

Assessing Signal Penetration Into Ice And Snow For The TanDEM-X Mission

Lukas Krieger, Tanvir Chowdhury, Erling Johnson, Wael Abdel Jaber, Dana Floricioiu

German Aerospace Center (DLR), Germany
*Author for correspondence : lukas.krieger@dlr.de

Introduction

- TanDEM-X (TDM) DEMs may contain a signal penetration bias leading to DEM elevations that lie up to 10m below the actual snow/ice surface. (Figure 1)
- The penetration bias presents a problem for detecting the real surface elevation of glaciers.
- The TDM mission started in June 2010 after the availability of coincident ICESat laser altimeter measurements. Absolute surface elevations can therefore only be co-registered to ICESat elevations over ice free terrain.
- There are near-coincident Cryosat-2 radar altimeter measurements for every TDM scene which may be used as reference for the real surface elevation.

Data and Method

- One single pass InSAR DEM of Petermann Glacier was processed from bistatic TDM data.
- Near-coincident Cryosat-2 SARIn measurements are provided by ESA as Level-2 elevations.
- Airborne laser altimeter measurements were acquired by the ATM sensor during Operation IceBridge (OIB) campaign only 4 days prior to the TDM acquisition.
- After a vertical co-registration of TDM elevations to OIB ATM data on ice free terrain, we report elevation differences between the datasets.
- The corresponding TDM elevations used for this comparison are sampled from:
 - The pixel at the annotated data point of the ATM data. (TDM resolution approx. 6m x 5m)
 - A 5m x 5m footprint in across and along track of the Cryosat-2 flight direction.

