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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Numerical Simulations of the 2004 Indian Ocean Tsunami Deposits Thicknesses and Emplacements" *by* Syamsidik et al.

Syamsidik et al.

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Dear Referee #1:

We thank to your valuable comments and your time to review our manuscript. Your comments have driven some important changes on our paper, such as performing more numerical simulations by incorporating three other sediment transport formulae (Engelun-Hansen 1967, Meyer-Peter-Mueller 1948, and Soulsby 1997), combining some figures, and adding more explanation and discussion in our revised manuscript. The lack of spatial distribution of sediment transport studies driven by the 2004 Indian Ocean tsunami has been one of our motivations in this study. Beside this, there have been a number of paleotsunami study conducted in the northern part of Sumatra that can also used to strengthen this research. Your comments are very much appreciated to ensure our manuscript meets scientific standard of the NHESS journal and useful for further development in tsunami sciences. Now, permit us to respond to your comments in more details. We divide your comments into 7 comments followed by our response to each of them.

COMMENT 1: Dear Editor, many thanks for the opportunity to review this manuscript on "Numerical Simulations of the 2004 Indian Ocean Tsunami Deposits Thicknesses and Emplacements" by Syamsidik et al. Dear authors, I read with pleasure your manuscript focusing on coupling field and numerical data in an Indonesian region affected by the 26th of December tsunami. Your manuscript is well-written and is easy to follow.

RESPONSE 1: We humbly offer our gratitude to your appreciation to our paper. We are pleased to learn that you acknowledge the manuscript is easy for you to follow and it has a well-written structure of a scientific manuscript. Thank you very much for this important statement.

COMMENT 2: I suggest that you largely reduce the number of images. Some are redundant while others can be easily merged (e.g. 3 and 4; 6, 7 and 8; 9, 10 and 11; 15, 16, 17 and 18).

RESPONSE 2: Thank you for suggesting to reduce some figures. Please find some figures attached in this response to demonstrate that we have combined some figures into one and will incorporate them into our revised manuscript. Merged Figures 3 and 4 is shown in Figure 1 of this response, combined Figures 6, 7, and 8 is shown in Figure 2 of this response, Figures 9,10, and 11 are merged become Figure 3 of this response, and Figures 15, 16, 17, and 18 are combined become Figure 4 of this response.

COMMENT 3: Regarding the literature review there are several very important papers that are not mentioned in the manuscript and need to be added (Paris et al., 2007;

2008; 2009; Costa et al., 2012; Szczucinski, 2012; among others). These papers discuss crucial ′ aspects such as inundation phases, tsunami sediment sources and paths, geomorphological constrains, preservation issues and the authors will certainly benefit for reading these manuscripts. Some of their reasoning is questioned by these papers (for example, number of waves or inundation limit) and the authors need to acknowledge this and explain it. For example, when the authors discuss post-depositional poor preservation, they need to understand and explain the natural processes behind it and clearly described in Szczucinski (2012). Moreover, when the authors mention that only two waves occurred ′ in this region, they should discuss this in relation with the 7 waves described in nearby Lhok Nga (see papers by Paris mentioned above).

RESPONSE 3: Thank you for suggesting importance and related references to be included in our manuscript. Paris et al. (2007) performed their study around Lhok Nga of Aceh Besar, which is about 20 km to the east of our study areas. Their study exhibited the influence of local topography on the sediment thicknesses found in the area. Thickest deposit was found at low topography situation and and steep slopes gave varied results in spatial distribution of the tsunami deposit. This was found true in Birek and Pasie Janeng of our study sites that are surrounded by hillsides. Costa et al. (2012; 2015) proposed the shape of the zircons in the sediment deposit could be used to interpret number of waves, and tsunami run-in or backwash processes. Szczucinski (2012) provided an excellent basis for our study, especially on consideration of any process followed after the tsunami that could erode or alter the tsunami deposit. Our study area is situated in a tropical area where rainy season occurs about 4-5 months in a year with high precipitation rate. After more than 10 years, the 2004 Indian Ocean tsunami deposit in this area have encountered some natural processes despite selection of the study area has made to select the most sediment preserved area in Aceh Besar district. Szczucinski also argues that tsunami inundation less than 3 m would unlikely to preserve the sediment deposit years after the tsunami event (Szczucinski, 2012). We are pleased to include them in Section 1 Introduction, Section 3 Methods, and Section 5 Discussion in our revised manuscript. Thank you very much for the suggestions.

