Author's response to Dr Dan Shugar review

The paper by Strzelcki and Kaskolski provides a useful contribution to efforts to understand large tsunamis triggered by landslides in high latitudes. These megatsunamis can be extremely destructive, but are rare enough that opportunities to study them are rare. The data and insights described in the paper stem from a field reconnaissance exercise two years after the event, and so it is likely that much of the more delicate evidence was eroded away prior to the authors' arrival on site. In general, the paper is well-written. My main issue is that I was underwhelmed by the level of detail presented and as a result, I can't recommend publication in its current state.

Both authors (Strzelecki and Jaskólski) thank you for your general comments and suggestions. We agree with you that Karrat Fjord tsunami provided very rare opportunity to study not only the geomorphological effect, but also observe how destructive was the wave for coastal infrastructure. Most of your general suggestions were already raised by the Reviewer 1 and we explained the corrections in response to his review, so in this response we only focus on specific comments.

GENERAL COMMENTS

The title should be changed. Warming is not actually addressed in the paper, and it is

not clear whether warming would have had an effect. The landslide was triggered by

an earthquake, and while permafrost thaw may have hastened collapse, these details

are not known (at least not from this manuscript). I was surprised by the lack of quantitative observations in the paper. For example, could the observed coastal erosion be quantified from field measurements, or satellite/DEM analyses?

As I said earlier, the paper is generally well-written but there are some grammatical issues and odd turns of phrase. I have elected not to mention them here, as I feel those are secondary issues and can be fixed later. More importantly, the issue of insufficient detail in the results needs to be addressed.

Author's Response: We have modified the title and add new paragraphs on study site characteristics, history of the settlement and more data on coastal relief changes, vegetation and infrastructure damages. Please keep in mind that we had a chance to spend only 2.5 days in this abandoned site which is under threat of another tsunami, so considering time spend in the field and health and safety matters it would be difficult to extract more for collected data.

SPECIFIC COMMENTS

L23 – The language about "shocking" the public is rather sensationalistic and I'm not

sure is actually fair. Also, the use of the term "Arctic" is not really appropriate. While

the 2017 landslide was north of the Arctic circle, many of the other events described in

the text are subarctic.

Author's Response: Thanks for the comment. We modified our sentence and wrote about tsunamis in cold regions (i.e. Arctic and subarctic).

L31 – For the Tyndall/Taan landslide, there are a few other papers that the authors may wish to familiarize themselves with:

1. Bloom and others wrote about the landscape modifications

https://www.sciencedirect.com/science/article/abs/pii/S0169555X19305215 2. George

and friends did some modelling https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017GL074341

3. Haeussler and colleagues published a paper based on field data (mostly in submarine realm): https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018JF004608

Author's Response: Thank you very much for suggestions. We have added Bloom et al. 2020 and Haeussler et al. 2020 to our reference list. We have noticed that you are the co-author of those interesting paper (Congratulations on those important contributions to cold region tsunami research. We are particularly impressed with the potential of fan deltas to preserve information of the tsunami impact).

L69 - I find this "50% larger" an odd statement (and I realize it's more or less exactly

what Gauthier said). The volume of Lituya 1958 was ~30x10^6 m3, and the reported

volume of the Karrat 2017 landslide was 35-58 x 10^6, so a range of 17-93% larger.

Author's Response: Thank you for suggestion. We have added the volume estimations to the text.

L73 – No need to describe who led the expedition or where they are from.

Author's Response: Thank you for suggestion. However, we would like to keep the name of the team and group leader in the text to acknowledge their tremendous research effort. This is a common practise in Arctic research community.

L90 – Here (and elsewhere), I found the descriptions of the deposits lacking in detail to

the point where they are not particularly useful for other studies.

Author's Response: Thank you for your comment, whenever we could we have added information about tsunami deposits thickness and dominant grain size.

L102 – As above, the description of "modified the relief of cliffs" is far too ambiguous.

Modified how? Can you explain the changes via some maps perhaps?

