First of all, I apologise for the delay to the authors and the editor. Please contact me if you have any questions. Pierre-Marie Lefeuvre

This paper presents a detection and volume distribution of calving events at Eqip Sermia glacier in Greenland based on an eight-day campaign of Terrestrial Radar Interferometer (TRI). The authors identify calving events using elevation changes at the glacier front from TRI-derived, 10-minute-stack Digital Elevation Models (DEM). Calving volume is computed from cumulated vertical changes scaled to the area by a watershed algorithm. The volume distribution is found to change from a power law distribution (self-organised critical system) in the deep part of the calving front to a log-normal in the shallow part (less complex system). The authors infer that higher ice cliff and decrease in subaerial melting in shallower parts lead to a decrease in complexity associated with a lower number of calving mechanisms.

The topography from TRI is a relatively new technique to analyze calving at marine terminating glaciers and only applied to Ilulissat glacier (Xie et al, 2016, 2019) and Eqip Sermia (Lüthi et al, 2016). This new inventory and derived calving volumes are important to link individual calving processes to long-term calving rates as there is a general lack of high temporal direct observations. This type of quantitative dataset contributes to the theoretical description of calving as a self-critical system which is currently based on only qualitative estimates of calving volume. In the long run, the measured calving distribution will support the development of more physical calving models integrated to ice-sheet models and a better quantification of the contribution of the Greenland ice sheet to sea level rise in the future. I thus recommend its publication in the Cryosphere and this study will be of great interest for its readers.

Overall the paper is well written and structured. My major comments are listed below and I am confident that the authors can correct them.

1. DEM derivation of the glacier front from TRI

The critical part of the paper is the derivation of digital elevation models of the glacier front from terrestrial radar interferometer as developed by Strozzi et al. (2012). However, this method is known to be uncertain, although the large glacier size should help having a greater signal to noise ratio. I think that it is important to extend the paragraph on the error analysis and dedicate a specific figure with a map of the derived DEM(s), statistical distribution of the error in the discussed stable terrain. Assess the uncertainty of the glacier part with the UAV derived DEM too by replacing Figure 3 as the velocity comparison is done in Rohner et al, 2019.
I would like to have a Figure showing a study case of the detection and watershed algorithm to assess issues with signal to noise ratio and uncertainty in radar geometry or cartesian coordinates (in the main text or supplementary material).

2. Issues in determining best fit models for calving distribution

As seen on Figure 6c and 6d, it is not possible to distinguish between a power law and a log normal models as indicated by a low loglikelihood ratio R between the two distributions and a poor significance value, $p>0.1$. The only evaluation possible of the power law is a comparison with other heavy-tailed distributions. The conclusion is that the shallow and deep part does not exhibit a transition in distribution from power law to log normal as they cannot be statistically differentiated from each other. Discuss instead whether the distribution over such a short period is representative.

3. Ice flux budget: bed topography and missing component

The paper bases its analysis on the depth of the fjord but no bed data is provided to support this description (just observations of surfacing rocks). Please use the BedMachine v3 to at least provide an idea of the fjord depth in front of the glacier to the reader. The shallow part may be constituted of

two bed pinning points beside a deep valley. Furthermore, simplify the subdivision of the shallow part to only the shallow part regrouping SL, SM and SR.
The simple ice flux calculation holds some caveats when identifying a missing volume due to the uncertain fluxgates and filtering of small events. The distribution of these small events may be related to calving mechanisms and ocean melting (undercutting). A more realistic flux can be derived by integrating the ice flux with your surface elevation and velocity data. See my minor comments to improve the understanding of section 5.1.

4. Better integration of calving wave dataset

The paper should integrate better the ocean wave data as an alternative dataset of calving events (including subaqueous ones?), explain this discrepancy and discuss other potential sources such as iceberg rolling. This better integration of the wave amplitude dataset with the TRI detected calving events would strengthen the discussion and conclusion of the paper.

Minor comments:

page 2

Abstract
Please mention that the study is based on derived digital elevation models. Focus on your findings right after your methods instead of following the paper structure: the characteristics of the shallow/deep part (l.5-7), then calving missing calving volume (l.8-10), self-critical system vs less complex model (l.10-11), Calving models vs front geometry (l.11-12) and finally lack of relation to air temperature and tides.

l.2: “in understanding **the processes of calving**”
l.4 “The **derived surface elevation** data with a **spatial resolution**”. Specify the vertical resolution as well as it is key to the method..
l.5 can you find a better word than “source area”? “vertical front area”?

