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Geoscientific Model Development Discussions

Interactive comment on "Sensitivity study on the main tidal constituents of the Gulf of Tonkin by using the frequency-domain tidal solver in T-UGOm" *by* Violaine Piton et al.

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Anonymous Referee #2 Received and published: 20 September 2019

We do thank Referee#2 for his/her careful reading of our manuscript and relevant comments. Below are his/her comments (in bold), followed by our responses and description (in italics). Changes in the revised manuscript are highlighted in red.

General comments: The authors applied the frequency-domain tidal solver in the hydrodynamic unstructured grid model T-UGOm to examine the sensitivity of the main tidal constituents of the Gulf of Tonkin. The model results are compared with observa-

tions collected from satellite. The model validation suggests that the model is able to capture the tidal dynamics in the Gulf of Tonkin. The authors also constructed a series of sensitivity model experiments to test the bathymetry and bottom friction parameterization. In my opinion, the paper is potentially a valuable contribution to the scientific literature of the Gulf of Tonkin, as the model constructed by the authors is able to well capture the tidal dynamics in the Gulf of Tonkin. More over the paper is clear and well written. In general, the figures are neat. I recommend publication of the paper in Geoscientific Model Development Discussions after minor revisions, in response to the following concernsÂă:

Specific comments:

1) L359-360: For the tidal open boundary condition, nine tidal constituents were considered. Why do you include the shallow water constituent M4? Does this tidal constituent contribute significantly to the tide in the GOT? How about other shallow water constituents such as MS4 and M6?

We thank the reviewer for addressing this issue and we understand his/her concern. First of all, the main objective of our study was to calibrate the astronomical spectrum of tide as it is dominant in the GoT over the linear spectrum (Wyrtki, 1961). Therefore, 8 out of the 9 constituents simulated are astronomical constituents, while the last one (M4) is a linear tidal constituent and was chosen as a representative of all linear interactions. We agree we could have simulated MS4 instead of M4 as their patterns of amplitudes are very similar (Fig. 1 a,b). M4 and MS4 amplitudes are maximum in the northern GoT (∼0.02 m), along the coast of Vietnam and at the western entrance of the Hainan Strait. These amplitudes are, however, roughly 50 times smaller than the maximal amplitudes of O1 and K1 and 15 to 35 times smaller than the amplitudes of S2 and M2, respectively (Fig. 1 a, b). Therefore, we believe simulating both M4 and MS4 or MS4 instead of M4 would not induce significant changes in the final tidal solutions. Lastly, M6 amplitudes were much smaller than M4 and MS4 all over the GoT, and was therefore neglected in our simulations (Fig. 1 c), as again, it should not induce significant changes in the final tidal solutions.

Figure 1: Tidal amplitudes (m) of M4, MS4 and M6 from FES2014b-with-assimilation product.

–>Following this comment, we have added a brief explanation about this choice of tidal constituents in the revised version of the manuscript (lines 379-381).

2) The model simulated tidal constants are compared with satellite data. a) Have the authors tried to compare the model results with the observations from tide gauge stations along the coast of the Gulf of Tonkin? b) How about the tidal current in the simulations? Have the authors validated the model -simulated tidal currents with observations?

a) We thank the reviewer for suggesting comparison of our simulations with tide gauge data, which contributes to make our model evaluation more robust. Following this comment we compared our results to tidal harmonics of 11 stations located along the Gulf coasts (see locations and names in Fig. 2 and on Fig. 4 a of the revised manuscript). These data are provided by the International Hydrographic Organization (https://www.iho.int/) and are available upon request at https://www.admiralty.co.uk/ukho/tidal-harmonics. –>This dataset is detailed in the manuscript lines 537-542.

Figure 2: O1 tidal amplitude (in m) from FES2014b-with-assimilation superimposed with locations of tide gauges (black cross). This figure now corresponds to Fig. 5 a of the revised manuscript.

RMS* errors between modelled and observed tidal harmonics from tide gauges are now shown in Fig. 16 b of the manuscript (and on Fig. 3 of this document). First, compared to TKN-gebco, TKN gives smaller errors for all four waves considered: RMS* for K1 are reduced by ∼40% in TKN compared to TKN-gebco and RMS* for M2 are reduced by ∼45% in TKN compared to TKN-gebco. This result again confirms that

the use of the improved bathymetry dataset significantly improves the tidal representation over the GoT. Second, TKN configuration shows also smaller RMS* errors than FES2014b-without-assimilation simulation for O1, M2 and S2. In addition, TKN even minimizes S2 RMS* errors compared to FES2014b-with-assimilation. Our improved configuration however fails to improve the solution of K1, compared to the two FES2014b products.

