Interpolation approach for wind prediction in a coastal area of Brazil

Isadora L. Coimbra1, Yoshiaki Sakagami1,2, Pedro A. Santos1, Reinaldo Haas1, Júlio C. Passos1, Frederico F. Taves1

Federal University of Santa Catarina, Federal Institute of Santa Catarina, ENGIE Brasil Energia S.A.

Introduction

The majority of Brazilian wind farms are located near the coast and wind prediction in these areas is not an easy task for mesoscale models, mainly due to the temperature gradient between land and sea, the change in topography and the discontinuity of surface roughness [1]. Therefore, coastal areas introduce additional challenges in the wind prediction and improvements are needed to assist the wind energy integration into the electrical system.

Objectives

The aim of this study is to investigate the onshore and offshore interpolation of wind predictions obtained by the Weather Research and Forecasting (WRF) model on the area of Pedra do Sal Wind Farm (PSWF), which is located on the northeastern coast of Brazil. As well as, this work will use linear interpolation as an approach to improve the wind predictions at the site.

Methods

The study covered the surroundings of Pedra do Sal wind farm (Figure 1) and the month of September of 2013. The site is located in a coastal region characterized by its flat terrain and wind conditions that are mainly influenced by trade winds and sea breeze circulation [2].

![Figure 1 – Location of PSWF. Source: Google Earth (modified).](image1)

The WRF model was simulated with one domain of 15 km of grid resolution and the chosen interpolation points are presented in Figure 2. The analysis consists of four offshore points (OFF-1, OFF-2, OFF-3 and OFF-4), the location of the met mast (ON-T) and two more onshore points (ON-1 and ON-2). These points were chosen along the north-south direction, in order to cross the shoreline and the wind farm. In addition, a nested domain, with 5 km of grid resolution, was used to evaluate the interpolation approach. The simulations used reanalysis data from NCEP-R2 as initial conditions and were initialized at 0000 local time, with a forecast horizon of 120 h and 10 min rate. All simulation data were validated using wind speed measurements at 98 m and analyzed through diurnal cycle.

![Figure 2 – Interpolation points and distances. Source: Google Earth (modified).](image2)

Results – WRF bias

A comparison between the observed and one domain simulated wind speed is presented in Figure 3. The WRF underestimates the measured wind velocity when interpolated in the location of the tower (ON-T). Also, as shown in the RMSE curve, the highest difference between forecasted and observed velocity occurs from 12 h to 16 h (local time), where the ON-T velocity is on average 32.9 % lower than the observed.

![Figure 3 - Wind velocity diurnal cycle at 98 m for WRF simulation (ON-T), observed data and RMSE.](image3)

Results – WRF interpolation

WRF interpolation with one domain: Onshore and offshore wind speed interpolations were compared with the measurements from the met mast, as displayed in Figure 4a. The results of the interpolation in the position OFF-2 showed a better agreement with the observed velocity in comparison with other interpolation points, presenting a mean bias of -0.02 m/s. Furthermore, the bias and delay between the wind speed of the WRF and the met mast increase as the interpolation moves onshore. The onshore interpolation at the met mast’s location (ON-T) did not present the best wind forecast near the coast when using a single domain of 15 km grid resolution, since the offshore condition prevails at the site.

![Figure 4 – Diurnal cycle for observed data and WRF results in different interpolation points (a) and diurnal cycle for observed data, offshore interpolation with one domain (OFF-2) and onshore interpolation with two domains (b).](image4)

WRF interpolation with two domains: Wind speed forecasts with one and two domains were analyzed, as presented in Figure 4b. The figure displays the hourly mean wind velocity curves for the measured, ON-T, OFF-2 and two domains data (interpolated in the tower’s position, ON-T-2D). It is noticeable a small improvement in the simulation with a nested domain. However this result is not better than the one domain offshore interpolation (OFF-2).

![Table 1 – Statistical metrics for the wind speed predictions.](table1)

Conclusions

Three main results were obtained through this case study. First, temporal and spatial biases were observed for the wind velocity forecast. Second, the offshore interpolations obtained better results than the onshore interpolations, due to strong offshore wind conditions. Third, the two domains simulation had a small improvement compared to the one domain, but is still not better than the offshore interpolation.

Therefore, the offshore interpolation approach proved to be effective when applied to Pedra do Sal wind farm. This technique uses less computational time than a nested simulation and obtains enhanced results for the wind velocity forecast. Further investigations are still necessary to understand the delay found on the local wind speed’s diurnal cycle.

Acknowledgements

Funding for the infrastructure was provided by the Brazilian Electricity Regulatory Agency (ANEEL) with ENGIE Brasil Energia S.A. (ENGIE Group).

References