Reply on CC1.

We thank the commenter for their positive and constructive comments on this manuscript. In the response below, we address the comments made by Jessey Rice and others, and explain the changes we would make to the manuscript. Comments are in black, and our responses are in red.

General comments:

The manuscript provides significant new insights into the subglacial geomorphology and subglacial evolution of the NEGIS. The identification of MSGLs under current low velocities and within relatively close proximity to an ice divide provides an important contribution to our understanding of subglacial dynamics. While this data provides invaluable details on subglacial landform geology and basal conditions, we feel this argument could be strengthened with a brief discussion of paleo-reconstruction from the LIS that has also highlighted warm-based, moderately fast-flowing conditions in relatively close proximity to ice divides (e.g., Hodder et al., 2019; Rice et al. 2020; McMartin et al. 2021). Specifically, Hodder et al. (2019) identified a complex till stratigraphy that suggested considerable till production in the vicinity of the last position of the Keewatin Ice Divide, possibly related to deposition as part of a large tributary ice stream flowing north toward the Arctic Ocean. McMartin et al. (2021) identified that the Dubawnt Lake Ice Stream propagated back to an area where the Keewatin ice divide migrated over and is presumed to have been located. Paulen et al. (2017, 2025) documented mineral dispersal from a rare earth element deposit occurring in the trunk of the Kogaluk River ice stream at Strange Lake, Labrador, where the onset zone of that ice stream (IS #187 of Margold, 2015) was a mere 30 km from the mapped location of the Ancestral Labrador Ice Divide in the George River region (Dubé-Loubert et al., 2021). Finally, Rice et al. (2024) provided evidence of ice divide migration in close proximity to both the Ungava Bay Ice Streams, the Cabot Lake Ice Stream, and the Smallwood Reservoir Ice Stream. We believe these LIS comparative studies, especially their documentation of “mixed bed landform assemblages,” provide particularly insightful examples for your manuscript, as they may have had similar glacial lineation formation to what you are observing in the NEGIS. Again, this manuscript provides important insights into the formation of these subglacial conditions, which offer unique insights into the broader subglacial mechanics at play, especially regarding ice flow velocities. However, we believe the examples from the LIS will also provide important insights into their formation and preservation. Please see specific examples below. If you have any questions or require any clarification on these comments, please feel free to reach out to me: jessey.rice@nrcan-rncan.gc.ca.

Jessey Rice, Geological Survey of Canada, Ottawa

We thank the commenters for their suggestions on how to strengthen the arguments in our manuscript, and agree that the some of the studies listed above are useful comparison points. We are very familiar with much of the work outlined above and completely agree that the onset zones of palaeo-ice streams in North America extended up-ice and very close to the position of the inferred ice divides. However, our key finding is that highly elongate bedforms (which we interpret as MSGLs) exist very close to the present-day ice divide. Few of the studies cited report evidence of MSGLs so close to an ice divide, although we would be happy to be corrected.

Specific examples:

Line 220 (Dowdeswell et al., 2014), the Amundsen Sea Embayment (Graham et al., 2009) and the North Sea (Roberts et al., 2019) (Fig. 7). These types of subglacial landscapes are

characterised by the presence of crag and tails, drumlins, and highly elongate lineations, and thought to be formed under ice streams (Roberts et al., 2019; Dowdeswell et al., 2014; Graham et al., 2009)

Additional North American studies that could strengthen this argument: Margold et al. (2015), Eyles et al. (2018), Sookhan et al. (2021), Rice et al. (2024).

Thank you for this suggestion. We would also reference Eyles et al. (2018) here, as it demonstrates the combined presence of bedrock outcrops and deforming sediment. We are familiar with the inventory of ice streams in Margold et al. (2015) but, having inspected those ice stream beds in detail, very few record MSGLs so close to the inferred ice divide.

Line 266: To our knowledge, the only other high-resolution survey of an ice stream onset zone (King et al., 2007) revealed classic drumlin forms (elongation ratios 1:1.5 to 1:4) and a potential ribbed moraine under Rutford Ice Stream, West Antarctica, where velocities accelerate from 72 to >200 m yr-1. Furthermore, the location of the MSGLs in our study, 600 km from the grounding line and only ~200 km from the main ice divide, is also the furthest inland that MSGLs have been identified

Depending on the definition of high resolution, air photo interpretation (see Geological Survey of Canada Canadian Geoscience Maps (CGM) 410 and 429 (1:100 000 scale) produced from 1:60 000 scale air photos) indicates the onset zone of an ice stream in even closer proximity to the divide (summarized by Rice et al., 2024). Similar findings using higher satellite imagery were made by Dubé-Loubert et al. (2021).

Here we were referring to high-resolution DEMs of modern ice streams, rather than surveys in general, and will clarify this as follows:

“To our knowledge, the only other high-resolution survey DEM of a modern ice stream onset zone (King et al., 2007) …”

As noted above, we are aware of ice stream onset zones extending very close to ice divides, but these are not usually characterised by well-developed MSGLs and will make that point clearer in the revised manuscript.

Line 270: Furthermore, the location of the MSGLs in our study, 600 km from the grounding line and only ~200 km from the main ice divide, is also the furthest inland that MSGLs have been identified.

Assuming this is just for the NEGIS, as MSGLs have been identified further inland in other regions of former continental ice sheets (i.e., the Laurentide Ice Sheet), can you please clarify?

This again was only referring to surveys of modern ice streams, so we will clarify this and also refer to a study you have highlighted (Hodder et al., 2016) to show that onset zones can be located close to ice divides, although rarely with identified MSGLs.

Line 308: Whilst we cannot rule out an episode of enhanced flow at this location in a previous glaciation, the sedimentary basins outside of the northwestern shear margin (Fig. 6) show little evidence of MSGL formation. This would mean that the ice stream would have to have formed in the same configuration as observed today in a prior glaciation, potentially with a higher velocity, to produce the observed MSGLs. Even so, if this had occurred, this would then suggest that MSGLs can be preserved for 100s to 1000s of years under relatively slow ice velocities.

We agree with this assumption, but postulate, is it potentially also possible that the lower velocity of the ice stream is due to ice divide migration closer to the study area? (i.e., was the

divide previously further upstream and slowly propagated toward the study area, lowering velocity as it did so?

We would regard this possibility as unlikely, as the folding of the internal reflection horizons within the ice stream indicate a slower convergent flow regime prior to the localisation of the shear margins, after which the ice stream starts to flow faster (Jansen et al., 2024). In addition, the rotation of the orientation of the ice crystal basal planes lead to mechanical weakening in the shear margins (Gerber et al., 2023), which in turn facilitates localised deformation and faster ice stream flow. Also, modelling of the NEGIS and Greenland Ice Sheet would indicate that the ice stream propagates from its outlet glaciers upstream (Tabone et al., 2024), meaning that the velocities present at the onset now would have only increased to their current velocity, rather than decreased from a higher velocity. This is a highly difficult scenario to constrain, but with our current knowledge, we would not think this is not the case. This will be discussed more thoroughly in Section 4.2.

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