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Atmospheric Stability Influence on Wind Resource Spatial Distribution for Wind Farm Micrositing

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Abstract

During the development of a wind farm the micro siting is based on the resource spatial distribution derived from the combination of on site measurements and flow modelling. Based on such mapping an optimum layout in terms of production is developed to fulfill constraints, maximize power output and minimize cost of energy.

The selection and tuning of the flow model is essential in order to correctly assess the real wind pattern, especially for sites where prevailing atmospheric stability deviates from neutral conditions. In such cases the optimum layout can be quite different from the one based on standard neutral-case flow models.

The present work focus on an Enel Green Power existing Wind Farm in Brazil located in complex terrain in an area with a prevailing stable atmospheric stability. The real resource spatial distribution emerging from both on site wind measurements and Wind farm operational data is compared against the one predicted by standard neutral flow models (both linear and CFD) and by a CFD implementing the stability buoyancy force through the solution of the energy equation.

KEYWORDS: Resource Assessment, Atmospheric Stability, CDF, Wind Farm micro sitting, Complex Terrain, Wind Farm operational analysis.

Objectives

The present work objective is to put attention into the effect of atmospheric stability on wind resource spatial distribution in complex terrain which is essential in the definition of an effective and optimum micrositing.

Method

The first stage of the work has been the analysis of both on site measurements and wind farm operational data in order to derive the real wind resource spatial distribution.

Then, the linear model WAsP and WindSim, a CFD – RANS k-epsilon model that solves the energy equation and implements the stability buoyancy force through the Boussinesq approximation, were used to estimate the resource spatial distribution.