COMMENT 4: Furthermore, the geological criteria to identify tsunami deposits is very poorly described (e.g. "presence of sea shells") and some images are not clear enough to see the lithostratigraphical contrast (e.g. 11). To ascribe a deposit to a tsunami event you need many other criteria and you should clearly express that in the manuscript.

RESPONSE 4: The presence of sea shells were identified through a microscopic observation of the sediment material. This could distinguish the tsunami-induced deposit from orignal top-soil material or other surface run-off process. Other criteria of the tsunami deposit were advised by Jaffee et al. (2003) and Peters and Jaffe (2010) where they put the methods of the tsunami-induced sediment transport investigation into one practical guideline. We followed exactly the steps of the guideline and clarify it using some microscopic observations. We spent a significant period (from 0.5-2.0 hours) for each of sample to carefully identify the tsunami deposit and distinguish it from other sources of sediment. In total, we collected 14 samples of the tsunami deposits and 22 locations of sampling performed by Jaffee et al. (2006). Simplified lithostratigraphical contrast of our surveys could be seen in Figure 3 of this response. We will add similar explanation to Section 3 Methods in our revised manuscript.

COMMENT 5: Finally, when you mention "As shown in Fig. 13, backwash produced a sediment deposit that was 0.38 m thick during the second wave." how did you confirmed that in the field? Costa et al. (2012) differentiated inundation and backwash with the shape of zircons, rounded and euhedral. Can you discuss this?

RESPONSE 5: We base our arguments on the wave heights from the simulation as presented in Figure 13 in our manuscript. Backwash process based on the shape of the sediment was beyond our field investigation. We appreciate the suggestion to refer to Costa et al. (2012) where the study was performed with detailed litostratigraphy processes, such as exoscopic, radio-carbon dating and micro palaenthology. The latter three processes were part of the limitation of our study. Costa et al. (2015) stated that euhedral zircon could be associated to backwash process. Meanwhile, rounded zircons could be attributed to deposition occurred during tsunami run-in process. The detailed observation is absence in our present study. It is certain that the references could leverage our future field investigation on tsunami-induced sediment transport.

COMMENT 6: Your results are interesting and move tsunami geoscience forward. Coupling COMCOT with Delft 3D is interesting but you simply accepted the sediment transport formulas by default. You accepted Van Rijn formulas 1997 and 2007, why did you not test other formulas (please see Delft 3D FLOW Manual for many examples). Apotsos and Gelfenbaum work applied Delft 3D in a very specific context in American Samoa. The formula tests and results these authors obtained are obviously related with a context. You need to do the same and test, at least, other sediment transport formulas provided by Delft 3D-FLOW.

RESPONSE 6: At the beginning of our study, we have performed a number of literature reviews on a number of sediment transport formulae used to simulate tsunami-induce sediment transport. One study prooved that van Rijn formulas 1997 provided the best results compared to tsunami-induce sediment transport experiments in a wave flume (Li and Huang, 2013). Notwithstanding with the reviews we conducted, we agree to follow your suggestions to incorporate more sediment transport formulas, such as Engelund-Hansen 1967, Meyer-Peter-Mueller (MPM) 1948, and Soulsby 1997. One of the results of the simulation can be seen in Fig. 6 of this response to compare our simulation results to sediment deposit measured by Jaffe et al. (2006) at Jantang. Using linear regression method, we found the van Rijn 1993 formulas gave the best approximation to the field data. Similar results were found at other three study sites with smaller r square. Comparison from all simulated sediment thicknesses to field data at four sites can be seen at Figure 5 of this Response. Figure 5 will be included in our revised manuscript in Section 4.4.3 Tsunami Deposit Thicknesses. Discussion of the results will be also elaborated further in Section 5 Discussion.

