Having measured mass balance in the field for 40 years. It is unusual for me to come across a paper that provides significant useful approaches and insights. This paper looking at the mass balance of two glaciers in Austria does so. The authors have collected and analyzed a data set that is richer spatially and temporally during the balance year than other mass balance programs. The density of measurement through space and time limits extrapolation challenges and illustrates problems with a fixed date approach, where the fixed date is inflexible. The paper also highlights the important value of more frequent observations during the ablation season. I have a number of recommendations and questions below that could add value. I do not think these rise to the level of requiring an additional review.

Thank you sincerely for reviewing and for these encouraging comments! All of the measuring team was very happy to read this. The frequent measurements are a lot of work (as you know) and it is very motivating that others see value in these data.

Responses to specific comments are provided below.

25: reword "…drives hydrological change across spatial scales"

OK!

44: Good point wonder if it is better worded with spatial and temporal resolution are included " Preserving all collected data with appropriate metadata captures the highest spatial and temporal resolution is essential for potential future reanalysis and homogenization of time series (Zemp et al., 2013)."

Yes, will change as suggested.

78: Because you refer to a plateau and valley section, it is worth noting elevation range of these sections of MWK.

The flat and wide uppermost regions of the glacier above around 3150m are considered the plateau part of the glacier. This part is confined by a mountain ridge of the Hohe Zaun summit (3450m) and an ice divide at around 3200m to the northerly glacier Schlatenkees and to Frosnitzkees in the east. Below 3150m, the glacier steepens until it ends in a small, narrow and by now relatively short glacier tongue below 2900m. We will add this information to the revised manuscript.

81: the 50-70 m thickness in 2003 not particularly relevant by the end of the study period when ice has become much thinner. Any updated thickness values?

Unfortunately no updated thickness values. The emergence of rock outcrops in the upper sections indicates substantial losses. We hope to update the thickness data in the coming

years either with another GPR survey or geodetic MB as new surface elevation data become available.

92: On VK is the accumulation zone fed by avalanching or significant wind deposition?

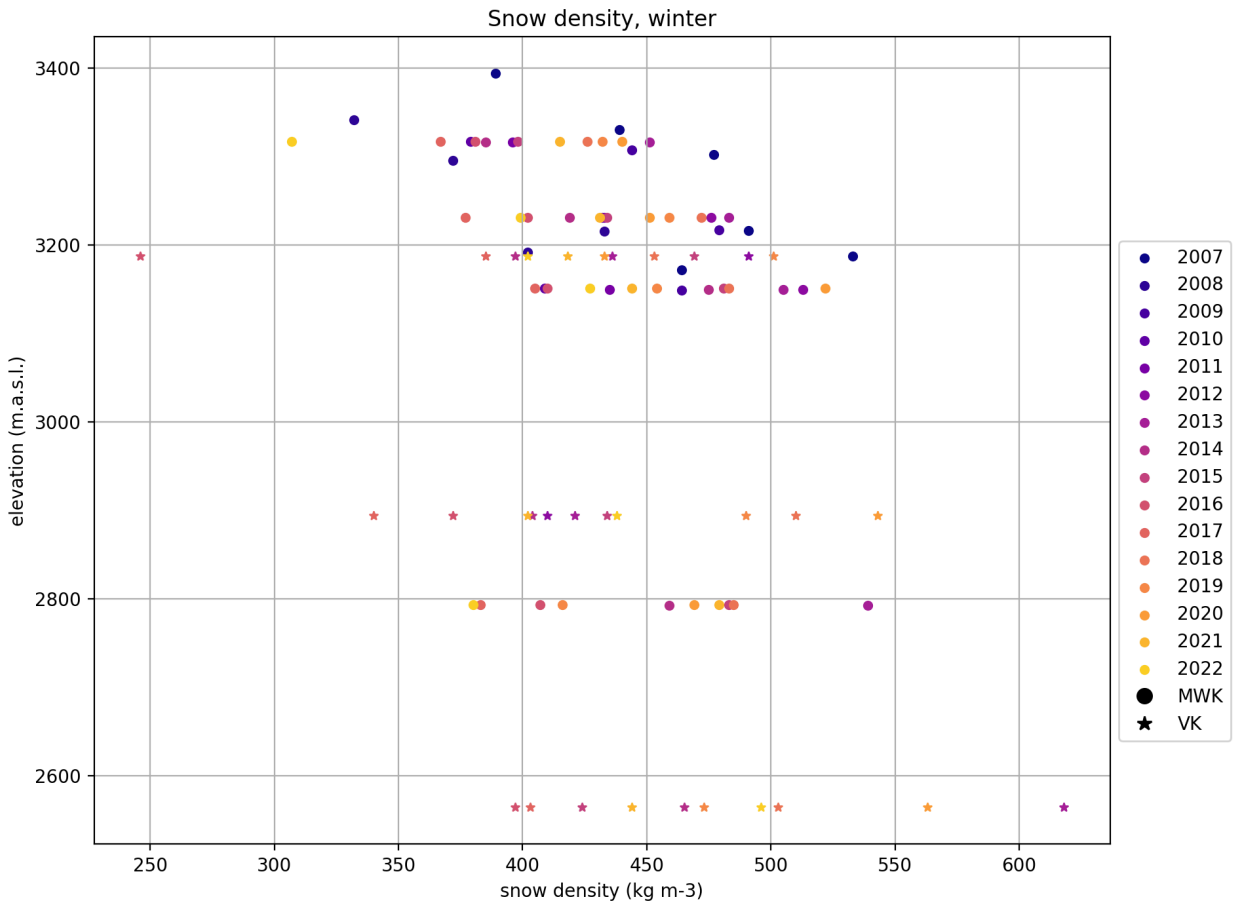
Avalanches do not contribute significantly in the accumulation zone. Strong foehn winds from the south produce wind drift/deposition and likely some additional accumulation below the north face of Großvenediger.

