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Interactive comment on "Global Storm Tide Modeling with ADCIRC v55: Unstructured Mesh Design and Performance" *by* William J. Pringle et al.

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Dear Reviewer,

Thank you for taking the time to read through our manuscript. We agree on many points that you raised which we will address in a later reply. But first we would like to comment here on the most critical aspect of your review.

The reviewer suggested that since there are a few local shelf regions in the global ocean that have over 10% M2 tidal error that the manuscript should not proceed unless "the authors explain why the model is locally not reproducing tides correctly or

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Discussion paper

better, improve their results". While we will include additional discussion in a revised manuscript on model properties that affect tide solutions (see next paragraph), we want to first highlight that the major point of our paper is not to present a model with the lowest tidal errors possible. Instead, it is to; 1) highlight improvements to the treatment of the governing equations and implicit time-integration in the new version of ADCIRC (v55), and 2) explore the effects of unstructured mesh design on storm tide solutions. We will state these aims more clearly in a revised version of the manuscript. Through these aims we wish to provide information for other researchers on how to design their own unstructured meshes (for instance, we quantified the critical impact of the topographic-length-scale (TLS) function on mesh resolution distribution) while balancing their tolerance for numerical accuracy vs. their capacity to simulate on meshes of a certain size. Further, by comparing our results to the previous version of ADCIRC we clearly show the impact of incorrectly treating the curvature terms in the governing equations, which is vital for global storm tide modeling.

Aside from further refining model resolution along the coastlines which likely would have a marginal effect on outer shelf and deep ocean solutions, the modeled tidal solutions are dictated by the three major aspects: bathymetry, internal tide wave drag, and bottom friction/bed stress. Both the suggested reference by the reviewer (Lyard et al., 2020), and our own previous study (Pringle et al., 2018) tackles these three aspects in detail. Ultimately, since we decided to focus this study on the effects of mesh resolution and the new ADCIRC version, we deliberately sought to avoid ad-hoc tuning of the internal tide wave drag and bottom friction, and only used the global GEBCO2019 bathymetry database (modified for depths under Antarctic ice shelves). Thus, we only used the typical bottom friction coefficient, Cf = 0.0025, everywhere except in the Indian Ocean and Western Pacific Ocean region where we had previously detailed our methodology (Pringle et al., 2018). Similarly, we only calibrated a global tuning coefficient for the internal tide wave drag term. The above decisions are clearly described in the supplementary material, and to prevent ambiguities concerning the main focus of this study we will add a brief summary of this in the main document of a revised manuscript.

In contrast to our study, Lyard et al., (2020) tunes the model by perturbing regionally disparate values of the internal tide wave drag coefficient and the bottom friction coefficient to obtain tide solutions with smaller errors. Moreover, Lyard et al., (2020) incorporated local bathymetric datasets and perturbed ocean depths in certain polygonal regions to further improve the tidal solutions. As stated in the last paragraph of our discussion, in future work we aim to address, in depth, the bathymetry, internal tide wave drag, and bottom friction/bed stress aspects on global storm tide solutions (in a systematic fashion so that other researchers can reproduce our solutions and efficiently design their own models for their own purpose). In fact, we are already making progress on this front; Figure 1 highlights an example of improved M2 tide errors we obtained by using a couple of local bathymetry datasets and tuning the internal tide wave drag coefficient differently to the current study.

