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Abstracts

Offshore Wind Atlases based on the meso-scale model WRF are presented and validated in this paper. The Work has been part of the EU-funded project NORSEWIND (Northern Seas Wind Index Database). Validations show that annual average wind speeds and wind-roses at hub-height (100m) are well represented by the model, while the model accuracy is poorer for the Weibull-k factor.

Objectives

One important objective of the NORSEWInD project has been to develop public available Wind Atlases for the Irish Sea, the North Sea and the Baltic Sea. A systematic collections, validations and combinations of different data sets have been carried out to generate the offshore Wind Atlases. The aims being to find the most appropriate data sets for the offshore Wind Atlases. In the present paper we show examples on the final results of the wind atlas together with a validation and estimation of the uncertainties of key wind atlas parameters.

Methods

Offshore measurements by meteorological masts or Lidars, satellite data and meso-scale model data are all sources for the development of offshore Wind Atlases. In the present study we have focused the development of offshore Wind Atlases on meso-scale model data since the access to measurements and satellite data have been limited. Considerable efforts have been devoted into understanding the quality of the meso-scale model data, its strengths and weakness during the application to offshore Wind Atlases.

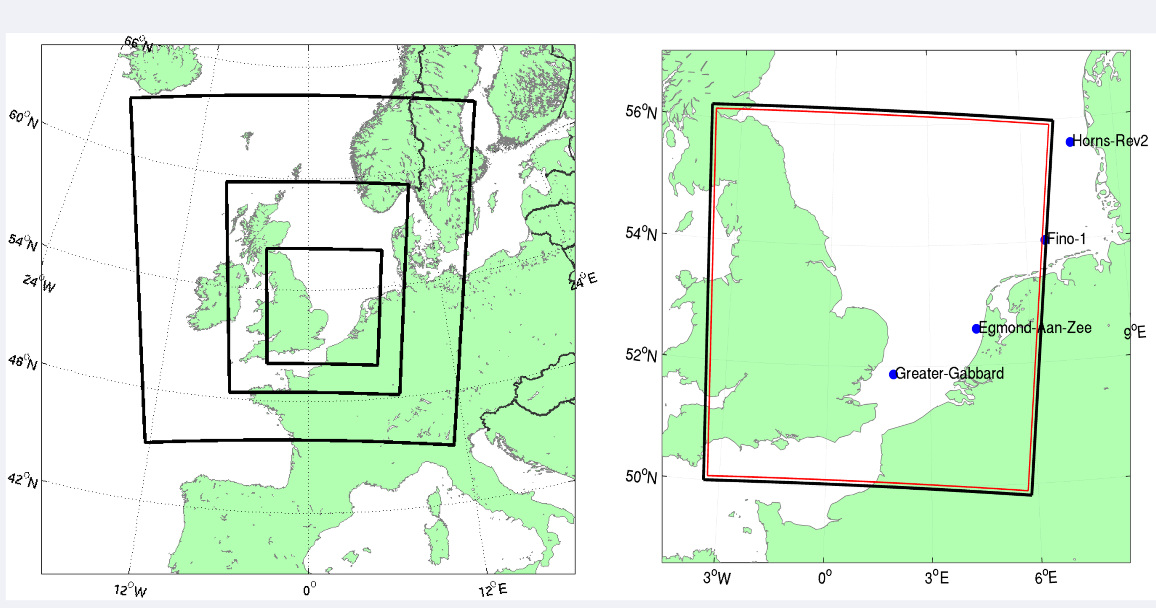

Figure 1. Example on a three domain nest for a sub-area of the Wind Atlas applying the mesoscale moldel WRF (Weather Research and Forecast model) setup. The horizontal resolution is 2 km, 6 km and 18 km for the inner, middle and outer nests, respectively. The inner nest including available observational stations are shown in the right panel.

Different mesoscale model runs were carried out for the purpose of the NORSEWInD Wind Atlases. Two focus areas with high horizontal resolution (2 km) were included. An example on the model domains applied to one of the focus areas is given in Figure 1. The final Wind Atlases are combinations of the finer scale runs and coarser domain run cover the entire area. Long-term corrections are applied to the annual average wind speeds. Here we present results for the Irish Sea and the North Sea. Results for the Baltic Sea are found in Berge et al. (2011) and Peña et al. (2011).

Results

Results from the Wind Atlas for the Irish Sea and the North Sea are presented in Figure 2. From the figure we see that the long-term wind speed levels vary from about 9 m/s in the southern part of the North Sea to about 10 m/s in the northern part. In the Irish Sea wind speeds are up to 10 m/s. The Weibull-k parameter varies in the range 1.7 to 2.3 in the North Sea/Irish Sea region (not shown). The lowest values are found on the west coast of Norway and England, and the highest values are encountered on the East coasts of England and Ireland.

