

Precision of EMD-WRF reanalysis for wind power estimations, using WindPRO

Popular scientific summary

Mathieu Bruneau

Division of Industrial Electrical Engineering and Automation

Faculty of Engineering

Lunds Tekniska Högskola

∩

ENCIS Environnement

Wind development is a long and costly phase, sometimes wind power plants can take more than four years to be build. In that context, one year is already used to record the wind data (speed and direction) and after a full year of recording, it is possible to notice that the site does not have enough potential to install a wind farm.

One solution looked into here is to use computer generated wind data, *reanalysis*, to do a wind estimation of a site. Those are available immediately and cover different years of data.

Unfortunately, their precision still need to be improved, my work focused on looking for criteria to reduce the uncertainty of those reanalysis. Terrain complexity was noticed as having an impact on the reanalysis precision.

I. INTRODUCTION

The layout of wind power plants has to be decided in order to produce the maximum power possible. To do so, an assessment of the wind strength as to be done at the installation site. It is possible to record wind on this site for a full year, using costly equipment such as measurement masts. But this thesis focus on the possibility to use computer simulated wind data, called reanalysis, in order to do those wind power estimations. Unfortunately, using only raw reanalysis data lead to uncertainty on the estimated production and overestimation of the actual wind potential of the site.

This article gives a summary of the master's thesis *Precision of EMD-WRF reanalysis for wind power estimations, using WindPRO*, which explores different possibilities to reduce the uncertainties linked to the use of reanalysis data to assess a site wind strength.

One main idea of this paper is to look if the precision of the recently released reanalysis EMD-WRF is linked to the terrain complexity of a given site. It is done by comparing the reanalysis data with 23 real life measurements made in France.

By separating the studied sites depending on the terrain complexity, it is possible to see that the imprecision increases with the terrain complexity. Moreover, for simple terrains, ie. flat and without a lot of forest, the precision of the reanalysis seems to be linked to the altitude of the terrain as well as the correlation coefficient between the real wind data and the reanalysis wind data. Finally a corrected version of the reanalysis is proposed, depending of the terrain, which allow us to reduce the error in wind power production calculations.

II. REANALYSIS PRECISION

Different reanalysis are available. They are developed from different companies that use various mathematical models to compute them. There are two classes of reanalysis: the global reanalysis, that have a spatial precision of between 20 km to 100 km and the mesoscale reanalysis, such as EMD-WRF, which possess a precision of 3 km.

A literature review of the reanalysis shows that :

- Reanalysis have usually a positive bias, ie. the reanalysis wind speed is generally higher than the real wind speed.
- Reanalysis have a bias depending on the seasons, the bias is higher during winter and lower during spring or summer

III. GENERAL COMPARISON

A. Method

The company *ENCIS Environnement* provided wind data recorded on 23 sites situated in France. Those recordings are between 6 and 125 months long and the height of the measurements differ from 42 m to 122 m. The reanalysis data is downloaded directly from the WindPRO interface, which is a wind power software. Unfortunately, those reanalysis are only available with a spatial step of 3 km, so there is a need to "move" them to the measurement location of each site. To do

so, the software WindPRO is used to shift the reanalysis data by taking into account the terrain specificity. Two terrain features are taken into account: the relief, called orography, and the type of surface, called roughness. Both can hinder or improve the wind flow.

Then for each site, the precision of the reanalysis is calculated. Also, the monthly variability of the reanalysis is also investigated. For each month the precision of the reanalysis is taken into account.

In parallel, a test is performed to see if there is a trend between the reanalysis precision and the altitude of the site. A similar test is performed to look for a trend between the precision and the coefficient of correlation of the reanalysis with the real measurement, called in the study R . Indeed, coefficient of correlation indicates if the variability of two data sets are similar, so this test is done to see if similar wind speed variation implies that the wind speed is the same.

B. Results

It appears that reanalysis data overestimate wind speed by 18.6 % with an high standard deviation of 12.52 %. The monthly study shows that in winter the overestimation is higher and in summer the overestimation is lower. The high standard deviation shows that the reanalysis overestimation varies a lot depending on the different sites, ie. for some sites the overestimation was extremely high, around 40 %, and for others it was almost null. That is why it was decided to look for categories of sites that would decrease the scattering of the data. Once it is done, the idea is to propose, for each categories, an offset that will correct the reanalysis data in order to be closer to the reality.

The tests on the trend between the precision and the coefficient of correlation R and the altitude of the site did not permit to draw any clear conclusions, but it was decided to do those tests again with the terrain separations.

IV. TERRAIN CATEGORIES

A. Method

Each sites studied was separated depending on the complexity of the orography and of the roughness. In order to assess the complexity of a relief, the *Ruggedness Index* was used. It is a tool in WindPRO that calculates the steepness of an area. Then, for the roughness, it was de-

cidated to calculate the density of tree in the studied site. For those two parameters a threshold value was chosen to define a terrain as complex or simple. By doing so, four cases were created:

- Case 1: complex orography and complex roughness
- Case 2: complex orography and simple roughness
- Case 3: simple orography and complex roughness
- Case 4: simple orography and simple roughness

B. Results

The terrain separation led to standard deviation smaller than the general case and at the same time the sites with simple terrain, ie. few trees and flat terrain, showed to be the site with the lowest site imprecision (around 10 % with a standard deviation of also 10 %).

The study of trend showed that, for simple terrain only, correlation coefficient has a link with the precision: if the reanalysis has a similar variability with the real wind data, then the precision of the reanalysis is more likely to be high. It was also true for the altitude of the sites: if a site is at an high altitude, the imprecision of the reanalysis is more likely to be higher than a site at a lower altitude.

V. WIND POWER APPLICATION

A. Method

In order to test the usefulness of the results found, it was decided to test the precision of the reanalysis in the context of a wind power plant production calculation. Five wind power farms production were modelled using reanalysis data as input and their production was compared to the real one.

Then an offset was added to the reanalysis data according to the category of each terrain. This corrected reanalysis is used to calculate another production that is also compared to real production.

B. Results

Without offsets, the reanalysis overestimated the production of around 20 % to 50 %, while with the offset the reanalysis underestimated the production between -20 % to 0 % as presented in the following table.

Site	Category	Imprecision (without offset)	Imprecision (with offset)
A	Case 3	48.8%	-0.9%
B	Case 3	21.1%	-21.1%
C	Case 2	48.8%	-19.9%
D	Case 1	50.2%	3.9 %
E	Case 4	28.3%	3.9 %

Those results are an improvement on the use of reanalysis data for wind power assessment, but would need more testing and a more precise offset in order to be certain on their precision.