Review response for *High-precision 1'×1' bathymetric model of Philippine Sea inversed from marine gravity anomalies*

Dear Reviewer,

Thanks for your useful suggestions and comments. We have carefully revised the manuscript according to the comments. Your opinions are reasonable, greatly helping me improve my article. The response to the reviewer's comments is as follows:

Specific Comments

1. Line30: why are there two trench-like terrains at (140°E-150°E, 30°N-35°N) and (125°E-127°E, 27°N-30°N)? This is clearly not true.

Response: We completely agree with this point and thanks for your careful observation. After investigation, we found that there were gross differences in the original shipborne bathymetric data on the two ship tracks (as showed in Extended Data Figure 1 and Figure 2). This part of the error was not effectively eliminated in the data preparation stage, which led to this situation. We have processed the bathymetric data again and recalculated the optimal bathymetric model (as showed in Extended Data Figure 3).
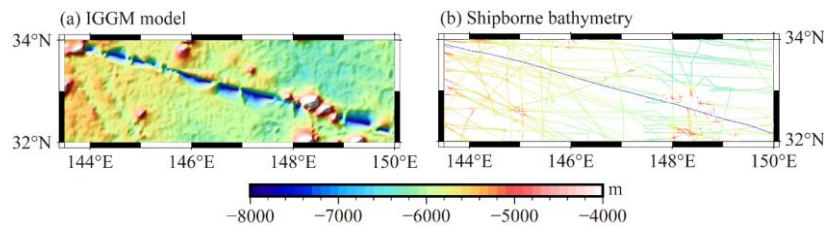

Extended Data Figure 1. IGGM model and shipborne bathymetric before correction in the region of 143°E-150°E, 32°N-34°N.
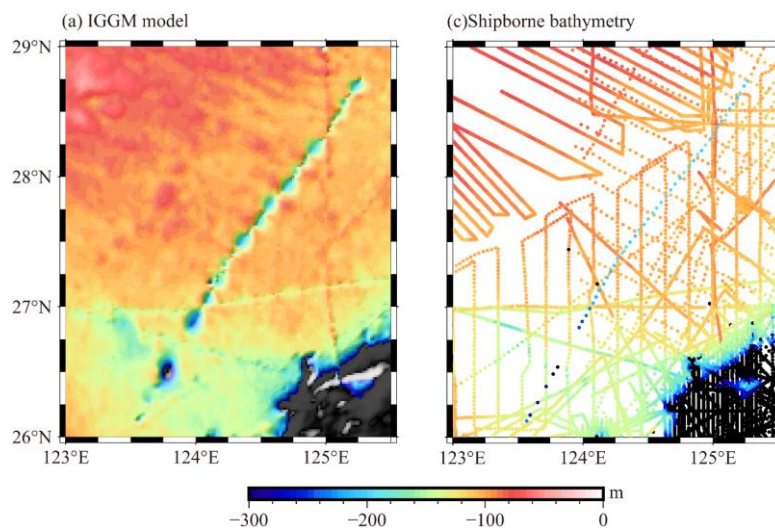
Extended Data Figure 2. IGGM model and shipborne bathymetric before correction in the region of 122°E-126°E, 26°N-30°N (Areas or points with water depths above 300 m are shown in black).

