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National Science Foundation's Geodetic Facility for the Advancement of Geoscience

Applied DinSAR Analysis to Crustal Deformation Along Greenland's Northwestern Coasts

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Introduction

Bedrock displacements on Greenland's coasts observed by the Greenland GPS Network (GNET) **(A)**.

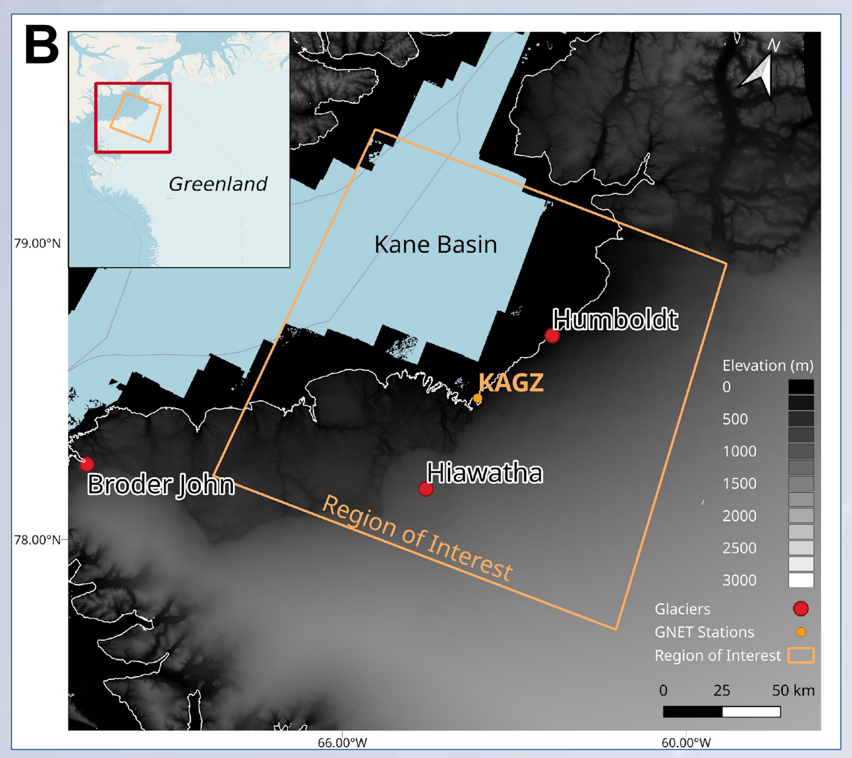
Differential Interferometric Synthetic Aperture Radar (DInSAR) is a satellite-based remote sensing technique offering better spatial coverage and resolution

- We create a surface deformation map for the coast of northwest Greenland using DInSAR techniques
- We generate a deformation time series that can be validated alongside corresponding GNET data, as well as extrapolate linear trends to predict future behavior.

A

Map of Region of Interest

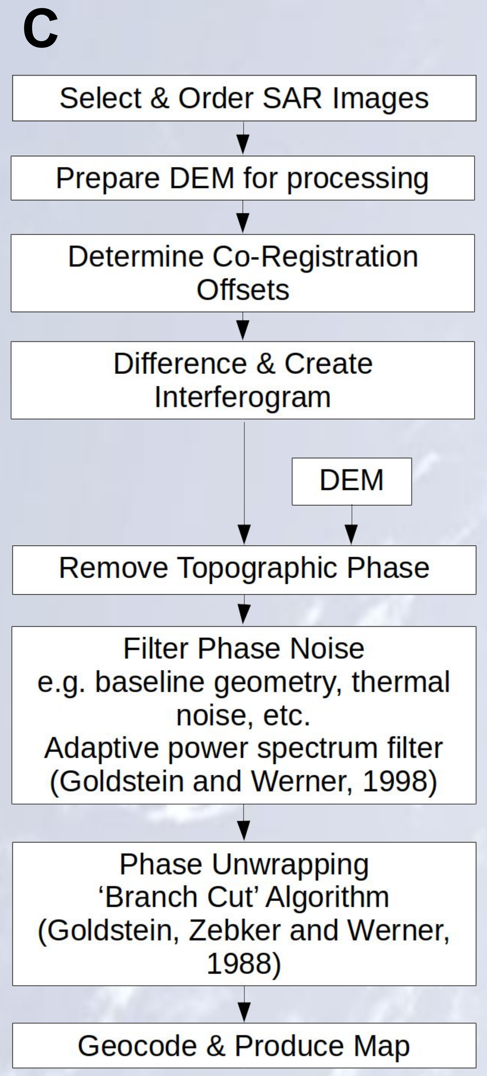
B



- **(B):** ~28300 km^2 region of interest at the northwest coastline of Greenland, approx. 79.417° N, -65.907° W.
- Background is a map of the region constructed from a 10m ArcticDEM, which is used during topography removal step.