Lastly, we would like to add some context to the reviewer's comment that "tidal predictions are locally weak compared to other well-established global tidal models". To be fair, the well-established tidal model that the reviewer mentions is only one (FES2014; Lyard et al., 2020), in which the manuscript has been under discussion in Ocean Science from October 2020, a few months after we submitted this manuscript. While we acknowledge that the FES model has been under development for a very long time (and our own understanding has greatly benefited from the progress made by that research team), Lyard et al. (2020) is the first study that we have seen clearly showing such small tide errors for the non-assimilated version. Furthermore, while the reviewer points out that the RMSE of the M2 for our model is more than 10% error in the Bay of Biscay and Patagonian Shelf (larger errors than for FES2014 in Lyard et al., 2020); for instance, the M2 RMSE of our model in the Gulf of Guinea (< 2.5 cm) is smaller than that of the non-assimilated FES2014. As stated above, these tidal solutions depend heavily on how one tunes the model. Specifically, our experience tells us that how you tune the internal tide wave drag coefficient in the Atlantic Ocean heavily dictates the solution in these regions, such that tuning the model to be accurate in the Gulf of Guinea leads to increased errors in the Bay of Biscay, and vice versa. These are the sorts of issues that we are actively researching but which is out of scope for the current study. Nevertheless, the non-assimilated FES2014 model presented in Lyard et al. (2020) does indeed seem to have smaller tide errors overall and we will include it as part of our comparison in a revised manuscript.

Sincerely,

William Pringle and co-authors.

References:

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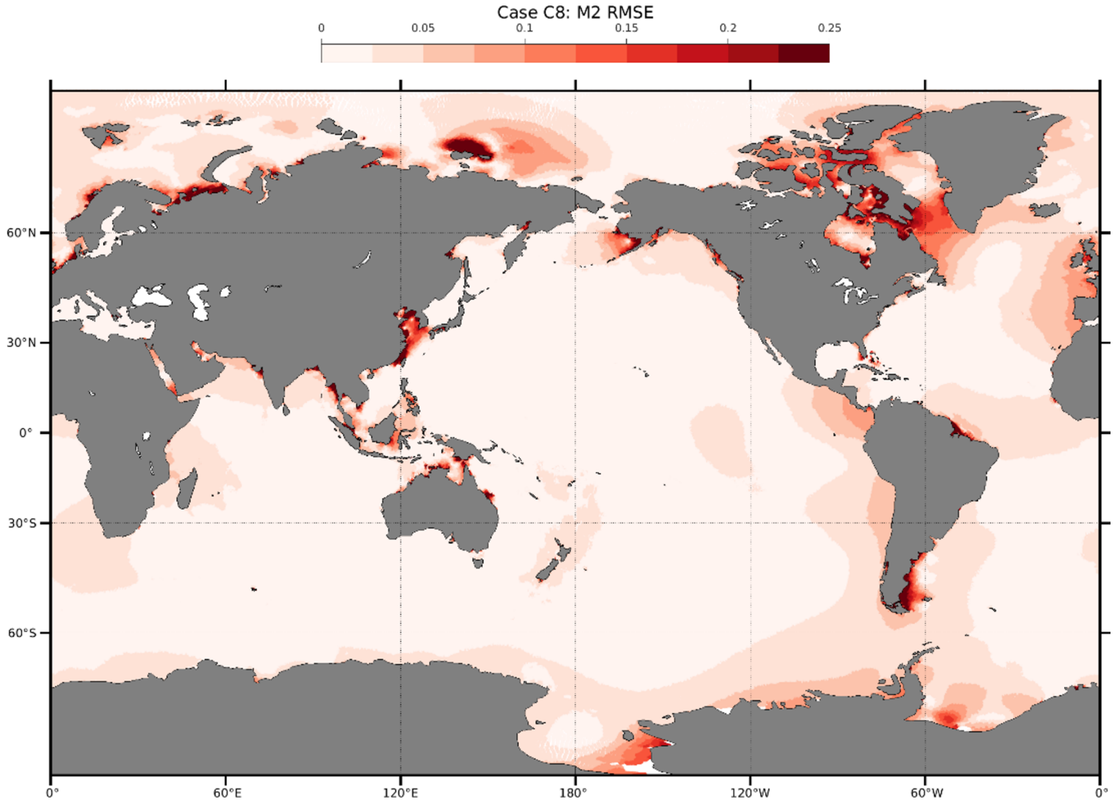

Fig. 1. M2 tide RMSE computed against the TPXO9-Atlas for a modified version of the model presented in the current study. The model shown here has smaller errors than shown in Fig. 6b of the manuscript.