Bathymetric model of Philippine Sea (BAT_PS model) inversed from marine gravity anomalies
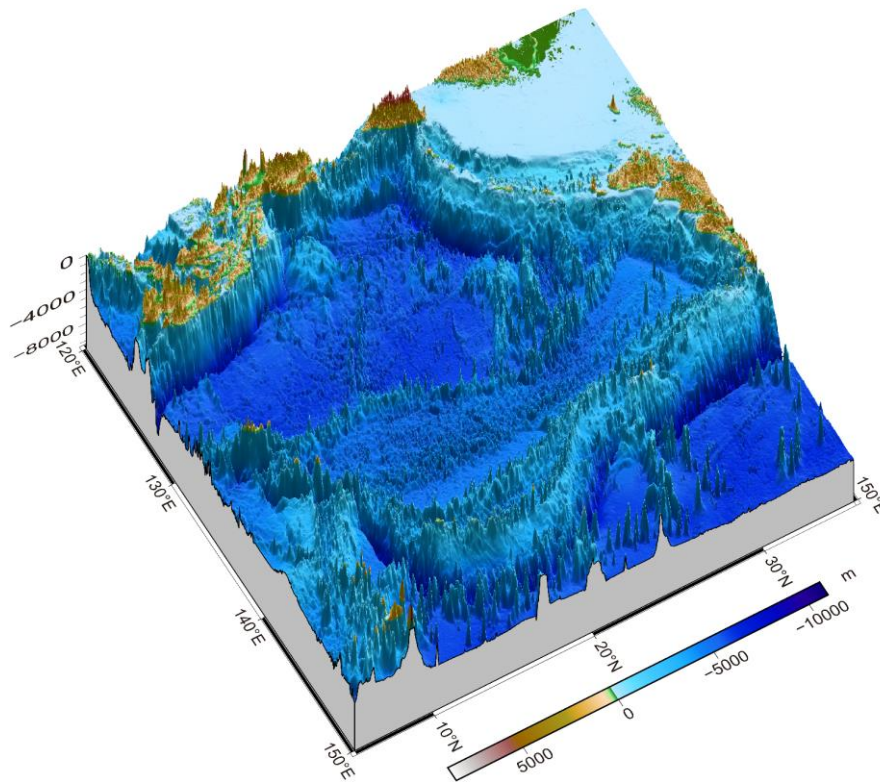
Extended Data Figure 3. Modified BAT_PS model

2. Line 43, please accurately list several GEBCO models.

Response: Thank you for the suggestion, we have added an observation with this point. "Additionally, multiple GEBCO models **(such as GEBCO_2019, 2020, 2022, etc)** have been released."

3. Line 126, in Eq. (2), how are parameters $\Delta\rho$ and D obtained?

Response: Thanks for your comments. We explain this question by referring to the statement in the paper: "D is a reference datum, which is generally the deepest depth of control points. The parameters $\Delta\rho$ are calculated by iterative method in IGGM. The correlation coefficient and STD between the predicted depth and the shipborne bathymetry at points i are analyzed under the conditions of different parameter values. When the correlation coefficient is the largest and the STD error is the smallest between predicted depths and measured depths (i.e. $\max_{1\leq i\leq n} CC_i$ and $\min_{1\leq i\leq n} STD_i$), the corresponding parameters are the optimal value."

4. Line 139, in Eq. (3), what does the letter "k" represent here? What is the influence of this parameter on the accuracy of bathymetric model inversion?

5.

Response: As you have highlighted, the parameter $'k'$ plays a crucial role in weighing the short-wavelength influence of surrounding points on the control points. It's used in conjunction with $'cos\theta_m'$, which is associated with the distance between the two points, and in this study the value of $'cos\theta_m'$ is between 0 and 1. Therefore, a larger $'k'$ represents a smaller proportion of the short-wavelength gravity effects caused by the surrounding points.

6. The elimination rate of data in Table 1 exceeds 1%, which will have an impact on the results of submarine terrain inversion.

Response: Thank you for your valuable comments on our paper. We appreciate your concern regarding the elimination rate of data exceeding 1% and its potential impact on submarine terrain inversion results. We want to clarify that the elevated rejection rate is attributed to the extensive time span of data collection, including instances before the advent of GPS technology, leading to poor positioning and notable measurement errors (Smith, 1993). To ensure the reliability of our shipboard bathymetric data, we must employ an effective rejection step to eliminate inaccurate or biased data. While we acknowledge the elimination rate surpassing 1%, our thorough analysis indicates that this does not significantly affect the final seafloor topographic inversion results. We are aware of this concern and plan to delve deeper into the impact of varying bathymetric data volumes on inversion results in future research to comprehensively assess the robustness of our approach.

7. When calculating the short-wave gravity at any point i, the long-wave gravity is derived from the long-wave gravity field, calculated using the tension spline function, and subjected to cubic spline interpolation. This entire calculation process inevitably introduces calculation errors. Does the paper address any relevant methods to mitigate or handle these errors?

