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A hybrid model for the wind profile (direction and speed) for the whole boundary layer

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The increase in wind-turbine height and the increase in area swept by the blades harvesting energy from airflow in the lower atmosphere have raised the need for better understanding of the structure of the vertical profile of the horizontal wind speed and direction (veer). Whereas the literature is rich in studies of the wind speed profile in the surface layer, only a few parametrizations have been suggested for the whole boundary layer. Investigations of the turning (veering) of the wind direction with height are rare despite their obvious importance for wind power and load assessments.

Here we present a hybrid model for the wind profile for the whole boundary layer. The model accounts for the effect of baroclinity, atmospheric stability and boundary-layer height. It consists of separate modules for the turning of the wind direction with height and for the wind speed.

For the profile of the wind speed the model suggested in Gryning et al. (2007) is extended to take into account the effect of baroclinity.

The Taylor-Ekman model forms the basis for the parameterization of the turning of the direction (veering). It is argued that the depth of the atmospheric boundary layer is poorly accounted for in the Taylor-Ekman model, resulting in a diminished turning of the wind direction and very poor agreement with measurements. When the difference of about a factor of two between depth of the real atmospheric boundary layer and the one predicted by the Taylor-Ekman model layer is accounted for, the agreement with measurements is much improved. The modified Taylor-Ekman formulation was tested on a limited dataset and found to perform well during both unstable and neutral atmospheric conditions. It under-predicts the veering during atmospheric stable conditions, likely caused by low level jets and waves in the atmosphere, effects which are not considered in the modelling framework.