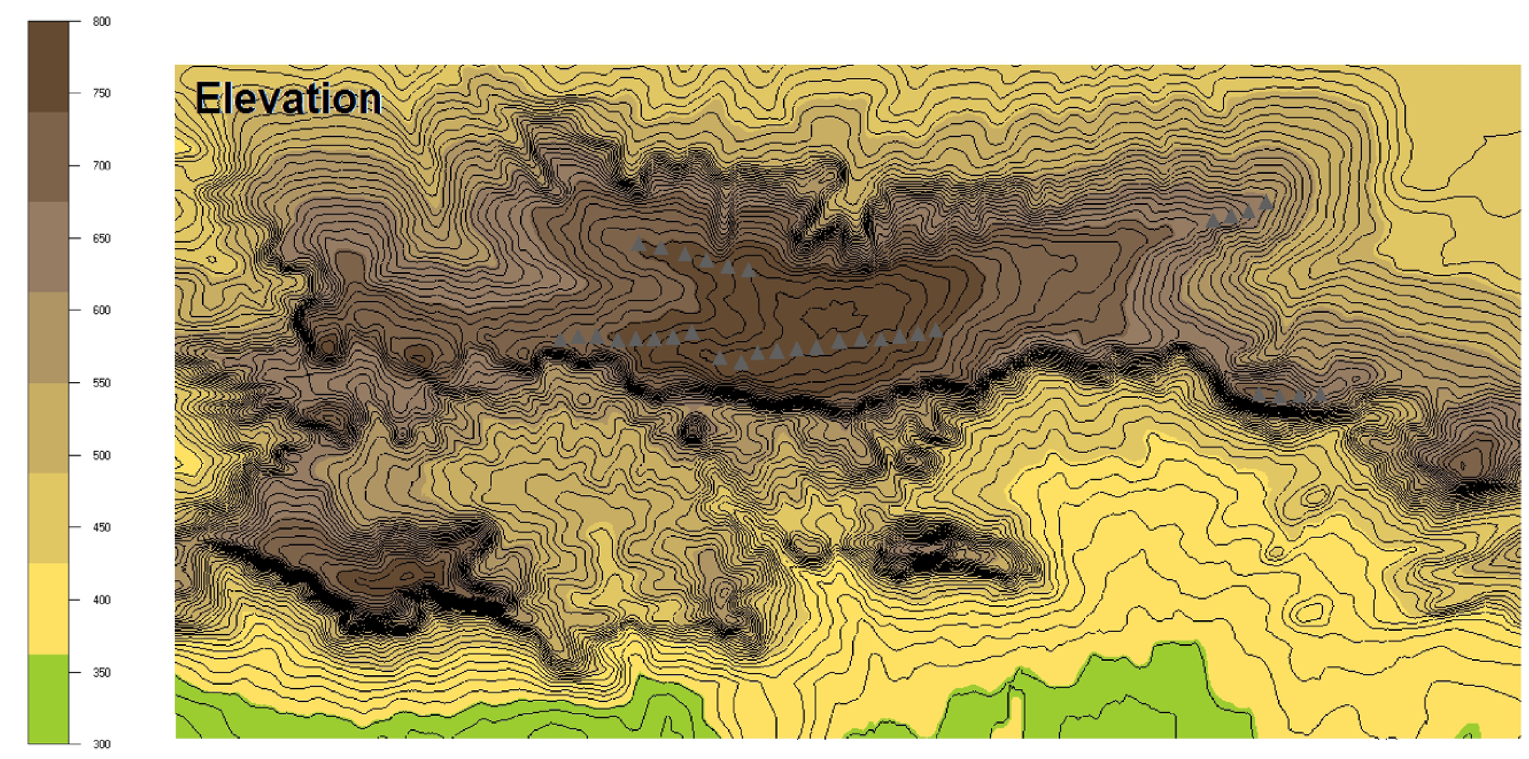
Results

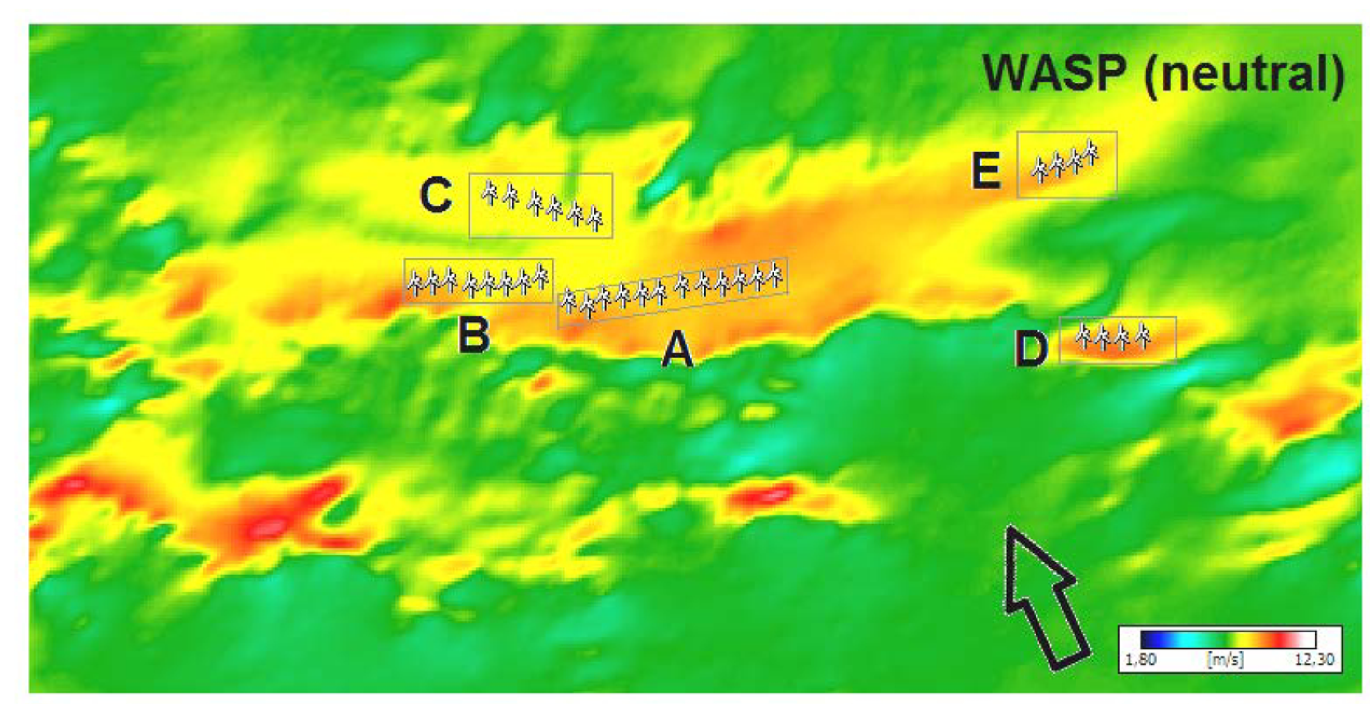
The following images shows wind speed fields for the prevailing direction(*) estimated by WASP (which is a neutral model) and by WindSim with two stability set ups, the first neutral and the second stable.

