SIMULATION OF THE WIND POWER OVER PARAÍBA-BRA STATE USING THE MODEL BRAMS

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ABSTRACT: Numerical simulations with BRAMS Model were used in order to analyze the wind power of the State of Paraíba in the four seasons and to highlight the regions where the behavior of the winds is more favorable to the generation of wind energy. Simulations were performed for the years 2007, 2008 and 2009. The results had been analyzed for two points, one on the coast and other at central of Paraíba. In a general way, the results suggest that the wind tends to be more intense in the continent comparing to the region and that the spring is the season of greater intensity of winds.
Key Word: Aeolian potential. Numerical simulation. BRAMS.

RESUMEN: Las simulaciones numéricas realizadas con el modelo BRAMS fueron utilizadas para analizar el potencial eólico del Estado de Paraíba en cuatro temporadas y destacar las regiones donde el comportamiento del viento es más favorable a la generación de energía eólica. Las simulaciones se realizaron para los años 2007, 2008 y 2009. Los resultados fueron analizados por dos puntos, uno en la costa y otro en el interior del estado. En general, los resultados sugieren que el viento tiende a ser más intenso en el interior que en otras regiones y que la primavera es la temporada que tiene vientos de mayor intensidad.
Palabras clave: Potencial Eólico. Simulación Numérica. BRAMS.

1. INTRODUCTION

Currently the wind energy has been identified as the source of most promising renewable energy for electricity production in the short term, considering aspects of energy security, social and environmental cost and economic viability (DE VRIES et al., 2007).

Due to the population growth, energy demand is currently one of the major problems faced by the contemporary society. Energy consumption is increasing and if the rate of current consumption is kept the world's reserves could be depleted within decades, since the dependence of non-renewable resources is still quite large.

Silva et al. (2002) in his study about the exploitation of wind as energetic potential show that its use depends on detailed knowledge of the wind characteristics over the area where wind farms will be implemented. Another practice that stands out is the forecast of winds, which bypass the man's inability to control the wind (SÁNCHEZ, 2006; GIEBEL, 2003), the main disadvantage of wind energy, helps to minimize the problem. In this context, mesoscale atmospheric models appear as a convenient solution, for the relatively low investment demand and to be over the last decades a reliable tool (DE MARIA et al., 2008).

The atmospheric modeling and the forecast of the wind energy applied to the sector have two main approaches, the average winds estimated taking into account climatological data and wind forecast for future time in the short to medium term. The first approach is aimed at selecting locations with the best wind conditions for wind power generation in order to provide the necessary data to evaluate the economic viability and to establish the parameters to be adopted

in the development of generating units and wind farms. The estimates of short term are particularly useful in identifying periods of increased occurrence of wind, and the occurrence of damaging winds to the system. Therefore wind forecast in the medium term is useful in the management of energy resources, and compensate for the deficiencies in the supply of wind power for electric energy from other sources.

2. OBJECTIVES

The aim of this study is to investigate the wind power of the State of Paraiba - Brazil, showing the regions where the behavior of the wind is more favorable for wind power generation. Thus, the model BRAMS - *Brazilian Developments on the Regional Atmospheric Modeling System* is used to generate scenarios of wind conditions for that State.

3. METHODOLOGY

3.1. The Study Area

According to the Brazilian Wind Energy Association only nine Brazilian States, five them are located in the northeast region have one or more wind farms in operation. Among them the State of Paraíba presents wind conditions favorable for wind energy production.

Situated near to the equator, temperatures of the State of Paraíba range from 28°C on the coast, 22°C in Borborema Plateau, reaching 30°C at the west part of State. Like most northeastern States, Paraíba has tropical humid type climate at coastal areas. In those areas the rains rain regime is regular, with relatively high pluviometric indexes. On the other hand, the central and the western portions of the State are predominantly semi-arid, with low pluviometric indexes, less than 800 mm per year.