144: Table 1 indicates an exceptionally high measurement density compared to the typical. This is worth pointing out as this also limits spatial extrapolation. The use of considerable fall probing is also something that is often not done reducing summer season measurement density.

We will add a note in the ‘outlook and conclusions’ section to point out the advantages of high measurement density.

165-How consistent is snow density in snowpits near end of melt season? On many temperate glaciers late season snowpack has effectively a uniform density.

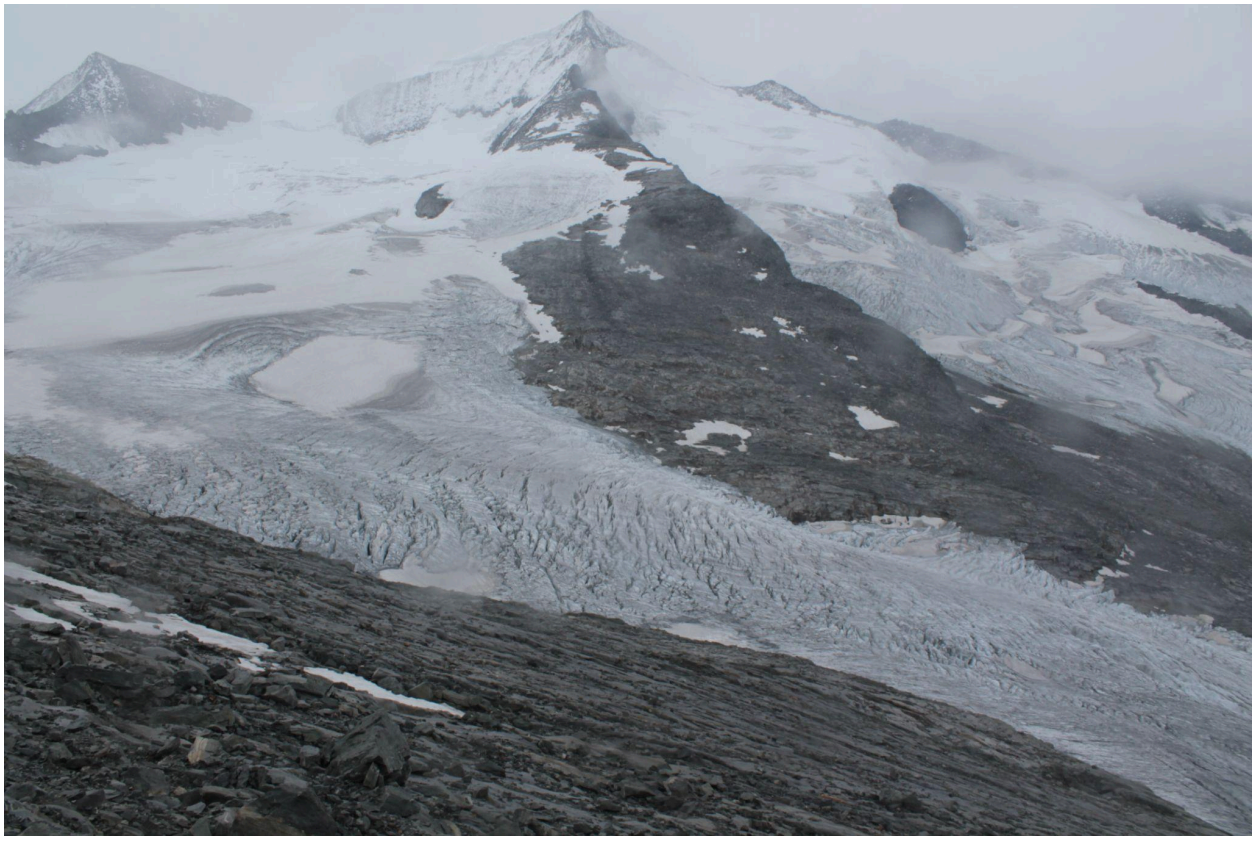
Density at the snow pits is mostly between around 370 and 500kg/m3, with seasonal variations and some elevation dependency. We aim to do the spring MB survey close to April 30 and have often found the snowpack at the lowest pit locations to be wet and mostly isothermal at this stage, while the snow is often still cold at higher locations.