Author's Response: Thank you for your comment. We have explained the cliff relief modifications in the next sentence informing that the edges of the sedimentary cliffs were gullied, and the steep cliff slopes were spread with eroded blocks of tundra and litter (Fig. 2e).

Regarding your question the we have made an attempt to apply remote sensing analyses to calculate erosion. The ArcGIS DSAS tool have shown a smaller change in the boundary line than the probable measurement error interval. As the coast around the settlement is predominantly rocky, the wave did not trigger significant erosion. The major erosional effects was limited to erosion and redeposition of tundra bluffs (1-2 m width). We treated this as a coastal landscape remodelling and showed in the pictures in Figure 2 & 5

L111 – I don't understand what "modified by snow-melt flow tsunami deposits accumulations" means.

Author's Response: Thank you for spotting this error. We have rewritten the sentence. We have found several sites were the thin layer (3-5 cm) of tsunami deposits were already slightly reworked by flowing water (snowmelt).

L120 – The idea that the finer deposits were trapped by vegetation and so didn't travel

as far as the coarser material is very interesting. Do you have any way to quantify (or

even qualify) the vegetation prior to the tsunami? My understanding of your results are

that they are limited to the post-tsunami landscape for the most part.

Author's Response: Thank you for your comment. The vegetation trapping the finer deposits was a working hypothesis we formulated in the field. Now, with time, and watching couple of short movies taken by local inhabitants during the event, we know that the vegetation was not so dense as present. We discussed our findings of relatively thin and scares preservation of tsunami deposits with leading experts in the field, which led us to the conclusiton that because of small amount of marine deposits sored tiny, pocket beach along predominantly rocky coast the tsunami did not transfer significant amounts of fine (sand, gravel) deposits on land. Therefore, we have decided to delete this fragment.

L130 – What are "point foundations"? Do you mean the building is set on top of (aboveground) boulders or concrete piers at the corners?

Author's Response: Thank you for your question, indeed we meant that the building is set on top of (aboveground) pier foundations. We have changed point foundation to pier foundation.

L144 – The section on waste is interesting but especially vague.

Author's Response: Thank you for your comment. We are aware that our paper lack the detailed analysis of the scale of the threat, but it seems to us that the presence and exposure of waste to harsh weather conditions is undoubtedly a threat itself. With this paragraph we would like to draw the attention of the local authorities that the mere presence of these materials in the Arctic environment poses a potential threat to the environment, and natural disasters associated with e.g. landslides, tsunamis or thawing permafrost can cause an ecological disaster.

L159 – I am really surprised to see no mention of the Vaijont disaster here. Yes, this

was in a reservoir and not the ocean but the mechanisms are very similar.

Author's Response: Thank you for your suggestion, you are right the mechanisms of the catastrophe were similar, but in our research we focus on the coastal environment in polar region.

L180 – This paragraph would benefit from some numbers describing the areas being

described. So for example, you state that Benjamin mapped 20 rock avalanches along

a "short section" of coast. What is short? 100m? 100km?

Author's Response: Thank you for your comment. We have added the missing information – the coast studied by Benjamin et al. 2018 was ca. 25 km long.

L185 – Why is this described as a "pilot study"?

Author's Response: Thank you for your comment. We treated our work as a pilot study meaning that we were the first research team to map the geo-ecological and infrastructural effects of the wave. We have deleted this unnecessary term.

L189 – If you are going to state that the "scientific community did not really believe. . ."

you definitely need a citation or two to back up that claim.

Author's Response: Thank you for your comment. We have modified the sentence to get rid of the journalese.

L195 – The conclusions raise several points that were not actually discussed specifically in the text. Similarly, Table 1 contains information that was not described in-text.

Author's Response: Thank you for your comment. We have developed our discussion using the data presented in Table 1. We also have added new paragraph in section 3 Research area - 3.2 Settlement history and economy where we present the key facts on Nuugaatsiaq settlement. Where we have mentioned about community abandonment too.

