We thank the reviewer for the thoughtful comments and suggestions for the manuscript. Below, we outline our changes for revision based on the comments. The reviewer comments are shown in **blue** and our responses are shown in **black** for clarity.

Summary

This manuscript combines terminus change and ice discharge time series to derive monthly terminus ablation time series for nearly 50 large outlet glaciers distributed across most regions of the Greenland ice sheet. The authors find that most of the sample exhibits coincident seasonal terminus change and ice discharge variability, with a summertime peak in ablation. On seasonal timescales, terminus change contributes to the majority of total ablation, often far exceeding the magnitude of intra-annual variations in flux gate discharge. In light of this, the study concludes that incorporating terminus change is an important component of seasonal and interannual ablation that is excluded from time series using ice discharge time series alone. The manuscript is well written and arranged in a comprehensive and logical structure, with appropriate figures that complement the main results in the text. The methodologies are appropriate for the study and the discussion/conclusions are aligned with the scope of the work presented. This manuscript is therefore nearly suitable for publication in TC in its current form, but there are several aspects of the manuscript that could benefit from additional context and/or clarity, which I detail item by item below:

Main

I think it could be worth including a brief discussion to address types of science questions that can be refined by incorporating a total ablation time series (like the one presented in this study) vs. applications where discharge-only, or similar time series, may be more appropriate. For example, for ensemble mass change studies that often compare Input-Output based methods to altimetry and GRACE, it is useful to derive changed in sea-level contributing mass fluxes. These variations in mass would precede terminus ablation (in conditions where the ablated terminus was floating or near-flotation) because that sea level volume has already been displaced. The manuscript does a good job of describing circumstances (specifically w.r.t fjord conditions and freshening) why total ablation is a refinement over ice flux alone, but does not mention that other mass change related studies may not necessarily benefit from this additional term.

We agree with the reviewer on the relevance of terminus ablation time series and discharge time series for different cases. Based on the suggestion provided, we will add the following paragraph on the discussion on line 299:

"While the seasonal terminus ablation helps in understanding seasonal processes at the fjord scale, discharge-based time series may be more appropriate for applications focused on large-scale ice sheet mass change and sea-level contribution (Gardner et al. 2013; Jacob et al. 2012). Intercomparisons of GRACE-derived mass loss (Velicogna et al., 2014; Sasgen et al., 2020; Groh et al., 2019) or altimetry-based mass balance (The IMBIE Team) should consider whether discharge or terminus ablation is more directly comparable at regional scales based on the likelihood that glacier termini reach flotation prior to iceberg calving."

References:

Gardner, A. S., Moholdt, G., Cogley, J. G., Wouters, B., Arendt, A. A., Wahr, J., Berthier, E., Hock, R., Pfeffer, W. T., Kaser, G., Ligtenberg, S. R. M., Bolch, T., Sharp, M. J., Hagen, J. O., Van Den Broeke, M. R., & Paul, F. (2013). A reconciled estimate of glacier contributions to sea level rise: 2003 to 2009. Science, 340(6134), 852–857. https://doi.org/10.1126/science.1234532

Groh, A.; Horwath, M.; Horvath, A.; Meister, R.; Sørensen, L.S.; Barletta, V.R.; Forsberg, R.; Wouters, B.; Ditmar, P.; Ran, J.; et al. Evaluating GRACE Mass Change Time Series for the Antarctic and Greenland Ice Sheet—Methods and Results. Geosciences 2019, 9, 415. https://doi.org/10.3390/geosciences9100415

The IMBIE Team. Mass balance of the Greenland Ice Sheet from 1992 to 2018. Nature 579, 233–239 (2020). https://doi.org/10.1038/s41586-019-1855-2

Velicogna, I., Sutterley, T. C., & Van Den Broeke, M. R. (2014). Regional acceleration in ice mass loss from Greenland and Antarctica using GRACE time‐variable gravity data. Geophysical Research Letters, 41(22), 8130–8137. https://doi.org/10.1002/2014gl061052

Sasgen, I., Wouters, B., Gardner, A. S., King, M. D., Tedesco, M., Landerer, F. W., Dahle, C., Save, H., & Fettweis, X. (2020). Return to rapid ice loss in Greenland and record loss in 2019 detected by the GRACE-FO satellites. Communications Earth & Environment, 1(1). https://doi.org/10.1038/s43247-020-0010-1