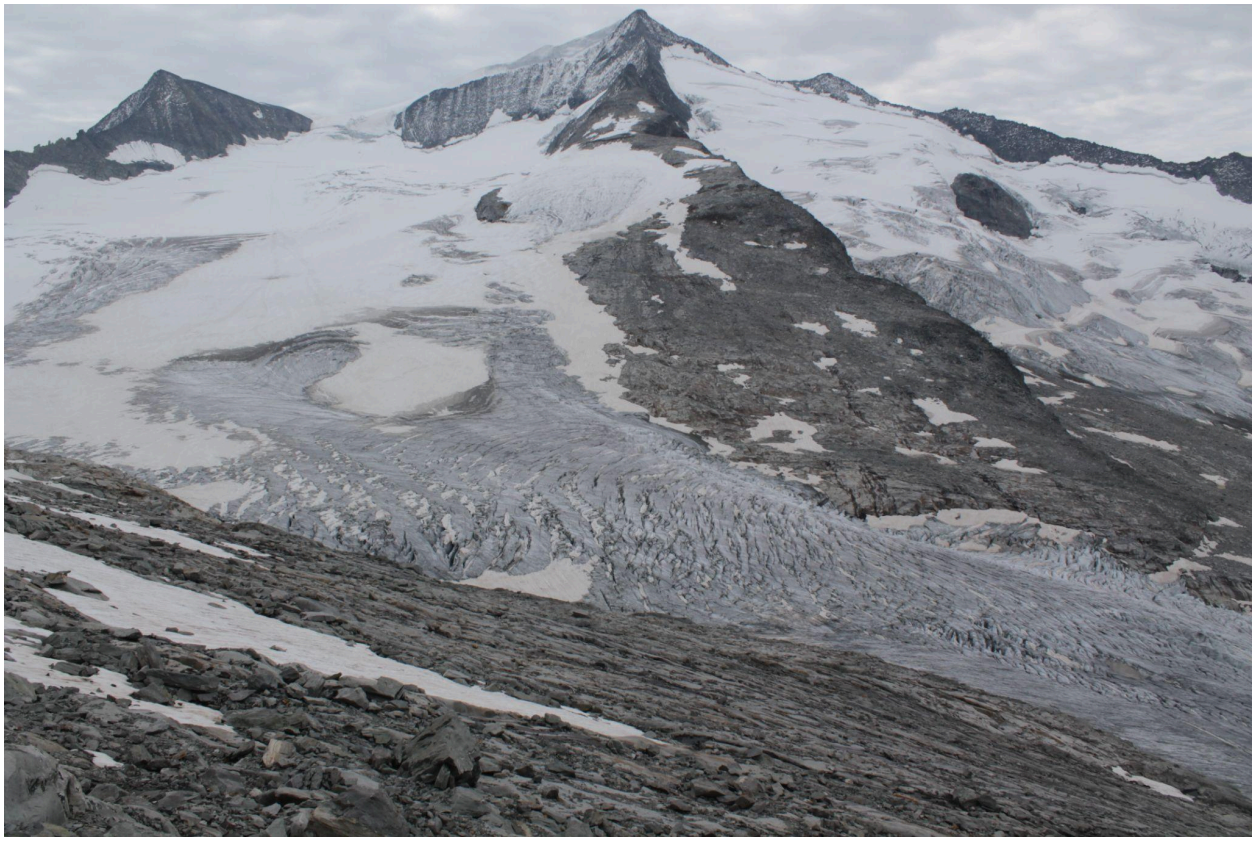
238: The ELA in this case is an average location for the elevation where the accumulation zone begins, how patchy is the accumulation zone, which would indicate how useful the ELA as a separate measure from mass balance? On North Cascade glaciers I have found it impossible to report an observable/useful ELA and instead focus on reporting AAR to WGMS.

At VK, the glacier geometry is such that the ELA value is typically quite representative. There is some patchiness but overall the ELA indicates whether and how far ablation progresses into the upper basin below the north face of Großvenediger. At MWK, the elevation range with the greatest accumulation is shifted due to wind-drift from the plateau and, consequently, ablation can occur above the accumulation area. Here the ELA value is indeed not very useful and we will make a note on this in the revised manuscript. The AAR for both glaciers is reported to the WGMS along with the other data.

Below are some example images from the automatic camera showing the snow line at VK during end of summer conditions in multiple years. The accumulation zone of VK is on the left, the peak in the center of the image is Großvenediger. 2020-09-23:



2021-08-22:



2022-09-07:

This picture shows Mullwitzkees in 2016. The accumulation area is patchy and generally below the highest reaches of the glacier due to local wind effects.

360: Why is it considered essential to convert to a fixed date from the measurement observations?

This is required by the funding organizations of these particular monitoring programs, i.e. governmental hydrology agencies. They operate in the context of the hydrological year and request the glacier data to be reported per hydrological year.

Figure 4 Is an exceptional display of data. Particularly 4a. It would be relevant to use a specific year as an example as well.

Thank you! We can adapt the figure to highlight a specific year, this example shows the 2022 stake readings in red:

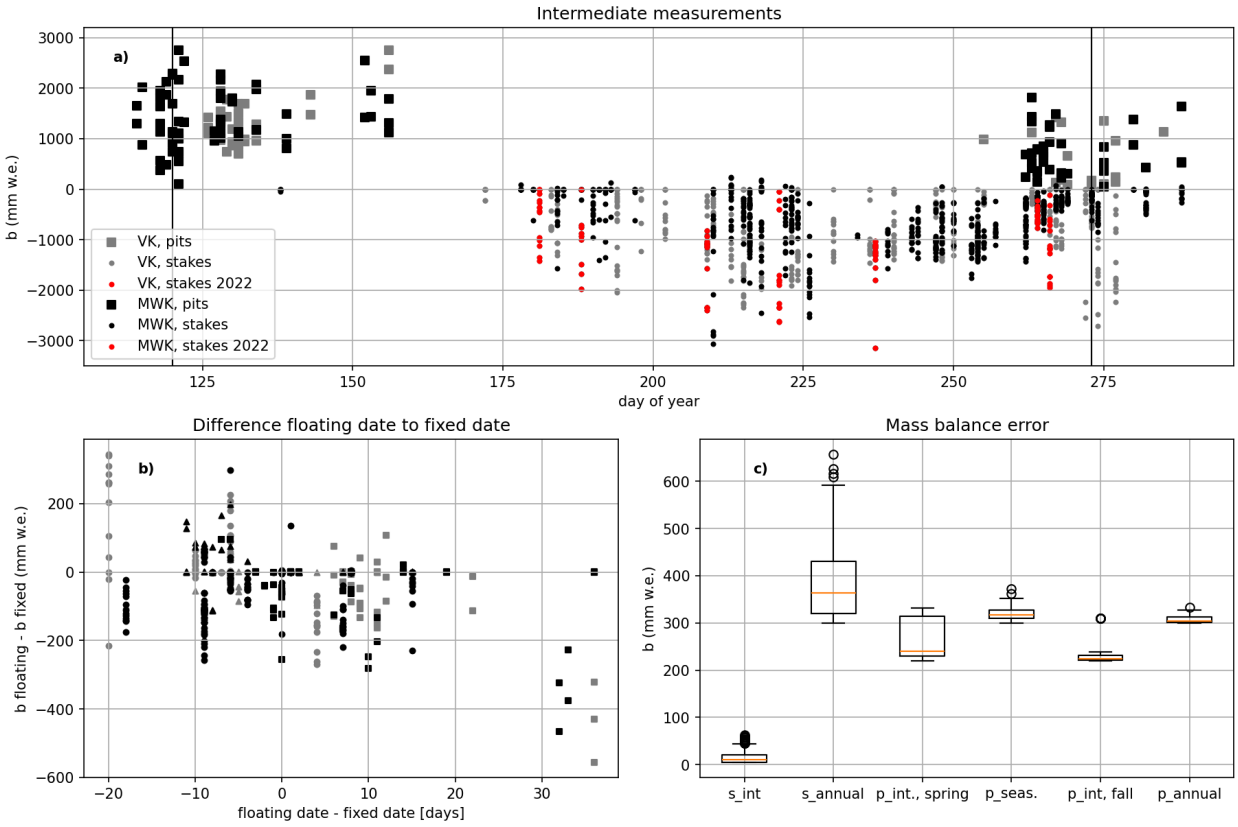