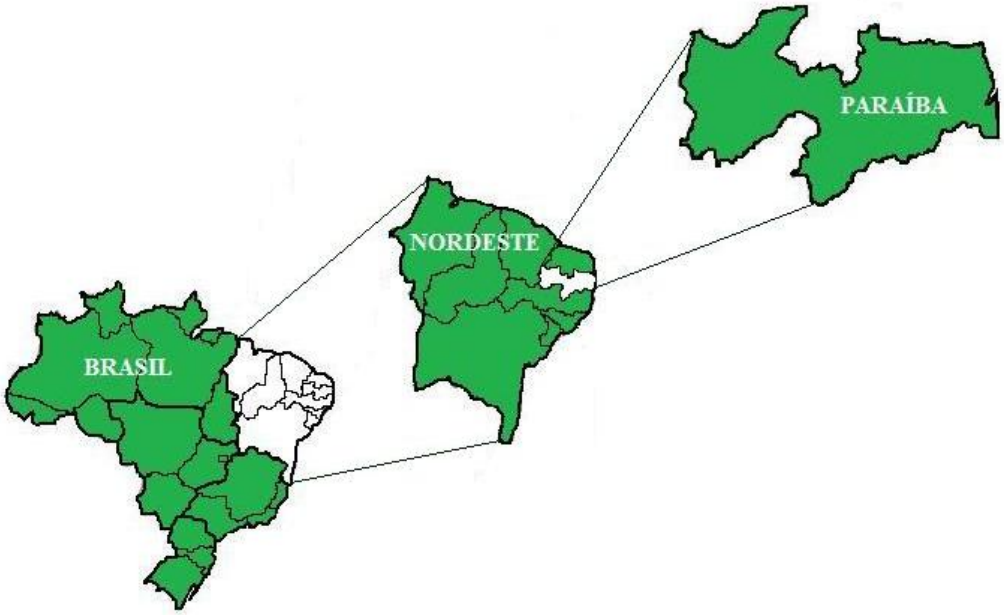


Figure 1 - Location of the State of Paraíba.

3.2. Model Used

In this paper the numerical model used was BRAMS, version 4.2. This model was developed from the Model RAMS - *Regional Atmospheric Modeling System*, which has its basic structure described by Pielke et al. (1992).

BRAMS is a mesoscale numerical model suitable to simulate atmospheric circulations in limited geographical area with a wide range of applications such as simulations of large eddies, storms, atmospheric dispersion and mesoscale phenomena. The initial condition can be retrieved from several observational datasets, and as boundary condition.

3.3. Description of Experiments

We performed simulations for the years of 2007, 2008 and 2009. The BRAMS model was run for four seasons with two nested grids. The external grid with 16 km resolution, covers part of the Northeast and the Atlantic Ocean and internal grid, with a resolution of 4 km, covers the entire Paraíba. Since the objective of this study is to identify the areas where the wind is behaving favorable to wind power generation in Paraiba, discussions were based on the 4 km grid.

Two points were chosen to be analyzed, one on the coast, P1 (7.38°S, 34.83°W) and another inland within the State, P2 (7.11°S, 36.56°W). We show mean values for each season for the chosen points. Model outputs will be analyzed at 70 m which is a typical height of wind turbine rotors. In addition, it will be shown the wind rose diagram for the selected points, which give an idea of the direction of the wind in the area.

4. RESULTS AND DISCUSSIONS

Paraíba is a privileged State both by geographical location and by the topography that favors the distribution of winds in the State. The distribution of the topography of Paraíba with 4km resolution is displayed in Figure 2. Thus, the topography of the State along with the dominant wind, which in most cases is easterly, explain the largest portion of the observed distribution of wind in the State.

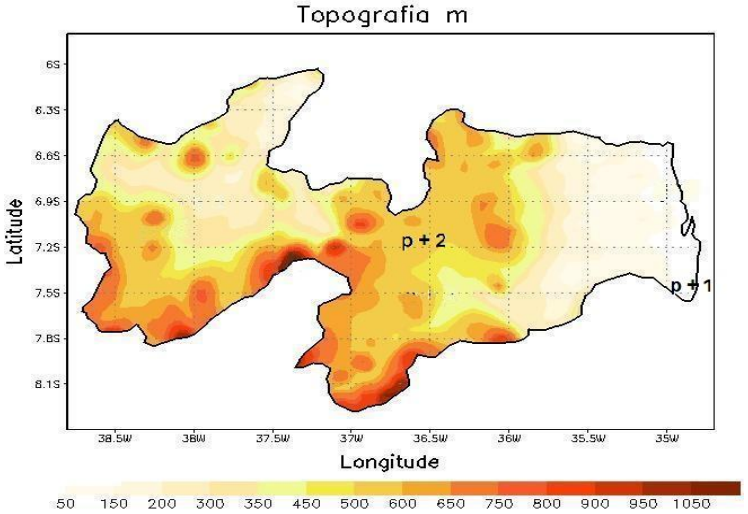


Figure 2 - Topography of Paraíba with a resolution of 4 km.

