Summary:

The authors introduce a novel technique to detect tidewater glacier calving events from a terrestrial radar interferometer (TRI). Their algorithm detects surface waves along the fjord surface that occur immediately following iceberg calving events. The authors apply their methods to observations acquired in July 2018 along Eqip Sermia, Greenland. They point out that the new method complements previous calving detection methods because it identifies, both spatially and temporally, the location of calving events along the front, and in particular, is the first to detect submarine calving events. They compare their findings against changes in water surface height derived from a water pressure sensor and find good linear relationship with those observations; thus, providing confidence for the technique.

Overall, the authors have presented a well-written and coherent manuscript with an interesting new algorithm that can be applied to other tidewater glaciers. Cryospheric applications of TRIs continue to evolve, and this manuscript demonstrates a novel use of TRI for calving event detection and source location. Many studies have demonstrated that frontal ablation accounts for nearly half of all ice mass lost in Greenland, yet adequate observations of calving processes remain elusive. Diverse calving mechanisms and the short time scales over which these processes occur inhibit observations. Here, the authors present techniques to assess a specific calving style (frequent and abundant calving of small ice chunks) that are nearly impossible to quantify in the field or through remote sensing techniques. Thus, this technique indeed complements other calving identification methods (photogrammetry, tide pressure gauges, seismometers) by capturing these small-scale events that accumulated over time, can represent significant portions of discharged ice. This manuscript will make a fine contribution to *The Cryosphere.* There are several issues that should first be considered. Most concerns are minor and could easily be addressed by providing additional details on the types of calving events observed. A general characterization of the calving event styles (submarine, subaerial, serac collapses, rotating slabs, etc) and approximate quantities of each type observed should be included, if possible, to help convey the utility of this new technique. My comments in the General and Line-by-Line sections below are provided to elucidate where these areas could be addressed in the manuscript.

General Comments:

1) A general characterization of the calving event sizes and styles should be included. The authors detected 2418 calving events over 7.5 days, equivalent to 1 calving event approximately every 4.5 minutes. This seemingly high number of calving events could have affected the geometry of the calving front, yet no discussion on the impact to the calving front is provided. *Did these events cause a change in terminus front position?* No estimate of glacier speed is provided; however, an earlier paper by several co-authors showed flow rates ranged from 1 to 6 m d^{-1} in Aug 2016. Assuming similar flow rates occurred in Jul 2018, the >2000 calving events observed would seemingly induce a significant retreat of the calving front, consistent with the "rapid retreat and flow acceleration" mentioned on L49. To be clear, a thorough characterization of all 2418 events is probably beyond the scope of this study (to introduce a novel calving event detection technique from fjord surface waves); however, additional context about the general size and style of calving events observed is warranted. This would help contextualize the types of calving events detected by this method. A simple characterization would further emphasize the advantage of this new technique to quantify small calving events (see #6 below). In addition, the authors might consider adding the minimum and maximum calving front positions to Fig 2 to demonstrate any change in terminus position, or lack thereof.

2) The authors repeatedly mention the utility of their technique for detecting submarine events; however, it remains unclear how many events were actually submarine in origin or how the surface wave signature from a submarine event may differ from subaerial events and rotating slabs. Their algorithm is based on the power spectra from 30 wave signals (~1% of the detected calving events). *Were these events subaerial or submarine events? Were they of similar event size? How would this algorithm change for larger calving events observed at other tidewater glaciers?* For example, the authors invoke an 800 m upper wavelength cutoff to suppress reflections from the shore. Assuming that bigger calving events produce bigger and longer surface waves, *how could future users differentiate between such events and reflections from the shore? Is this technique limited to tidewater glaciers that only produce small calving events?*

3) The authors use an integration interval of 6 minutes (+/- 3 minutes from maximum wave height) to calculate the Integrated Wave Height Squared (IWHS). This time interval was specifically chosen to "capture most of the wave energy without overlap with following waves" (L142). If calving events occurred, on average, every 4.5 minutes, *how do the authors prevent aliasing from events within short time intervals (e.g. < 6 minutes apart)?* Could the authors please clarify this?

4) The use of TRI for meltwater plume detection is itself novel and intriguing and could be quite valuable to the ice-ocean and fjord circulation communities. However, important details are missing, which should be included. On L148-150, the authors define plume detection as the absence of ice debris coverage (mélange) in azimuth lines along the calving front. *How do the authors discern between plume activity and mélange dispersal due to calving and/or wind events?* The images provided (Fig 1, 2, 5) show the ice mélange at Eqip Sermia appears as a veneer of small iceberg bits floating along the surface that does not occupy the entire fjord (Fig 1). Similarly, both Fig 1 and 5 show alternating areas of sediment rich and clear water. Given the varying surface conditions and lack of an extensive ice mélange that occupied the entire fjord width, *how do the authors differentiate between open water that appears naturally (i.e. in the absence of plumes) from plume driven polynyas?* Finally, including a few of the 195 hourly MLI image stacks could be useful for conveying plume detection with the TRI.

5) Given that several comparisons between the shallow and deep sectors of the bay are made in the manuscript (e.g. Figs 1, 5, 6 and 9 and throughout the text in the results and discussion), the authors might consider quantifying or providing some constraints on the depths in these regions. Walter et al, (2020) demonstrated that sections of the shallow region are actually above sea level. Calved ice falling onto shorelines are likely to create very different surface waves than ice falling into deep water. *Do the authors, in fact, see differences in the surface waves along the very shallow shorelines and those generated in deeper water?* Regardless, some estimate of bed elevation would be useful.