Response: Thank you for your valuable comments. In our calculations for short-wave gravity at any point i, the long-wavelength gravity is derived from a tension spline function using GMT (Generic Mapping Tools) and is subsequently subjected to cubic spline interpolation. We recognize that this entire computation process may introduce errors. We believe that calculation errors in densely sampled areas of shipborne depth data are acceptable, while sparsely sampled areas may introduce noticeable errors. As of now, this issue has not been well-resolved, and our paper does not explicitly propose specific methods to mitigate these errors. We acknowledge the importance of addressing this issue and plan to explore and implement improved measures in our further research and revisions. Our goal is to reduce the impact of computational errors to the greatest extent possible, and we appreciate your feedback as it guides our ongoing efforts to enhance the accuracy and reliability of our methodology.

8. Fig7: The image is low resolution and I can't see the distribution of the black pints.

Response: Thanks for your input, we have redrawn Figure 7 in higher resolution to ensure better visibility of the distribution of the black points.
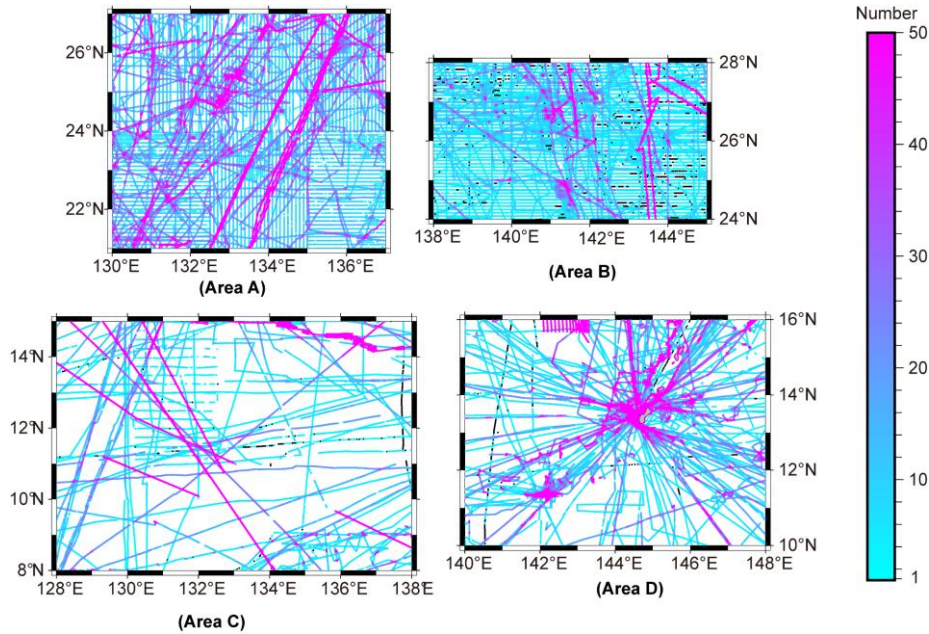
Figure 7. Total number of surrounding points within 2′ of each shipborne point as the center (black points represent no other single-beam shipborne points within a 2′ radius)

9. Fig9 (b) and (c): Unlike Fig8(c), the comparison between the GEBCO model and the GGM/IGGM model should be described as the absolute value of the difference.

Response: Thank you for your suggestions, we have added the appropriate explanations. "The GEBCO model and the absolute value of its differences in comparison with the GGM/IGGM models."

10. For the BAT_PS model and other reference models, there are still very large errors at some ship measurement points (Table 5). Can shipborne bathymetric data be used to further improve the accuracy of the model? For example, the difference at the ship measurement point can be added to the BAT model as a correction.

Response: We appreciate your thorough review of our paper and your invaluable suggestions. Your recommendation to use shipborne bathymetric data for model improvement is highly insightful. To further enhance the accuracy of the BAT_PS model, we have adopted your suggestion and implemented the following steps (SRTM, 2019):

(1). Interpolate the BAT_PS model to obtain predicted depths at ship measurement points and calculate the difference from the actual measured depths.

