

November 21, 2025

**Community comment to Dachauer et al., TCD,
“High spatio-temporal velocity variations driven by water input at a
Greenlandic tidewater glacier”**

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 mélange, 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.

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 100m 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?

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 3h 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.
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.
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.

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.
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.
3. L114: Interpretation of tides, how well is the measured tide captured by a tide model such as Greenland 1km Tide Model (Gr1kmTM, Howard and Padman, 2021) ?
4. L158: Are the following correlations statistically significant ? How about any correlations to absolute/specific humidity ?
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.

6. L225: Why is the analysis constrained to a centerline, and not the full spatial resolution of the TRI utilized and explored ?
7. L226: 'typical' always needs at least one e.g. type citation. Similar to the word 'generally' elsewhere.
8. L237: 'Fig. 4C' typo.
9. L238: How do rocky areas behave during these times ? Are they showing similar oscillations as observed on the glacier ?
10. L255: Quantify 7% of mean velocity and compare it to the uncertainty of the TRI measurement.
11. L287 why cite Fig. 5c and d for foehn events ? Double check the figure references. There is no panel 5d.
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.
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.

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

- 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.
- 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.
- 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.
- 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.
- 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.
- 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 A1, A2, A4, A5, A8, A9 are too small. Please increase in a revised manuscript
- 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.
- Figure A7: seeing the rocky areas, and how the spatial pattern of the signal evolves through this lake-drainage event, would greatly improve confidence
- Figure request: Delineate ROIs of blocks and show the time series of their movement with associated standard deviations.

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.