Dear Dr. Harcourt,

Thank you very much for reviewing the manuscript. We have greatly improved the paper by addressing your valuable comments. In this document, we list our replies (in black) to each of your comments/questions (in blue) and changes (in red) that are going to be integrated into the revised manuscript:

Overview

This paper uses radar measurements from OIB campaigns in summer 2021 over Alaska to 1) track annual snow layers in radargrams, 2) estimate the snow accumulation rate over Mt Wrangell, and 3) analyse snow strata within ice facies. The authors develop a radar age-depth model from Clark et al. (1989) to quantify the two-way travel time of the radar wave through the snow and ice, and constrain the associated parameters using a cost function that aims to minimise the difference between two snow depositional ages to annual increments (i.e. 1 year). The modelled age-depth relationship fits the derived data sets very well and hence provides confidence that the subsequent estimated accumulated rate is sufficiently accurate, with the caveat that local surface processes such as wind redistribution are not completely accounted for. The key result from a glaciological perspective is shown in Figure 8 which shows increasing accumulation rates between 2004 to 2021.

Thank you for your overview. We agree with you that the key results are shown in Figure 8.

General Comments

The paper is well-written overall and provides a very detailed account of the methods used to constrain the parameters in the age-depth model and the subsequent extraction of key variables such as annual snow accumulation rate. The results will be of significant interest to glaciologists and hydrologists interested in understanding glacier mass balance and its impacts on catchment hydrology. Whilst the technical details of the paper are well described, the glaciological interpretation of the data set is under-developed. In particular, I think the paper would benefit from a discussion about surface mass balance processes and how these have changed over time e.g., what are the processes underpinning the increasing accumulation rates in Figure 8. Are there any regional SMB measurements that you can compare to? I've noted some relatively minor technical corrections below which are mostly areas of clarification. If the authors can integrate these suggestions into a revised manuscript, I believe the paper will be ready for publication.

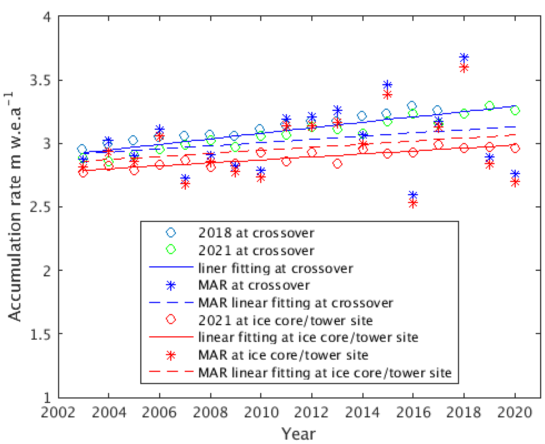
Thank you for your positive general comments and insightful suggestions. Based on your suggestions, in the revised manuscript we provided discussions about the surface mass balance processes and comparisons with the regional SMB and accumulations derived from the Modèle Atmosphérique Régional (MAR) regional climate model data. We worked on this with Dr. Xavier Fettweis who is an expert in the regional atmospheric climate model. Both Dr. Xavier Fettweis and Ibikunle Oluwanisola are now coauthors of this paper for their important contribution to MAR data analysis. We added the following at the end of Section 3.2:

In addition to comparing the accumulation rates estimated from our radar data with the limited available ground truth from the temperature sensor measurements, we also compared our results with the surface mass balance (SMB) estimates using the regional atmospheric climate model MAR (Modèle Atmosphérique Régional). The MAR model simulates energy and mass flux between the atmosphere and the snowpack using EAR5 reanalysis outputs as a 6 hourly forcing dataset. As it was run here at high resolution (5 km), it replicated mesoscale meteorological processes more realistically and has been validated with in situ data and remotely sensed data over polar ice sheets such as Greenland Ice Sheets (GrIS). Further details about the model were discussed in [Fettweis, 2007; 2020] and more recently in [Amory et al., 2021]. For our comparison, we used MAR v3.12.1 which provided over 80 climate fields such as density profiles, SMB, etc. at 5km-grid resolution across Alaskan mountains, permanent ice fields, and glaciers. We computed the annual SMB by summing the daily measurements within the same cycle used in estimating the annual accumulation rates from radar data (May-to-April). The daily SMB was the sum of snowfall and rainfall minus the sublimation, evaporation, and run-off meltwater for each day. Figure 8(b) shows the mean annual SMB over Alaska glaciers between 2016-2021 using the May-to-April cycle. For comparison, we computed the annual SMB at the crossover and the 2004 ice core/2005 temperature sensor tower sites by synchronizing the radar flightline's coordinates and the gridded MAR model output using 2D Delaunay triangulation-based interpolation.

