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Investigation of tidal grounding line migration using SAR line-of-sight offset time series

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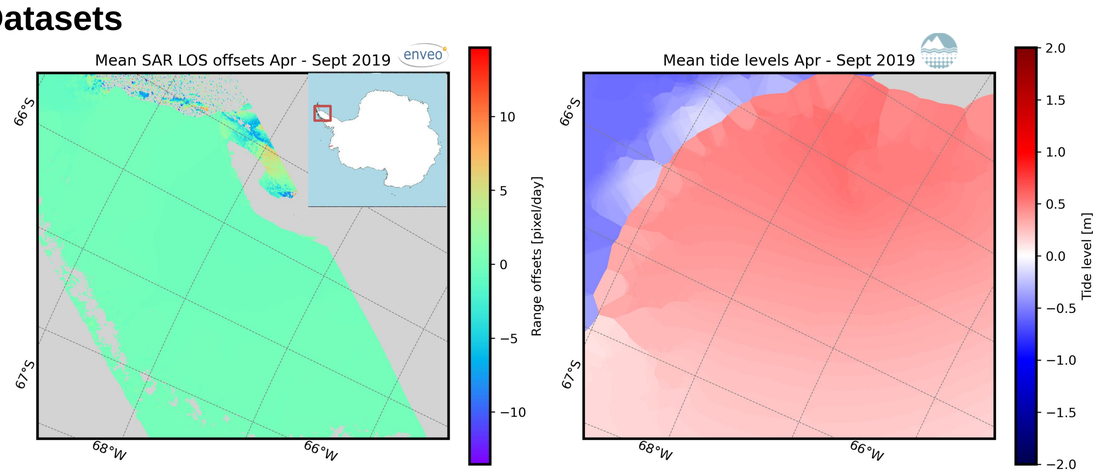
Motivation

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] – [3], implying that the tidal component does not diminish in an interannual time series.

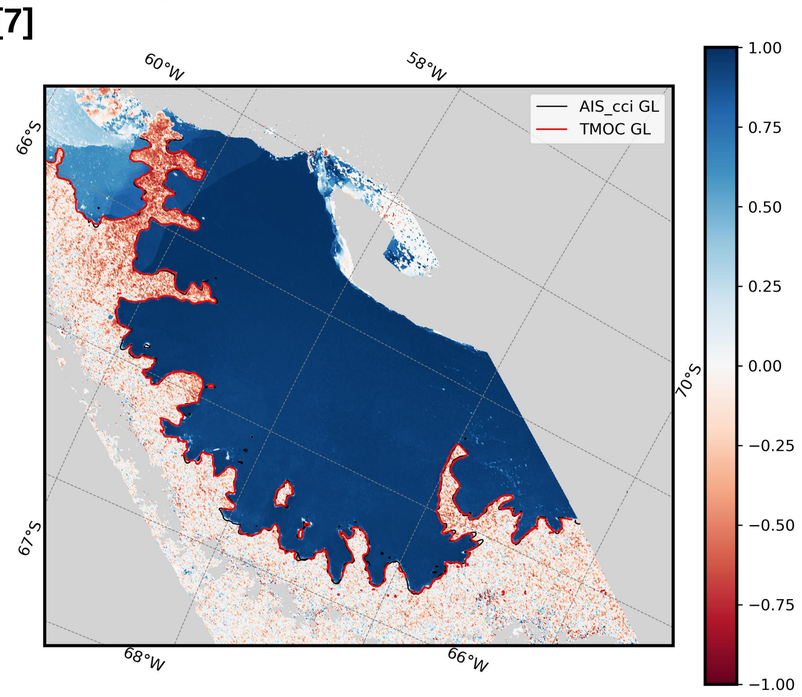
We explore the use of SAR line-of-sight (LOS) offsets to provide insights into tidal migration of the grounding line. We used a times series from 2019 - 2021 of LOS offsets from 6-day repeat cycle Sentinel-1 acquisitions over Larsen C Ice Shelf. We derived an average GL for each year by correlating the offsets with modelled tide amplitudes and tracked GL movement along several flowlines across the ice shelf.

