Review of ”Fully Coupled High-Resolution Atmosphere-Ocean-Wave Simulations of Hurricane Henri (2021): Implications for Offshore Load Assessments”

This study investigates the effects of using different combinations of COAWST modeling components on the simulated Hurricane structure: Atmosphere only, Atmosphere-Ocean, and Atmosphere-Ocean-Wave. Various measurements are used to validate the results, and help to interpret the mechanisms of the interactions between atmosphere, wave and ocean. It also discusses the relevance to the calculation of loads for offshore wind turbines.

The paper is well written, with clear research questions, reasonable methodology, convincing presentation of results and analysis. I recommend the paper Minor Revision, with the following comments and suggestions.

We are sincerely grateful to the reviewer for their time, thoughtful comments, and constructive questions, all of which have significantly enhanced the clarity and robustness of our manuscript. Below, we provide a detailed, line-by-line response to each of the reviewer's comments.

In addition, we have substantially reduced the manuscript's length while preserving the core ideas and analyses, in line with Reviewer #1's suggestions. Our revisions emphasize the primary objectives of the study: introducing and demonstrating a new atmosphere-ocean-wave coupled modeling system, and examining how wave dynamics influence TC evolution, particularly wind structure, which is a critical factor in risk assessment and the design of offshore wind energy infrastructure.

To maintain a focused and concise scope, we have reformatted our introduction to describe our motivation for the study more clearly and removed the original implications section from the revised manuscript. The wind-wave misalignment and alignment analysis has been incorporated in Section 4.4: Ocean Surface Waves. The wind veer analyses have been omitted, and a more comprehensive wind energy-focused analysis, leveraging the fully coupled model introduced in this study, will be presented in a dedicated follow-up study.

Sec 2.1, line 132: it is written that "we have modified the WRF code to enable…". How does this work with the SWAN model? Isn't the Taylor-Yelland roughness length algorithms included in SWAN?

Thank you for this important question. SWAN calculates and provides wave parameters such as significant wave height and steepness; however, it does not directly compute surface roughness length (Z_0). Instead, Z_0 is derived from coupled atmospheric–wave process, as it depends on both wave characteristics and wind stress, which are parameterized within the atmospheric component (WRF).

To ensure that wave effects are reflected in the surface roughness seen by WRF, we modified WRF surface layer schemes to ingest wave parameters, specifically significant wave height and peak wavelength, from SWAN. These parameters are used in WRF's surface scheme to compute the surface roughness length following the Taylor and Yelland (2001) formulation. This allows the atmosphere model to account for sea state-dependent surface drag based on dynamically evolving wave conditions, rather than relying on default roughness parameterizations that do not consider wave information.

Sec 3.1, line 198: "a resolution of 4 km or less is adequately convection-permitting in WRF for simulating extreme events" – what do you mean "adequate"?

We have revised the sentence to: "4 km resolution or less supports convection-permitting simulations" (lines 138–140). This resolution range has been widely used in previous studies to simulate extreme weather events such as tropical cyclones (TCs) and mesoscale convective systems, where it has been shown to capture key convective features, storm structures, and precipitation patterns more realistically than coarser-resolution models with parameterized convection (e.g., Gentry and Lackmann, 2010; Prein et al., 2015).

The paragraph starting from line 200 seems to be about the ocean modeling. Yet the last sentence seems to belong to the atmospheric modeling, or does it?

The section has been completely restructured to clearly distinguish the atmospheric and ocean modeling components in Section 3.1.

Fig 3: many figures, including this one, miss x and y-axes labels. Please add all of them.

Thank you for pointing this out. We have added descriptive labels to both the x- and y-axes in Figure 3, as well as in all other figures (Figures 2, 4, 7, 8, 9, 10, 11, 12, and S1), where they were previously missing, to improve clarity.

Fig 3: What is the temporal resolution of the Best Track data in Fig 3b? What are the heights of winds from the modeling in Fig 3c?

We used the International Best Track Archive for Climate Stewardship (IBTrACS) for the best track data shown in Figs. 3a-c. The dataset provides storm information at 6 hourly temporal resolution. For Fig. 3c, the winds from the model are 10-meter winds derived from WRF output, consistent with standard practices for surface wind analysis. We have clarified both the temporal resolution of the best track data and the wind height from the model in the revised figure caption and corresponding text in lines 156-158.

Fig 4: Did the authors explain why the two time are chosen for the analysis? What about other time? Please add Unit to the color bars – not only to this figure but to all figures.

We have selected these two times because NOAA WP-3D airborne Doppler radar (TC-RADAR) observations are only available at those specific times, providing high-resolution three-dimensional wind structure data from 500 m to 9 km altitude. These observations offer a valuable reference for evaluating model performance, especially given that such detailed airborne radar measurements are not routinely available for every TC. The availability of TC-RADAR data during Hurricane Henri represents a unique opportunity to conduct a more rigorous assessment of the modeled wind field. While we examined model outputs at multiple times as part of our internal analysis, we found that the spatial distribution and structure were generally consistent with the times shown.

Additionally, we have added units to the color bars in Fig. 4, as well as to all other relevant figures throughout the manuscript as suggested.

Fig 7: The profiles in this figure, is it an average over a certain period or is it a snapshot on the day?

The profiles in this figure (now Fig. 6 in the revised manuscript) are based on dropsondes that were released during a single NOAA WP-3D flight that traversed the storm center from east to west within approximately 50 minutes from 23:21 UTC on 21 to 00:11 UTC on 22 August 2020 (with exact times indicated in Fig 3d). For the model results, we used a single output time at 00:00 UTC on 22 August 2021 to align with the timing of the observational data. We have clarified this in the revised main text (lines 166-168) and in the captions for Figs. 3 and 6.

Also, these dropsondes present azimuthally averaged vertical wind profiles in the inner-eyewall ($0.2 \leq r/RMW \leq 1$) and outer-eyewall ($2 \leq r/RMW \leq 2.5$) regions, based on the locations of the seven dropsondes highlighted in blue dots in Fig. 3d.

Fig 10a: add legend. Fig 10e and f: do you think the difference between wind and wave directions is caused by swell? What is the model's ability in capturing swell?

Thank you for pointing this out. We have added appropriate legends to Fig. 10 (now Figure 8 in the revised manuscript) in the revised manuscript to improve clarity.

The wave model should be able to capture swell adequately, but we do not believe this is the reason for the differences. Previous studies (e.g., Tolman et al., 2005) have shown that wave accuracy is highly sensitive to the quality of atmospheric forcing, particularly during hurricanes. This sensitivity helps explain the discrepancies observed in our wave model results shown in Fig. 10 (Fig. 8 in the revised manuscript). We attribute these differences primarily to wind forcing and the relative position of each buoy to the TC center. For instance, the overprediction of wind speed at buoy 41001 around 00 UTC on 22 August leads to an overestimation of wave height. Additionally, because the simulated TC track passes farther east than the observed track when approaching buoy 41002, the discrepancy in the timing of the wave direction shift can be attributed to this track error.

Please make sure all figures have axes labels, legends and color bars with units.

Thank you for the observation. We have carefully reviewed all figures in the manuscript and ensured that each includes clearly labeled axes, appropriate legends, and color bars with units where applicable. These updates have been made throughout the revised manuscript to improve clarity and consistency.

Citation: https://doi.org/10.5194/wes-2025-47-RC2

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