Response to Anonymous Referee #2

General comments

- The article presents the combination of large-eddy simulation with a control theory model for ground-gen and fly-gen fixed wing airborne wind energy systems. There is a complex interaction between the different components of the model. Each component in the model is explained to a certain level in a dedicated section.
- The level of fidelity of the wind model is high, except for the relatively low grid resolution, while the model of the airborne wind energy system is very simplified.
- The control strategy uses the model with several constraints, among others to avoid flying in the own wake. It results in the generation of optimal trajectories.
- After explaining the model, results are presented for 3 different farm configurations. Wake effects are shown to be of importance. The fly-gen systems cause significantly stronger wakes than the ground-gen systems. In all farms, the flight path stays close to the optimal trajectories.
- The article is technically of a high level, uses a scientific method and is definitely relevant for the wind energy science community. The amount of information and the forward references make the article a challenge to read, but this is unavoidable given the amount of work that is presented.
- The open data will be an added value for the community.

We would like to thank the reviewer for the time and effort spent in reviewing this article. The reviewer comments have contributed to improve the quality of the paper. Below, we discuss the specific comments of the reviewer and indicate how they are addressed in the final manuscript.

Specific comments

- Line 155: The authors state that fewer states and control variables result in a less computationally intensive model. However, is this reduction relevant compared to the computational cost of the LES calculations? Some information about the time spent in each component of the model would be an interesting addition.

  The computational cost of one NMPC evaluation is indeed in most cases much smaller than the computational cost of one LES time step. However, given that AWES dynamics are faster than ABL flow dynamics, the control actions of each AWES are evaluated several times per LES time step. Consequently, the total execution time of the LES time step may depend on the execution time of individual NMPC evaluations.
  For drag-mode AWESs, the execution time of NMPC evaluations is almost negligible, accounting on average for less than 5% of the execution time of an LES time step. For lift-mode AWESs, the execution time of NMPC evaluations can vary substantially. While about 95% of the evaluations are performed in less than $1.0\,\mathrm{s}$, similar to drag-mode AWESs, the remaining 5% of the evaluations require about 15–$30.0\,\mathrm{s}$. This performance drop is generally observed when AWESs operate in heavily-constrained regions of the variable space or transition between considerably different reference flight paths.
  Additionally, synchronization of the NMPC evaluations of all AWESs at the end of each LES

time steps are necessary in the implementation, further reducing the computational performance of the framework. Also, given that NMPC evaluations are performed by one unique processor, the scalability of the framework is limited. Last, the performance of NMPC evaluations depends on additional parameters, such as the length of the prediction horizon or the number of model variables. The employed point-mass model consists of only 11 states and 3 control variables, whereas the rigid-body model (Malz et al., 2019) consists of 23 states and 4 control variables. Given the important number of NMPC evaluations (54000 evaluations per AWES) and the aforementioned performance bottleneck of the current implementation, the model choice may further limit the computational performance of the framework.

The reviewer underlines a significant point – the computational performance of the LES framework – which is often discussed in LES studies. A paragraph containing the presented arguments and computational cost of the simulation was added in Sect. 3 on page 29: "*The simulations are performed on the high performance computing infrastructure of the Flemish Supercomputer Center (VSC). The computational cost of one LES time step typically largely exceeds the computational cost of one NMPC evaluation. Hence the required computational resources depend heavily on the grid resolution, which also limit the simulation horizon. However, given that AWES dynamics are faster than ABL flow dynamics, the control actions of each AWES are evaluated several times per LES time step. In total, 54000 evaluations per AWES are performed during the simulation horizon of 4500 s. Consequently, the total execution time of the LES time step may depend on the execution time of individual NMPC evaluations. The performance of NMPC evaluations depends on several parameters, such as the length of the prediction horizon or the number of model variables. For drag-mode AWESs on the one hand, the execution time of NMPC evaluations is almost negligible, accounting on average for less than 5% of the execution time of an LES time step. For lift-mode AWESs on the other hand, the execution time of NMPC evaluations can vary substantially. While about 95% of the evaluations are performed in less than* $1.0\,\mathrm{s}$*, similar to drag-mode AWESs, the remaining 5% of the evaluations require about* $15\text{–}30.0\,\mathrm{s}$*. This performance drop is generally observed when AWESs operate in heavily-constrained regions of the variable space or transition between considerably different reference flight paths. As a result, the drag-mode AWE park simulations require about 1200 node-hours (or 52 node-days) while the lift-mode AWE park simulation requires about 1600 node-hours (or 67 node-days) on the Tier-2 hardware of VSC.*"

- Line 209: The authors obtain the model-equivalent angle of attack from the aerodynamic state, which is then used to define the orientation of the airborne wind energy system and as such influences the calculation of the aerodynamic forces. The authors had to do something to complete the limited information provided by the 3DOF model, and there is no obvious other way of doing this, but it remains a questionable approach in my opinion.

We agree with the observation of the reviewer. The limitations of this assumption are known to us and are highlighted in the manuscript on P7-L159. We originally opted for the point-mass model for its simplicity, scalability and versatility in order to demonstrate the capability of the fully-coupled LES-OCP framework. The model limitations can be resolved by using a rigid-body model such as the reference model defined by Malz et al. (2019). In this model, the body-fixed orientation frame (ie. the 9 components of the basis vectors) and the angular velocity of the aircraft are explicit states of the AWES and are incorporated in the system dynamics. We identified this model update as a major improvement to the framework and already mentioned it in the conclusion on P38-L729. In order to better highlight this point, we have improved the list of recommendations in the concluding remarks in Sect. 5 on page 40.

Technical corrections

- Line 30: axissymmetric => axisymmetric
- Line 36: can not => cannot
- Line 98: N_s probably refers to the number of segments of the wing, but this is not mentioned explicitly.
- Line 260: eventual => if applicable
- Line 357: The “min” and “s.t.” are aligned too much to the left.
- Line 405: The “min” and “s.t.” are aligned too much to the left.
- Line 655: stremwise => streamwise
- Line 757: magnitude aerodynamic => magnitude of the aerodynamic
- Caption figure A4: Is there a precursor simulation in this case? Isn’t it a turbulence free, sheared inflow according to line 786?

Thank you for these specific corrections, they have been incorporated in the revised manuscript.