Author reply of egusphere-2025-5193:
High spatio-temporal velocity variations driven by water input at a Greenlandic tidewater glacier

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We thank the editor, the reviewers and the scientific community for their thoughtful and constructive comments on our manuscript. We have carefully considered all comments and suggestions and we are convinced we managed to address all of them. Below, we provide detailed, point-by-point responses to each comment with our revisions. The reviewer comments are noted below in Roman type, our author's response is in italics and the adjustments in the manuscript are marked with "blue". The line numbers in the reviewers comments still refer to the first original submission.

1 Editor's remarks after quick access review: Reinhard Drews

- Phase unwrapping: How do you choose your phase reference point and is it located on a fixed target (i.e. a rock)?
  A clarifying sentence has been added (methods 2.3.1).
  "At a next step, the phase signal was unwrapped using a stable location on bedrock as a control point. The phase differences between consecutive unwrapped interferograms, can be converted into LOS displacement δ by:
  $$\delta = -\frac{\lambda\phi}{4\pi}, \tag{1}$$
  where $\lambda = 17.4\,\mathrm{mm}$ is the wavelength, ϕ is the differential phase difference, and the displacement measurement sensitivity is better than 1 mm (Werner et al., 2008a). Note, pixels with a stacked coherence < 0.8 were masked out before unwrapping. However, since we originally measured the 1-min displacement, the coherence on the glacier was always given."

- The information that the glacier is grounded is key for the analysis in terms of interactions (or lack thereof) with tides. The references to Rosier 2025 is good in this regard, but it is helpful to let the reader know explicitly from which data this is inferred without the need to go to an external reference.
  A clarifying sentence has been added in the field site section (2.1).
  "(bathymetry data collected using single beam echosounder (Rosier, 2025))"

- Atmospheric path delays can be quite prominent in the TRI data. It would be good to show that the 30 minute averaging works by showing that a fixed target on a rock face does not show displacement variability to the same degree as what is detected on the glacier.

We will added a new figure in the Appendix and changed the text in the manuscript accordingly. In section 2.3.2: "Additionally, our data quality assessment deriving velocity estimates over exposed stable bedrock along the glacier showed that atmospheric noise increases with distance from the calving front due to longer travel times of the radar beams through the atmosphere (Fig. A4b). [...] In section 4.1: A velocity analysis conducted over exposed bedrock along the glacier to assess data quality (Fig. A4a) shows that the influence of atmospheric noise on the diurnal velocity measurements is negligible, and the correlation to temperature is weak (0.2 at a lag of 4 h)."

- Consider adding "idiot lables" on Figs 2 and 3 marking the events that you refer to in the text (e.g., the multi-day speed up). Like this the reader can capture the information faster without figuring out the dates on the x-axis.
  Lake drainage events and the foehn event were added to Figs. 2 and 3.

2 Review comment 1: William David Harcourt

Summary

The study of Dachauer et al. (2025) utilises a high temporal resolution terrestrial radar data set of a tidewater glacier in south Greenland to study its response to meltwater inputs to the glacier system and the impact on ice flow. They show that, even at the end of the summer season when the subglacial hydrological system is likely predominantly efficient, that diurnal fluctuations in ice velocity correlate to changes in air temperature, suggesting that the system remains active and sensitive to meltwater inputs. Furthermore, during periods of reduced ice velocities, the glacier sped up in response to the drainage of a lake (which I assume was an ice-marginal lake although the text was a bit unclear on this). Finally, the authors suggest that the diurnal signal propagates from the upper glacier to the terminus on slow flow days, but during velocity speed up events the diurnal signal propagates from the terminus and up glacier. The results demonstrate the sensitivity of the glacier to meltwater inputs over shorter timescales even in late summer when the subglacial system has transitioned to a predominantly efficient system.

General Comments

I found this paper to be an interesting read and the analysis that has been done nicely highlights the interesting dynamics associated with the glacier. Measurements such as these are hard-won - it takes significant logistical planning and often long periods in the field collecting the measurements. The authors should be congratulated on generating such a useful data set! I have provided technical comments below that ask for clarification in several areas. I have a few more substantive comments that I ask the authors to consider in their revision:
We thank the reviewer for acknowledging our analysis and data collection. We have carefully addressed all of the reviewer's valuable comments in our individual responses below and made corresponding revisions in the manuscript.

- Methods: The methods are insufficiently described in the paper. Although the TRI measurements have been widely described in previous studies, the paper still needs to include a description

of the specific set up used in this study, including key equations to derive displacement measurements, derive 3D data (i.e. DEMs) and other processing steps e.g. coregistration (e.g. due to wind buffeting of the radar).
The authors understand the point raised by the referee and describe the used method now more thoroughly. In particular, the process used to derive the velocity maps is described in more depth. The method section has been expanded and more details added at several paragraphs: "The range resolution is about 0.75 m, while the azimuth resolution is 0.4°, which corresponds to 6.9 m at a slant range of 1 km and in our case about 21 m at the calving front (Werner et al., 2008b,a)."

In section 2.3.1: "To support this choice, several temporal baselines between 10 min and 1 h were tested, with the aim to minimize noise while maximising temporal resolution. While the main velocity variation patterns could already be detected on a 10 min resolution, a resolution of 30 min allowed us to get rid of most of the atmospheric noise and prevent misinterpreting noise as a physical signal."

In section 2.3.1: "At a next step, the phase signal was unwrapped using a stable location on bedrock as a control point. The phase differences between consecutive unwrapped interferograms, can be converted into LOS displacement δ by:

$$\delta = -\frac{\lambda\phi}{4\pi}, \tag{2}$$

where $\lambda = 17.4$ mm is the wavelength, ϕ is the differential phase difference, and the displacement measurement sensitivity is better than 1 mm (Werner et al., 2008a). Finally, the displacement data were used to calculate LOS velocity maps that allow for investigation of spatial and temporal flow speed variability (Werner et al., 2008a). For visualization purposes, the radar image pixels were transformed into Cartesian coordinates. Since resampling may introduce errors, all computations were conducted in the original radar geometry, with georeferencing applied only to the final outputs."

In section 2.3.2: "Additionally, our data quality assessment deriving velocity estimates over exposed bedrock along the glacier showed that atmospheric noise increases with distance from the calving front due to longer travel times of the radar beams through the atmosphere (Fig. A4b). [...] In section 4.1: A velocity analysis conducted over exposed bedrock along the glacier to assess data quality (Fig. A4a) shows that the influence of atmospheric noise on the diurnal velocity measurements is negligible, and the correlation to temperature is weak (0.2 at a lag of 4 h)."

Several smoothing filters were tested. In section 2.3.2: "The Butterworth low-pass filter and the according cut-off period was chosen because this configuration was found to performed best to effectively suppress outliers while still preserving the full diurnal velocity variability."

new section 2.3.3: "Processing of TRI DEMs The TRI DEMs used to identify calving events were generated using a workflow similar to that applied for deriving TRI velocities. However, spatial interferometry was obtained by analysing the phase signal difference between the two receiving antennas. The resulting interferograms, that have an original acquisition time interval of 1 minute, were unwrapped using a stable location on bedrock as a reference and subsequently converted into topography following the workflow of (Strozzi et al., 2012). To correct systematic errors such as reference height inaccuracies, baseline errors and antenna misalignment (Strozzi et al., 2012), a correction factor was derived by comparing the generated DEMs with the ArcticDEM (Porter et al., 2023) using stable control points at different radar distances. This factor was applied to the computed topography to reduce elevation uncertainty. To reduce atmospheric noise, 10 consecutive elevation maps were stacked, leading to a final temporal resolution of 10 min (Walter et al., 2020). Then, elevation changes between sequential stacked elevation models were calculated and negative changes at the front attributed to a calving event. Because of the stacking procedure, events occurring within a 10-minute interval were combined. Elevation changes of less than 5 m are considered as noise and filtered out (Walter et al., 2020), leading to a detection of calving events exceeding a volume of 5,000 m^3."

Tests on the stable bedrock showed that wind buffeting effects were minor and therefore no co-registration needed to be performed.

- The upward and downward propagation of the diurnal velocity signal is not clear to me. After looking at Figs. 4 and 5 several times I can start to see it, but I think it needs a bit of explanation. You could use an example of where the upward/downward propagation signal is clear in a single figure - you have attempted this in Fig. 6, but it would be useful to also show the 1D profiles as an example. My broader point is that these are referenced several times in the discussion and it is sometimes very hard to see it - case in point is Fig. 8 where these propagation patterns are mentioned several times but I struggle to see the patterns.
  We see the difficulty to observe the upward and downward propagation of the diurnal velocity signal in Figs. 4 and 5, mostly due to the packed plot where the entire 2 weeks of data are shown simultaneously. To address this issue - which was also mentioned by other reviewers - we now provide an additional plot with a zoom-in example of Figs. 4c/5c accompanied by supporting labels and arrows to better visualize the upstream versus downstream propagation.
  This figure is added in Appendix Fig. A8. Additionally, the green/orange color-coding boxes of downward/upward propagation direction from Fig. 5 were also added in Fig. 8 to support the discussion.

- The implications of the study are not effectively described in the context of Greenland Ice Sheet dynamics and future changes. Part of the problem here is that a research question is not stated in the introduction, so it currently reads a bit more as a description of results and interpretation of them. These then need to be combined to provide an holistic overview of the glacier dynamics. I.e. the overarching conclusion is that the glacier is sensitive to meltwater inputs in late summer when the subglacial system should have an efficient drainage system. Quantifying the sensitivity (see comments below) would enable you to compare this to other outlet glaciers, but also whether the processes observed at EKaS are representative of other regions. Articulating a clear process-driven framework for the processes and then expanding that view to the whole of Greenland would be a nice way to summarise the data in a way that brings all the analyses and interpretations together.
  The referee raises a fair point. We refined the elaboration of our research question in the introduction. A comparison with other outlet glaciers is challenging, since not many studies with comparable temporal/spatial resolution exist, but we already refer to these studies in the discussion. Nevertheless, in the newly added paragraphs in Discussion and Conclusions (see below) we

tried to integrate our results more into broader context.
Added research gap at the end of the introduction: "With this approach, we aim to address the basic research gap in understanding how variations in water input impacts short-term flow dynamics at a tidewater glacier grounded well below sea level, and how related velocity variations propagate along the glacier. We interpret our results in the context of the interaction between ice flow and the evolution of a subglacial drainage system."

