Dear Editor,

We have revised our paper “Coupled simulation of landslide, tsunami, and ground deformation for the 2017 Nuugaatsiaq event in Greenland “ according to the comments by two reviewers. As we had replied interactively on-line, we brought main revision in the following points.

- [novelty] We clarify our novelty in abstract. **“The detailed seismic signals captured both near and far from the epicentre shed light on the multi-stage dynamics of such cascading phenomena. To monitor landslide occurrence and estimate potential tsunamis early, such analyses should be systematically conducted in real time and could be utilized in early warning systems. “** In Introduction, **“The whole forward modelling process from landslide, tsunami to ground deformation will clarify the probable and detectable ground deformation level near the coastline according to the ongoing tsunami propagation.”**
- [Chapter structure for Methods and Results] We separated the method part from the results. The methods part consists of seismological inversion process, landslide-tsunami generation and propagation, and ground deformation. More explanations and more references are added.
- [Figures] We changed Figures 1, 2, 3, 4 and 7.

The following is our reply to each comment. (The reviewer’s comment is in italic.)

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*Reviewer 1:*

*Line 17: I'm not sure what you mean by 'understand the causality of this cascade mechanism', because it seems pretty clear what happened.*

We change to “clarified the sequential processes of this cascading phenomenon. “

*Line 38: close parenthesis*

We corrected.

*Line 43: 'melting' -> thawing?*

We corrected.

*Line 44: 'huge' is not very scientific, huge compared to what?*

The ambiguous word is removed.

*Line 45: what is your definition of megatsunami? does it really apply here? / Svennevig et al. are not the first to report this event, but I guess you put this reference because they summarized the previous ones?*

It was too much exaggerated. We remove the word of “mega”. Svennevig et al (2020) is not the first one, but a synthetic paper on this event. Other references are added.

*Line 55: tsunamigenic*

We corrected.

*Line 61: do you mean in fjords in general?*

We mean general coastal region, including fjords. We change the expression to “along coastal area including fjords".

*Line 65: remove the –*

Removed.

*Line 68: you also modelled the landslide. More details about VolcFlow would be welcome. / modelling or modeling, the classic en-US/en-GB, be consistent in the whole paper*

We added more detail for VolcFlow. We write uniformly in British English.

*Lines 75-76: you already said that in the introduction. I would remove this and add the references to Svennevig in the intro.*

We corrected.

*Line 84: Karrat*

We corrected.

*Lines 99-100: 'This is the main response of tsunamis', do you mean in general? Or this one specifically ?*

It is specifically on this waveform. We changed the expression to ", which is the main response of this tsunami".

*Lines 98-101: instead of 'top', 'second' and 'bottom' panel, I would use the letters that you have on the figure.*

We changed to (b), (c) and (d).

*Figure 1: maybe put the star in colour ? it's not easy to see in black like this*

We changed the colour.

*Lines 131-142: I have to admit I'm not qualified to review this paragraph. Just put a point at this end on line 142.*

We added a period (.) at the end of the paragraph.

*Lines 170-172: could you add some examples of tsunami studies using FUNWAVE? I have Abadie et al. (2020) on La Palma in mind for example*

The description of FUNWAVE is modified with some more references.

*Lines 176-177: I would specify that you are using the Boussinesq model for the dispersion / Why start at 120 seconds? The landslide is faster than that, so the wave is already formed, what motivated the choice of this value?*

The simulation of VolcFlow results indicate that the avalanche ceased at about 120 s. To ensure the landslide-generated waves were fully developed, we extended the simulation to 120 s. Nearshore landslide tsunamis have wavelengths not much larger than the water depth (e.g., about ten times), so frequency dispersion and nonhydrostatic effects can be important. Boussinesq models provide more accurate wave speeds, evolution, run-up, and arrival times than the shallow water equations.

*Line 182: where did you find the value of 49.7 Mm3?*

We precise that we re-estimated the volume of 49.7 Mm3 directly based on the bathymetry data used in Paris et al. (2020).

*Lines 184-185: what do you mean by 'our estimation varied by a factor of 2'?*

It is ambiguous expression. We removed it. Later, we carry out the parameter study on the landslide volume.

*Lines 131-137, 162-185 and 204-216: we are in a results section but for me, these lines describe the methods, not results, so they should be part of a methods section*

We reconstructed the sections separating Method and Results.

*Line 187: please explain what you mean by 'coherent tsunami wavefront'*

We changed the sentences to "We observe that the first tsunami wave front arrives in front of NUUG station at about 500 seconds, and the long-period harmonic wave oscillates until 1000 seconds. "

*Line 189: like you said in the conclusion, this is due to the reflections in the fjord.*

We specified "due to the multiple reflections".