COMMENT 7: Again, this is an interesting manuscript despite its weaknesses in sedimentological aspects and the straightforward application of a very competent open-source software. In my opinion, this manuscript requires major changes before it is accepted for publication on NHESS. As mentioned above, the science is there but the authors need to redo some figures, add references, test new sediment transport formulas and totally reconsider its discussion based on previous findings described in the papers mentioned above. Kind regards

RESPONSE 7: Thank you for your comments. We are pleased to present our findings and follow comments from all referees, including your comments. Your comments are very valuable. They have driven a number of changes and motivated us to present clearer arguments and findings in our revised manuscript.

REFERENCES

Costa, P.J.M., Andrade, C., Cascalho, J., Dawson, A.G., Freitas, M.C., Paris, R., and Dawson, S.: Onshore tsunami transport mechanism inferred from heavy mineral assemblages. The Holocene 1-15, 2015. DOI:10.1177/0959683615569322.

Costa, P.J.M., Andrade, C., Freitas, M.C., Oliveira, M.A., Lopes, V., Dawson, A.G., Moreno, J., Fatela, F.F., and Jouanneau, J-M.: A tsunami record in the sedimentary archive of the central Algarve coast, Portugal: Characterizing sediment, reconstructing sources and inundation paths. The Holocene 1-16, 2012. DOI: 10.1177/0959683611434227.

Jaffe, B., Gelfenbaum, G., Rubin, D., Peters, R., Anima, R., Swensson, M., Olcese, D. Bernales L., Gomez, J., and Riega, P.: Tsunami Deposits: Identification and Interpretation of Tsunami Deposits from the June 23, 2001 Peru Tsunami, Proceedings of the International Conference on Coastal Sediments 2003, CD-ROM Published by World Scientific Publishing Corp and East Meets West Productions, Corpus Christi, TX, USA. ISBN 981-238-422-7, 13 p. 2003.

Jaffe, B.E, Borrero, J.C, Prasetya, G.S, Peters, R, McAdoo, B, Gelfenbaum, G, Morton, R, Ruggiero, P, Higman, B., Dengler, L., and Hidayat, R.: Northwest Sumatra and offshore islands field survey after the December 2004 Indian Ocean Tsunami. Earthquake Spectra 22, 105-135, 2006.

Li, L. and Huang, Z.: Modeling the change of beach profile under tsunami waves: A comparison of selected sediment transport models. J. Earthq. Tsunami 7, 2013, DOI:10.1142/S1793431113500012.

Paris, R., Lavigne, F., Wasmer, P., and Sartohadi, J.: Coastal sedimentation associated with the December 26, 2004 tsunami in Lhok Nga, west Banda Aceh (Sumatra, Indonesia). Marine Geology 238(1-4), 93-106, 2007. DOI: 10.1016/j.margeo.2006.12.009.

Peters, R. and Jaffe, B.E.: Identification of tsunami deposits in the geologic record: developing criteria using recent tsunami deposits. U.S. Geological Survey Open-File Report 2010-1239, 39 p., 2010.

Szczucinski, W.: The post-depositional changes of the onshore 2004 tsunami deposits on the Andaman Sea coast of Thailand. Natural Hazards 60, 115-133, 2012. DOI 10.1007/s11069-011-9956-8.