Then, results will be discussed separately for each season and analyzed for points P1 and P2 shown in Figure 2. The point P1 (7.38 °S, 34.83 °W) is located in the coastal region of the State. The point P2 (7.11 °S, 36.56 °W), is in the middle of the State.

Figures 3a and 3b show the mean wind speed between the years 2007-2009 for Summer and Autumn, respectively. Note that these two stations the wind is more intense in the continental part of the State, especially in Borborema Plateau between latitudes 6.3°S-8.3°S and longitudes 36°W-37.5°W. In this region the mean wind speed ranges from 4 to 7 m/s for the Summer and from 3 to 8 m/s for the Autumn, reaching more than 9 m/s at some points. It is also possible to observe that at point P1 the mean wind speeds is around 4.5 m/s, and point P2 between 5-6 m/s for the two seasons.

Figures 3c and 3d show the mean of wind speeds for the Winter and Spring, respectively. Both Winter and Spring the wind is more intense in the region of Borborema Plateau, as noted earlier for the Summer and Autumn. However, note that from the Winter wind speeds tend to increase reasonably. The values in the region of Borborema range from 4 to 12 m/s in both seasons. For the Spring, at some points one can see values above 12 m/s.

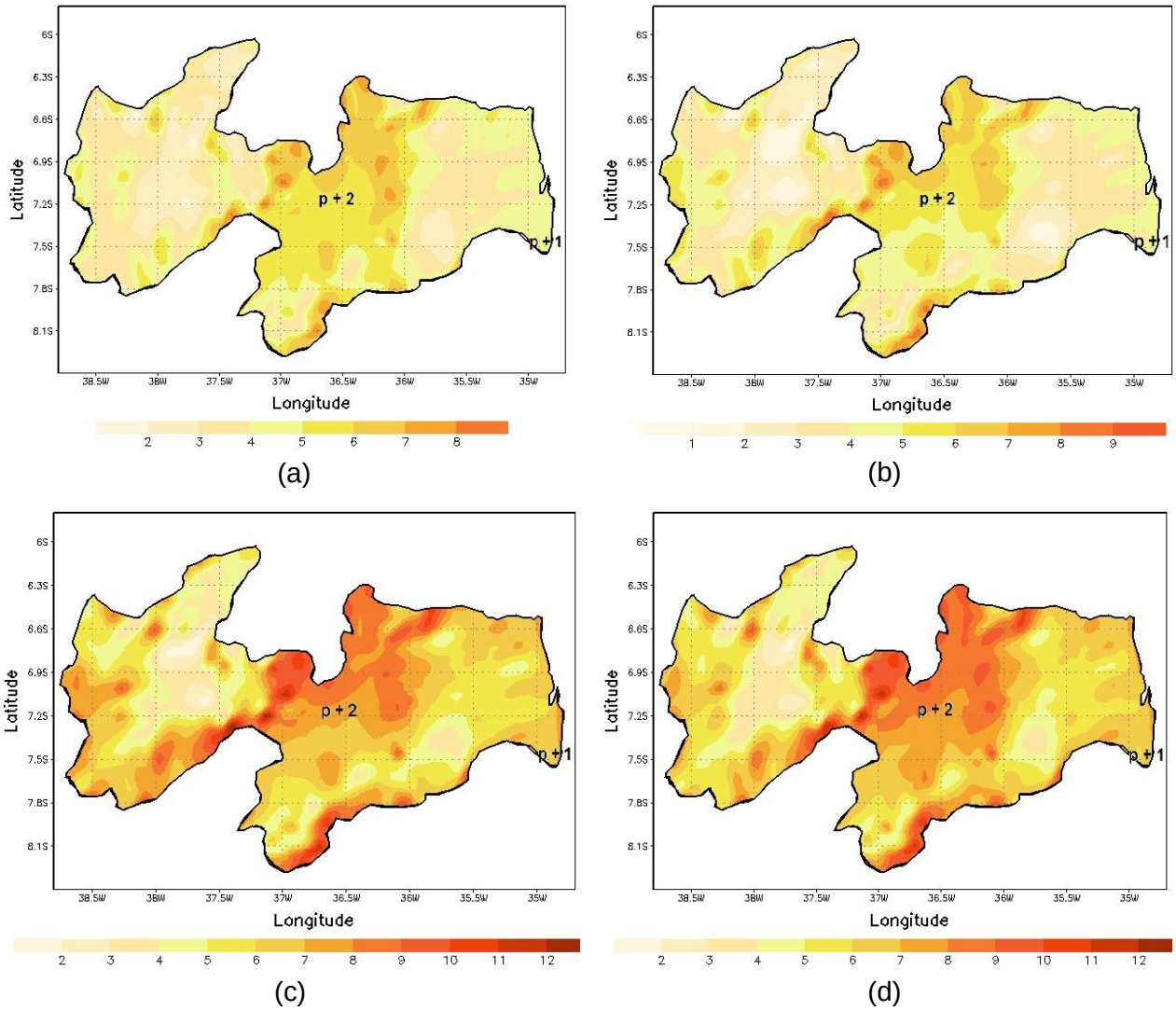


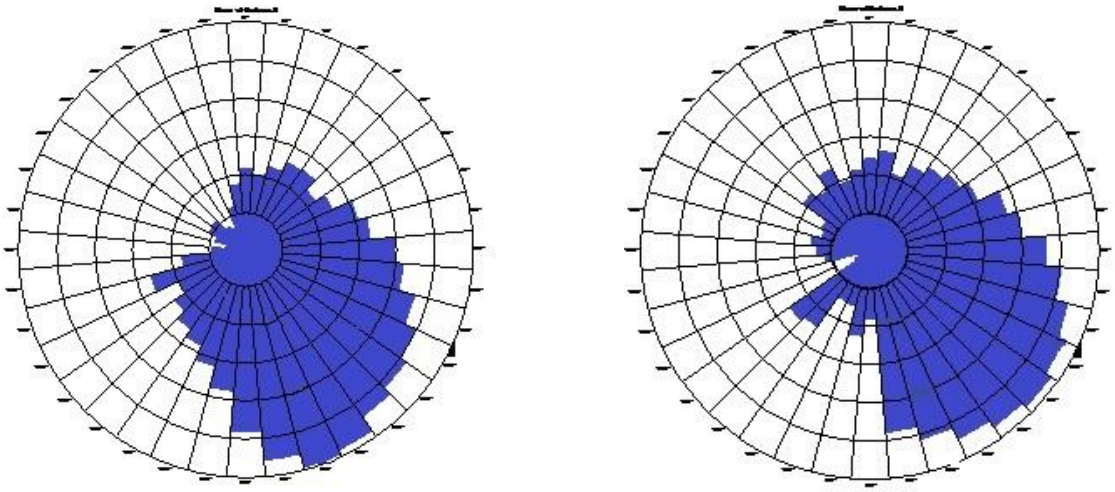
Figure 3 - Mean wind speed to 70m higth for: (a) Summer, (b) Autumn, (c) Winter and (d) Spring.

In Winter (Figure 3c) the means were between 8.7 m/s for the two points analyzed. In the Spring (Figure 3d) as well as in Winter, the point P1 presented values around 8.7 m/s, already at the point P2, these values were somewhat higher, between 8.9 m/s.

