Quantification of tidal grounding line migration using Sentinel-1 observations

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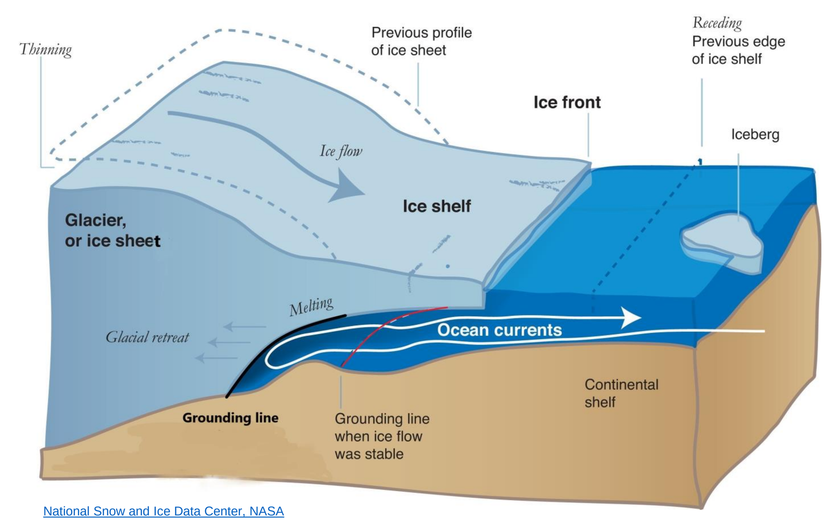
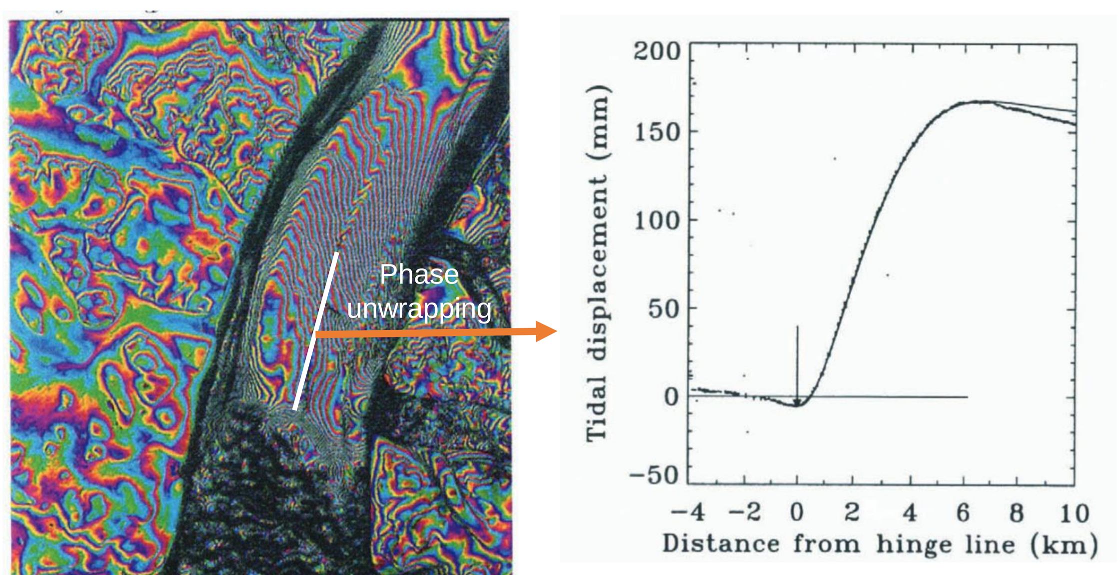
Motivation

Grounding lines (GLs) are subsurface geophysical features that represent the boundary between grounded ice and floating ice shelves. GLs derived from tidal remote sensing methods such as Differential Interferometric SAR, laser and radar altimetry contain an ephemeral displacement in addition to their true location. Previous works have demonstrated that grounding lines migrate with distances ranging from a few hundred meters to several kilometers heterogeneously and out of phase with ocean tides [1] – [2], implying that the tidal component does not diminish in an interannual time series.

