Coupled simulation of landslide, tsunami, and ground deformation for the 2017 Nuugaatsiaq event in Greenland

by Aochi et al.

This study considers the complete chain of events resulting from the rockslide in Karrat Fjord, Greenland. A number of substantial improvements have been made to the original landscape but there are still a number of clarifications that I think are needed before it can be considered for publication. My greatest worries regard the correct interpretation of the seismic data and I think a lot more clarity about how the raw waveforms are processed to arrive at the conclusions reached. I have been unable to match the waveforms displayed in Figure 6. I may have made errors in processing the data but this is all the more reason to show explicitly what has been done, for the sake of reproducibility.

(All line numbers relate to the document with track-changes "egusphere-2025-3803-ATC1.pdf")

Abstract:

The new sentence “The volume was estimated ...”. I feel this sentence loses a bit of meaning without saying what the estimate and uncertainty are. These numbers are more important than the number of seismic stations involved. Later in the abstract we read about “uncertainties in the landslide volume”- maybe it is easier just to remove the new sentence and be more precise about the measurement and the uncertainties later?

I see later (e.g. line 193-194) the value 44 * 10^6 m^3 which is qualitatively in-line with other estimates (lines 207-209). What are the error bounds associated with the 44 from this calculation?

Can we adjust the terms “sea level change” and “ground deformation”?

“sea-level-change” almost always refers to a slow change in the long-term baseline level, not a wave-associated change in water height. I suggest “A 1m water surface elevation ...” – it is semantics but it creates a completely different impression.

Similarly, ground deformation tends to imply a permanent remoulding of the rock which is also not the case here – this is also an elastic response to the forcing. Can we use “ground displacement”? The seismograms eventually return to their normal displacement as a result of the water wave.

(It says still in lines 170-171 “The seismic waves usually propagate at a speed of a few kilometres per second, and the static displacement remains after the passage of the seismic waves” – I really cannot reproduce this! I have read in a very long segment of data from station DK.NUUG and converted to displacement and I do not see any permanent deformation. Can you please demonstrate – e.g. in the supplement - the code you use to demonstrate a permanent deformation. I may have made a mistake or an assumption here, e.g. in the way I have removed the instrument response, but I cannot find an offset in the data.)

In the start of the introduction we say “have been melting at unprecedented rates for 4 millennia” – do you mean “melting now at rates that are unprecedented given the estimated melting rates over the last 4 millennia”? As the sentence stands now it sounds that the melt has been going on at this rate for thousands of years ...

Line 66-69: Are we talking about the Greenland seismic network here? Is it actively being used for early warning purposes? If so I think this needs a reference. The use of seismic data for early warning has very special usage in seismological literature and I am not aware of the Greenland network being specially applied for early warning. It is true that the seismic waves travel faster than the tsunami waves but this is of little consequence if there are not systems in place to monitor this in near-real-time.

In the caption to Figure 1, panel b) says > 0.001 Hz but in the caption, it says highpass filtered at 0.0005 Hz. Why is the seismic coda in panel (c) labelled “Initial tsunami”? On what basis are these waves identified as coming from the tsunami rather than seismic coda waves? (I am not saying that it is not the tsunami, and it may be contributing, but to me this looks completely normal for coda from a non-tsunamigenic source. In lines 104-105, it too mentions “smaller amplitude waves related to the beginning of the tsunami” – what is it that makes it clear that this is the source?

I had a feeling that the numerical resolution of the slide would be about ~10 pixels and this is confirmed here. Is this enough? In line 149-150, it states that the finer resolution would likely not have a great impact on the tsunami simulations – this is correct – a simple “box” shaped source is often used for modelling a landslide’s tsunamigenesis. However, is the ~10 pixels enough to model the dynamics of the slide itself? It may be fine, but a word that gives confidence that a model with ~20 pixels or ~200 pixels would give a qualitatively similar result would be appreciated. (This may be completely normal for VolcFlow simulations and it may be well documented that this is sufficient, but it would be nice to say so here for us that are not familiar with VolcFlow.)

In lines 151-155, I understand that at 120 seconds, one model takes over from another. What does the FUNWAVE-TVD code need to initiate the simulation? Is an initial condition that is a direct output from VolcFlow enough?