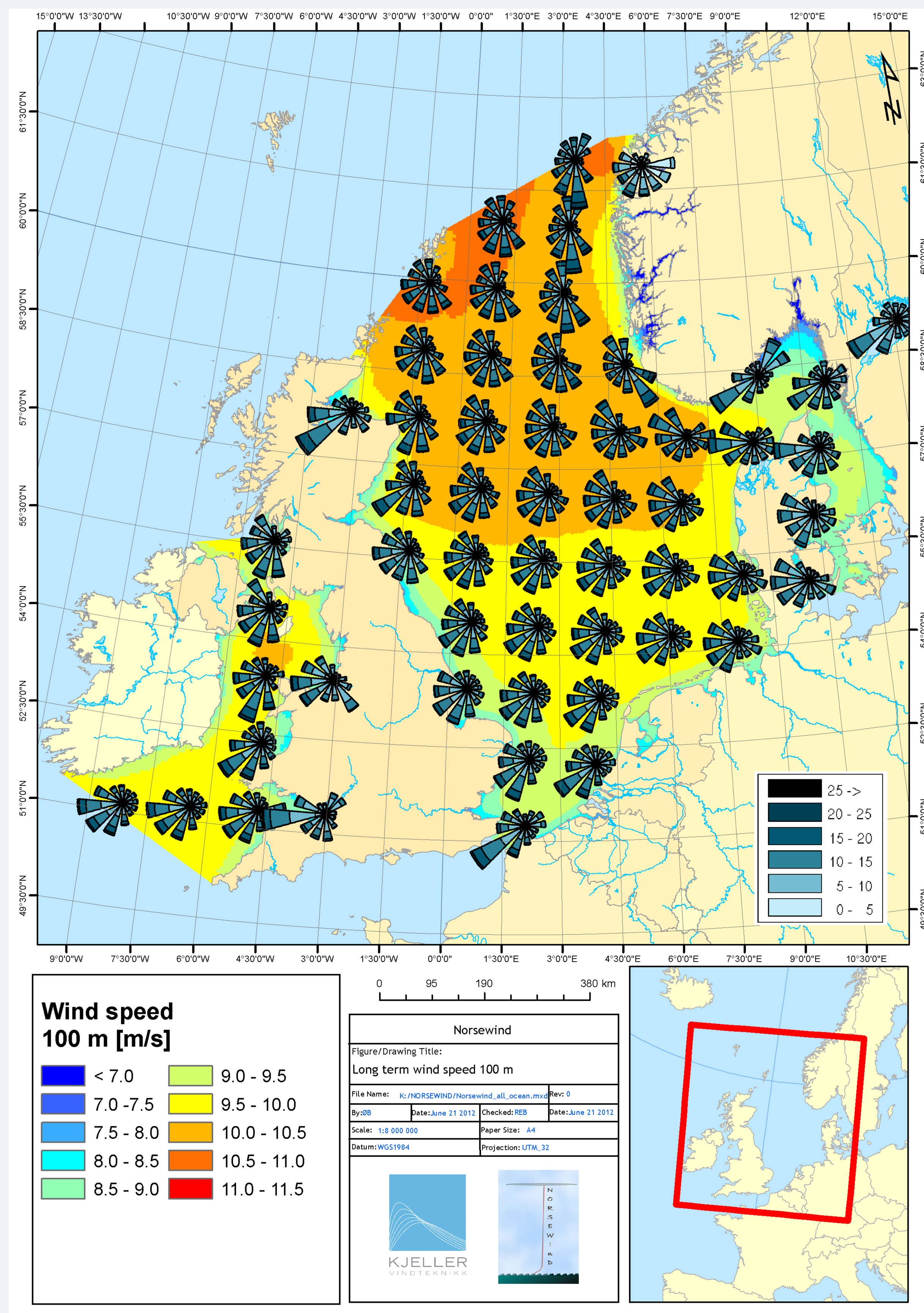

Figure 2. Long-term adjusted wind speed (100 m) and wind roses (100 m) based on the Wind Atlas for the Irish Sea and the North Sea.

In Table 1 a validation of the Wind Atlas is given. It is emphasized that the number of measurements is low and the data sample for statistical analysis is small. The random uncertainty in the annual average wind speed has been estimated to ±4.2 % based on measurements in the North Sea and the Baltic Sea, while a bias of -1.3 % is found. For the Weibull k-parameter we estimate a random uncertainty of ±4.0 % and a bias of -6.4 %. The average deviation in the annual wind direction is 3° . For annual average temperature a bias of –1.3ºC is encountered. Due to the small data samples no random uncertainty has been estimated for wind direction and temperature.

The uncertainty of the mesoscale calculations are considerable lower than what is expected onshore for the annual average wind speed (see for example Byrkjedal and Åkervik, 2009)).