6) The proposed technique presents an obvious advantage over other methods: to quantify calving losses produced from frequent small calving events that are not captured by other methods, including earlier TRI techniques that used similar radar return images to quantify geometric changes along calving fronts. Specifically, this new technique capitalizes on the radar's ability to detect fjord surface waves generated from calving events that produce icebergs that are smaller than the resolution of the radar (e.g. icebergs <32 m in a single dimension at a 4.5 km slant range distance) at temporal sampling rates that are orders of magnitude higher than can be obtained by satellite observations; thus, the technique measures ice mass loss that would otherwise go undetected. As shown in earlier work by some of the co-authors, several thousand of these small events integrated over a 1-week period could produce ice discharge values comparable with fewer but larger events at other glaciers. The major advantage of capturing these small-scale calving events to produce a comprehensive calving record is alluded to in the manuscript, but never stated explicitly. The authors should consider highlighting this benefit to readers.

Line-by-line comments:

L14 & L16: Ice Sheet should be capitalized when used as a proper name (i.e. preceded by Greenland).

L41: Kane et al,(2020) used surface waves to detect calving. The current manuscript quantifies this technique in new and exciting ways. Nonetheless, the Kane reference should probably be included here.

L50: “associated with high calving…”.

L62: The GPRI’s effective resolution is 7 m at 1 km slant range, not 4.5 km. Please correct.

L67: This statement could be written more concisely. Recommend changing to “..water surface height to retrieve the amplitude and timing…”

L71: Only the signal strength (amplitude) is used in this study, the phase is not. Consider removing the mention of phase to avoid confusion or specify that only the amplitude images are used.

L72: raw radar acquisitions “were” stored as…

L83: recommend change “of” to “from”

L91: Do you multi-look the MLI images? If so, please indicate how many pixels in range and azimuth are multi-looked.

L94: “differenced”

L96: Here and elsewhere, wavelengths should be one word, not two. (see also L99, L104)

L97: Only the electromagnetic phase measurements are affected by atmospheric noise. The MLI images (signal amplitude) are not. Since this study only uses MLI images, there should be no need to filter atmospheric noise. Please clarify or remove this statement.

L147-154: As mentioned above, this section would benefit from additional details to bolster the use of TRI for plume detection.

L170: How are wave widths defined? At the time of impact? A maximum width after some length of time? Please clarify.

L175-180: Do you have a figure to support this correlation? It is hard to visualize this relationship.

L194-195: Why are these statistical relationships not shown in Fig 8? Including the linear LSQ fits would be helpful.

L195: Can you explain what you mean by “where open water without obstacles prevails”? What obstacles are you referring to? Bedrock? Sediment shoal?

L238: Recommend removing “The”. As written, it appears as though there are only two TRI-based calving detection methods. Note that the use of TRI MLI images has been used to detect calving before. See, for example, Lüthi et al, (2016), Cassotto et al, (2019), and Kane et al, (2020).

L273: Why are low atmospheric disturbances mandatory if the only TRI product used in this technique is the amplitude of the returned radar wave (i.e. the MLI)?

L279-291: It would seem that in the Ku-band, a significant fraction of the fjord nearest the terminus would need to be sufficiently covered by iceberg bits, an ice mélange veneer, to obtain sufficient radar returns from the fjord water surface. This is alluded to in the paragraph, but not stated explicitly. This seems like an important limitation that should be stated clearly, especially for use in future studies.

L311: Do you mean Figure 2?

L313-315: Perhaps this would be a good paragraph to mention the minimum ice mélange conditions for the detection of surface waves.

L360: Do you mean “Our attempts to …”?

Figure 4: What is the difference between the dashed and solid lines?

Figure 5: “20 minute stacks” – minutes should not be plural in the figure caption. Also, could the authors make the colored lines in panel b (WPI values) thicker to improve readability? Or perhaps modify the color scale to emphasize higher values of WPI? It is difficult to differentiate the higher WPI values (reds, yellows?) from the low values (blue and purples) that appear to dominate the figure.

Figure 6: The value of this figure remains a little unclear. Doesn’t this figure show generally the same result as Figure 5? Furthermore, if I understand the figure correctly, it demonstrates that the magnitude of waves is higher in deeper water than in shallow water, but the wave width is smaller. Is this a consequence of ice falling into very shallow water or perhaps partially on land (shoreline)? Walter et al (2020) showed portions of the shallow region are actually grounded above sea level. This could account for differences in calving induced wave activity. There is no discussion whether ice in the shallow section fell partially into the water. Please address this and whatever impacts it may have on fjord surface waves.

Figure 7: Recommend increasing font size of the ticks along both axes.

Citations:

Cassotto, R., Fahnestock, M., Amundson, J. M., Truffer, M., Boettcher, M. S., la Peña, de, S. and Howat, I.: Non-linear glacier response to calving events, Jakobshavn Isbræ, Greenland, Journal of Glaciology, 65(249), 39–54, doi:https://doi.org/10.1017/jog.2018.90, 2019.

Kane, E., Rignot, E., Mouginot, J., Millan, R., Li, X., Scheuchl, B. and Fahnestock, M.: Impact of Calving Dynamics on Kangilernata Sermia, Greenland, Geophysical Research Letters, 47(20), 1–11, doi:10.1029/2020GL088524, 2020.

Luthi, M. P. and Vieli, A.: Multi-method observation and analysis of a tsunami caused by glacier calving, The Cryosphere, 10(3), 995–1002, doi:10.5194/tc-10-995-2016, 2016.