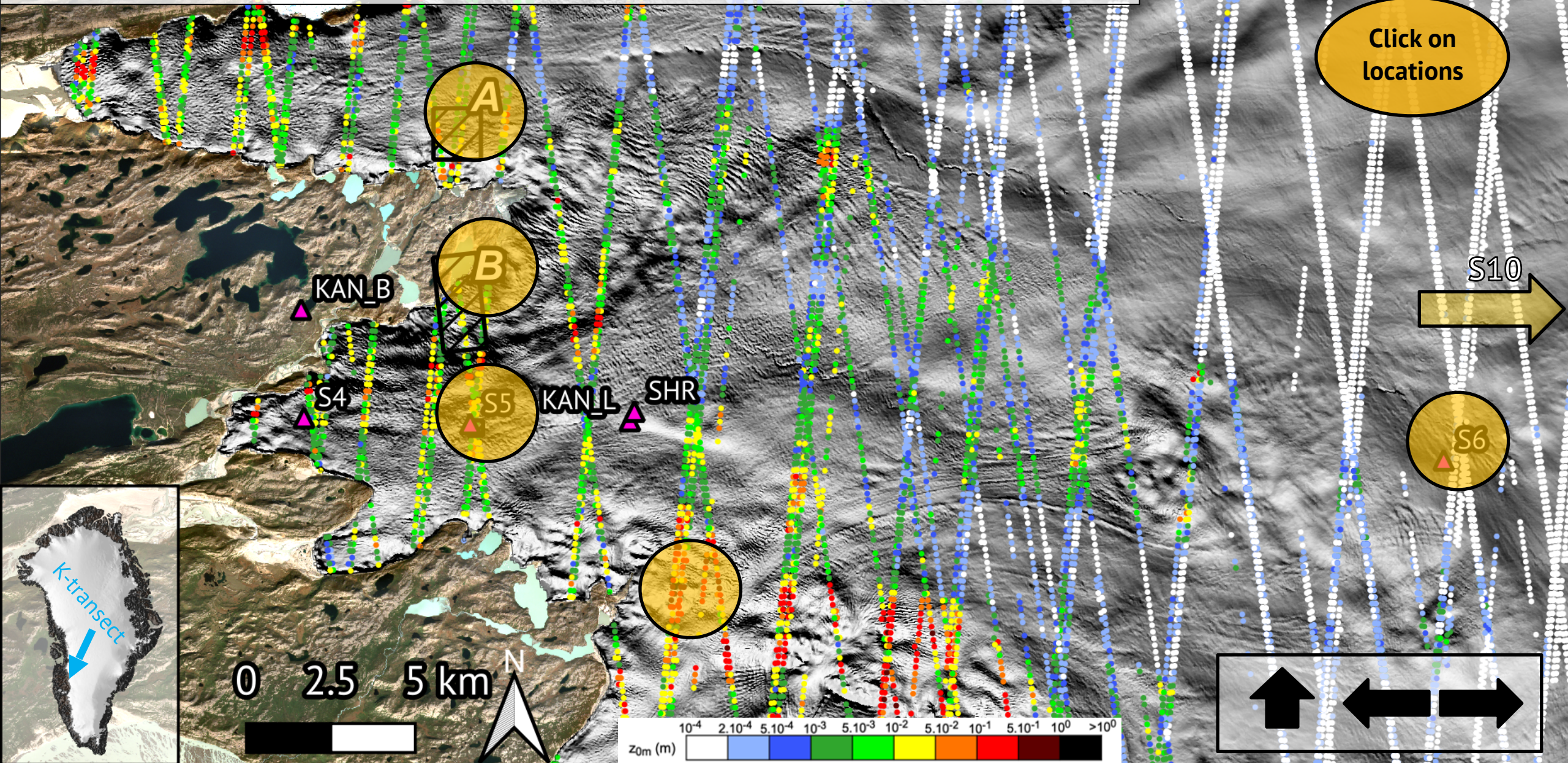


Mapping the aerodynamic roughness of the Greenland ice sheet using ICESat-2

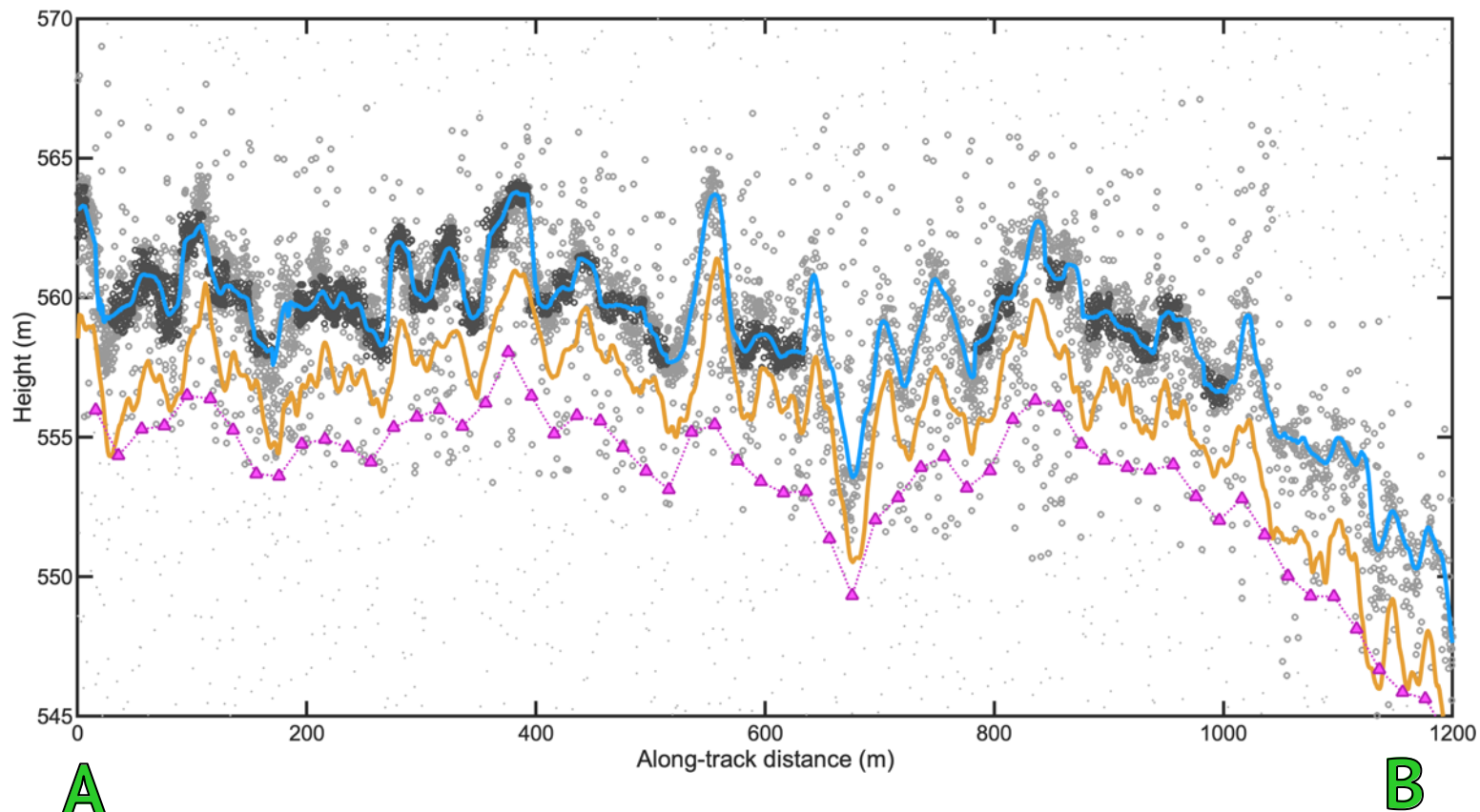