*Figure 4: please add axis units. Legend: kilometres is en-GB*

We changed to "kilometres".

*Line 209: close the parenthesis*

We corrected.

*Line 213: 'typical value for crustal bedrock', give examples/references*

We added the reference of the standard crust model CRUST1, accessible from https://igppweb.ucsd.edu/~gabi/crust1.html.

Laske, G., Masters., G., Ma, Z. and Pasyanos, M., Update on CRUST1.0 - A 1-degree Global Model of Earth's Crust, Geophys. Res. Abstracts, 15, Abstract EGU2013-2658, 2013.

*Line 222: 'These effects… are consistent with the observation', I'm not sure to understand, what is consistent, the shape of the signal? the small amplitude (even with a factor 10)?*

We clarified the expression.

"The first movement appears about 30 seconds after the landslide enters the sea. The body waves travel a distance of 30 km between the landslide site and NUUG station in about 5-10 seconds, so that the impact of this landslide process on the ground motions fades quickly within a minute, which is recognized in the observation (Fig. 6b). "

*Lines 231-232: it does not seem like a new learning, we used this in Paris et al. (2019) based on the work of Okal, EA (2007). If I missed something, please explain it to me*

We “demonstrate” instead of “learn”.

*Line 233: seawater*

We corrected.

*Figure 7: too many pixels on this figure. Legend: remove respectively and use ‘left panel’ and ‘right panel’*

The computation was done on a grid of each 5 km, i.e. at the pixel centre. In order to show correctly the spatial variation, we plot directly the value with big pixel, instead of smoothing it.

*Table 1: a small detail, here you write A.P. and in the text AP; did I miss the explanation for ‘smooth3’ and ‘smooth5’? / ‘It is worth noting… landslide volume’: I would remove this sentence from the legend and put it somewhere in the text*

Smooth3 and smooth5 are the averaged models over 3x3 and 5x5 grids, respectively. We clarified this in Table 1 caption.

*Section 4.2: I don’t know what to think about this paragraph. It looks more like a review than a comparison with what you did. Either include more comparison with your work, or maybe move this paragraph in a restructured introduction*

We summarized the available observations in Table 2 to compare. We keep this in Discussion.

*Lines 299-300: I’m not a seismologist so my question is, how do you know that the signal is a landslide that collapsed? The signal of the 2017 event was first treated as a M4.2 earthquake, so no tsunami alert would be triggered for this magnitude. Would you identify areas of risks and lower the magnitude of alert in these areas? I’m curious about your thoughts on that.*

Thank you for this question. We added “Analysing source mechanism of seismic wave radiation allowsi to identify landslides and earthquakes.” This is technically feasible , but not implemented systematically on any system nowadays.

*Line 311: with the sentence construction we can think the ground deformation affected the village*

We corrected. We do not need to cite here the village of Nuugaatsiaq.

*Line 362: Madariaga*

We correct.

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Reviewer 2

*Figure 1: I would appreciate the starting time of the traces displayed ( 2025-06-17Z23:39? ) and the channel displayed. (I am assuming that this is a vertical component seismograph – is it BHZ, HHZ?). I think this is quite important for reproducibility. (The common convention for channel labelling is network.station.location.channel, e.g. DK.NUUG.--.HHZ )*

We specified the component (HHZ) and time zero et to the origin time (23:39:12) in the figure caption.

*Figure 2: There are two references contained in this Figure that do not appear in the reference list. (Yamada et al., 2013; Shi et al., 2012). There is no reference for the final box, «Boussinesq solution"). Boussinesq solution here refers to Ground Motion and not tsunami propagation?*

These are added in the reference. "Boussinesq solution" means the analytical solution of the elastic deformation (Boussinesq 1885) here, and we change the expression to avoid the confusion from the Boussinesq problem in tsunami propagation.

*[Section 3: In the inversion from the seismic data, have you accounted for the azimuthal orientation of the horizontal components? ….. ]*
We really thank you for this remark. We have checked all the stations. We confirm that the other stations have been correctly used during the inversion (Figure S1). We correct Figure 3 (NUUG), which is not used in the inversion, and we find that the synthetics fits better the horizontal components, and we also correct the corresponding text. Further discussion is unchanged.

*Section 3.2: Line 162. I note a lateral resolution of 100 meters for both landslide and tsunami. What is the lateral scale of the landslide? (i.e. how many pixels are resolving this sliding volume?) Have convergence checks been made in the landslide simulation? (i.e. if you double your resolution, is your solution essentially unchanged?) What is the spatial resolution of the GEBCO topobathymetry? I think it is coarser than 100m (?) – so I am assuming that a remeshing/interpolation has been done. This should be explicitly stated together with the method or software used.*

*(1) The lateral scale of the landslide*

The landslide source is partially covered by an area of 10 × 9 pixels on the 100 m grid, corresponding to a net surface of approximately 1,200 m × 580 m along the major and minor axes. There are horizontally 54 grid cells assigned to the landslide. This is specified.

