Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2017-445-AC1, 2018

Natural Hazards and Earth System Sciences
Open Access
Discussions

Interactive comment on "Tsunami run-up estimation based on a hybrid numerical flume and a parameterization of real topobathymetric profiles" *by* Íñigo Aniel-Quiroga et al.

Íñigo Aniel-Quiroga et al.

anieli@unican.es

Received and published: 13 February 2018

Anonymous Referee #1 The manuscript proposes a methodology to estimate tsunami runup by mixing up a classical Tsunami code (COMCOT), for the first stages, and an averaged NavierStokes model for the runup process. In my opinion, the manuscript exhibits a well and organized work and I suggest that it should be published after minor revision regarding specific points that shold be clarified, because they affect in the understaing and make the manuscript not fully reproducible.

REPLY: We thank reviewer 1 for the thorough review of our manuscript and the positive comments regarding its organization. We have added their ideas and modifications to

Printer-friendly version

Discussion paper

the paper (green color in the attached revised version), increasing its overall significance.

Major comments:

1) Time computation is regularly mentioned, however there is no solid numbers. For example, how long it takes a regular tsunami running? How long it takes obtain the Final run-up estimation with the presented methodology?

REPLY: Thanks a lot for coming up this topic. Computational time information is basic to have a more global approach of the process of construction of the database, and to understand how it makes easier and faster the run-up calculation. On hazard assessments, in particular of large areas, the computational time become a key element on the methodology to apply. For example, in the case of a simulation of an event that travels through the ocean basin and then floods a local area, it can require several levels of nested grids to simulate the tsunami including a high resolution grid for the local area. The computational time to conduct this simulation depends on many aspects but it can take 10 to 16 hours in a common computer. In the methodology presented in this paper, the interpolation itself takes just some seconds. If a numerical simulation with SWE model is carried out to obtain the wave conditions to use them as input for the IH-TRUST, then just a single grid for the whole ocean basin is necessary, what could take around one hour, depending again on the simulation domain. Finally, the simulations that are of the database required a long time for calculation depending mainly on the size of the VOF domain. Typical times range from 2 hours to 16 hours. This data has been added to the new version of the manuscript in the conclusions section (page 41, lines 6-8)

2) It is also not mentioned, but I guess authors have assumed an instantaneous tsunami generation. This have to be very clear. In general, there is lack of details on the tsunami modeling. Domain size, computation time, CFL condition (depending on your chosen grid size), etc. You should, at least, comment some lines due to the fact

that time characteristics of the seismic source can enhance the tsunami amplification. This becomes important in huge and rare events as The 1960 Chilean Earthquake and 2004 Sumatra Earthquake, where the source time function is not well resolved (specially in the Chilean event). Besides of all the earthquake parameters, there is the slip distribution. It is demostrated that the runup can be amplified up to six times (Geist (2002), Ruiz et al. (2015)). So, the kind of seismic sources should be clearly defined.

REPLY: As the reviewer correctly addresses, the tsunami generation follows some hypothesis or simplifications. Specifically, an instantaneous generation and a regular and constant slip distribution were assumed. In this way, it is interesting to highlight, as the reviewer remarks, that when historic or past events are being simulated a proper source could be evaluated and used to determine the H and T of the tsunami wave to be used as an accurate input for the methodology. On the other hand, potential events that are part of tsunami hazard assessments commonly use idealized sources, that can be used to evaluate H and T. Anyway, the tsunamigenic sources used for elaborating the database were idealized parameterizations that were transformed into initial water surface displacement by means of Okada model. Regarding the grid size for COMCOT simulations, it was set to Δx=500m. Depending on the maximum depth of the grid the necessary time step to satisfy Courant Condition was calculated and used, based on the restriction of the model for the condition Cr=0.5: (CÂůΔt)/Δx<C_r,where c=$\sqrt{}$(gÂůh) Clarifying lines have been added to the manuscript (page 9 and page 14)

3) The approximation of the topo-bathymetryc profiles are fitted from the GEBCO data, but no resolution is mentioned. The authors fixed the profiles with four (4) segments: a constant depth (1) conected to two lines offshore (2) and another line inland (1). The first and natural question is why to set 4 segments?? Is it because the 5-space of parameters is already big enough? Another issue, is that the trench morphology is not captured, or at least, not showed in the manuscript. This is because in subduction zones, before the ocean becomes "constant", there is a huge depression, especially in The Marianas trench, where the water column is higher and faster.

