Authors answers to RC3 comments/questions/recommandations

(for commodity reasons, we have reproduced the reviewer text in black, answers are in light blue, further action to the revised manuscript in bold blue)

This is a nice overview of the evolution and present status of the FES series of global tidal models. Brief descriptions of the major components in the model (e.g., finite element/volume approaches, assimilation techniques and data, self-attraction and loading, bottom friction and internal drag coefficients, barotropic to baroclinic conversion) are given along with numerous figures illustrating improvements from earlier versions, and comparisons with other global models. Though I recommend publication, I feel the paper would be stronger if the following, generally minor, issues could be addressed.

General Comments:

1. Though the manuscript title specifies "atlas design and performance" (I suggest making "performances" singular), I would like to see more information on the atlas itself. The manuscript states (page 4, line 22) that the actual FES tidal constituent harmonics can be found on an "AVISO+" website, but I think the specific URL should be given (here or in an Appendix) (https://www.aviso.altimetry.fr/en/data/products/auxiliaryproducts/global-tide-fes.html ?) along with a short summary of what (not only data but software?) is available.

**Short description will be added in the revised manuscript**

2. Though the numerous global maps have lots of information, not all of the details are accessible. Specifically, as a coastal modeler I would not only like to see the M2 and K1 amplitudes in the specific region where I work but also the location of assimilated tide gauge, cross-over, and along-track data. (This information will assist in determining whether: i) FES could be used to provide boundary conditions for a regional model, and ii) the FES de-tided altimetry is likely to have adequately removed smaller scale tidal variations.) For many of the global figures in this manuscript, even when I zoomed in, it was not possible to see this information clearly. I don't know how this manuscript will be published electronically but urge the authors (and the journal's scientific and technical editors) to provide sufficiently, highly-resolved figures so that when zoomed in, interested readers can pick out the details they want. On Figures 2, 3, 9, 10, and 13 for example, this may require changing the dot scaling so that as one zooms-in, the dots become smaller so their precise locations become evident. In the case of Figs 2 and 3, smaller dots would no longer obscure the background image but perhaps also allow more amplitude contours to be displayed.

We are now re-generating the figures to improve their graphical quality.

**Your recommendation will be taken into account in the revised manuscript as much as feasible.**

3. Along the lines of comment 2, I also would like to see the actual FES model grid (page 6, lines 14-22), especially its coverage and resolution in shelf and coastal regions. Figure 1 partially addresses the resolution issue but even when zoomed in, it doesn't provide the detail I would like to see. Perhaps an image of this grid (with zoom in capability) exists somewhere on an AVISO+ or LEGOS/CRNS/CNES website but I couldn't find it in a quick search. If it does exist, then that location should be given. If it doesn't, then I strongly recommend that be done, as again, the information would be useful for regional and coastal modelers

We are now re-generating the figures to improve their graphical quality.

**Your recommendation will be taken into account in the revised manuscript as much as feasible.**

Specific Comments:

1. Page 3, line38-40: What other norms can be used? A reference should be given.

There are many other norms than can be used (L1, L-infinite, etc…). The best references I can think about are as following:

Bennett, A. (1992). Inverse Methods in Physical Oceanography (Cambridge Monographs on Mechanics). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511600807

Tarantola, Albert. (2005). Inverse Problem Theory and Methods for Model Parameter Estimation. 10.1137/1.9780898717921.

2. Page 5, line 5: remove "about"

**Fixed in the revised manuscript**

3. Page 5, line 33: Has NCP1 been defined?
**Definition added in the revised manuscript**

4. Page 6, line 5-8: Give a reference for this statement
To my knowledge, D. Leroux is one of the head investigator of that type of numerical studies, see for instance: Le Roux, Daniel & Rostand, Virgile & Pouliot, Benoit. (2007). Analysis of Numerically Induced Oscillations in 2D Finite-Element Shallow-Water Models Part I: Inertia-Gravity Waves. SIAM J. Scientific Computing. 29. 331-360. 10.1137/060650106.
**Reference will be added in the revised manuscript**