Additionally, we added a paragraph at the end of the discussion (section 4.4) and Fig. A5, analysing the glacier's sensitivity to additional meltwater input over the course of the season: "While the mean discharge is lower in July 2024 compared to 2023, the modelled discharge relies on numerous assumptions, making it difficult to draw firm conclusions about the sensitivity of the glacier flow to the evolving subglacial drainage system over the course of the season. Instead, an analysis of the average diurnal temperature and velocity cycles for periods that are not directly influenced by multi-day speed-up events (Aug 11-13, 2023 and July 16-18, 2024) was performed. Fig. A5 shows that the absolute and relative peak-to-peak amplitudes for both temperature and velocity are similar between the two years, even though the 2024 data was recorded nearly one month earlier in the year. We conclude that, on seasonal timescales, the subglacial drainage system at EKaS is more established later in the season (e.g. Sole et al., 2011; **?**; Gjerde et al., 2025), as evidenced by a lower average velocity (Fig. 7). On diurnal timescales, however, the glacier's speed responds similarly to temperature forcing in July and in August. This demonstrates that, from July onwards and at short timescales, the flow sensitivity to additional meltwater input does not change as the season progresses, indicating an already well established drainage system at the terminus of EKaS by July."

Lastly, the final paragraph in the conclusions has been adapted: "We conclude that the studied tidewater glacier, despite having established an efficient drainage system towards the end of the melt season, remains very sensitive and reacts fast to surplus water entering its basal system. Lower average velocities later in the season indicate a progressively more established subglacial drainage system. However, the glacier's diurnal velocity response to temperature forcing remains constant from July to August. While the diurnal velocity variations observed at EKaS are at the upper end of those reported for even faster-flowing tidewater glaciers, the distinctive spatial pattern of acceleration propagation documented here underscores the need for further investigation of these processes and highlights the profound influence of water input and basal hydrology on the short-term, small-scale flow dynamics of tidewater glaciers near the terminus. "

Technical Corrections (References to line (L) numbers in preprint)

- L1-2: Aren't ice discharge and frontal ablation essentially considered the same?
  While the two processes behind ice discharge and frontal ablation differ, it can be considered the same under the assumption of a steady-state, which is not given here. However, to avoid confusion and to make the meaning more clear, we rephrased that sentence.
  "Ice flow controls the ice discharge at tidewater outlet glaciers and is, together with frontal ablation, a key process driving the mass loss of the Greenland ice sheet."
- L5: If the data were gridded on a uniform grid, you should state the resolution precisely.

The grid is not uniform. The range resolution is about 0.75 m, while the azimuth resolution is 0.4°, which corresponds to 6.9 m at a slant range of 1 km. This is already stated in the methods section but we make this more explicit in the text there. Therefore, we decided not to state this more explicitly in the Abstract.
We added to the Methods: "The range resolution is about 0.75 m, while the azimuth resolution is 0.4°, which corresponds to 6.9 m at a slant range of 1 km and in our case about 21 m at the calving front (Werner et al., 2008b,a)."

- L6-7: Sensitivity in terms of rapid change in velocity in response to meltwater inputs? Or something else? Be precise.
  Exactly. Is stated more clearly now.
  "We observed clear diurnal and multi-day ice flow speed variations and link these to a high ice flow sensitivity to additional freshwater input to the glacier system."

- L13-14: You may touch on this later, but it would be useful to state a clear outcome of the paper succinctly - the relationship between meltwater and dynamics is complex and widely studied, so what exactly does this study find that contributes to this knowledge?
  We rephrased the sentence to make it clearer and added further clarifications on the aim of the paper at the end of the introduction (see general comment further above).
  "We further conclude that the flow remains sensitive and reacts fast to short-term surplus water input, despite having established an efficient drainage system towards the end of the melt season."

  The authors are thankful for the list of suggestions below for improving the introduction (comments L16 - L63 below). We included all proposed changes in the revised manuscript.

- L16-18: Glaciers are still the largest contributor, check out the recent GLAMBIE community estimate (link). There are also more recent references that should be cited alongside these e.g. Otosaka et al. (2024).
  References added and text adjusted to "one of the largest contributors".

- L20: I wouldn't say it is limited? It's a very active research area! I would instead tease out the key processes of most interest e.g. meltwater and basal sliding feedbacks, ocean thermal forcing, precipitation changes.
  Sentence was adjusted: "Yet, the coupling between meltwater input, subglacial hydrology, and flow velocity that governs these processes is complex and remains poorly constrained."

- L23: E.g. studies such as Tedstone et al. (2015) (link) that showed long-term slowing down of a land-terminating glacier in response to larger melt input to the bed.
  New references added.

- L28: Optical and SAR are imagery, I think you mean feature speckle tracking in optical and SAR image pairs.
  Sentence rephrased for clarification: "such as feature tracking of optical imagery and speckle tracking of SAR imagery,"

- L30: Far more than a few studies.
  "a few" replaced with "several".

- L32-34: Remove the tidal forcing part from this sentence - use a separate sentence to discuss tidal impacts on velocities.

Tidal forcing part was removed. Tidal influence discussed later in Discussion but not in Introduction since the authors want to focus on the processes (e.g. melt) that actually matter at this study site.

- L34-35: Broad statement that is not always true. I think it's important to acknowledge the complexities here e.g. drainage may shut down over winter (not always if meltwater can be stored at the bed). In spring, there may be a spike in velocity due to a sudden input of meltwater, then at the end of summer velocities may decline. Diurnal changes can be observed, whilst long-term changes are less well known due to observational constraints.
  The complexity of the matter was better acknowledged here in the introduction: "Yet, the coupling between meltwater input, subglacial hydrology, and flow velocity that governs these processes is complex and remains poorly constrained, in particular across different timescales...". To highlight the importance of the evolution of the subglacial drainage system, the following sentence was added later in the introduction: "Meltwater input is able to constantly alternate the subglacial channel size (Röthlisberger, 1972) and therefore the efficiency of the subglacial drainage system, which can have a large impact on the ice dynamics (Tedstone et al., 2015)."

- L36: Challenges? I assume you are referring to measuring the inaccessible bed?
  added: ", mostly due to their inaccessibility for direct measurement"

- L39-40: Sentence needs to be qualified with the reasons why we need short-term and high resolution observations. To observe diurnal patterns? Response to calving?
  added: "that resolve diurnal and multi-day variability".

- L58-63: It would be good to highlight other GPRI / terrestrial radar studies to investigate tidewater glacier dynamics as there are now quite a few. You could dedicate a whole paragraph to this, or at least a few sentences, particularly discussing the benefits and limitations of the approaches and processing complications.
  We added a few sentences on this: "To address these limitations, we deployed a terrestrial radar interferometer (TRI) to investigate short-term and small-scale ice flow variations over the terminus area of a major outlet tidewater glacier in South Greenland. Previous studies have demonstrated that the TRI can overcome many of these observational constraints and has significantly advanced our understanding of ice-flow dynamics of tidewater glaciers, particularly with respect to the interactions among ice flow, calving, ice mélange, and tidal forcing (e.g. Voytenko et al., 2015; Xie et al., 2019; Walter et al., 2020; Kane et al., 2020; Kneib-Walter et al., 2021; Drews et al., 2021; Wehrlé et al., 2025). Many investigations focused on fast-flowing glaciers in Greenland such as Sermeq Kujalleq in Kangia (e.g. Xie et al., 2018; Wehrlé et al., 2024; Cassotto et al., 2021) and Helheim Glacier (e.g. Voytenko et al., 2015; Holland et al., 2016; Kim et al., 2025)."

- L60: What is the research question being addressed?
  We refined the elaboration of our research question in the introduction.
  "With this approach, we aim to address the basic research gap in understanding how variations in water input impacts short-term flow dynamics at a tidewater glacier grounded well below sea level, and how related velocity variations propagate along the glacier. We interpret our results in the context of the interaction between ice flow and the evolution of a subglacial drainage system."

- L74: Could you put this into perspective with other glaciers? How does it compare to the big tidewater glaciers in Greenland e.g. Jakobshavn, Helheim etc.?
  Was added.
  ", equivalent to roughly 10 % of the ice discharge at major tidewater glaciers such as Helheim glacier (Kim et al., 2025)."

- L84: Do you have a picture of the set up? Could add this to Figure 1. It's to confirm visually the field of view.
  Added to Fig. 1

- L87-89: This should go in the data processing section, including a slightly expanded explanation of how the DEMs were generated and then the DEM processing.
  Was moved to the data processing section and expanded.

- L99: Did they capture the regional temperature trends? Figs A1 and A2 seem to, but would be good to qualify this sentence with a statement saying that they do and any biases.
  The visual proof of Figs. A1 and A2 was supplemented with a more concise statement that the regional temperature trends are captured.
  "Since different weather stations were used to derive the air-temperature records for the two years, we compared both datasets with the AWS at Narsarsuaq to ensure that they reflect regional temperature variability rather than site-specific effects (e.g. temperature inversions). As shown in Figs. A1 and A2, the regional temperature signal is well captured in both cases. The only exception is the initial phase of the 20 July 2024 foehn event, which was suppressed at the Fjord station by a local inversion. Therefore, data from the Hill station were used in 2024."

- L118: No mention of how the DEMs were derived?
  Is explained now in a new subsection in the data processing section.
  New section 2.3.3: "**Processing of TRI DEMs** The TRI DEMs used to identify calving events were generated using a workflow similar to that applied for deriving TRI velocities. However, spatial interferometry was obtained by analysing the phase signal difference between the two receiving antennas. The resulting interferograms, that have an original acquisition time interval of 1 minute, were unwrapped using a stable location on bedrock as a reference and subsequently converted into topography following the workflow of (Strozzi et al., 2012). To correct systematic errors such as reference height inaccuracies, baseline errors and antenna misalignment (Strozzi et al., 2012), a correction factor was derived by comparing the generated DEMs with the ArcticDEM (Porter et al., 2023) using stable control points at different radar distances. This factor was applied to the computed topography to reduce elevation uncertainty. To reduce atmospheric noise, 10 consecutive elevation maps were stacked, leading to a final temporal resolution of 10 min (Walter et al., 2020). Then, elevation changes between sequential stacked elevation models were calculated and negative changes at the front attributed to a calving event. Because of the stacking procedure, events occurring within a 10-minute interval were combined. Elevation changes of less than 5 m are considered noise and filtered out (Walter et al., 2020), leading to a detection of calving events exceeding a volume of 5,000 m^3."

- L119-127: Although the method is well described in previous studies, I think you do need to discuss a bit more detail about the interferometric approach including key equations of how you related phase changes to displacement. Did you have to coregister the images e.g. due to wind buffeting of the radar?