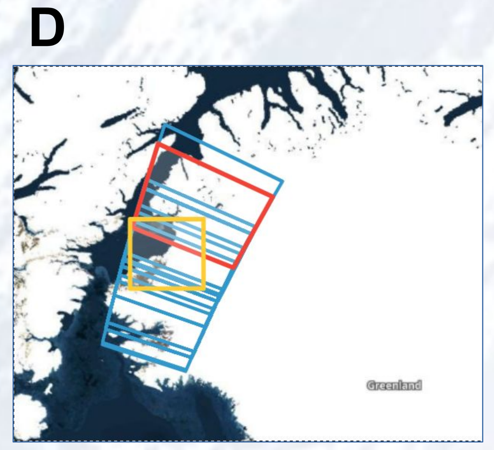
Data & Methods

C



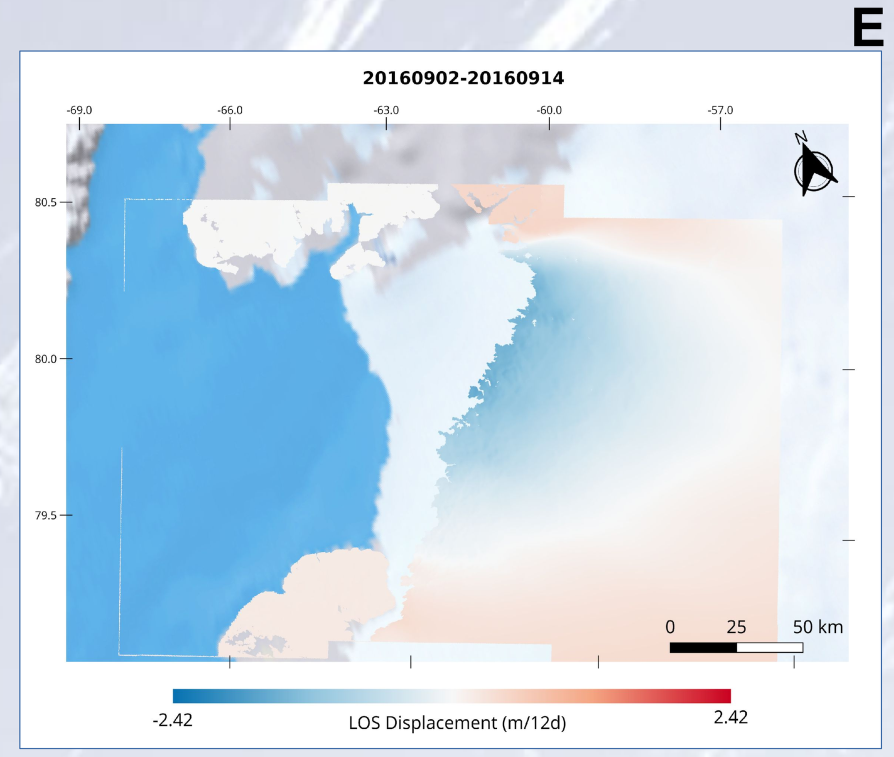
- **(C)**: workflow for DInSAR processing using JPL/Caltech/Stanford InSAR Scientific Computing Environment (ISCE) package (Rosen et al., 2014).
- SAR images used: 90 ESA Sentinel-1 Single-Look Complex (SLC) Images
- Range, azimuth looks: 12, 2
- Average incidence angle Θ: 38.126°
- **(D):** region of interest (yellow) overlying the Sentinel 1A Descending Track (Path 26) used for this study (blue). From search.asf.alaska.edu.