Jacob, T., Wahr, J., Pfeffer, W. T., & Swenson, S. (2012). Recent contributions of glaciers and ice caps to sea level rise. Nature, 482(7386), 514–518. https://doi.org/10.1038/nature10847

Line 60, On filtering based on BedMachine source: Can the authors provide how many glaciers were excluded due to not meeting the BedMachine source criteria? My understanding was that for the majority of outlets near the margins, mass conservation was a common method for deriving bathymetry estimates (as compared to further inland where kriging is more common). Additionally, how close to the terminus do a direct radar observation hold as applicable to that glacier? For example, do direct observations need to fall within a certain length threshold to be considered robust for the downstream flux ate and terminus thickness calculations?

We selected 58 glaciers across the GrIS based on proximity to radar-based ice thickness/bed elevation estimates. Of these glaciers, 10 did not have sub-annual terminus position time series and were therefore excluded from our seasonal terminus ablation estimates. Most of the glaciers that were excluded due to terminus position availability were above ~80°N (Goliber et al., 2022).

Reference:

Goliber, S., Black, T., Catania, G., Lea, J. M., Olsen, H., Cheng, D., Bevan, S., Bjørk, A., Bunce, C., Brough, S., Carr, J. R., Cowton, T., Gardner, A., Fahrner, D., Hill, E., Joughin, I., Korsgaard, N. J., Luckman, A., Moon, T., Murray, T., Sole, A., Wood, M., and Zhang, E.: TermPicks: a century of Greenland glacier terminus data for use in scientific and machine learning applications, The Cryosphere, 16, 3215–3233, https://doi.org/10.5194/tc-16-3215-2022, 2022.

Line 113, Glacier speed-based filtering threshold: How was the 2x averaged speed threshold (used for filtering erroneous terminus advance observations determined? Was this an empirical Threshold?

The choice of the 2x averaged speed threshold was determined empirically as a tradeoff between improving the quality of the time series and minimizing the loss of temporal resolution. We tested different thresholds (0.5x, 1x, 1.5x, 2x, 2.5x, and 3x the averaged speed) across various glaciers to find the optimal balance—eliminating erroneous terminus advance observations while preserving as much of the original dataset as possible. Among these, the 2x averaged speed threshold provided the best results. In the absence of high-spatial-resolution velocity time series, a broader threshold (e.g., 3x maximum flow speed) is recommended (Liu et al. 2021).

Reference:

Liu, J., Enderlin, E. M., Marshall, H., & Khalil, A. (2021). Automated detection of marine glacier calving fronts using the 2-D Wavelet Transform Modulus Maxima Segmentation Method. IEEE Transactions on Geoscience and Remote Sensing, 59(11), 9047–9056. https://doi.org/10.1109/tgrs.2021.3053235

Line 150, on unaccounted mass change between terminus and ice flux: I understand that past studies have made similar assumptions given the small overall uncertainty this component would add in to the total ablation. However, for glaciers where persistent retreat occurred throughout the study period, resulting in a terminus much closer to the gate than the beginning of the time period, it could be a useful metric to provide the maximum bias this assumption could possibly impose on the final time series. While the number I likely to be small, providing bounds of uncertainty for at least several glaciers where its impact is likely to be the largest, would help support the decision to exclude mass change over this intermediate region.

Thank you for pointing out that we should minimally provide estimates of mass loss due to surface mass balance from previous studies in our discussion. Based on the suggestion provided, we will add the following paragraph on the discussion on line 291:
….is densely packed within fjords. "*We assume that unaccounted mass change between the terminus and the ice flux gate is minimal due to the close proximity of the flux gates to the termini and the fast flow of these glaciers. The majority of the glaciers in our study exhibit relatively stable inter-annual variability, reducing the likelihood of substantial unaccounted mass loss. Specifically, only 7 glaciers, including the fast-flowing Helheim, Jakobshavn, and Kangerlussuaq glaciers, experienced terminus retreat exceeding 3 km over the 10-year study period (Fig. R1). For these glaciers, ice typically flows at approximately 2 km to 6 km per year (Gardner et al., 2019), facilitating the rapid delivery of ice from the flux gate to the terminus. Even under conditions of elevated melt rates, surface melting over this period would amount to only a few meters of ice thickness. Given that ice thickness at the flux gates generally exceeds several hundred meters, this surface melt contribution represents less than 10% of the total ice thickness, making mass loss due to surface melt between the gate and the terminus a minor component of overall ablation. Kochtitzky et al. (2023) estimate that subaerial melting*