Table 1. Comparison of annual averages of the Wind Atlas with measurements

Annual averages at 100 m	Number of stations	Random uncertainty	Bias (model - obs)
Wind speed	7	4.2 %	- 1.3 %
Weibull k	6	4.0 %	- 6.4 %
Wind direction	3	—	3°
Temperature	1	—	- 1.3 ºC

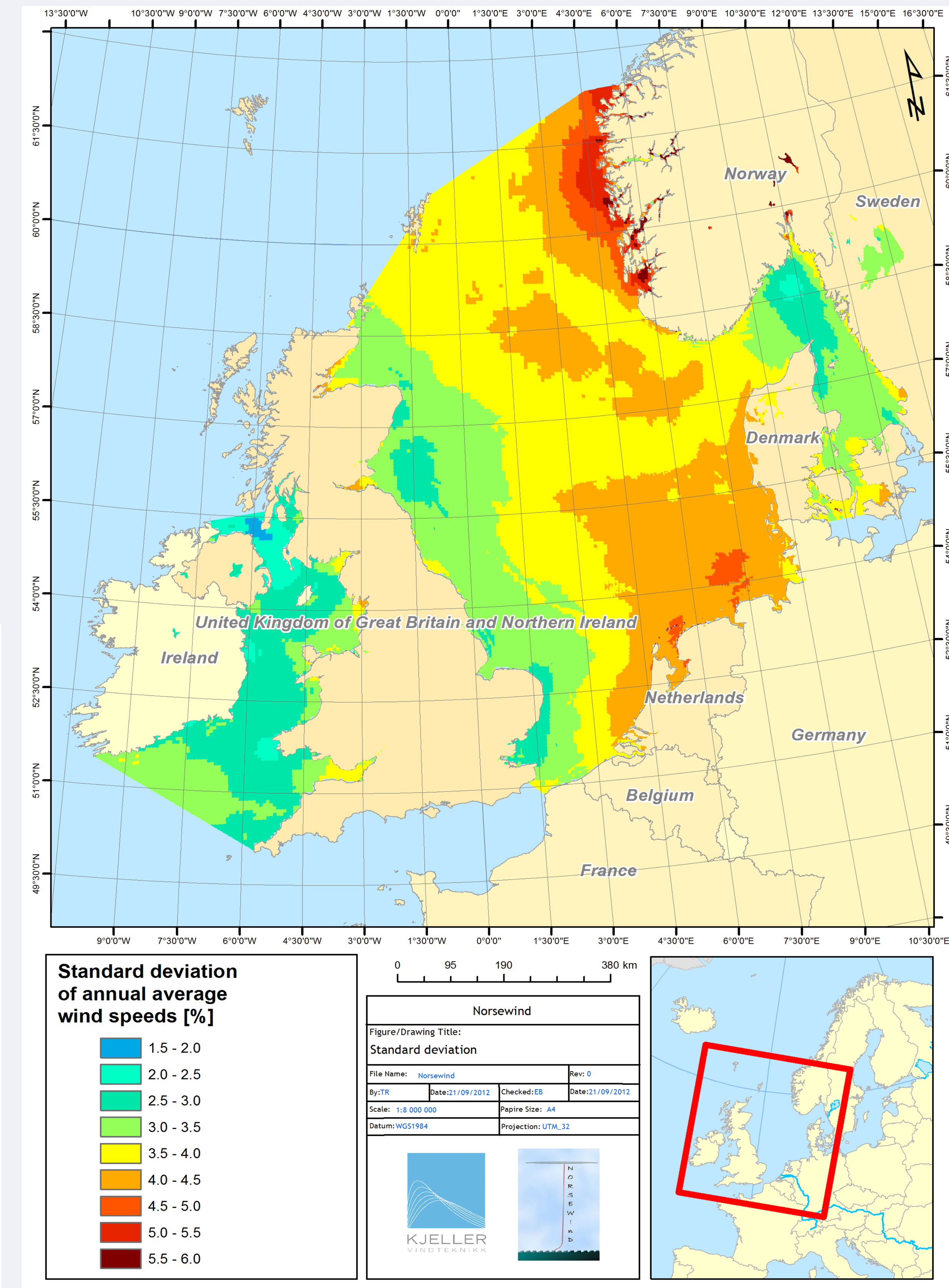

Figure 3. Standard deviations of the long-term annual wind speeds (100 m) of the Wind Atlas.

The bias in the Weibull-k parameter is as large as – 6.4 %. For the annual average wind speed regime of the North Sea, a high Weibull k factor is beneficial for the energy production, thus the k-factor of the Wind Atlas will give rise to some underestimation of the energy production.

Figure 3 shows the standard deviations in the annual average wind speed based on 10 years of reference data. The standard deviation is important for estimating the uncertainty in the annual average wind speed and the wind energy yield of a potential wind farm. We find the highest standard deviations (4-6 %) near the west coast of Norway and in the southeastern part of the North Sea. Lower values (2.5-3.5 %) are seen close to England and in the Irish Sea. Thus a longer measuring time-series would be needed close to the Norwegian coast as compared to close to England for establishing the same confidence in the annual average wind speed estimate.

Conclusions

Mesoscale model data have proven to be an efficient and accurate tool for generating offshore Wind Atlases. Long-term annual average wind speeds are estimated to have a random uncertainty of 4.2 % which is lower than onshore. But the amount of validation data is small and considerable spatial variability of the uncertainty can be expected. Near coastal zones model errors may be expected to be larger than far offshore. The deviations in the Weibull-k parameter is larger (in percent) than for the annual average wind speed.

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