Authors' response to the reviewer's comments

Title: Tsunami Hazard Assessment in the South China Sea Based on Geodetic Locking of the Manila Subduction Zone

We are very grateful to the reviewer for the comments and suggestions to improve the manuscript. Following the reviewer's suggestion, the manuscript has been revised accordingly.

The manuscript "Tsunami Hazard Assessment in the South China Sea Based on Geodetic Locking of the Manila Subduction Zone" presents a new tsunami hazard assessment for the South China Sea due to earthquakes triggered in the Manila Subduction Zone. The new assessment incorporates geodetic information that is used to increase the likelihood of hosting larger slip within highly coupled regions and to determine an upper limit for the maximum earthquake moment magnitude. The study provides a significant advance to the efforts assessing tsunami hazards in the South China Sea. Here, I provide some comments to further improve the paper.

Response: Thank you very much for your review work and valuable suggestions. These will also be of great help to our future work.

Major Comments:

1. The paper needs a deeper analysis of previous geodetic studies in the Manila Subduction Zone. For example, I would include a deeper analysis of previous GNSS data used by Hsu et al. (Hsu, 2016, 2012) in the introduction. That study served as reference for several PTHA studies in the past (to define earthquake magnitude recurrences). It is also important to compare differences in the estimated coupling ratios of past studies to identify improvements in your new inversion.

Response: The analysis of previous geodetic studies and estimated locking ratios of past studies has been provided in the Introduction, as follow:

So far, there already are some studies on locking inversion in the Manila subduction zone. Galgana et al. (2007) showed that the locking degree of the Manila subduction zone is very low, with a locking coefficient of 0.01. Hsu et al. (2012) suggested that the Manila subduction zone is partially locked between 14.5-17.0°N, with an average locking coefficient of 0.4. Hsu et al. (2016) estimated that the locking coefficient of the Manila Trench at 15.0-19.0°N is 0.34~0.48. Those works are good references for the present study, but further analysis is still needed for deeply integrating the effect of locking distribution into PTHA.

2. The locking model is a very important input in the new tsunami assessment. Because of this, I recommend to add more information about the inversion method. For example, you need to provide information on how the Gaussian and Gamma distribution enter in the inversion method. Also, you shall need to provide some measure of the inversion constraints. For example, your slip seems to concentrate in shallow regions. Is this a bias due to the GPS station locations? This information will be very important for future

efforts to improve the geodetic network or understand tsunami hazard uncertainties.

Response: The information on how the Gaussian and Gamma distribution enters in the inversion method and measure of the inversion results are provided. Generally, the locking distribution along the dip profile is assumed to have similarity, and parameterized functions are used as a primary guess of locking distribution. The Gaussian function and the Gamma function are widely used in the locking inversion. The Gaussian type refers to the distribution of locking coefficients along the dip profile as a Gaussian function; Gamma type refers to the exponential distribution of locking coefficients along the dip profile. The goal of inversion is to find the optimal parameters of the assumed function that minimizes the chi-square value between the observed data and the model data. In Gamma distribution, it is assumed that the locking coefficient is maximum at the shallowest part of the subduction zone, so the locking distribution and slip deficit distribution are concentrated in the shallow regions.

3. Due to computational limitations, the tsunami modeling of the study is based on linear superposition of unit sources. This approach has to assume linear tsunami waves. Though, tsunami waves are very non-linear in shallow waters. Because of this, the study would not be able to determine tsunami heights in coastal regions. If the linear superposition at the coast is used, I'm afraid the results will be very different from an approach using non-linear tsunami models. The authors, therefore, may be only allowed to determine wave heights in relatively deep waters (at some distance from the coast) and for waves that have not propagated through shallow waters before. This is an important limitation which can be only overcome by running non-linear models (where the unit source superposition is not valid). Furthermore, bottom friction will contribute with energy dissipation. This linear superposition limitation is discussed in several papers (Williamson et al., 2020; Sepulveda et al., 2019; Li eta al., 2017). An easy way to overcome this difficulty would be to analyze tsunami heights far from the coast. This would be easy as the authors already have the model results in all the domain. Finally, the innovative idea of using linear superposition (in the past) was designed before Zhang and Niu (2020). For example, Li et al. 2016. Please indicate if there is something different in the most recent cited paper or change the citation.

