Anonymous Referee #1

This manuscript presents a well-executed study on regional wave simulations along the Australian coast using the WAVEWATCH III (WW3) model, with particular emphasis on improving model performance over the Great Barrier Reef (GBR) through a two-step subgrid parameterization approach. The study is timely and relevant, demonstrating both technical rigor and practical applicability in modeling ocean waves in complex coastal environments.

I believe this manuscript is suitable for publication after minor revisions. I recommend the authors consider the following suggestions to further enhance the clarity and completeness of the work:

Thank you very much for your positive comments. We will revise our manuscript by following all of your suggestions. Please see our point-by-point reply below.

1. Brief description of the prevailing wave conditions along the northeastern Australian coast would help contextualize the results. Based on the manuscript, the region appears to be predominantly swell-influenced. It would be helpful to comment on model performance under wind-sea–dominated conditions.

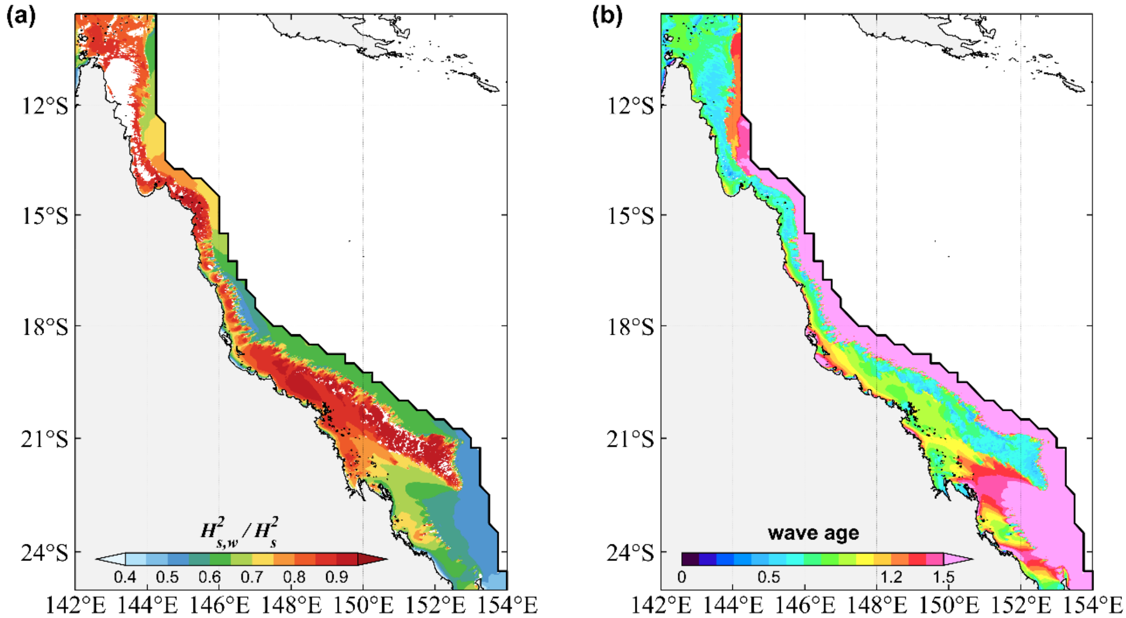

Figure R1. Spatial distribution of the (a) wind sea fraction and (b) wave age in the Great Barrier Reef region, based on the Run 7 simulation for 2011.

- Thank you for this comment.
- Figure R1 presents the spatial distribution of the wind sea fraction, calculated as $\left(H_{s,w}/H_s\right)^2$, where $H_{s,w}$ and H_s are the significant wave heights of wind sea and the total spectrum, respectively, and wave age ($c_p/U_{10}\Delta\theta$, where c_p is the phase velocity for the peak wave frequency, U_{10} is 10 m wind speed and $\Delta\theta$ denotes the angle between the wind direction and peak wave direction) in the Great Barrier Reef (GBR) region based on our Run 7 simulation for 2011. The results show that the seaward side of the GBR and its southern region are primarily dominated by swell originating from the

Coral Sea (e.g., Smith et al., 2023). Due to the dissipation of long-period wave energy by the coral reefs, the wave field over the reef matrix is largely composed of wind sea, with relatively low wave age values (ranging from 0.5 to 1). The inter-reef areas, however, remain significantly influenced by offshore swell. In the lee of the reef, the wave field is primarily governed by locally generated waves (e.g., Gallop et al., 2014).

- Based on the results shown in Fig. R1, it can be indicated that the outer edge of the GBR is dominated by swell conditions. As the low-frequency energy is dissipated, wind sea conditions become dominant within the reef matrix. This suggests that our model does indeed represent both wave regimes, and the overall reasonable performance demonstrates the robustness of our approach.
- Moreover, in our modelling framework, the UOST energy dissipation is applied separately across wave directions and frequencies. A correction factor, ψ (Eq. 14), is included in the UOST scheme to adjust the level of dissipation based on wave age (Mentaschi et al., 2015). As indicated by the equation, full dissipation is applied only when the wave age exceeds 1.5, corresponding to swell-dominated conditions. When the wave age lies between 0.5 and 1.5, representing mixed sea states, the dissipation is gradually scaled. For wave age below 0.5—indicating wind-sea-dominated conditions—the UOST source term does not contribute to energy dissipation.
- In summary, wind sea conditions are reasonably accounted for in our model. We will clarify this point in the revised manuscript.