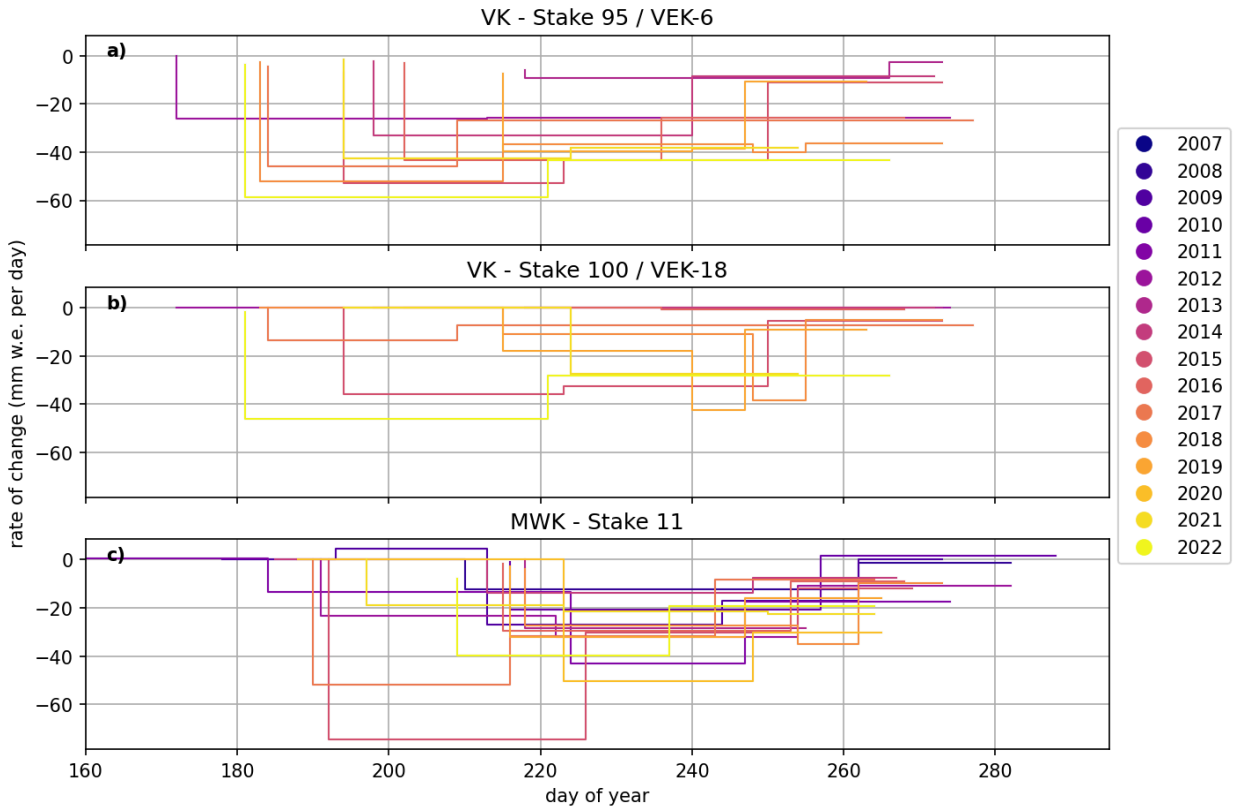