(1). Supplement grid points located 5 minutes away from the ship measurement points with zero-depth differences. These additional zero-depth data points prevent the interpolation algorithm from generating abrupt changes in gaps adjacent to areas with rapid depth variations.

(3). Use the GMT module "surface" to generate a corrected grid (Figure 12(a)) by combining the depth differences at ship measurement points and the zero values at grid points.

(4). Restore the corrected grid to the BAT_PS model to obtain the CBAT_PS (constrained BAT_PS) model, as shown in Figure 12(b).

We also added the corresponding explanation in the paper and the final model has been uploaded to *Zenodo* (https://zenodo.org/records/8351399).
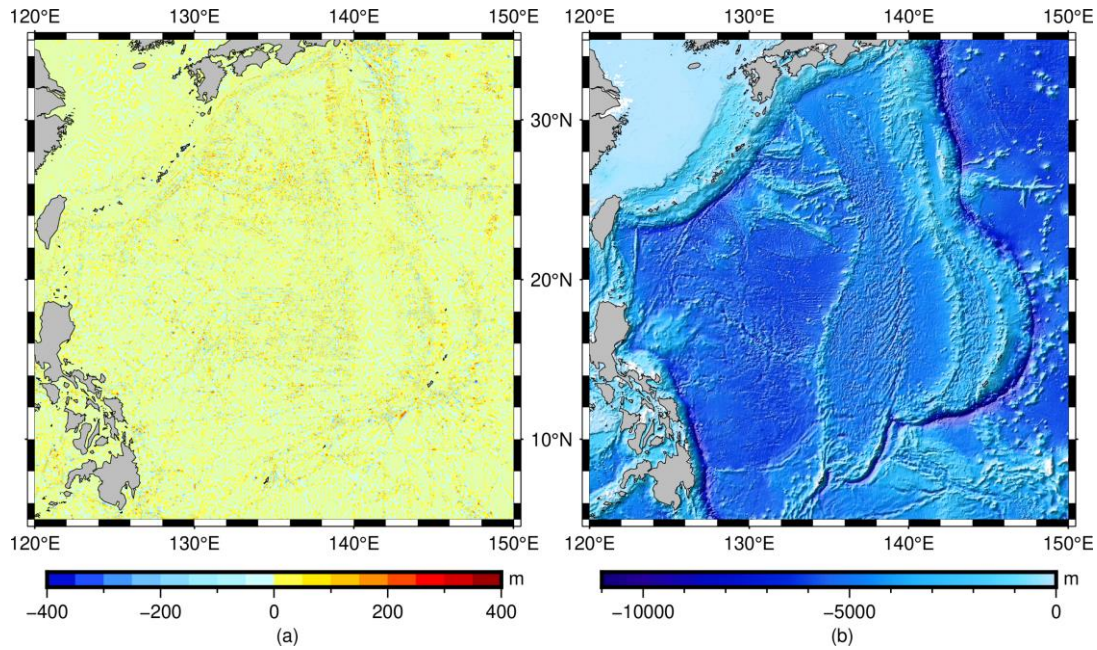
Figure 12. (a) Depth correction grid constrained by shipborne bathymetry. (b) CBAT_PS model constrained by shipborne bathymetry.

11. Is it reasonable to determine the computational radius to be 2′ for the entire Philippine Sea area? In general, re-selecting the optimal value for each sub-region is required to obtain a locally optimal model.

Response: Thank you for your valuable suggestions and comments. Regarding the predetermined computational radius of 2′ for the entire Philippine Sea area, our decision is based on two primary considerations. Firstly, numerous experiments have revealed that, within a certain range, variations in the calculation radius do not significantly impact model accuracy. Additionally, given the substantial amount of data available for the Philippines, we aim to improve calculation efficiency while ensuring accuracy. Predetermining this parameter in advance is a pragmatic approach. We are also in the process of applying this approach to global model building. We appreciate your thoughtful input, and we believe that these considerations contribute to a fair and effective modeling strategy.

12. Line 287: How are the boundary points of each region treated? How are the subregions stitched together?

Response: Thank you for your comment. The stitching of subregions is accomplished using GMT. For the coincidence points at the boundary, their average value is taken as the value of respective node.

