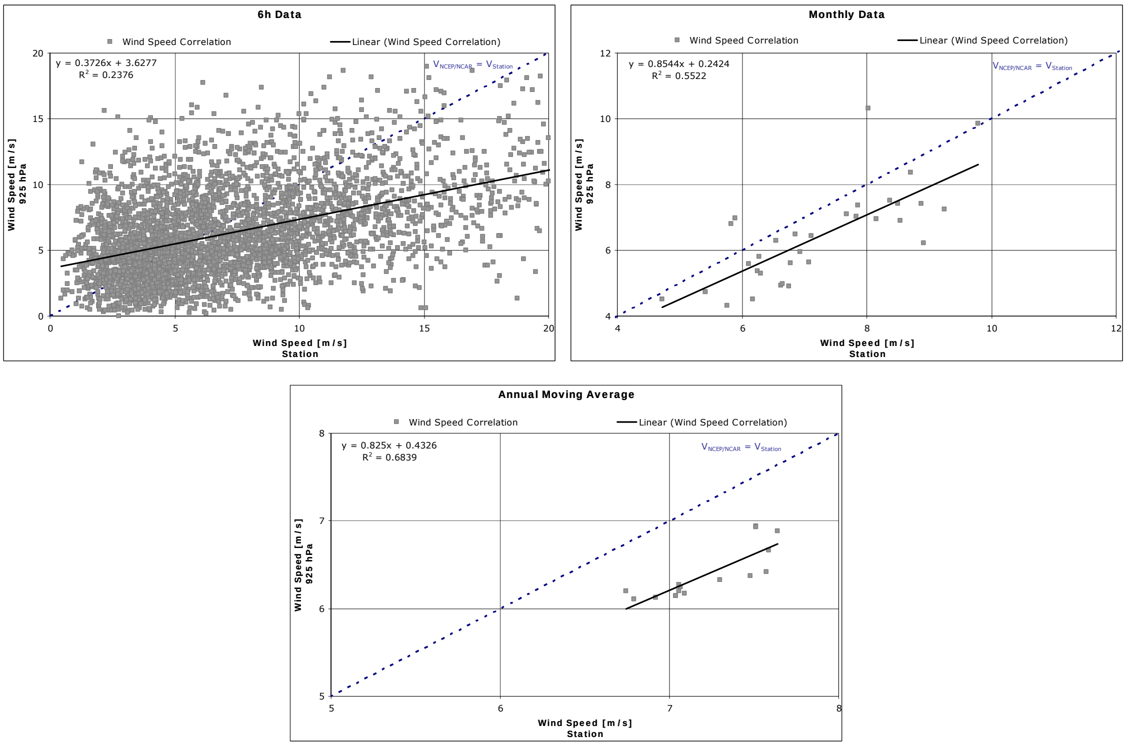

Figure 6: Correlation of station 18 data and the 925 hPa pressure level for different integration periods

WIND RESOURCE VARIABILITY

The Reanalysis and the station 18 data sets were investigated for a first evaluation and comparison of the variability in the wind intensity for a given period.

The studied period corresponds to a total of 32 months, from December 2001 to December 2004.

Tables 4 and 5 summarise the absolute deviations of wind speed from average for the 6h (ΔH), the monthly (ΔM), and the annual moving average (ΔA) data.

Table 4: Variability of the wind resource: absolute deviations from average

	925 hPa Pressure Level Data			
	Average	Maximum	Minimum	Standard Deviation
ΔH [%]	43.9	225.8	0	32.8
ΔM [%]	16.5	32.0	4.5	9.1
ΔA [%]	4.6	6.5	1.4	1.6

	Station 18 Data			
	Average	Maximum	Minimum	Standard Deviation
ΔH [%]	49.5	335.8	0	40.4
ΔM [%]	14.6	35.7	1.4	8.8
ΔA [%]	3.7	6.4	1.2	1.7

Remarkably the variability found, for all integration periods, is very similar in order of magnitude for both data sets. On an annual basis both series approximate the figure of 4 %. This gives a good indication for the use of Reanalysis data to assess annual deviation from long term average.

CONCLUSIONS AND FUTURE DEVELOPMENTS

In general, the geostrophic data seems to provide a useful approximation to the monthly and annual variations of wind intensity in mainland Portugal.

The six-hour data from the Reanalysis project has a poor correlation with measurements from local stations due to the high variability of both data series. The correlation tends to improve when the data is compared on a monthly and annual basis.

The surface level data seems inadequate to be used in wind energy studies due to the poor correlation on all stations.

The pressure level demonstrates a good approximation to the local measurements with special relevance for the 925 hPa pressure level.

The wind intensity variability from the average for the analysed period shows a similar behaviour for both the 925 hPa pressure level data and the station 18. The deviation is smaller when compared on an annual basis and approximates to 4 % on both data sets.

Further work must be done and this analysis should be continued with other wind measurement stations comprising longer periods of data as they become available.

The same study should be performed on other NCEP/NCAR Reanalysis grid points and the correlation quality between the different grid points and theirs combinations should also be evaluated.

Possible relationships between terrain characteristics and correlation values should also be investigated.

The establishment of the existence of a predominant periodicity in the long term wind variation could provide valuable information on the behaviour of the wind climate for the upcoming years.

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