Figure 3: RMS* errors between numerical simulations (TKN, TKN-gebco, FES2014b-without-assimilation, FES2014b-with-assimulation) and tide gauges harmonics for O1, K1, M2 and S2.

These results suggest that TKN configuration brings a clear improvement in tidal solutions compared to TKN-gebco configuration, and a slight improvement compared to FES-without -assimilation. They also confirm that FES-with-assimilation logically produces the smallest error, thanks to the use of assimilation and of a unstructured grid specially designed to represent the complexity of coastline and coastal bathymetry. –>This is now further detailed and discussed in the manuscript lines 7435759.

b) Regarding the reviewer's concern about modelled tidal currents, we indeed did not evaluate our model against in situ observation. Until recently, current-meter observations in the GoT were scarce (only limited to specific areas such as the Hainan Strait) and limited in time (daily to seasonal). Deriving clean and robust tidal currents from these datasets would have been challenging, if not impossible, as it requires long and accurate time-series. Since late 2012 however, hourly surface currents data are available from HF radars, at a resolution of 5.85 km. These HF radars are part of the Global High Frequency Radar Network (Roarty et al., 2019). We soon expect to derive tidal currents from these valuable data. From now however, the dataset still suffers from correction errors and varying spatial coverage due to seasonal monsoon patterns. TUGO has already proven its accuracy in reproducing shelf tidal currents, for example on the shelves around Australia (https://www.researchgate.net/publication/322331188_Assessment_of_the_FES2014_Tidal_

), it therefore certainly reproduces tidal currents over the Gulf of Tonkin shelf. However, we completely agree that this assumption will have to be confirmed thanks to future comparison with quality checked HF radar data (Rogowski et al., 2019). This will be done in the on-going phase of our work, i.e. the implementation and evaluation of the 3D SYMPHONIE-MUSTANG model used for our study of dynamics and sediment transport variability in the Gulf of Tonkin.

–>Following this comment, we acknowledged this issue in the revised version of the manuscript lines 320-321 and lines 951-954.

3) The Red River is the most important freshwater discharge in the Gulf of Tonkin. The freshwater from the Red River may influence the tide near the estuary. Have the authors considered the effect of the freshwater discharge on the tidal simulations?

We understand the reviewer's concern about the potential effects of strong discharge, which is indeed strong in the region, on tide. Previous studies in the Red River estuaries and plume suggest that water discharges could have an influence on tide, but rather the other way around: tides can influence water discharges. Lefebvre et al. (2012) and Vinh et al. (2018) showed that during the early wet season, spring tides enabled saline water intrusion up to 20-30 km along the Cam-Bach Dang estuary. In the Van Uc river (3rd biggest river of the Red River system), Piton et al. (under review) suggested that during the dry season, neap and spring tides were able to reverse the river flow up to 20 km upstream from the river mouth, and that spring tides at high tides were able to reverse the intense river flow of the wet season. Therefore, the potential effects of discharges on tide might only happen during the wet season at neap tides, and could be localized in the very near coastal area. Furthermore, taking the effects of water discharges on tide would not affect the statistics presented in our manuscript, as altimetry data, that we use for model performance assessments, are not available in the coastal and shallow area of the Red River Delta. Such assumptions should however be verified with a sequential model, more adapted than a spectral model to take into consideration the seasonal variability of water discharge which is very strong in

the region. This could be done using the 3D SYMPHONIE model implemented for our hydro-sedimentary study over the Gulf of Tonkin, and will definitely be one of our future research topic.

–>Following this comment, we acknowledge this issue lines 977-979.

Technical corrections:

L106:Quiongzhou Strait should be Qiongzhou Strait.

We thank the reviewer for spotting this mistake, is has been changed accordingly line 107.

Please also note the supplement to this comment:
https://www.geosci-model-dev-discuss.net/gmd-2019-40/gmd-2019-40-AC1-supplement.pdf

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Interactive comment on Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-40, 2019.

