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Theme: RESOURCE ASSESSMENT Topic: Advances in measuring techniques for resource assessment

IN THE WAKE OF BOLUND: BENAKANAHALLI - STRATIFICATION AND COMPLEX TERRAIN

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Introduction

Micro-scale numerical flow models are the cornerstones of wind energy site assessment. With more and more new sites in complex terrain the model requirements have increased dramatically in the recent years. This has been followed by a demand of full scale measurement campaigns designed to benchmark the models in complex terrain. The Bolund measurement campaign performed near Risø DTU, in 2009 (Boundary Layer Meteorology 141, p. 219 & p. 245, 2011) provided significant insight into flow in complex terrain and has proven very suitable for benchmarking of models. Even though up-scaling is permitted to some degree, the 12 m tall peninsula, the Bolund Hill, is still too simple for many purposes; it lacks atmospheric stratification and the Coriolis effects. In addition the wake of Bolund was very poorly resolved. Though an optimal test case for micro-scales model Bolund is not a realistic wind turbine site. With this in mind a new measurement campaign was planned and conducted as a joint collaboration between Risø DTU and Vestas Technology R&D.

Approach

Main body of abstract

In this presentation we will present the first results of a new large scale measurement campaign where the flow is altered by both the presence of complex terrain and atmospheric stratification. Whereas studies of complex terrain have been done mainly in neutral conditions and studies of atmospheric stratification in primarily flat terrain, a study where also the combined non-linear effects are studied should be much welcomed in the wind energy community, since a large part of turbines today are erected exactly at places where these are non-negligible.

The name of the campaign is Benakanahalli. The measurements were conducted from February to April 2010 in the province of Karnataka in India close to the village of Benakanahalli. Five 80m masts were erected near and on a long almost two-dimensional 120m natural ridge with slopes of around 30 degrees. The hill type is very common in wind energy, which can easily be verified by a short drive in the area where a huge amount of wind turbines are erected on similar hills.

Equipped with sonic anemometers in five different heights, both the mean flow and the turbulence are well resolved. In addition temperature sensors were mounted on the upstream mast. Together with measurements of heat fluxes from the sonic anemometers a good estimate of the thermal stratification is thus obtained. Three masts were positioned in the wake of the hill giving us the opportunity to estimate its size and hence the recovery length of the wind speed.

Conclusion

We will show the first comparison with a numerical micro-scale model, the Risø DTU EllipSys3D RANS k-epsilon model, which manage to capture many of the interesting features happening as a result of the interplay between complex terrain, thermal stratification and Coriolis force.