We explore the use of SAR Differential Range Offsets Tracking (DROT) to provide insights into tidal migration of the grounding line. We used a times series from 2019 of LOS offsets from 6-day repeat cycle Sentinel-1 acquisitions over Larsen C Ice Shelf. GL positions from the offset profiles were derived by inverting the 1D elastic beam model using the Cross Entropy-based Importance Sampling for Bayesian Updating (CEBU) algorithm [3].



GL detection from InSAR phase [4]



$$w(x) = A_0(t)[1 - e^{-\beta x}(\cos\beta x + \sin\beta x)]$$

x: horizontal axis
$w(x)$: tidal deflection
$A_0(t)$: level of ice shelf if floating in isostatic equilibrium

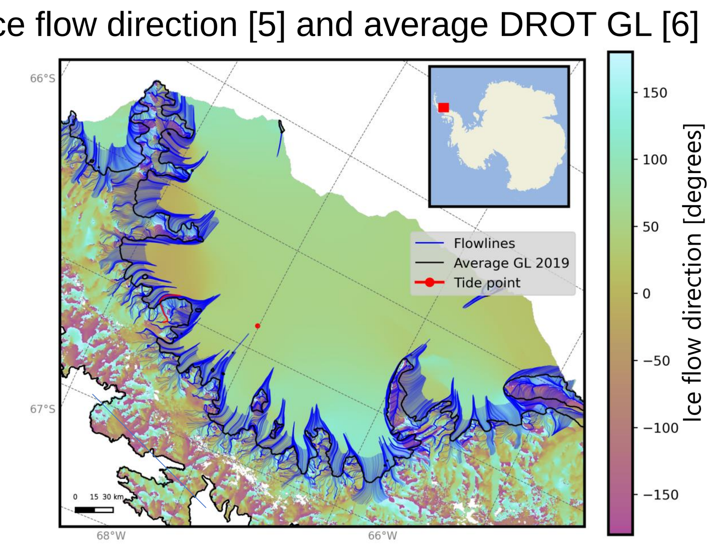
$$\beta = \sqrt[4]{\frac{3\rho_{sea}g(1-\nu^2)}{Eh^3}}$$

h: ice thickness
ν: Poisson's ratio
E: Young's modulus
g: acceleration due to gravity
ρ_{sea}: density of sea water

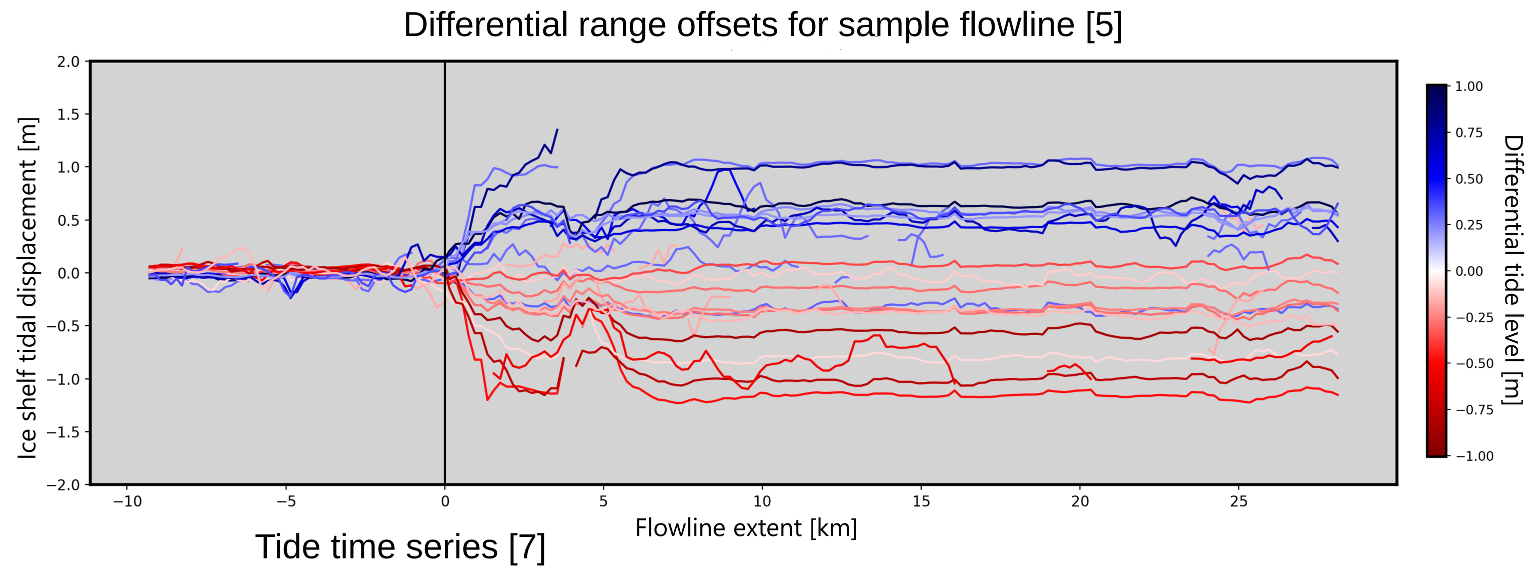
Large variation in E (0.1 – 10 Gpa)
Uncertainties in h and tide elevation!

