I appreciate the authors addressing virtually all of my comments satisfactorily, and greatly increasing the clarity and readability of the manuscript. And it remains an interesting application and one of potential great importance.

Unfortunately I am still troubled by my Comment 8 on old Line 184, which I noted at the time was my biggest concern. (And Reviewer 2's Comment 2 suggests they have a similar concern.) Specifically, the inclusion of an elevated momentum source due to increased friction velocity from the turbines. I think there is some general confusion on these matters, so some leeway can be permitted, but I would make the following points.

Responses to the comments of Reviewer #1:

We sincerely thank the reviewer for the suggestions and comments that help us improve the quality of our manuscripts.

**) I am still not sure how new equation (22) is derived, specifically the derivation of the momentum flux term (delta_tau S Vijk (zk+1 - zk) in the mean kinetic energy budget, where delta_tau is the change in rho * ustar * ustar induced by turbine-impacted waves. Momentum flux times mean velocity is not a tendency of kinetic energy. (Negative) vertical gradient of momentum flux times mean velocity can be a tendency of mean kinetic energy. If the momentum flux really had this (constant with height) value up to 100 m and then became zero, you would have infinite accelerations at 100 m, and no accelerations above and below.*

**) In reality, vertical turbulent momentum mixing in WRF is done with a turbulence closure parameterization, usually a function of the TKE equation and some diagnostics. Momentum flux convergence / divergence is one of these terms. The only role of surface roughness / momentum stress in this framework is as a lower boundary condition such that these divergences can be computed.*

**) I would also say that there is not generally a 'constant momentum flux layer' in the atmosphere -- it is more correct to say that the surface layer is defined as a layer thin enough such that the momentum flux may be treated as approximately constant. Since it generally decreases on the scale of the boundary layer height, this is generally 10% of that value. But this means that wave impacts on surface roughness can cause drag to be transmitted throughout the depth of the PBL given enough turbulent transport.*

**) Less essentially, it should be noted that 100 m can be well above the surface layer in marine conditions, in which case a constant stress formulation would be inappropriate.*

**) In summary, without working through all details, I would advocate for wave-roughness modifications on momentum flux to be applied at the surface only, and then either transmitted throughout the PBL by the PBL parameterization, or perhaps somehow specified to decrease with height to the boundary layer top as long as double counting is avoided.*

Response: Thank you for your suggestion. We agree that the previous equations are not appropriate for the new wind farm parameterization scheme. In particular, we simply define the near-surface layer as a height of 100 meters above the sea surface, which should not be a constant. Following your suggestion that the roughness length modifications on momentum flux should be applied at the surface only, and then transmitted throughout the PBL by the PBL parameterization. We have modified the parameterization scheme with the following flow chart (Figure R11), the 3D wind speed at the wind turbine location is calculated by the PBL and passed to the wind farm parameterization to modify the inflow wind speed. We have re-run the simulations and made comparisons, and the new results are presented in the revised manuscript.