1. Introduction
It is well written and nicely placing the work in its context.

page 3

l.12 Add Kohler et al., 2015 in Polar Research [TOCHECK] as they produced the longest calving time series based on seismic records (20 years)
l.14 Delete “can only detect large events” as they can detect small events (even ice falling in a crevasse at the front, Kohler et al., 2019 in The Cryosphere Discussion) when placed close to the glacier front. Their main issue is the volume scaling.

2.1 Study area
l.30 Add that the glacier has been stable and even advanced since 2016 similarly than Jakobshavn Isbrae (based on Planet daily imagery).
l. 32 Indicate the time period when 16 m day-1 was obtained: “as measured over our two week period in 2016”? as the 2.5 and 5 m day-1 represents annually averaged velocities, correct?

page 4

l.1-7 Also present the glacier bed or bathymetry provided in the BedMachine as it covers an area that is now deglaciated (as they use an older surface elevation and glacier mask) and upstream bed geometry is also important to understand the glacier flux at the front.

page 4-5

The TRI and environmental data parts are complete and informative.

page 6

3.1 TRI data processing

l.15-17 Is the elevation difference just a shift in absolute elevation explained by a difference in geoid or geo-referencing problems of the Arctic DEM or your DEM? Also co-registering the two DEMs before differencing is useful to assess systematic errors outside obvious artefacts.

l.18-19 Please provide a sentence about precision change over time on stable terrain and also ice. You could plot this variability on stable terrain and some upper part of the glacier for the single DEMs and the stacked ones to appreciate the effect of atmospheric disturbances and the improvements from stacking. You could use this variation to provide first order error bars for your volume estimates on Figure 6. In the discussion could you compare your precision to what other studies found.

l.20-21 Indicate that the watershed algorithm uses elevation change as source image and merges calving events occurring within 10 minutes due to the stack. Can you define algorithm parameters like the number of start points or maximum points for reproducibility? Please plot an example of your watershed results (here or in supplementary materials) to assess the effect of noise on your segmentation. An error of 10 pixels in radar geometry already causes a volume error of 5625 m3 in range and 12000 m3 in azimuth using 150 m of ice thickness, that is the same order of magnitude than your calving volumes.

l.23-24 "10 pixels **in area**" Specify that in the context of your grid asymmetry, your area filter is more likely to remove events that are long instead of wide, thus you apply this second filter of 3 pixels. Add that 3 pixels is equal to 11.25 metres.

l.24 "When applying [...] are removed". The noise observed on stable terrain is not removed, but the signal to noise ratio is higher for the filtered events. Moreover, quantify the number or area of excluded events or give a percentage.

l.20-24 How do you deal with the zero elevation or water elevation when calving occurs along the entire ice column (i.e. column collapse)? Parts of the DEM covering the sea may have Not A Number values or problems with icebergs?

page 7

l.4-6 Rephrase the last line that explains what a "good" *p* value is and means. Specify that the maximum-likelihood methods are used because of the non-linearity of the fitted curve and that one implication is that the resulting log-likelihood is a relative score of how good two fitted models perform against each other instead of "an absolute score".

l.8 Add that 120 interferograms is approximately 2 hours.

l.7-10 Indicate the theoretical maximum velocity that the TRI measures with an interval of one minute (it should be of the order of 6 metre per day) as this will be useful to explain the differences with the UAV velocity data. [TAZIO equation]

3.2 Pressure sensor data processing

l.15 Indicate the frequency of the low pass filter or used methods.

4. Results

The key result of the paper is the TRI-derived DEMs but the velocity (4.1) is presented first instead. Add text and figure(s) specifically on the generated DEMs and signal improvement by stacking before section 4.2 on calving detection results or a comparison with the UAV DEM.