Data

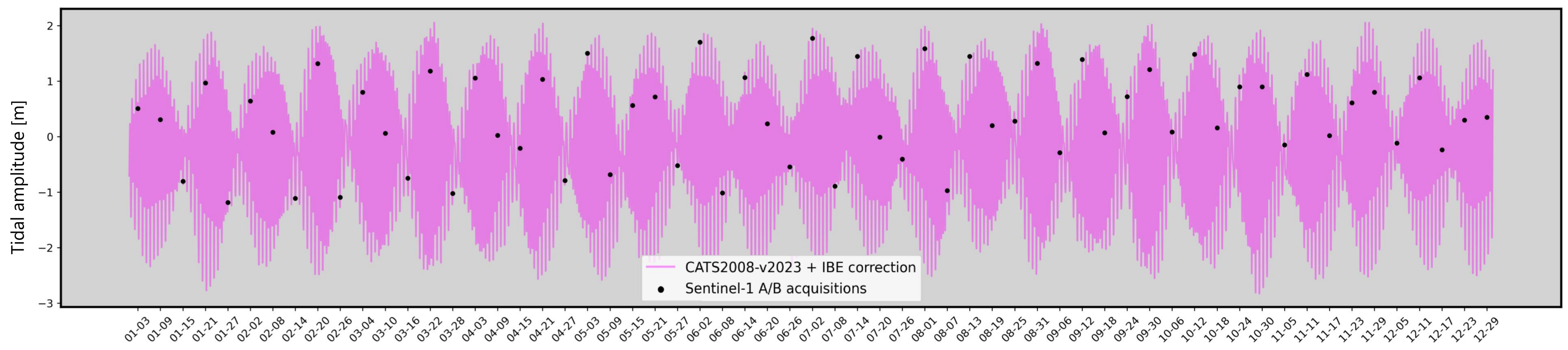
Ice flow direction [5] and average DROT GL [6]



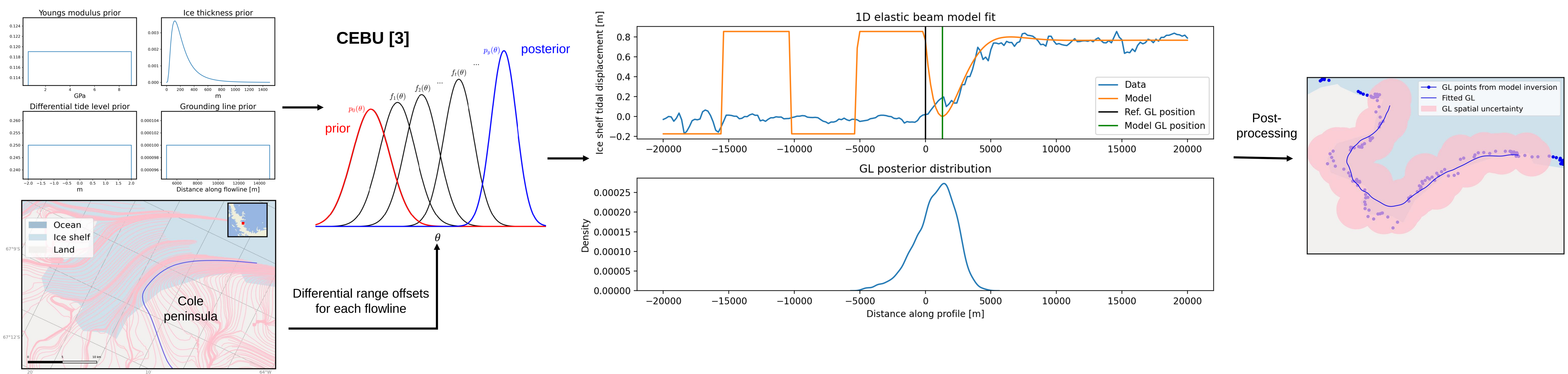
Differential range offsets for sample flowline [5]



