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

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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 diunal 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 substantative comments that I ask the authors to consider in their revision:

- 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 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.

- 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 glcier 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.

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

L1-2: Aren't ice discharge and frontal ablation essentially considered the same?

L5: If the data were gridded on a uniform grid, you should state the resolution precisely.

L6-7: Sensitivty in terms rapid change in velocity in response to meltwater inputs? Or something else? Be precise.

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?

L16-18: Glaciers are still the largest contributor, check out the recent GLAMBIE community estimate (https://www.nature.com/articles/s41586-024-08545-z). There are also more recent references that should be cited alongside these e.g. Otosaka et al. (2024)

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.

L23: E.g. studies such as Tedstone et al. (2015) [https://www.nature.com/articles/nature15722] that showed long-term slowing down of a land-terminating glacier in response to larger melt input to the bed.

L28: Optical and SAR are imagery, I think you mean feature speckle tracking in optical and SAR image pairs

L30: Far more than a few studies.

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

L34-35: Broad statement that is not always true. I think its important to acknowledge the complexities here e.g. drainage may shit 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. Diurmal changes can be observed, whilst long-term changes are less well known due to observational constraints.

L36: Challenges? I assume you are referring to measuring the inaccessible bed?

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?

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.

L60: What is the research question being addressed?

L74: Could you put this into perspective with other glaciers? How does it compare to the big tidewater glaciers in Greenland e.g. Jakobshavn, Helhim etc.?

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.

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

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.

L118: No mention of how the DEMs were derived?

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 inc. key equations of how you related phase changes to displacement. Did you have to coregister the images e.g. due to winf buffeting of the radar?

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

L124: Important recognise throughout the paper that the temporal resolution of your measurements is 30 minutes and NOT 1 minute, as is claimed.

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).

L168: I note here that the method to extract mélange presence / absence has not been described in the methods, but should be. Some for the detection of plumes.

L174: It's slightly off that these are not disucssed in chronological order i.e. 2023 and then 2024.

L185: State dates.

L190: Reference relevant section / figures.

L194: Isn't it an ice-marginal lake? Reference the figure where it is labelled L1 - Figure A3 I think.

L195: How was this calculated?

L196: Is there a figure showing the lake drainage event?

L198: When did the lake drain? Do you have exact dates?

L203: Reference relevant figure. Wasn't L2 a supraglacial lake?

L204: True if it's a supraglacial lake, unclear if it's an ice-marginal lake.

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.

L218-222: What about calving and diurnal variations - are there any signals or correlations?

L230: I assume the contant difference means the dirunal signal is clear at all distances from the terminus? I'd explicitly state this.

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 assertaion may be partially true, but I think its worth stating that this may only hold when the 'high velocity days' are significantly larger than the base velocity level.

L239: Were the orange/green boxes calculated manually? Or some other way?

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 clairty - I assume it relates to the step-like pattern clearly visible in Fig, 6a.

L255-261: I would start with a comparison to other Greenlandic outlet glaciers and then consider other glaciated regions (e.g. Alaska).

L273-275: Does the July 23 precipitation have any relationship to the velocity increase on July 25th?

L276-282: This is quite vague - how would wing speed affect the velocity variations? For cloud cover, I suspect it is not a straight 1-1 relationship, does you RH data provide any clues as to the relationship?

L302-304: I must admit, I am struggling to see the acceleration. Is it the multi-day slowdown that is important here?

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.

L322: To prove this point, you need a graph over the same period showing frshwater discharge - I assume you more broadly mean 'melt' i.e. a temperature graph would suffice?

L326-327: You might discuss thebelow, but this part is interesting - stored meltwater at the bed over winter? Possibly, considering the recent findings of Hansen et al. (2025).

L344-245: 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 Appendic C! But can you use this to quantify the sensitivity of the drainage system over the velocity time series in Figure 7?

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.

L377: ‘were selected’

L378: ‘time-series extracted and shown in Fig. 8’

L377-378: Maybe I missed it, but I am not sure thge term ‘upstream transition regime’ has been explicitly stated as this before.

L381-383: Not clear to me what this relates to in Fig. 8b?

Figures

Figure 4: Might be more intuitive to have the brighter colours representing higher velocities.

Figure 8: Can you add a colorscale indicating the distance from the terminus?