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Comment on gmd-2022-52

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Referee comment on "Development and validation of a global 1/32° surface wave-tide-circulation coupled ocean model: FIO-COM32" by Bin Xiao et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-52-RC1, 2022

The paper "The development and validation of a global 1/32° surface wave-tide-circulation coupled ocean model: FIO-COM32" by Bin Xiao et al. describes the initial stages of developing a 1/32 degree version of the FIO model. Based on past successes of the FIO models, the Bv scheme is prominently discussed, as is the incorporation of tides. The paper focusses on the last year of two 2-3-year simulations EXP1, not including tides or Bv waves, and EXP2 including both. Two other important simulations are noted for future work.

In general, the paper describes a milestone of expensive work in progress, and for this reason many aspects of incomplete experimental design may be overlooked. However, some important theoretical aspects of the work are not mentioned (although they are relevant) and some additional analysis would be informative. Here is my short list of these issues:

1) In the mesoscale 1/10 degree model, wave effects on currents (WEC) and current effects on waves (CEW) are not expected to be very strong. However, as shown in McWilliams & Fox-Kemper (2013: http://dx.doi.org/10.1017/jfm.2013.348) and Suzuki et al. (2016: http://dx.doi.org/10.1002/2015JC011566) the expected magnitude of the WEC effects can be estimated using the epsilon parameter. Given the interest of FIO modeling to include wave impacts in their modeling family, it would be very interesting to see the epsilon parameter estimated in the MASNUM-1/10 and MASNUM-1/32 models.

2) It is not mentioned whether the EXP1 or EXP2 currents refract/diffract/affect the waves in the 1/32 models. It is well known from operational wave modeling that these effects become important roughly in the 1/10 resolution range. They are very important at 1/32 degree resolution. Some estimate of these effects would strengthen this work and provide impetus for a coupled wave-ocean simulation at this resolution to come.

3) Given the offline MASNUM calculation, rather than the directly coupled MASNUM-1/32, it is probably impossible to include both the WEC and CEW effects in the model. However, points 1&2 would show the need for such improvements. This is more interesting than the Bv parameterization result, which shows that small-scale turbulence parameterizations still affect simulations at this resolution. That is not surprising, given that those small-scale turbulence remain far below the resolution at 1/10, 1/32, and even 1/300 degree resolutions. What is more interesting as wave effects over the range of scales from 1/10 to 1/32 is the wave-current coupling.

A) Aside from waves, the new information here primarily results from inclusion of tides. It is an interesting result that tides are significantly improved in the 1/32 degree over 1/10 degree model. However, most of the key metrics discuss only the coherent tides (e.g., Fig 5). As 1/32 degree current calculations could interact much more strongly with tides than the 1/10 degree model, some mention of enhanced incoherent tides would be interesting (and found from a straightforward comparison between EXP1 and EXP2).

B) There is no discussion of the subgrid damping used and how it scales with resolution. Furthermore, a power spectrum showing the rotational and divergent power spectra contributions would be extremely valuable in understanding how the 1/10 and 1/32 models differ at small scales. This information together with more information about the damping would be valuable in understanding the choices made and their consquences, as well as the effective resolution of the vortical and wave/tide modes. This could supplement Fig 9 in a meaningful way, revealing more of the dynamics underpinning the better match of EXP2 to Jason than EXP1.

i) For a submesoscale-permitting model, it would be nice to see what submesoscales are expected to be permitted at 1/32 resolution. The stronger submesoscales in wintertime are now customary, but the weaker submesoscales in summer may be illustrating the limits of 1/32 resolution. It would be nice to include a discussion of Dong et al. (2020: http://dx.doi.org/10.1175/JPO-D-20-0043.1), along with some estimation from the MLD analysis as to the scale of submesoscale baroclinic instabilities. It would be particularly interesting to know if the Bv scheme deepens the MLD or mixes the stratification of the ML enough to have a detectable effect on MLI scale and whether it is more resolvable using Bv. Dong et al. has a similar analysis comparing MLI scales under different boundary layer schemes.