Dear Mr. Ken Mankoff,

Great to hear that the intended updates are sufficient and have improved the manuscript, we are grateful for the reviewers' comments. We also responded to your additional comments and revised the manuscript further, where needed; thank you for the suggestions.

Sincerely,

Dakota Pyles and co-authors

Dear Authors,

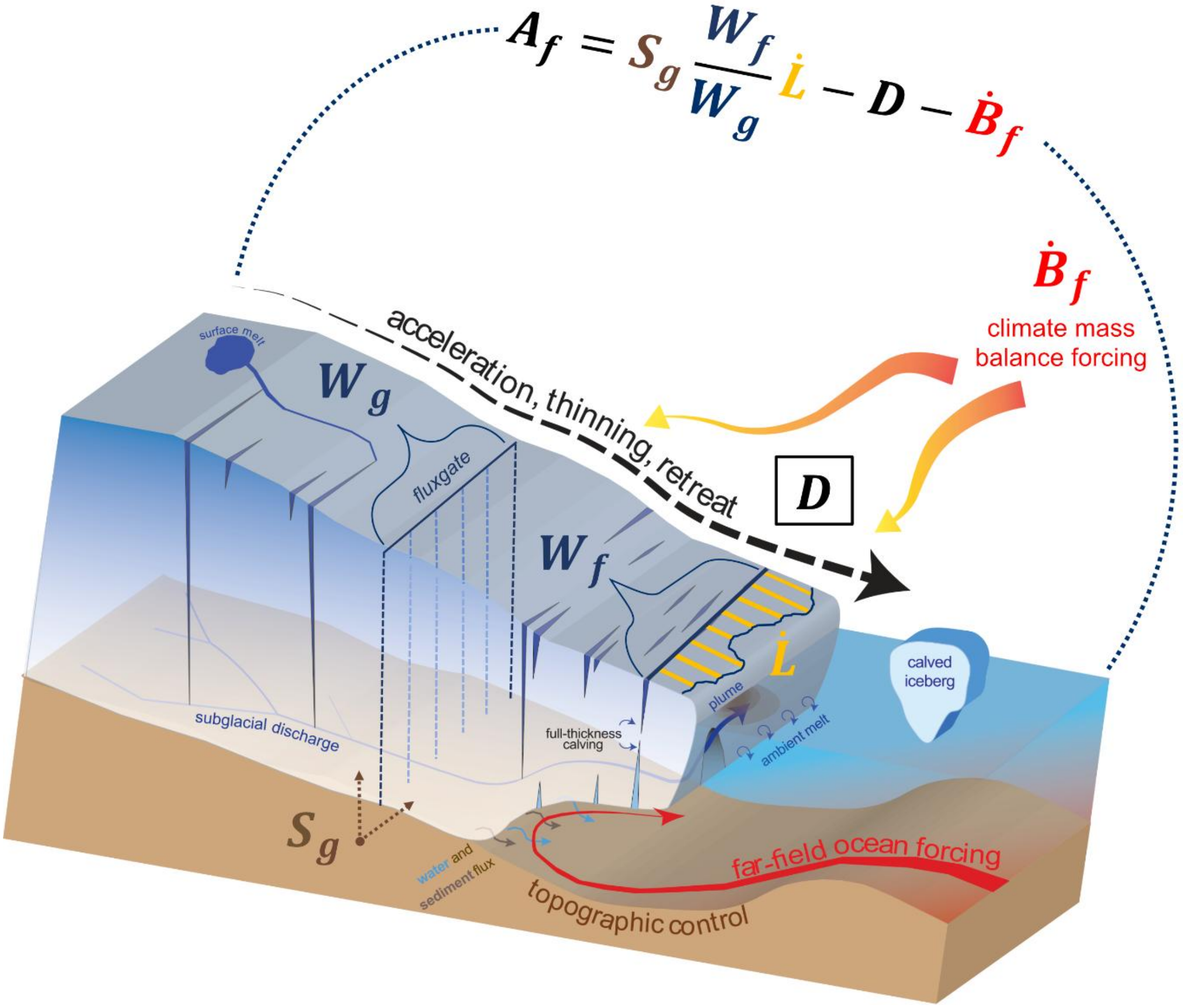
Thank you for your responses to reviewers. Overall I think your intended updates based on reviewer comments are sufficient and will lead to a better manuscript. I also encourage a few additional changes.

General comment on tone from R1: You argue to leave in "unprecedented" and "new/novel". Please follow R1 suggestion and remove. Everything is new and unprecedented by some definition (unless it's plagiarism), including this sentence. Tight writing omits unnecessary words.

Done.

Fig 2: "we cannot reasonably remove them". You can reasonably, if Ginny allows. Or at least modify - make less relevant components grayscale? Something to clean it up. It's a very confusing image and if you spent some time simplifying it would be a good thing. Bf arrows into the water - is that really part of the mass budget of a marine terminating glacier?