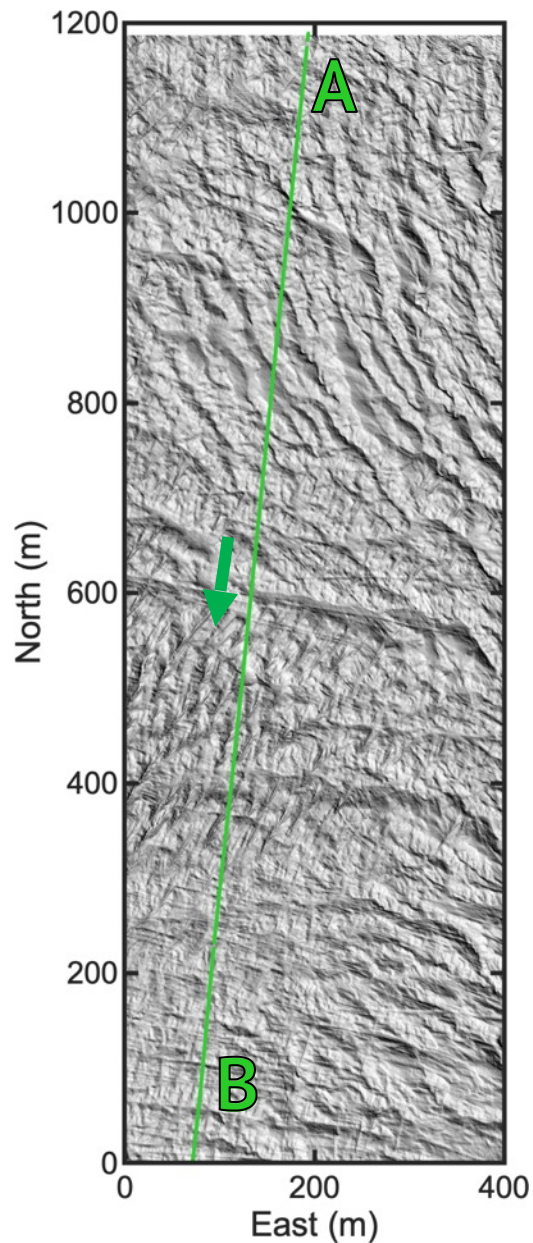
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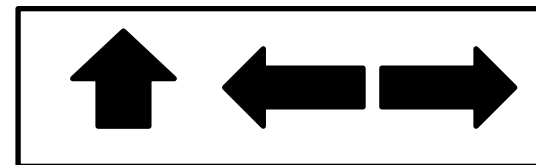