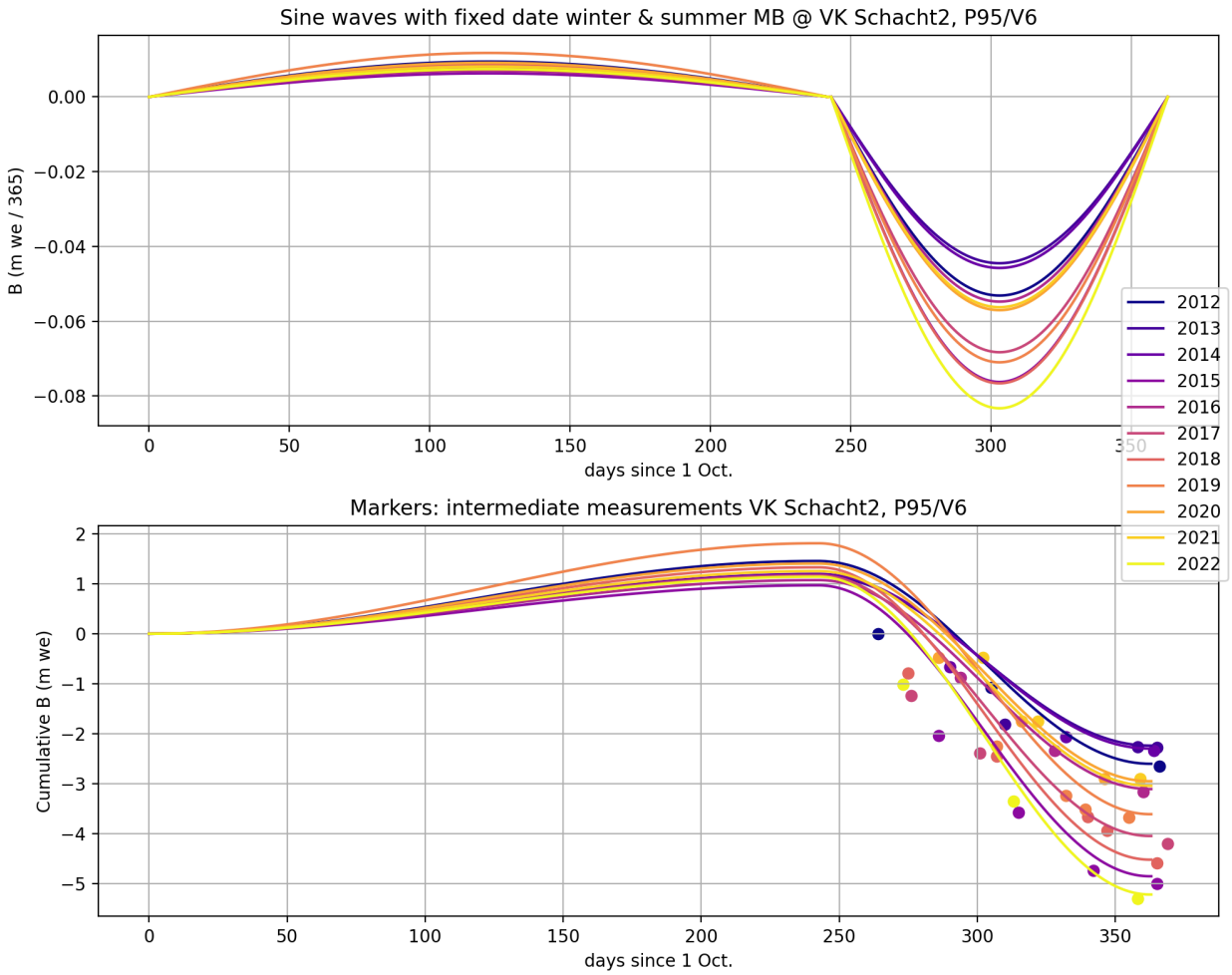
Figure 5 illustrates ablation through time at specific stakes. Visually the rate of loss from year to year appears mostly consistent, statistically how consistent is it?