In general, analyzing Figures 3a, 3b, 3c and 3d one can see that the lowest mean values of wind speed are found in the region west of the Paraíba State. This is probably due to the influence of the topography of the region. The prevailing wind direction is from southeast.

The wind rose diagram for the points P1 and P2 are shown in Figures 4a and 4b, respectively. Note that in both points the winds are more frequent in the southeast quadrant. Wind "blowing" the southeast is consistent with the action of the Trade Winds in the South tropical region where is located the Paraíba. So dominates directions simulated by the model BRAMS are within the standard, taking into account that in Paraíba, according to Silva et al. (2002), the prevailing wind direction varies from northeast to southeast.

Taking into account the mean values wind speed in the literature, the simulation results presented here suggest that the State of Paraíba has regions where wind speed is appropriate for wind power generation. However, more detailed studies on the behavior of the wind in these regions should be performed in order to have a more consistent and reliable understanding about the behavior of this variable over the years.



(a) (b)

Figure 4 - Wind rose diagram at 70 m: (a) point **P1** (7.38°S; 34.83°W), and (b) point **P2** (7.11°S; 36.56°W).

5. CONCLUSION

Based on the results, we conclude that for the two points analyzed the lowest the mean wind speed on the Paraíba occur in the first semester, that is, between the Summer and Autumn. The highest values were showed between Winter and Spring (second semester), especially in the Spring for which obtained the highest values. In general, the results suggest that the wind tends to be more intense in the center of state, especially in the region of the Borborema, than in other regions in both the first and second semester.

6. ACKNOWLEDGEMENTS

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