*(2) Convergence check*

A formal convergence study for the landslide simulation was not performed. In the present study, numerical convergence is influenced not only by the model and grid spacing but also by the landslide source representation and local bathymetry (see below comment). The topography is already smoothly resampled and further detail will not affect the long-period wave of tsunami. We added the precision.

*(3) The spatial resolution of the GEBCO*

The original data resolution is 200 × 200 m from IBCAO v4.0. We resampled it to 100 × 100 m. More detail is added to the revised manuscript.

*In line 177, why and how is the FUNWAVE simulation only started at 120 seconds? Why not at zero seconds, or at least from the moment that the landslide touches the water? I sort of see in lines 185-186 that one tsunami model is switched to another at this time – but how? How is the matching performed? Is there some kind of discontinuity? I am assuming that this is difficult to implement (I wouldn't know how to do this and I think it would be helpful to the readership to have this spelled out.) In a perfect world, scripts and input files and notes for the simulations themselves would be put on a repo.*

Please also see the comment to Reviewer 1. "To incorporate frequency dispersion effects during tsunami propagation, FUNWAVE-TVD is employed to model wave dynamics starting from 120 seconds onward. This transition time is selected to ensure the landslide-generated waves are fully developed, as VolcFlow results indicate the avalanche ceased at about 120 s."

We also have performed a temporal-overlap check and verified the convergence of the solutions that the simulated time series are continuous. More technical detail of VolcFlow and FUNWAVE-TVD are added in the text.

*Line 211: What does "The seismic waves usually propagate with a speed of a few kilometers per second, followed by static deformation." mean? There is no permanent deformation to the best of my knowledge outside of the immediate source region. Or is there?*

The static permanent deformation remains after the passage of the seismic waves. Thus, there is no deformation before the onset of the seismic waves. We changed the expression.

*Figure 6: (lowpass filter for 0.001 Hz) means frequencies below 0.001 Hz – not above as indicated in the label for panel (b) To me, the likeness between (a) and (b) is good – the uncertainties influencing the tsunami height from the slide model are large (frontal area, entrainment … ) In panel (c), I see significant motion right at the start (t=0). What is this?*

In panel (c), the low pass filter contaminates the causality of the waveforms. There is an early arrival of the seismic waves (briefly 30 (km)/6 (km/s) = 5 seconds or later). This is why the filtered waveform does not start from zero. The same as in observation (panel d), but the static analytical solution does not have such phases, so the waveform remains close to zero at the beginning.

*Are the simulations only performed for this time-window or is this the only time-window displayed in order to correspond with the seismic data displayed? I see time-series that are very much non-resolved. i.e. I would like to see it start from zero and end with zero. If there is no reason to show this, that is fine, but the numerical modeller in me wants to know what happens next. Is it resolved in a sensible way?*

It is carried out in the shown time window. The tsunami is always on-going in the simulation and the long-time behavior of tsunami is physically difficult to realize in the simulation. This is why the ground motion does not finish by zero.

*The waveforms in panels (c) and (d) seem exactly out of phase.*

This also depends on the tsunami origin time, which is not at the time t=0. It depends on how landslide occurred and frapped the seawater (see also Table 1). For the ground deformation simulation, the time may be shifted. We specified it in the revision.

*[Figure 7: color palette]*

We revised the color palette.

*Table 1: I do not understand why the times are so different when the waveforms are so similar.*

We think that the times are rather close each other as we discuss the ground deformation at a scale of 0.01 Hz (100 seconds).

*I think the "Data availability" section needs to be expanded greatly to cover also the software used for the different parts of the workflow.*

Thank you for this comment. Although we noted the relevant references in the text, we precise them in data availability session. All the codes (VolcFlow, FUNWAVE, FDM) are fully available.

*It would be a positive precedent to provide input files and running scripts for the simulations themselves for the sake of reproducibility.*

Thank you for this comment. We have been checking the possibility, but as we have used the model from Paris et al. (2019), it would not be appropriate to update that input files by our side. All the used codes are quite common, and the online site is dedicated to the utilization. Nevertheless, we are glad to provide further information in the future on demand.

*Finally, there are many small grammatical and formulation issues. But I will not focus on them as I think there are more pressing issues that need resolving before these need addressing.*

We checked our English in the revision.

*I hope that another reviewer is able to assess the Ground Motion Modelling aspect of this work as this falls outside of my expertise.*

Your comments on the seismological data were very valuables for us. Thank you very much.