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Evaluation of Wind Speed Profile Models over the North Sea

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For a wide variety of purposes, meso-scale model simulations have become an important tool, also for offshore wind energy resource assessments. The accuracy of common meso-scale wind speed calculations between the sea surface and 200m height depends mainly on the global weather analysis data used as input and the parameterisation of vertical turbulent fluxes in the planetary boundary layer (PBL-scheme).
In this study, we describe the vertical wind speed and turbulence profiles over the sea that result from our improved PBL-scheme for the WRF model and compare it to observations and 1-dimensional approaches (Monin-Obukhov etc.).

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 include 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 improved WRF-formulation for the mixing length in the PBL-scheme from Mellor, Yamada and Janjic (MYJ), the master length scale itself depends on the Monin-Obukhov-Length as a parameter for the heat flux effects on the turbulent mixing. This 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 also achieved with two more detailed micro-scale approaches:

- the parameterisation proposed by Pena, Gryning and Hasager (2008) that depends on the boundary layer height and
- 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.