Replies to RC #3

This manuscript presents a global map of the sea-surface height (SSH) signals of the N_2 internal tides observed by satellite altimetry. The topic is important for mapping the tidal energy available for diapycnal mixing and also for reducing the tidal signals in SSH data in the studies of mesoscale and sub-mesoscale phenomena. Although I do not understand the technical details, the presented maps of the N_2 internal tides seem all reasonable.

Thank you for your time and suggestions.

Minor Comments:

The explanation about the method for extracting the N2 internal tides (section 2.2) is hard to understand. I would suggest the authors rewrite this part more to the point, or omit it. Right now, the readers who are not very familiar with this method cannot judge whether this method is really suitable for mapping the N2 internal tides.

In the revised manuscript, I rewrite my methods and give more details. Now Figures 1–5 give more information on data, tidal aliasing, mapping methods, and model errors.

A few specific examples of the above comment are:

1. Why are "five" plane-waves needed to fit the N2 internal tides?

The mode-1 N_2 internal tide field contains long-range internal tides originating from various source regions. We thus should fit multiple internal tidal waves at each grid point. In this study, I fit five mode-1 N_2 internal tidal waves in each 160 km by 160 km fitting window. The five waves are determined one by one. They are sorted with decreasing amplitudes. That is, the first wave at each grid point is the largest, and the fifth is the smallest. In most cases, only three waves are sufficient to account for >95% variance. We have tested fitting six or seven waves. But the sixth and seventh waves are usually lower than model noise level (see Figure 4c for model errors).

2. Is the plane wave fitting applicable when the wavenumber of the internal tide changes rapidly over variable bottom topography?

Good point. My plane wave analysis assumes simple plane waves in fitting windows of 160 km by 160 km (this study). This assumption is perfect in the open ocean. However, it is not a perfect representor in source regions due to complex topographic feature. This may lead to underestimation of internal tide amplitudes. This problem can be partly solved using smaller and smaller fitting windows (now limited by the wide ground tracks of nadir-looking altimeters). For example, 40 km by 40 km windows are used for nonrepeat altimetry missions (Zhao 2022 JPO). However, smaller fitting windows also lead to larger model errors.

3. Bandpass filtering in the wavenumber space: The barotropic tides may have horizontal scales comparable to those of the mode-1 internal tides. Does this matter? Also, what happens when the mode-2 and higher mode internal tides have large amplitudes near the generation sites?

Mode-1 N_2 internal tides have wavelengths typical of 150 km. In contrast, N_2 barotropic tides have wavelengths >3000 km. Mode-2 N_2 internal tides have wavelengths <80 km. They can be easily separated by any 2D bandpass filter.

4. What happens if the larger-amplitude M2 and S2 internal tides are Doppler-shifted to the N2 tidal frequency by time-varying background fields?

This is very interesting and challenging question. I spent a lot of time to prepare my answer. The answer is that our mapping of N_2 internal tides is not affected by the presence of M_2 internal tides. It is because N_2 and M_2 have different periods (12.6583 and 12.4206 hours), the 27-year-long SSH time series are sufficiently to separate them in the frequency domain.

My answer is supported by my work below:
First, I map N_2 internal tides using two data sets. One is the original 27-year-long data. The other is the same data but M_2 internal tides are predicted and subtracted using my M_2 internal tide model. I find that the resulting two N_2 internal tide models are almost the same.

Second, I map 13 sets of background internal tides between M_2 and N_2. Their tidal periods are linearly interpolated (with 1-min intervals) between M_2 and N_2. The 13 sets of internal tides are uncorrelated and just noise---they have no relation with the N_2 or M_2 internal tides. Since M_2 and N_2 cannot affect the 13 tidal periods between them, M_2 and N_2 internal tides must be independent with each other.

5. Do the results depend on the choice of several arbitrary parameters (such as the size of the fitting window)?

I want to stress that the parameters are chosen empirically, not arbitrary. In this study, I fit five waves (as explained above) in 160 km by 160 km window (as explained above) using a bandwidth of [0.8 1.25] times local wavenumber (explained in my reply to Reviewer #2). My empirical model is surely affected by these selections, but not much. And the degree of their influence varies from one region to another. Among these parameters, the large fitting window is an issue. I think I can continue to improve my model by fine adjusting these parameters (and thus seek maxima variance reduction).

6. Although the results presented in the manuscript seem reasonable overall, it is unclear what are the new findings in terms of the internal tide dynamics. Now the manuscript reads more like a progress report.

My initial plan is to publish a short note to simply present my new N_2 model. Now I change it to a full-length paper. The revised manuscript now has 13 figures (previously 4 figures). Now it presents new scientific findings in Figures 10-13. For example, Figure 12 shows that N_2 internal tides are around the New Caledonia, one SWOT calibration/validation site proposed by French scientists. To my knowledge, this feature has been reported in the literature.