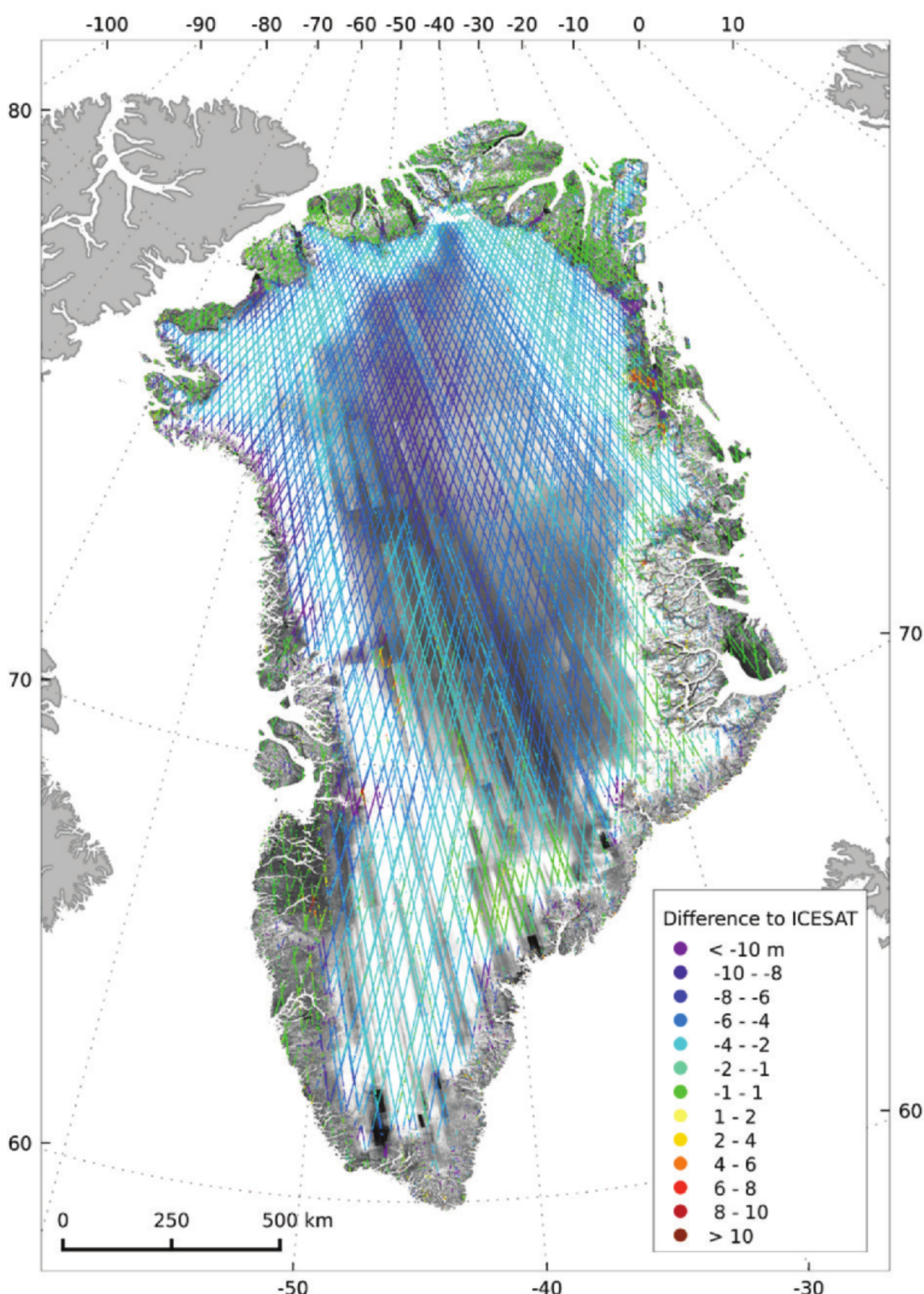


Figure 1: The TanDEM-X backscattering amplitude mosaic of Greenland superimposed with color-coded height differences (TanDEM-X - ICESat). Especially in the interior of ice sheet, the differences due to the signal penetration bias are up to 10m. The figure is adopted from [1].

Petermann Grounding Line

The grounding line location (GLL) has been delineated on DInSAR interferograms that were processed with the Antarctic Ice Sheet Climate Change Initiative (AIS_cci) GLL processor.

Data	Satellite	Rel. Orbit	Tide level
2017-01-18	Sentinel-1B	26	-0.19m
2017-01-24	Sentinel-1A	26	0.09m
2017-01-30	Sentinel-1B	26	-1.00m

