Anonymous Referee #2

The authors present a numerical simulation study of ocean waves in the Great Barrier Reef (GBR) region of Australia. This research incorporates state-of-the-art physics and numerical schemes, with principal methodologies comprising: implementation of an unstructured mesh to accurately resolve Australia's extensive coastline, and development of a two-step modeling strategy to address unresolved individual coral reefs and their dissipative effects. This two-step strategy treats discrete reefs as unresolved obstacles that act as complete barriers to wave energy, and parameterizes subgrid-scale reef-induced dissipation through a novel source term to represent the effects of unresolved obstacles. Critically, the experimental design features comprehensive controls: appropriate specification of open boundary conditions; isolation of interference from wind forcing errors, tidal currents, and surface circulation on GBR wavefield simulations. Validation against satellite altimetry and buoy observations demonstrates reduction of wave height bias from >100% to <20%, providing compelling evidence of substantially enhanced model performance following strategy implementation.

This methodology offers valuable insights for simulating wave fields in archipelago-fringed marginal and regional seas where dense reef systems exist. I recommend acceptance of this work for publication in your esteemed journal. However, I think a minor revision is necessary before the acceptance. Below are a few comments and suggestions for the authors' consideration.

Thank you very much for your thoughtful comments and suggestions. We will address all of these points in the revised manuscript. Please find our point-by-point reply below.

1. The coral reef location data used in this study were extracted from the global dataset provided by UNEP-WCMC et al. *(2010), which defines the outer polygons of reef structures. These polygons may represent reef platforms rather than the actual outlines of reef canopies, and such discrepancies could introduce uncertainties into the model results. A comment on the possible effect of the accuracy of the reef outline on the model performance is desired in the discussion or conclusion section.*

- Thank you for this insightful comment.
- The multi-source global coral reef dataset v4.0, compiled by UNEP-WCMC et al. (2010), is widely used as a standard reference in reef-related modeling studies (e.g., Lowe and Falter, 2015; Lyons et al., 2024), and was among the highest-quality publicly available datasets at the time of our study. This dataset was compiled from a global collection of Landsat 7 ETM+ satellite imagery, along with various other sources and nautical charts at different scales, with a maximum achievable spatial resolution of approximately 30 meters.
- In this study, we extracted the reef outlines of the GBR from the UNEP-WCMC v4.0 dataset. Based on these outlines (shown as grey squares in Fig. 3), two transparency parameters, α and β, were calculated.
- As the reviewer pointed out, the accuracy of the reef outline could influence model performance and, more specifically, could affect the calculation of the α and β coefficients in our scheme. If higher-resolution or more accurate datasets become

available in the future (e.g., Lyons et al., 2024), this issue could be further investigated using higher-resolution models. We will include a brief discussion of this potential source of uncertainty in the revised manuscript.

UNEP-WCMC, WorldFish Centre, WRI, and TNC: Global distribution of warm-water coral reefs, compiled from multiple sources including the Millennium Coral Reef Mapping Project, Version 4.0. Includes contributions from IMaRS-USF and IRD (2005), IMaRS-USF (2005), and Spalding et al. (2001). Cambridge (UK): UNEP World Conservation Monitoring Centre. http://data.unep-wcmc.org/datasets/1, 2010.

Lowe, R. J. and Falter, J. L.: Oceanic Forcing of Coral Reefs, *Annual Review of Marine Science*, 7, 43–66, https://doi.org/10.1146/annurev-marine-010814-015834, 2015.

Lyons, M.B., Murray, N.J., Kennedy, E.V., Kovacs, E.M., Castro-Sanguino, C., Phinn, S.R., Acevedo, R.B., Alvarez, A.O., Say, C., Tudman, P., and et al.: New global area estimates for coral reefs from high-resolution mapping. *Cell Reports Sustainability*, 1(2), https://doi.org/10.1016/j.crsus.2024.100015, 2024.

2. The application of UOST has clearly improved the model's performance in simulating significant wave height and peak period in the Great Barrier Reef region. However, the simulated values of T02 are underestimated. This may be related to the choice of the empirical coefficient ψ in Eq. (14). I would appreciate if the authors could stress the limitation of this engineering scaling on the model results.

- Thank you for your valuable comment.
- We appreciate this comment and consider it as a valid point—the underestimation of T02 may be related to the use of the empirical coefficient ψ in Eq. (14). This coefficient was introduced into the UOST scheme based on previous theoretical arguments and modelling experiences (Mentaschi et al. 2015, Mentaschi et al. 2018). When the shadow effect term S_{se} (Eq. 13) was derived, an important assumption is that for the cell in question, its upstream energy F_{Ad} equals to its cell-averaged energy F_B, provided that the local wave growth and other physical processes changing wave energy are neglected. If, however, there is local wind wave growth, an assumption $F_{Ad}{\sim}F_B$ may cause overestimation of the dissipation owing to the shadow effect. Therefore, an empirical (engineering) scaling function ψ was proposed to reduce the shadow effect for relatively young wave components. Thus far, the validity of this empirical scaling function has not been checked seriously. For doing so, dedicated spectral observations in the proximity of both the upstream and downstream of islands and reefs are desired, which are unfortunately unavailable to us at present.
- Following the suggestion of the reviewer, we will include the discussion above in the revised manuscript to further stress the uncertainty and the possibility for further improvement of the current approach.

