Ocean Science Discussions

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Comment on os-2021-112

William Pringle (Referee)

Referee comment on "Data-assimilation-based parameter estimation of bathymetry and bottom friction coefficient to improve coastal accuracy in a global tide model" by Xiaohui Wang et al., Ocean Sci. Discuss., https://doi.org/10.5194/os-2021-112-RC2, 2022

General comments:

This study uses a parameter estimation methodology implemented in an unstructured mesh global tide and surge model (GTSM v4.1) to estimate bathymetry and the bottom friction coefficient to reduce modeled tide errors at the coast. The parameter estimation methodology was developed by the authors in Wang et al. (2021, 2022), which focused on computational efficiency and memory efficiency of the parameter estimation algorithm by using model order reduction in space (Coarse Incremental Calibration) and in time (Proper Orthogonal Decomposition onto principal modes of variation). In those previous works the authors focused on perturbations to bathymetry to improve tide solutions. Therefore, the predominant novelty of this study is the simultaneous perturbation of the spatially varying bottom friction coefficient along with the bathymetry in a global model to assimilate tide observations and estimate these two parameters.

Although the tide errors of GTSM v4.1 are small and reasonable, I think the manuscript needs to do a better job of discussing why the errors in this model cannot be made as small as FES2014. Precisely what is the difference in data assimilation (DA) methodology that makes the TPXO/FES-type DA models able to give more accurate results overall than the parameter estimation technique used here? Also, what are the remaining major obstacles to further reducing tide error using the presented parameter estimation technique?

One of the reasons outside inaccurate bathymetry and unknown dissipation parameters for tide solution discrepancy could be errors associated with hydrodynamic simulation of the tide without concurrent simulation of meteorological-driven flow (surge). In shallow waters the estimation of bottom friction coefficient could be quite different in certain regions if surge is included due to nonlinear interaction. Furthermore, two recent related studies by the authors (Wang et al., 2021, 2022) also just investigate tide-only simulation, so to bolster this study the authors should consider adding in simulation(s) with meteorological forcing to show the sensitivity of tide solutions to concurrent surge simulation, especially since one of the main stated advantages of GTSM over FES/TPXO is the ability to simulate tide and surge together (“combined tide and surge model”).

The other comment I have is on subdomain selection. In this study the two regions selected, Hudson Bay and European Shelf, are based on high tidal dissipation, which makes some sense. However, it is not clear how the subdomains within those regions are selected, although it appears to based on the authors’ intuition (Line 284: “The region of Scotland, the Faro Islands and Shetland have mountainous ocean bathymetry, where expect to a higher bottom friction coefficient”). Have the authors investigated sensitivity to subdomain selection/size? Perhaps a spatial clustering type analysis or other could be used to more objectively find the suitable subdomains.

Point-by-point comments:

- Line 52: “We found only one application [of data-assimilation to estimate parameters] at a global scale (Lyard et al., 2021)…”.
  Although it is a very recent study available as a pre-print, Blakely et al. (2022) also tries to “optimize” parameters for internal tide and bottom friction in a global tide model using the TPXO tide solutions, which I think would be worth referencing and comparing to in this manuscript.
- Line 59: “The sensitivity to bottom friction is very small in deep water, but is often the most sensitive parameter in shallow water”.
  Can the authors find some reference(s) for this? For one, I suggest Zaron (2017) here who presents a friction number that denotes the relative importance of the friction parameter in the momentum balance, and I think Zaron’s paper will also provide material that can be used to improve the ideas presented in this part of the introduction.
- Section 2.1: There are numbers quoted for the tidal energy dissipation, 3.7 TW; 2.39 TW for bottom friction and 1.12 TW for internal tides. Do these numbers always stay constant no matter the bathymetry and bottom friction parameters being estimated? I also suggest to put these numbers in context with other tidal dissipation values from the literature as well to give an idea to the reader of the typical ranges and inter-model variability.
- Line 111: "[The Chezy formulation] is important for hydrodynamic conditions”.
  What does this mean?
- Lines 114-116. These statements require more detail. Exactly how is the internal tide friction term corrected for layer thickness in the salinity/temperature dataset (what does this mean?). How was the retweaking of the bottom friction and internal tide coefficients done and how does this compare to this study which is trying to find improved bottom friction coefficients?
- Lines 118-119: States the RMSE is without the bias difference. Does just mean the RMSE used here is the standard deviation of the error? I notice Figure 9 panels have the title of “Standard Derivation …” which maybe should read standard deviation. Please clarify.
- Lines 128-129: “However, the spectral tide model cannot describe the interaction between different tide components in shallow waters.”
  What is meant by “describe” here? In Le Provost & Lyard (1997), which is the underpinning of the FES model, the methodology considering tide component interaction through linearization of the bottom friction term is presented. So while it’s

true that the tide component interaction in a spectral model cannot be computed "exactly" like in a time-stepping shallow water model, some interaction through the bottom friction term can be accounted for.

- Section 4.1.2: Parameter estimation results: Only relative changes to the parameters are shown but I think it would be interesting information for readers to know the initial and final values of the bottom friction coefficients (which may be compared to bottom friction values obtained in Blakely et al., 2022).
- Lines 491-492: "Tide representation in shallow waters benefits from the optimization of bottom friction coefficient, contributing to a more accurate water level forecast when including wind and air pressure conditions for surge simulation".
  This is more than likely correct but is not a conclusion that can be straightforwardly made from the study. If, as I mention in the general comments, this study considers the sensitivity of the parameter calibration to tides with concurrent simulation of surge, it should help to provide stronger evidence for this statement.

Technical corrections:

- Line 126: What is SLA?
- Table 1/Line 127: TPOX09 to TPXO9.
- Lines 355-369: In these two paragraphs a confusing terminology of the RMSE being reduced to X% is used. I think it's easier to understand how much the RMSE was reduced BY.

References:

- Blakely, C. P., Ling, G., Pringle, W. J., Contreras, M. T., Wirasaet, D., Westerink, J. J., Moghimi, S., Seroka, G., Shi, L., Meyers, E., Owensby, M., & Massey, C. (2022). Dissipation Processes in an Unstructured Mesh Global Tidal Model. Under review at Journal of Geophysical Research: Oceans. https://doi.org/10.1002/essoar.10509993.1
- Le Provost, C., & Lyard, F. (1997). Energetics of the M2 barotropic ocean tides: an estimate of bottom friction dissipation from a hydrodynamic model. Progress in Oceanography, 40(1), 37–52. https://doi.org/10.1016/S0079-6611(97)00022-0
- Wang, X., Verlaan, M., Irazoqui Apecechea, M., & Lin, H. X. (2021). Computation-Efficient Parameter Estimation for a High-Resolution Global Tide and Surge Model. Journal of Geophysical Research: Oceans, 126, e2020JC016917. https://doi.org/10.1029/2020JC016917
- Wang, X., Verlaan, M., Irazoqui Apecechea, M., & Lin, H. X. (2022). Parameter Estimation for a Global Tide and Surge Model with a Memory-Efficient Order Reduction Approach. Under review at Ocean Modelling.
- Zaron, E. D. (2017). Topographic and frictional controls on tides in the Sea of Okhotsk. Ocean Modelling, 117, 1–11. https://doi.org/10.1016/j.ocemod.2017.06.011