ANSWER TO STEINFELD'S COMMENTS

"On the wind stress formulation over shallow waters in atmospheric models" Pedro A. Jiménez and Jimy Dudhia.

Short comment 1

GENERAL COMMENT

The topic discussed in the manuscript by Jimenéz and Dudhia, a poor parameterization of the sea surface roughness in the mesoscale model WRF as a reason for the deviation between simulated and observed wind speeds and the presentation of a parameterization leading to an improved agreement is very interesting and of relevance, e.g. for the purpose of an improved accuracy of offshore wind resource estimates. The manuscript is well written and presents innovative and new results. However, we think that there is especially a lack of information on the observational data used in this study. Therefore, we would like to ask the authors to extend their description of the observational data and how it has been processed for the purpose of their study. The authors should mention how they took into account the previously reported (e.g. http://www.dewi.de/dewires/fileadmin/pdf/publications/Magazin40/09.pdf) mast shadow effects of the FINO1 met mast in their analysis and how they took into account in their analysis that the measurements at FINO 1 have been disturbed by the construction, testing and operation of the wind turbines in the wind farm alpha ventus since spring 2009 (http://www.alpha-ventus.de/fileadmin/userupload/avFactsheetenglDec20122.pdf). Alpha ventus is situated only 400 m east of FINO1. Did the authors filter for the mast shadow (north-westerly winds for the cup anemometers, south-easterly winds for the sonic anemometers at FINO1) as well as for possible wind turbine wake effects (easterly winds, i.e. about 0-180)? The first sentence in section 4 let us assume that there was no filtering of the data done, as according to that sentence fig. 1 contains data from 8760 h of 2009, i.e. from the whole year 2009. In fig. 1 it seems as if the overestimation of observed wind speeds by WRF starts at about 3-4 m/s. Interestingly, this is about the cut-in wind speed of the wind turbines of alpha ventus. According to fig. 3 the performance of the WRF model with Charnock parameterization seems to get worse with increasing wind speeds. Note that the velocity deficit due to the mast shadow impacting the anemometers at FINO1 for certain wind directions also increases with increasing wind speed.

ANSWER

We appreciate the positive perspective that this short comment provides of the manuscript.

We applied a basic QC to the data following ideas described by Jiménez et al. (2010). The QCed 10-min data were subsequently averaged to obtain the hourly observations used in this work. Hence we didn't apply any filtering to the data. We believe that the effects of the wind farm and the shadowing of the tower do not affect the conclusions of the manuscript since the frequency of winds from these directions is low. The sensors on towers are usually located in the less frequent directions of the winds to minimize the distortion of the records. This is the case of FINO1 were the prevailing winds are from the SW. The wind rose calculated with the observations of 2009 is shown on Fig. 1 of this document. The predominant winds are from the SW which is the direction that introduce the smaller perturbations on the observations.

We believe that the effects of the wind farm are of even smaller magnitude. The first turbine of the wind farm was installed on August 2009. The whole wind farm did not start to operate until November. The small period of 2009 with the wind farm in operation together with the infrequent eastern winds (Fig. 1) suggest the potential disturbances from the wind farm are small in this study.

To confirm our hypothesis, we calculated the bias for the whole year of 2009 and for the predominant-unperturbed winds from the SW and were very similar, 0.44 m/s for the SW winds and 0.39 m/s for the complete period.

We will mention in the new version of the manuscript that we applied a QC to the data and that the expected disturbances introduced by the shadowing of the tower and a nearby wind farm installed at the end of 2009 are small since they are located on infrequent wind directions.

COMMENT 1

Our further comments/questions are as follows:

- The simulations were performed with 36 vertical levels. Did the authors perform sensitivity studies with a varying number of vertical levels? When comparing with met mast data (100 m top height) wouldn't it be better to have more vertical levels especially in the lowest 100 m? - The authors should state on the physical reason for the different performance of the roughness parameterization for different atmospheric stabilities as seen in fig. 3. - Data of two different met masts situated at sites with similar water depths are used. Besides the parameter 'water depth' also the parameter 'distance to the coast' might be a crucial factor determining the wave

heights and therefore the wind conditions at the site, see e.g. Dörenkämper et al., Boundary-Layer Meteorol., doi:10.1007/s10546-015-0008-x. While FINO1 is situated about 45 km from the coast, the distance from the Noordwijk site to the coast is only 10 km. - Data at 60 m: There are both cup and sonic anemometers installed at that height. It should be clarified the data of which sensor has been used for this study? - The authors show results for different atmospheric stability conditions. Which stability parameter has been used? - What is meant by percentile-percentile plot (fig. 1)?