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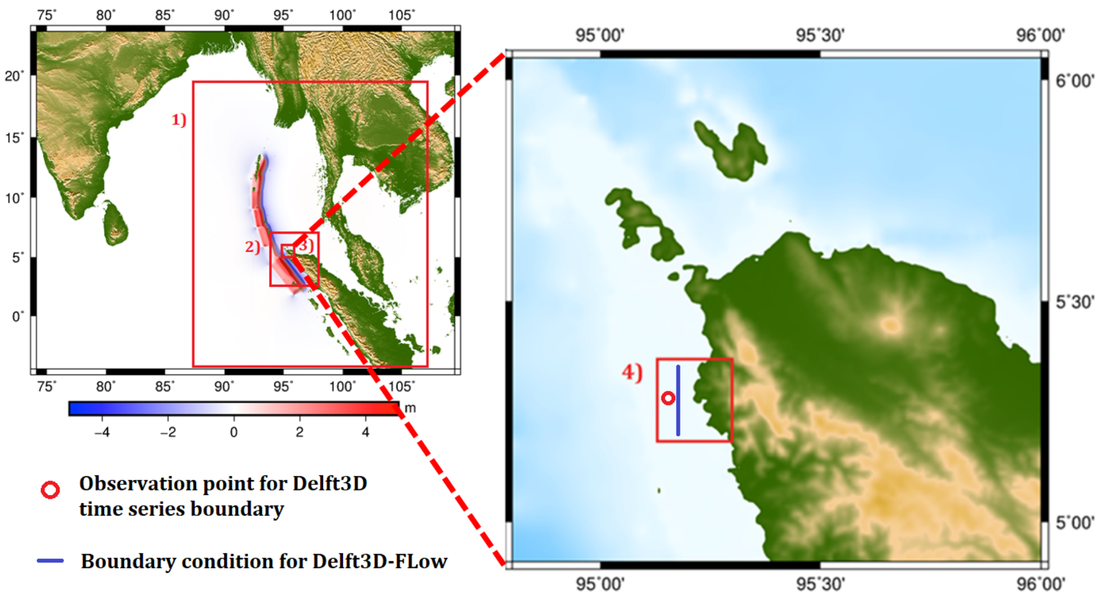

Fig. 1. Numerical Simulation Layers and Domain in COMCOT and Delft3D-FLOW (Layer 4 of COMCOT)

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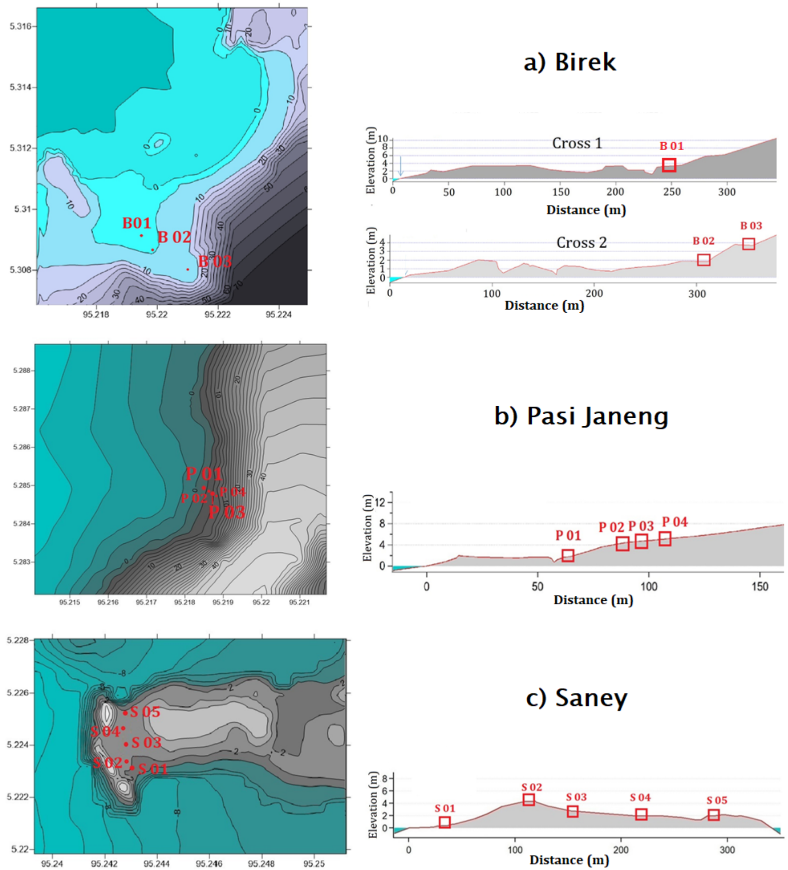

Fig. 2. Topography condition of Birek, Pasie Janeng, and Saney.