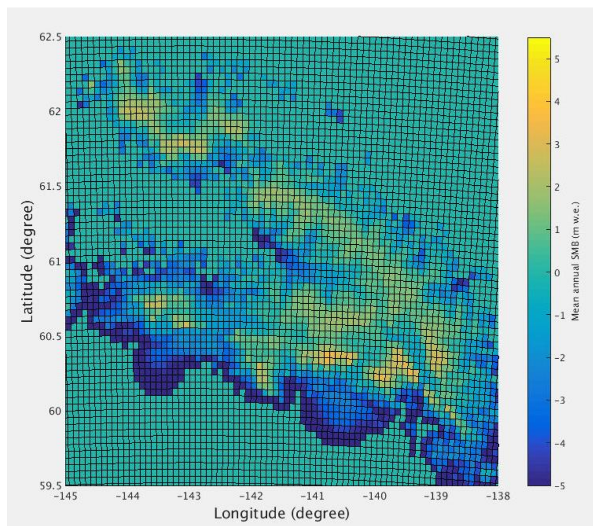
In Fig.8(a), the blue and red stars present the annual SMB values of MAR results at the crossover and the 2004 ice core/2005 temperature sensor tower sites, respectively. The blue and red dashed lines are the linear fitting of these SMB values at the two sites, showing both annual increases of ~0.013 m w.e.a^{-1}. At the ice core/tower site, the MAR SMB between 2005 and 2006 is 2.86 m w.e.a^{-1} compared to the estimated accumulation rate from radar data, which is 2.82 m w.e.a^{-1}. Figure 8(c) presents the differences between the annual accumulation rate r_a estimated from radar data and the SMB computed from MAR outputs, in which the black dashed line with stars shows the site-averaged differences. The absolute values of the site-averaged differences are less than 0.27 m w.e.a^{-1} before 2015 and the maximum site-averaged difference is 0.58 m w.e.a^{-1} in 2016. The linear increasing trend from MAR data is almost the same as what inferred from radar data between 2003 and 2021, although the MAR results have larger variations from year to year, especially after 2015. This linear increasing trend and apparent larger temporal variability in MAR versus radar-based estimates are linked to the increase of snowfall and rainfall events as a result of global warming (see the increase of 0.86°C in 19 years in this area over 2003-2021 in Fig.8(d) according to MAR). This SMB variability driven by the presence of liquid water into the snowpack is smoothed in the radar retrieved signal due to the snowpack compaction and its ability of fully retaining the liquid water. According to MAR, the recent increase of SMB over 2003-2021 is 88% driven by the increase of snowfall accumulation and 12% by the mass gained by rainfall (that is fully retained by the snowpack). The increase of rainfall exceeded the interannual variability, and thus is more statistically significant while the increase of SMB and snowfall are within the interannual variability.

According to MAR data, the surface density in Mount Wrangell's caldera is 317.50 kg/m^3. This figure is 16% less than the value we used in the study, 377.36 kg/m^3. The models' and accumulation estimations' sensitivity to the surface density values was therefore further evaluated. The discrepancies in the density-depth profiles for the two surface density values are depicted in Figure 9(a). As seen in Fig. 9(b), as depth is increased, the projected depositional ages for the tracked layers would get less due to the lower surface density. As opposed to 18.6 years for 377.36 kg/m^3, the age of the deepest monitored layer is 17.10 years for 317.50 kg/m^3. The variations between the annual accumulation estimates are compared in Figure 9(c). Although there are some variations in the annual accumulation rate within a given year, the linear increasing trend is nearly the same (0.011 $m\,w.e.a^{-2}$ for 317.56 kg/m^3 against 0.012 $m\,w.e.a^{-2}$ for 377.36 kg/m^3). This makes sense given that, for a lower snow density, the snow mass likewise decreases as the age difference between two snow layers narrows. As a result, we deduced that the linear upward trend in the annual accumulation rate seen between 2003 and 2021 is not affected much by the surface density.

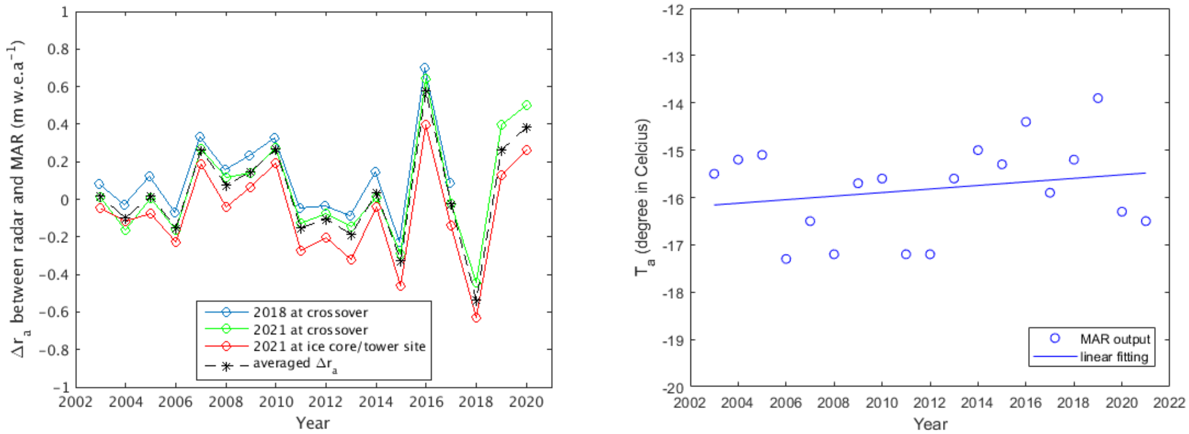
Table 3 summarizes the comparisons among the ground truth, radar, and MAR results. This is the first time that airborne radar observations, temperature sensor measurements on the ground and MAR outputs have been compared to validate annual snow accumulation over Alaska glaciers where MAR has been applied for the first time with success. The significant finding of a linear rising trend in accumulation rate between 2003 and 2021 may aid in more precisely estimating the mass loss of Alaskan glaciers and their impact to sea level rise.



(a)

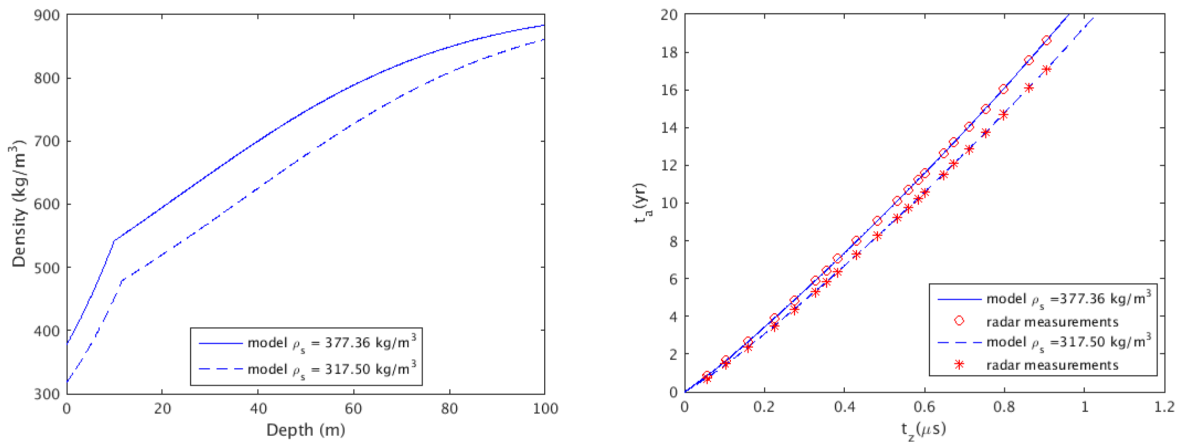


(b)