Datasets



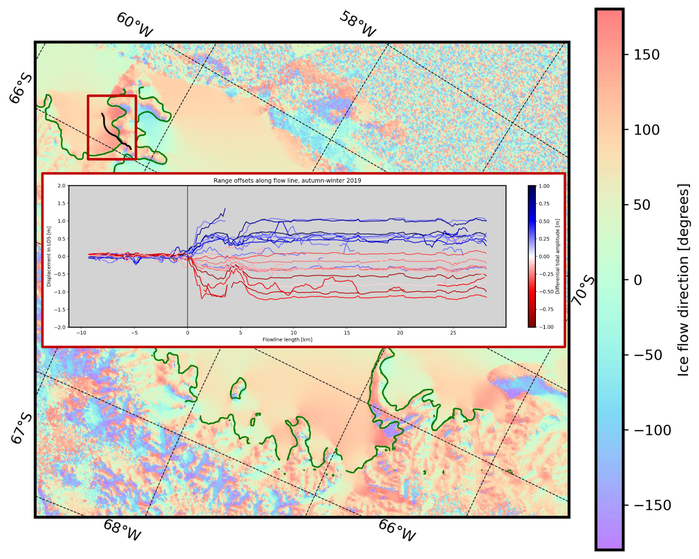
Dataset	Dataset provider	Temporal extent [years]	Pixel size [m]
SAR LOS offsets [4]	ENVEO IT	2019 – 2021	200
CATS2008_v2023 [5]	U.S. Antarctic program data center	Coincident with SAR acquisitions	2000
Antarctic Ice Sheet climate change initiative (AIS_cci) GL [6]	ESA	1994 - 2022	-

Average grounding line for 2019 using Tidal Motion Correlation Offset (TMOC) [7]