I am happy to see the improvement to Figure 3 resulting from the rotation of the horizontal components of DK.NUUG. Please mention this in the caption (as Paris et al. do) – it helps the literature to serve as a guide to future study.

My question about the filtration of the observed data in Figure 6 I think has been misunderstood. Panel (c) says (Obs > 0.001 Hz) which means highpass filter. But it says in the caption lowpass filter. If it is highpass, then please correct the lowpass to highpass. If it is indeed lowpass, then please write (Obs < 0.001 Hz) in the figure. I have tried to reproduce these figures of the observed seismograms and I cannot which is why I would really appreciate the filtering parameters and the exact starting times of the segments shown. (You have the sign the right way around for highpass in Figure 2!)

I think it would be better to show an extended segment of the filtered seismograms with a “zoom-in window” to the segment shown. In the reply to the reviewers’ comments it says “There is an early seismic arrival … which is why the waveform doesn’t start at zero.” – can you add this to the caption too?

It says in line 233-234 that the observed seismic displacement is much larger: it is over 20 times larger! This is why I am worried that we are looking at something completely unrelated here.

Figure 7 is a great improvement! The new colour scale improves our understanding greatly.

I do not understand the time-scale in Figure 8. The label on the x-axis is “Origin Time” – origin time is just a single point, so I presume this should read “Time after Origin Time”. I am trying to see the connection between Figure 8 and the numbers in Table 1. The time given in Table 1: “First wave Time” – this is at the source right, not at Nuugaatsiaq (at which place the wave arrives after several hundred seconds. But how is the water reached after ~15 seconds and the wave not generated until ~30 seconds? This is the time of the first negative wave amplitude, meaning the first local minimum. OK, I think I understand – but it says “in the sea area” – so this is not necessarily the same location?

The numbers in the final two columns of Table 1 are given to cm-precision which is a level of accuracy not warranted by the model. (It was the fact that the number of significant figures given in the second-to-last column are not consistent that drew my attention to the matter!) To me, Table 1 tells us that all the models produce qualitatively similar waves.

In line 289 of the Table 1 caption we read “brief estimation” (brief = approximate?)

The phrasing of 350-351 is a bit strange. (“playing a crucial role in introducing artificial phases”). I think I know what you are saying but …

Finally, regarding the motivation of the study, there is much mention of early warning. However, it is not clear how and to what degree this would be implemented in an Urgent Computing mode. Is the entire workflow envisaged in a rapid reaction response? I see that this would be challenging. Or is it just the interpretation of seismic data that would be incorporated into an emergency workflow? How would you distinguish between a tsunamigenic event and a non-tsunamigenic event. It was only the very long period and large amplitude waves at DK.NUUG that alerted the seismological community to the tsunami aspect of this event. But once these are observed and identified, presumably it is too late to use this seismic data for warning purposes – the wave has already washed ashore. I think an Early Warning application is a great goal and a great application, but I do not think it is clearly outlined here how this would work in practice.

This is the code I use for converting the seismic data to displacement and then performing a bandpass filtration.

```
from obspy.clients.fdsn import RoutingClient
from obspy import UTCDateTime
from obspy.signal.invsim import cosine_taper

# Initialize client and time
client = RoutingClient("eida-routing")
t = UTCDateTime('2017-06-17 23:39:17')

# Download waveform and metadata
start = t -  6000
end   = t + 18000
st = client.get_waveforms(channel="HHZ", station="NUUG", network="DK", location="*", starttime= start, endtime=end)
inv = client.get_stations(network="DK", station="NUUG", location="*", channel="HHZ", starttime= start, endtime=end, leve
l="response")

# Remove instrument response to get displacement
st.remove_response(inventory=inv, output="DISP", pre_filt=(0.001, 0.005, 45, 50), zero_mean=True, taper=True)

# Plot the displacement
st.plot(method="full")
freq1 = 0.005
freq2 = 0.010

st_bp_filtered = st.copy()        # keep original untouched
st_bp_filtered.filter("bandpass", freqmin=freq1, freqmax=freq2, corners=4, zerophase=True)

st_bp_filtered.plot(method="full")
```