Response: You are right that the tsunami modeling of this study would not be able to determine tsunami heights in coastal regions. The water depth of target points in this study is all greater than 100 m. Earlier papers on linear superposition techniques have been cited. This study used the same unit source database with study of Zhang and Niu (2020), so this paper is still cited. The description related to linear superposition limitation has been supplemented in Section 2.3, as follows:

It should be noted that due to the limitation of the superposition method, this study would not determine tsunami heights in coastal regions and the water depth of target points is all greater than 100 m. Tsunami waves propagating in shallow water will show complex non-linear behaviours, which can be simulated using non-linear models. The tsunami height in shallow water can be obtained approximately from the tsunami wave height at offshore point such as 100 m depth through multiplying the nearshore amplification factors (Glimsdal et al., 2019; Gao et al., 2022). Generally, the tsunami dataset in this study can be adopted as the boundary condition for detailed nearshore hazard analysis.

4. The abstract does not mention the very important innovations of the study. It rather focuses on ideas that are well-known from the past. For example, lines 12-14 compares the new slip model with the old uniform-slip model. Rather than this, I would tell how relevant is to include the locking distribution in the new slip model, compared to a slip model that only uses stochastic slip.

Response: The abstract has been revised to include the innovative points regarding the impact of locking distribution on tsunami hazard assessment, as follows:

Moreover, the assessment results involving the effect of locking distribution should be more realistic, and show a larger tsunami height than only considering the stochastic slip in most areas, which prompt the coastal management agencies to enhance the tsunami prevention awareness.

5. I could not see the details of the PTHA. What are the recurrences for every magnitude (i.e., p_i in Equation 1)? Are you able to determine new a and b value to create a Gutenberg-Richter Law? Please clarify as this is a very important input for future studies.

Response: The detail of PTHA has been provided. p_i is estimated statistically using the historical earthquake data. The historical earthquake data from 1900 to 2022 of the United States Geological Survey (USGS) is used to calculate the coefficients in the Gutenberg-Richter relationship.

6. Line 121-125. Here I got confused. First, it says that the Okada (1985) model is used to get the tsunami initial condition unit (which assumes that water elevation mimics co-seismic deformation). Though, in line 124 you say "same Gaussian distribution initial water level is set on each point source". Please clarify.

Response: Additional description has been provided. Unit sources have the same initial water level field of Gaussian distribution. The initial water level distribution of unit sources will be stacked according to certain proportion coefficients to obtain the initial water level field of tsunami event calculated by the Okada model.

7. The introduction contains some ideas which may be true some years ago but not today: Line 44: "traditional tsunami research often assumes that earthquake rupture is uniform". I think this is not true anymore. I rarely see tsunami assessments with uniform slip, even in the engineering industry. Line 48: "…unit source or sub-fault methods are usually used to convert tsunami simulation into linear superposition...". I also think, the linear superposition is not used so often. Especially because tsunami hazards are commonly evaluated close to the coast.

Response: The relevant sentences have been revised. For example, some traditional tsunami research assumed that earthquake rupture was uniform. And in some PTHA work, unit source or sub-fault methods are used to convert tsunami simulation into linear superposition of unit sources based on the linear characteristics of tsunami waves in deep water, thereby reducing the computational complexity.

8. To make the manuscript reproducible, the results need to be provided in accessible files. Are the coupling and locking rates included in a text file or repository in “Code/Data Availability”. These are essential to reproduce results.
Response: They are not in Code/Data Availability for now. Readers can obtain locking data from authors via email.

Minor Comments:
1. Line 66: I would replace “increase the probability” by “correct the probability”
Response: The text has been revised.

2. Line 72-73: I would remove the sentence “TDEFNODE is an inversion program developed by Professor McCaffrey of Portland State University in the United States” and rather talk about the method and formulations (which are missing in the text).
Response: The text has been revised and the method of TDEFNODE has been supplemented.

3. Line 88: what constitutes ‘great uncertainty” for the study? Please provide quantification or justification.
Response: If the velocity data uncertainty of a GPS station is greater than 3.3 mm/a, this data is thought to have great uncertainty and is eliminated.

4. Line 147: “…1.26x10^20 N*m/a, respectively.”
Response: The text has been revised.

5. Line 153: maybe use “the aforementioned studies” instead of “the latest research results”, to emphasize that you are talking about the papers you described in the previous sentence.
Response: The text has been revised.

6. Line 156: “locking may only be released” instead of “locking can only be released”
Response: The text has been revised.

7. Line 258: Sentence starting with “In the current researchs…” I would suggest “Existing studies rarely consider the…”
Response: The text has been revised.