Tide time series [7]

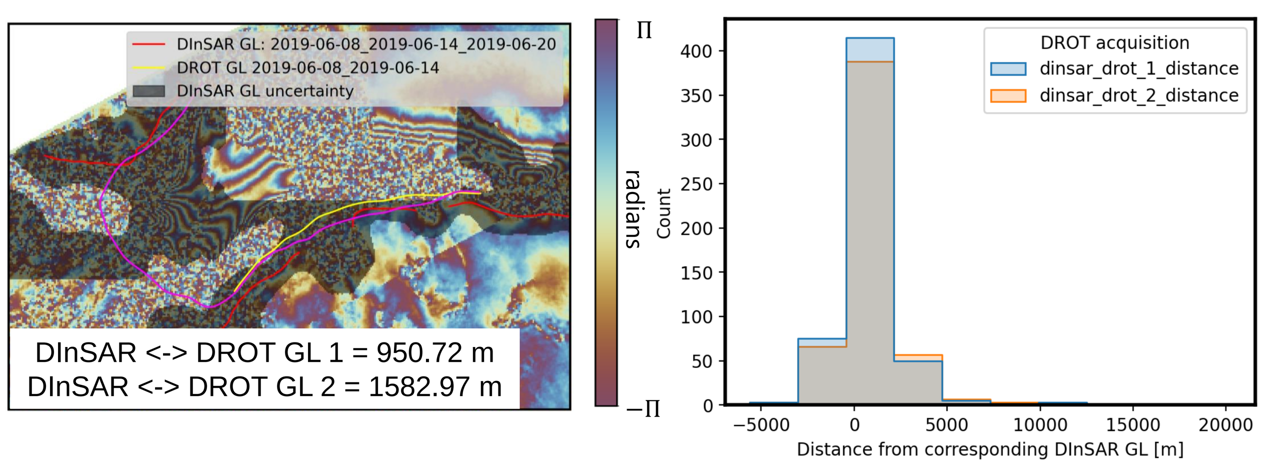


Workflow

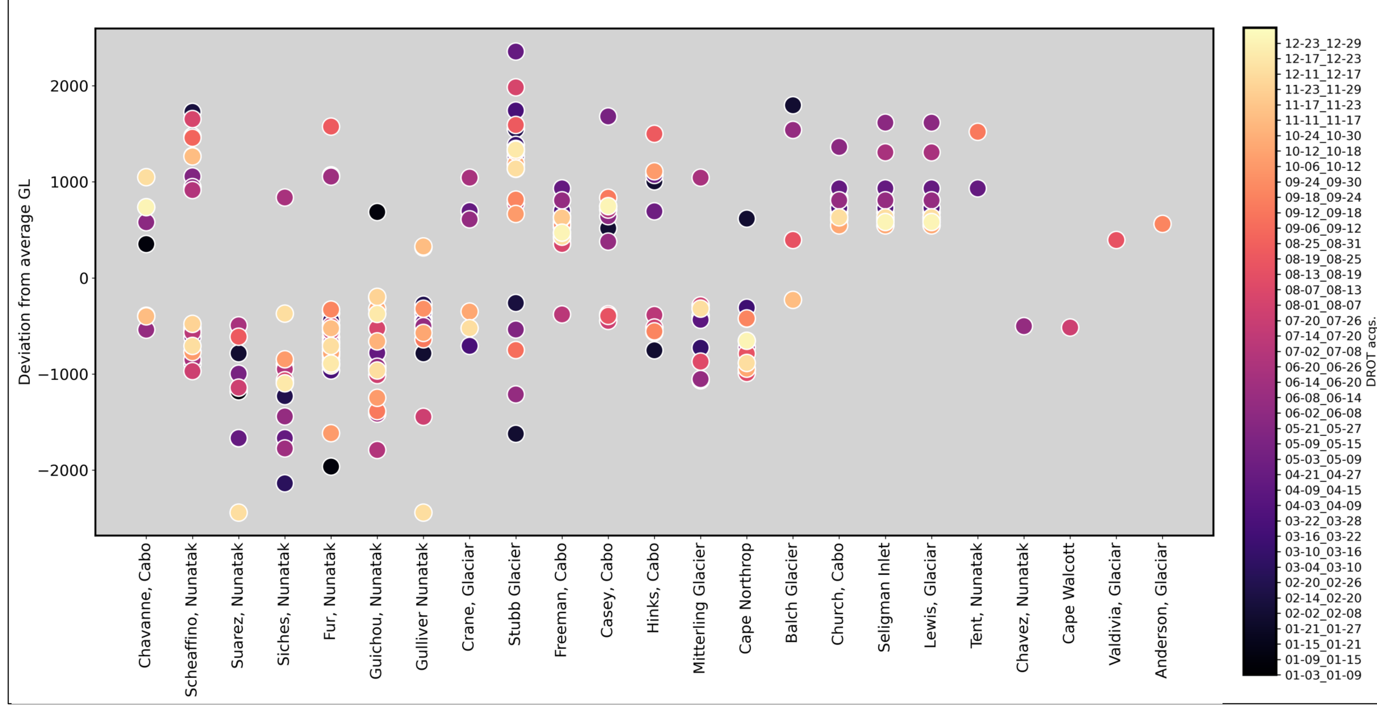