5. Page 6, line 10: CFL vs CLF ?
**Fixed in the revised manuscript**

6. Page 6, lines 19-22: As above in general comments 2 and 3, it appears from zooming-in on Fig 1 that Juan de Fuca and Queen Charlotte Straits (south and north of Vancouver Island) are in the grid (resolution 5-10km?) but the Strait of Georgia (which has a partial TPJ track) and its northern passages are not. Presumably you compensate for this by assimilating crossover, tide gauge and along-track data. Zooming-in on Figs 9 and 11, I can see what crossover and tide gauge data are used but not so for locations of the along-track data in Fig 10. Furthermore, zooming-in on Fig 3 doesn't provide the detail to see, for example, if those data have caused the FES solution to at least partially capture smaller scale features like the surface signature of K1 shelf waves off the Vancouver Island coast.
The FES2014 mesh resolution is quite poor in all the western Canadian and Alaska coastal regions, and it results in a loss of details/accuracy in all this area. For computation cost limitation reasons, higher coastal resolution was deployed only where accurate bathymetry has been found by the project group, and this was not the case at the time of FES2014 production. Later on, and thanks to some discussions with our Canadian colleagues, this issue has been identified as quite damaging, but this happened too late to be corrected in FES2014 atlas. It can be mentioned that a special care will be given to the region in the next FES atlas release.

7. Page 6, line 27: Gb vs Go ?
**Fixed in the revised manuscript**

8. Page 7, line 24: It's not clear if these coefficients are spatially constant over the entire globe or they differ within say, the polygons in Figs 7 and 8.
Most of T-UGOM model parameters can be tuned locally using various methods (pre-defined regions, polygons inclusion, node or element vector, etc…). In the FES2014 stlas simulations, internal wave drag coefficients are tuned using a global ocean regional partition (distinguishing north, tropical, and south basins in the various oceans plus Arctic sea and Mediterranean Sea), and bottom frictions coefficients are tuned by using polygons (focused on large bottom friction dissipation areas). In both cases, a global default value is locally used at locations not being part of the regions/polygons definition.

9. Captions to Figs 2 and 3: These are not clear. The a), b), and c) references suggest there should be 3 panels, yet only 2 are presented. If a zoom-in capability were available for these figures, you could probably include the shallow/coastal crossover locations too.
Legend was obsolete (originally 3 panels were displayed, but reduced to 2 panels during final writing).
**Figures are being generated and should support zoom-in capabilities in the revised manuscript.**

10. Section 3: I wonder about non-stationarity, especially in coastal regions where seasonal changes in river discharge, winds, and ice cover may interact with the tides. Is this considered?
Despite the authors are fully aware of, it was not, mostly because the objective was not to produce a seasonally varying tidal atlas. However it is quite a challenge for the future atlases in the context of SWOT, which will provide data in estuaries and deltas, and in very high latitude regions. Also tides/storm surges interactions need to be considered in altimetry high frequency corrections in shelf and coastal seas, but will require to renew the present correction paradigm (separate tides and storm surges corrections) in the operational data processing.

11. Page 9, line 20: Give a reference for Parceval's rule.
"Parseval equality", Encyclopedia of Mathematics, EMS Press, *2001 [1994]*

**Reference will be added in the revised manuscript**

12. Page 10, line 14: In the Canadian Arctic, the additional drag from seasonal ice cover changes the constituent amplitudes and phases at some coastal locations. Can this non-stationarity be accounted for?
Basically, we have not considered this issue, despite we are aware of (and made several investigation in the past about it). It would lead to a season-dependent atlas, which was not suitable in the usual altimetry data correction framework.

13. Page 10, lines 19-22: I'm interested in more details on this. Is there a reference?
No reference yet, it was imagined and implemented during the FES2014 project , may be I should give more details on it.

14. Page 10, line 29: The text says the filtering wavelength is in km while the Fig 5 caption says it is in number of along-track points.
Wavelength haven been estimated in km, then converted into equidistant along-tracks points
**Comment will be changed to be coherent with the Fig5 caption.**

15. Page 11, lines 28-30: Why is that?
First the FES2014 hydrodynamic configuration has been adjusted (i.e. bottom friction and IWD) in simulations using the FES99 LSA, and part of it is an error compensation story. The most sensitive component in adjustment process is clearly M2. The main reason for that is that bottom friction is truly non-linear for M2, as it has the stronger currents and the dominate the current amplitude in the friction term, and the other constituents have a sort of quasi-linear friction in presence of M2 dominant velocities. So using a more modern, and potentially more accurate LSA, will usually profit to all constituents but M2, as it would require to re-process the adjustments steps to get back at least to a similar or improved accuracy.