contributes approximately ~3% to decadal terminus ablation. Similarly, Bollen et al. (2022) report that unaccounted mass change from Greenland's marine-terminating peripheral glaciers amounts to ~0.4 Gt/year relative to a total discharge of ~4 Gt/year. Importantly, these peripheral glaciers flow significantly slower and contribute less discharge than major outlet glaciers. Moreover, estimates for these losses show a decline from ~0.5 Gt/yr when termini were more extended to ~0.3 Gt/yr during the 1999-2018 period. Given these findings, we conclude that the unaccounted mass change between the terminus and the flux gate is within the overall uncertainty range."

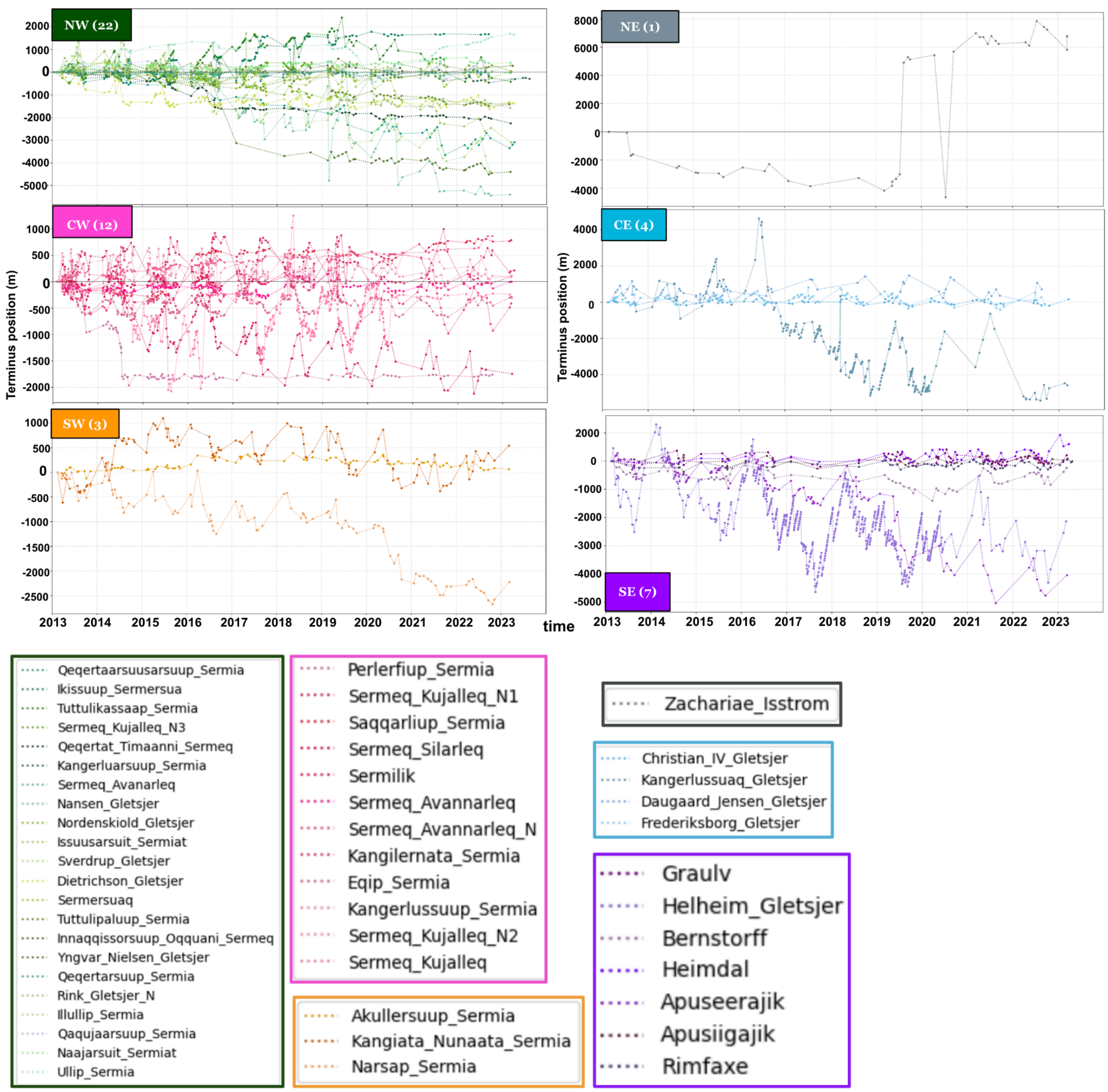

Fig R1: Terminus position time series for each region, with colors corresponding to the regions in Figure 1. Each line indicates an individual glacier corresponding to the names in the lower panel highlighted by the respective region. The numbers in parentheses indicate the number of study glaciers in the region.

