# Response to the reviewer

We thank the reviewer #1 for their useful comments and the time invested in reviewing our manuscript. We have addressed each of the referee comments as detailed point by point below, which we believe has significantly improved the quality of the manuscript.

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# Reviewer 1

### Main Comments

**Reviewer Point P 1.1** —

The revised grid refinement study uses a grid size that hardly changes, namely, $N_x = 550, 600, 650$, which is a refinement ratio of 1.08-1.09; the previous study used $N_x = 227, 332, 469$. This revised grid refinement study uses far too small refinement ratios and it is likely that you get similar results between the different grids as you also find; you write at Line 109: The results obtained with 3 different meshes of increasing resolution show negligible sensitivity on the wind profiles at three different towers on the ridges and inside the valley. In this case, you cannot conclude to get grid independent results. You need to have at least a grid refinement ratio of $\sqrt{2}$, similar to what you used in R1 (personally I always use a factor 2). You mention that you are limited to memory requirements, but you can always add results of coarser grids, for example you could use something as $N_x = 300, 450, 675$ using a refinement ratio of 1.5. If the grid results indicate that the error due to grid resolution is not converging then you would need to go finer. If you are limited to memory to do so, then you could also change to a higher order numerical scheme to reduce the grid resolution errors or simply run on a high performance computer cluster, which I believe the von Karman institute has access to (https://www.vki.ac.be/index.php/facilities-other-menu-148/hpc-cluster)

There is also a choice made in the revised grid refinement study that I would have done differently, which I would like to share for food for thought. When I perform a grid refinement study then I would not change the inflow profile per grid size because it would mean that you would model a different case per grid size. I do understand your choice because you focus on validation and are trying to mimic the inflow conditions of the measurements. However, for a more fair grid refinement study it would be better to not change the inflow parameters in my opinion and separate the model verification (grid refinement study) from the model validation (comparison with measurements). For example, you could have chosen to use the inflow profile based on the finest grid and use this inflow for all other grid sizes. Furthermore, the results of a grid refinement does not have to be compared with measurements as the reader could then be tempted to pick a grid result that is closest to the measurements, instead of taking the grid size that has negligible numerical errors due to grid resolution; the latter is the purpose of a grid refinement study.

**Reply**: We thank the reviewer for this comment. As indicated, the grid refinement study uses small refinement ratios and it is indeed likely that there are similar results between the different grids due to this reason. For the updated study, we use a grid coarsening approach in all three directions. Two additional coarse grids ("Very Coarse" and "Coarse" cases) with a grid refinement factor of around 1.4 are added for the mesh refinement study along with the previous three grids as shown in Table 1. Based on the study we conclude that the present results indeed appear to be grid-dependent for the range of grids that have been investigated and a further study needs to be done on a finer grid which is a part of future work. This sentence has been added to the paper in the Methodology and Appendix sections.

Table 1: Grid refinement study parameters showing the number of cells per main direction.

| Case | Nx | Ny | Nz | NCells (million) |
|---|---|---|---|---|
| **Very Coarse** | 300 | 300 | 80 | 12 |
| **Coarse** | 460 | 460 | 120 | 30 |
| Medium | 500 | 500 | 150 | 62 |
| Fine* | 550 | 550 | 170 | 88 |
| Very Fine | 650 | 650 | 190 | 115 |

Significant differences are seen between the very coarse and medium grids especially close to the ground near the Tower 20 (Calibration tower) on the South West ridge seen in Fig 1, inside the valley as seen in Fig. 2, and at Tower 29 close to 100 m on the North East ridge seen in Fig 3. Larger differences are seen close to the ground as the topology of the terrain is further resolved near the surface upon grid refinement. The structured grids are generated using the `terrainBlockMesher` tool [1], which interpolates the SRTM terrain data and creates the terrain patch on which smoothing is applied towards a cylindrical domain on the sides. Increasing the number of cells refines and slightly modifies the surface mesh close to the ground. Furthermore, a small change in the prediction of the extent of the re-circulation zone could have a significant change and uncertainty in the predictions inside the valley and on top of the Northeast ridge. This suggests that grid spacing is an important parameter for flow prediction around a complex terrain, and a grid-independent solution could be challenging to achieve based on the complexity of the flow topology. The difference in profiles is of the same order of magnitude as the differences caused by different model setups.

We also plan to include this grid study in the Appendix as the editor suggested investigating if the "grid refinement error" is of the same order as the differences caused by other set-up selections, in order to identify the signals that potentially dominate the simulation error when compared to experiments and mentioning it as future work for performing simulations on a much finer mesh. As a clarification, we indeed run simulations on the cluster. However, we generate the mesh on a local/personal machine, since the grid generation is compiled for an older version of OpenFOAM and the memory issues are related to the creation of the mesh. The "Very Fine" grid mesh is the maximum number of cells that could be generated. Hence we suggest that future work should include an investigation with a much smaller grid size. We also agree that the best way is not to change the inflow for each grid. However, we were not sure of deciding on the finest grid and the inflow applied to it, hence we opted for the calibration approach for each grid.

