Response to RC1

7th January 2022

Dear Dr. Rabinovich,

We sincerely thank you for the constructive comments that greatly helped us to improve the manuscript. Here we present our point-by-point responses and revision to the comments.

Sincerely,

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General Review Comments

This is an interesting and, in general, is well written paper. However, I believe that some of the results can be and should be presented in a more informative and spectacular way and the entire text and figures should be polished! Therefore, my recommendation "Acceptable after revision".

Comment 1

My main suggestion is related to Figure 4 and the respective text. The most noteworthy point of this event and the corresponding study is that there were TWO earthquakes with an interval less than 2 hours between them. The authors declare that the tsunami waves associated with both events are clearly seen in Figure 4. But for readers (in contrast to the authors) this is not obvious! What the authors should do is to construct the theoretical dispersion curves for both events (following papers of González and Kulikov, 1993 and Kulikov, 2006) and demonstrate that the observed f-t extrema are in good agreement with the theory. BTW, the source regions of these two events are relatively small; therefore, the dispersive effects for propagating waves should be clearly seen in the wavelet plots. All details and necessary equations can be found in Fine et al. (2019).

The dispersion curves and corresponding f-t diagrams are constructed as functions of frequency (not of period!) (e.g. Thomson and Emery, 2014); now all plots in Figure 4 are upside down and wave dispersion is difficult to identify. (Actually, the authors themselves call these plots "frequency-time analyses", not "period-time"). So the figures should be presented in the standard way.

I believe that if the authors prepare everything in the best way, the corresponding figure will become striking and highly quoted! The authors of the listed papers used the f-t diagrams to identify a specific event and to examine the dispersive properties of tsunami waves. However, I do not know any study where this approach has been used to identify and separate two events following each other!

Response and Revision

Thank you. This is very helpful. In response to this comment, we revised Figure 4.

(1) We plotted the dispersion curves at those tide gauges whose dispersive effects are clear. In Line 172 (Please note that the number of line refers to the revised file with track changes), we added:

'We note that the dispersive effects of tsunamis from the second event are evident on the wavelet plots as tsunami dominant period for the few initial waves is around ~20 min, whereas it linearly shifts towards ~10 min for the later waves, giving us the opportunity to plot the inverse dispersion lines (black dashed lines in Figure 4).'

In the caption of Figure 4, we added:

'The dispersion curves are plotted by black dashed lines.'

(2) We used f-t diagrams for Figure 4 rather than period-time diagrams. In Line 153, we changed:

'Wavelet analyses reveal the variations of dominant tsunami ~~peak periods~~ frequency over time (Figure 4).'

Comment 2

Spectral analysis, Figure 3. This figure is prepared in a very "unfriendly manner"! I know that the second author loves to combine a numerous number of plots in one figure. However, in that case the value of each plot tends to zero. What are the specific spectral features that the authors would like to demonstrate? Spectral peaks? The differences of the tsunami spectra from the background spectra? The differences between two tsunamis? Any of these features are unclear in this figure.

The spectra are strongly vertically compressed; the scale of the Y-axis looks strange: 10-5 , then 100 and nothing between! As a result, all spectra look flat. BTW, I believe that the dimension of the Y-axis is cm2 /Hz, not cm/Hz.

An additional question is units. Typical periods of seismic waves are second; therefore, it is natural use Hz for their frequencies. However, typical periods of tsunami waves are minutes and fractures of an hour. Besides, the sampling interval of the data is 1 min. Thus, it would be natural for tsunami spectra to use cycles per minute (cpm) or cycles per hour (cph). This will be helpful for readers, and they will not need to use a calculator to estimate the period of a specific spectral peak. (The same comment is just for Figures 5c and 5d).

Also, what is the meaning of the magic numbers for periods: 1,7, 16.7 and 166.7 min in the scale of periods?! The Nyquist period for these spectra is 2 min, the fundamental period is 120 min (2 hours). The meaning of the shown magic periods remains totally unclear and does not help a reader to detect the periods of spectral maxima.

The last but not least comment to these spectra: the confidence levels are not shown and without confidence levels all results of spectral analysis are senseless (e.g. Thomson and Emery, 2014).

Response and Revision

Acknowledged. We made several changes to address this comment.
(1) We plotted these spectra to show the main energy distribution of two tsunamis at each tide gauge. The gap between the tsunami and background spectra is attributed to the tsunami energy. In response to this comment, we added notations of main spectral peaks of two tsunamis to Figure 3 and listed these values in Table 1.
(2) We changed the unit of y-axis from to cm/Hz to cm^2/Hz. In addition, we also made the y-axis less compressed to show the vertical contents clearly.
(3) We changed the unit of x-axis from Hz to cycles per minute (cpm). We also made such changes to Figures 5c and 5d.
(4) We changed the annotation of periods to 100, 10, and 1 min.
(5) We added the 95% confidence bounds to these spectra. In the caption of Figure 3, we added:

‘The 95% confidence bounds of two tsunami spectra are indicated by dashed curves.’

