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WESD

Interactive comment

Interactive comment on "The impact of a forest parametrization on coupled WRF-CFD simulations during the passage of a cold front over the WINSENT test-site" *by* Daniel Leukauf et al.

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1 General comments

The paper presents a case study of a cold front passage across a complex wind energy site in Germany, simulated in high-resolution by WRF and the OpenFOAM driven by WRF-derived lateral boundary conditions. In the study, the authors investigate the impact of including forest parameterization in the models and validates the simulations against measurements from a meteorological mast and UAS flights.

Although the paper is generally well written and presents some interesting results, it

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Discussion paper

lacks in describing important details to allow the reader to draw conclusions or allow the study to be reproduced. Specifically, the paper lacks details on the microscale model formulation and on the coupling between WRF and OpenFOAM.

The UAS measurements are used for qualitative evaluation of the WRF simulations but add very little to the quantification of the improvement of the WRF model by using forest parameterization, or to the improvement of the results by using the high-resolution OpenFOAM model compared to WRF. At the same time, the mast measurements are not used to quantify the accuracy of OpenFOAM vs WRF results, e.g. via a comparison of error statistics.

2 Specific comments

- L63-64 - This sentence is inaccurate. It implies that the PBL/TKE scheme is not part of the turbulence parameterization.
- L74-75 - Six hours spin-up time for WRF is short compared to the existing literature. Why did you choose six hours? and are you confident that six hours are sufficient to spin up the model?
- L87 - What WRF domain is used? domain 5?
- L91-94 - Please be explicit about the details of the OpenFOAM model and the configurations used, e.g. is it a Finite-Volume model? does the model describe an incompressible fluid? are variables collocated or staggered? What vertical coordinate is used?
- L94-95 - What modifications specifically was used? are they the same as in El Bahlouli et al. (2019)? i.e. based on Apsley and Castro (1997)? Please add specific details or state the reference.

- L107 - Do you use the same forest height (20 m) for both the mesoscale and the microscale simulations? or 30 ± 5 m for WRF like in Wagner et al. (2019)? If 20 m is used for the mesoscale simulations, how can 2–3 points be influenced by the parameterization when the lowest model level is at 10 m and $\Delta z = 15$ m?
- L108-110 - The Boussinesq approximation permits gravity waves in the model. How did you treat gravity waves in the CFD model? e.g. did you use any damping layers? did you observe gravity waves during the simulations?
- L110 - What was the time-step used?
- L110-112 - Additional information that describes the coupling is needed, including details on the following.
  - What kind of spatial interpolation of WRF data to the microscale boundaries was used?
  - Was output written from WRF every 2 min? or did you interpolate in time? what kind of interpolation?
  - What did you prescribe at the microscale boundary below the lowest WRF vertical level?
  - What surface temperature did you use from WRF? the skin temperature ("TSK" variable)?
  - What processing did you do, if any, of the surface temperature before prescribing it in the microscale model?
  - Was the same surface temperature prescribed everywhere, or did it vary with surface elevation?
  - Did you treat the varying surface temperature and its impacts on the momentum and heat fluxes in the microscale model in any special way? to e.g. avoid surface detachment from the upper air during rapid surface cooling.

- L114 - Please provide more detail about the microscale grid. Is the horizontal grid resolution finer near the ground? what about the vertical grid resolution? at what height is the first level? what is the Δz near the surface?
- L134-137 - Please specify how long each flight leg took?
- L140-145 - How did the atmospheric stability vary during the period?
- L168-172 - How did the forest parameterization in WRF influence the temperature and atmospheric stability?
- Fig. 4 - Please state whether the streamline thickness is related to the speed and what the approx. wind speed magnitudes are.
- Fig. 8 - It is difficult to compare the data here. It may be helpful to the reader if you interpolate the WRF data to the UAS positions and plot the wind speed and direction differences between the model and UAS data in a separate plot or a third row in the existing plot.
- L270-284 - It would be useful to have error statistics for WRF, WRF-F, OF-F(WRF), and OF-F(WRF-F), just like you presented for WRF and WRF-F in section 3.2. Does OF-F(WRF-F) improve the results compared to WRF-F?
- L286-287 - This sentence is misleading. It is not the vertical resolution alone that makes the WRF model unstable but the combined effect of resolution, time-step and vertical velocity, i.e. the CFL number.
- L312 - This is very vague. It would be helpful to provide some quantification of how well the models reproduce it.
- In Fig. 8. you present UAS measurements compared to WRF-F, why not also present the results for OF-F(WRF-F)?

3 Technical corrections

- L275 - filed $\longrightarrow$ field?
- L285 - Section 33.1 $\longrightarrow$ Section 3.3?

4 References

Apsley, D. D. and Castro, I. P. (1997) "A limited-length-scale K-ε model for the neutral and stably-stratified atmospheric boundary layer", Boundary-Layer Meteorology, 83(1), pp. 75–98. doi: 10.1023/A:1000252210512.

El Bahlouli, A. et al. (2019) "Comparison of CFD simulation to UAS measurements for wind flows in complex terrain: Application to the Winsent test site", Energies, 12(10). doi: 10.3390/en12101992.

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