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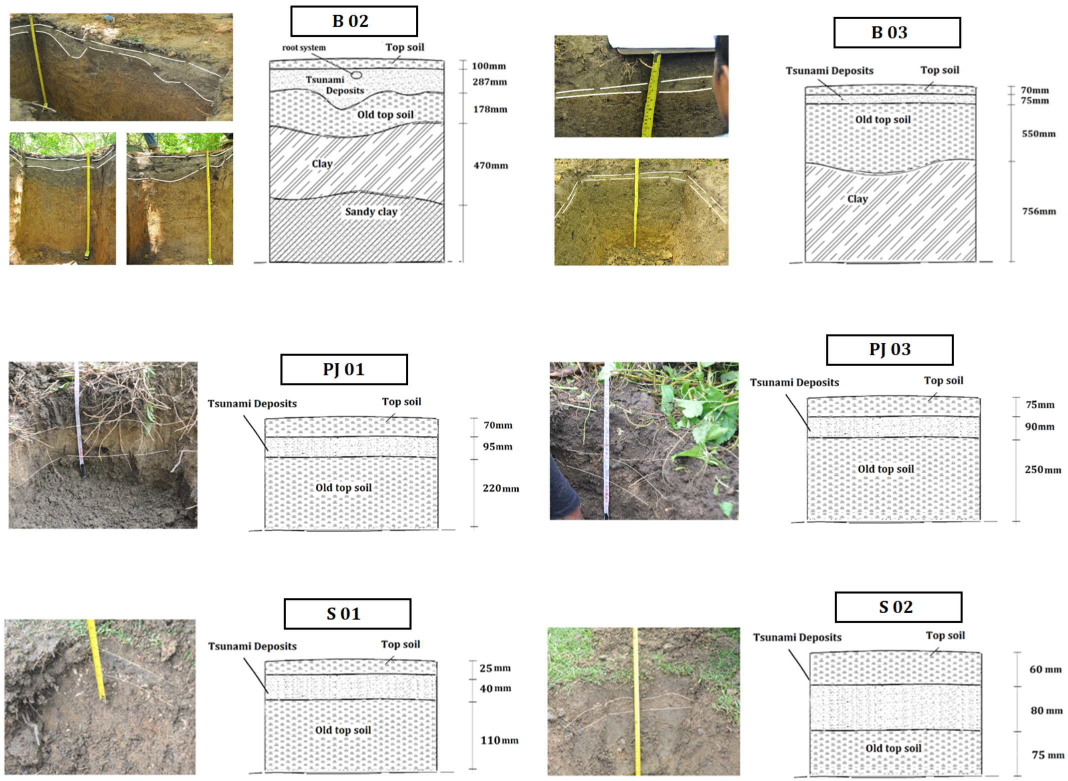

