Response to Referee #2 Comments

Anonymous Referee #2
Referee comment on "The Met Office operational wave forecasting system: the evolution of the Regional and Global models" by Nieves G. Valiente et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-261-RC2, 2023

This paper gives an overview of the wave modelling and forecasting model suite at the Met Office. The paper is well written and describes the various components in some detail.

Our thanks to the reviewer for positive and constructive critiques. Comments have been addressed and we feel these have significantly improved the manuscript.

The manuscript has been modified substantially and special emphasis has been put in: (i) reduction in length, (ii) accuracy of the models with a specific focus on the influence of spatial resolution and wave-current interactions that will lead to further development.

Note that line number corresponds to the revised manuscript with "All Markup".

My main concern is that the wave-current model AMM15 is only very cursorily described. I would want to see a more detailed discussion of why the model seems to have improved directional and wave periods but less accurate significant wave height in regions with strong currents.

A new section on the influence of wave-current interaction on the model accuracy has been added. See Section 5.4 (L386-441).
Additionally, we included a specific paragraph that tried to answer the question of why the model seems to improve direction and wave period but this is not so obvious for significant wave height:

> "Differences in the accuracy of both configurations suggests that wave refraction and shifts in the relative frequency are better captured with the addition of the sea surface currents in most of the domain. However, overall metrics for Hs are slightly weaker in certain areas of analysis such as the Irish and Celtic Seas, English and Bristol Channel and E coast of England. To isolate the effect of currents and not account for any differences in resolution, we run the AMM15SL2 configuration without currents during August 2019 and compare model differences in Hs over two tidal cycles during spring tides (Fig. 10a). Positive residual differences in Hs correspond to those locations where AMM15SL2 presents some degradation respect GS512L4EUK. Model evaluation showed that both configurations tend to slightly overestimate Hs, therefore, the overall positive bias is exacerbated by the contribution of the residual currents in AMM15SL2. Additionally, the evaluation of the currents effects on the wave energy distribution in two different shallow coastal locations demonstrate that including tidal currents produces a consistent shift towards longer periods (Fig. 10e,g) reducing the energy bias between model and observations at low frequencies (not shown), hence the better agreement for the period in AMM15SL2. In terms of Dir, model differences during ebb (Fig. 10b) and flood (Fig. 10c) tide conditions show wave refraction angles of ±10º when currents are included, helping to better capture the distribution of the wave energy in the directional space (e.g., Fig. 8f). This suggests that AMM15SL2 captures the distribution of the energy in terms of frequency and direction better whereas the total energy might be sometimes too large in this configuration. In other words, the bulk energy imparted to the ocean surface waves might be excessive during low-moderate conditions."

More specifically I would want to see a more in-depth discussion of why the authors still think it is worth running the forecast model.

The focus is in the global and regional models that, although not coupled, are the baseline configurations of all the systems currently run operationally at the Met Office. We believe that including a more in-depth evaluation of AMM15 coupled ocean-wave forecasting system with the other models might be too ambitious for a paper (i.e., four models to evaluate), with also further implications such as having to assess a different set of forcing conditions (ECMWF winds). Additionally, the ocean-wave coupled system has been previously described in Tonani et al. (2019) and Bruciaferri et al. (2021), and Valiente et al. (2021b), which demonstrate that model accuracy is almost equal in both coupled ocean-wave AMM15 and wave-only with currents as forcing conditions (similar to an offline coupling).

Regarding why AMM15 wave-only is still a key component in the Met Office forecasting system, we acknowledge that the Met Office wave forecasting products are currently key components for the decision making of multiple organisations and businesses. Many of these clients require systems that provide updated forecast several times a day. This requirement makes the AMM15SL2 UK Waters wave model an essential system that cannot be replaced by the current AMM15 ocean-wave coupled model, a more complex and computationally expensive model only run once a day.

It is mentioned in L524-531 that "For the case of the operational AMM15 ocean-wave coupled with data assimilation, this is currently run once a day providing 5 days forecast. This is still computationally expensive with increased resource demands over the wave-only operational model with currents as forcing that delivers data four times a day. Met Office internal testing demonstrates that a coupled simulation increases 10% the running time per model respect their standalone version; i.e., if an ocean model needs n nodes to run and a wave model needs m nodes, the ocean-wave coupled simulation of the two will need n+m nodes with an increase of 20% in the running time. While studies continue toward a fully coupled prediction system with atmosphere, ocean, land, ice and wave components, the maintenance and development of each of the model components is crucial in NWP."

Minor comments:
Figs 3 and 4, panels g and h, claim to present the standard deviation of the difference between the model and the observations, but I think you are really presenting the standard deviation of the model values alone, NOT the difference. Please confirm.

Corrected. Both Figs read now as:

> L307: "Figure 4. (a,b) Mean, (c,d) bias and (e,f) root mean square deviation (RMSD) between modelled significant wave height (Hs) and merged altimeter observations (MA_SUP03), and (g,h) model standard deviation (SDmodel) across the global domain for GS512L4EUK-AN."
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> L312: "Figure 5. (a,b) Mean, (c,d) bias and (e,f) root mean square deviation (RMSD) between wind (U10) forcing conditions and merged altimeter observations (MA_SUP03), and (g,h) model standard deviation (SDmodel) across the global domain for GS512L4EUK-AN."

L 27: You claim that there is a 20% improvement in wave period and direction in nearshore regions. How is this number arrived upon? Compared against which model, AMM15SL2? Please describe the control run for this comparison.

The abstract has been restructured significantly and this statement was removed. A similar statement is now included in Conclusions where the control run is specified. See L546 "…with >20% reduction in the RMSD respect GS512L4EUK."

L 636: tunning -> tuning

Corrected.

L 643: Recent ... Hersbach and Bidlot (2008) is hardly recent.

Reference has been removed and only recent publications were left.

I think the paper can be accepted after these minor revisions.