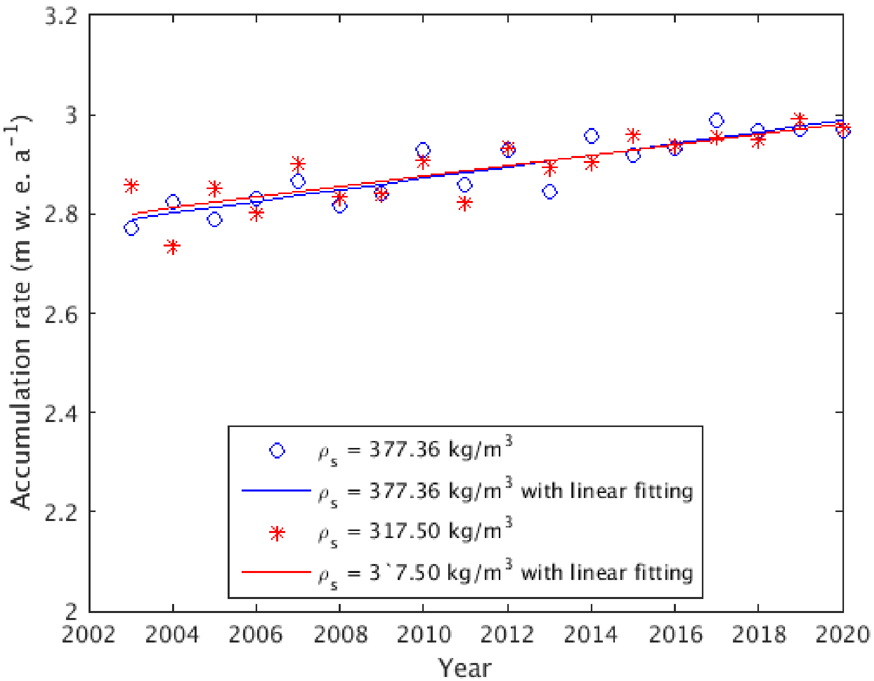


(c) (d)

Figure 8: (a) Estimated annual accumulation rates; (b) MAR map of mean annual SMB over Alaska glaciers between 2016-2021; (c) Differences between r_a from radar data and SMB from MAR; (d) Averaged annual temperature from MAR.



(a) (b)



(c)

Figure 9: Depth-density profiles (a), Snow layer depositional ages (b), and estimated annual accumulation rates (c) for two different surface density values.

Table 3: Maximum layer depth observed D_{max}, effective snow relative permittivity ε_{r_eff} and accumulation rates r_a estimated at the two study sites.

	2004/ 2005 ice core & temperature sensor tower site (61.9908°N, 144.0256°W)			**2018/2021 crossover (61.9859° N, 144.0068°W)**	
D_{max} (m)	78.91			70.78/80.78	
ε_{r_eff}	2.96			2.89/2.96	
r_a (m w. e. a^{-1})	Radar	MAR	Temperature sensor	Radar	MAR
2005-2006	2.82	2.86	2.75 (ground truth)	2.97	2.90
2003-2021 (averaged)	2.89	2.96	NA	3.10	3.03
Linear trend (m w. e. a^{-2})	0.011	0.012	NA	0.022	0.013

We accordingly revised L19 in the abstract as:

Additionally, we discovered a linear increasing trend between the years 2003 and 2021 of 0.011 m w. e. a^{-1}, which was supported by comparisons with the surface mass balance (SMB) derived for the same period from the regional atmospheric climate model MAR (Modèle Atmosphérique Régional). According to MAR data, which show an increase of 0.86°C in this area for the period of 2003-2021, the linear upward trend is associated with the increase of snowfall and rainfall events because of global warming. The findings of this study confirmed the viability of our methodology, as well as its underlying assumptions and interpretation models.

We also accordingly revised L357-359 in Section 4 for summary and conclusions:

The noteworthy discovery of the linear rise trend in accumulation rate between the years 2003 and 2021 as a result of global warming was corroborated by comparisons with the SMB derived for the same period from the MAR model. The findings of this investigation confirmed the validity of our technique and the assumptions and interpretation models it was based on. Future research may extend these findings throughout the entire caldera for the geographical pattern of snow accumulation utilizing gridded observations of strata.

Technical Corrections (References to line numbers in preprint)

Abstract

L9-L10: This sentence should come straight after your introductory line. Then you can launch into a description of your findings including observing snow strata in ice facies.

As suggested, we reordered L8-L13 as:

This paper reports seasonal snow depths derived from radar data. We found large variations in seasonal radar-inferred depths with multi-modal distributions assuming a constant relative permittivity for snow equal to 1.89. About 34% of the depths observed in 2018 were between 3.2 m and 4.2 m, about 30% of the depths observed in 2021 were between 2.5 m and 3.5 m. We observed snow strata in ice facies, wet-snow/percolation facies and dry snow facies from radar data and identified the transition areas from wet-snow facies to ice facies for multiple glaciers based on the snow strata and radar backscattering characteristics.

Introduction

L25: Not sure what is meant by 'Earth's ecosystem'. Maybe just 'the Earth's climate system'.

Revised as suggested:

Glaciers outside Greenland and Antarctica play an important role in the Earth's climate system and respond rapidly to changes in climate which impacts regional hydrology and the local economy.

L25-26: Suggest change to: 'in the Earth's climate system and respond rapidly to changes in climate which impacts regional hydrology and the local economy.'

Revised as suggested, see our reply above.