4.2 Magnitude and source of area of calving events

Abandon the subclassification of the shallow sector as it confuses the results

l.25 I suggest a simpler section title: Area and location of calving events?

l.29 Add the number of filtered/removed events for each sector as the filter may affect the number of calving events. I have a hunch that the deeper sector may have more small events, likely filtered out, due to the effect of higher submarine frontal ablation.

page 8

l.1 Replace “frequencies“ by “number”
l.2 “**four** orders of magnitude”.
l.2 Use the same order of magnitude i.e. 10ˆ3 for easier comparison, too.
l.2 I do no understand how you get a minimum volume of 160 m3. If you take a minimum area of 10 pixels with 30 m2 per pixel, you get a height of 0.53 m. This does not match your vertical change threshold of 5 m. So, I guess the comma is misplaced, it must be 1.6 10ˆ3 m and you were correct with “three orders of magnitude”.
Volume / (10x Pixel Area) = Height or 160/(10x3.75x 8) = 0.53.
l.8-11 Delete the subdivision of the shallow sector it does not bring much to the comprehension of the calving distribution. Or just keep the rock part: M.

page 9

Table 1: Could this table be combined with Figure 6a and 6b by placing a text in the corner or a horizontal boxplot at the top? Rarely calving distribution are presented as a table, making it difficult to compare with other studies.

page 11

l.19-21 Develop the detail of your computation (numbers?) and how you obtain 25% in the text and on Figure 5d.

4.3 Calving statistics
l.23 Describe first what you want to achieve, meaning model the calving distribution with non-linear fitting models to assess whether you observe a “self organised critical system”.
l.27-31 It is not clear to me what is the basis for selecting a log-normal against a power-law in both sectors as the results of the maximum likelihood (and visual inspection) show that the fitting models are as good and with similar parameters.

page 12

4.4 Pressure sensor records
In order to find the missing component presented in the discussion, it would really help to derive a rough calving catalogue based on a peak detector or even manual picking and neglecting other sources of wave oscillations such as iceberg rotation.

page 13

5. Discussion
l.14-15 “[...] no clear temporal pattern of tidal or diurnal recurrence [...]” comes to me as a surprise as it is not presented in the results (but should be, including Figure 9).

5.1 Relation to ice flux and other processes
l.16 Which “other processes”? Be specific. Here you want to close the “ice flux budget at the calving front” or find the “Missing volume in the deep sector”
l.17-23 Your simplification to compute the ice flux is fair but neglects variations in ice thickness and important processes such as submarine melt. It is thus not convincing that the total calving volume matches the computed flux. Try to obtain the ice flux by integrating the glacier velocity, height for aerial calving (ice thickness would be better assuming a certain bed topography) and the glacier discrete width (for each space unit) maybe even upstream of the front assuming constant front

position. Also, rephrase this part by first stating what are your assumptions and the missing elements.

page 14

l.1-6 I am confused here as you seem to compute the aerial ice flux using the ice height above water (150 m) and thus the missing aerial volume in the deep sector cannot be directly caused by oceanic melting, but indirect effect of the undercutting and thereby lower stress threshold for breakoff. Compare the volume you detect with the aerial ice flux in the deep sector with an ice height of 50 m. The estimated volume from the ice flux is then threefold lower than your previous estimate and is closer to your TRI calving volume estimate.
l.3-4 Before neglecting the role of filtered calving events in explaining the missing volume, could you check that the number of filtered calving events is proportionally the same in the shallow and deep sector assuming a homogeneous noise along the front? The effect of oceanic ice melt and undercutting in the deep sector may cause smaller blocks to fall at lower stress threshold than in the shallow part. This is coherent with your observation that few large calving events occur in the deep part.
l.8-15 Good discussion and comparison. I would just add the year when the oceanic melt was obtained as it depends on warm Atlantic water intrusion that has reached a peak in 2007 and has weakened since (hence the glacier advances in the region).
l.15 “the contact area [...] is much smaller” by how much?
l.20 Indicate that the 75% mass removal in the deep sector occurs only over two third of the calving front, showing a greater efficiency of melting in the submarine part of the front.

5.2 Influence from cliff height and shape
Overall, the discussion is good, but there is no discussion on the effect of undercutting on stress regime (see comments in 5.1).
l.22 Alternative title: “Effect of steeper and higher ice cliff ” or “Role of front geometry on stress regime”

page 15

l.1 “decreasing water level” do you mean tides or specify what causes water level to decrease in crevasses.
l.3-7 Nice interpretation that could also be applied to the deep sector. You can verify your hypothesis by comparing front positions and the glacier retreat seen in Figure S.1 may be significant.

