Wind flow modelling in complex sites of North-Eastern Brazil

M. Ranaldo1, E. Monfort1, F. Catalano1, R. Bispo2, J. Vidal1
1 UL-AWS Truepower, Barcelona, Spain
2 UL-DEWI, São José dos Campos, Brazil

Abstract

The wind flow modelling in two complex sites of North-Eastern Brazil is hereby studied. The analysis of the diurnal wind speed profile confirmed that katabatic circulation is a main driver of the nocturnal wind flow in both sites. Then, the performance of three different wind flow models is compared: two micro-scale models and a coupled meso+micro scale model. The cross-predictions between masts show that coupled meso+micro-scale model (which takes into account thermal circulations) can simulate the wind flow better than micro-scale models alone. The high errors of the latter ones are mostly explained by the verified presence of katabatic winds in the area.

Objectives

The analysis carried out in this study is a step-forward to better understand wind flow models performance in a region where many wind farms are currently under development. For complex sites with evident thermal circulations, meso-scale models which solve the complete set of atmospheric equations are generally required to obtain realistic wind maps.

Sites Description

The terrain elevation (contour lines every 50 m) and met mast locations for the two studied sites are shown in the figures below. Both sites offer multiple masts with high-quality data: four and eight masts are respectively available for site 1 (78m) and site 2 (100 m).

All masts have from 1 to 6 years of data: a total of about 35 years of usable data are available. Mast data were validated and long-term adjusted.

Katabatic Winds Analysis

Katabatic wind is a nocturnal circulation produced by the faster cooling of the higher part of a mountain with respect to the valley. In both sites nocturnal wind speeds are higher than diurnal ones. As shown in next figure, the nocturnal acceleration is much greater at masts located in the lower part of the mountain (mast 2): nocturnal wind speed differences between mast 2 and mast 1 are higher than 2 m/s and 4 m/s at site 1 and site 2 respectively.

This confirms that katabatic circulation, which is more developed in the hillside than at the top, is highly affecting wind resource distribution within the area. In fact, even if mast 2 is located at a lower height than mast 1, it has a higher mean wind speed.

Wind Flow Models Comparison

The following three wind flow models are compared:
- WASP [1, 2] (WASP 11) a linear wind flow model
- WindMap [3], a mass-conservation model, available in Openwind [4]
- SiteWind [5], a coupled meso-scale (a Numerical Weather Prediction model) + micro-scale (WindMap) model.

Next table shows the BIAS, Root Mean Square Error (RMSE) and maximum Absolute Error (Max AE) of a round-robin approach, i.e. using one mast as the predictor and looking at the difference between measured and predicted mean wind speed at all the other masts.

<table>
<thead>
<tr>
<th>Site 1</th>
<th>Site 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIAS 0.05 m/s</td>
<td>1.32 m/s (17.0%)</td>
</tr>
<tr>
<td>RMSE</td>
<td>1.71 m/s (22.0%)</td>
</tr>
<tr>
<td>Max AE</td>
<td>0.44 m/s (5.7%)</td>
</tr>
</tbody>
</table>

SiteWind errors (RMSE below 7.5% and max AE below 20%) are significantly lower than those obtained by the micro-scale models (WASP 10% and max AE above 30%) at both sites.

Next figures shows the mean wind speed maps obtained with WASP and SiteWind in site 1 using only mast 1 (mast at the top) as reference station. The resulting maps show different patterns: while the micro-scale model indicates that the best resource area is located at the top of the mountain, SiteWind indicates it is located on the hillside, such as confirmed by measurements.

Conclusions

In this study, the performance of three different wind flow models in two sites in North-Eastern Brazil was analysed: two micro-scale models (a linear wind flow and a mass-conservation model) and a coupled meso+micro scale model (SiteWind). The analysis of the diurnal wind speed profile confirmed that katabatic circulation is a main driver of the nocturnal wind flow in both sites. The SiteWind model can simulate the wind flow better with respect to micro-scale models alone: this is mostly due to the strong thermal circulation in the area. In fact, katabatic winds can only be “seen” by meso-scale meteorological models, which solve the complete set of atmospheric equations.

References


Meet us at stand 1A42

windeurope.org/confex2017
#windeurope2017