Comment 3

Figure 5c. The idea to estimate “relative spectra of tsunamis” as the ratio of various tsunami events was first proposed by Miller (1972). The authors mention this study (Line 44), but it is absent in the List of references. Also, they do not mention this paper when they discuss their Figure 5c.

It should be emphasized that this approach (the authors call it “empirical Green’s function”, EGF) does not allow to reconstruct the tsunami source spectrum because it shows not the properties of the second source themselves, but the differences of the second source from the first one. As was indicated by the authors (e.g. Lines 168-169), the seismic mechanisms of the two events are very similar. Therefore, the mutual part of the two sources (in particular, mutual spectral peaks) is not seen in Figure 5c. From this point of view, it would be interesting to see the tsunami/background ratio for the first event (i.e. a figure similar to Figure 5d, but for the first tsunami).

Response and Revision

In response to this comment, we added Miller (1972) to the Reference. We also plotted the tsunami/background ratio for the first event in Figure 5e.

(1) In Line 194, we added:

'…assumes that the smaller event acts as the EGF for the larger event (Miller, 1972; Heidarzadeh et al., 2016)'.

(2) In Line 203, we added:

'In addition, we also computed the spectral ratio of the first tsunami to the background signals at those tide gauges with evident records and calculated their normalized average (Figure 5e). This plot yields only the dominant periods of the first tsunami (generated by Mw 7.4 earthquake) showing that the energy is mainly distributed in the period range of 5–17 min, indicating that the size of the tsunami source of the first event is smaller than that of the second event.'

(3) In the caption of Figure 5, we added:

'(e) Spectral ratio of the first tsunami spectrum to the background signal spectrum. Green curve is the normalized average of different tide gauges.'

Comment 4

Equation (1) (Line 183) is the exact solution for periods of standing (eigen) modes in a closed rectangular basin of uniform depth h = const. This equation for n = 1 allows to estimate very roughly the order of periods of generated tsunami waves. However, a real tsunami source is far away from being uniform and rectangular; thus, even for the first mode, this estimate is a very approximate. So, this estimate is rather qualitative than quantitative. From this point of view, it is strange to see that the authors use this equation for PRECISE estimation (with fractures of minutes!) the "source periods", and even not only for the first but also for the secondary modes.

Response and Revision

We agree. We referred to Rabinovich (2010) for Equation (1). We acknowledge that this equation is a rough estimation of the period. In this paper, though we calculated the source periods with a fraction of minutes, we still regarded it as an approximation. A discrepancy of up to 20% was allowed when we make the comparison. In response to this comment, we added more explanations.

(1) In Line 214, we added:

"We acknowledge that Equation (1) is a rough approximation of dominant tsunami source periods, and therefore we allowed a discrepancy of up to 20% while making the comparison."

Comment 5

The authors use a high-pass filter to remove tides from the original records; this is definitely not the best way to suppress tides! Any unnoticed spike, shift or gap (small *in comparison with tides) will strongly distort the tsunami signal (and even create some "artificial tsunamis"; the corresponding examples are well known!). It is much better to subtract predicted or calculated tides (as was done by the authors in some other their papers. BTW, the authors write: "…we applied a second-order high-pass filter with the corner frequency of 0.00014 Hz (7,200 s) to remove the tidal components". Why "Hz", why "seconds"?! The sampling interval of the data is not seconds, but 1 min; it would be much easier for readers if the authors write: "We applied a 2-hour (or 120-min) high-pass window"!*

Response and Revision

We agree. We acknowledge that subtracting tides from the original records is a good way to suppress tides. Here we refer to Heidarzadeh et al. (2015 *PAAG*), which showed that the high-pass filtering yields similar results as subtracting tides, because tsunami is a very long wave. In our study, we conducted quality control to ensure that there were no spike, shift, or gap in the time series that we analyzed. In response to this comment, we explained our method and changed the expression.

(1) In Line 68, we changed:

"Then, we applied a ~~second-order high-pass filter with the corner frequency of 0.00014 Hz (7,200 s)~~ 2-hour (120-min) high-pass filter to remove the tidal components (Figure 2) (Heidarzadeh and Satake, 2013)."

(2) In Line 70, we added:

"Heidarzadeh et al. (2015) showed that the high-pass filtering yields similar results as subtracting calculated tides from the original records."