We were able to get an editable version of the underlying base figure we adapted from Ginny's 2020 paper, and we made several changes, including covering up the arrow pointing to water as well as the one point above the fluxgate. For the record, we did not draw the water arrow, it was already in Ginny's published base figure; also, one could say that if a major mechanism of the CMB forcing is solar radiation, then the incoming radiation into the water should warm the near-surface water and provide more heat to the submerged part of the glacier, likely resulting in stronger frontal ablation. This would be a reason to keep that arrow, but in the end, it does not matter so much and is just a schematic. As we also wrote to reviewer 1, this figure is not meant to show our specific processing chain but rather an overview of a tidewater glacier, the relevant frontal ablation processes (subglacial discharge, plumes, ambient melt, calving, etc.) and the main frontal ablation equation terms at meaningful positions relative to Ginny's base figure. This is why Ginny's base figure works well, as it has these processes very nicely visualized and we tried to make our additions as minimally intrusive as possible in the final adapted figure. Many of the adjustments included moving/resizing some of Ginny's glacier process annotations, deleting unnecessary arrows (on the iceberg, extra ambient melt arrows, CMB arrows, etc.), removing many of the ice cracks that were overlapping with the ice fronts/glacier width brackets, and moving the iceberg further from the terminus to not overcrowd that area. The figure is less visually cluttered now.



Sg in the figure looks like Subglacial something. It's brown like the other sediment terms. But it's a cross-sectional area according to the text (why those letters? Why not A?). Should it be blue and maybe rotated into the ice, the way "fluxgate" is rotated?

Sg is defined directly above the figure in the manuscript text as the cross-sectional area of the fluxgate. Yes we agree, intuitively the notation Sg can look like something subglacial in glaciology, but we did not choose this notation in the equation (if we did, we would have probably called it "Ag"), it is directly copied from an established equation/paper in Minowa et al. (2021), which is also referenced in the manuscript text directly above the figure. We did not want to cite Minowa's equation, then change the notation they used just so it looks more intuitive on the figure.

Further, we chose to put Sg at the bottom to not clutter the top area (i.e. the glacier part), and we chose dark brown because it naturally gave the best contrast above the light brown shading of the bedrock. Realistically there is not a great open space to place the Sg text within or around the fluxgate, except for the bottom where it already is; we also used a bracket of dark brown dashed arrows at the bottom to show that it is integrated across the glacier width and through the ice thickness (i.e. the idea of rotating the notation like we did with the "fluxgate" text). Given the fluxgate dashed lines, and the cross-cutting fluxgate line and bracket pointing to Wg at the glacier top it would be hard to fit it at the top, and because it's a cross-sectional area it should be either at the top left or right OR bottom left or right. Unfortunately there is no space on either of the right sides, but we appreciate your suggestions. If you think, there is a better spot for it that is positioned somewhere on/over the glacier, we are happy to hear a different suggestion, for now we kept it how it is and updated the figure caption to include each of the equation 1 terms and better describe that there are two front lines shown.

Figure 1. Frontal ablation schematic adapted from Catania et al. (2020) and annotated with Eq. 1 terms to visualize the relevant mass budget processes at a marine-terminating glacier. Ice discharge (D) is computed at the fluxgate, the CMB ($\dot{B}_f$) is estimated over the glacier domain between W_g and W_f, while the width-averaged frontal displacement rate ($\dot{L}$) is averaged between two timesteps of the terminus position (straight and sinuous blue lines) and S_g is the cross-sectional area at the fluxgate. Frontal ablation is primarily accounted for by calving events and ambient undercutting melt from the ocean, as well as subglacial discharge and localized meltwater plumes. By the equation's convention in Minowa et al. (2021), positive frontal ablation indicates terminus advance and/or ice thickening within the domain, opposed to frontal retreat and/or thinning for negative values.

According to the figure caption, CMB is between Wg and Wf, the latter being a straight line. Graphically, L is downstream of Wf. Is CMB correction downstream of Wf done? Is this in the error estimates if not? Fig. 8 suggests CMB is to the downstream edge of L, different from Fig. 1.

