Answer to the interactive comment on "Contribution of Coastal Retrogressive Thaw Slumps to the Nearshore Organic Carbon budget along the Yukon Coast" ***by*** **Justine L. Ramage et al.**

We thank the two reviewers and the editor for the thorough revision of our manuscript and their constructive comments that helped to improve the paper. Our replies to the comments are written in green. Line numbers given in our replies refer to the revised version of the manuscript.

Anonymous Referee #2

The submitted paper 'Contribution of Coastal Retrogressive Thaw Slumps to the Nearshore Organic Carbon Budget along the Yukon Coast' by Ramage et al. gives an indication of the specific impacts of slumps on the sediment budget and on the carbon budgets of Arctic tundra coasts in northern Canada. The focus is on three main topics as stated at the end of the introduction: 1) definition, quantification and temporal analysis of RTSs; 2) estimation of sediment/ice and OC budgets related to these slumps; and 3) measure the OC fluxes between 1972 and 2011. Looking to these aims of the study, I have some specific comments related to these different goals and will come with suggestions to restructure some parts of the paper to make it more focused on the RTSs. The data presented is very valuable and the paper will after restructuring be a valuable contribution to better understand Arctic coastal environments and its changes.

Ad 1) The coastal stretch in NW Canada is probably very representative for a large part of the Arctic coastal environments. The different geomorphological units (or geological units as stated in Figure 1) cover a wide range of environments and the coastal stretch with its units can probably be used to upscale the findings. You can state explicitly that you use the findings along this stretch to upscale in the future.
We are not sure we understand correctly this comment.
Ground ice and OC data from Couture (2010), Couture and Pollard (2017) and Tanski et al. (2016) were upscaled from single field sites to the entire coastal segments. These data were further interpolated to costal segments showing similar permafrost conditions.
We added more details in the methods sections 5.2 and 5.3.

We did not upscale our data in the future. The number of RTS and their size were mapped based on 3 type of imagery from 1952, 1972 and 2011.
Volumes of material and OC stocks were estimated for a subset of the number of RTSs identified in 2011. OC fluxes were calculated for RTSs that initiated after 1972.

Upscaling our results to the future would require a more complex approach, including changes in temperature, precipitations and sea ice properties, which are major controls for RTSs development.

Use Figures 2 and 6 to define what RTSs are.
We added a definition of RTSs in the introduction and described them further in the methods section.
Page 2, line 12: *"Retrogressive thaw slumps (RTSs), a type of slope failure caused by permafrost thaw, (...)"*

Tables 1 and 2 give an indication of the amount and sizes of RTSs for different units. It would be good to start the explanation of the spatial pattern, followed by the development in time. Now, it starts with changes in time, without having an idea how many and how large the RTSs are in the different units.
We described the current (2011) distribution of RTSs in a paper published in 2017: Ramage, J.L., Irrgang A.M, Herzschuh U., Morgenstern A., Couture N., Lantuit H.: Terrain Controls on the Occurrence of Coastal Retrogressive Thaw Slumps along the Yukon Coast, Canada. *Journal of Geophysical Research: Earth Surface,* 2017.

We replaced the tables 1 and 2 by a Figure (Fig.5), combining the information provided in both Tables.

Another thing is the use of the terms active or stable RTS. What kind of conditions do you use to call a RTS active or stable? Is it related to fresh scarps, vegetation coverage?
To clarify this information to the reader, we added this information in the section 3.1:
Page 4, line 7: *"Active RTSs are characterized by steep headwalls exposing ice-rich permafrost, slump floors with thawed sediments, and incised gullies. Stable RTSs comprise gently sloping and vegetated headwalls, vegetated slump floors, and no visible active gully systems (Ramage et al., 2017; Lantuit and Pollard, 2008; Wolfe et al., 2001)."*

Ad 2) Estimation of the sediment/ice erosion due to RTS and OC budgets is quite straightforward and the best you can do with the limited Lidar data. Figure 6 in your discussion is very nice and can be used to explain your estimation of budgets in an earlier phase.
Thank you for the suggestion. We move the Figure 6 to the method section and renamed it as Figure 4 and clarified the methodology:

"3.2.3 Volume of eroded material
To calculate the volume of eroded material from the headwall of the RTS identified in 2011, we subtracted the mean surface elevation values obtained from the LiDAR dataset from the mean interpolated surface elevation values (Fig. 3). However, these volumes do not account for the material eroded from the RTS headwalls that settles within the RTS floors and for the material eroded and transported alongshore by coastal retreat (Fig. 4). Due to ground ice melting, ca. 5.5% of the reworked sediments subside and remain compacted in the RTS floor (Obu et al., 2016). We therefore adjusted the material volumes based on this value (Fig.4, c). Additionally, we measured the volumes of material eroded and transported by coastal retreat using the rate of coastal change between 1952 and 2011 from Irrgang et al. (2017). Using this rate, we calculated the volumes of eroded material between 1952 and 2011 for each RTS. For the RTSs that initiated after 1972, calculated the volumes of eroded material between 1972 and 2011 (Fig. 4, d).
To differentiate between the volumes of ice and sediments eroded, we used the volumetric ice content provided for each coastal segment in Couture and Pollard (2017). The model interpolates the data collected on 19 coastal segments to the whole Yukon Coast based on similarities between surficial geology and permafrost conditions. Ice contents were determined from shallow cores collected from upper soil layers and from bluff exposures.

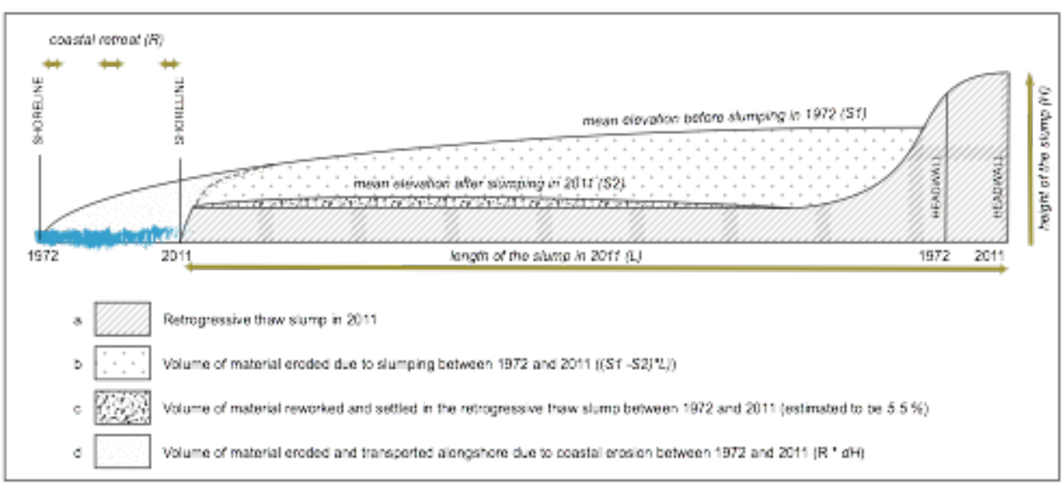

Figure 4: Cross-section of a retrogressive thaw slump (RTS) illustrating the calculated and omitted volumes of sediments eroded through slumping between 1972 and 2011. The calculation estimates the amount of material released to the nearshore zone through slumping (b) and takes

into account the material eroded from the RTS headwalls that remains within the RTS floors where it settles (c), and (d) the material eroded and transported alongshore by coastal erosion. The volumes of material that remains within the RTS floors were estimated from Obu et al. (2016)."

The presentation in Figures 4 and 5 is often a bit confusing. You followed a spatial axis on the x-axis, but you don't use this in the rest of the discussion. It would probably more interesting to group it according to the geomorphologic/geologic unit and discuss this variation in time. You also gave this unit related results in tables 3,4 and 5. The volumes of eroded materials will be better visible if you don't use a cumulative sediment and ice volume on a logarithmic Yaxis, but come with values for sediment and ice (different symbols).
We modified the Figures 6 and 7. We removed the logarithmic axis and plotted the material released per RTS for each coastal segment. We did not group the values by geologic unit because we present those results in the tables 1 and 2.