D

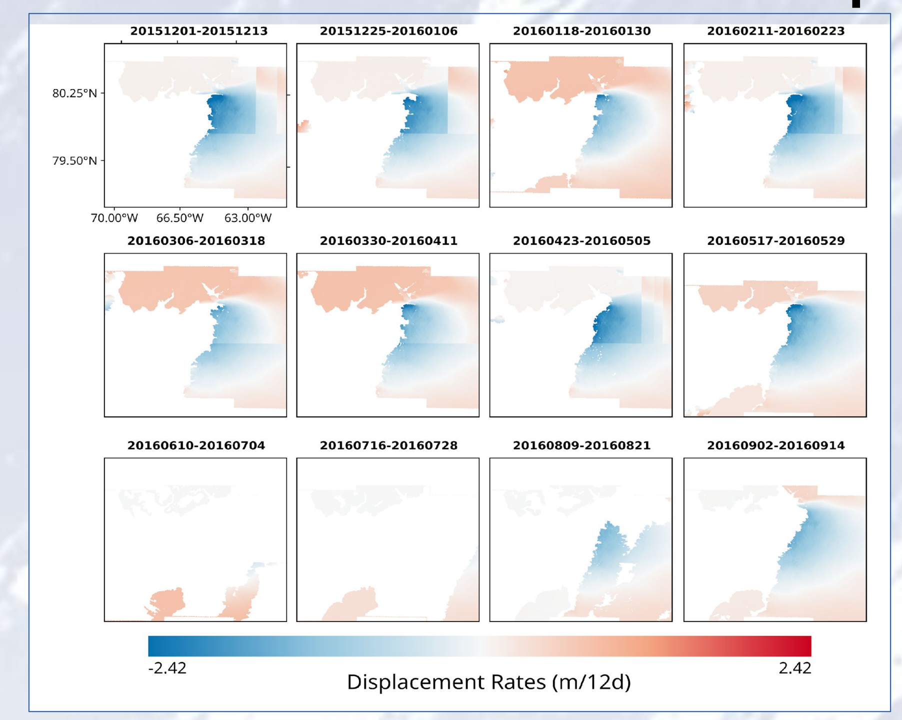


DInSAR Processing Results

E



F

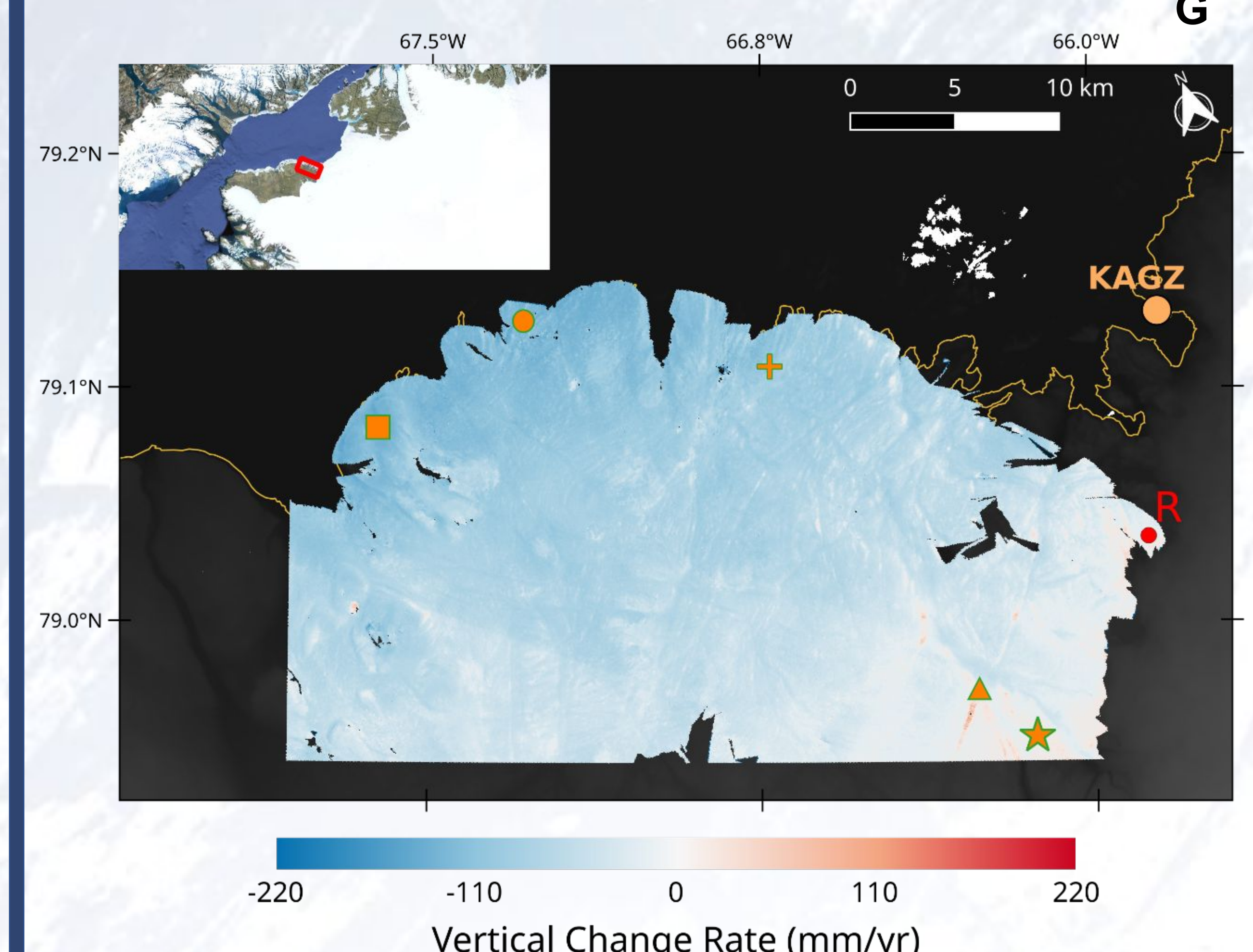


We produce 78 interferograms using DinSAR over our region of interest.

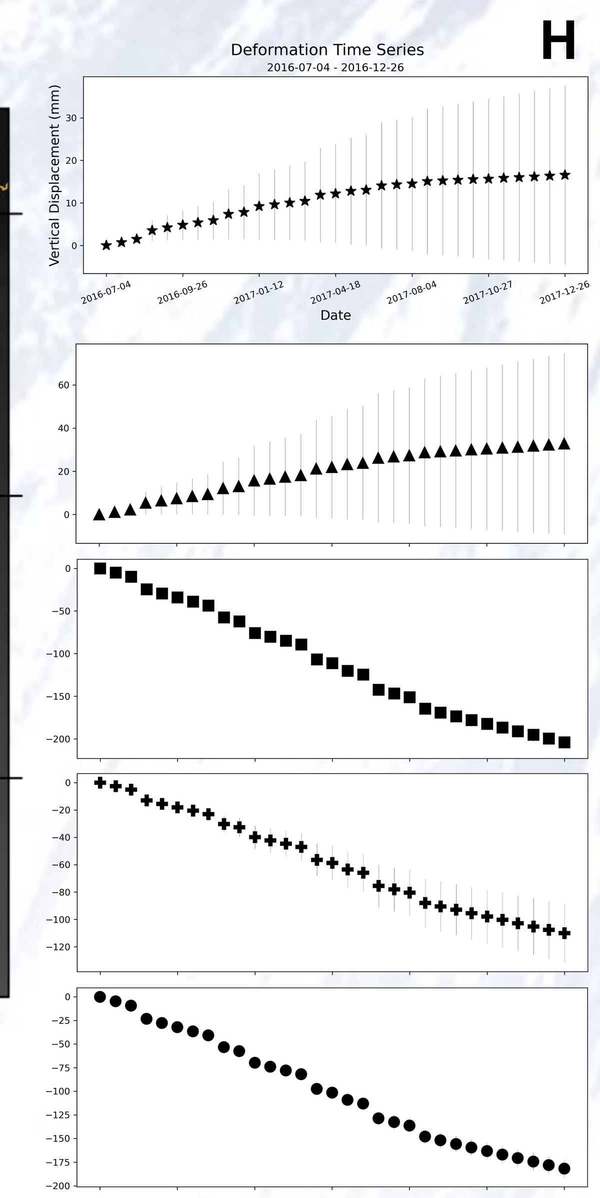
- **(E):** example interferogram produced using SAR images spanning a twelve-day period from September 2, 2016 to Sep-tember 14, 2016. Deformation in the Line-Of-Sight (LOS) ranged from -2.42 to +0.55 meters over a 12 day period.
- **(F): s**ample series of 12 interferograms generated by DInSAR processing over a period from December 01, 2015 to September 02, 2016. Dates are in YYYYMMDD format.
- The summer period between June and August of each year studied (2016, 2017) demonstrated notable loss of interferogram coherence. We surmise that melting over the glacier ice resulted in a poor radar signal.