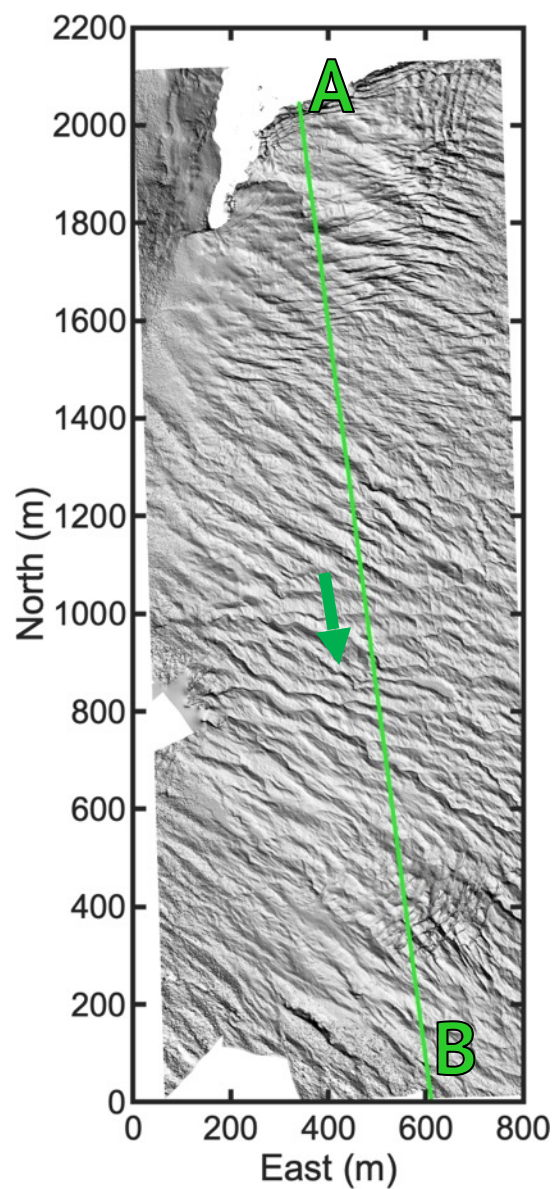
Area A: rough & crevassed ice on edge of Isunnguata sermia

latitude/longitude [\(67.1650 / -50.0796\)](#)



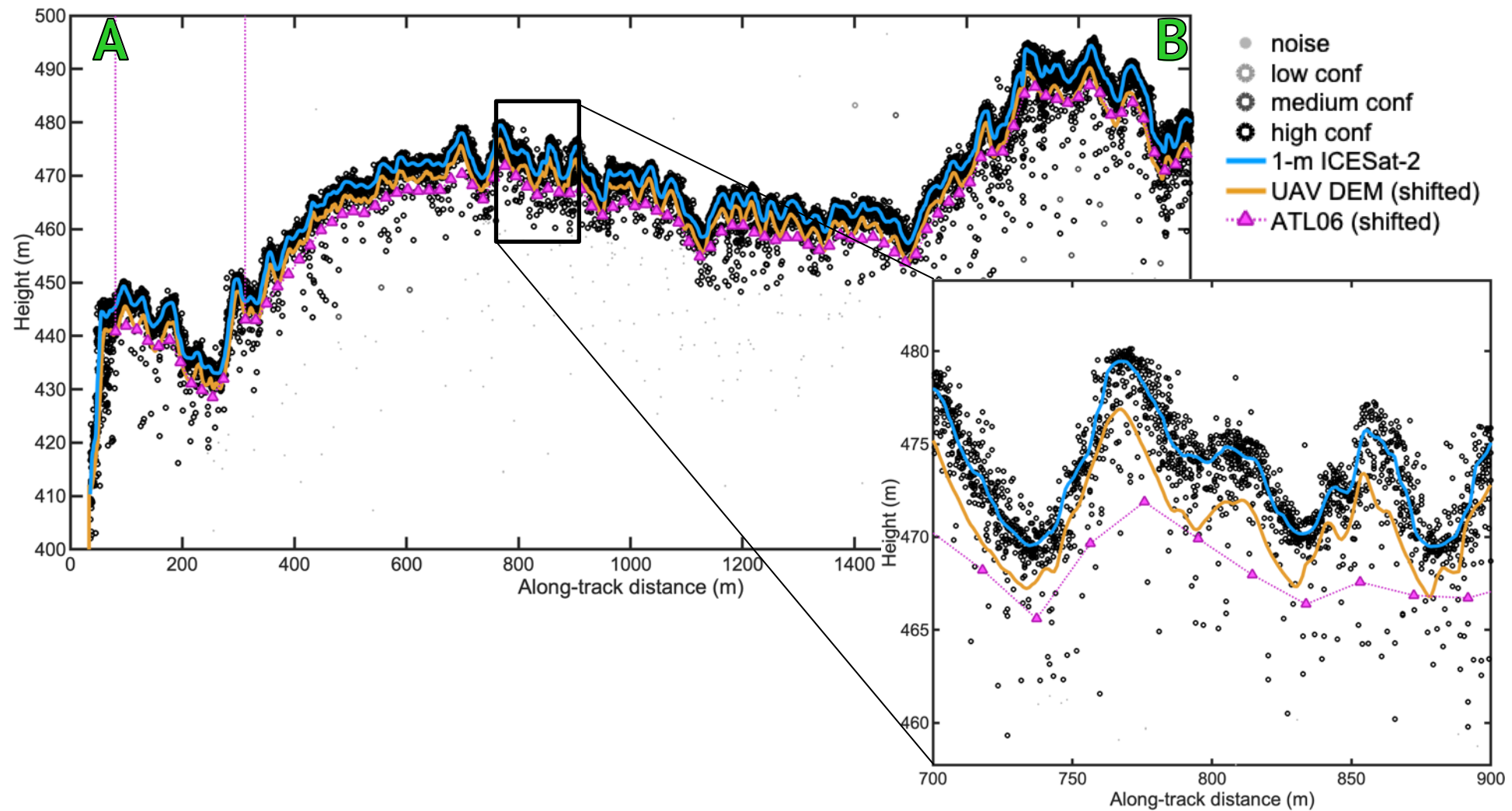
- noise
- low conf
- medium conf
- high conf
- 1-m ICESat-2
- UAV DEM (shifted)
- ATL06 (shifted)