We added more details about the method used to generate the velocity maps.
"At a next step, the phase signal was unwrapped using a stable location on bedrock as a control point. The phase differences between consecutive unwrapped interferograms, can be converted into LOS displacement δ by:

$$\delta = -\frac{\lambda \phi}{4\pi}, \tag{3}$$

where $\lambda = 17.4\,\mathrm{mm}$ is the wavelength, ϕ is the differential phase difference, and the displacement measurement sensitivity is better than 1 mm (Werner et al., 2008a). Finally, the displacement data were used to calculate LOS velocity maps that allow for investigation of spatial and temporal flow speed variability (Werner et al., 2008a). For visualization purposes, the radar image pixels were transformed into Cartesian coordinates. Since resampling may introduce errors, all computations were conducted in the original radar geometry, with georeferencing applied only to the final outputs."
"Tests on the stable bedrock showed that wind buffeting effects were minor and therefore no co-registration needed to be performed."

- L120-121: Reword: 'The TRI transmits from a single antenna and measures radar backscatter using two receiver antennas.'
  Done.

- L124: Important to recognise throughout the paper that the temporal resolution of your measurements is 30 minutes and NOT 1 minute, as is claimed.
  Was stated more clearly to avoid confusion.
  We added: "operating with a 1 min sampling interval (30 min resolution after processing)" at Abstract and in Introduction where it was still unclear."

- L147: Although this section is generally well-written, it was sometimes unclear when you were discussing 2023 and 2024 data. E.g. the peak-to-peak amplitudes were stated to be 0.5 m/d, but what year? I would discuss each year in turn for clarity (within each section though, I like having the results section split into themes as you have done).
  The text in section 3.1.1.was re-written to ensure clarity about the year throughout the entire section.
  The average peak-to-peak amplitude of 0.5 m/d is valid for both years as written in the sentence. However, we agree with the referee and separated the paragraphs into years: "In 2024, cross-correlation analysis of the velocity and air temperature time-series reveals a peak correlation of 0.6 at a lag of 4 hours, indicating a moderately positive relationship throughout the entire 2-week field period. In other words, the ice flow speed reaches its daily maximum 4 hours after the temperature peak. For the days from July 16, 2024, onward, the correlation becomes even stronger, reaching a cross-correlation of 0.8, again at a lag of 4 hours. However, before July 16, no correlation between flow speed and air temperature can be detected, with a cross-correlation value < 0.1 at a lag of 4 hours. Furthermore, the fjord was strongly covered by ice mélange, while the plume extent remained small for most of the time during the 2024 campaign (Fig. 3d)."

  "In 2023, the cross-correlation between air temperature and flow velocity over the entire dataset is weak (cross-correlation < 0.1), but still most positive at a lag of 4 h. Nevertheless, for the last few days, between August 12-15, 2023, the cross-correlation is moderately positive, with a value of 0.7 at a lag of 5 hours. In that year the glacier terminus was barely covered with ice mélange and the plume extent fluctuated in size (Fig. 2d)."

"In both years, periods with poor correlation between air temperature and flow velocity are likely due to additional processes disrupting the diurnal signal (see below). Additionally, no clear link to multi-day scale velocity variations was found for either the ice mélange or the plume extent. Further, the diurnal ice velocity variations are also not directly correlated to the tidal signal, with cross-correlation values close to zero regardless of any lag (Figs. 2e and 3e). At the study site, the tides are dominated by a shorter periodicity of 12.4 h."

- L168: I note here that the method to extract mélange presence / absence has not been described in the methods, but should be. Same for the detection of plumes.
  We added both to the methods.
  The two methods are already described in section 2.2.3. together with the time-lapse imagery, which was the data source. However we further clarified this in the method section 2.2.3): "This allowed us to classify the evolution of the ice mélange extents and subglacial plume extents using a visual assessment of the images. Plume extents were classified based on their estimated relative coverage in the observed area: none (0 %), small (1–25 %), medium (26–50 %), and large (51–100 %). Ice mélange was similarly classified, but with a slightly adjusted percentage range: none (1–25 %), small (26–50 %), medium (51–75 %), and large (76-100 %). Both variables were extracted twice a day in the time-series of Figs. 2d and 3d, with the four classes determined by visually estimating the relative extents."

- L174: It's slightly off that these are not discussed in chronological order i.e. 2023 and then 2024.
  Starting with 2023 now.

- L185: State dates.
  Done.

- L190: Reference relevant section / figures.
  This sentence is a transition to the following subsection. It has been re-written to make this more clear.
  We decided to move the sentence in an alternated version to the start of the next section to make the transition within the relevant section: "Both years show a multi-day speed-up event (August 7-10 2023, July 12-15 2024), which exhibits only weak correlation with air temperature and therefore cannot solely be explained by surface melt. Instead, these events align with the timing of subglacial and marginal lake drainage episodes."

- L194: Isn't it an ice-marginal lake? Reference the figure where it is labelled L1 - Figure A3 I think.
  L1 is a subglacial lake, L2 is ice-marginal indeed. We added the Figure reference A3 and make sure the lake types L1 and L2 are mentioned clearly throughout the manuscript.
  Figure reference added and terms marginal and subglacial consequently used throughout the manuscript.

- L195: How was this calculated?
  This is a rough estimation knowing the subglacial lake area and the rough surface elevation change from time-lapse imagery. An additional sentence was added for clarification.
  Added in methods: "A second camera on the hill east of the terminus, running at the same

intervals, allowed to estimate the rough timing, area and surface elevation change of a major subglacial lake drainage event L1 from the western tributary of EKaS.”

- L196: Is there a figure showing the lake drainage event?
The area of the subglacial lake drainage is highlighted in the inset map of Fig. A3. Since L1 is a subglacial lake discharge event, Sentinel-2 images provide only little evidence of the event. However, we have time-lapse imagery which nicely illustrate the timing of the event. According imagery was added to the Appendix.
Time-lapse imagery of lake drainage L1 added.

- L198: When did the lake drain? Do you have exact dates?
Between July 4 and July 15, as already mentioned on L196.
added: ”occurring from July 4-15”

- L203: Reference relevant figure. Wasn't L2 a supraglacial lake?
L2 is an ice-marginal lake. We added the Figure reference A3 and made sure the lake types L1 and L2 are mentioned clearly throughout the manuscript.
Done.

- L204: True if it's a supraglacial lake, unclear if it's an ice-marginal lake.
The authors are confident that the water from the ice-marginal lake discharge event L2 must have drained through the glacier, as there is no other way the water could possibly drain (see Fig. A3).

- L212-222: As noted above, a description of the methods used to calculate these should be provided. Are volumes calculated for all calving events? Might be useful to add these to Figures 2 and 3.
Was mentioned in a new subsection in the data processing section. The calving events are already added in Fig. 2d and 3d, but we made sure to mention this more clearly. All calving events with a volume ¿ 5,000 m^3 *were calculated subsequently added to Figure 2d and 3d.*
New section 2.3.3: ”Processing of TRI DEMs The TRI DEMs used to identify calving events were generated using a workflow similar to that applied for deriving TRI velocities. However, spatial interferometry was obtained by analysing the phase signal difference between the two receiving antennas. The resulting interferograms, that have an original acquisition time interval of 1 minute, were unwrapped using a stable location on bedrock as a reference and subsequently converted into topography following the workflow of (Strozzi et al., 2012). To correct systematic errors such as reference height inaccuracies, baseline errors and antenna misalignment (Strozzi et al., 2012), a correction factor was derived by comparing the generated DEMs with the ArcticDEM (Porter et al., 2023) using stable control points at different radar distances. This factor was applied to the computed topography to reduce elevation uncertainty. To reduce atmospheric noise, 10 consecutive elevation maps were stacked, leading to a final temporal resolution of 10 min (Walter et al., 2020). Then, elevation changes between sequential stacked elevation models were calculated and negative changes at the front attributed to a calving event. Because of the stacking procedure, events occurring within a 10-minute interval were combined. Elevation changes of less than 5 m are considered noise and filtered out (Walter et al., 2020), leading to a detection of calving events exceeding a volume of 5,000 m^3.”

- L218-222: What about calving and diurnal variations - are there any signals or correlations?
No correlation could be found on a diurnal time-scale. A clarifying sentence was added.
”Additionally, no diurnal pattern for the appearance of calving events could be found.”

- L230: I assume the constant difference means the diurnal signal is clear at all distances from the terminus? I'd explicitly state this.
  Exactly. We stated that more clearly as proposed by the referee.
  added: "indicating a consistently detectable diurnal signal of similar magnitude at all distances from the terminus."

- L234-242: The primary point here is that diurnal fluctuations propagate from the top of the centreline profile to the terminus on low velocity days, whereas on high velocity days it propagates from the terminus. However, in 2023 this is not clear as the green boxes appear before the high velocity days. In 2024, there does seem to be a correlation. So, based on the data available, this assertion may be partially true, but I think it's worth stating that this may only hold when the 'high velocity days' are significantly larger than the base velocity level.
  While the authors agree with the referee that the pattern is more clear in 2024, we would still argue, that the statement is also valid in 2023. However, sometimes the signal is somewhat noisy (e.g. around 2023-08-09), which is color-coded in green-orange stripes. Additionally, the downwards pointing deceleration in the evening of 2023-08-09 is likely linked to the arrival of the lake discharge L2, as highlighted in A7, which might interfere with the general pattern. Thus, we still clearly observe upstream propagation on high-velocity days and downstream propagation on low-velocity days, also in 2023. To address this issue we adjusted the text for more clarity, at the same time considering the comment of referee 2 on the same matter.
  "For better readability, a zoomed-in representation with supporting labels is provided in the Appendix (Fig. A8)". This reference to Fig. A8 is also added in the caption of Fig. 5.

- L239: Were the orange/green boxes calculated manually? Or some other way?
  Yes, they were calculated manually by investigating the time-series of acceleration maps. We added an according sentence.
  "(manually detected and marked as orange boxes in Fig. 5c)".

- L243-252: Can you label to the side of the maps which represent downward propagating and upward propagating diurnal velocity variations. This section is a bit hard to read because you reference velocity speed up events (which relate back to Figs 2 and 3) but you showing acceleration maps, so it is not clear where I should be looking. You also mention the 'outlines' of the block like pattern of flow, but this should be labelled for clarity - I assume it relates to the step-like pattern clearly visible in Fig. 6a.
  We added a title/label to the panes of Fig. 6 to clarify the propagation direction. Exactly, the outlines refer to the step-like pattern most obvious on Fig. 6a. We added thin outline-lines in the map.
  Fig. 6 was updated by adding labels for each subfigure highlighting the propagation direction, acceleration sign and time of the day. Additionally, the zones with clear rift structure were highlighted in the plots of Fig 6 and Fig. A8. The figure caption is updated accordingly: "Black dashed polygons represent zones with major rifts (Fig. A9), potentially influencing the spatial acceleration signal on certain days (panel a and b)."