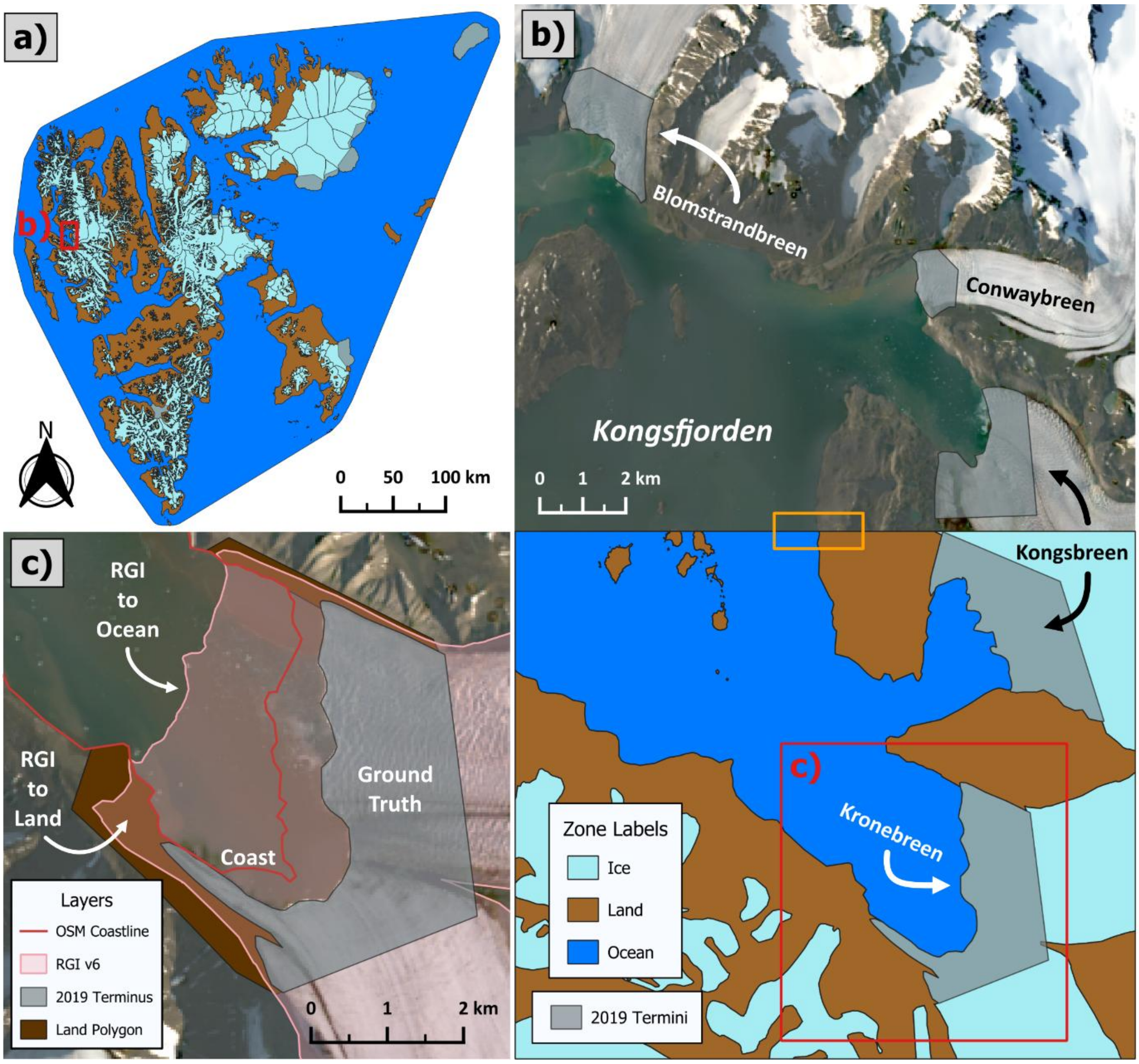
Fig. 8 and Fig. 2 are not meant to be directly compared in that sort of way. On Fig. 2, we are showing two front positions (the squiggly and straight lines, that the yellow lines are connecting). We did this to show an approximation of what $\dot{L}$ visually looks like (the width averaged frontal displacement rate between two monthly front positions timesteps), as it is a term in the main equation. This is why it is not comparable to Fig. 8, which shows just one frontal position. Naturally, we put the second straight front line along the full thickness calving event annotation in Ginny's base figure, as it was intuitive. If it helps, we can put a f1 and f2 notation next to each front, but we originally chose not to do that so the figure does not receive more annotations and also that might confuse readers, since we only need one width of the front in the frontal ablation estimate (we use the width at the second timestep of the calculation, which is written in Sect. 3.1.6).

To more directly answer your question, in Fig. 2, we would integrate the CMB between the fluxgate and the squiggly front line for that time step (i.e. Feb. 2016), and the fluxgate and the straight front line for the second time step (i.e. Mar. 2016), independently, because they are separate glacier domains.

Fig 3: Better in revision, but I'm not sure what the upper portion of (b) provides. Text says "The top panel shows the termini polygons manually delineated by Kochtitzky et al. (2022b) in 2019, with the Landsat-8 image (July 28, 2019) they used for front mapping plotted as background.", but why am I seeing this? I think you improved something, but the comparison (c) is of a different region than (b top). Maybe remove b top? If you do keep it, rather than the orange box, I suggest opening the upper and lower portion in Inkscape or your favorite graphic editor and fade between the two, I think a smooth transition would make it obvious that this is one connected geospatial region.