Technical corrections

1. In line 47, the sentence "as compared to other observation methods" can be changed to "compared to alternative observation methods".

Response: We thank the reviewer for rising this point. We have revised this sentence to make it more understandable.

2. In line 59, the first occurrence of 'SIO' should be provided in full.

Response: We thank the reviewer for rising this point. We have revised this sentence to make it more understandable.

3. In lines 74-77, the sentence is too long to convey its meaning accurately.

Response: We thank the reviewer for rising this point. We have removed burdensome expressions to make it clearer.

4. In line 100, please provide an accurate explanation for '3b' to ensure understanding for all readers.

Response: Thank you for the suggestion, we have rewritten the sentence to improve understanding for all readers: "Interpolate the GEBCO_2022 model to the shipborne bathymetry points, calculate the difference with the shipborne depth, and then exclude points where the difference exceeds 3 times the standard deviation (STD) of the whole differences."

5. Line105: "is a continuous global terrain model".
Response: Noted.

6. Figure 3 needs to be redrawn, the text in the figure is not clear, and the flowchart logic is confused.

Response: We thank the reviewer for rising this point. Figure 3 has been redrawn to enhance clarity, making the text more legible and improving the logic of the flowchart.
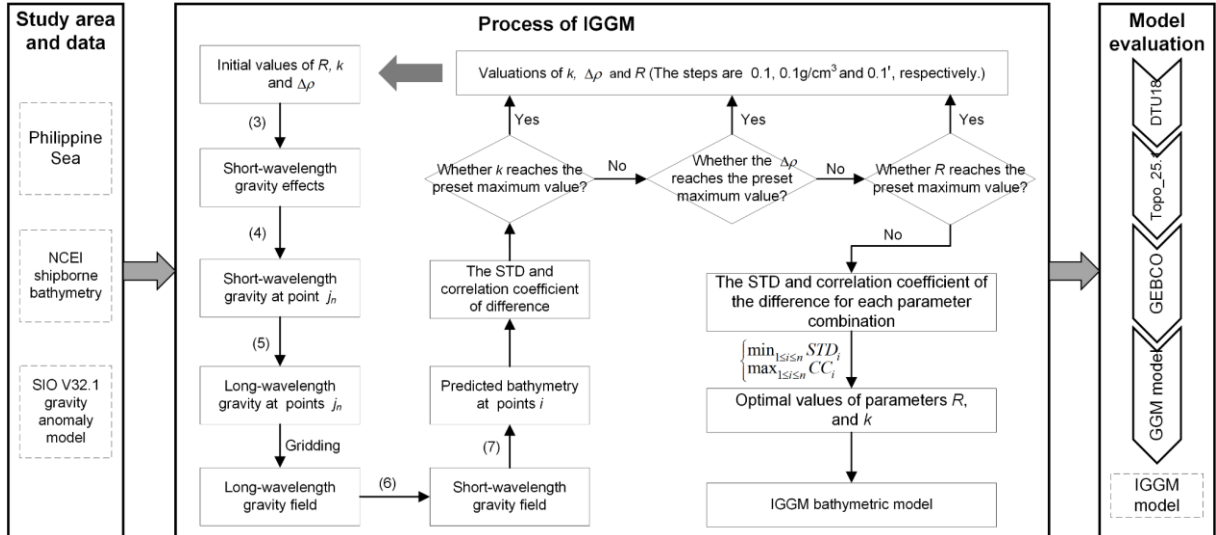

Figure 3. Flowchart of the IGGM.

7. Line218: Does "the total number of surrounding points within a $2'$ radius centered on each shipborne point" include the centre point? The minimum value of colorbar in Fig7 starts at 2.

Response: Yes, the representation in the previous manuscript included the central point. However, we have redrawn Figure 7 and its colorbar for clarity. In the updated version, 'the total number of surrounding points within a 2' radius' does not include the center point.

8. Check the formatting of references, e.g. Lines 394, 402, 429, 437, 460.

Response: Noted. Thanks for your comments.

9. Line 153: "value" should be "values".

Response: Noted.

10. Line345： "were not utilized" should be deleted.

Response: Noted.