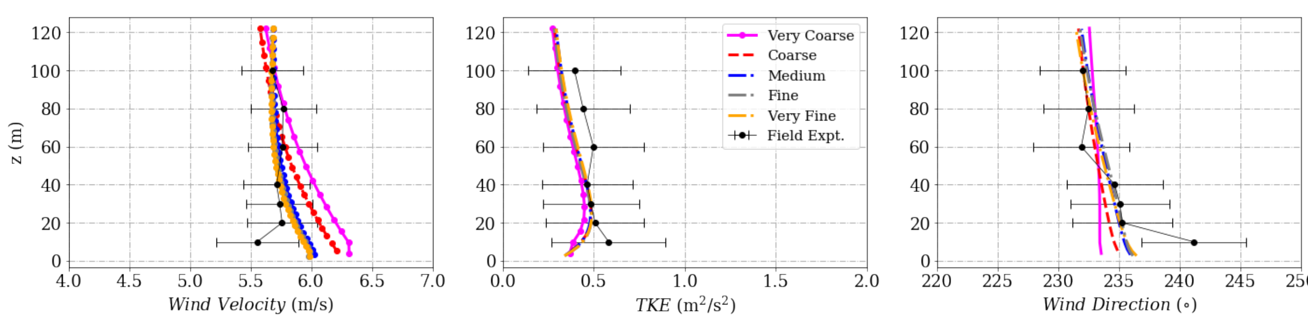


Figure 1: a) Wind velocity magnitude b) Wind direction c) Turbulent kinetic energy tuned to reach calibration at height 573 m corresponding to 100 m at Tower 20 (tse04)

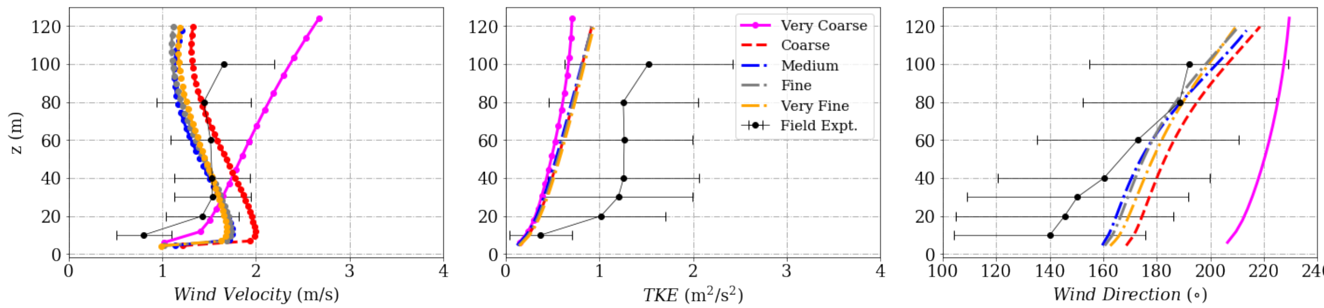


Figure 2: a) Wind velocity magnitude b) Wind direction c) Turbulent kinetic energy at Tower 25 (tse09)

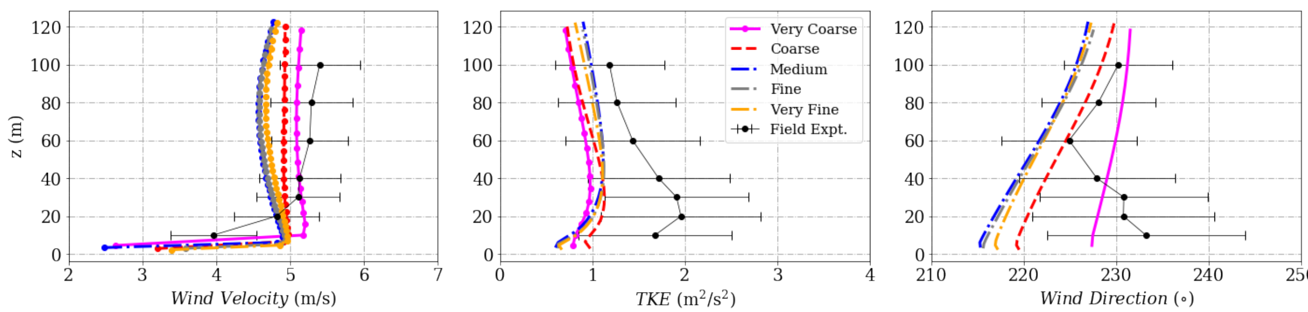


Figure 3: a) Wind velocity magnitude b) Wind direction c) Turbulent kinetic energy at Tower 29 (tse13)

## References

[1] Jonas Schmidt, Carlos Peralta, and Bernhard Stoevesandt. "Automated generation of structured meshes for wind energy applications". In: London: Open Source CFD International Conference, London, Oct. 2012.