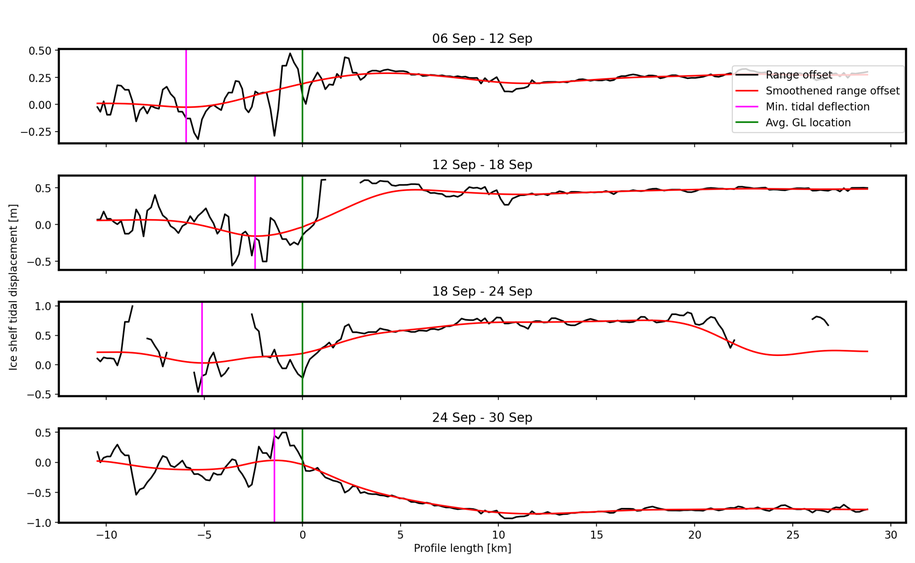


Method

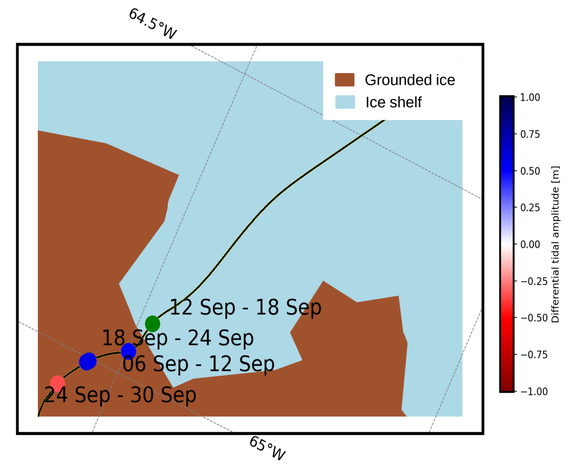
1. Extract offset along flowline



2. Smoothen profiles and identify point of minimum tidal deflection



3. Geocode minimum tidal deflection points

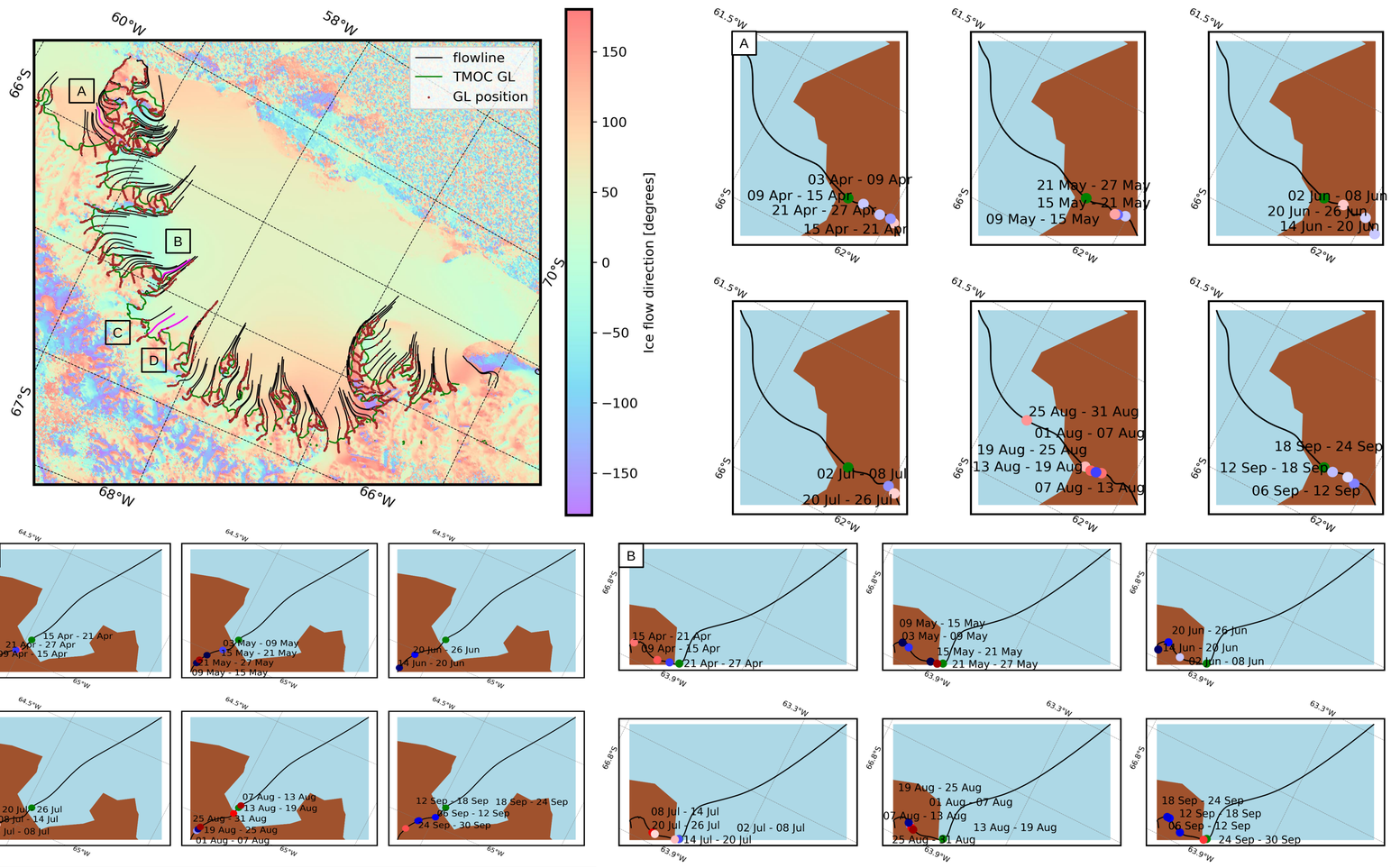


Results

- The migration extent spans several km and is not uniform across the ice shelf
- There is no apparent linear dependence between GL position and differential tide level, as also observed in [2] for Amery Ice Shelf.

Future work

- Improve the automatic detection of minimal tidal deflection from the offset profiles
- Investigate the cause for the non-linear and out-of-phase migration, accounting for bed topography and slope at grounding zone
- Quantify the tidal migration across the whole ice shelf
- Apply this method to other outlet glaciers and ice streams where tide range > 2m → Antarctic-wide dataset of monthly grounding zones



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[6] D. Floricioiu et al., " ESA Antarctic Ice Sheet Climate Change Initiative (Antarctic_Ice_Sheet_cci): Grounding line location for key glaciers, Antarctica, 1994-2020, v2.0. NERC EDS Centre for Environmental Data Analysis.
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