- L255-261: I would start with a comparison to other Greenlandic outlet glaciers and then consider other glaciated regions (e.g. Alaska).
  The order of the sentences was changed as suggested.
  "Diurnal velocity fluctuations were also found on large Greenlandic tidewater glaciers such as Helheim Glacier and Sermeq Kujalleq in Kangia, but the amplitude only covers about 1 %-2 %

of their average flow speed (Davis et al., 2014; Stevens et al., 2022a; Podrasky et al., 2012). On tidewater glaciers in Alaska, diurnal fluctuations with amplitudes ranging from 2.5 % to 8 % have been observed—similar to those found in our study (Meier et al., 1994; O'Neel et al., 2001)."

- L273-275: Does the July 23 precipitation have any relationship to the velocity increase on July 25th?
  This is a valid observation and one we also considered. However, given the generally rapid response of velocity to temperature changes (on the order of 4 hours), we consider a direct influence on July 25th unlikely, particularly given the low precipitation rate. The effect of rainfall is more plausibly indirect, acting through reduced temperatures, which likely led to a diminished diurnal velocity peak on July 24. The pronounced peak observed on July 25 remains partly unexplained; however, we know that it is strongly influenced by an acceleration at the front (see Fig. 8). We made it more clear that the rainfall event only influences the temperature/velocity on July 24.
  "Given that the glacier velocity typically responds within a few hours, the rainfall event is unlikely to be responsible for the velocity increase observed around July 25."

- L276-282: This is quite vague - how would wind speed affect the velocity variations? For cloud cover, I suspect it is not a straight 1-1 relationship, does your RH data provide any clues as to the relationship?
  The sentence was rephrased to make it more clear.
  Sentence adjusted and reference added: "The ice surface melt depends not only on air temperature, but also on other factors such as cloud cover and wind conditions (Laffin et al., 2023)."

- L302-304: I must admit, I am struggling to see the acceleration. Is it the multi-day slowdown that is important here?
  The authors mean the acceleration phase at the upper part of the centerline in the night of Aug 10, 2023, which is best seen in Fig. 4c and Fig. A11. However, we agree that it is not very easy to spot and we adjusted the manuscript to further highlight the matter.
  For clarification, the centreline was added on the Fig. A11 and the caption adjusted: "Potential ice-marginal lake drainage event L2 approaching the terminus on August 10, 2023 a) leading to a weakened mid-night deceleration (light-blue colours at lower part of centreline) or even an untypical acceleration (red colours at upper part of centreline), b) followed by the development of a large plume visible at the terminus in the time-lapse imagery from 6:00 am onwards (green rectangle). The number in the box shows the local Greenlandic time. The black line in a) represents the centreline and the background image is a Sentinel-2 acquisition from Aug 7, 2023 (Copernicus Data Space Ecosystem, 2025)."

- L310-315: If the water is being channelised and propagating along the bed, would there be spatial velocity variations - i.e. high flow over the channelised region, slow flow over the less non-channelised sections (assuming no water here, or maybe there will be some form of distributed drainage system?). I guess I am looking to see here a bit more underpinning theory related to the observation rather than simply stating water flow down and then the ice flow increased.
  The authors want to emphasize that we purposely focus on our observations and try to avoid speculative conclusions. Nevertheless, we tried to rephrase the section and better link our argumentation to existing theory.
  We added more theory based on other studies: "Thus, an efficient subglacial drainage system driven by an already high background freshwater discharge enables a rapid velocity increase

followed by a quick drop below pre-event values, and recovery within days–as observed on fast-flowing Helheim glacier (Stevens et al., 2022b)."

- L322: To prove this point, you need a graph over the same period showing freshwater discharge - I assume you more broadly mean 'melt' i.e. a temperature graph would suffice?
  The referee is right assuming that we mean "during times of high temperature in summer", indirectly assuming that this leads to increased melt and freshwater discharge. We adjusted the sentence accordingly and refer to other work that shows increased temperatures and thus melt during the summer in Greenland.
  "More specifically, the speed of EKaS declines during times when warm summer temperature lead to increased surface melt (Fang et al., 2023), leading to a minimum speed by the end of summer."

- L326-327: You might discuss the below, but this part is interesting - stored meltwater at the bed over winter? Possibly, considering the recent findings of Hansen et al. (2025).
  The reference was included and the sentence adjusted accordingly.
  "While there is evidence for winter discharge at our study site (Hansen et al., 2025), the velocity increase is likely driven by channel closure, as the rate of creep closure progressively exceeds subglacial channel melting once discharge declines, leading to increased subglacial water pressure (Vijay et al., 2021)."

- L344-345: Is it possible to calculate average diurnal melt rates and therefore volumes that are transferred to bed? This might allow you to quantify the sensitivity of the bed to extra meltwater inputs by comparing with the velocity changes over the same time period - I would expect to see a declining sensitivity over summer. Ah, I see you have done in Appendix C! But can you use this to quantify the sensitivity of the drainage system over the velocity time series in Figure 7?
  All reviewers commented on Fig. 7 with diverging opinions (from further expanding investigation to putting it into the Appendix). The authors agree with some reviewers that it is important to discuss our observations in the context of seasonal variations and therefore, we decided to keep the figure in the main manuscript. The suggested sensitivity analysis will be challenging to assess. However, we tried to investigate the velocity sensitivity by combining the diurnal variations in velocity to those in temperature/ablation for different times of the year.
  A sensitivity analysis with the melt rates proved to be unsuccessful, mostly because too many assumptions were needed for the discharge calculations. Additionally, we have only short time periods (2 weeks) which are both heavily influenced by lake discharge events. However, we further elaborated the temperature-velocity analysis for days that show supposedly little influence of lake discharge events and managed to draw some sensitivity conclusions, which we summarized in Fig. A5 and in the following paragraph: "While the mean discharge is lower in July 2024 compared to 2023, the modelled discharge relies on numerous assumptions, making it difficult to draw firm conclusions about the sensitivity of the glacier flow to the evolving subglacial drainage system over the course of the season. Instead, an analysis of the average diurnal temperature and velocity cycles for periods that are not directly influenced by multi-day speed-up events (Aug 11-13, 2023 and July 16-18, 2024) was performed. Fig. A5 shows that the absolute and relative peak-to-peak amplitudes for both temperature and velocity are similar between the two years, even though the 2024 data was recorded nearly one month earlier in the year. We conclude that, on seasonal timescales, the subglacial drainage system at EKaS is more established later in the season (e.g. Gjerde et al., 2025; Hoffman et al., 2016), as evidenced by a lower average velocity (Fig. 7). On

diurnal timescales, however, the glacier's speed responds similarly to temperature forcing in July and in August. This demonstrates that, from July onwards and at short timescales, the flow sensitivity to additional meltwater input does not change as the season progresses, indicating an already well established drainage system at the terminus of EKaS by July."

- L376-388: It is difficult to relate the text to areas on the figure, probably because the changes are subtle and/or embedded within the multiple lines shown in Fig. 8b. Can you help to identify these locations more clearly e.g. lines on the graph, annotations? This would certainly help improve the clarity of reading in this section.
  We will add date-periods for low-velocity and high-velocity days to highlight to which parts of the graph the given numbers belong. Additionally, colors (e.g. yellow-ish for terminus) will be appointed to the text to further clarify.
  "Again, on days with upstream propagation of velocity changes (e.g. July 20), points at the terminus (yellow) change from positive to negative acceleration (e.g. crossing the zero-line of Fig. 8b) earlier than locations further upstream (blue); on days with downstream propagation of velocity changes (e.g. July 18), upstream locations (blue) undergo this acceleration sign change before the terminus (yellow) does."

- L377: 'were selected'
  Added.

- L378: 'time-series extracted and shown in Fig. 8'
  Added.

- L377-378: Maybe I missed it, but I am not sure the term 'upstream transition regime' has been explicitly stated as this before.
  Was made consistent.
  transition regime replaced by "days with ... propagation of velocity changes".

- L381-383: Not clear to me what this relates to in Fig. 8b?
  We added "... along the centreline (i.e. all lines overlap and show a similar magnitude), with values..." to clarify.
  "Additionally, Fig. 8b shows that on days with a downstream propagation, the acceleration time-series of all locations overlap, indicating uniform acceleration and deceleration with similar magnitudes along the entire centreline."

Figures

- Figure 4: Might be more intuitive to have the brighter colours representing higher velocities.
  We tried to apply the reverted color-scale for both Figure 1 and Figures 4/5, which we want to have consistent. We came to the conclusion, that the current color-scale is easier to read. In particular, the higher velocity values towards the front are easier distinguishable with stronger colors (Fig.1) and also the diurnal cycles are better visible that way (Figs. 4/5).

- Figure 8: Can you add a color scale indicating the distance from the terminus?
  Distance information was added to the graph.

3 Review comment 2: anonymous referee

Summary

This manuscript investigates short-term ice-flow speed variability at Eqalorutsit Kangilliit Sermiat, South Greenland, over sub-diurnal to multi-day timescales using Terrestrial Radar Interferometer (TRI) measurements. The authors document clear diurnal and multi-day velocity variations that are associated with episodic water inputs, including surface melt, supraglacial lake drainage, and subglacial or marginal lake drainage events. A significant difference between the two transition regimes is the glacier's response at the terminus, where acceleration and deceleration during high-velocity periods are larger than at locations further upstream. When water input decreases, basal water pressure appears to collapse in a block-wise pattern, resulting in abrupt deceleration of basal sliding at the terminus that subsequently propagates upstream. During such events, this mechanism overrides the downward-propagating diurnal signal observed during low-velocity periods and prevents the more uniform acceleration and deceleration behavior of the glacier.

The study demonstrates the strong potential of TRI observations to resolve short-term velocity changes, and the resulting dataset is highly valuable. Overall, the interpretations are well aligned with the scope of The Cryosphere and provide meaningful insights into short-term glacier dynamics. I have some suggestions to improve this manuscript, as below.

We appreciate the reviewer's positive and constructive evaluation of our study. Below, we have carefully addressed each of the reviewer's insightful comments in our point-by-point responses and have updated the manuscript accordingly.