L29-L33: This is a long sentence and can be shortened. Focus on the global trend and then specify exactly the mass loss from Alaskan glaciers as an example. Where possible, avoid lots of clauses as it breaks up the flow of the sentence.

This long sentence was revised into two short sentences as suggested.

Another study claims that global glaciers are increasingly losing ice mass since the twenty first century and contributed 6 to 19 percent of the observed acceleration of sea-level rise during 2000-2019; the mass loss of Alaska glaciers was the biggest contributor and accounted for 25 percent of the global glacier mass loss compared to the second largest contributor, glaciers of the Greenland periphery, with 13 percent [Hugonnet et al., 2021].

L34: Start new sentence here: '…Hill et al., 2015).The changes in glacier discharge…'

Revised as suggested.

L35: 'home to important'

Revised as suggested.

L39: Maybe spaceborne?

Revised as suggested.

L41: 'However,"

Revised as suggested.

L51-53: Worth stating that ground-based measurements are also used for satellite validation of snow products.

Revised as suggested:

Ground-based measurements are used to validate both airborne and satellite observations and data products, and airborne data can also be used to validate satellite observations and data products [Lindsay, et al., 2015; Ramage, et al., 2017; Largeron, et al., 2020; Jeoung et al., 2022].

L55: 'at a glacier-scale'

Revised as suggested.

L58: 'within temperate firn'

Revised as suggested.

L63: 'with a 6-GHz'

Revised as suggested.

L64: Reference Figure 1 here

Revised as suggested.

L66: ‘using snow pit measurements to 10 m depth’

Revised as suggested.

L71: ‘across a broader spatial region than compared to the 2018 campaign (Li et al. 2019)’

Revised as suggested.

Data collection and processing

L79: ‘over 8 days covering 5115 linear km’

Revised as suggested.

L80-88: It would be better to briefly describe and LiDAR system and discuss the radar antenna installation in a little more detail rather than referring to a previous paper. A table of critical radar system parameters would also be useful.

We added the following information as suggested:

Table 1 lists the key system parameters of the CReSIS’s compact FMCW snow radar system. The details of the on-board LiDAR from the University of Alaska, Fairbanks can be found in [Johnson et al., 2013]. The snow radar’s transmit antenna was installed in a protective dielectric radome under the noise of the aircraft, and its receive antenna and the LiDAR were installed in a circular port located in the aft area of the aircraft.

Table 1: System parameters

Parameter	Value	Units
Weight	35	lb
Dimensions (WHD)	14.5,9,7	inch
Frequency band	2-6	GHz
Pulse duration	250	Ms
Pulse repetition frequency	4	kHz
Peak transmit power	1	W
Range resolution	3.75 (free space)	cm
Hardware averages	16	
Antenna type (TX/RX)	Horn	
bandwidth	2-18	GHz

beamwidth	86-19/52-9	degrees
gain	7-13/9-23	dBi
A/D converter	14	bit
Sampling rate	125	MSPS

L81: 'altitude above ground level (AGL)'

Revised as suggested.

L83-84: To understand this the reader would also need to know the ADC sampling frequency, which can go into a table of parameters.

Revised as suggested (see Table 1).

L85: State the vertical resolution before and after changing the bandwidth.

Revised as suggested.

L90: Change brown to colour to distinguish from red; black might work?

Changed as suggested.

L92-93: State spatial coverage in km2?

We rewrote L90-94 to address your comment on Fig. 1, and the spatial coverage was stated accordingly in km^2. See our reply to the comment on Fig. 1.

L99: What was the magnitude of the correction applied to the radar system delay?

The corrections applied to the radar system delay were 0.064 μs and 039 μs in 2018 and 2021, respectively. We added this information in the revised manuscript.

L101-104: It would be helpful to provide a little more detail on these processing steps e.g., general outline of how the processing performed, performance improvement and the reason for using each step. Does the order matter? Similar to the deconvolution, were any of these steps applied differently to previous campaigns? Results analysis and discussions

We added a processing flowchart in Figure 2 and greatly expanded the discussion with details:

Figure 2 shows the data processing flowchart with 8 main steps:

1) The GPS and radar data were synchronized using the UTC time stored in the raw radar data files. The accurate longitudes, latitudes and elevations of the radar phase center along the flight path were computed with the position information of the radar and GPS antenna and the information of aircraft attitudes provided by the onboard IMU (Inertial Measurement Unit) system. Each trace of the raw radar data was tagged with the longitude and latitude of the radar antenna's phase center as its geolocation, and the elevation of the antenna's phase center was used as the zero reference for the two-way travel time (TWTT) from the aircraft to the surface.
2) The coherent noises were automatically tracked by finding the near-DC component in slow-time and were removed by subtraction. The coherent noises were caused by the feedthrough signal due to antenna coupling and undesired spurious signals generated from active microwave components of the radar system. These noises would reduce the signal-to-noise ratio (SNR), interfere with surface tracking and deconvolution if were not removed.
3) A fast-time FFT (Fast Fourier Transform) was applied trace by trace with a Hanning window to reduce sidelobes. This step, analogous to pulse compression, obtained the target response as a function of range.
4) A deconvolution filter was applied after the fast-time FFT to further reduce sidelobes and the range resolution degradation due to any other system artifacts, such as signal reflections between radar hardware components, filter's nonlinear group delay, the digital chirp's amplitude variations and frequency nonlinearity. Minimizing sidelobe level is important because sidelobes from strong interfaces could be misinterpreted as snow layers or mask weak reflections from real interfaces. The implemented deconvolution filter was an inverse filter of the radar system impulse response which was derived using specular returns from electrically smooth surface such as the calm-water surface of a lake.
5) The coherent integration was performed by stacking data traces together with the averages. This process was an unfocused SAR (Synthetic Aperture Radar) processing to improve the SNR. It included hardware and software stacking. The hardware stacking was implemented in the radar's digital system and reduced the volume size of the recorded data. The software stacking was carried out after the deconvolution in data processing. The incoherent integration was carried out after the coherent software stacking by taking the average of

the squared data of several traces. Incoherent integration reduced the signal fading effects and the data size of the final radar echogram. The number of traces in the coherent hardware integration was 8 and 16 in 2018 and 2021, respectively. The number of traces in the coherent software and incoherent integrations was 2 and 5 respectively in both 2018 and 2021. The PRF (Pulse Repetition Frequency) was 4000 Hz and 6250 Hz in 2018 and 2021, respectively. The combined coherent and incoherent integrations determined the spatial sampling frequency along the flight path and the along-track resolution depended on the aircraft velocity and the effective PRF which is 50 Hz and 39.0625 Hz in 2018 and 2021, respectively. At the typical velocity of 50 m/s during the surveys, the along-track resolution was 1m and 1.28 m in 2018 and 2021, respectively.

