Response to Comments of Three Referees on "Reciprocal Green's Functions and the Quick Forecast of Submarine Landslide Tsunami" (nhess-2019-124)

Three new figure (Fig. 5-7) and three new sections (Sec. 4.2, Sec. 4.3 and Sec. 4.4) have been added to better reply to the comments of three referees. Besides Kaohsiung (KH), another coastal city Anping (AP) on the southwest coast of Taiwan have been calculated. Accordingly, the comparison between direct simulations and the RGF approach in Fig. 2, Fig. 3 and Fig. 4(b) have been extended to both cities.

The followings are our responses to referees #1, #2, and #3. Their comments are in italics. Our responses are in roman type. The sentences and paragraphs in the manuscript which has been added or revised are marked in yellow. The details are as follows:

Referee #1 (Anita Grezio):

General Comments: The tsunamis generated by submarine slides are not as frequent as the submarine earthquakes. However, they can be locally devastating and their potential tsunamigenic impact need to be analyzed. For this reason the paper is interesting. It is well written and deserves publication with minor revisions.

Reply: The comments given by the referee are appreciated. The language problems indicated in the comments have been fixed, and the manuscript has been modified according to the referee's suggestions. Statements on the 2018 Sunda Strait tsunami have been removed. It should be noted that the Line number used in the comments of the first referee (Anita Grezio) is based on the earliest version of the manuscript and is quite different from the revised version because of the format change.

Detailed Comments:

1. *Introduction Line 43: please provide references of the "previous studies".*

Reply: because of format change according to the manuscript requirement of NHESS, "Line 43" has been changed to "Line 27," and a reference (Chen et al. 2015) has been provided.

2. *Line 50-53: please remove this sentence. The Sunda Strait 2018 tsunami was generated by a lateral collapse of the Anak Krakatau volcano and not by a submarine mass failure. It seems that the relative web site citations are not deeply documented on the subaerial characteristics of this event.*

Reply: Statements on the 2018 Sunda Strait tsunami have been removed.

3. *Line 59: at the end please use "." instead of ":".*

Reply: done (Line 37).

4. *2. Methodology Line 76: please rename the section "Research Method" as "Methodology".*

Reply: done (Line 46).

5. *Line 77: please remove the word "Mathematically" at the beginning of the sentence.*

Reply: done (Line 50).

6. *Lines 77-79: I suggest to change the text in this way: "Two equation sets will be presented: 1) the shallow water equations (SWEs) with SMF forcing, and 2) the SWEs with impulsive forcing represented by a delta function.*

Reply: done (Lines 50-51).

7. *Line 83: shallow water equations are mention but never written. For clarity, please insert the SWEs before Line 83.*

Reply: SWEs have been added in the beginning of Sec. 2 on Line 48.

8. *Line 88: please provide the reference for the COMCOT model here, not at Line 156.*

Reply: Wang and Power, 2011, has been provided (Lines 56-57).

9. *Line 101: please remove the words "The good news" and start the sentence with "This" .*

Reply: done (Line 64).

10. *Line 105: please remove the words "shallow water equations" (already written) and leave the acronym.*

Reply: done (Line 67).

11. *Line 114: please write Greek symbol delta near "(delta function)"*

Reply: done (Line 74).

12. *Line 116: please explain x_s and y_s coordinates.*

Reply: done (Line 77).

13. Line 117: Is v equal to V in Line 110?

Reply: *v* has been changed to *V* (Lines 75-76, 79).

14. Line 118: please say if g is gravity.

Reply: done (Line 49).

15. Line 121: please say what "dA" is.

Reply: *dA* has been changed to *dxdy*, as shown on Lines 79 and 81.

16. Lines 182-185: the meaning of these sentences is not clear, please explain and re-write them.

Reply: modified (Lines 123-125).

17. 3. Results Line 223: please write "Case 1 considers a fast bottom movement. The" instead of "For the first case with". In this way you schematize the list cases.

Reply: done (Line 167).

18. Line 237: for an easier reading I suggest that Figure 1c should be Figure 2; Figure 2 should be Figure 3; Figure 3a and Figure 3b should be Figure 4a and Figure 4b.

Reply: done, as shown in Figures 1-4.

19. Line 242: please write "Case 2 considers the slow sea bottom change" and remove the words "Another idealized situation with" and "is also considered in case 2".