Area B: rough & crevassed ice on edge of Russell glacier

latitude/longitude [\(67.1144 / -50.0847\)](#)



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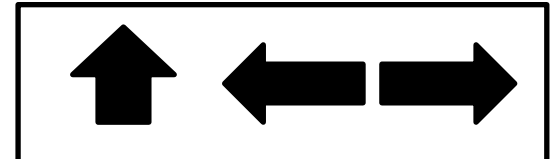
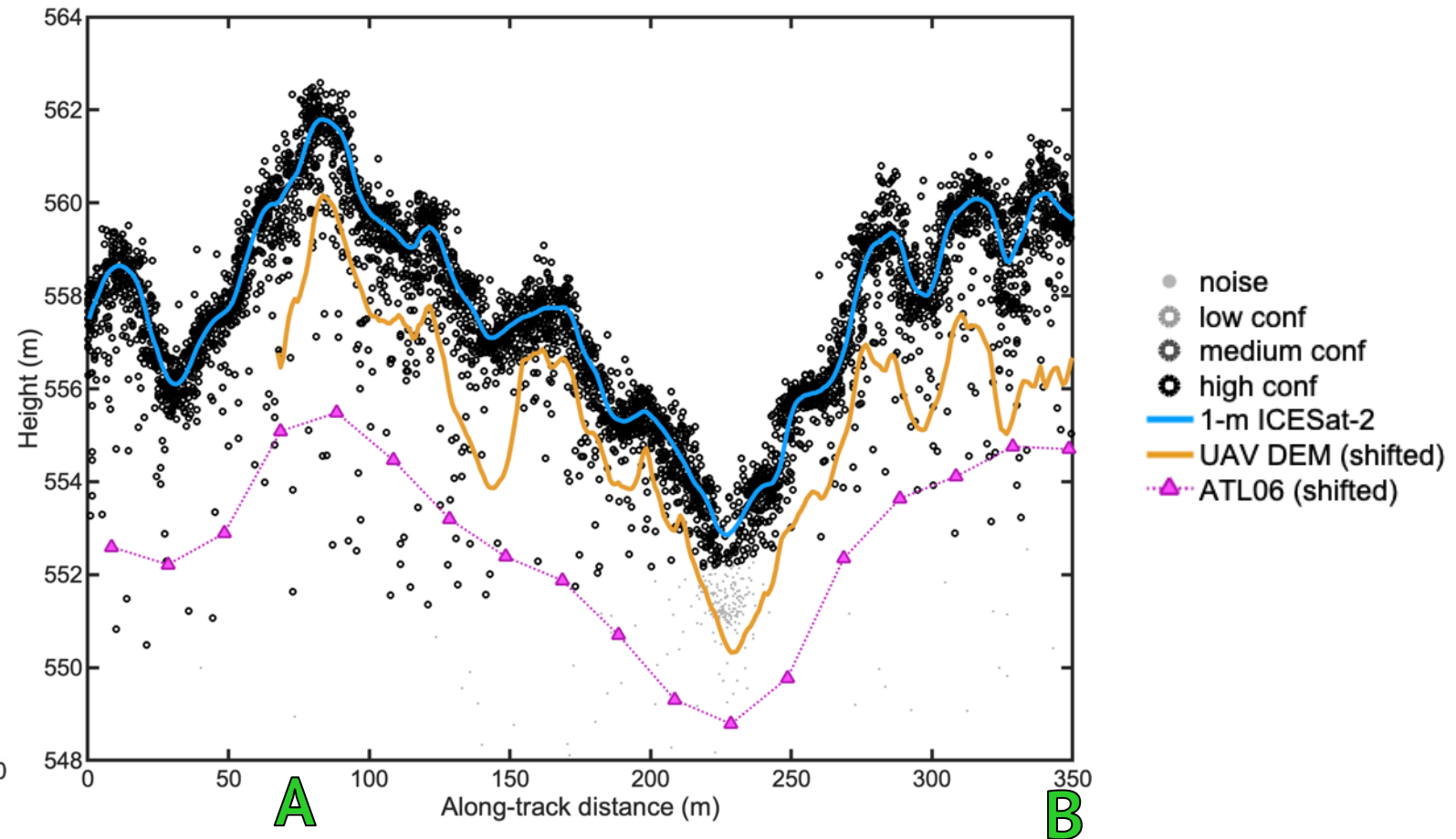
