Wind Energ. Sci. Discuss., referee comment RC1
https://doi.org/10.5194/wes-2022-113-RC1, 2023

Demystifying the terra-incognita

Javier Sanz Rodrigo (Referee)

Referee comment on "Lessons learned in coupling atmospheric models across scales for onshore and offshore wind energy" by Sue Ellen Haupt et al., Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2022-113-RC1, 2023

General comments

Excellent work summarizing a long research program on the complex topic of mesoscale-to-microscale coupling of atmospheric models for wind energy applications. The authors have covered a lot of ground exploring different techniques aiming at closing the gap between flow models that have been developed primarily by meteorologists using weather models on the mesoscale side and wind engineers on the microscale side using CFD codes. Hence, the challenge is not only scientific and technical but also sociological towards the development of a long-lasting interdisciplinary collaboration. Kudos to MMC for that!

The summary is quite comprehensive, given the complexity of the topic, with well-described challenges, core scientific topics and computational techniques established along a validation framework of case-studies of increasing complexity. I like the narrative of the research journey. If anything, the authors could try to mitigate some of the fluid dynamics jargon to improve accessibility to researchers from other neighboring disciplines.

Out of each chapter there are a number of lessons learnt that are collected in the conclusions with reference to all the papers published by the team. Since the topic is still far from being solved it is highly appreciated all the efforts being made by the MMC team to open-source much of the code and data through GitHub repositories and a documentation website. As the main deliverable of the MMC project I would try to publish these repositories properly by associating them with persistent DOIs to allow citation and to track usage and impact.

I have identified other topics in the text that I believe deserve being highlighted because of the practical benefits they bring. I've also raised a few questions to see if the MMC team has arrived to some consensus on the best method to produce high-quality input data for offline coupling to microscale. I believe this is a key objective. Since WRF is the de-facto standard mesoscale model for wind energy it would be worth having a reference setup that narrows down the configuration options and provide valid simulations in the terra incognita and/or consistent input data to drive microscale models. I believe it is the right time to make explicit all the guidelines that can help reducing the spread of model configurations so research efforts can be focused on the key drivers of uncertainty for wind energy. As it is discussed in section 2.5, much work remains on uncertainty characterization by blending high-fidelity modeling and data-driven ML approaches. Is coupling to data *the next terra incognita*? I believe so…

Specific comments

53: Please provide a bit more context about what the Boussinesq approximation stands for.

54: Please provide more context on why the surface conditions are inherently different.

90: Although this is defined in detail later, can you define what online vs offline mean since these terms are used in many other domains?

93: dealing with (flow?) complexity.

111: I would add a reference to the public repository and associated documentation in the References section and then use citations in the text. In fact, you may use Zenodo's GitHub integration to archive the repo and automatically issue a new DOI each time you create a new GitHub release. https://docs.github.com/en/repositories/archiving-a-github-repository/referencing-and-citing-content

121: presnts > presents

148: "In some situations": can you be more specific?

135: The MMC team has correctly focused on a single mesoscale code (WRF) to explore its use in the “terra-incognita”. This has resulted in some guidelines and case-study setups that constitute valid benchmarks to improve upon in the future. Would it be worth highlighting this deliverable of the project? Is there a reference WRF-LES setup that can be used by the wind industry to run meso-micro simulations at ~100 m resolution? This version-controlled benchmark model will be used to quantify improvements going forward as the model is tested in other sites subject to different wind climates and terrain complexity than those used so far by the MMC project. Such reference (namelist) configuration files are made available in the code repository (section 2.7) but it could be provided as an Annex of this paper to highlight this release in a similar way as it was done in the New European Wind Atlas WRF model (https://doi.org/10.5194/gmd-13-5053-2020).

226: This categorization of coupling strategies is very comprehensive. It would be worth highlighting this with a chart or a table so this can stand out from the rest of the text of this section.

250: What about using heterogeneous mesoscale tendencies (3D instead of 1D)? Has this option been discarded by the group for any reason or simply not tested? This approach was followed in the Alaiz benchmark showing added value of 3D vs 1D tendencies in the prediction of mean wind speed profiles in complex terrain especially under stable conditions (https://iopscience.iop.org/article/10.1088/1742-6596/1934/1/012002).

