Influence of topographic maps on energy production assessments

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Abstract

The accuracy of Energy Production Assessments (EPA) strongly depends on the input data. It will be shown that the use of accurate maps can prevent from large errors on the wind flow modelling results. A number of sites for this investigation has been selected which are grouped in three classes; simple terrain, complex terrain without forestry and complex with forestry. Final EPAs are based on maps which are considered the reference scenarios ("reference maps"), whilst the results obtained with low-resolution satellite based maps deviate from the reference. In addition, reference maps have been clipped within a larger area and combined with satellite based maps.

Objectives

Despite the recognised importance of the map quality, few studies on the subject can be found in the literature and they typically focus on a limited amount of sites only. It is acknowledged that high resolution topographical data suitable for wind energy applications are not readily available in all countries. Therefore, low resolution satellite based digital maps can be a valuable alternative as they are freely available and cover currently almost 80% of the total Earth landmass. As their use for wind flow modelling may represent a source of error in any energy production assessment especially for complex and mountainous terrain, we have investigated the effects of low resolution satellite maps in terms of bias and statistical scatter introduced into the predicted wind speeds.

Methods

The topographical data available for the investigations were either 1:25,000 maps from the Italian military institution IGM (Istituto Geografico Militare) or higher resolution CTR (Carta Tecnica Regionale) maps which are typically 1:10,000 or 1:5,000 from local authorities. Publicly available digital terrain and elevation models include maps derived from satellite data; the most common source of such data is the National Aeronautics and Space Administration (NASA) Shuttle Radar Topographic Mission (SRTM) [1]. As part of this work, 29 different wind farm sites in Italy have been identified: 8 in simple terrain, 12 in complex terrain without forestry and 9 in complex terrain with forestry (picture as example), for a total of 417 turbine locations.

All locations have been investigated considering both a mono-directional and a multi-directional wind speed and direction frequency distributions at 80 m height. The wind flow model used for the calculations is the Wind Atlas Analysis and Application Program (WASP) [2]. For the purpose of this work, the wind flow model simulations were performed at each site with both the reference and the SRTM based digital height contour maps as input topographical data. We have also investigated the effect of clipping the reference map and using it in combination with SRTM data on 9 sites. The reference maps have been increasingly cropped and the removed area replaced by SRTM maps.

Results

The data are presented as the ratios of the wind speeds at the turbine locations calculated with the SRTM maps over the wind speeds calculated with the reference maps. These are referred to as ratios R. The ratios R are plotted for the three cases (simple, complex without forestry and complex with forestry terrain) in terms of frequency of occurrence and fitted by normal PDF functions based on the mean and standard deviation values obtained with the data. The agreement between the data and the normal PDF function is observed to be excellent for the complex terrain without forestry case. Some deviations can be observed in the other cases. Although this is expected for the simple terrain case, the result was not anticipated for the complex sites with forestry and further investigations will aim at including additional sites in the analysis.

Conclusions

Standard deviations of 0.6%, 1.5% and 1.4% are obtained in simple terrain, complex terrain without forestry and complex terrain with forestry respectively when satellite based maps are used instead of high resolution maps to calculate the wind speeds at given positions. In complex terrain, the results suggest that SRTM based maps tend to introduce some bias into the wind speed predictions if compared to the reference case. The results of the investigations on the clipping of the reference map suggest that acceptable levels of accuracy are achieved with a relatively limited extension of the high resolution map. However, the statistical significance of the results must be increased by including additional sites in the analysis.

References


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