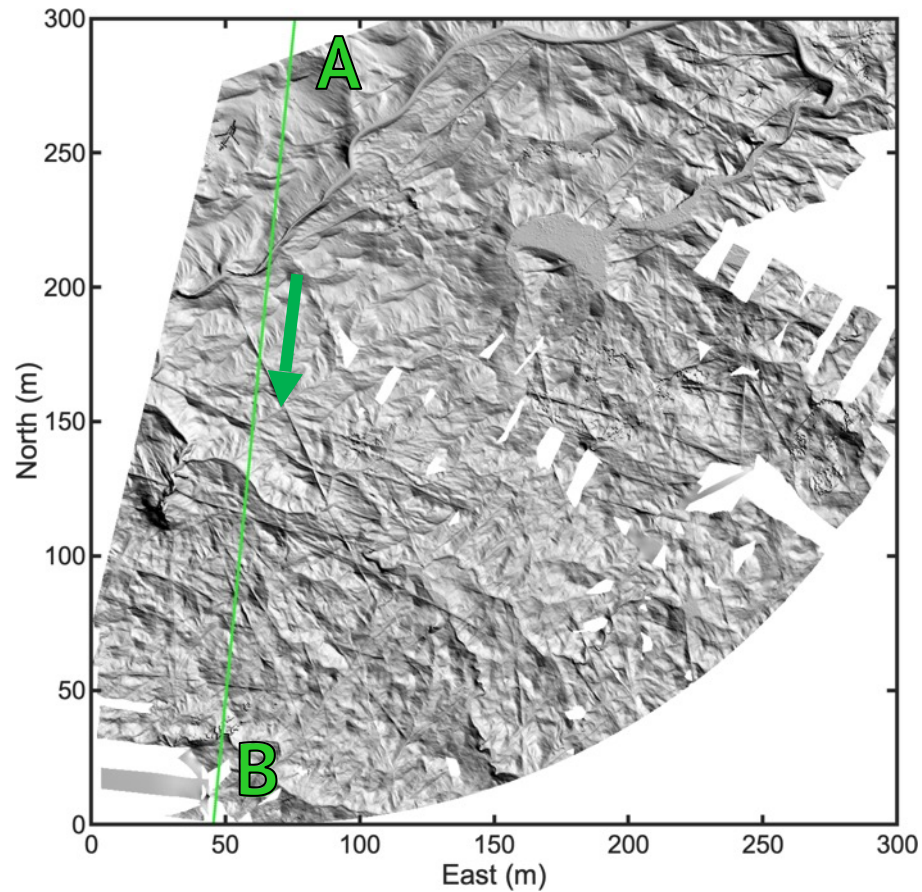
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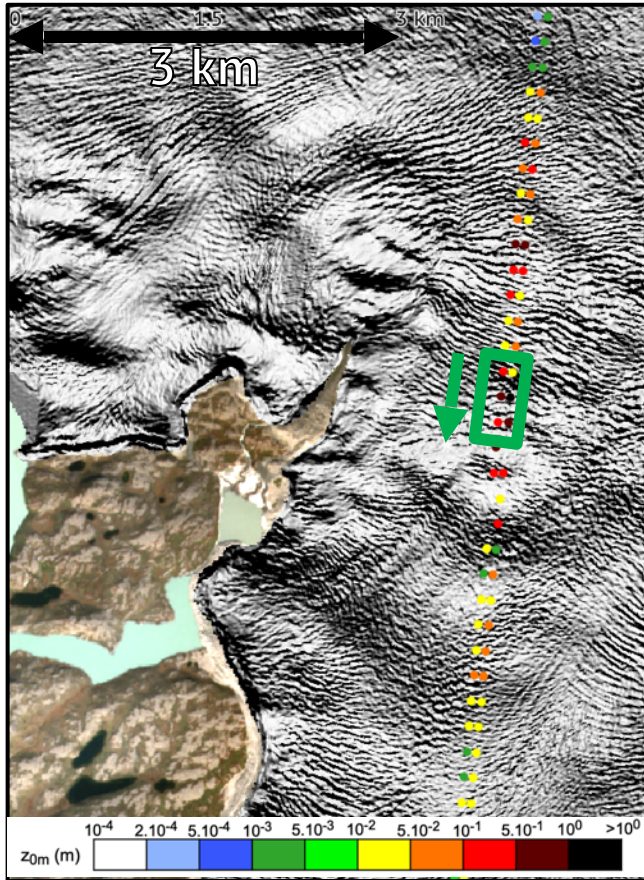
S5: rough ice & measurement site since 1993

latitude/longitude [\(67.0919 / -50.0670\)](#)