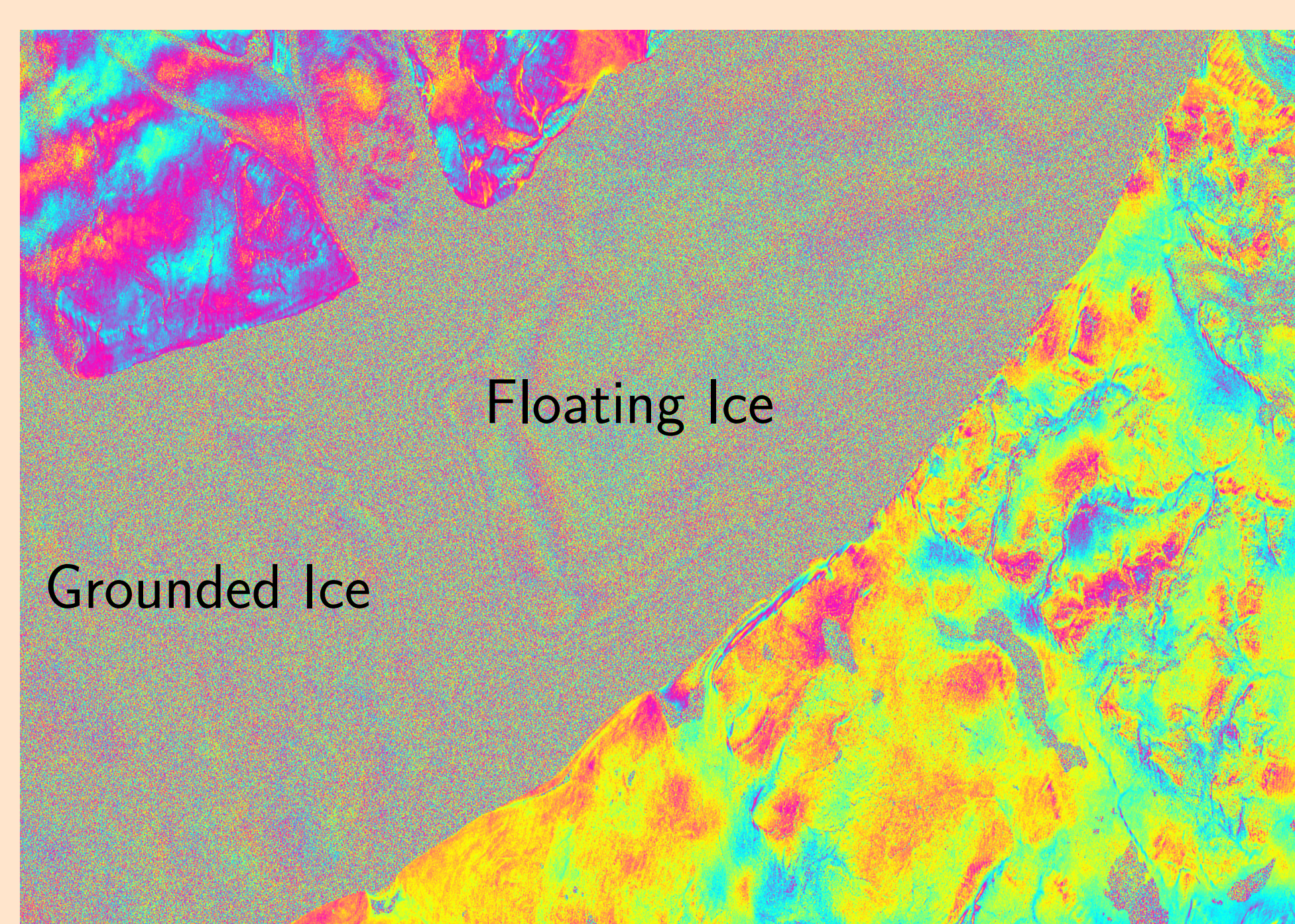


Figure 2: A DInSAR interferogram of the grounding zone of Petermann glacier generated from 6-day repeat pass interferograms of Sentinel-1 A/B IW acquisitions. The temporal decorrelation makes it difficult to delineate a clear hinge line that marks the end of the grounded ice sheet. We use the GLL only to separate measurements on the floating ice tongue from ones on the grounded ice sheet.

Grounding Line Presentation

See Paper 434 by Chowdhury, Tanvir Ahmed
Wednesday 09:40 - Session title: Ice and snow