Results

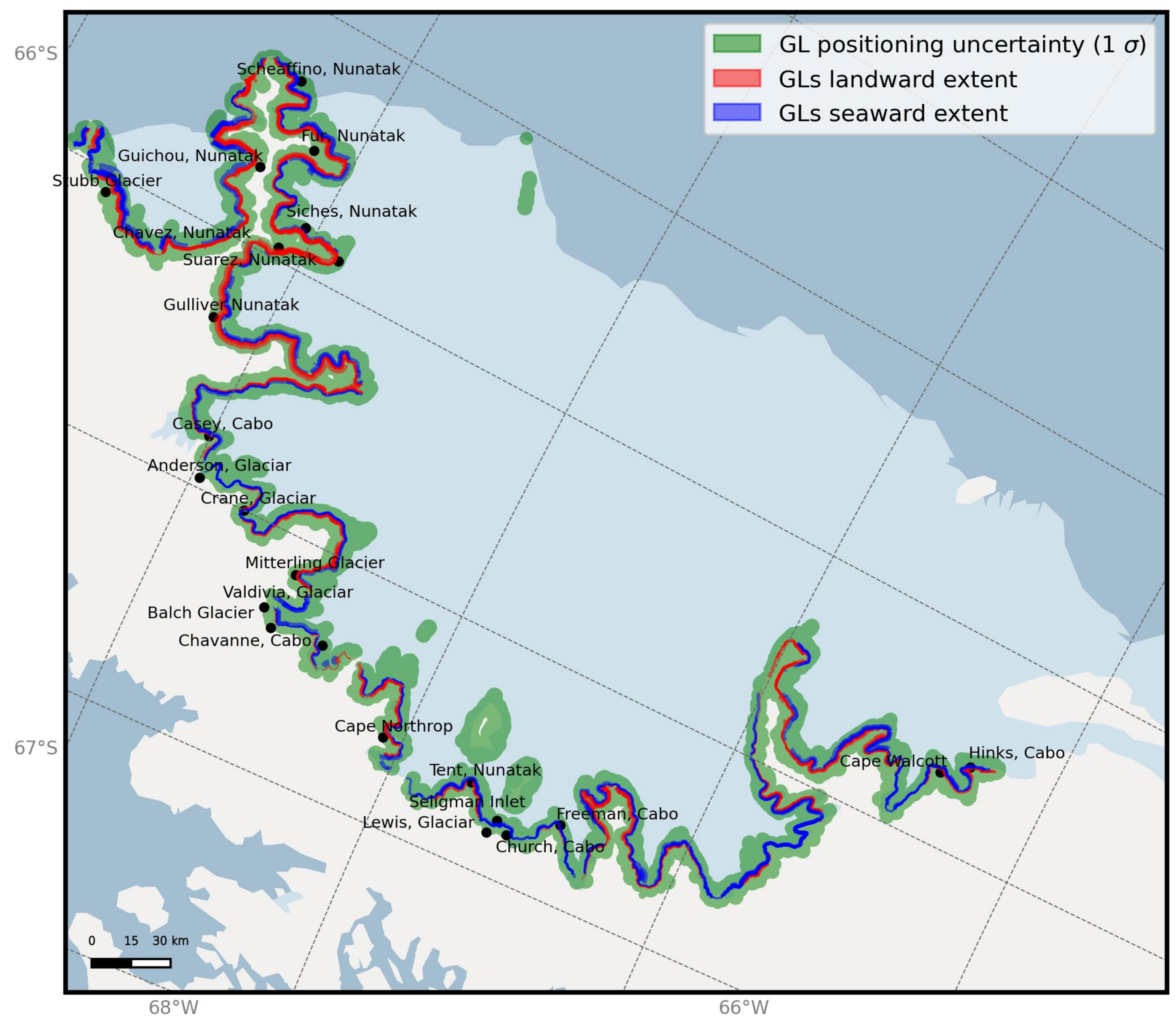
1. Comparison to deep-learning DInSAR GLs