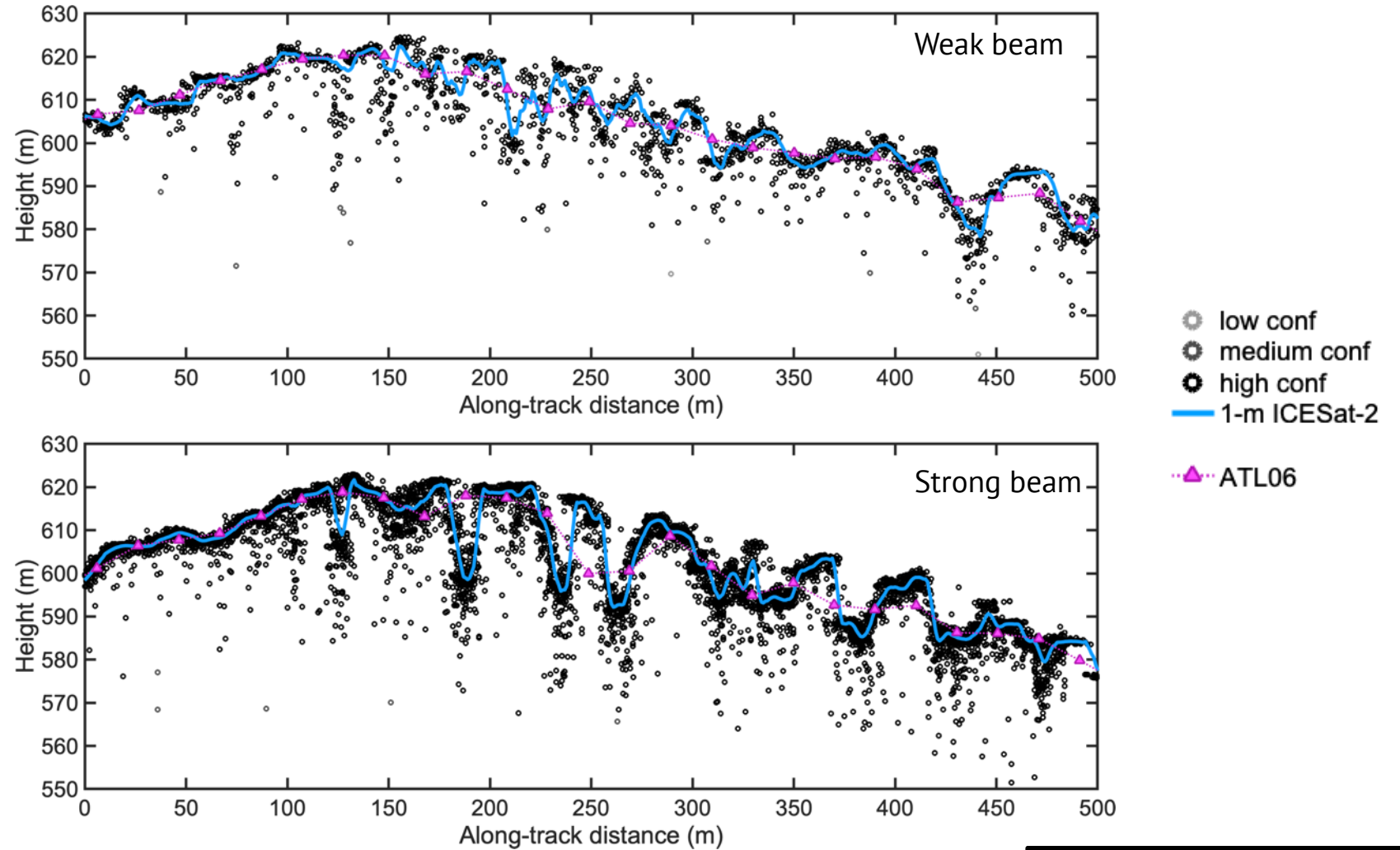


A crevasse field between Leverett glacier and Ørkendalen glacier

latitude/longitude [\(67.04987 / -49.93205\)](#)