General Comments

- The advantages of using TRI are not sufficiently articulated. In particular, the rationale for the chosen temporal resolution (30 minutes) and cut-off period (3 hours) is unclear. Please provide justification for these choices, including discussion of coherence, signal-to-noise considerations, and any thresholds applied.

  We stated the justification for the 30 min resolution and smoothing period in the manuscript. Additionally, we will provide information about the thresholds we used in regards to data quality (signal-to-noise).

  In section 2.3.1: "To support this choice, several temporal baselines between 10 min and 1 h were tested, with the aim to minimize noise while maximising temporal resolution. While the main velocity variation patterns could already be detected on a 10 min resolution, a resolution of 30 min allowed us to get rid of most of the atmospheric noise and prevent misinterpreting noise as a physical signal."

  Several smoothing filters were tested. In section 2.3.2: "Therefore, a 30-min interval time-series covering the entire two-week period was processed for each pixel using a Butterworth low-pass filter with a cut-off period of 12 hours. The Butterworth low-pass filter and the according cut-off period was chosen because this configuration was found to performed best to effectively suppress outliers while still preserving the full diurnal velocity variability."

  In section 2.3.1: "Note, pixels with a stacked coherence smaller than 0.8 were masked out before unwrapping. However, since we originally measured the 1-min displacement, the coherence on the glacier was always given."

In section 2.3.1: "Additionally, our data quality assessment deriving velocity estimates over exposed bedrock along the glacier showed that atmospheric noise increases with distance from the calving front due to longer travel times of the radar beams through the atmosphere (Fig. A4b). [...] A velocity analysis conducted over exposed bedrock along the glacier to assess data quality (Fig. A4a) shows that the influence of atmospheric noise on the diurnal velocity measurements is negligible, and the correlation to temperature is weak (0.2 at a lag of 4 h)."

In section 2.2.1: "The range resolution is about 0.75 m, while the azimuth resolution is 0.4°, which corresponds to 6.9 m at a slant range of 1 km and in our case about 21 m at the calving front (Werner et al., 2008b,a). [...] Temporal interferometry was obtained by analysing the phase signal recorded by a single receiver antenna (in this case, the upper antenna) at consecutive acquisition time intervals of 1 minute (Werner et al., 2008a), resulting in a 1-min single-look interferogram time-series. A multilook factor of 5 was applied to spatially average the TRI data in range direction (e.g. Kane et al., 2020), as a compromise between noise reduction and high spatial resolution along the flowline, resulting in a resolution of 3.75 m (range) x 21 m (azimuth) at the glacier front."

- L58-63: This is not the first study to use TRI for this type of analysis. Additional relevant literature should be cited (e.g., Drews et al., 2021; Holland et al., 2016; Voytenko et al., 2015; Xie et al., 2018, 2019).
  The study was better embedded into existing TRI investigations.
  "Previous studies have demonstrated that the TRI can overcome many of these observational constraints and has significantly advanced our understanding of ice-flow dynamics of tidewater glaciers, particularly with respect to the interactions among ice flow, calving, ice mélange, and tidal forcing (e.g. Voytenko et al., 2015; Xie et al., 2019; Walter et al., 2020; Kneib-Walter et al., 2021; Drews et al., 2021; Wehrlé et al., 2025). Many investigations focused on fast-flowing glaciers in Greenland such as Sermeq Kujalleq in Kangia (e.g. Xie et al., 2018; Wehrlé et al., 2024; Cassotto et al., 2021) and Helheim Glacier (e.g. Voytenko et al., 2015; Holland et al., 2016; Kim et al., 2025)."

- L77-86: The TRI azimuth resolution varies with range. If the region of interest is within 6 km, what is the effective resolution near the ice front and at upstream locations? While the resolution of 6.9 m at 1 km and the maximum system range of 16 km are stated as system specifications, more detailed information is needed for the actual region of interest. Please also specify the multilook factors applied and explain why these choices were made.
  More details about the azimuth resolution at the region of interest and processing parameters was added.
  "The range resolution is about 0.75 m, while the azimuth resolution is 0.4°, which corresponds to 6.9 m at a slant range of 1 km and in our case about 21 m at the calving front (Werner et al., 2008b,a)."
  "Temporal interferometry was obtained by analysing the phase signal recorded by a single receiver antenna (in this case, the upper antenna) at consecutive acquisition time intervals of 1 minute (Werner et al., 2008a), resulting in a 1-min single-look interferogram time-series. A multilook factor of 5 was applied to spatially average the TRI data in range direction (e.g. Kane et al.,

2020), as a compromise between noise reduction and high spatial resolution along the flowline, resulting in a resolution of 3.75 m (range) x 21 m (azimuth) at the glacier front."

- L104: The plume extents are classified as (1) none, (2) small, (3) medium, and (4) large. Please clarify the criteria or thresholds used for this classification. Was this done qualitatively (e.g., visual inspection) or quantitatively? A similar clarification is needed for L168 regarding the definitions of small, medium, and large mélange-covered areas.
  The classification was done qualitatively through visual inspection of time-lapse imagery from the opposing hill. We adjusted the text accordingly.
  "This allowed us to classify the evolution of the ice mélange extents and subglacial plume extents using a visual assessment of the images. Plume extents were classified based on their estimated relative coverage in the observed area: none (0 %), small (1–25 %), medium (26–50 %), and large (51–100 %). Ice mélange was similarly classified, but with a slightly adjusted percentage range: none (1–25 %), small (26–50 %), medium (51–75 %), and large (76-100 %). Both variables were extracted twice a day in the time-series of Figs. 2d and 3d, with the four classes determined by visually estimating the relative extents."

- L236: The statement describing a lag of approximately two hours between the terminus and the location 6 km upstream is unclear. For example, deceleration appears to occur earlier and more strongly at the terminus on 2023-08-10, 2024-07-15, and 2024-07-20. Please clarify how the lag was determined and how it varies among events.
  The statement highlights the average time-lag of the acceleration sign change between the front and upstream regions. This can either be earlier on the front on high-velocity days or earlier upstream on low-velocity days. However, the actual time-difference fluctuates from day to day, usually between 1-3 hours, but 2 hours on average. We made this point more clear in the text.
  "For better readability, a zoomed-in representation with supporting labels is provided in the Appendix (Fig. A8)" and referred to in the text and caption of Fig. 5.

- L243-252: The description of Figure 6 would benefit from clearer visual guidance. Please consider annotating the figure (e.g., with arrows or highlighted regions) to indicate the areas discussed in the text, as the current presentation is not very intuitive.
  We are thankful for the feedback and adjusted the graph with visual support from labels and/or highlighted regions.
  Fig. 6 was updated by adding labels for each subfigure highlighting the propagation direction, acceleration sign and time of the day. Additionally, the zones with clear rift structure were highlighted in the plots of Fig 6 and Fig. A9. The figure caption is updated accordingly: "Black dashed polygons represent zones with major rifts (Fig. A9), potentially influencing the spatial acceleration signal on certain days (panel a and b)."

- L262: The manuscript states that a Fourier analysis of the two velocity time series revealed strong 24 h peaks for both years, but the results are not shown. To support the subsequent conclusion that this reflects a solar rather than lunar influence (12.4 h), the Fourier analysis should be presented, at least in the Appendix.
  An according figure was added in the Appendix, see Fig. A9

- L274: The manuscript suggests that the relatively low precipitation rate resulted in only a small velocity response. Please clarify the basis for this interpretation. Is this because precipitation

does not immediately translate into enhanced basal lubrication? Is there any relationship between precipitation and the acceleration observed on 2024-07-24?
We assume the referee refers to the acceleration observed on 2024-07-25. This is a valid observation and one we also considered. However, given the generally rapid response of velocity to temperature changes (on the order of 4 hours), we consider a direct influence on July 25th unlikely, particularly given the low precipitation rate. The effect of rainfall is more plausibly indirect, acting through reduced temperatures, which likely led to a diminished diurnal velocity peak on July 24. The pronounced peak observed on July 25 remains partly unexplained; however, we know that it is strongly influenced by an acceleration at the front (see Fig. 8). We made it more clearly that the rainfall event only influences the temperature/velocity on July 24.
"Given that the glacier velocity typically responds within a few hours, the rainfall event is unlikely to be responsible for the velocity increase observed around July 25."

- L298: If Sentinel-1 imagery is not shown or analyzed in this paper, please clarify why it is mentioned here, or include the corresponding results in the Appendix.
  The Sentinel-1 imagery was provided in the Appendix.
  Added to Fig. A3.

- L303: The manuscript refers to acceleration during the night of 2023-08-10. However, this pattern is not clearly shown in Figures 2a and 4c. Please clarify this interpretation or revise the text and/or figures accordingly.
  The acceleration phase on the upper part of the centreline in the night of Aug 10, 2023 is best seen in Fig. 4c and A11. However, we agree that it is not very easy to spot and we adjusted the manuscript to better highlight the matter.
  For clarification, the centreline was added on the Fig. A11 and the caption adjusted: "Potential ice-marginal lake drainage event L2 approaching the terminus on August 10, 2023 a) leading to a weakened mid-night deceleration (light-blue colours at lower part of centreline) or even an untypical acceleration (red colours at upper part of centreline), b) followed by the development of a large plume visible at the terminus in the time-lapse imagery from 6:00 am onwards (green rectangle). The number in the box shows the local Greenlandic time. The black line in a) represents the centreline and the background image is a Sentinel-2 acquisition from Aug 7, 2023 (Copernicus Data Space Ecosystem, 2025)."

- L369: Several previous studies have used GPRI for similar analyses, rather than relying solely on GPS point measurements along the glacier centerline. These studies should be cited, including Kane et al. (2020), Xie et al. (2018, 2019), and Drews et al. (2021).
  We refer to these previous studies that used TRI data towards the end of the introduction.
  "Previous studies have demonstrated that the TRI can overcome many of these observational constraints and has significantly advanced our understanding of ice-flow dynamics of tidewater glaciers, particularly with respect to the interactions among ice flow, calving, ice mélange, and tidal forcing (e.g. Voytenko et al., 2015; Xie et al., 2019; Walter et al., 2020; Kneib-Walter et al., 2021; Drews et al., 2021; Wehrlé et al., 2025). Many investigations focused on fast-flowing glaciers in Greenland such as Sermeq Kujalleq in Kangia (e.g. Xie et al., 2018; Wehrlé et al., 2024; Cassotto et al., 2021) and Helheim Glacier (e.g. Voytenko et al., 2015; Holland et al., 2016; Kim et al., 2025)."

Figures

In general, the figures, axis labels, tick labels, colorbars, and legend texts are too small and difficult to read. Please enlarge them to improve clarity.
Done as suggested.