6) The surface was automatically tracked at this step using a threshold method. The automatic tracking usually picked the surface nicely except at the locations where the Nyquist zone changed, or the surface elevation changed very rapidly between narrow valleys. In the latter case the backscattering from both sides appeared in the leading edge of the surface and affected the threshold tracker. At these locations we corrected the surface tracking semiautomatically in our picker using manual control points.
7) The data was elevation compensated with accurately tracked surface to remove large aircraft elevation changes for effective data truncation, display radar echograms and post radar images. Two mostly used compensation options were WGS-84 elevation compensation and depth elevation compensation. The radar echogram or image was showing the real surface topography in WGS-84 datum after the WGS-84 elevation compensation. The surface was flattened after the depth elevation compensation to better display the depth between snow layers. The depth elevation compensation was implemented by using a low pass filter to get a smoothed version of the tracked surface in radar echograms, the smoothed surface was then used as the zero-depth reference and the radar echograms were normalized to this reference. The high-frequency texture of the surface was therefore kept after the surface flattening.
8) The final processed radar data and images were generated according to selected elevation compensation method.

The same processing steps and parameters were used in processing the 2018 and 2021 datasets except the above-mentioned different bandwidth, hardware stacking and PRF settings. More discussions about the data processing procedures can be found in [Panzer et al. 2013; Yan et al., 2017].

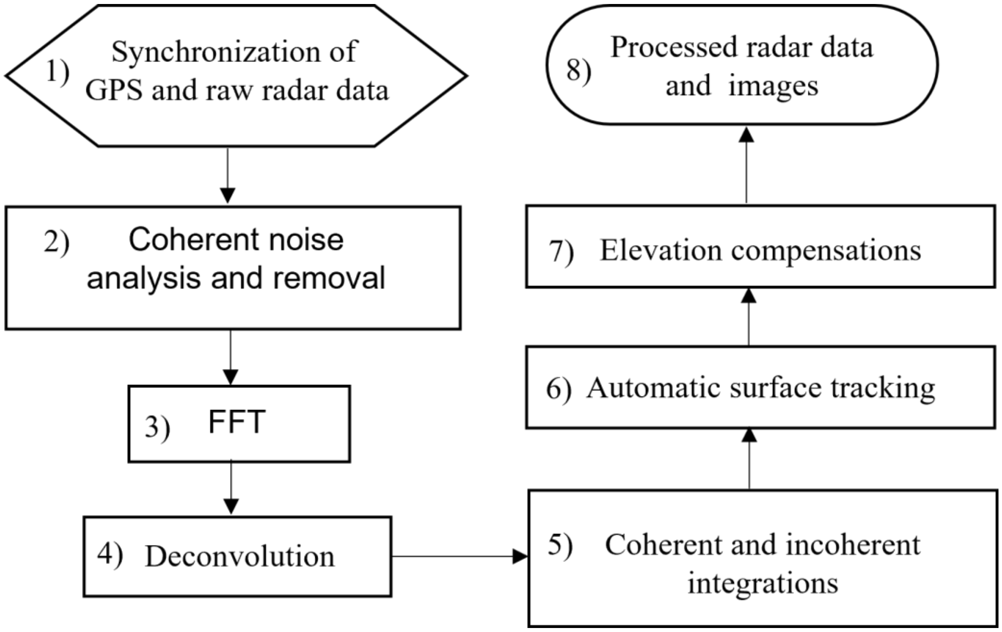


Figure 2: Flowchart of data processing main steps

L112: “above sea level”

Revised as suggested.

L113: ‘focus on the analysis of

Revised as suggested.

L114: ‘discuss observations along the transition from the accumulation to the ablation zone along

Revised as suggested.

L122: I assume by ‘flattening’ you mean normalised to surface elevation? If so, was this from the lidar data?

No, the “flattening” did not use lidar data. See the above explanations for processing step 8.

L124-126: Both years have multi-modal peaks largely ranging between 1-6 m. Better to state this and the means of each individual distribution. This would also reveal the lack of a third peak in the 2021 data. Why might this be? More melt?

We revised L124-126 according to the suggestion and explained the lack of a third peak in the 2021 data:

Both years have multi-modal peaks largely ranging between 1-6 m. For the 2018 data, the mean values of the three distributions are around 1.2 m, 3.7m and 5.5 m. For the 2021 data, the mean values of the two distributions are around 1.1 m and 3 m. The third distribution in 2018 were mainly from thick seasonal snow along Logan Glacier and the upper Hubbard Glacier where we did not fly over these locations in 2021 (See Fig 1(c)).

We revised L10 in the abstract:

We found large variations in seasonal radar-inferred depths with multi-modal distributions assuming…

We also revised L348-340 in section 4 for summary and conclusions:

The seasonal snow depths have multi-modal distributions. About 34% of the depths observed in 2018 were between 3.2 m and 4.2 m, about 30% of the depths observed in 2021 were between 2.5 m and 3.5 m.

L133: What month were the 1994 measurements taken and are you able to quantify differences in air temperature between that study and this one?