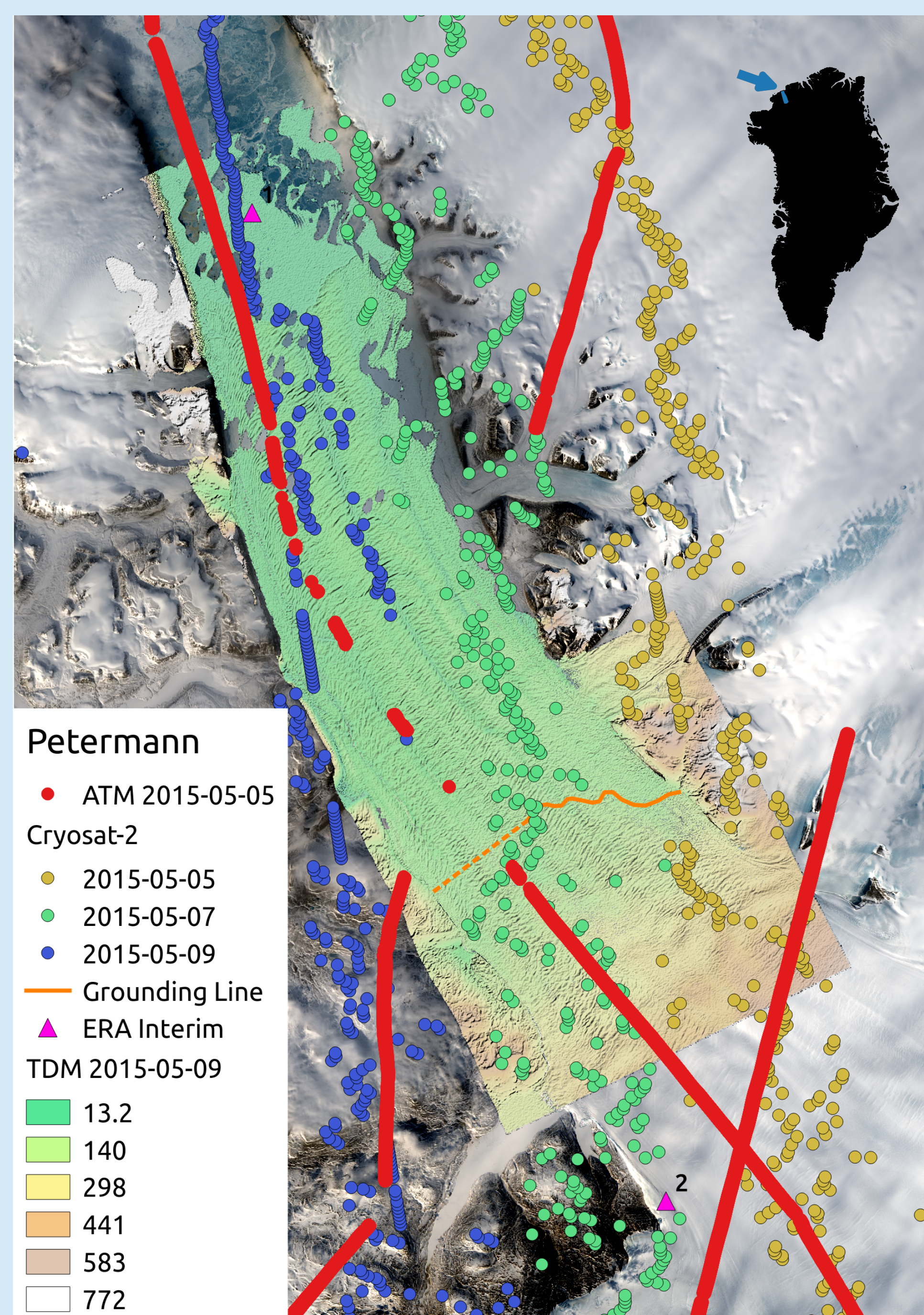


Figure 3: TanDEM-X elevations of Petermann glacier in May 2015 with 3 near-coincident Cryosat-2 tracks and IceBridge ATM measurements. Offsets between the datasets are reported in the table on the right.

Elevation differences on Petermann

$$\text{Offset [m]} = \text{TDM} - \langle \text{Dataset} \rangle$$

OIB: Operation IceBridge
CS2: Cryosat-2

Dataset	Mean	Std	# of points
OIB Off Ice	-0.03	0.67	275
OIB Grounded	-1.23	1.10	3289
OIB Floating*	-0.47	0.77	1623
CS2 Off Ice	0.54	3.48	3
CS2 Grounded	-0.76	2.33	40
CS2 Floating*	0.02	2.17	72

*Corrected tide with AOTIM-5 model

Conclusion & Outlook

- We present a comparison of altimeter and InSAR measurements with respect to real surface elevations over a glaciated area.
- Offsets between CS2 and TDM data are caused by X-Band signal penetration and have to be taken into account when using TDM elevations over glaciers.
- Outlier elimination of Cryosat-2 measurements will be improved.
- The elevation accuracy of Cryosat-2 will be tested with other retracking procedures.

References

1. Wessel, B., Bertram, A., Gruber, A., Bemm, S. & Dech, S. A new high-resolution elevation model of Greenland derived from TanDEM-X. *ISPRS Ann. of Photogramm. Remote Sens. Spatial Inf. Sci.* **3**, 9–16 (2016).

Acknowledgments:

Research supported by the German Research Foundation (DFG) project *Variations of ice sheet geometry, ice flow, and mass distribution in Northeast Greenland in the context of oceanic and atmospheric interactions*

ESA Fringe 2017 Conference, 5-9 June 2017, Aalto University, Helsinki, Finland