- Figure 7: This figure appears to add limited new information to the manuscript. Consider moving it to the appendix.
  All reviewers commented on Fig. 7 with diverging opinions (from further expanding investigation to putting it into the Appendix). The authors agree with other reviewers that it is important to discuss our observations in the context of seasonal variations and therefore, we decided to keep the figure in the main manuscript, but further discuss its implication (see reviewer 1).
  Response to reviewer 1: A sensitivity analysis with the melt rates proved to be unsuccessful, mostly because too many assumptions were needed for the discharge calculations. Additionally, we have only short time periods (2 weeks) which are both heavily influenced by lake discharge events. However, we further elaborated the temperature-velocity analysis for days that show supposedly little influence of lake discharge events and managed to draw some sensitivity conclusions, which we summarized in Fig. A5 and in the following paragraph in section 4.4: "While the mean discharge is lower in July 2024 compared to 2023, the modelled discharge relies on numerous assumptions, making it difficult to draw firm conclusions about the sensitivity of the glacier flow to the evolving subglacial drainage system over the course of the season. Instead, an analysis of the average diurnal temperature and velocity cycles for periods that are not directly influenced by multi-day speed-up events (Aug 11-13, 2023 and July 16-18, 2024) was performed. Fig. A5 shows that the absolute and relative peak-to-peak amplitudes for both temperature and velocity are similar between the two years, even though the 2024 data was recorded nearly one month earlier in the year. We conclude that, on seasonal timescales, the subglacial drainage system at EKaS is more established later in the season (e.g. Gjerde et al., 2025; Hoffman et al., 2016), as evidenced by a lower average velocity (Fig. 7). On diurnal timescales, however, the glacier's speed responds similarly to temperature forcing in July and in August. This demonstrates that, from July onwards and at short timescales, the flow sensitivity to additional meltwater input does not change as the season progresses, indicating an already well established drainage system at the terminus of EKaS by July."

- Figure A3: Please consider also showing the Sentinel-2 images corresponding to drainage event L1.
  Since L1 is a subglacial lake discharge event, Sentinel-2 images provide only little evidence of the event. However, we have time-lapse imagery which nicely illustrate the timing of the event. According imagery was added to the Appendix.
  Done, see Fig. A3.

- Figure A4 and A5: Including 2D spatial velocity maps as animations or videos would be more effective in illustrating diurnal velocity fluctuations.
  The presentation of Figs. 4 and 5 were mentioned by several referees with different propositions. To best account for all suggestions, we provided an additional plot with an example zoom-in accompanied by according labels and arrows (see suggestion by reviewer 1).
  Done, see Fig. A8.

- Figure A7: Please consider overlaying the glacier centerline to improve interpretability, particularly in panel (a).

Done, see Fig. A11.

Minor comments

- The manuscript uses both “ocean-terminating glacier” and “marine-terminating glacier.” Please choose one term consistently throughout the text (or, “tidewater glacier”).
  We made sure to be more consistent. Now only marine-terminating glacier used.
- L69: The statement that the glacier’s terminus has advanced over the past few decades should be quantified (e.g., by how much).
  According numbers and potentially a reference to another paper in press was added.
- L73: Citation error (also occurs at L330).
  Thank you for pointing out.
- L125: The statement “which has a sensitivity of less than 1 mm” requires a reference.
  Was provided.
- L206: Please consider showing the Sentinel-1 data, at least in the Appendix.
  Was provided, see Fig. A3.
- L237: “Fig. 4c and Fig. 4c” typo.
  Thank you for pointing this out.
- L287: “Fig. 5d” no such panel exists.
  Thank you for pointing this out, changed to Fig. 3c

4 Community comment 1: Christian Wild

Dear Armin Dachauer and co-authors,

My name is Christian Wild, and I am a geophysicist at the University of Innsbruck, Austria. I have experience working with terrestrial radar interferometry (TRI) in both polar and alpine environments and have recently discussed Dachauer et al. in my MSc-level literature seminar. Our group’s discussion raised a number of stimulating points that we believe could contribute to further strengthening the presented conclusions. We outline our comments below and hope that our feedback will be useful to the authors.

Summary:

The study investigates short-term velocity variations (sub-diurnal to multi-day) at the terminus of the tidewater glacier Eqalorutsit Kangilliit Sermiat in South Greenland. Using a terrestrial radar interferometer (TRI) with high spatial (metres) and very high temporal (1 minute) resolution, the authors capture line-of-sight velocity changes and relate them to hydrological forcing. Sub-diurnal velocity variability is associated with surface melt, and multi-day speed-up events are linked to lake drainage. Important conclusions are made towards the mechanistic link between structural controls (rift systems) modulating hydrologically induced flow.

This dataset is exceptionally rare, and we acknowledge the considerable logistical and environmental challenges required to collect it. At the same time, the richness of the observations implies that additional analyses could help test the robustness of the proposed mechanisms and extract even more insight. Our comments are offered with the intention of helping the authors make the most of the already-processed data and the code they have available, without the need to constrain an ice-dynamical model with their observations to support some of their conclusions.

Strengths:

- The novel resolution provided by the TRI enables unprecedented detail of glacier dynamics, which are outside the resolution of conventional satellite or UAV campaigns. Its richness offers substantial potential for further scientific insight.

- The study reveals that the glacier's response to hydrological forcing is more complex than a simple uniform sliding mechanism, with contrasting behaviour observed up-glacier versus down-glacier. The possibility that existing rift networks modulate these responses is both important and intriguing, and represents a meaningful scientific contribution.

- TRI data processing is inherently complex and often difficult to convey in a clear and accessible manner. The authors demonstrate that they mastered the method, and present the workflow in a way that is both understandable and reproducible. The figures are clear and thoughtfully constructed. In particular, the creative Figure 8 is especially effective in illustrating and synthesizing the key ideas discussed, and deserves special acknowledgement for how well it supports the interpretation.

Weaknesses:

- In its present form, the paper reads as observational rather than improving our understanding on a system-level or the broader context. The paper could connect subglacial hydrology more directly to implications for mass loss, calving behaviour and interactions with ice melange, plumes versus terminal velocity (Helheim Glacier, Melton et al., 2022) or even sea-level projections. One possible approach, with the processed data at hand, is to look along ice-cliff transects (or even better delineating the rift clusters, a.k.a. blocks for more detailed analysis of the proposed mechanisms). There is a figure buried in the SI, to investigate the proposed mechanistic link without the need for modeling experiments. Figures 2 and 3 are getting there, but are then disregarded in the text in this context.

- The TRI data set is not fully explored. The advantage of the system is its high spatio-temporal resolution (as reflected in the title), but temporal downsampling from the TRI's native resolution of 1 min to 3 h, and lack of spatial heterogeneity of the presented analysis (flow-parallel transects, versus possible 2d fields) raises doubt about the robustness of the results. Further analysis of shorter/longer temporal baselines, especially the evolution of rocky areas and coherence, would greatly strengthen the conclusions about the subglacial hydrology, by excluding atmospheric variability, or spatially heterogeneous ablation, as alternative mechanisms captured by the system.

We thank the additional evaluator and his group for recognizing the methods and findings of our study, as well as for the valuable suggestions provided in the community comment. In our point-by-point responses below, we have addressed all comments and incorporated the according revisions into the manuscript.

Major comments:

1. Why are rocky areas excluded from the analysis? The TRI illuminates not only the moving ice surface, but also relatively stagnant rock faces and slopes. These areas can be used to assess the level of background noise, but even more importantly also to clearly distinguish between real glacier acceleration and apparent motion due to atmospheric variability. If the detected accelerations of the ice surface (up/down glacier and vice versa) also occur on the rocky areas nearby, clearly they are driven by atmospheric variability, if not, the author's reasoning in Section 3.2.2 are strengthened. Mean velocity fields (Fig. 1) and mean centerline velocity averages (Figs. 2 and 3, averaged over the first 2 km, but excluding a 100 m section right at the terminus. The justification for using only this part remains rather vague. See Minor comment 1) are presented, but not their standard deviations. How does LOS velocity variability change over time and space? Is there a connection to range when looking at the mean standard deviation of each pixel? How does velocity variability compare to the determined velocity increase of $15-30\%$ above average speed?
   The authors agree with the referee and the editor - who already raised the same point - that velocity time-series on rock faces nicely illustrate the uncertainty of the instrument, while at the same time highlighting the atmospheric variability and its influence on the data quality. Therefore, we provided an according bedrock velocity time-series in the Appendix. Additionally we will provide variability measures (e.g. standard deviation) to make sure an uncertainty assessment is provided.
   We added a new figure A4 showing the spatial and temporal velocity estimates over exposed bedrock along the glacier (red line) to assess data quality. The LOS velocity at the bedrock is close to zero, in particular within the distance of the centreline part (bold blue line), which is used for the mean LOS velocity calculations. This highlights that the influence of atmospheric noise on the diurnal and multi-day velocity signal is negligible. Text in the manuscript was adapted accordingly in section 2.3.2: "Additionally, our data quality assessment deriving velocity estimates over exposed bedrock along the glacier showed that atmospheric noise increases with distance from the calving front due to longer travel times of the radar beams through the atmosphere (Fig. A4b)." And in the Discussion 4.1.: "A velocity analysis conducted over exposed bedrock along the glacier to assess data quality (Fig. A4a) shows that the influence of atmospheric noise on the diurnal velocity measurements is negligible, and the correlation to temperature is weak (0.2 at a lag of 4 h)."

2. Temporal downsampling. How robust are the results when shorter or longer temporal baselines are used to calculate interferograms? How was the presented temporal baseline of 30 min chosen in the first place? We understand that TRI data were acquired at 1 min intervals, stacked to 30 min and then smoothed using a 3 h low-pass filter to derive the presented values, which are then correlated with the time series of air temperature and relative humidity. Wouldn't it make more sense to similarly smooth the AWS data for a better comparison to the TRI-derived numbers? Moreover, the propagation speed of radar waves is controlled by the absolute amount of water vapour in the air (Goldstein 1995) so using relative humidity is not an ideal quantity in this regard, we suggest to use absolute humidity or specific humidity, as typically used to study

adiabatic processes in atmospheric science. Other processing choices of the TRI were assumed to be well established, but they are not yet. How were these determined? In particular, can you provide reasoning for your choice in the temporal baseline, stacking interval for averaging, filtering, and geocoding.
We stated the justification for the temporal downsampling (i.e. 30 min resolution) and smoothing period in the manuscript (see comment reviewer 2). The purpose for showing the relative humidity is the evidence of a foehn event around 2024-07-20, characterized by very low relative humidity and a change in wind direction, rather than the influence on data quality. To test the data quality we showed a graph with the velocity time-series on a rock surface (see comment 1). Other TRI velocity processing parameters will be provided in the methods (see comment reviewer 1 and 2).
In section 2.3.1: "To support this choice, several temporal baselines between 10 min and 1 h were tested, with the aim to minimize noise while maximising temporal resolution. While the main velocity variation patterns could already be detected on a 10 min resolution, a resolution of 30 min allowed us to get rid of most of the atmospheric noise and prevent misinterpreting noise as a physical signal."