We intentionally included the top (b) panel for a visualization of the polygons Kochtitzky et al. mapped relative to the exact optical image as background, and in the bottom panel is the final resulting zone labels once the processing steps/layers in panel (c) are applied (also described in the Sect. 3.1.3 text). We opted for splitting the Kongsfjorden with an optical image top panel and the zone label bottom panel to show the accuracy and high level of detail the zone labels are manually curated with. This feeds into another reason why we have the orange box to show that the top/bottom are connected; (1) it shows that they are spatially connected by ocean/land inside the box on both the top/bottom panels and (2) it directly shows the accuracy of the zone label relative to the optical image with how similar the coast boundary is between the top/bottom panel within the box. Because the manuscript paragraph directly above the figure discusses the connection and use of Kochtitzky's manually mapped fronts, we took the opportunity to show this relationship in a creative way (split panels, one fjord), and it pairs nicely with panel (c) as a sort of before/after processing visualization. Also, we tried fiddling with a fade between the top/bottom panel in a graphic editor and it did not look good.

Anyway, if the reader looks at panel (a) first, there is a location box of panel (b) directly on the Svalbard zone label map over the Kongsfjorden; this is the exact spatial window being shown in panel (b) and should be apparent to the reader (the orange box is just an extra helper showing that the panels are continuous). If you want we can put a red outline around the entirety of panel (b) so that it intuitively matches the red location box in panel (a) (this looks a little tacky), but for now we just made the orange box smaller, so it isn't so striking on the figure.



Also, we addressed all of the suggestions in Robert's comment directly, and he never made a comment about panel (b) needing a change in the top panel (neither did reviewer 1), just that we should add the location box for the window (c) in the bottom panel and relabel this big panel from (c) to (b):

"Fig. 3: I suggest swapping panels a) and b), so that the context map is on the top, labeled a); the large panel showing all of Kongsfjorden could then be labeled b), and the detailed inset of Kronebreen could be labeled c). I also suggest showing the context box for the Kronebreen detail within the larger panel."

You mention OpenStreetMap. OSM has coastline errors of 100s of m in many places in Svalbard. How is this handled?

The coastline errors do not matter for our use case due to the meticulous manual delineation of each fjord/terminus/outlet area (i.e the land, water, ice boundaries) of all 147 glaciers within the RGI boxes, when we were updating the RGI v6 ice extent (Sect. 3.1.3). We used the exact Landsat image that Will Kochtitzky used to map the ground truth fronts as a visual reference in case OSM was wrong near the terminus (explained in Sect. 3.1.3). Since these manually curated zone labels are eventually fed to the segmentation model for training, the model learns each glacier's terminus environment (within the RGI boxes in Fig. 1) with high detail.

While the regional style training data include large areas of the Svalbard coastline that we did not manually curate, the sheer size/data volume of Svalbard's areas that the segmentation model sees in the Sentinel-1 imagery and zone labels are more important for the training than absolute accuracy at that scale.

Your updated text for Fig. 6 caption in response to R2 still mentions "Lilliehøøkbreen glacier" which is repetitive because "breen" = "glacier".

Fixed, thank you for noticing that mistake.

From my original email, Code: All code related to your work should be available with the submission. This is primarily the code that generated your product, but also code to generate the figures in your manuscript (which will help users use your product correctly). We support open science. If you do not think the code is ready to release, then your paper or data is probably not ready to be reviewed. Open science is a subset of well-documented, user-friendly, or reproducible science.

The pre- and post-processing code is designed to work with the Sentinel-1 ARD data specifically provided by DLR terrabyte team for this analysis in a specific data storage format, within the DLR terrabyte data storage. Consequently, the code can not be run on other Sentinel-1 data distributions outside of DLR terrabyte. DLR terrabyte computing power is reserved to DLR staff or for projects with collaboration from external institutions, like this project. Consequently, the community will not benefit from the release of the code. However, under the code and data availability section we added the GitHub repository for the segmentation model developed by our co-authors, jointly in this project. We also included the DOI for the CaFFe benchmark dataset that the segmentation model was pretrained on.

Code and data availability

The monthly frontal ablation, ice discharge/velocity, and calving front datasets, as well as relevant vector geometries (regional zone labels, fluxgates/points, RGI boxes, etc.), are publicly available in version 2 of the dataset at https://doi.org/10.5281/zenodo.19481461 (Pyles et al., 2026).

The code for the multi-temporal segmentation model is publicly available on GitHub at https://github.com/ki7077/Multi-Temporal-Tyrion. The CaFFe benchmark dataset, which the model is pretrained on, is publicly available at https://doi.org/10.1594/PANGAEA.940950.

I look forward to seeing the updated ms.

Citation: https://doi.org/10.5194/essd-2026-273-EC1