According to [Arcone, 2002], the 1994 measurements were taken in early summer. The specific month were not stated, but I guess it should be in June, the first month of the summer in Alaska. According to the regional atmospheric climate model MAR, the average temperature in June was -0.85 degrees Celsius in 1994; the average temperature in May was -3.9 and -3.4 degrees Celsius in 2018 and 2021, respectively.

L139: Change 'massive' to 'large'

Revised as suggested.

L141: 'researchers have been drawn to study glacier-volcano interactions

Revised as suggested.

L144: 'are also both'

Revised as suggested.

L145: 'covers a 4.2 km by 2.7 km area.'

Revised as suggested.

L155: 'subsurface layers'

Revised as suggested.

L169: ‘shows a plot of the flight line’

Revised as suggested.

L180: It might be beneficial to have a short sentence explain what is meant by an ‘interpretation model’.

We added the following to explain the “interpretation models” after Eq. (7):

We refer to the empirical density-depth profile, the snow density-permittivity profile, and the physical processes and assumptions underlying the equations as interpretation models.

182-189: It’s very hard to differentiate the notation for density and pressure. Maybe change the notation for pressure to capital P for readability?

We changed the notation for pressure to capital P as suggested.

L210: I agree with the assumption of steady-state conditions. Maybe also state that based on S3 there is also a skew towards more positive differences which could imply more snow accumulation in winter 2021.

Actually, the skew towards more positive differences implies less snow accumulation in 2021. We added the following at the end of L210:

Based on Fig. S3(c), there is a screw towards more positive differences which implies less snow accumulation in 2021. This is supported by MAR outputs which shows the surface mass balance was 3.1 m w. e. and 2.7 m w. e., respectively in 2018 and 2021.

L227: As far as I can see you haven’t stated how the layers were picked – manual, semi-automatic or automatic?

We added the following at the end of L228:

The snow layers were tracked using semiautomatic methods through the GUI (Graphic User Interface) of our picking tool. Control points were manually placed along each layer and one of the automatic linear interpolation, snake and Viterbi trackers was selected to best track the layer between these control points efficiently. In most cases the Viterbi tracker best and efficiently tracked the layers [Berger et al.,2019].

L228: What density values were used to calculate the permittivity, kg/m3?

The density values were not directly used to calculate the effective permittivity. We added Eq. (11) in the revised manuscript to explain how it was calculated. According to Eq. (7), the density values are 823.53 kg/m^3 and 847.61 kg/m^3 for effective permittivity values of 2.89 and 2.96 respectively. L288-289 were revised as:

The effective relative snow permittivity ε_{r_eff} in Table 3 is calculated as:

$$\varepsilon_{r\_eff} = (\frac{c\, t_{z\_max}}{2D_{max}})^2 \quad (11)$$

where t_{z_max} is the two-way travel time from the surface to the deepest layer at the depth of D_{max} observed by the radar.

L229: 1.127 km east, west, north or south?

Revised as "1.127 km southeast of the ice core site".

L251: 'values of the cost'

Revised as suggested.

L257-258: Exactly how is the value of J applied to calculate the depositional ages of the tracked layers?

As the cost function, J was minimized to determine b_w and Δ_0, two parameters needed to solve Eqs. (1)-(8) for the depositional ages of the tracked layers. We added the following in L258:

The closer J is to 1, the more the tracked layers are annual accumulation layers. J increases when there are intra-annual layers tracked. Because we counted dispositional ages from the surface when the data was collected, there might be a constant offset if the first annual layer was not formed one year ago. However, this offset will not affect the annual accumulation rate estimation.

L259-261: Not entirely clear why these are accumulation layers – they broadly fit into the sequence of annual integer increments…

See our comments above.

L269: "Therefore, our purpose" (i.e. because of the shift identified in the previous paragraph, only accumulation rates can be determined)

Revised as suggested.

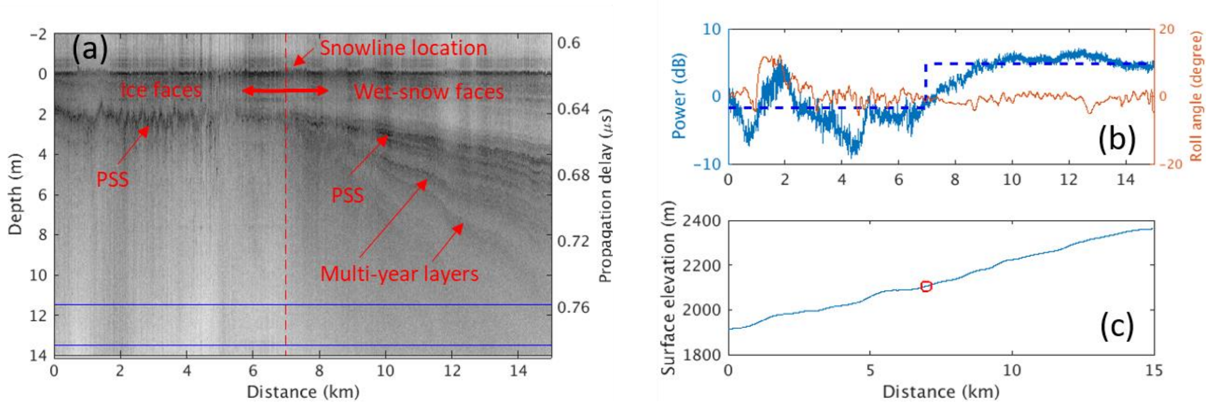
L279-309: These are interesting results and their glaciological intepretations should be assessed further. Why is there a rising trend in accumulation? How does this relate to glacier mass balance? Is there any evidence for melt on ice internal layers and radar backscatter? It's worth highlighting in this section that you are interpretating radargrams from the dry snow facies to illustrate that melt layers are unlikely to be present.

We have revised L279-299 and answered most of the above questions (see our replies to your general comments). We added the following in L302 after "dry snow faces":

(for instance, the two research sites in Section 3.2 near Pit 5 in [Benson, 1968] are on the dry-snow line and represent dry snow facies since we did not observe internal layer melt from radar echograms).