16. Page 11, line 37: Presumably there was a dissipation cutoff to determine these polygons, as not all purple regions warranted one. What was it?
The definition of tuning polygons is a compromise to include the most significant sites for tidal dissipation, limited individual polygon area and the number of polygons (to limit too many additional members in our ensembles).

17. Page 12, line 23: The polygons on Fig 8 are not numbered.
**It will be fixed in the revised manuscript**

18. Page 12, line 32: Does it have to be the same everywhere? You probably need 10m in regions like the Bay of Fundy but it shouldn't have to be that large in many other coastal areas.
The depths found in most bathymetry databases in the 0-10m (and probably 20m) range is anything but reliable. In most places, the depths are linearly varying with distance from 0m at coastline to the 10m isobaths, which is not the usual morphology you will find in the true ocean. Such artificial very shallow water patches can have a damaging impact on bottom friction budget in coastal areas. The 10 m limitation is just a safety limit set to model bathymetry, and has been verified to be quite reasonable by experiments in the last 2 decades of tidal modelling. Having said that, in regions were bathymetry databases are highly accurate, it is preferable to keep the true depths (and do wetting/drying). But it represents only a tiny portion of the global ocean coastal regions.

19. Page 14, line 18: "used in" vs "kept from" ?

20. Page 15, line 36: It seems that TPXO9 is more accurate than FES2014b in the shelf and coastal regions. Can this be attributed to their generally higher (1/30 degree) spatial resolution?
To be fair with TPXO atlases, we have chosen to compare with the very last release, and not the release available at FES2014 production time (TPXO8), which shows less accuracy than FES2014. So probably the new TPX09 atlas has taken profit of longer time series for altimetry data, and possibly improved bathymetry for its prior simulations (or any others improvements in the regional hydrodynamics models configurations).

21. Page 17, line 6: Why is there a peak at about 14km from the coast in the left panel of Figure 17?

Difficult to tell with full certitude, the most likely explanation is that near-shore performance in FES2012 and FES2014 is limited by local bathymetry accuracy and coastal detail discretization, and ensemble/representers being less able to properly describe local errors statistics, so data assimilation improvements in FES2014 propagate only partially toward nearshore zones.

22. Page 17, line 28: Give a URL for this portal.
https://imos.org.au
**It will be added in the revised manuscript**

23. Page 17, line 36: Often phase lags are included in these ellipses by showing the current vector position at the time of maximum tidal potential at Greenwich. Also, an arrow is sometimes placed on the ellipse itself to denote the sense of rotation. Were these not done in Figs 19 and 20 because they would make the figures too complex?
We are now re-generating the figures to improve their graphical quality.
**Your recommendation will be taken into account in the revised manuscript as much as feasible.**

24. Page 17, line 42: You should change the scale to make the ellipses larger for K1. Perhaps a zoom-in capability (ellipse size changing as you zoom-in) is needed here in order to decipher which ellipses belong to which dot.
We are now re-generating the figures to improve their graphical quality.
**Your recommendation will be taken into account in the revised manuscript as much as feasible.**

25. Page 18, line 11: I can guess which station this is but maybe you should give the approximate lat/lon to help readers.
**It will be added in the revised manuscript**

26. Figure 21: A zoom-in capability that doesn't blur the color details would be useful here.
We are now re-generating the figures to improve their graphical quality.
**Your recommendation will be taken into account in the revised manuscript as much as feasible.**

27. Page 19, lines 5-6: Why does the lower panel of Fig 22 show wave-like (Gibbs?) patterns, for example radiating eastward and westward from the Canadian Pacific coast?
This is likely due to differences between Green's functions based computation of LSA (as in FES2014 atlas) and spherical harmonics based computation (GOT).