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Ocean Science Discussions

Interactive comment on "Can wave coupling improve operational regional ocean forecasts for the North-West European Shelf?" *by* Huw W. Lewis et al.

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We thank the reviewer for his positive review, and in particular for highlighting a strength of the paper being "to study the impact of ocean-wave coupling vs forcing in both assimilated and non-assimilated framework". A few minor comments were suggested, which are addressed below and in the revised manuscript.

** SC1: Using the stress calculated from the wave model raises two issues 1) the momentum flux is calculated for neutral conditions and 2) the momentum flux is no longer in equilibrium with the turbulent fluxes of heat and humidity.

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Discussion paper

The reviewer is correct to highlight that there remain limitations in the representation of the momentum budget in the coupled system described. While moving from use of a 'tauoc' fraction as in Breivik et al. (2015) to using the stress components computed by WAVEWATCH III does improve the consistency of information within the system, the momentum flux is indeed calculated for neutral conditions in WAVEWATCH III (rather than adjusting for stability as in the ocean bulk forcing) and may not be in equilibrium with other atmospheric fluxes in the bulk formulation. Offline testing of this change, not discussed in detail in the paper, showed little sensitivity of results. However, we also plan a more thorough review of the surface momentum budget across atmosphere, ocean and wave models in the coming year to better explore these issues. While in practice this is outside the scope of the current study to address this in the simulations presented, additional text has been provided on p6 to acknowledge the current limitations as set out by the reviewer.

** SC2: The Craig and Banner coefficient 'phioc' is not modified from the standard value of 100 in this study, while others introduce a wave energy dependence on turbulent kinetic energy.

As the reviewers state, many studies have shown that the Craig and Banner coefficient can be highly variable. As an initial implementation of the wave coupling scheme, particularly aiming to be readily implemented into operational systems, it was considered that further testing was required to characterise the range of parameter values simulated by the WAVEWATCH III model, and its impact on the NEMO ocean results in the coupled system. For example, it may be necessary to define some plausible range within which the coefficient should lie to avoid spurious results. These decisions have been informed by the Wave2NEMO R&D project within the CMEMS Evolution projects (J. Staneva, pers. comms.) and the NEMO Waves Working Group. A further line of explanation has been added to the end of section 2.3 in the revised manuscript.

** SC3: Data assimilation compensates for the cooling caused by the enhanced mixing forced by waves seen in the non-assimilative coupled results. Does this mean that the

summer cooling produced by wave forcing is unrealistic?

As stated in the final paragraph of Section 4.3, and in the Conclusion from l25 on p16, “it could be argued that the degradation of summary metrics for CPL_FR relative to FR is indicative that the AMM15 ocean model configuration and assimilation have been well optimised for running in uncoupled mode. . ..”. The results in the Celtic Sea (Fig. 6(a)) are perhaps also instructive here for example. This is a location with strong relative summer cooling in the coupled run (Fig. 3), and we show the Mean Difference (MD) = 0.00 K for the DA run overall during 2017. Coupling leads to a relative cooling both with (MD=-0.03 for CPL_DA results) and without assimilation, although the effect is substantially larger in the non-assimilative runs (MD=-0.33 for FR compared with MD=-0.45 for CPL_FR). The control DA simulations are therefore largely unbiased, and overall warmer than FR. Adjustments through wave coupling have a tendency to slightly degrade model skill of the AMM15 system (e.g. Table 2, Table 4). The assimilation in the CPL_DA run therefore tends to pull simulations back towards the control, minimising the wave-induced cooling effect within the mixed layer. We do not consider the cooling effect to be unrealistic however, only introducing a new feedback to a relatively well optimised uncoupled system.

** SC4: Comments on the interaction of waves and currents with tide. Worth saying a few words about it in the manuscript.

The results discussed in the draft manuscript focussed on the impact of wave coupling on seasonal and longer-term means. The explicit effect of tidal interactions are therefore largely masked in the mean plots (e.g. Fig. 3), or from the comparison of observed and simulated spectra at selected sites (e.g. Fig. 6). Some indications of wave-current-tide interactions may be apparent when focussing on shorter timescale results, such as shown in the salinity results in Fig. 13. The recent work of Matt Lewis et al. (2019) may be of relevance here, and has now been referenced along with additional text suggested by the referee in the revised manuscript on p. 14 (with reference to salinity results) and line 28 of the conclusions (p17).

** TC1: Typo in Figure 17 description

Corrected in the updated manuscript

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