5.3 Calving statistics
Although the discussion is well written and nicely supported with recent studies, the low *p* values of the likelihood test on Figure 6 show me that both a power law and log-normal can explain your distribution in both sectors. Thus reformulate your question here as the power law distribution can also be attributed to the shallow sector.
l.8 Alternative title: “Self-organised critical system vs less complex systems” or “calving distribution and driving mechanisms” or “calving distribution”
l.12-13 All cited studies estimate aerial calving and neglects subaqueous events. The main reason for a too steep power law curve may be that the study period is too short and there were too many (or not enough) calving events larger than 10ˆ5 m3 (or between 10ˆ4 and 10ˆ5 m3). This would also explain the misfit on Figure 6c.
l.16 “[...] instability with **many small** events [...] events of **greater** magnitude”
l.17-18 I do not understand the point of that sentence. Rephrase or delete.

5.4 Comparison with pressure sensor data

Discuss whether you can identify waves of rolling iceberg from those of calving events. Subaqueous events can often be confused with icebergs rolling close to the glacier front as we can often only identify them from the produced waves.
l.25 Alternative title: “Comparison with calving wave signal”

page 16

5.5 Relation to external forcing
The air humidity is not present here (section 2.3) and would be useful to assess potential precipitation periods and atmospheric disturbance on the radar signal. Precipitation tends to mess up surface melt and tidal signals seen in calving event occurrence.
The temporal resolution used in Figure 9 for your calving events may be too high to find a relation that often occurs on hourly time scale. On Figure 9d-e, resample your calving data and apply a cutoff for the two-three largest events around 0.2 in 9d and 10 in 9e. The legend can be plotted once in between the two panels.
l.12 Alternative title “Absence of meteorological and tide effect”
l.14-15 The sentence on surface melt is not coherent with the sentence before that finishes on tide effects.

page 17

6. Conclusion
Update the conclusion after answering my comments.
l.10 “We developed a novel **detection** method **based on TRI DEM differencing** to establish [...]”

---- Figures ----

Figure 3
Remove the velocity comparison as a more thorough comparison is achieved in Rohner et al, 2019 (refer to their Figures). Instead show here a plot of the mean velocity for the entire period and beside or in another figure plot a comparison of the TRI DEM and Arctic DEM including a distribution of their difference (or do you have the UAV derived DEM as well?). Eventually, in a new figure plot the DEM before and after one selected calving event, the subtraction of the DEMs, mask of the glacier front and the watershed result. Condense the caption: “Velocity field at the glacier front measured a) with the TRI on 19 August 2016 and b) with a UAV”

Figure 4
Plot the rough location and view angle of the picture

Figure 5
Panel a
Could you use an image taken from the TRI position or the radar image in Figure 4 cropped and rotated to fit the format here and with the line you use to stack your data in c)? The current image is confusing as it is in a different orientation than the TRI (taken from a hike to front, I guess) and saturated (I cannot see the front texture).
Panel b-d
extend the plot to the end of the right plot margin. If this was for the legend in b, change min max lines to a polygon (shadow) and place the legend horizontal at the bottom of the panel such as --- Elevation ---- Mean velocity |grey box| Min/max velocity. Indicate the location of the sectors above panel b) and delete them form panel c).
Panel c
Please use a linear colour scale. Your current palette highlights mostly areas with no calving volume change and the yellow parts of your spectrum (7000 m3) and a bit the red ones. Choose a linear colour scale from light yellow to red or blue. Write “data gap” between 22 and 23 Aug.
Panel d

Delete the red dashed line representing 50% and 100% of the mean calving volume in the shallow sectors. I don't understand which message it is supposed to convey. Do you mean that 50% is equal to ~0.4 10^6 m^3 of calving volume?

Figure 9

Stretch the vertical axis for all panels to highlight the variations of your parameters. Shift the shortwave data so that we see that the curve goes to zero during the night (there must still be some light at this latitude mid-august?). Use the same temporal resolution for the Volume and number of events than the two first panel for instance hourly. Cutoff the extreme value on the 26 Aug. evening and write its value on the figure with an arrow pointing to the top. (also see comments *page 16*)