ANSWER

The impact of changing the vertical resolution is very likely to be dependent on the parameterization. The two turbulent closures based on TKE should be less sensitive to the changes than the other two parameterizations based on a first order closure. It is probably not a good idea to have the lowest model level much lower than 15 m specially for the first order closure parameterizations.

Our approach is to configure the WRF vertical levels in a standard approach using a higher number of levels closer to the surface. This configuration is therefore more similar to the one used by other modelers and to the one used by the developers of the parameterizations than the one resulting of doubling the number of the current vertical levels. We will not introduce any change in the manuscript regarding this comment since we are using a rather standard number of vertical levels.

On Figure 3 we just want to highlight that the new formulation improves the wind speed estimation during both stable and unstable conditions, and thus the improvements on the wind speed estimations are not just the result of improving the simulation under just one stability regime.

We used the cup anemometer at 60 m.

According to the publication mentioned in the comment, Dörenkämper et al., the distance to the coast can potentially affect the offshore environment under situations of strong stability. These situations are very infrequent at FINO1, the model shows only about 1/3 of stable situations during 2009. The majority of these situations show a z/L parameter close to zero indicating weak stable conditions. Hence, the effects of the proximity to the cost should be of smaller dimension than the effects associated with the depth of the ocean. This parameter, z/L, was the one we used to define the atmospheric stability in the manuscript. This will be clarified on the caption of Fig. 3.

The percentile-percentile comparison is a standard approach to compare histograms. The method is also known as quantile-quantile plot or QQ plot (Wilks, 1995). Fig. 1 plots the observed percentile 1 versus the modeled percentile 1, the observed percentile 2 versus the modeled percentile 2 and so on. We will mention that the percentile-percentile is a rather standard statistical comparison and we will add a reference to Wilks (1995).

References

Jiménez, P. A., J. F. González-Rouco, J. Navarro, J. P. Montávez, and E. García-Bustamante, 2010: Quality assurance of surface wind observations from automated weather stations. *J. Atmos. Oceanic Technol.*, **27**, 1101–1122.

Wilks, D. S., 1995: *Statistical Methods in the Atmospheric Sciences*. Academic Press, 467 pp.

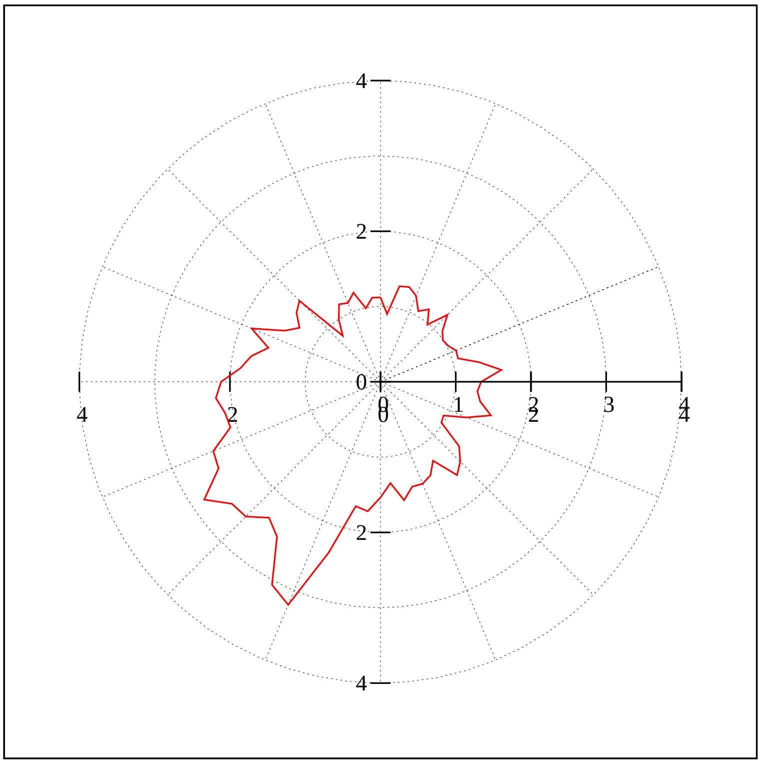

Figure 1: Wind rose at FINO1 for the year of 2009.