References:

Bollen, K. E., Enderlin, E. M., and Muhlheim, R.: Dynamic mass loss from Greenland's marine-terminating peripheral glaciers (1985–2018), Journal of Glaciology, pp. 1–11, https://doi.org/10.1017/JOG.2022.52, 2022

Gardner, A. S., Fahnestock, M., and Scambos, T.: MEaSUREs ITS_LIVE Landsat Image-Pair Glacier and Ice Sheet Surface Velocities: Version 1., 2019

Kochtitzky, W., Copland, L., King, M., Hugonnet, R., Jiskoot, H., Morlighem, M., Millan, R., Khan, S. A., & Noël, B. (2023). Closing Greenland's mass balance: frontal ablation of every Greenlandic glacier from 2000 to 2020. Geophysical Research Letters, 50(17). https://doi.org/10.1029/2023gl104095

Line 181, positive mass change from terminus advance: I did not follow the attribution here that negative terminus ablation was due to an underestimation of bias-induced terminus mass loss. Can the authors provide more explanation here? From my understanding, the fact that seasonal signals present in the Fourier analyses necessitate positive terminus change (or "Negative terminus ablation", i.e., advance) in addition to retreat to exhibit seasonal-scale variability. Can the authors clarify whether all instances of terminus advance are considered a result of bias in their analyses, or whether this refers to a specific treatment of terminus change with respect toa. Reference position?

Thank you for calling it to our attention that we need to more clearly explain how to interpret terminus ablation values. As shown in equation 1, change in near-terminus mass change ($\Delta M/\Delta t$) can be positive (when the glacier is advancing), negative (when the glacier is retreating) or zero (no mass loss at the terminus).

$$A_{terminus} = D - (\Delta M/\Delta t),$$

We will add the following section after equation 1 to clarify.

"The only instance wherein [D – $(\Delta M/\Delta t)$] would be negative is if $(\Delta M/\Delta t)$ > 0 (glacier advance) and $(\Delta M/\Delta t)$ > D. However, negative terminus ablation doesn't just mean that the terminus is advancing, it means that the terminus is gaining mass at a greater rate than the glacier flow rate. Therefore, we attribute negative terminus ablation largely to interpolation effects."

Table 2: Consider adding in variance or STD in paratheses beside the mean values for discharge and ablation in each season. This would provide readers with a sense of interannual variability across the regions and how discharge amplitude and seasonality scale with total ablation.

We agree that the inclusion of the standard deviation for each region is helpful for interpretation of the data and we are going to revise the table based on the suggestion as shown below:

Table 2. Terminus ablation and discharge (in Gt/yr) values averaged across seasons with standard deviations

Regions	Winter		Spring		Summer		Fall	
	Discharge	Term Abl	Discharge	Term Abl	Discharge	Term Abl	Discharge	Term Abl
NW	57 (2)	59 (12)	58 (2)	52 (10)	59 (3)	85 (28)	56 (3)	64 (14)
CW	73 (6)	72 (9)	71 (6)	71 (10)	74 (6)	85 (12)	76 (7)	70 (10)
SW	8 (0.5)	8 (0.7)	8 (0.4)	9 (1.2)	8 (0.4)	9 (0.7)	7 (0.4)	7 (0.8)
SE	47 (3)	42 (15)	47 (3)	50 (15)	47 (3)	60 (19)	47 (3)	41 (19)
CE	41 (2)	39 (10)	41 (2)	30 (13)	41 (2)	50 (15)	40 (2)	51 (16)
NE	15 (1)	17 (6)	15 (1)	12 (5)	16 (1)	24 (16)	15 (1)	18 (7)

Term Abl = Terminus Ablation; Both discharge and terminus ablation are in Gt/yr with values averaged across the entire decade based on the season (rounded to the nearest whole number). Standard deviations are provided in parentheses. Winter = December to February; spring = March to May; summer = June to August; fall = September to November.