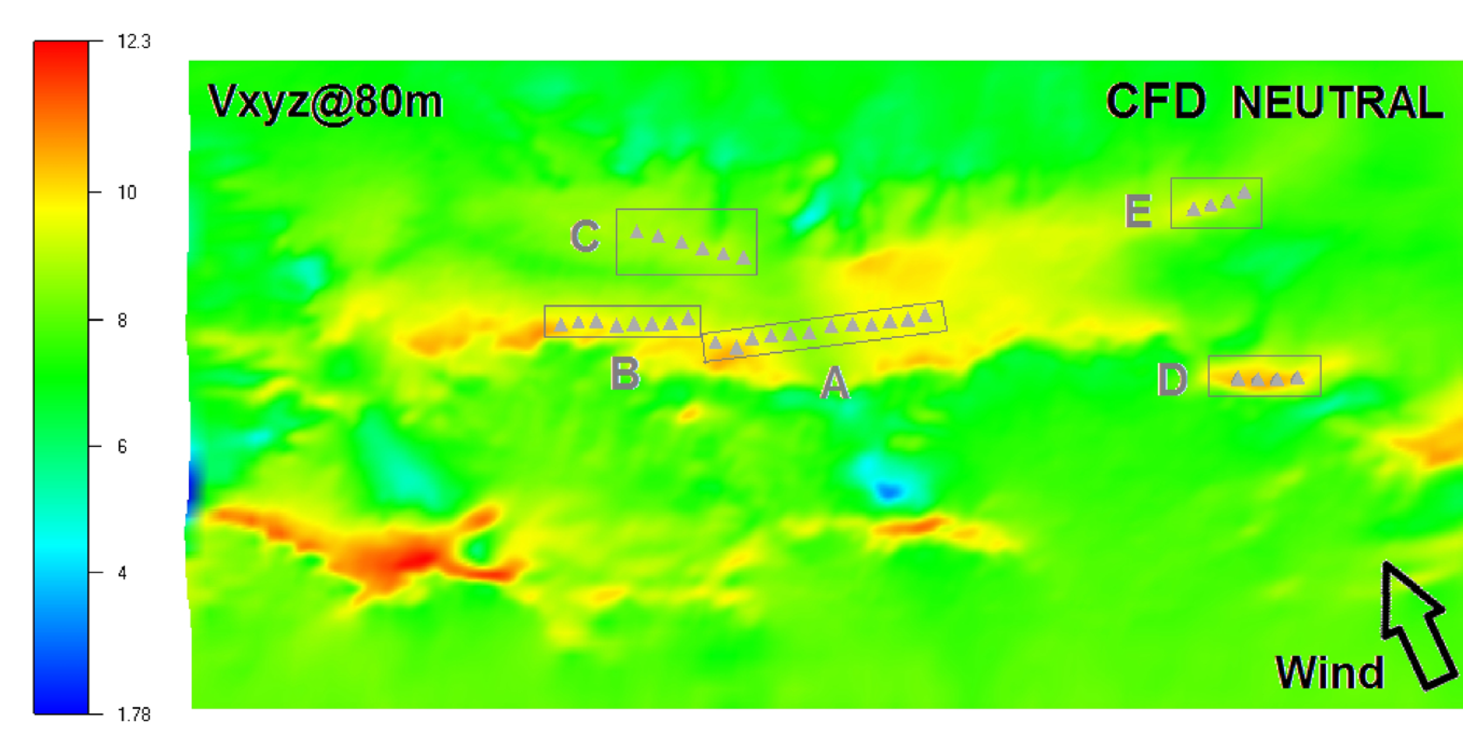
It can be noted how the wind field changes from the neutral simulations to the stable one. The area of biggest wind speed is reformed and moved to the rear part of the ridge as the buoyancy force is introduced in the model.