262: "mesoscale meteorology models are usually not developed with LES applications in mind". Would the authors suggest putting more efforts into improving computational efficiencies in the meso-micro (WRF-LES) range or, as the text suggests, would the MMC team rather focus those efforts on improving the offline coupling approach to benefit from the greater flexibility and throughput of microscale models?

264: Offline boundary coupling: Is there consensus on what are the best practices for the mesoscale model to provide consistent inputs to microscale models (e.g. resolution, domain size, etc)? Would the same guidelines for online coupling (nesting) hold for offline coupling? It would be worth making these guidelines explicit.

282: To provide some perspective on the magnitude of the computational burden, can the authors provide an estimate of the computational overhead due to the additional fetch required to spin up turbulence? (e.g. with respect to a simulation with periodic boundary conditions)

341: Can you provide references about the parameter ensemble approach and meta-modeling techniques?

400: This paragraph is not specifically addressing complex terrain. It rather discusses the advantages of using a microscale model. Maybe it could be moved to section 2.3.

411: "or sometimes it may be of secondary importance" I would remove this statement since it is already implicit in the previous one.

420: While the Rayleigh damping method is relatively simple, based on two parameters, section 2.6.2 suggest that the selection of these parameters is difficult to judge a priori involving fine tuning to the specific site. Are there some guidelines that could be provided? Again, making these explicit would be great even if some fine tuning would still be necessary.

435: SST gradients: I guess this argumentation is also valid for onshore conditions when we may need to account for surface temperature heterogeneity in complex terrain or across different land-use patches. Is this a particular challenge for offshore because its relative importance in the flow field is greater than in onshore conditions?

452: "very complex modeling framework requiring the coupling of ocean and atmospheric models". Not sure if atmospheric here would only relate to mesoscale models (probably not). Would the authors suggest that the main complexity resides in the mesoscale range such that we could essentially use the same microscale model setups that we used in flat-terrain onshore conditions? Is there any particularity on surface boundary conditions for microscale models to mimic different ocean conditions? Can we still use MOST? I guess these questions will be addressed in future MMC offshore-focus research projects but it would be nice to elaborate a bit on perspectives for microscale models.

455: It is great to make the MMC project open source. As mentioned earlier, the only missing piece is to have the repositories associated to DOI so they can be cited appropriately. Otherwise, it's all very comprehensive and well-structured for anyone to follow and contribute.

505 (and elsewhere): I would move the link to the reference list as a website-type publication.

520: The GABLS3 case can be mentioned as an alternative to study a flat terrain diurnal cycle with high-altitude measurements (1000m+).

- https://doi.org/10.5194/wes-2-35-2017 (meso-micro paper)
- https://doi.org/10.5281/zenodo.834355 (repository)
- http://iopscience.iop.org/article/10.1088/1742-6596/854/1/012037 (benchmark results)

565 (Figure 2): For completeness, can you provide a definition of lamda?

635 Figure 4: Are these integral lengths scales all calculated at the same height (same as in Figure 3)? Please specify in the caption for completeness.

703: I assume that all domains are running on the same vertical levels. Please confirm and provide some indication about horizontal and vertical resolutions to get some perspective about the transition from mesoscale to microscale across the different domains.

710 Figure 8: what is “error”? The text says "ensemble mean error" but it is not clear which simulations form the ensemble and which metric is it (MAE, RMSE, etc). Please clarify and add units to the variables.

743: Simulations with 250 m resolution using the 3D PBL Mellor Yamada are still called mesoscale. Is this because the MMC team is trying to bring mesoscale inputs closer in resolution to the LES domain as introduced in section 2.1? What does this mean in practice? Is this 3D PBL scheme enabled in all mesoscale domains? What is the computational overhead vs traditional 1D PBL? Can this allow (much) smaller LES domains to improve computational efficiency or do we still need large LES domains to allow meso-micro turbulence to develop? I'm just trying to understand if 2D PBL is part of the WRF-LES strategy or simply meant to be used as a mesoscale-only approach to increase resolution and improve accuracy in complex terrain sites.

785: Please define the variables in the Figure. What does "Ug and Vg only" means?