Background: ArcticDEM + Sentinel-2



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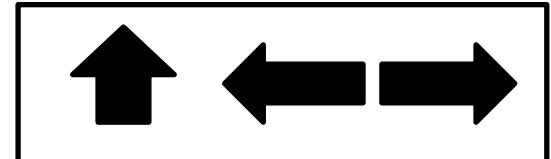
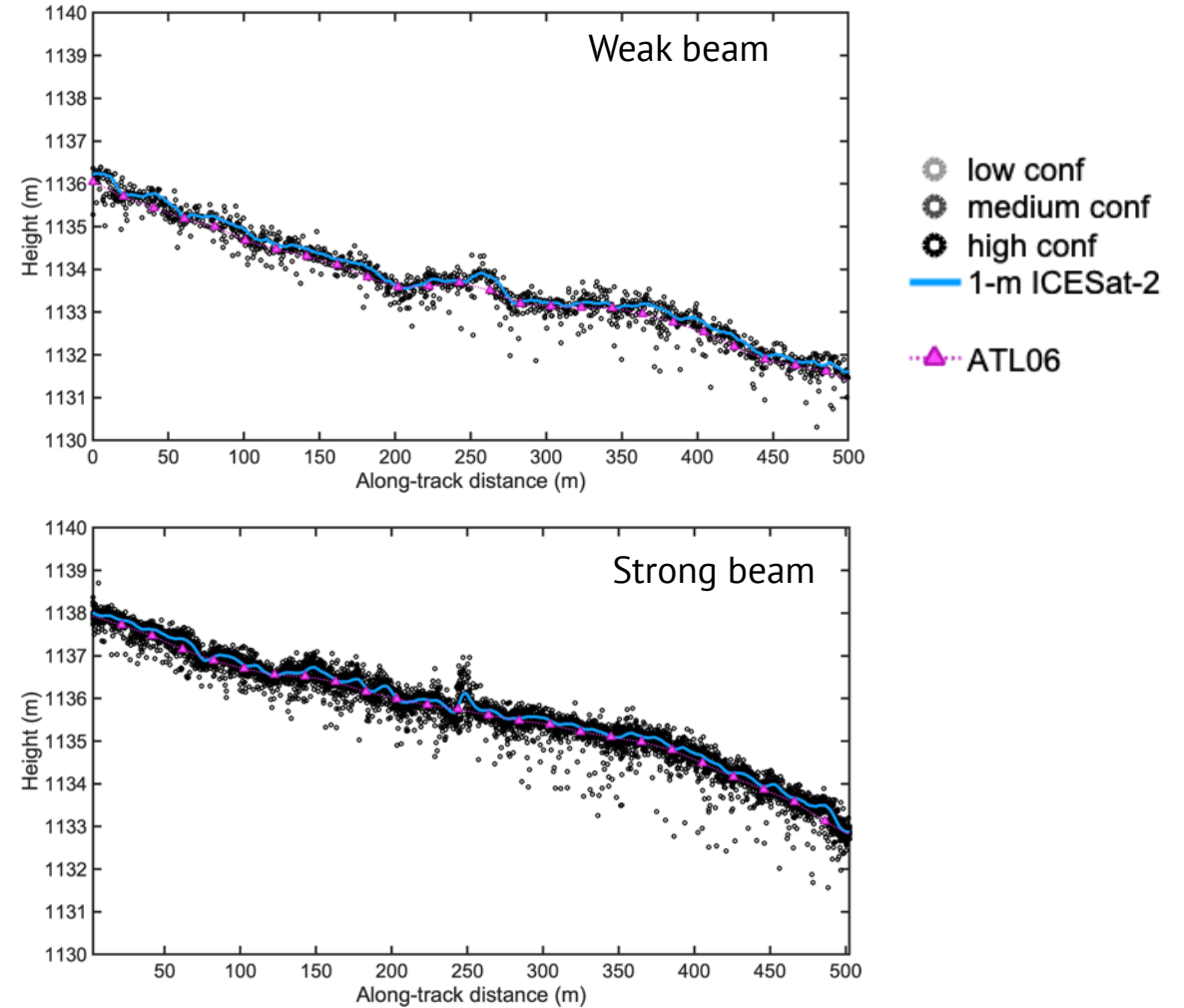
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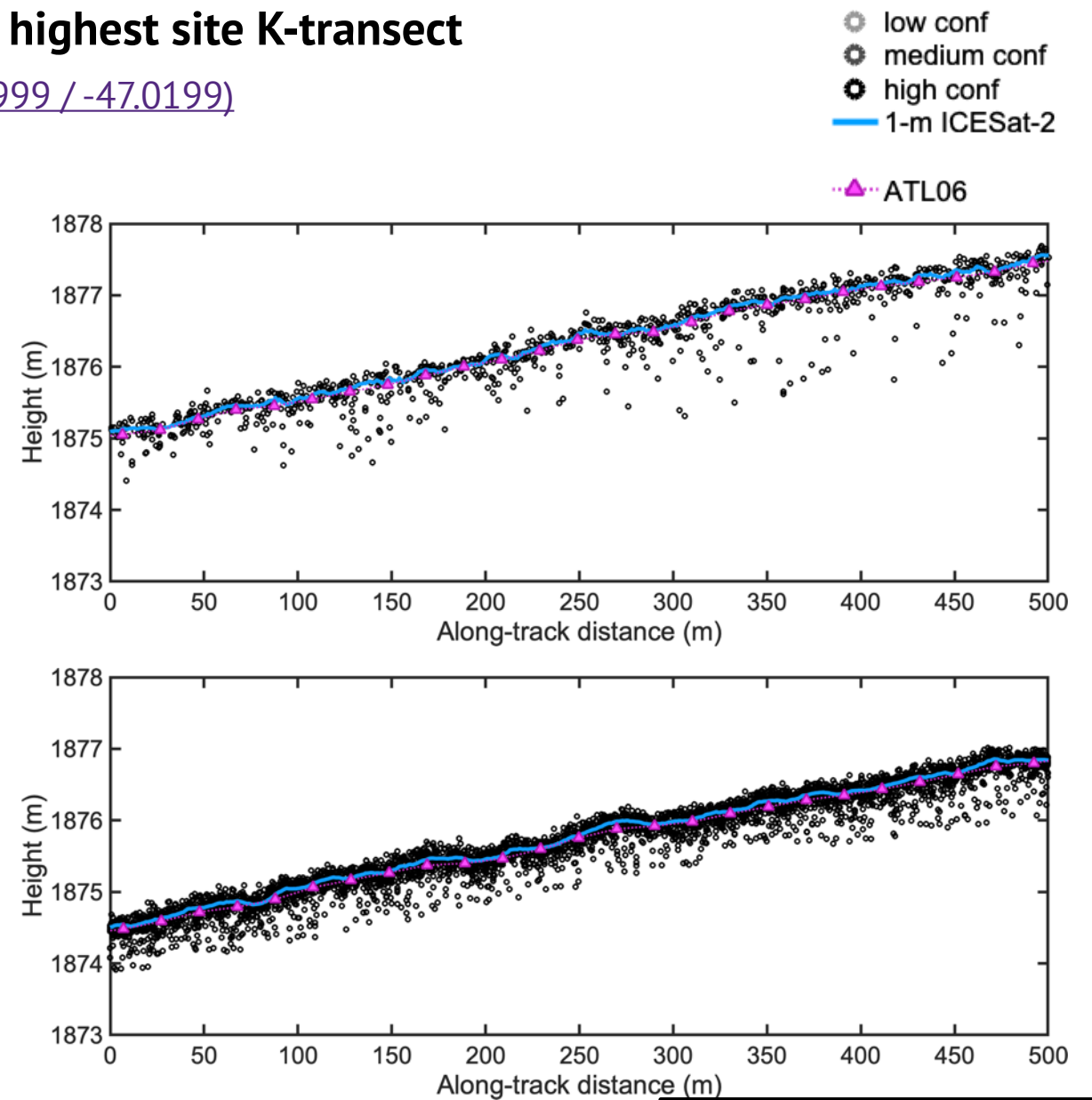
S6: small ice hummocks & measurement site since 1993