L327-332: This description would benefit from some annotations of Figure 10a, particularly highlighting the broad locations of the facies.

We added annotations for snowline, previous summer layer, multi-year layers, ice facies and wet snow-faces in now Fig. 11(a).



Figures

Figure 1: A little difficult to see the flight lines. Could you have a small inset panel for the region and then extent indicators showing the two main regions surveyed?

We replaced Fig. 1 with Fig.1(a), (b), and (c), and rewrote L90-94 accordingly; we also referred to Fig. 3(a) and (b) for detailed flight lines at Mount Wrangell (WR) and Mount Bona (BO) summits:

The two survey regions A and B in Alaska are shown in Figure 1(a) on the hillshade map using the geographic coordinate system NAD83. A is a 4500 km^2 area that was only surveyed in 2018. The primary region, B, is 83,200 km^2, and it was surveyed in 2018 and 2021. The locations of Ultima Thule Lodge are indicated by the red start. The flight paths for areas A and B in both years are shown in Figures 1(b) and (c), respectively. The campaign's flight lines for 2018 are colored green and red, while those for 2021 are colored black and blue. There are many areas of B that were examined in both campaigns that overlap. The two-letter annotations, which use the first two letters in their names, identify the locations of the glaciers and mountains discussed in this text.

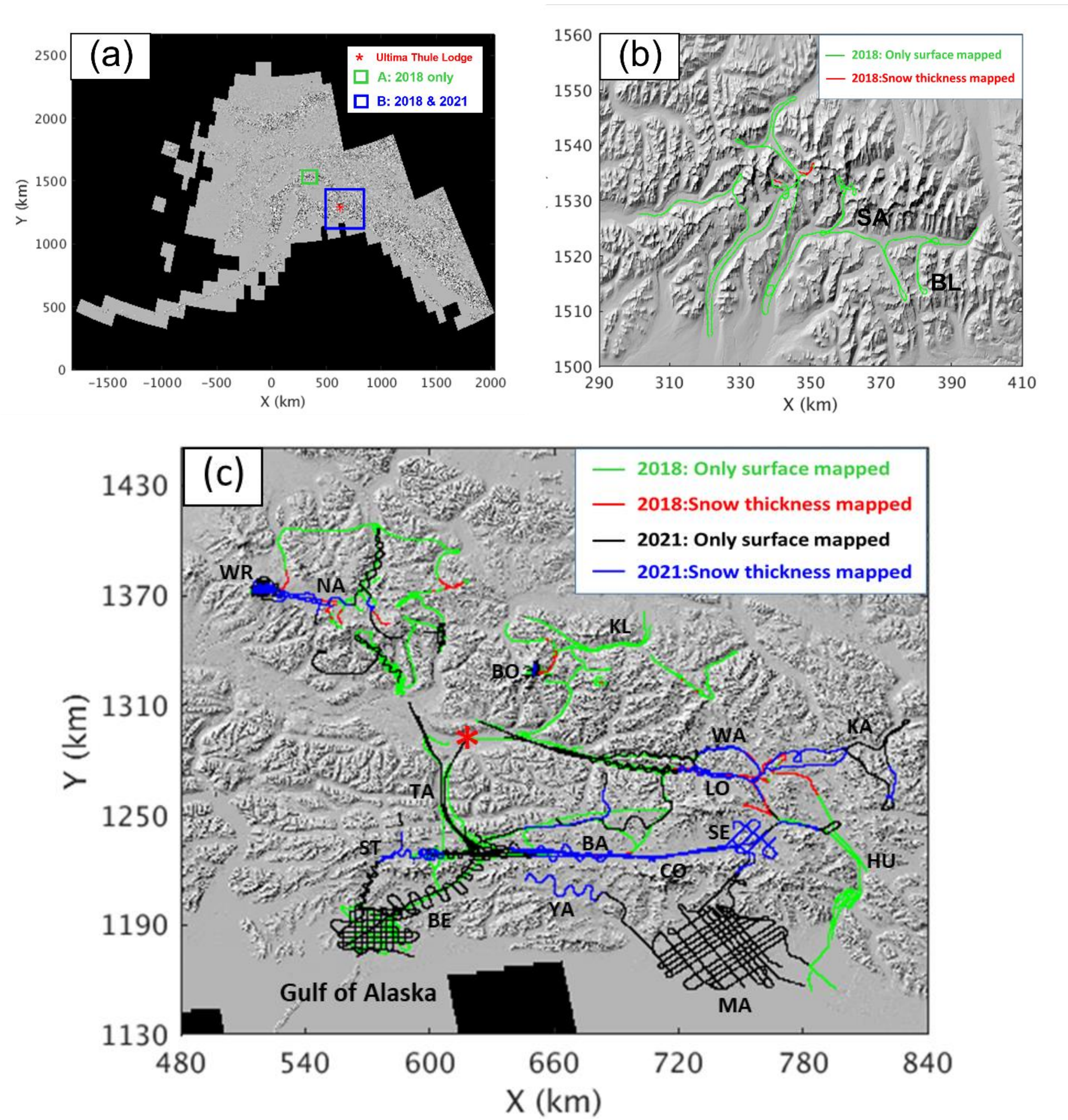


Figure 1: Coverage maps of Snow Radar data from the OIB surveys in Alaska: (a) locations of survey area A and B; (b) Flight lines over A, surveyed in 2018 only; (c) Flight lines over B, surveyed both in 2018 and 2021. Green and red colors represent the locations where the Snow Radar collected data in 2018; flight lines in black and blue colors represent the locations where the Snow Radar collected data in 2021; specifically, the red and blue lines represent the locations where snow layer or snow-ice interface or snow-rock interface below the surface were observed by the compact Snow Radar. The red star marks the location of Ultima Thule Lodge. The two-letter annotations indicate the locations of some glaciers and mountains using the first two letters in their names. Refer to Fig. 3(a) and (b) for detailed flight lines at Mount Wrangell (WR) and Mount Bona (BO) summits. The hillshade map was provided by Dr. C. Larsen.