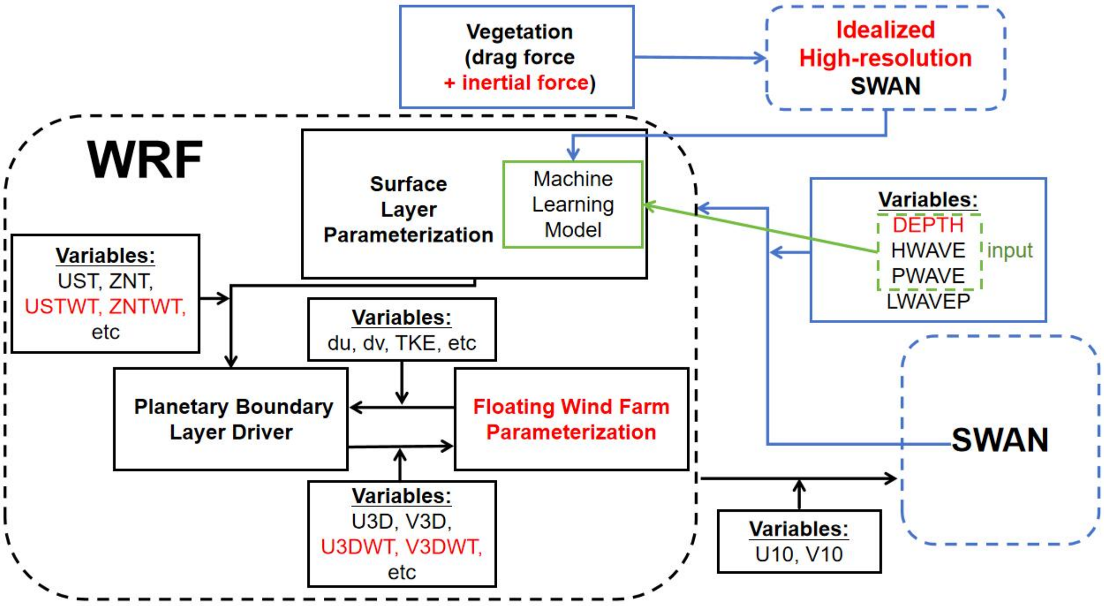


Figure R11. Flow chart of floating offshore wind farms parameterization implemented in the coupled model (HWAVE = significant wave height, LWAVEP = peak wave period, PWAVE = peak wave length, DEPTH= water depth, U10 = zonal wind at 10 m, V10 = meridional wind at 10 m, UST= frictional velocity, USTWT= frictional velocity at the wind turbine, ZNT = roughness length, ZNTWT = roughness length at the wind turbine, U3D = three-dimensional zonal winds, V3D = three-dimensional meridional winds, U3DWT = three-dimensional zonal winds at the wind turbine, V3DWT = three-dimensional meridional winds at the wind turbine, TKE = turbulent kinetic energy, du = zonal momentum increment, dv = meridional momentum increment).

We have re-run the simulation and made comparisons. A brief description of how the new results are different is given in this response, and the details are in the revised manuscript. The results indicate that the power output of the entire floating wind farm in the Fitch scheme is higher only (<3 %) in the upwind grid compared to the FWFP scheme. The power output is low in most of the other grids, within 20 % (Figure R12). There is also a significant difference in the wind speed deficit caused by the two schemes. As a result of the FWFP modification of the inflow wind speed, the wind speed in the upwind region increases (<0.4 m/s) relative to the Fitch scheme. Wind speeds in the downwind region are reduced, but to a greater extent, to within 1.8 m/s (Figure R13). The distribution of the differences in TKE corresponds well to the distribution of the differences in wind speed. Compared to the Fitch scheme, the

FWFP scheme generates less TKE in the upwind region (< 0.6 m2/s-2) and more TKE in the downwind region (< 1.4 m2/s-2) (Figure R14).