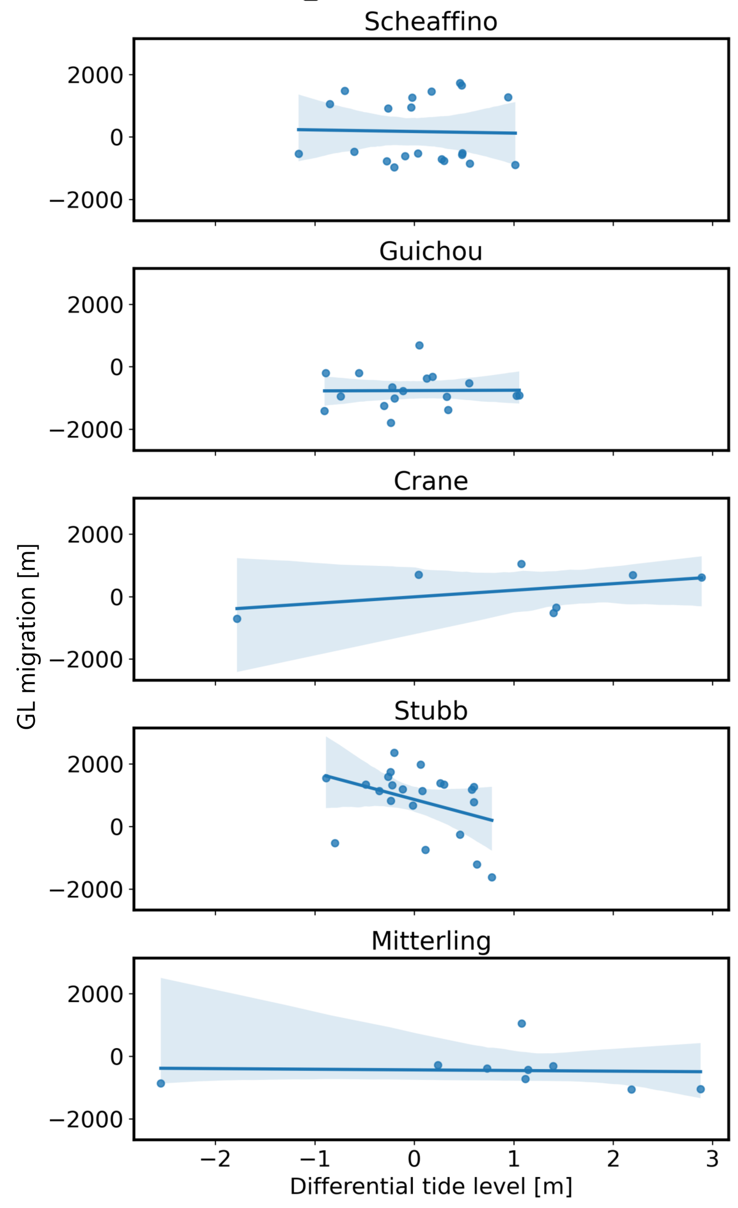
2. GL migration w.r.t average GL



3. GL spatial uncertainty



4. GL migration vs. tides



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