Several smoothing filters were tested. In section 2.3.2: "Therefore, a 30-min interval time-series covering the entire two-week period was processed for each pixel using a Butterworth low-pass filter with a cut-off period of 12 hours. The Butterworth low-pass filter and the according cut-off period was chosen because this configuration was found to performed best to effectively suppress outliers while still preserving the full diurnal velocity variability."

In section 2.3.1: "Note, pixels with a stacked coherence smaller than 0.8 were masked out before unwrapping. However, since we originally measured the 1-min displacement, the coherence on the glacier was always given."

In section 2.3.1: "Additionally, our data quality assessment deriving velocity estimates over exposed bedrock along the glacier showed that atmospheric noise increases with distance from the calving front due to longer travel times of the radar beams through the atmosphere (Fig. A4b). [...] A velocity analysis conducted over exposed bedrock along the glacier to assess data quality (Fig. A4a) shows that the influence of atmospheric noise on the diurnal velocity measurements is negligible, and the correlation to temperature is weak (0.2 at a lag of 4 h)."

In section 2.2.1: "The range resolution is about 0.75 m, while the azimuth resolution is 0.4°, which corresponds to 6.9 m at a slant range of 1 km and in our case about 21 m at the calving front (Werner et al., 2008b,a). [...] Temporal interferometry was obtained by analysing the phase signal recorded by a single receiver antenna (in this case, the upper antenna) at consecutive acquisition time intervals of 1 minute (Werner et al., 2008a), resulting in a 1-min single-look interferogram time-series. A multilook factor of 5 was applied to spatially average the TRI data in range direction (e.g. Kane et al., 2020), as a compromise between noise reduction and high spatial resolution along the flowline, resulting in a resolution of 3.75 m (range) x 21 m (azimuth) at the glacier front."

In section 2.3.1: "For visualization purposes, the radar image pixels were transformed into Cartesian coordinates. Since resampling may introduce errors, all computations were conducted in the original radar geometry, with georeferencing applied only to the final outputs."

A similar smoothing of the air temperature was applied, in particular for the correlation investigation and the diurnal cycle analysis (Fig. A5). The correlation values remained the same, therefore we decided to keep the non-smoothed values in Fig. 2/3b.

3. Some major conclusions read deterministic (e.g., L416 'driven by additional water input from surface melt', or L422 'could clearly be linked to lake drainage events') without direct observations in the subglacial system, such as ground-penetrating radar or additional evidence from modeling experiments. Does the temporal coverage of the TRI data set justify these conclusions, if only the end of a drainage event is captured? In contrast, these core conclusions are only made from 'weak' temporal correlation (L158: 0.6 at a lag of 4 hours) without rigorous analysis of their statistical significance. We suggest moving these conclusions, which are only partly warranted by the data analysis, to a dedicated discussion section, if no further evidence from auxiliary analysis are presented.
Given the strong correlation between air temperature and velocity for periods with not additional signal such as lake discharge events (0.7 in 2023 and 0.8 in 2024), together with the fact that the timing of L1 and L2 fits well with the periods of low cross-correlation, we are confident that the given conclusion is justified. Furthermore, the comment somewhat contradicts with reviewer 1, that demanded a clearer positioning of the implications of the study. However, we rephrased this sentence to weaken the deterministic touch of our conclusion.
"We found that the glacier's velocity shows clear temporal fluctuations on both diurnal and multi-day scales, likely driven by additional water input from surface melt or lake drainage events. [...] Additionally, several detected multi-day events with substantially enhanced flow velocities could be linked to subglacial or ice-marginal lake drainage events."

4. Given the spatial detail resolved by the TRI measurements, we would appreciate a more in-depth examination of how the rift system mechanically influences hydrologically driven flow near the terminus. Previous studies (e.g., Ultee et al., 2022) generally assume spatial homogeneity when assessing terminus variability, but here we have the opportunity to investigate this signal at much finer spatio-temporal scales. We therefore recommend focusing the analysis on ROIs where individual blocks exhibit distinct behavior, and we request an additional figure showing the locations of these blocks and their respective LOS velocity evolution over time.
The temporal investigation of individual blocks is indeed very interesting. Having this motivation in mind, the authors tested several option to best visualize the processes. Finally, we decided that the spatial detail can best be presented with a combination of Fig. 6 and Fig. 8. At Fig. 8, different colours belong to points within the individual "blocks", and therefore show the LOS velocity evolution over time for different sections at the glacier (see section 4.6).
Fig. 6 was updated by adding labels for each subfigure highlighting the propagation direction, acceleration sign and time of the day. Additionally, the zones with clear rift structure were highlighted in the plots of Fig 6 and Fig. A9. The figure caption is updated accordingly: "Black dashed polygons represent zones with major rifts (Fig. A9), potentially influencing the spatial acceleration signal on certain days (panel a and b)."

Minor comments:

1. TRI data processing: How was the geocoding performed? What DEM? Temporal baseline, how was this determined to be a representative time scale? What pixel was used for the phase unwrapping, and how was it chosen (coherence?)? What is the temporal variability of the phase at the chosen pixel and how does that add to the overall uncertainty? L134: 'Where data quality is highest' reads subjective, is there a threshold in coherence applied? L82 please add or reword to mentioning range/azimuthal resolution at the actual study site, which is $3 - 9$ km away.

   The temporal baseline was discussed in major comment 2, the uncertainty in major comment 1. We further elaborated the geocoding, phase unwrapping and the data quality threshold. The azimuth resolution at the area of interest will be added (see reviewer 2).

   In section 2.3.1: "For visualization purposes, the radar image pixels were transformed into Cartesian coordinates. Since resampling may introduce errors, all computations were conducted in the original radar geometry, with georeferencing applied only to the final outputs."

   In section 2.3.1: "To support this choice, several temporal baselines between 10 min and 1 h were tested, with the aim to minimize noise while maximising temporal resolution. While the main velocity variation patterns could already be detected on a 10 min resolution, a resolution of 30 min allowed us to get rid of most of the atmospheric noise and prevent misinterpreting noise as a physical signal."

   Several smoothing filters were tested. In section 2.3.2: "Therefore, a 30-min interval time-series covering the entire two-week period was processed for each pixel using a Butterworth low-pass filter with a cut-off period of 12 hours. The Butterworth low-pass filter and the according cut-off period was chosen because this configuration was found to performed best to effectively suppress outliers while still preserving the full diurnal velocity variability."

   In section 2.3.1: "At a next step, the phase signal was unwrapped using a stable location on bedrock as a control point. The phase differences between consecutive unwrapped interferograms, can be converted into LOS displacement δ by:

   $$\delta = -\frac{\lambda \phi}{4\pi}, \tag{4}$$

   where $\lambda = 17.4\,\mathrm{mm}$ is the wavelength, ϕ is the differential phase difference, and the displacement measurement sensitivity is better than 1 mm (Werner et al., 2008a). Note, pixels with a stacked coherence < 0.8 were masked out before unwrapping. However, since we originally measured the 1-min displacement, the coherence on the glacier was always given."

   In section 2.3.1: "Additionally, our data quality assessment deriving velocity estimates over exposed bedrock along the glacier showed that atmospheric noise increases with distance from the calving front due to longer travel times of the radar beams through the atmosphere (Fig. A4b). [...] A velocity analysis conducted over exposed bedrock along the glacier to assess data quality (Fig. A4a) shows that the influence of atmospheric noise on the diurnal velocity measurements is negligible, and the correlation to temperature is weak (0.2 at a lag of 4 h)."

   In section 2.2.1: "The range resolution is about 0.75 m, while the azimuth resolution is 0.4°, which corresponds to 6.9 m at a slant range of 1 km and in our case about 21 m at the calving front

(Werner et al., 2008b,a). [...] Temporal interferometry was obtained by analysing the phase signal recorded by a single receiver antenna (in this case, the upper antenna) at consecutive acquisition time intervals of 1 minute (Werner et al., 2008a), resulting in a 1-min single-look interferogram time-series. A multilook factor of 5 was applied to spatially average the TRI data in range direction (e.g. Kane et al., 2020), as a compromise between noise reduction and high spatial resolution along the flowline, resulting in a resolution of 3.75 m (range) x 21 m (azimuth) at the glacier front."

2. General level of processing: How was the plume size determined? Was there a quantitative component to the use of "small", "medium" or "large"? L87: Were calving events detected manually, semi-automatically or automatically from the TRI derived DEMs? Similar for time-lapse imagery (L104), how was ice melange extent and subglacial plume extent quantified? L106: Add when the subglacial lake drainage event occurred approximately to help the reader.
   The specific method of the plume, ice melange and calving extraction was added (see Technical corrections reviewer 1). Calving events were extracted automatically from the TRI derived DEMs, the according method added in the data processing section 2.2.3. (see review 1).
   We added ins section 2.2.3.: "This allowed us to classify the evolution of the ice mélange extents and subglacial plume extents using a visual assessment of the images. Plume extents were classified based on their estimated relative coverage in the observed area: none (0 %), small (1–25 %), medium (26–50 %), and large (51–100 %). Ice mélange was similarly classified, but with a slightly adjusted percentage range: none (1–25 %), small (26–50 %), medium (51–75 %), and large (76-100 %). Both variables were extracted twice a day in the time-series of Figs. 2d and 3d, with the four classes determined by visually estimating the relative extents."

3. L114: Interpretation of tides, how well is the measured tide captured by a tide model such as Greenland 1 km Tide Model (Gr1kmTM, Howard and Padman, 2021)?
   A second pressure sensor was installed in close proximity and yielded comparable results, thereby supporting the reliability of the measurements. As the tide gauge plays only a minor role in this manuscript—being used primarily to determine the timing of diurnal tide cycles and spring tides, which we consider to be sufficiently constrained by the existing setup—we did not incorporate additional applications or products, such as the referenced tide model.