Figure 3: A legend stating what the blue and red dots represent would be helpful.

Added legends as suggested:

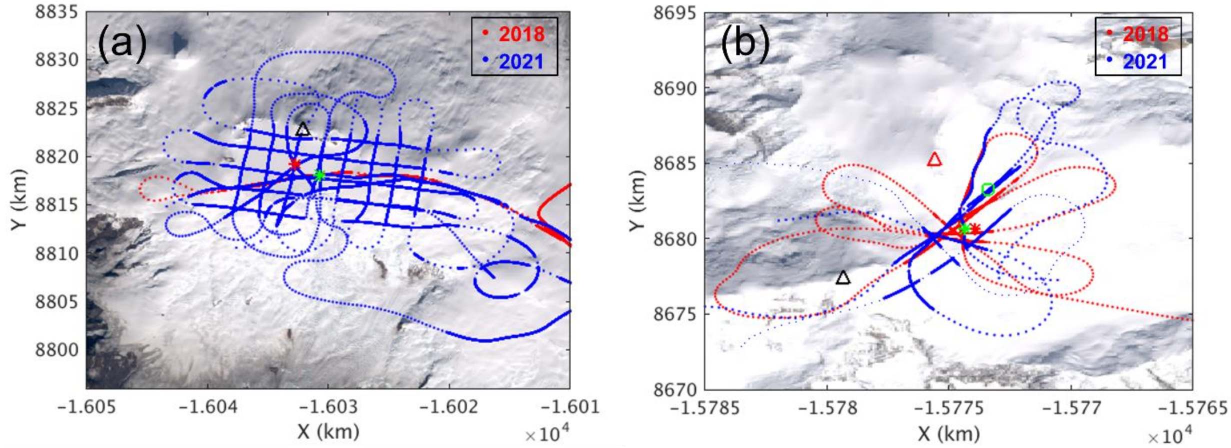


Figure 4: Could you also annotate the location of the surface for clarity?

We added annotations for the surface:

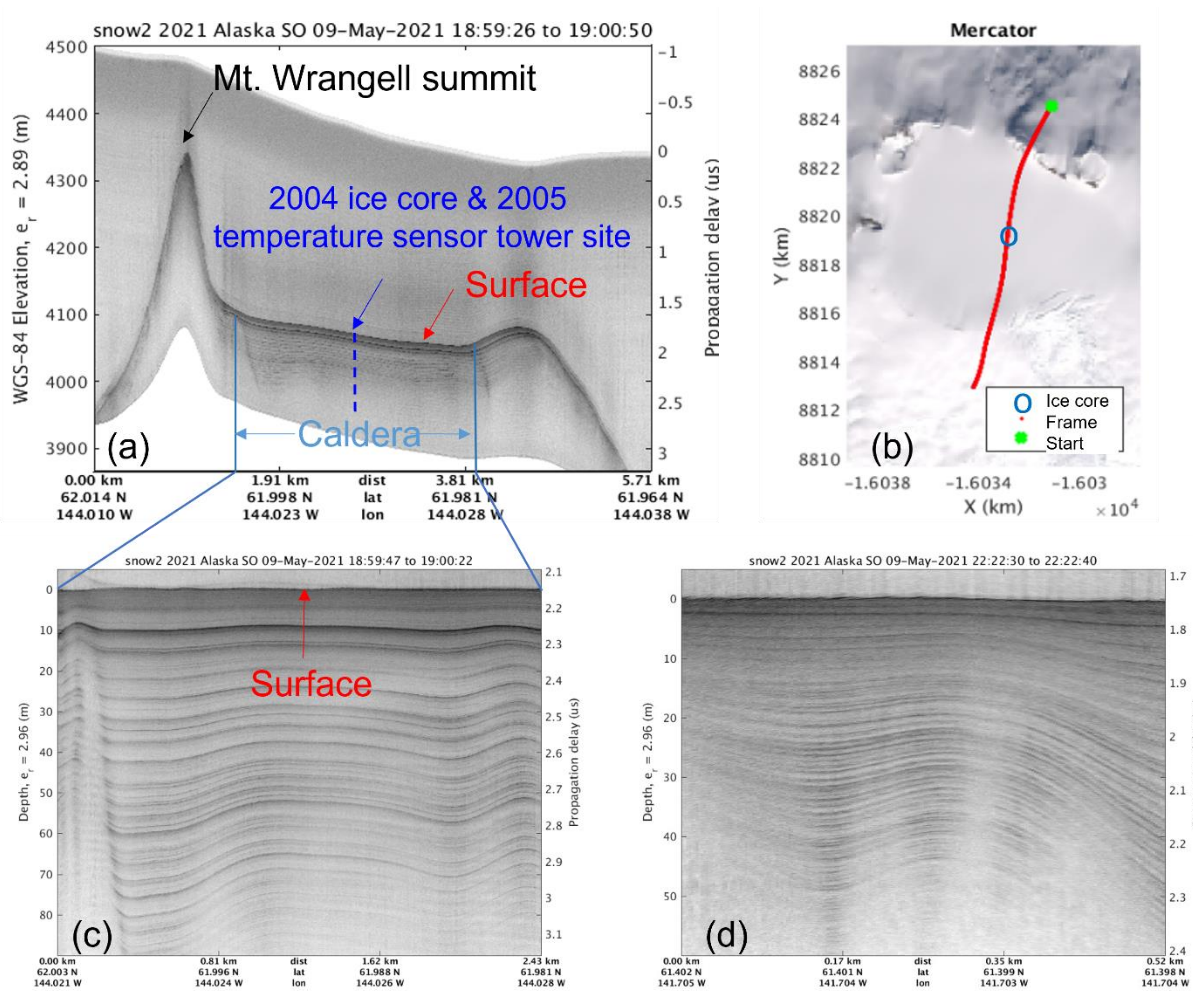


Figure 9: Better to state the elevation of the snow surface in panel d.

As suggested, we changed the y-axis label as "Surface elevation (m)".