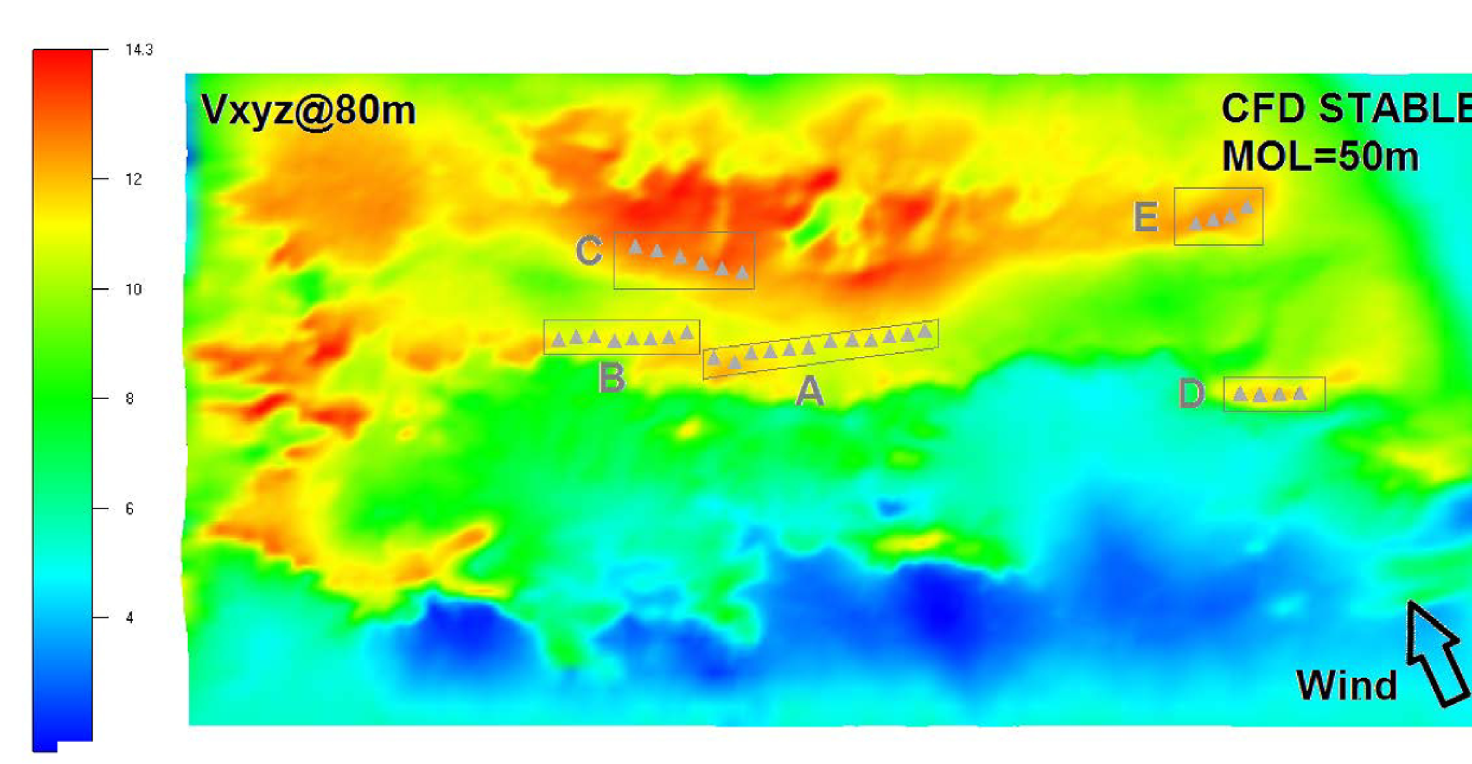
In the plot below the wind speed ratios estimated by the flow models are compared with those derived from wind farm operational data.