4. L158: Are the following correlations statistically significant? How about any correlations to absolute/specific humidity?
   The correlation to humidity values was checked. Relative humidity values for both field periods show a weak (and negative) correlation to flow velocity for a) the entire period and b) the period with high agreement in the temperature-velocity correlation (2023: a)-0.1, b) -0.5; 2024: a)-0.3, b)-0.5). Due to the low correlation, we decided to not include that data in the manuscript.

5. L178: Could this be a low-pass filtered humidity signal? A comparison to a nearby rocky area, and its apparent velocity variability, might further support the observation of a real response of the ice to melt triggered by the drastically high air temperatures.
   This issue is discussed in major comment 1.

6. L225: Why is the analysis constrained to a centerline, and not the full spatial resolution of the TRI utilized and explored?
   The visualisation of a 2D velocity field over time is generally rather challenging. Therefore, the authors decided to provide a combination of figures using a centreline (e.g. Figs 2,3,4,5)

and figures showing 2D maps of the velocity (e.g. Figs. 1 and 6). To further investigate the spatial variability, we created a plot with several flowlines (Fig. A6) and crosslines (Fig. A7), which indicate that the diurnal variability is spread homogenously throughout the entire area (see section 3.2.1). With Fig. 6 we provide a 2D velocity map to highlight the spatial variations in acceleration. Like this, we hope to present our results in the best way while still keeping the plots readable.

7. L226: 'typical' always needs at least one e.g. type citation. Similar to the word 'generally' elsewhere.
   This part of the sentence was removed because it is not relevant at the Results part of the manuscript.

8. L237: 'Fig. 4C' typo.
   Thanks for pointing out.

9. L238: How do rocky areas behave during these times? Are they showing similar oscillations as observed on the glacier?
   See major comment 1 above.

10. L255: Quantify 7% of mean velocity and compare it to the uncertainty of the TRI measurement.
    See major comment 1 above.
    An additional figure was added (A5) that quantifies an average diurnal cycle for both temperature and velocity. The uncertainty of the TRI data is highlighted on Fig. A4.

11. L287 why cite Fig. 5c and d for foehn events? Double check the figure references. There is no panel 5d.
    Thanks for pointing out this typo. This was changed to Fig. 3c. 5d will be removed.

12. L327: Agree that the mean velocity fits well, but the TRI variability is much larger than the satellite-derived variability at this time of the year. Given that the TRI measures only the LOS component, one would expect a smaller mean and smaller variability when compared to the satellite? Rotating the satellite derived velocity into LOS would be beneficial to this comparison, which requires geocoding of the TRI.
    The authors agree that the TRI "only" measures LOS velocity and therefore misses a part of the absolute signal as compared to the satellite-derived velocity values. However, the set-up of the TRI is ideal in a way that it captures the large majority of the velocity signal, despite the LOS restriction. Furthermore, the purpose of the graph is to highlight the annual velocity variability of the glacier. We adjusted the figure caption/manuscript to make it more clear.
    Figure caption: "Satellite-derived, year-round velocity estimates of EKaS' centreline by Gardner et al. (2023) highlighting the intra-annual velocity variations of EKaS, as well as TRI time-series of the two field campaigns (green) indicating the measurement period within the annual cycle. Note that the data from TRI only captures the line-of-sight component of the velocity.". Also added in manuscript: "Note that the data from TRI only captures the line-of-sight component of the velocity."

13. L371: The sub-daily pattern could also be atmospheric variability on a daily cycle, couldn't it? Again, a comparison to nearby rocky areas would help to strengthen the observed response of the glacier.
    This issue was discussed in major comment 1.

Figures

- General: Label foehn events and lake drainage events between figures (f.e. with shading, or labels) to better link figures and concepts across the text.
  The lake drainage events L1 and L2 are already added in Fig 2 and 3, respectively. There is only one foehn event occurring during the two field periods, which is widely discussed in section 3.1.2. Since Figs. 2 and 3 are already quiet dense, we chose not to add additional shading for this single foehn event in order to avoid overloading the figures and to maintain readability.
  Lake drainage events are added in Figs. 2/3a, foehn event was added to Figs. 3b/c to avoid overloading.

- Figure 1: Consider adding a photo of the TRI in the foreground, and the illuminated surface in the background to make the viewing geometry more accessible to the casual reader. L:71 describes the illuminated ice cliff, l: 78 the viewing geometry, but sensitivity of the TRI at such a shallow viewing angle will mostly be horizontal velocity component, and not vertical deflection as was the focus of studies investigating tidal displacement (Drews et al., 2021). It would be good to see a DEM of the glacier surface, so consider a contourmap on ice and rock. Shown is realistic, mean LOS velocity for each glaciated pixel, please add temporal standard-deviation for each pixel as well as avoid masking out the rocky areas.
  A photo of the TRI set-up will be added to the Appendix (see technical corrections reviewer 1). We checked adding a contourmap as well as removing the masking and see if the readability is still guaranteed. A temporal standard-deviation will only reflect the high temporal variability of velocity during the measurement period and therefore not add any uncertainty information. However, a measure for data uncertainty was provided (see major comment 1).
  TRI photo was added into Fig. 1. Temporal and spatial uncertainty information is given in the new Fig. A4. Unfortunately, a contourmap added to the graph was overloading the figure and clearly reducing readability. Therefore, we decided to not add a contourmap and hope that the provided image together with distance and elevation information at our study site ("EKaS has an approximately 3 km wide and 360 m high calving front, which is grounded at a water depth of 280 m (bathymetry data collected using single beam echosounder (Rosier, 2025)).[...] The instrument was positioned on solid bedrock atop an opposing hill, 496 m above sea level and three kilometres from the calving front") would give sufficient elevation information.

- Figures 2 and 3: The 'LOS velocity' is the mean along a section of a flowline. How does the standard deviation around the presented time series of mean values evolve? Consider plotting Figures 2/3 side by side to make it easier for the reader when text compares similarities/differences between the seasons.
  A measure for data uncertainty along the time-series was provided (see major comment 1). The plotting of the two Figures next to each other was considered by the authors. Unfortunately, it comes at the disadvantage of shrinking the already well-loaded plots and reducing readability of the diurnal variability within the time-series, which are a key finding of this study. Therefore, we kept the two individual plots.
  Temporal and spatial uncertainty information is given in the new Fig. A4. Figs. 2 and 3 are updated showing the ± standard deviation of the presented time-series instead of raw velocity values.

- Figure 4 and 5: a legend of the coloured boxes and their meaning would be useful. Different color to the presented anomalies. Put arrows down/up direction for intuitively. If it is uncertain

do an up / down arrow or maybe a question mark.
The presentation of Figs. 4 and 5 were mentioned by several referees with different propositions. To best account for all suggestions, we provided an additional plot with an example zoom-in accompanied by according labels and arrows (see reviewer 1 and 2).
Fig. A8 shows an explanatory zoom-in of the acceleration supported by labels and arrows.

- Figure 6: Couldn't this also be atmospheric variability? This is where showing the rocky areas will have a huge impact on the interpretation of the signal. Delineate the discussed blocks which are nicely discussed later for spatial heterogeneity. Colorbar labels need to be much bigger.
  Atmospheric impact was discussed in major comment 1. The blocks were better highlighted (see referee 1). Colorbar label was increased.

- Figure 7: comparison of satellite derived speed and TRI derived LOS velocity. Can the ITS_Live be rotated into the TRI viewing geometry for a direct comparison? It is surprising to see larger variability in a LOS velocity component when compared to an absolute speed.
  The authors agree that the TRI "only" measures LOS velocity and therefore misses a part of the absolute signal as compared to the satellite-derived velocity values. However, the set-up of the TRI is ideal in a way that it captures the large majority of the velocity signal. The authors are not surprised by the larger short-term variability observed in the LOS velocity component compared to the absolute speed. Short-term velocity increases (e.g. during foehn events) cannot be resolved by satellite-based velocity estimates, which provide observations only every 1–3 days, which have been smoothed by multi-day averaging necessitated by limited data availability. We consider this effect being much larger than the "signal loss" when only capturing the LOS component.

- Figure 8: Please add labels specifying down- to glacier acceleration, and vice versa. For panel B. It's a nice creative figure but it would help to have some guidance for getting the main point. Include modifying the caption, and provide shading to link events across figures.
  Figure was adjusted and caption modified for more clarity.
  The updated figure shows distance information of each location. Additionally, the green-orange color-coding boxes from Fig. 5 were also added on Fig. 8 to guide through the events. The caption was modified accordingly.

- Figure A1, A2, A4, A5, A8, A9 are too small. Please increase in a revised manuscript.
  Figure sizes was increased.

- Figure A6 would benefit from being shown side-by-side with satellite-derived shear strain rates from the mean ice-flow product, ideally rotated into line-of-sight (LOS) for a more meaningful comparison. At present, it is unclear how useful shear strain rates derived directly from LOS velocities actually are. Longitudinal, transverse, and shear strain rates are defined within a coordinate system aligned with the mean flow direction, whereas TRI-derived LOS velocities are strongly influenced by the instrument's viewing geometry and sensitivity patterns. As a result, calculating strain rates from LOS measurements alone does not yield physically interpretable quantities in the glacier flow frame and may be misleading without appropriate geometric transformations.
  The purpose of the LOS shear strain rate map is to highlight the position of the main rift systems, which potentially influence the block-wise acceleration and deceleration pattern. Since the absolute values and thus the uncertainty regarding the viewing geometry are secondary, the authors decided to only show the figure in the Appendix. However, to address the issue we considered

adding thin outline-lines of the rift 'blocks' in the map of Fig. 6 (see referee 1).
The zones with a clear rift structure were highlighted in the plots of Fig 6 and Fig. A9. The figure caption is updated accordingly: "Black dashed polygons represent zones with major rifts (Fig. A9), potentially influencing the spatial acceleration signal on certain days (panel a and b)."

- Figure A7: seeing the rocky areas, and how the spatial pattern of the signal evolves through this lake-drainage event, would greatly improve confidence.
Velocity time-series on a rocky area was shown throughout the entire period, not only the lake-drainage event (see major comment 1).

- Figure request: Delineate ROIs of blocks and show the time series of their movement with associated standard deviations.
The temporal investigation of individual blocks is indeed very interesting. Having this motivation in mind, the authors tested several option to best visualize the processes. At Fig. 8, different colours belong to points within the individual "blocks", and therefore show the LOS velocity evolution over time for different sections at the glacier (see section 4.6).

Thank you again for the time and care you've put into presenting this impressive TRI dataset. We're confident that the study will make a valuable contribution to the field, and we believe it is very well suited for The Cryosphere.

Sincerely, Christian Wild.

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