Reply: done (Line 176).

20. Line 257: "the" instead of "this"

Reply: done (Line 187).

21. Line 268: depth was previously indicated by d and not z, please use the same notation or explain.

Reply: "depth" has been changed to "the shape of the slide," as shown on Line 192.

22. Line 283: please explain the parameters theta, g, t0,t

Reply: done (Lines 49 and 205-209).

23. Lines 289-292: the sentence is not clear, please re-write it.

Reply: modified (Lines 213-215).

24. Line 296: remove the Line, no need for a subsection on computer time comparison. May be move the Lines 297-302 in the discussion part.

Reply: computer time comparison has been moved to Sec. 4.1 (Line 223).

25. 4. Discussion and Conclusions Line 303: generally it is written "Discussion and Conclusions", please change "Conclusion and Discussions".

Reply: "Conclusion and Discussions" has been changed to "Discussions and Conclusion" according to the second referee's suggestion (Line 222). There are more than two subsections for discussion and hence "discussion" is in plural form.

26. Lines 331-333: the sentence is too long and not clear. Please modify the text.

Reply: modified (Lines 245-247).

27. Line 306: please note that after ":" the first word does not need the capital letter. Figure and Captions Not clear why the captions are written twice. Please re-organize the number of the figures as previously suggested.

Reply: done, as shown in Figures 1-4.

28. Table Lines 414-415: suggestion to re-write the caption this way: "The SMF information to the southwest of Taiwan used in the tsunami simulation of Case 3".

Reply: done, as shown in Table 1 (Line 371).

Referee #2 (Xiaoming Wang):
General comments:
The authors present a method for quick forecast of submarine landslide tsunami in coastal areas using Reciprocal Green's Function approach. The methodology is sound and the results are convincing. This study provides an alternative to commonly used pre-calculated Green's Function approach in tsunami forecast and early warning, and is valuable to the advancement of knowledge and technology required for tsunami hazard mitigation in coastal areas vulnerable to submarine landslide tsunamis. This study is of great interest to landslide tsunami hazard evaluation and hazard mitigation communities. The

topic is suitable for publication in NHESS.

However, in its current form, the manuscript does not fully meet the quality requirements for publication, largely due to its writing. I strongly recommend the authors to further polish the manuscript to improve its clarity and readability. A minor revision is recommended before it can be accepted.

Reply: The comments given by the referee are appreciated. Most language problems indicated in the comments have been fixed, but "an" SMF is used because "s" starts with a vowel. The statement on the 2018 Sunda Strait tsunami has been removed. A brief explanation has been given on Lines 142-157 in two paragraphs to explain why the dispersion effect due to short length scales of GF/RGF is neglected.

Detailed comments:

1. *Please check the consistency of the use of term tsunami throughout the manuscript. in the manuscript, sometime it is treated as countable noun, sometimes as uncountable, and some locations "tsunami" is treated as plural, e.g. at Line 41.*

   Reply: done, and the mentioned problem has been fixed (Line 41).

2. *At Line 11 in Abstract, please change "of" to "in" in the sentence of "the forcing of the continuity equation.....".*

   Reply: done (Line 11).

3. *At Lines 16-20 on page 1, I don't fully agree with the statements here. "quickly" and "satisfactory accuracy" are related to the time we would have. It will be extremely difficult to achieve satisfactory accuracy for local source tsunamis. In the first 20-30 minutes after a local earthquake, we even may not have a finite fault solution available.*

   Reply: one reference (Hsieh et al., 2014) and more explanations have been added (Lines 18-20).

4. *At Line 20 and other locations, please change "Green's function" to "Green's Fuction", change "reciprocal Green's function" to "Reciprocal Green's Function" as here is where abbreviations GF and RGF are defined.*

   Reply: done (Line 22).

5. *At Lines 25-26, add reference(s) to "previous studies" mentioned in this sentence.*

Reply: Chen et al., 2015, has been added (Line 27).

6. At Lines 31-32 on page 2, for this event, more accurately, the tsunami was caused by the flank failure of Anak Krakatau volcano.

Reply: the statement on the 2018 Sunda Strait tsunami has been removed.

7. At Line 39 on page 2, in "On the other hand, an SMF forces.....", change "an" to "a".

Reply: “an” SMF is used because “s” starts with a vowel (Line 39).