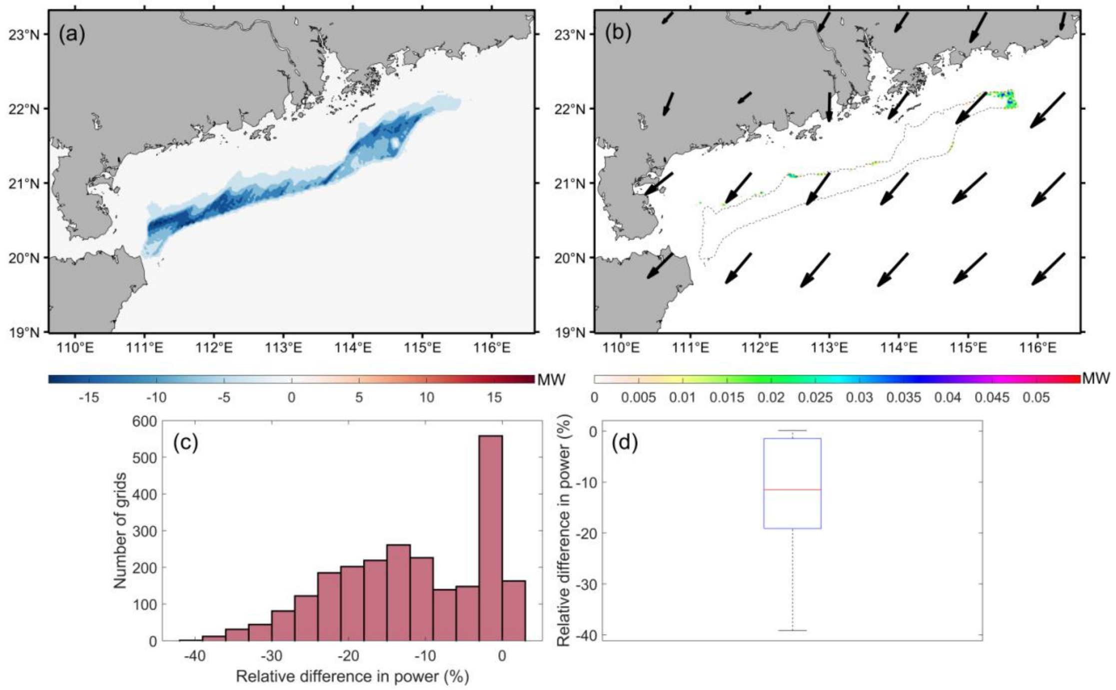


Figure R12. (a) (b) Power output of the WRF-Fitch case minus the WRF-FWFP case, but only positive values are shown in Figure R12b. The black dashed line indicates the outer boundary of the wind farm, and the black arrow indicates the wind direction. (c) Histogram of the relative difference between the power output of the WRF-Fitch case and the power output of the WRF-FWFP case. (d) Boxplot of the relative difference in the power output, the same as Figure 6.

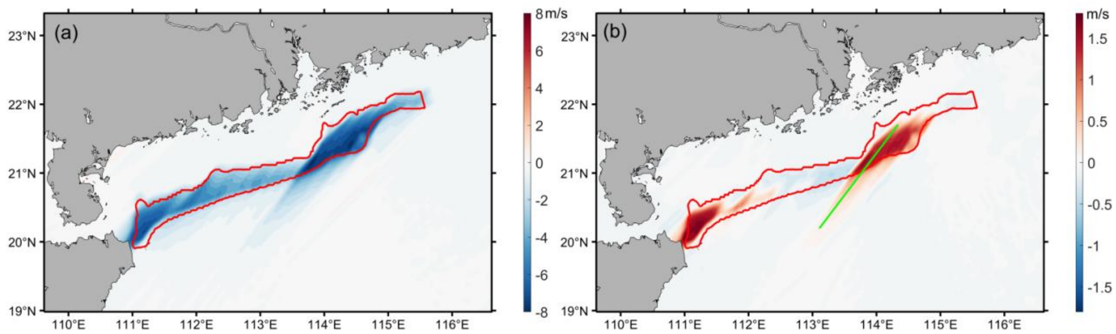


Figure R13. Horizontal wind speed of (a) the WRF-FWFP case minus the WRF-CTL case and (b) the WRF-Fitch case minus the WRF-FWFP case at the hub height level. The red solid line indicates the outer boundary of the wind farm, and the green solid line indicates a cross section analyzed further.

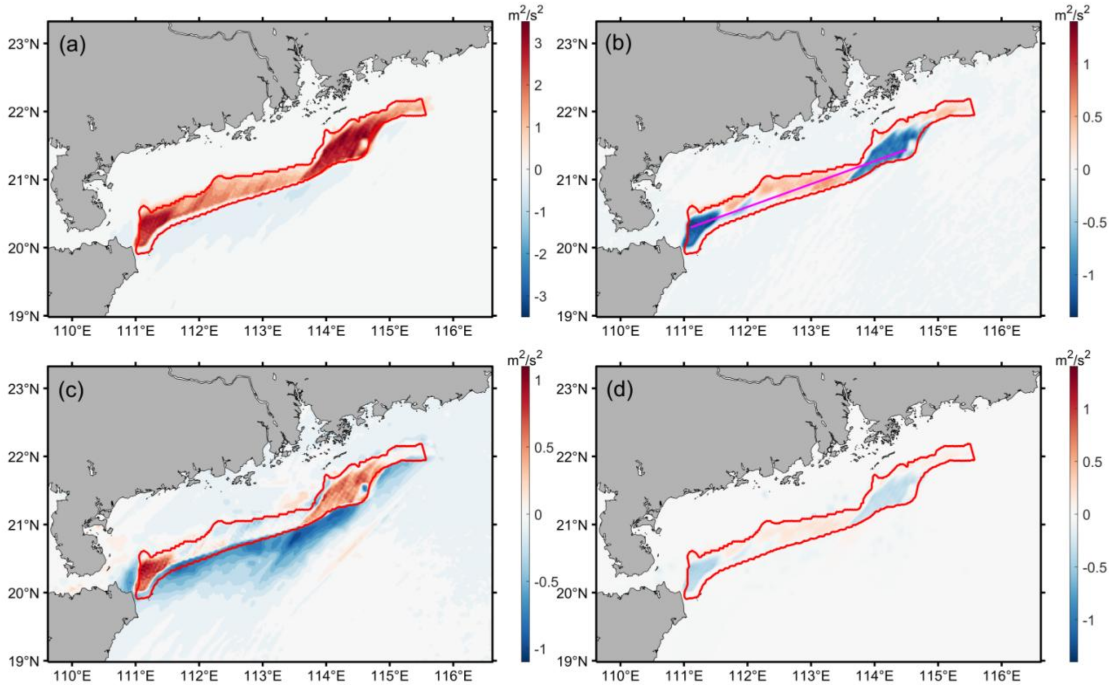
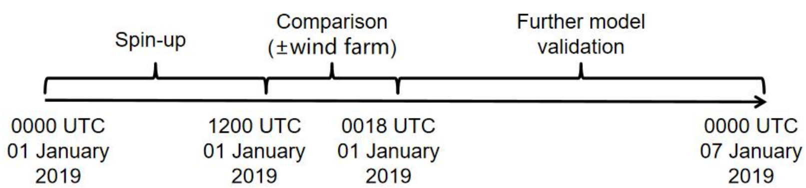


