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Natural Hazards and Earth System Sciences
Discussions
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Interactive comment on "Speeding up and boosting tsunami warning in Chile" *by* Mauricio Fuentes et al.

Anonymous Referee #1

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The paper presents a methodology aimed at speeding up the generation of a tsunami forecast as part of tsunami warning operations. The authors modeled tsunamis for twelve of the largest earthquakes that occurred between 1992 and 2015 applying a) their newly proposed linear method assuming an elliptical slip distribution, and b) a fully non-linear method. Comparison of the results indicates that the proposed linear method allows the generation of a much faster tsunami forecast that matches the results of the fully non-linear method with an accuracy of up to 80% but 20 times faster. These results make the paper worthy of publication and of interest to the tsunami warning and disaster management community. As written, however, the paper needs a significant amount of work before we can consider it ready for publication. The text needs major revisions to improve its overall readability and flow. Instead of providing

an exhaustive list of all the grammar and composition issues we have found, however, we have taken the liberty of editing most of the text and will attach it as suggested edits with the hope that it will help with the editing process. Please find below some additional comments and specific suggestions:

1) The title of the paper does not reflect the actual contents and results presented in the paper.

The title of the paper suggests that the research results included in it will speed up the issuance of tsunami warnings in Chile. At present, however, most tsunami warning protocols implemented in the world rely on using a quick estimate of an earthquake's magnitude as a proxy to evaluate its tsunamigenic potential. To date, within the context of tsunami warning operations, only the P-wave moment magnitude (Mwp) method implemented at the US Tsunami Warning Centers in the late nineties has significantly sped up tsunami warning in general. More recent earthquake magnitude estimations methods like W-phase, although more robust, accurate, theoretically sound, and faster than other CMT methods, lacked and still lack the speed needed to truly speed up tsunami warning in general. At the time of publication of the seminal paper on the Wphase CMT method paper in 2008, for instance, the PTWC routinely issued tsunami warnings and tsunami messages within 12 minutes of origin time. At present, the PTWC issues its tsunami message products, on average, in less than 6 minutes of origin. In contrast, it still takes between 20$\sim$25 minutes to obtain the results of a W-phase CMT inversion, and around 10$\sim$15 minutes for a regional implementation. Faster implementations turn possible only in regions with a high density of seismic stations like Chile, Japan, or the West Coast of the United States. Even for these regions the generation an issuance of a tsunami message in less than 5$\sim$6 minutes turns close to impossible relying on a W-phase solution. In other words, despite the paper's title, the proposed linear tsunami simulation methodology does not speed up the issuance of tsunami warnings in Chile. The proposed linear method seems to rather speed up considerably the generation of tsunami propagation and inundation forecasts that provide faster and more accurate estimates than those currently in operation. For this reasons, the authors should consider changing the title of the paper to something more reflective of both, the scope of the paper and its results such as: "Speeding up Tsunami Forecasting to boost Tsunami Warning in Chile", with the possible substitution of "boost" with "enhance" or "improve" instead.

b) Towards the end of the introduction the authors state that many of the current warning systems have pre-computed tsunami scenarios at their core. This turns inaccurate, as most warning systems currently operational in the world use the preliminary earthquake location and magnitude as a proxy to evaluate tsunamigenic potential and issue their warnings accordingly. Many use pre-computed tsunami scenarios to generate a tsunami forecast following that initial warning, while others use a combination of pre-computed tsunami scenarios and real time tsunami simulations based on the linear shallow water equations. Generation of this last type of forecast currently takes between 3 to 7 seconds for an area covering 1000 to 1500 square kilometers around the earthquake's epicenter, and 10 minutes or less for the whole Pacific basin depending on magnitude and resolution settings.See the reviewed text in the pdf file for suggested edits.

b) All twelve historical earthquakes used in the study generated tsunamis recorded by sea-level instruments, either by tide gauges located along the coast or by DART buoys located in deep water. The paper would benefit by the inclusion of a table listing the tsunami waves heights recorded at these point locations together with the corresponding wave heights predicted by both the linear, and non-linear modeling approaches. Doing so would validate not only a model against another considered theoretically superior but also against the actual field measurements of the phenomenon under study. This turns into the ultimate validation of the accuracy and usefulness of both tsunami modeling, and any forecast based on it.

c) The authors should consider renaming some of the sections as suggested in the attached pdf file. In addition, the conclusions should list the most relevant results of the

study after a brief summary of the work done in the paper. We attempted to summarize the results in the attached pdf file containing a reviewed version of the text, but the authors should consider adding or modifying whatever they consider relevant.

d) The labels of figures and tables should describe their contents to make them self-contained. When referencing the figures inside the text we suggest applying the same format to all instances, as for instance "Fig. 1", or "Figs. 2 and 3" instead of using "Figure 1". Please find below a list of suggested edits to the current labels of Figures and Tables in the main text. Consider applying similar edits to the labels included in the supplement:

Figure 1. Schematic showing the discretization of the calculation domain for parallel computation.

Figure 2. Near field simulation of the 2015 Illapel earthquake with an elliptical source (left), and a finite fault model (right). The colors assigned to different areas indicate the expected run-ups in meters: a) red for run-ups larger than 3 m, b) orange for run-ups between 1 and 3 m, c) yellow for run-ups between 0.3 and 1 m, and d) green for run-ups smaller than 0.3 m.

Figure 3. Regional field simulation of the 2015 Illapel earthquake for an elliptical source (left), and a finite fault model (right). The colors assigned to different areas indicate the expected run-ups in meters: a) red for run-ups larger than 3 m, b) orange for run-ups between 1 and 3 m, c) yellow for run-ups between 0.3 and 1 m, and d) green for run-ups smaller than 0.3 m.

Figure 4. Normalized run-up energy rate during the first two hours of tsunami simulation. The upper left panel shows the run-up rate along latitude and time, the upper right panel the final maximum run-up, and the bottom left panel the normalized energy rate for the whole process as a time series.

Figure 5. Tsunami travel times across the Pacific basin for the 2015 Illapel earthquake.

The left panel shows the travel times after the shallow water equations, while the travel times in the right panel include the effects of dispersion and the earth elasticity for a wave frequency of 2 mHz.

Figure 6. Flow chart of the methodology proposed in this study.

Table 1. Correlation of the run-up distribution obtained from our linear model solution and the JAGURS code.

Table 2. Summary of the CPU time in seconds for the twelve events. tIC indicates the time needed to compute the initial conditions, tPr the processing time, tTP the time to compute the tsunami propagation, and tT the total time.

Please also note the supplement to this comment:
https://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2019-9/nhess-2019-9-RC1-supplement.pdf

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