MSBAS Time Series Inversion

G



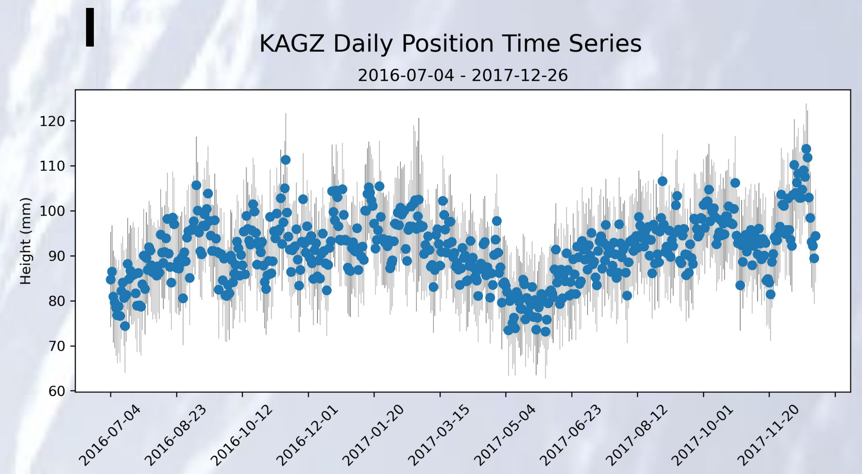
H



The Multidimensional Small Baseline Subset (MSBAS) technique (Samsonov and d'Oreye, 2012) is used to generate a map of deformation velocity and a displacement rate time series for each coherent pixel.

- **(G)** ice-free sub-region we chose for this processing. To obtain a relative deformation rate, we set a reference point at -65.88 W, 79.04 N to validate against KAGZ, a GNET GPS station.
- Vertical ground deformation rates range from -591.1 to +109.0 mm/yr.
- **(H)**: time series for selected regions
- **(I)**: time series of vertical displacement for KAGZ

I



Discussion

- The large number of SAR images gathered within our study period allowed for spatially-dense, high coverage interferograms to be generated nearly constantly every 12 days from December 2015 to May 2018.
- DinSAR is a promising technique for monitoring slow bedrock mass movements over large kilometer-scale areas in polar regions.
- The MSBAS methodology has returned vertical displacement measurements on a similar scale to that of GNET's GPS readings for that area.

Further Work

- Time series inversion using our chosen reference point (Figure (A), 'MSBAS Time Series') did not result in plots that agreed with data returned by GPS station KAGZ. The GNET time series displays an annual oscillation due to both ice mass changes and atmospheric forcing.
- SAR image coherence over KAGZ is necessary to obtian meaningful comparisons with GPS data. Coherence during the summer melting season should also be improved.

Acknowledgments

This work is made possible by funding from the UNAVCO RESESS internship program.
Greenland is a historical and cultural territory of the indigenous Greenlandic Inuit, and gratitude is extended to the Kalaallit, Inughuit and Tunumiit peoples for providing the opportunity to study this region.
We honor and acknowledge that the University of Colorado's four campuses are on the traditional territories and ancestral homelands of the Cheyenne, Arapaho, Ute, Apache, Comanche, Kiowa, Lakota, Pueblo and Shoshone Nations.
This material is based upon work supported by the National Science Foundation under Grant No. 1724794. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.
Special thanks to Dr. Kristy Tiampo, Dr. Mike Willis, Joel Johnson (University of Colorado, Boulder), Zach Little (North Carolina State University), & CIRES Staff for their invaluable help & support throughout this project.

References

Rosen, P. A. (2014, August 4). Principles and theory of radar interferometry. Reading presented at InSAR: An introduction to processing and applications using ISCE and GIAnT, in Boulder, CO.
Samsonov, S., & d'Oreye, N. (2012). Multidimensional time-series analysis of ground deformation from multiple InSAR data sets applied to Virunga Volcanic Province. Geophysical Journal International, 191(3), 1095-1108.
Goldstein, R. M., & Werner, C. L. (1998). Radar interferogram filtering for geophysical applications. Geophysical Research Letters, 25(21), 4035-4038. doi:10.1029/1998gl900033
Goldstein, R. M., Zebker, H. A., & Werner, C. L. (1988). Satellite radar interferometry: Two-dimensional phase unwrapping. Radio Science, 23(4), 713-720. doi:10.1029/rs023i004p00713