Dear Peter,

thank you very much for the detailed comments to improve the manuscript. We changed the manuscript accordingly and highlight the most important changes below. Unfortunately, I found an error in some of the presented plots and data. I accidentally used the total volumetric and area change instead of the yearly change to compute the PDFs and associated rollover, cutoff and exponential decay coefficients. Thus in Figures 4, 5 and Tables S1 and S2 the presented data is based in the total volumetric and area change rates. This was due to an error when reading-in the data were the index was off by 1. Using the corrected data (yearly changes) leads to a reduction in the quantities related to the PDFs of about a factor of 4. I have corrected now Figure 4, 5, the Tables S1 and S2 and all occurrences in the text. It does not effect in any other way the content of the paper like for example the difference between study sites stay the same. I also checked all other data again and everything is correct otherwise. I highlighted all the made changes in the change document and I hope this is not a problem.

Many thanks and best regards,
Philipp Bernhard

Author Reply to the Editor comments.
In the following we appreviate: Editor Comment as EC and Author Comment as AC.

EC:
L5: “Please highlight in your abstract the use of PDFs for change rate distributions as I think that you may be the first (or at least among the first) to apply PDFs to RTS, so there is novelty.”

AC: We changed the order in which we present the results in the abstract and highlight the use of PDFs. I found one study that has already presented a frequency distribution of RTSs on Svalbard. Even when in this study there was not a detailed analysis of the frequency distribution I don’t think it is fair to say that we are the first. I cited the paper in the introduction.

EC:
L18-20: “Too sensational. Most thaw from a regional perspective will not be rapid, but will be gradual, "Press" thaw. Only specific locations will experience faster thaw, usually where there is excess ground ice and thermokarst. Thermokarst operates on up-to decadal scales, so it that "rapid"? See Grosse et al. 2011) who say "Press disturbances of relatively slow but persistent nature such as top-down thawing of permafrost, and changes in hydrology, microbiological communities, pedological processes, and vegetation types, as well as pulse disturbances of relatively rapid and local nature such as wildfires and thermokarst,"
RTS are rapid to initiate, a "Pulse" thaw", but the thaw continues for some time until the RTS stabilizes.
I think that you could easily re-cast this and rely on the "Press" and "Pulse" language presented in Grosse et al. 2011, and use as "thermokarst" instead of

"rapid thaw". These alternative terms, in my mind, are more effective at describing the various thaw rates and will get your point across better to geomorphologists."
L20: "Sensational. All permafrost has these impacts, not just Pulse type thaw."
L23: "Again, the thaw event presented by an RTS is not rapid, it is the initiation that is "rapid""

AC:
We agree with the assessment and we changed the part in the introduction and used the suggested terms "Press" and "Puls" disturbances.
"With climate warming these permafrost regions become increasingly vulnerable to thaw. This thaw manifest itself first in a slow but gradual deepening of the seasonally thawed active layer (press disturbances) and secondly in a more rapid and local way by the development of thermokarst features (pules disturbances) (Grosse et al., 2011; Schuur et al., 2015). Both forms of permafrost degradation have major impacts by changing ecosystem and hydrological equilibria and impact the Earth system on a global scale by reinforcing climate change with the additional mobilization of organic carbon that was previously stored in the frozen soil. One important thermokarst feature arising from pulse disturbances are retrogressive thaw slumps (RTS)."

EC:
L36,37: Please highlight if you are the first to apply PDF to RTS.
AC:
We added to the manuscript: "Currently there is only one study quantifying the area frequency distributions of RTSs, were orthophotos for a study site on Svalbard was used to measure the area disturbed by RTSs (Nicu et al., 2021)."
Nicu, I. C., Lombardo, L., and Rubensdotter, L.: Preliminary assessment of thaw slump hazard to Arctic cultural heritage in Nordenskiöld Land, Svalbard, Landslides, pp. 1–13, 2021.

EC:
L 73: "For consistency, please use either "sites" or "regions" throughout. I suggest "sites" as you use "regions" in other contexts."
AC:
We use now the term "study site" and changed all occurances in the manuscript

EC:
L83 "Not clear. Do you mean: "Within these extensive regions we selected representative locations for our study sites"?"
AC:
Yes, thats what we mean and we adopted the suggested fomulation.

EC:
L86.87: "Topography and soil type are almost always drivers of near-surface ground ice variation at only at very local scales, and on the order of metres. At larger scales, there are typically much different reasons for high and extensive ground ice contents that yield RTS. E.g., buried glacial ice, or massive syngenetic ice, or syngenetic permafrost aggradation as in Yedoma deposits. There may be relations between topography and soil type with RTS initiation,

but the ground ice that you are really talking about, which relates to RTS, is not *due to* topography.
Please clarify this section for the reader."