Mentaschi, L., Pérez, J., Besio, G., Mendez, F. J., and Menendez, M.: Parameterization of unresolved obstacles in wave modelling: A source term approach, *Ocean Modelling*, 96, 93–102, https://doi.org/10.1016/j.ocemod.2015.05.004, 2015.

Mentaschi, L., Kakoulaki, G., Vousdoukas, M., Voukouvalas, E., Feyen, L., and Besio, G.: Parameterizing unresolved obstacles with source terms in wave modeling: A real-world application, *Ocean Modelling*, 126, 77–84, https://doi.org/10.1016/j.ocemod.2018.04.003, 2018.

3. In line 551 of the Appendix, the authors mention a comparison between model results and satellite altimeter data before and after accounting for tidal effects (Run5 vs. Run8). However, the results of this comparison are not presented. It is recommended that the authors include these results, as they could provide useful reference for future research.

- Thanks for your suggestion.
- We appreciate your careful reading of the Appendix. The comparison between Run5 and Run8 was not originally included because the differences in statistical metrics (e.g., bias and RMSE) were relatively minor. However, we agree that presenting these results could still provide useful context for future applications. Figure R1 presents the comparison results between Run5 and Run8, and we will include this figure in the Supplements of the revised manuscript.

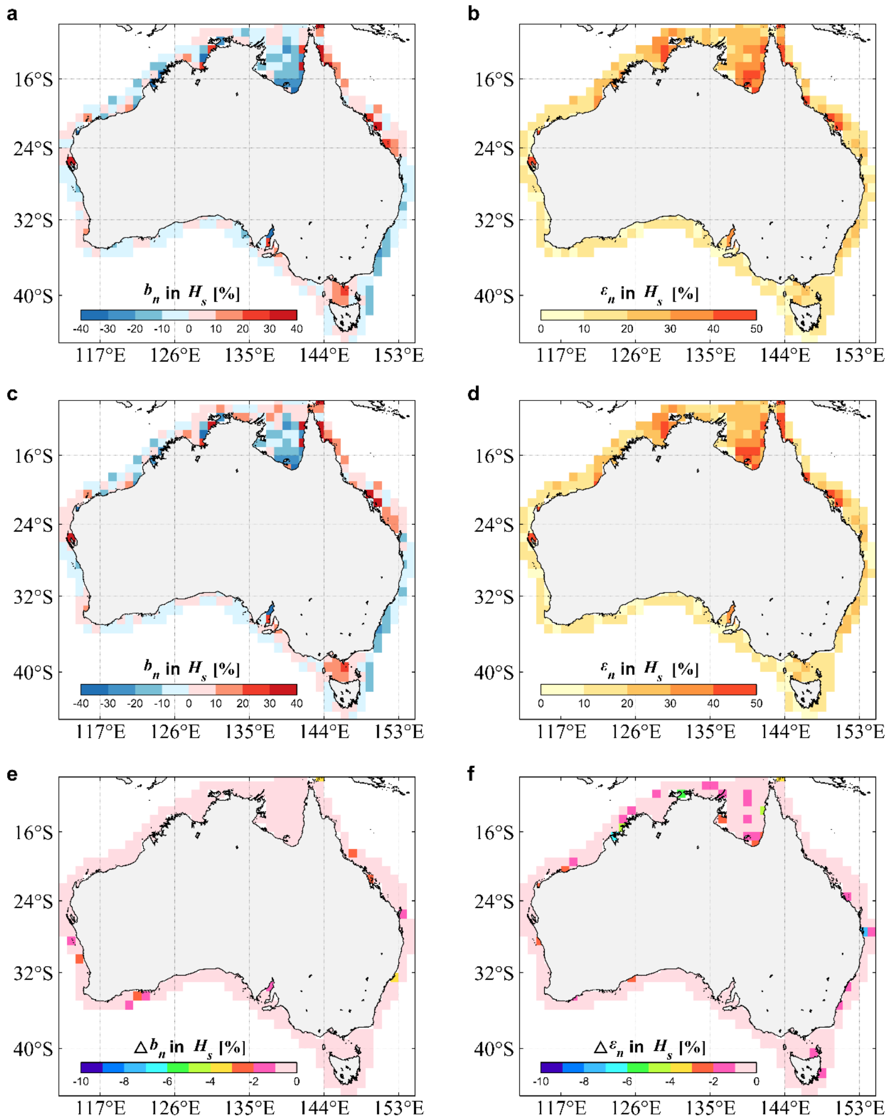

Figure R1. Error statistics of the significant wave height H_s gridded in 1°×1° bins for the WW3 for a two-month period (October – November 2011). (a, b) Run 5 (without FES2014) and (c, d) Run 8 (with FES2014) relative to the altimeter wave records: (a, c) the normalized bias b_n, (b, d) normalized RMSE ε_n. (e, f) Differences in H_s errors between the two WW3 runs: (e) $\Delta b_n = b_{n,8} - b_{n,5}$, (f) $\Delta\varepsilon_n = \varepsilon_{n,8} - \varepsilon_{n,5}$.