Reply in response to Journal reviewer 1 comments of

“Mid-field tsunami hazards in greater Karachi from seven hypothetical ruptures of the Makran subduction thrust”

a manuscript by Haider Hasan, Hira Ashfaq Lodhi, Shoaib Ahmed, Shahrukh Khan, Adnan Rais, and Muhammad Masood Rafi submitted for publication in *Natural Hazards and Earth System Sciences* (nhess-2024-110)

Revised manuscript title

“Mid-field tsunami hazards in greater Karachi from hypothetical ruptures of the Makran subduction thrust”

1. ***Discussion of Results:*** *The paper lacks sufficient discussion regarding the results, particularly in comparing the actual Karachi marigram with the simulated results. Other studies have presented more robust simulations between the real data from the 1945 tsunami and their results. The authors should indicate that the discrepancies between their findings and the actual 1945 tsunami waveform may come from their simplistic representation of the tsunami source. The differences observed between the simulations and the two marigrams may not solely be attributed to tide gauge errors, but also to our limited understanding of the 1945 tsunami source.*

   This study concentrates on the implications that the emergency managers might have to consider while planning for mid-field cities such as Karachi. The purpose of the paper is not rather to delve into the 1945 tsunami source. Though the authors agree that the discrepancies may be due to simplistic source and not solely due to the tide gauge error. The same has also been reflected even in the abstract. In response to your comment, we will include a brief discussion in the revised manuscript to clarify that while the discrepancies observed may be partly attributed to the limitations in the representation of the tsunami source, they also highlight the challenges associated with modelling historical tsunami events.

2. ***Title Adjustment:*** *I recommend removing the word "seven" from the title.*

   I agree that removing the word "seven" would make the title more concise and focused. I will revise the title accordingly.

3. ***Abstract Corrections:*** *In Abstract (line 13), "km" should be corrected to "km²." Additionally, in line 21, the repeated use of "neither" makes the text unnecessarily verbose.*

   i. I have considered your comment regarding the use of "km" in line 13. The dimensions " 100 × 150 km to 355 × 800 km" are intended to specify the length and width of the rupture area. To ensure clarity I will include the units of both dimensions: 100 km × 150 km to 355 km × 800 km. Therefore, I will retain "km" to accurately represent the dimensions of the rupture areas.

   ii. I will revise line 21 to avoid the repeated use of "neither," making the text more concise.

4. ***Typos and References:*** *The manuscript contains several typographical errors, such as "Tohuku" (which should be "Tohoku") and "20011" (which should be "2011"). Moreover, in several instances,*

the authors have neglected to include the publication year of references in parentheses. A thorough review of the text for typos and potential grammatical errors is recommended.

Thank you for your careful review and for pointing out the typographical errors and inconsistencies in the references.

i. I will correct the typographical errors, such as changing "Tohuku" to "Tohoku" and "20011" to "2011."

ii. I will thoroughly review the manuscript to identify and correct any other typographical or grammatical errors.

iii. I will ensure that the publication years for all references are included in parentheses where appropriate.

5. ***Figure Combination:*** *It appears that Figures a&b could be combined into a single figure unless additional details (e.g., an earthquake catalog) are added to panel (a).*

   I presume this comment refers to Figure 1 (a) and 1 (b). After careful consideration, I believe it is important to retain these figures Figures 1 a and b separately to maintain clarity and avoid clutter.

   Figure 1 (a): Geographical Overview: Arabian Sea and surrounding nations. This figure provides a broad geographical context, which is crucial for understanding the regional setting of the study area.

   Figure 1 (b): Dimensions and locations of hypothetical rupture scenarios: Makran Subduction Zone. This figure focuses specifically on the detailed dimensions and locations of the hypothetical rupture scenarios, which is essential for comprehending the specifics of the simulations.

   Combining these figures into a single panel would make it cluttered and potentially obscure important details. Therefore, to ensure clarity and effective communication of the information, I would like to retain Figure 1 (a) and Figure 1 (b) as separate entities.

6. ***Model Details:*** *Additional information about the GeoClaw model should be included, such as inputs and outputs, the types of water equations used, the algorithms employed for inundation calculations, the nature of the friction effects (whether constant or variable), and whether structured or unstructured grids are used.*

   Given that GeoClaw is a well-established model in the field, we aimed to focus on the aspects most pertinent to our study. However, to address your query more comprehensively:

   i. **Model Inputs and Outputs:** GeoClaw utilizes a range of inputs including topography and bathymetry data, initial sea levels, and earthquake parameters. The model outputs are primarily related to water elevations, inundation extents, and flow velocities.

   ii. **Water Equations Used:** GeoClaw is based on the shallow water equations, which account for conservation of mass and momentum. These equations are well-suited for modeling tsunami dynamics and inundation processes.

iii. **Algorithms for Inundation Calculations:** The model employs a high-resolution shock-capturing finite volume method, which is enhanced by adaptive mesh refinement (AMR). This approach allows for detailed resolution of tsunami waves and inundation areas while efficiently managing computational resources.

iv. **Friction Effects:** GeoClaw incorporates bed friction effects through the Manning coefficient. This parameter can be adjusted based on the varying characteristics of the coastal and bathymetric surfaces within the model domain.

v. **Grid Structure:** GeoClaw uses structured rectangular grids that adapt dynamically through AMR. This higher resolution in areas of interest, such as nearshore regions, while maintaining computational efficiency.

We hope this additional information provides a clearer understanding of the model setup and its application in our tsunami hazard simulation for Karachi.

7. ***Font Size in Figures:*** *The font size in Figure 2 should be increased for better visibility.*

I will ensure the text within figure is easily readable.

8. ***Scenario Simplifications:*** *More details are needed regarding the simplifications made in selecting scenarios. Such simplifications (e.g., rectangular sources and uniform slip) could lead to potentially underestimated or less complex wave height distributions. The strike angle of 270 degrees appears inconsistent with the tectonics of the Makran thrust; any alterations in the strike direction could yield different wave directions and results. These simplifications require a more thorough explanation. Furthermore, these scenarios do not seem to offer new insights compared to those proposed in previous studies.*

We acknowledge the simplifications made in our scenario selection and their potential implications. Several simplifications were made in selecting our scenarios to standardize the analysis and align with previous studies, such as Smith et al. (2013). First, we chose to represent rupture areas as rectangles. While real earthquake ruptures are often more complex in shape, using rectangular sources simplifies the modeling process and provides a clear basis for comparison across different scenarios.

We also assumed a uniform slip distribution across the rupture areas. In reality, slip can vary significantly across the fault plane, which may lead to more complex and varied wave height distributions. This simplification could result in potentially underestimated wave heights, especially in regions where slip is concentrated.

The strike angle was assumed to be 270 degrees, which may not fully align with the tectonic structure of the Makran thrust. Variations in the strike direction could produce different wave directions and characteristics, affecting the results of the tsunami hazard assessment.

While these simplifications help to standardize the scenarios and facilitate the analysis, they also introduce certain limitations. Recognizing these limitations is crucial for understanding the scope and applicability of the results. Further refinement of the models, including more complex slip distributions, non-rectangular rupture geometries, and different strike angles, could provide a more detailed understanding of the potential tsunami hazards in the Makran subduction zone.

We will revise section 3.2 to clarify the reasons behind the simplifications and acknowledge the implications, so that the section aligns with the request for more thorough explanations.

9. ***Table A3 Enhancements:*** *In Table A3, please add an additional column indicating the moment magnitude (Mw) for each scenario.*

   I agree that this information is crucial for a comprehensive understanding of each scenario, hence, will add a column to Table A3 to include the moment magnitude (Mw) for each scenario.