8. In multiple locations, it seems better to change ":" to ".", e.g. at Lines 46, 130, 220.

Reply: done (Lines 134 and 248). However, on Line 50 the “:” is unchanged according to the suggestion of referee #1.

9. At Line 53 on page 2, please add reference "Wang and Power 2011" here.

Reply: done. Wang and Power 2011 has been added (Line 56-57).

10. At Lines 64-70 on page 3, strictly speaking, the term "mass flux" used here refer to "volume flux" as it is missing the factor of density. Please change it accordingly.

Reply: done (Lines 67 and 69).

11. At Line 65 on page 2, for the description "....., and equals the average velocity multiplied by the undisturbed water depth d", please note that this statement may be true only when the vertical distribution of horizontal velocity is Linear or uniform.

Reply: modified. At the end the sentence, “if the vertical distribution of horizontal velocity is uniform” has been added (Line 69).

12. At Line 98 on page 5, "Wang and Liu 2006" is missing in References.

Reply: fixed (Lines 361-362).

13. In 3 Results section, "direction simulation of COMCOT" is better to be changed to "direct COMCOT simulation".

Reply: done (Line 161).

14. At Lines 148-149 on page 7, the last sentence is a bit confusing. Should it be something like "The whole rectangular area is subsiding at a velocity of -0.025 m/s for 120 seconds"?

Reply: done (Line 169).

15. At Line 154 on page 8, please change "of" to "in" in the sentence "......by the red Line of Fig. 1(c)".

Reply: done (Line 174).

16. At Line 162 on page 8, in "The record has it that when ......", a typo?, should "has it" to be "shows"?

Reply: done (Line 183).

17. At Line 200, please change "Conclusion and Discussions" to "Discussions and Conclusion".

Reply: done (Line 222).

18. At Lines 130-136 on page 7, could you please elaborate more about computational demands for pre-calculating GFs vs. pre-calculating RGFs?

Reply: the calculations of GF and RGF are exactly the same except for the initial conditions, as has been explained on Lines 140-141.

19. In computing pre-calculated GF or RGF with impulsive sources, the waves will be highly dispersive considering small spatial scales of the impulsive sources, e.g. 2 min mentioned for the 2011 Tohoku source area. It seems that SWEs are used in the calculation, however SWEs are non-dispersive. This leads to a theoretical inconsistency. Maybe I don't interpret it correctly. Could you please provide some discussions on this?

Reply: explanations have been given on Lines 142-157 in two paragraphs to explain why the dispersion effect due to short length scales of GF/RGF is neglected.

Anonymous Referee #3

It is always interesting to see papers on tsunamis generated by landslides. However, the present manuscript fails to address some important issues linked to tsunamis generated by landslides:

1. Dispersion is usually more important for tsunamis generated by landslides than for tsunamis generated by earthquakes. The authors don't discuss dispersion and use the shallow water equations, both in their own tool and in the numerical code they use to compare their results with (COMCOT). A discussion is essential.

Reply: the comments given by the referee are appreciated. A new section (section 5.2) and a new reference (Kilinc et al., 2009) have been added in the manuscript to discuss the dispersion effect of an SMF tsunami.

2. Landslides are quite complex and involve a lot of different parameters. In the present paper, simplistic models of landslides are used and I am afraid that the present tool cannot be used for tsunami forecast. The bibliography is quite restricted and doesn't cite some key review papers, such as "On the characteristics of landslide tsunamis" by Løvholt et al. https://doi.org/10.1098/rsta.2014.0376

Reply: Løvholt et al. (2015) has been cited and more explanations on SMF tsunami have been added (Lines 99, 189, 199-201).

3. It is almost meaningless to present numerical results without saying anything about the convergence of the results and about their precision.

Reply: The numerical precision is 10^{-13}(Line 224-225). Two new sections have been added. Sec. 4.3 is to discuss the convergence of the numerical simulation of SMF tsunamis. A new figure, Fig. 6, has been added to see if the simulations of two successive grid sizes are close to each other. Based on this convergence test, we choose 0.06 min. grid spacing which is much smaller than the 0.3 min.

we used previously (Lines 218-220).
For grid spacings as small as 0.06 min., the coast effect is significant after the first few waves. A new section, Sec. 4.4, is added to discuss the applicability of RGF approach and is concluded that the coast effect is due to the shallow water depth near the coastline.