Fig. 3. Tsunami Deposit Features found at Pit Test Locations

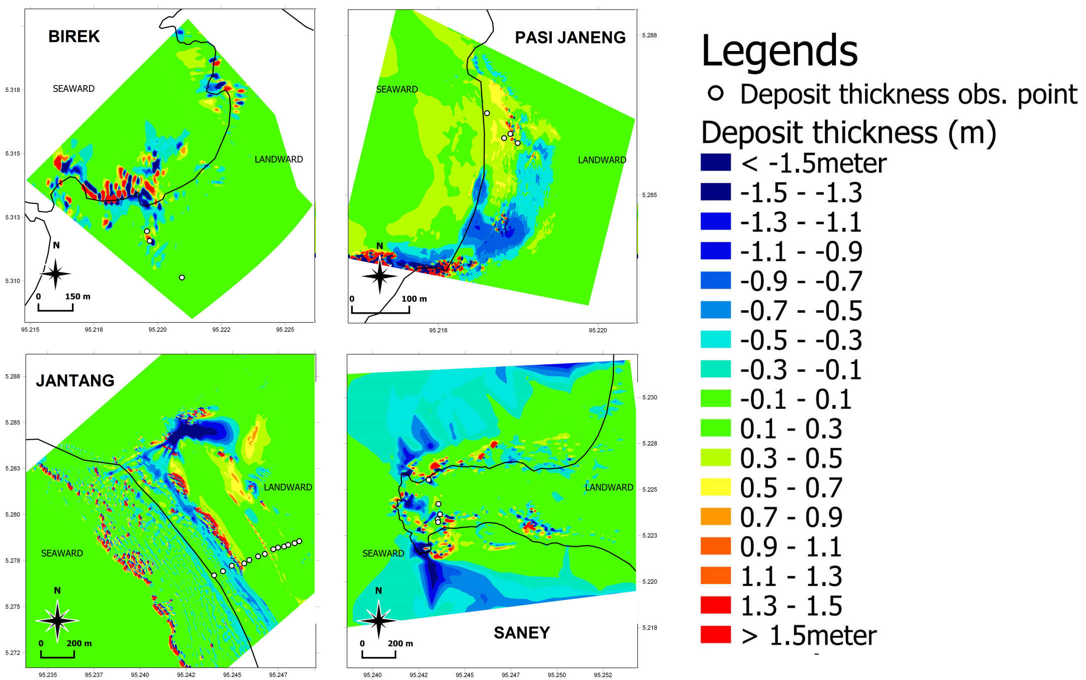

Fig. 4. Spatial Distribution of Acumulation of Sedimentation and Erosion obtained from Numerical Simulations.

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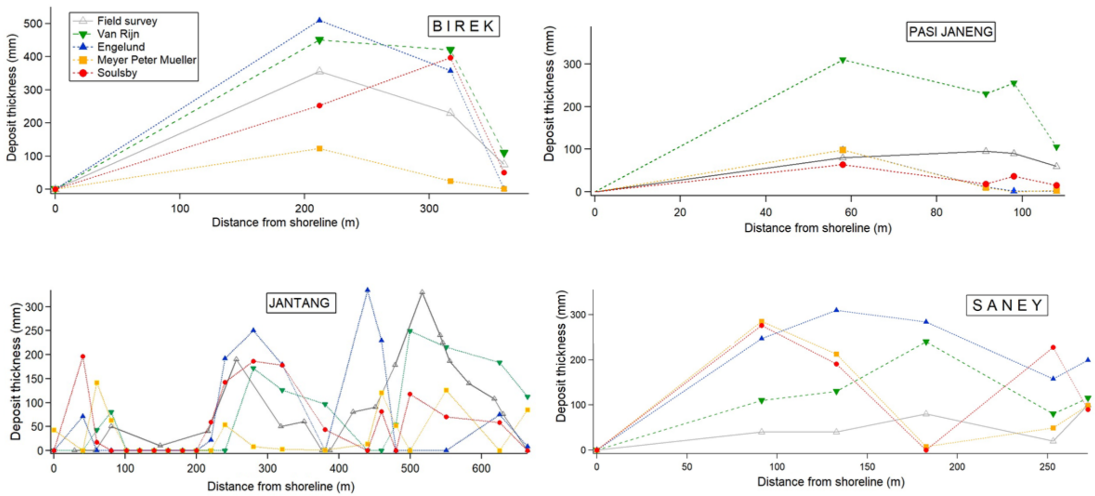

Fig. 5. Comparison of four sediment transport formulae applied in Delft3D-FLOW to Field Data

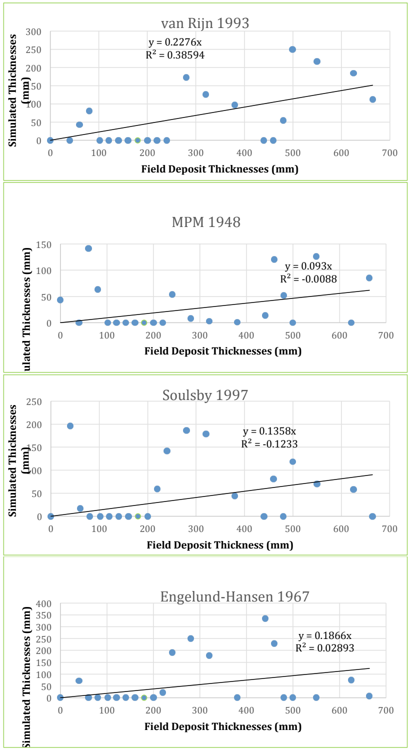

Fig. 6. Regression result of sediment transport numerical simulation and field data collected in Jantang by Jaffee et al. (2006).