Figure R14. Horizontal distribution of TKE differences at the top of the turbine between (a) WRF-FWFP and WRF-CTL cases and (b) WRF-Fitch and WRF-FWFP cases, near the sea surface between (c) WRF-FWFP and WRF-CTL cases and (d) WRF-Fitch and WRF-FWFP cases. The red solid line shows the outer boundary of the wind farm, and the pink solid line indicates a cross section analyzed further.

Minor comments:

Line 276: You say that 'the model is run for an additional 150 hours for further validation (0000 UTC 01 January to 0000 UTC 07 January)' but 00 UTC 01 Jan to 00 UTC 07 Jan is six days = 144 hours, and the six hour period for all later analyses falls within this interval. So I am still a little confused about the time intervals involved.

Response: Thank you for your suggestion. Sorry for the confusion, we modified it in line 279 of the revised manuscript. The following figure may help to understand this better. The simulations are integrated first for 12 hours without the turbines to reach a steady state, and then run for another 6 hours for comparison. The model is also run for an additional 126 hours for further validation.



Response to comment 12, line 351: I could quibble about the degree that the Taylor Yelland parameterization is iterative. While this is technically true, the iterative *aspect of the scheme is in a viscous term that is actually derived from laminar theory, and in practice provides a roughness length in conditions for which wave roughness is zero. In regions of interest for wave roughness, this term should hopefully have negligible effect, in which case iteration is not needed to determine the roughness height.*

However, it is certainly true that the similarity schemes and turbulence physics of WRF overall are complex, and there are a number of reasons why reductions of SWH might not increase near-surface wind speeds. What I might suggest is to just remove the reference to '(Taylor and Yelland 2001)' here but leave it in Table 1.

Response: Thank you for your suggestion. We agree that the similarity schemes and turbulence physics of WRF are complex. Reduction of SWH impacts frictional velocity, roughness length, etc., which doesn't necessarily lead to an increase in near-surface wind speeds. And only in Table 1 have we retained '(Taylor and Yelland, 2001)'.

Thank you again for your great comment.

I appreciate all the author's comments and changes to the manuscript. The manuscript improved considerably, but I believe there are still a couple of points that need to be addressed more thoroughly.

Responses to the comments of Reviewer #2:

We sincerely thank the reviewer for the suggestions and comments that help us improve the quality of our manuscripts.

Major Comments:

1. Modifications to momentum equation:
a. Momentum source: In the response to reviewers' comments, the authors argue that sub-grid momentum fluxes may be misrepresented when modeling floating wind turbines in mesoscale models. This is a valid and interesting hypothesis. However, the authors do not provide evidence to support this statement. More important, the authors do not provide evidence/references in their manuscript to justify adding a source of momentum and an explanation of why this source of momentum is added to the lowest 100 m. Making such a statement without referencing other work that highlights this problem would require either observational or high-fidelity simulation results. This is a crucial part of this manuscript that needs to be addressed prior to publication as it has first-order effects on wake recovery and, thus, on the power output of the model.

b. Depth of momentum source: In the response to reviewers' comments, the authors argue that they add the source of momentum in the lowest 100 m of the atmosphere because this is the depth of the surface layer (constant flux later). However, the surface layer depth changes constantly, as the authors imply in Figure R22 where the depth of the surface layer is assumed to be between 50 and 100 m above the surface. For instance, for some stably stratified flows, the surface layer may be a couple of meters in depth and the boundary layer may be about 100 m in depth. Therefore, this assumption does not hold for simulating realistic atmospheric flows. Like I mentioned in the previous comment, making this assumption without referencing prior work would require observational evidence or results from high-fidelity simulations.