AC:

We clearified this distinction between large and small scale variation in ground ice. We added to the manuscript:
"On large scales, high ground ice content is associated with the climatic history (e.g. syngenetic ice-wedges) and the associated extent of past glacial ice (e.g. buried glacial ice). On small scales ground ice content can vary due to for example soil type (Lacelle et al., 2004).

EC:

L93: Tables have single sentence titles, rather than captions as figures do. Please move this table title above the table. Please repeat for other tables.

AC:

We corrected the formating for all tables

EC:

L115-121:
"This paragraph needs an introductory sentence, probably something that links to the final sentence."
"If there are any please cite, otherwise there are none rather than a limited number."
"Are these limits based on using TanDEM-X DEM, or from some other source? If related to the TanDEM-X DEM, then can't you simply say that these reflect the accuracy and precision of the TanDEM-X DEM?
It is just not clear in this section if you are talking about inventories, or your own data."
"Please re-write for clarity. What is the role played?"

AC:

To adress the made points we rewrote the part in the manuscript:
" The error sources and uncertainties that govern the lower RTS detection limit in terms of headwall height and retreat rate are manifold and difficult to quantify. This is mainly due to the small amount of available high resolution, three dimensional RTS inventories (Swanson and Nolan, 2018; Van der Sluijs et al., 2018), were also timescales on which the RTSs are monitored plays an important role. To get an estimate on the lower limit of RTS induced elevation changes to be detectable we can analyse the smallest detected RTSs in our sample. The 10 smallest detected RTSs have elevation changes in the range of 1.6 - 1.9 m and can be seen as an approximation for the smallest RTS headwall heights that are detectable, which are on the same order then the general TanDEM-X DEM accuracies. Similarly, the smallest total area changes of detected RTSs are on the order of 500 - 1000m^2,corresponding to about 10 - 12 pixels. Consequently, if the size of the erosion features approaches the pixel resolution also the accuracy of the estimated volume loss increases. Additionally, processes related to the observation properties and interferometric processing further complicate the error estimations. For example the about 40 degree right looking viewing geometry leads to different pixels resolution depending on aspect and slope of the observed area.
These error sources and increased uncertainties especially for small RTSs, both in terms of spatial and vertical changes, should be considered in the interpretation and future use of the dataset.

EC:
L133: “This doesn't quite make sense to me. Do you mean: " For some study sites (list them) several winters of observations were available (2010/11, 2011/12, and 2012/13).”
AC:
We mean that parts of the study sites have not a complete coverage in all of these winters. This is the case for all sites. To clearify we slightly changed the sentence to:
“For parts of the study sites observations during winters in 2010/11, 2011/12 and/or 2012/13 were available.”

EC:
Table 2: “Please always use names as indicated in Tables and figures for consistency. Please check the entire manuscript for consistency”
AC:
We checked the manuscript again and always use the study site abbreviations.

EC:
Figure 5: “For consistency, please write either "(a)" or "a)", but not both. Currently both styles are used throughout the text body, captions, and figures.”
AC:
We changed all labeling to a), b)...

EC:
L220: “ In Methods Section 3.5 the scaling parameter is given as gamma, but in this section is given as alpha. Please be consistent. Depending on what you use, you may have to adjust details in figures or tables.”
AC:
We use now alpha throughout the manuscript for the volume-to-area scaling coefficent.

EC:
Figure 7: “Please clarify if the centerline values and the mean/median are for the entire study region.
Rather than splitting the violin plot, as the probability density distributions are often quite different for hillslope versus shoreline, it might be better to have two violin plots for each study region according to location.“
AC:
We clarified that the white dot and the thick line are related to the RTSs in the total study site. We think that this presentation (top shoreline and bottom hillsope) makes the comparison easy.We think that adding additional 8 violin plots makes the Figure more confusing and does not add important additional information.

EC:
L.286“I'm not sure that most would consider ground ice content as a soil property, as ground ice is most common below the soil (ground ice that matters to RTS in any case). Perhaps: "physical characteristics of ground materials"?”
AC
We added the suggestions.

EC:
L303: “transition to what? Deeper thaw and RTS development? Please clarify.”
AC:
We change the sentence to: “Furthermore, most RTSs initiate as shallow active layer detachments. The gradual increase in headwall heights following the initiation event could lead to a temporal change in the scaling coefficient.”