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Mesoskalige Modellierung und Variabilität der Windenergie über Europa

J. Tambke (1), L. von Bremen (1), M. Schmidt (1), G. Steinfeld (1), J. De Decker (2), and J.-O. Wolff (3)

(1) ForWind, Institute of Physics, University of Oldenburg, Oldenburg, Germany (jens.tambke@uni-oldenburg.de), (2) 3E nv, Brussels, Belgium, (3) ICBM, University of Oldenburg, Oldenburg, Germany

This study comprises two parts:

First, we describe the vertical wind speed and turbulence profiles that result from our improved PBL scheme and compare it to observations and 1-dimensional approaches (Monin-Obukhov etc.). Second, we analyse the spatio-temporal correlations in our meso-scale simulations for the years 2004 to 2007 over entire Europe, with special focus on the Irish, North and Baltic Sea.

1.) Vertical Wind Speed Profiles

The vertical wind profile above the sea has to be modelled with high accuracy for tip heights up to 160m in order to achieve precise wind resource assessments, to calculate loads and wakes of wind turbines as well as for reliable short-term wind power forecasts.

We present an assessment of different models for wind profiles in unstable, neutral and stable thermal stratification. The meso-scale models comprise MM5, WRF and COSMO-EU (LME). Both COSMO-EU from the German Weather Service DWD and WRF use a turbulence closure of 2.5th order - and lead to similar results. Especially the limiting effect of low boundary layer heights on the wind shear in very stable stratification is well captured.

In our new WRF-formulation for the mixing length in the Mellor-Yamada-Janjic (MYJ) parameterisation of the Planetary Boundary Layer (PBL-scheme), the master length scale itself depends on the Monin-Obukhov-Length as a parameter for the heat flux effects on the turbulent mixing. This new PBL-scheme shows a better performance for all weather conditions than the original MYJ-scheme. Apart from the low-boundary-layer-effect in very stable situations (which are seldom), standard Monin-Obukhov formulations in combination with the Charnock relation for the sea surface roughness show good agreement with the FINO1-data (German Bight). Interesting results were achieved with two more detailed micro-scale approaches:

- the parameterization proposed by Pena, Gryning and Hasager [BLM 2008] that depends on the boundary layer height
- our ICWP-model, were the flux of momentum through the air-sea interface is described by a common wave boundary layer with enhanced Charnock dynamics.

2.) Wind Field Variability

Time series of wind speed and power from 400 potential offshore locations and 16,000 onshore sites in the 2020 and 2030 scenarios are part of the design basis of the EU-project www.OffshoreGrid.eu. This project investigates the grid integration of all planned offshore farms in Northern Europe and will serve as the basis for the "Blueprint for Offshore Grids" by the European Commission. The synchronous wind time series were calculated with the meso-scale model WRF from NCEP/NCAR. The simulation comprises four years and was validated with a number of wind measurements. We present detailed statistics of local, clustered and regional power production. The analysis quantifies spatial and temporal correlations, extreme events and ramps. Important results are the smoothing effects in a pan-European offshore grid.

Key words: OffshoreWind Resource Assessment; Marine Meteorology; Wind Speed Profile; Marine Atmospheric Boundary Layer; Wind Variability, Spatio-temporal Correlation; Electricity Grid Integration