Response: Thank you for your suggestion. We agree that it is not always reasonable to add additional sources of momentum directly to the wind farm parameterization, not to mention that it is indeed difficult to define whether they are positive or negative. We also agree that the thickness of the near-surface layer cannot simply be defined as a constant (100 m). Especially when the subsurface is marine, the thickness is usually smaller. We have revised the new wind farm parameterization, taking into account the suggestions you made with another reviewer. Please refer to the flow chart below (Figure R21). We used the Planetary Boundary Layer Driver module in WRF to calculate the 3D wind speed as the frictional velocity, roughness length, etc. are changed. This 3D wind speed is passed to the wind farm parameterization as the new inflow wind speed.

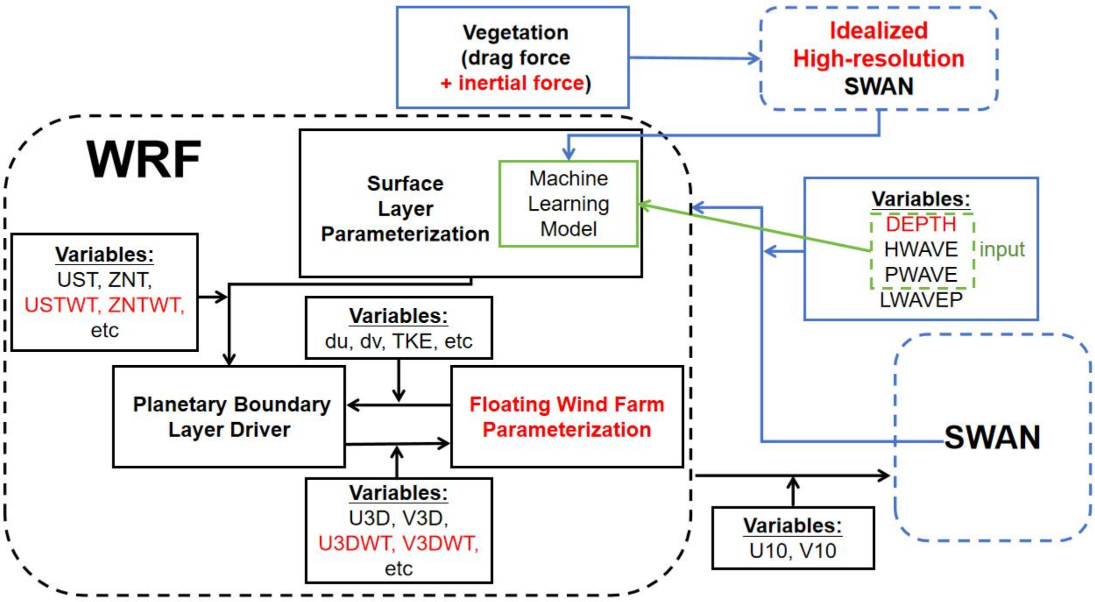


Figure R21. Flow chart of floating offshore wind farms parameterization implemented in the coupled model (HWAVE = significant wave height, LWAVEP = peak wave period, PWAVE = peak wave length, DEPTH= water depth, U10 = zonal wind at 10 m, V10 = meridional wind at 10 m, UST= frictional velocity, USTWT= frictional velocity at the wind turbine, ZNT = roughness length, ZNTWT = roughness length at the wind turbine, U3D = three-dimensional zonal winds, V3D = three-dimensional meridional winds, U3DWT = three-dimensional zonal winds at the wind turbine, V3DWT = three-dimensional meridional winds at the wind turbine, TKE = turbulent kinetic energy, du = zonal momentum increment, dv = meridional momentum increment).