REPLY: Regarding the GEBCO bathymetry, the topobathymetric profiles that were used in the elaboration of the database were obtained from GEBCO, using the resolution provided by this database, 30” (around 900 m in the Equator). Regarding the chosen geometry, we analyzed worldwide profiles trying to find a parameterization that covered two main aspects. First, and mainly, that they could represent appropriately most of the profiles and second, that the selected parameterization allowed managing the database to be created. The technique for classification (Maximum dissimilitude) and interpolation (radial basis functions) are specially designed to work on high dimensional domains (i.e. Camus et al., 2011), therefore the number of segments is not an issue. Nevertheless, a run-up calculation requires the parameterization of a profile as input, therefore that parametrization must be functional. After considering other options, like adding a new segment, we considered that our parameterization achieved this equilibrium between representability and functionality. Regarding the subduction trench, its applicability, as it can be seen in the applications cases is limited to those generation areas that are deep enough to be part of a profile included in the database. In this sense, the system works quite well if this is the case, as it was observed in the examples of Chile. However, there is a limitation, well noted by the reviewer: the profile parameterization falls out of the application range (see page 34 line 13). The result of assuming that the seabed is constant seawards the generation area gives a good approximation of the “trench problem”.

Some lines explaining these aspects have been included in the new version of the manuscript (page 7, 5, 35.) and in the conclusions section

4) Authors "cheats" the tsunami interaction of the reflected wave by assuming a constant and flat region with open boundary condition. However, would not this add some kind of artifacts to the model? Test regarding this issue should be do it.

REPLY: One of the biggest issues to perform the coupling between models was to obtain a clean input wave for forcing the VOF domain. The problem arises because the wavelength of tsunami waves is, in some cases, longer than VOF model domain. This

Printer-friendly version

Discussion paper

implies that before a tsunami wave passes completely through the boundary between models, the wavefront reaches the coast, is reflected and return to the initial boundary aliasing the wave amplitude. Several tests have been run to assure that this artifice of assuming plane beach and open boundary do not affect the numerical simulation. This artifice avoids the interaction of the tsunami wave arriving to the coast and the reflected wave, "cleaning" optimally the signal of the tsunami waves that were included in the development of the database, as explained in figure 6.

5) Authors make use of analytical solution of Synolakis (1987), however, I'm not convinced that is the good one here. There are analytical solutions in piecewise bathymetries (e.g. Kanoglu & Synolakis (1998), Fuentes et al. (2015), Riquelme et al. (2015)). Actually, in figure (13) the results do not agree with those analytical solution which state that offshore slope closest to the coast controls the runup process.

REPLY: We really appreciate this comment. We have used Synolakis as an example of comparison because although it was created for Solitary waves it has been commonly used on tsunami risk assessments, despite its application is not appropriate as highlighted by Madsen (2008). In order to improve this, we have added a new column to the comparison tables with the value of the run-up but calculated with Madsen and Shaffer (2010) for single waves, as also suggested by Reviewer 2. In addition, we have included the given references in order to have a complete view of the existing solutions, In the case of solitary waves, it was shown by Kanoglu and Synolakis(1998) that the slope closest to the coast controls the run-up. Our results show that, actually, the slope closest to the coast is very important in the final value of the tsunami run-up. However, according to our results, in the case of tsunami waves the influence of the other slopes, especially the one of the next segment seawards should not be neglected, remarking again the difference in the wavelength of solitary waves and tsunamis, what leads to a different behavior, a different time while the wave is affected by each segment of the bathymetry, affecting the reflection, shoaling etc. This aspect, also noted in Naik &Behera (2016) using numerical models, has been also added to the manuscript, in page

26 and in the discussion section.

6) It is not mentioned the criterion to trace the profiles. Perpendicular to the shore? Paralel to the wave travel?? REPLY: Orientation of profile is a key piece on the runup calculation using this method. As the database was constructed using a numerical flume in which wave direction of propagation and profile coincide, this is, of course, the best configuration to trace profiles. Nevertheless, in real scenarios is not so simple to define this direction. This aspect has been added in the new version of the manuscript (page 18)

7) The methodology is compared with numerical models and retrieves same estimations. The fact that inacessible high-resolution data can be overcame should be more highlighted. Again, I dont think Synolakis's formula is comparable here, since it uses a Solitary wave as initial condition, and there are analytical solutions that can handle with arbitrary shapes (Madsen & Schaffer,(2010) , Fuentes (2017)). REPLY: The fact that inaccessible High-Resolution data can be overcome is now highlighted appropriately (Page26) and it has been included as well in conclusions section (page 41, line 16). AS explained in the reply to the comment 5, we have included the results of the application of Madsen formula, highlighting the fact, remarked by the reviewer 1, that Synolakis formula, although widely applied, was created for Solitary waves.

Specific comments: REPLY: Thanks a lot for this specific comments. We have added all of them to the new version of the manuscript. First line of intro: Add the 2010 Chile tsunami. Page 9, 5: It seems that "H" is unnecessary here. Also, it should be clarified that period relation is valid in the linear regime. Please add geographic axis to the map plots. Page 36, 5: Authors say "the results are accurate". Please, add a percentage based on the results.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-445/nhess-2017-445-AC1-supplement.pdf

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2017-445, 2017.