Ad 3) I wonder why you made a separate aim only following OC budgets in time. I think it is more logical to describe the estimation of budget terms under 2) and thereafter discuss all terms (sediment / ice / OC) in more detail in time.

In the section 4.2, we use 2 different dataset:

1. 162 RTSs that were identified on the 2011 imagery. We don't know when those RTSs were initiated
2. 49 RTSs that were identified on the 2011 imagery but not on the 1972 imagery. We named those RTSs "RTSs initiated after 1972". For these we were able to calculate fluxes.

We initially described the volumes of eroded material for both of these dataset and then described the different parts (sediment / ice / OC), as you suggested. However, we found difficult for the reader to distinguish between the 2 datasets and decided to talk first about the volumes of material and related stocks of sediment, ice and OC and then to focus more on the fluxes using the dataset 2.

Discussion and conclusions
The discussion of the paper is now in 4 subsections (erroneous numbered 5.1, 5.2, 5.3 and 5.3). Following the three aims and the structure of the results, it is perhaps very attractive to start a discussion about the 'static' description of RTSs (sizes, amounts, coupling to geo units) and about the uncertainties in determining the RTSs using the data set. This can be followed by a second section about the changes in slump activity (your acceleration of slump activity). Then we have two sections related to the second aim: your sections about Eroded material from RTSs and Calculated OC fluxes. Finally, you can place it in a broader prespective as you tried to do in 5.4. This can also include some remarks about upscaling to Arctic shorelines.
Thank you for these suggestions. We modified the discussion following the points 2,3 and 4. The "static" description of RTSs for 2011 was already done in Ramage et al. (2017). We added a sentence at the beginning of the section 5.1 to mention the results of this previous study.

We kept the first section of the discussion 5.1 on the evolution of RTSs along the coast. We then merged the previous sections 5.2 and 5.3 into a section 5.2 on the Eroded material from RTSs and calculated OC fluxes and kept section 5.4 renamed as 5.3.

The conclusions are to the point.

Title The title is not covering the work done. You have showed many more results on the losses of ice and sediments and its changes in time as well. Impact not only OC budgets.
Following your suggestion, we modified the title of the manuscript.

Line edits:

Page 2
line 9: Hugelius et al., 2014 is not in the reference list.
Thank you for noticing. We added the citation in the reference list.

Page 5
line 20: n=125 refers to?
The n = 125 refers to the number of RTSs discarded. We modified the sentence to
"We discarded the 125 RTSs outside of the LiDAR scan from the volume and flux analyses."

Page 6
Figure 3: Are all splines in the RTSs giving a sloping surface from N to S?
Not all splines give a looping surface from N to S in the study area. The orientation of the splines depends on the orientation and the topography of the coast surrounding the RTSs on which RTSs occur. On the Figure 3, all RTSs are facing south because the example is taken from a south facing and sloping coastline. We decided to modify Figure 3 in order to clarify this point.

line 12: Can you estimate the coastal retreat impact (or assume ..%)?
In the first manuscript we decided to leave aside these two processes because we did not have accurate erosion rates for the area. Meanwhile, a new study from our colleagues was accepted for publication in JGR:Earth Surface (Irrgang et al., 2017, in review). We therefore modified our dataset to take into account:

1. the 5.5% of material that subside in the slump floors (Obu et al., 2016)
2. the area of the slump that is being washed away by coastal retreat yearly. For this we used coastal rates of change from the study from Irrgang et al., 2017

We added the previously Figure 6 in the method section as Figure 4 and clarified out methodology (section 5.2.2 and 5.2.3).

Page 11
Figure 4: Only Mr?
Thank you for pointing out the mistake. Following the recommendations of the other reviewer, we modified the figure.

Page 13
line 21: Wolfe and Dallimore or Wolfe et al. (see reference list)
We modified the reference as Wolfe et al., 2001.

Page 16
line 13: Should be section 5.4.
Changed accordingly.