Wind Energ. Sci. Discuss., author comment AC3
https://doi.org/10.5194/wes-2021-12-AC3, 2021

Reply on RC4

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Author comment on "UNAFLOW: a holistic wind tunnel experiment about the aerodynamic response of floating wind turbines under imposed surge motion" by Alessandro Fontanella et al., Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2021-12-AC3, 2021

Dear Refree,

Thank you for the extended and accurate feedback.

We agree with you that it would be useful to make the dataset more accessible for future research. It is currently hosted on a Polimi ftp, but we are currently uploading it on Zenodo and we believe it will be possible to include the reference to the latter in the final paper. If this won't be possible, we will for sure include more details about how to access the current ftp-based database.

A part from that, there are some comments we would like to answer here because we think they are of great value for the article and our research.

RC1: I'm not sure I would agree with this statement. If you are looking at tools to design floating wind systems, many were adapted from land-based and offshore tools directly for floating wind, with limited use for bottom-fixed. I would say rather that they were adapted from land-based tools.

AC1: Thank you for this comment. We think our sentence is inaccurate and the one you propose is closer to what we meant. Wind turbines and wind farms are often designed by means of engineering tools that were adapted from land-based tools. In this adaptation process, the aerodynamic model has remained almost unchanged.
However, floating turbines are subjected to peculiar inflow conditions that are not present in land-based turbines. The rotor of land-based turbines undergoes small-amplitude motions associated to the tower flexible response. The motion of an FOWT rotor is in large part set by the rigid-body motion of the support platform, and is in general of higher amplitude and lower frequency than in land-based turbines. The accuracy of land-based-derived aerodynamic tools in this new inflow conditions is yet to be assessed. An accurate prediction of the aerodynamic response caused by rotor motion is crucial. As said, this occurs at lower frequencies than in land-based turbines and, differently than in the latter, it causes significant interactions with the turbine controller (i.e., the aerodynamic response in FOWTs is inside the bandwidth of the turbine controller) that may lead to instability.
Experiments play a crucial role in verifying whether the aerodynamic codes are accurate

also for floating turbines, to get a deeper understanding of the peculiar aerodynamic phenomena that occurs when the wind turbine undergoes large motions and, based on this knowledge, to develop better simulations tools.

RC2: I'm not sure I agree with this statement. There are many floating wind tests that have been done in wind/wave facilities focused on aerodynamics, but not in a good wind environment like a wind tunnel, and with little focus on wakes.

AC2: You are right and also these have to be mentioned in the literature survey.
In parallel with wind-tunnel experiments, a series of floating turbine model-tests was performed in different wave-basins. Among the goals of these experiment was to investigate the effect of turbine aerodynamic loads on the global response of the system. In "Experimental Comparison of Three Floating Wind Turbine Concepts" the response to wind and wave excitation of three 5MW FOWT concepts was investigated at 1/50 scale. The blades of the turbine model was a geometrically-scaled copy of the NREL 5MW blade, and the aerodynamic performance (thrust force and power) of the rotor was not representative of the full-scale turbine. This was found to be a consequence of the Froude-scaled low-Reynolds wind. To cope with this issue, a new rotor was designed and a second set of tests was carried out in "Additional wind/wave basin testing of the DeepCwind semisubmersible with a performance-matched wind turbine". This second campaign proved that wind-turbine aerodynamic loads must be reproduced correctly when assessing the global response of FOWTs in wave-basin tests.
More recent research efforts, like "Experimental observations of active blade pitch and generator control influence on floating wind turbine response", "The Triple Spar campaign: Model tests of a 10MW floating wind turbine with waves, wind and pitch control" studied the interaction between turbine-control, aerodynamic forces and platform motions.
Overall, integrated wave-basin tests proved to be very useful in studying the coupled response of floating turbines modeling simultaneously wave excitation, wind and turbine control.
However, reproducing the turbine aerodynamic response is hindered by the low-Reynolds number imposed by Froude-scaling ("A wind tunnel/{HIL} setup for integrated tests of Floating Offshore Wind Turbines") and by the quality of the wind environment ("Methodology for Wind/Wave Basin Testing of Floating Offshore Wind Turbines"). With these limitations, reproducing a realistic turbine wake is usually out of reach.

RC3: What do you mean by a low uncertainty level? Was uncertainty assessed? What was improved upon from the previous Bayati campaigns which makes this one more useful?

AC3: Thank you for this comment that gives us the opportunity to discuss some important points about the test campaign of this article and research activities we are planning for the near future.

Uncertainty was not quantified in the present test campaign. However, quantifying uncertainty of experimental results is important to interpret them correctly. The UNAFLOW dataset is currently utilized in the OC6 project, and quantify uncertainty of datasets used for the validation of numerical tools is among the project goals. For this reason, we are currently planning a test campaign similar to the one discussed in this paper but dedicated to uncertainty quantification.

Concerning the last question, we can say the UNAFLOW experiment improved the upon the Bayati campaigns in the following aspects:
- The full-turbine experiment was designed based on a systematic approach. In particular,

knowledge about the aerodynamic response of the 2D airfoil was exploited to select the wind and surge-motion conditions of the full-turbine experiment
- Improved accuracy of force measurements. The accuracy of force data in the previous test campaigns was penalized by tower flexibility that created issues in the measurements, making their use for code validation difficult.
- The turbine wake was investigated with PIV and hotwire measurements for several surge motion conditions.

The UNAFLOW experiment generated a comprehensive database that covers in a coherent manner different aspects of the unsteady aerodynamic response of an FOWT rotor: aerodynamic coefficients of the blade airfoil, rotor-integral forces and near-wake. The database is also freely available for the community.

RC4: What are the limitations of studying these issues at this small scale?

AC4: 2D sectional airfoil experiments were carried out mainly for two reasons. Knowledge of the airfoil response was leveraged to select the surge-motion conditions of the full-turbine experiment and to provide a reliable polar-dataset that can be used to create numerical models of the experiment. Studying these issues at small scale has some limitations because it is not possible to reproduce exactly all the physics of a full-scale system (e.g. structural response, inflow conditions, ...). However, this disadvantage is offset by the possibility to control precisely and know better the test conditions, and to implement more measurements. Please let us know if this is not a sufficient answer to your comment and you think more details are needed here.

RC5: Was the tower frequency designed to represent a scaled version of the full-scale design? Could the system not be made stiffer to eliminate this issue [tower flexibility]?

AC5: Thank you for these comments that help clarifying the tower-flexibility issue.The tower was designed to reproduce the frequency of the 1st fore-aft mode of the DTU10MW (i.e., 6.29 Hz at model scale), and the model frequency was 6.75 Hz. The turbine FA modes are set by tower stiffness and weight of the rotor-nacelle assembly. Frequency is increased by reducing the latter and increasing the former. Slight stiffness increments are possible modifying the tower design, for example using carbon fiber in place of aluminum. RNA mass is instead heavily constrained by the mass of actuators (generator and pitch), control electronics, and sensors, that are commercial components, and cannot be modified.

Finally we are grateful for all comments about figures and text structure. We will keep them in great consideration as we are sure they can improve the paper quality.