latitude/longitude [\(67.0800 / -49.4063\)](#)



S10: Accumulation area & highest site K-transect

latitude/longitude [\(66.9999 / -47.0199\)](#)



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Mapping the aerodynamic roughness of the Greenland ice sheet using ICESat-2

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Abstract

Assets

Discussion

Metrics

08 Jan 2021

Review status: a revised version of this preprint is currently under review for the journal TC.

Mapping the aerodynamic roughness of the Greenland ice sheet surface using ICESat-2: Evaluation over the K-transect

Maurice van Tiggelen¹, Paul C. J. P. Smeets¹, Carleen H. Reijmer¹, Bert Wouters^{1,3}, Jakob F. Steiner^{2,4}, Emile J. Nieuwstraten², Walter W. Immerzeel², and Michiel R. van den Broeke¹

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Abstract. The aerodynamic roughness of heat, moisture and momentum of a natural surface is an important parameter in atmospheric models, as it co-determines the intensity of turbulent transfer between the atmosphere and the surface. Unfortunately this parameter is often poorly known, especially in remote areas where neither high-resolution elevation models nor eddy-covariance measurements are available. In this study we adapt a bulk drag partitioning model to estimate the aerodynamic roughness length (z_{0m}) such that it can be applied to 1D (i.e. unidirectional) elevation profiles, typically measured by laser altimeters. We apply the model to a rough ice surface on the K-transect (western Greenland ice sheet) using UAV photogrammetry, and evaluate the modelled roughness against in situ eddy-covariance observations. We then present a method to estimate the topography at 1 m horizontal resolution using the ICESat-2 satellite laser altimeter, and demonstrate the high precision of the satellite elevation profiles against UAV photogrammetry. The currently available satellite profiles are used to map the aerodynamic roughness during different time periods along the K-transect, that is compared to an extensive dataset of in situ observations. We find a considerable spatiotemporal variability in z_{0m} , ranging between 10^{-4} m for a smooth snow surface over 10^{-1} m for rough crevassed areas, which confirms the need to incorporate a variable aerodynamic roughness in atmospheric models over ice sheets.

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