This depends on the stake and the time of year. Fig 6 shows annual ablation at the stakes (panels c and d) and the range of values recorded in different years. Generating representative statistics on subseasonal rates of loss is challenging since measurement intervals are irregular and the timing of snowmelt varies. Below are two plots attempting to visualize daily change rates for the intermediate measurements. This shows daily change

rates for the same stakes as in Fig. 5 (i.e., the intermediate ablation values divided by the number of days between measurements).



This is a sine wave interpolation as per Zemp and Welty (2023) for a location where we have both a stake and a winter pit (same stake as panel a in the above plot):



394: Not sure I see this as a challenge of this method. I see this as a benefit of the method of such a high density of points. This limits spatial extrapolation which is the benefit of high density mass balance measurement programs.

Will rephrase this so that both points (challenges inherent to probing and benefits of many points) are mentioned: “This represents only a relatively small fraction of the total probe points in the data sets, highlighting the challenges of the method and the importance of a high density of measurement points to capture spatial variability.”

418: Is this reduced ablation because of a higher albedo or simply excess accumulation due to the avalanches that remains after ablation conditions?

Both. Due to the avalanches, snow depth is locally higher and snow melt accordingly takes longer than at nearby stakes without avalanche input. Albedo is higher at the locations with avalanche input for a longer amount of time since they are snow covered for a longer amount of time.

473: Overall did the AWS snow height sensor add any value?

Debatable... The VK AWS location is very wind exposed and the snow height at the AWS is not representative of general conditions. For the MWK AWS, we believe the snow height does represent “average” conditions in the area and problems were related to the sensor rather than the location. The MWK snow data may be helpful for future applications (the faulty sensor has been replaced) and statistical comparisons between the AWS data and the snow measurements on the glacier could be interesting once the AWS time series is a bit longer.

500: Why not note the advantages of moving to a system that tracks the balance year and is not fixed date?

Good point, we will add a note in the revised manuscript to point this out!

References:

Zemp, M., & Welty, E. (2023). Temporal downscaling of glaciological mass balance using seasonal observations. *Journal of Glaciology*, 1-6.