We have re-run the simulation and made comparisons. A brief description of how the new results are different is given in this response, and the details are in the revised manuscript. The results indicate that the power output of the entire floating wind farm in the Fitch scheme is higher only (<3 %) in the upwind grid compared to the FWFP scheme. The power output is low in most of the other grids, within 20 % (Figure R22). There is also a significant difference in the wind speed deficit caused by the two schemes. As a result of the FWFP modification of the inflow wind speed, the wind speed in the upwind region increases (<0.4 m/s) relative to the Fitch scheme. Wind speeds in the downwind region are reduced, but to a greater extent, to within 1.8 m/s (Figure R23). The distribution of the differences in TKE corresponds well to the distribution of the differences in wind speed. Compared to the Fitch scheme, the FWFP scheme generates less TKE in the upwind region (< 0.6 m2/s-2) and more TKE in the downwind region (< 1.4 m2/s-2) (Figure R24).

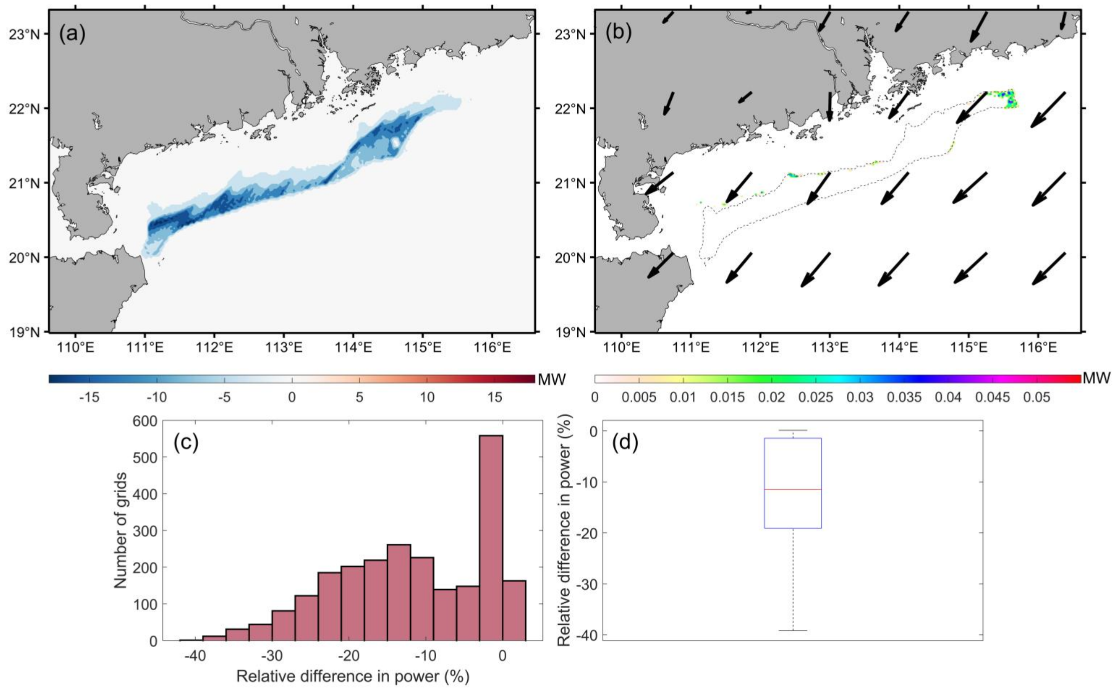


Figure R22. (a) (b) Power output of the WRF-Fitch case minus the WRF-FWFP case, but only positive values are shown in Figure R12b. The black dashed line indicates the outer boundary of the wind farm, and the black arrow indicates the wind direction. (c) Histogram of the relative difference between the power output of the WRF-Fitch case and the power output of the WRF-FWFP case. (d) Boxplot of the relative difference in the power output, the same as Figure 6.