Fig 4 – I found that it was not easy to compare panels (a) and (b) since they are from

slightly different vantages. Panel (c) is also confusing. The red buildings are damaged

or destroyed? And the yellow buildings were moved from where?

Author's Response: Thank you for your comment. We have prepared a new Figure 4 (now Figure 6) , hope now it is much clearer to notice the infrastructure damages and changes.

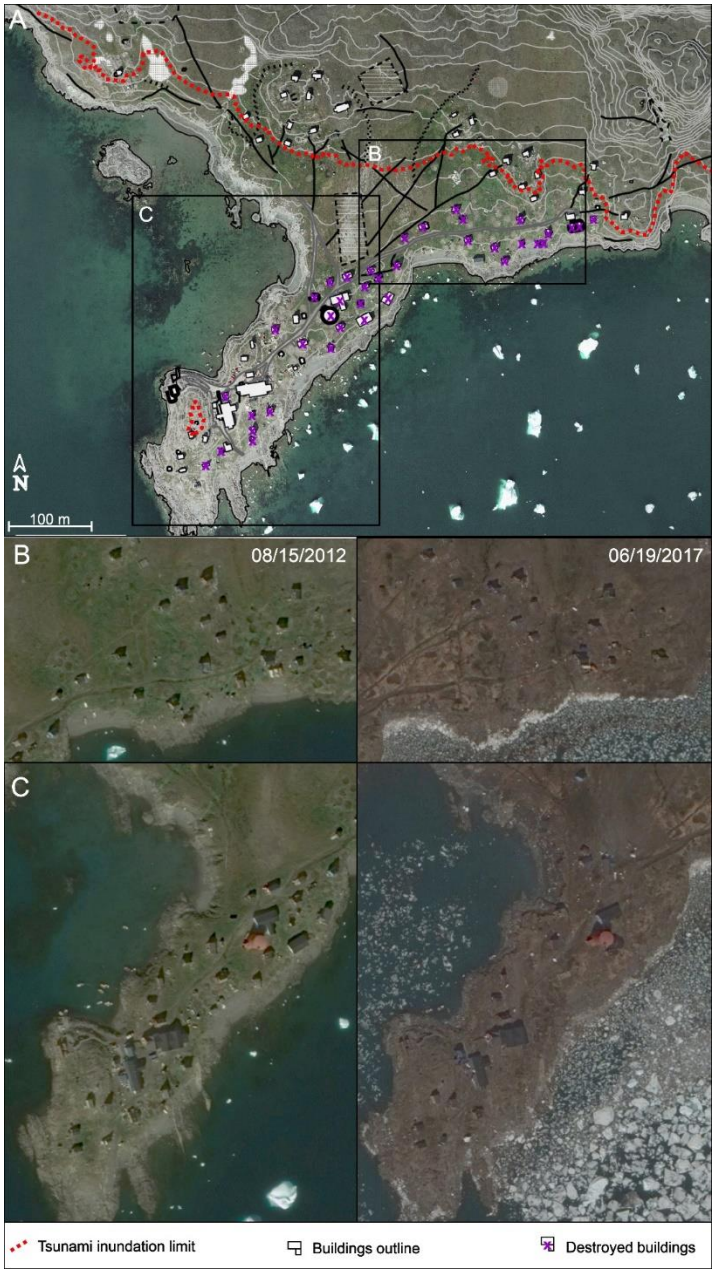

Figure 4. Scale of destruction in settlement infrastructure. (A) General overview of area inundated by tsunami with location of damaged buildings. The inventory of tsunami-induced changes of settlement infrastructure are based on interception of aerial images, local spatial plans and field surveying. Background ortophoto & technicalmap: nunagis.gl.; (B) Satellite image of settlement before the tsunami impact (15th August 2012) and; (C) Satellite image of settlement after the tsunami impact illustrate the scale of destruction and dislocation of buildings (19th June 2017) Background Google Earth Image © 2020 Maxar Technologies.