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Methods to assess uncertainty of wind resource estimates determined by mesoscale modelling

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Abstract

What is the uncertainty of a wind resource map? The numerical wind atlas methodology developed at Risø DTU and based on KAMM/WAsP mesoscale modelling has been in a large number of different configurations in order to estimate the sensitivity of the wind resource assessment on the set-up of the model system. A number of physical phenomena provide mechanisms for creating areas with a locally high sensitivity, or conversely, areas with locally low sensitivity to adjustment in the model system. Here, these sensitivities, as well as horizontal gradient of mean wind speed and measures of topographical complexity, are used to estimate an uncertainty map of the wind resource calculation.

Method and Results

The idea is to relate model sensitivities, wind climate gradients and topographical complexity to uncertainty in the final wind resource estimate. Within the Dongbei wind mapping project[1], verification of numerical wind atlas results against measured wind climates using the WRP-G generalization process[2] at 9 sites was carried out. The calculated climatological mean wind speed at 10 m is shown in Figure 1.

A selection of model sensitivities is shown in Figure 2. The sensitivities have different magnitude and sign for different locations in the region of interest. In Figure 3 the measured error is plotted against the sensitivity of KAMM/WAsP. There is a significant scatter of the data points, which suggests that the error is made up of many contributions from different sensitivities, or indeed that the error may be unrelated to the sensitivity.

Linear regression is used to find combinations of sensitivities to yield error estimates. Only combinations with positive coefficients are permitted. Results from two combinations are given in Figure 4 (ii) and (iii). The multimodality is 0.768 and 0.854 respectively. Applying the linear relationships for the whole area of interest gives estimated uncertain maps given in Figure 5.

Conclusions and Discussion

The uncertainty has been mapped by using a linear regression to determine a linear relationship between model sensitivity, horizontal gradient of mean wind speed and complexity of topography. Two different combinations have been used. The former has the advantage that the uncertainty can be estimated over sea, whereas for the latter this is not possible because the topography complexity definition is not appropriate over water bodies. A simple improvement to this study would be afforded by having a larger number of measurement masts, set in diverse locations, including over sea, so that a grid of data population could be used for the linear regression. This is perhaps difficult in the standard configuration of resource assessment projects, where masts are procured and located for the purpose of estimating and verifying wind resource. To verify uncertainty estimation either a larger number of masts is required, or, less accurate but more achievable in practice, a pooling of many resource assessment projects and their associated verification studies is recommended.

The investigation of error and causes of error can benefit from another important technique to characterize the wind resource maps via inspection of the horizontal spectra of mean wind speed maps. This allows for identification of model limits, related to spatial resolution and also introduction of errors inherent in the estimation methodology. Figure 6 shows the spectra of the measurement masts. It is seen that KAMM/WAsP has more energy compared to WRP-WAsP, perhaps indicative of a less diffuse model or an issue with model spin-up. At low wave numbers a divergence is observed with decreasing wave numbers due to the way the mesoscale model is forced by sets of horizontally uniform winds. The investigation of spectral aspects of resource estimation will need to be pursued further in current and future wind resource assessment studies.

Acknowledgements and References

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