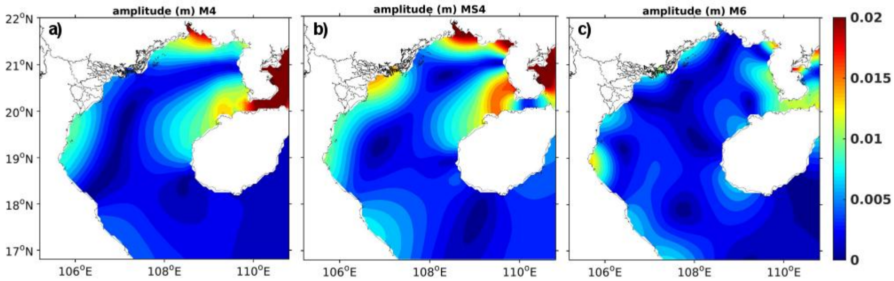
amplitude (m) M4
amplitude (m) MS4
amplitude (m) M6
a)
b)
c)
0.02
0.015
0.01
0.005
0

Fig. 1.

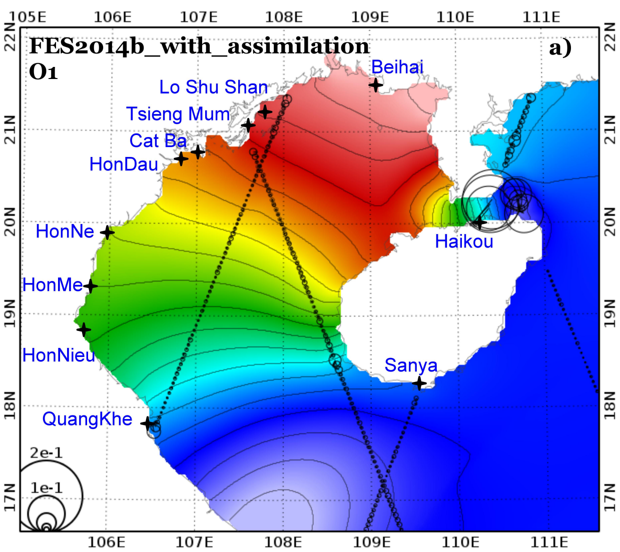
FES2014b_with_assimilation
O1
a)
Beihai
Lo Shu Shan
Tsieng Mum
Cat Ba
HonDau
HonNe
HonMe
HonNieu
QuangKhe
Haikou
Sanya
2e-1
1e-1

Fig. 2.

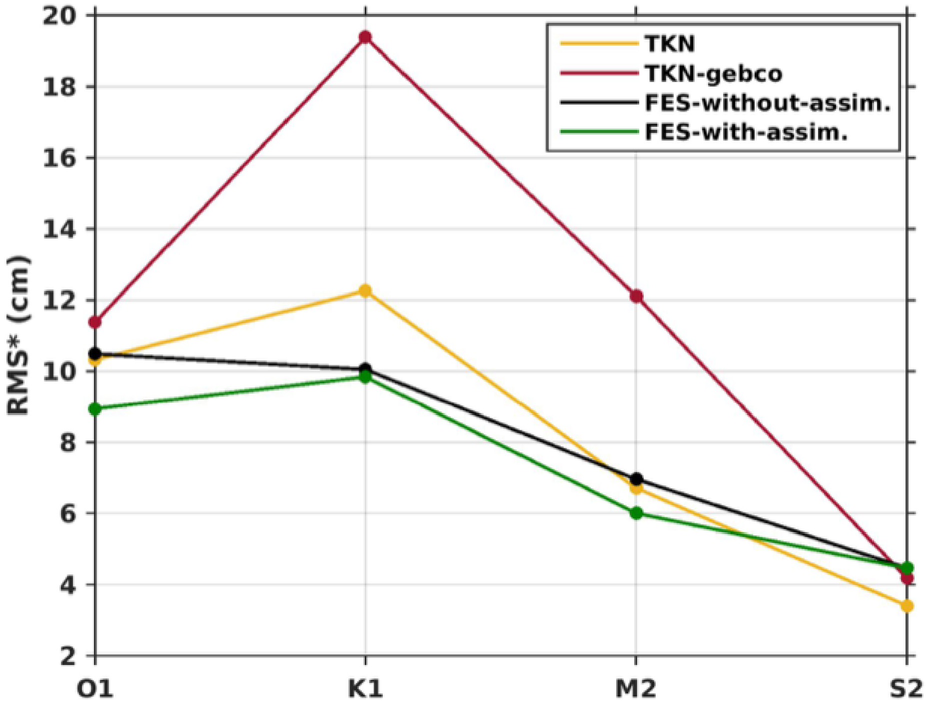
TKN
TKN-gebco
FES-without-assim.
FES-with-assim.
RMS* (cm)
20
18
16
14
12
10
8
6
4
2
O1
K1
M2
S2

Fig. 3.