Smith, C., Vila-Concejo, A. and Salles, T: Offshore wave climate of the Great Barrier Reef. *Coral Reefs*, 42, 661–676, https://doi.org/10.1007/s00338-023-02377-5, 2023.

Gallop, S. L., Young, I. R., Ranasinghe, R., Durrant, T. H., and Haigh, I. D: The large-scale influence of the Great Barrier Reef matrix on wave attenuation. *Coral Reefs*, 33, 1167–1178, https://doi.org/10.1007/s00338-014-1205-7, 2014.

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.

2. The authors have carefully included several important coastal processes, such as tidal variations and wave–current interactions. However, the representation of wind stress could be further improved. The drag coefficient used in ST6 is originally developed for open-ocean conditions; a brief discussion of its applicability and limitations in reef-dense or shallow water environments would be valuable.

- Thank you for the comment.
- As the reviewer pointed out, the drag coefficient used in ST6, based on the work of Hwang (2011) was originally developed based on open-ocean observations. Please note that, this empirical drag coefficient is used by ST6 for two purposes: 1) converting the usually used U_{10} to friction velocity u_*, 2) acting as an upper limiter for the wave-induced stress which can be calculated from the wind input term (e.g., Zieger et al. 2015). Our present results suggest that nearshore wave simulations using this configuration perform reasonably well, indicating that this drag coefficient might be reasonably applied to shallow coastal environments. In this regard, I would like to note that a drag coefficient law of the similar form to the one used by ST6 has been

implemented by SWAN (Zijlema et al. 2012) and were extensively used for coastal wave modelling. The reviewer is referred to Liu et al. (2017, their Fig. 9) for the comparison of C_d between the studies of Hwang (2011) and Zijlema et al. (2012).

- That said, we agree that the representation of wind stress could be further improved. For example, Chen et al. (2020) investigated the impact of shoaling wind waves on C_d in coastal waters. We will include a brief discussion about this aspect in the revised manuscript.

Hwang, P. A: A note on the ocean surface roughness spectrum. *Journal of Atmospheric and Oceanic Technology*, 28(3), 436-443, https://doi.org/10.1175/2010JTECHO812.1, 2011.

Zieger, S., Babanin, A. V., Rogers, W. E., and Young, I. R: Observation-based source terms in the third-generation wave model WAVEWATCH III. *Ocean modelling*, 96, 2-25, http://dx.doi.org/10.1016/j.ocemod.2015.07.014, 2015.

Zijlema, M., Van Vledder, G. P., and Holthuijsen, L. H: Bottom friction and wind drag for wave models. *Coastal Engineering*, 65, 19-26, https://doi.org/10.1016/j.coastaleng.2012.03.002, 2012.

Liu, Q., Babanin, A., Fan, Y., Zieger, S., Guan, C., and Moon, I. J: Numerical simulations of ocean surface waves under hurricane conditions: Assessment of existing model performance. *Ocean Modelling*, 118, 73-93, https://doi.org/10.1016/j.ocemod.2017.08.005, 2017.

Chen, X., Hara, T., & Ginis, I. (2020). Impact of shoaling ocean surface waves on wind stress and drag coefficient in coastal waters: 1. Uniform wind. *Journal of Geophysical Research: Oceans*, 125(7), e2020JC016222, https://doi.org/10.1029/2020JC016222, 2020.

3. While the manuscript addresses the challenges of wave modeling over complex reef geometries, it would strengthen the discussion to acknowledge potential limitations in applying the UOST scheme to other reef-rich coastal systems globally.

- Thank you a lot for the suggestion.
- As discussed in the Introduction and Section 2.3, the Great Barrier Reef (GBR) is the largest coral reef system in the world, consisting of nearly 3,000 individual reefs arranged in a complex and irregular pattern (e.g., Fig. 4). In such areas, the use of the UOST scheme helps correct the excessive overestimation of wave energy. As shown in Fig. 8, the improvements achieved by applying the UOST scheme are more evident in regions with higher reef density. This suggests that the structural complexity of the reef matrix s likely a key factor influencing wave energy dissipation.
- In addition to offshore reefs such as the GBR, coral reef systems also include fringing or land-backed reefs that are directly attached to coastlines or islands, such as those found in the Philippines. In these cases, because the reefs are closely connected to land, their additional capacity to dissipate wave energy may be limited. As a result, the improvements achieved by applying the UOST scheme may not be as significant in such areas, where the role of the reef in energy dissipation is less pronounced compared to offshore, structurally complex reef systems like the GBR. This may represent a potential limitation of the current approach, and we will include a comment of this point in the revised manuscript.