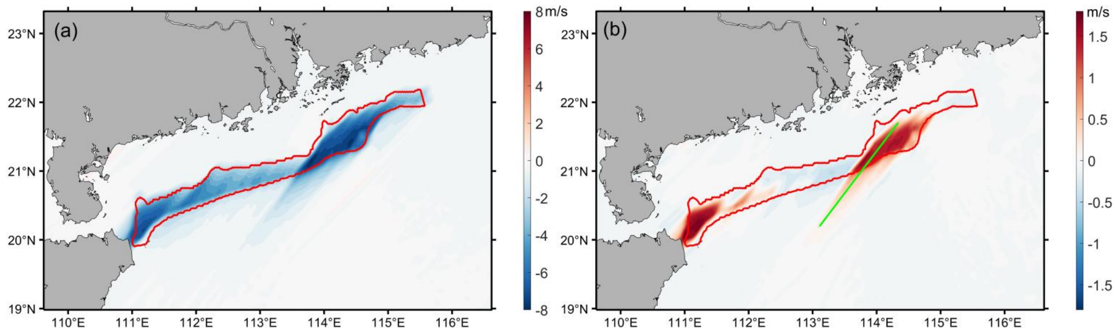


Figure R23. Horizontal wind speed of (a) the WRF-FWFP case minus the WRF-CTL case and (b) the WRF-Fitch case minus the WRF-FWFP case at the hub height level. The red solid line indicates the outer boundary of the wind farm, and the green solid line indicates a cross section analyzed further.

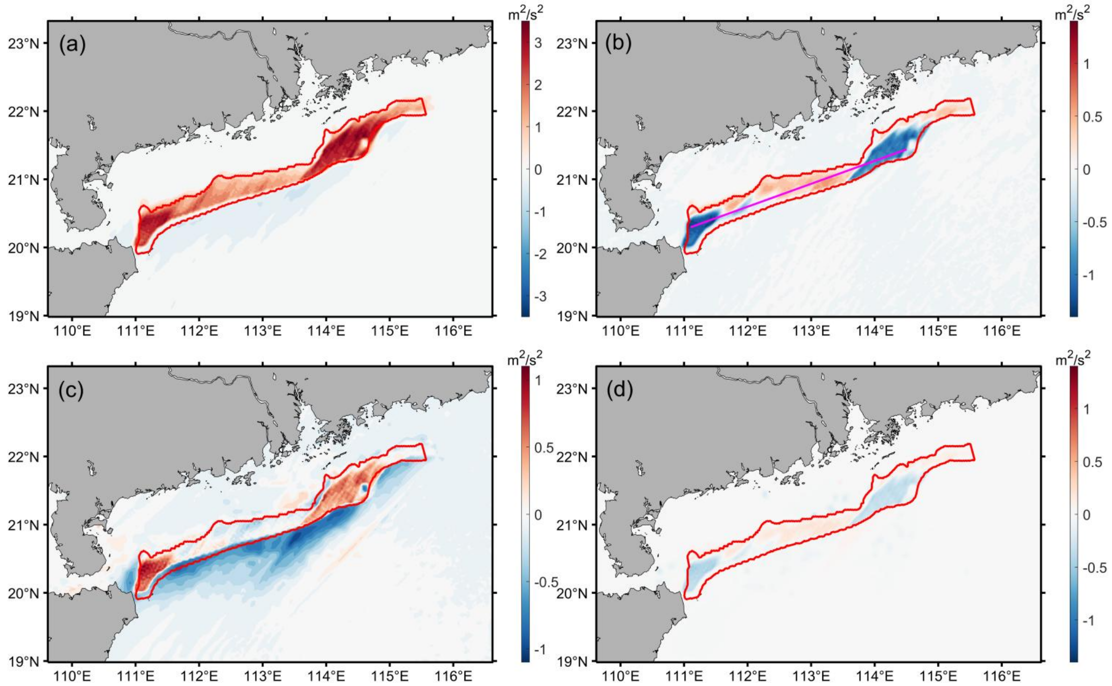


Figure R24. Horizontal distribution of TKE differences at the top of the turbine between (a) WRF-FWFP and WRF-CTL cases and (b) WRF-Fitch and WRF-FWFP cases, near the sea surface between (c) WRF-FWFP and WRF-CTL cases and (d) WRF-Fitch and WRF-FWFP cases. The red solid line shows the outer boundary of the wind farm, and the pink solid line indicates a cross section analyzed further.

Minor Comments:

1. It is not clear from Figure 10 that the FWFP simulations can produce lower power output compared with Fitch. From a visual inspection, Figure 10a does not have any clear red contours, which presumably mean Fitch produced more power than the FWFP. Also, the color bar on Figure 10b only has positive values. Why are there red contours in Figure R23, but there aren't any (at least not discernable) in Figure 10a?

Response: This is a good comment. The previous Figure 10 and Figure R23 are actually the same, only the range of the color bars is different. But we have performed new experiments.

Thank you again for your great comment.