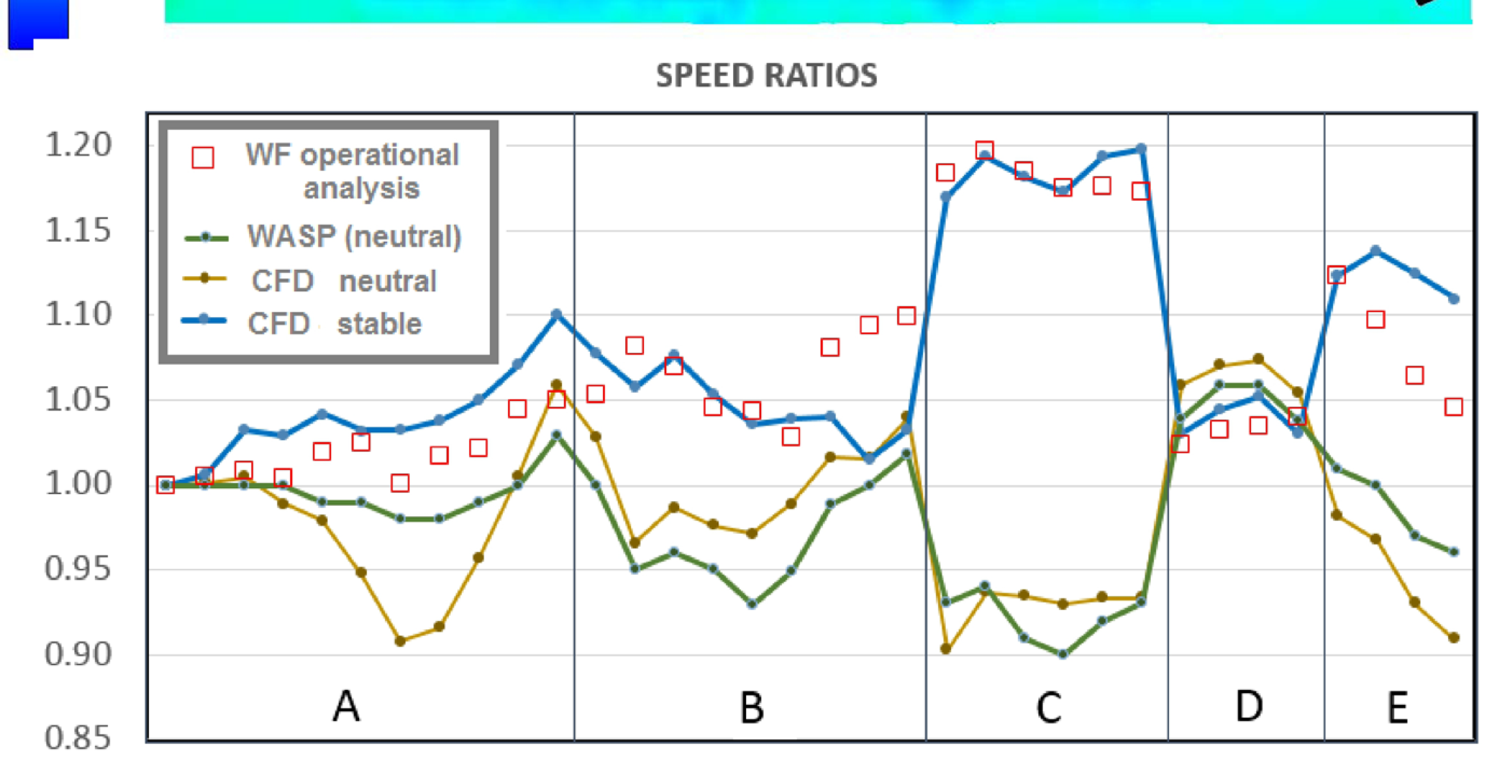
(*) The terrain has been rotated in the CFD for meshing efficiency purposes.











Conclusions

- Atmospheric stability plays a key role in the determination of the wind field and resource pattern in a site, especially in complex terrain. Different levels of stability determines a different spatial resource distribution which should be accounted when performing a wind farm micro siting.
- The stability inclusion in models and its tuning is essential in order to obtain a wind field pattern close to reality and to be able to define a real optimized layout.
- When properly tuned , a CFD – RANS k-epsilon model that implements the stability buoyancy force like WindSim can be useful for the task.

References

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