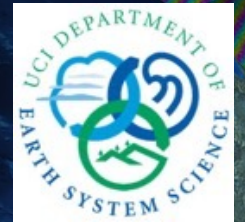


Towards a Multi-Frequency Virtual SAR Constellation for Grounding Line Measurements



Bernd Scheuchi
University of California, Irvine

Eric Rignot (UCI), Enrico Ciraci (UCI),
Hanning Chen (UCI), Pietro Milillo (UH)

FRINGE 2023

University of Leeds, UK | 11 - 15 September 2023.

ESA UNCLASSIFIED - For ESA Official Use Only



→ THE EUROPEAN SPACE AGENCY

In memory of Jeremie Mouginot (1982-2022)



MEaSURES Antarctica



NASA Program:

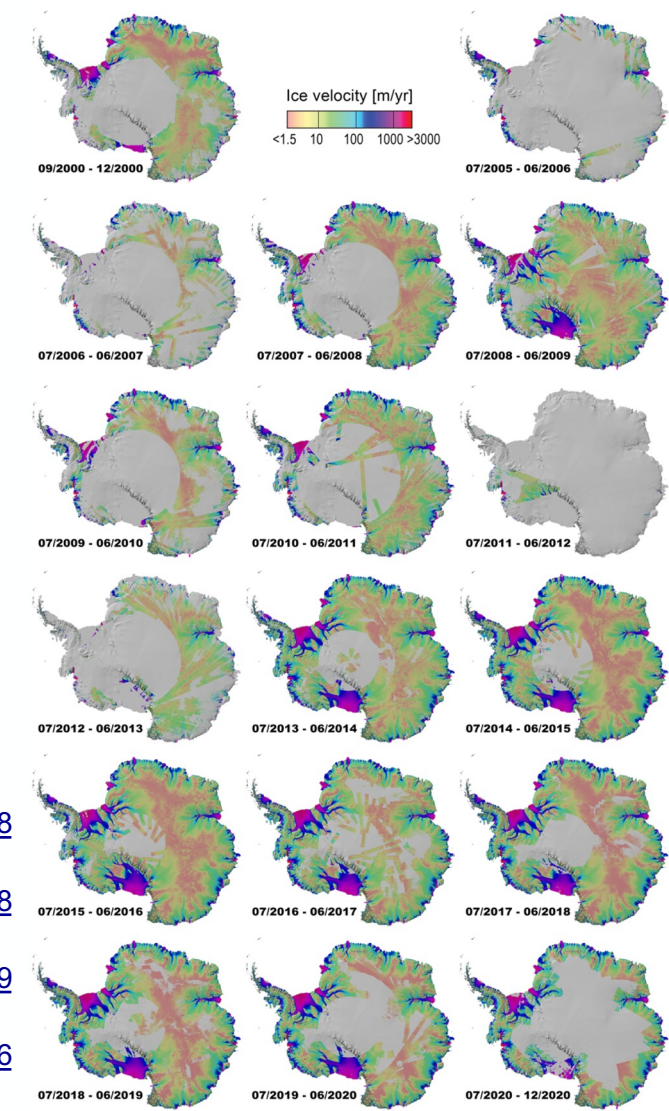
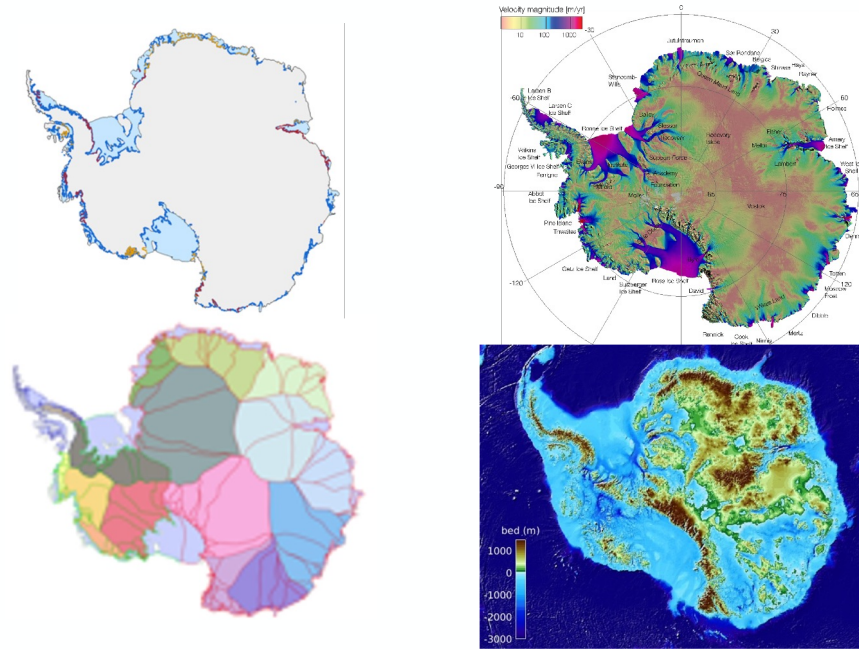
Making Earth System Data Records for Use in Research Environments (MEaSURES)

Funding Period: 2023-2028 (4th phase)

PI: Eric Rignot

Co-Is: Mathieu Morlighem, Bernd Scheuchl

Goals: Provide L3 and L4 data sets for the climate change community (IPCC), ice sheet modelers, and support NASA's study of Earth's ice masses and sea level.



Data Sources:

ERS-1, ERS-2, RADARSAT-1, RADARSAT-2, ENVISAT ASAR, ALOS PALSAR, ALOS-2 PALSAR-2, Copernicus SENTINEL-1a/b, Cosmo SkyMed, TerraSAR-X, TanDEM-X, NISAR, LANDSAT-8, SENTINEL-2, TanDEM-X DEM (Copernicus DEM), REMA DEM, NASA Operation IceBridge

ESDRs:

http://nsidc.org/data/measures/data_summaries

Ice Velocities:

- <https://nsidc.org/data/NSIDC-0754>
- <https://nsidc.org/data/NSIDC-0484>
- <https://nsidc.org/data/NSIDC-0720>
- <https://nsidc.org/data/NSIDC-0545>
- <https://nsidc.org/data/NSIDC-0525>
- <https://nsidc.org/data/NSIDC-0761>

Grounding Line:

<https://nsidc.org/data/NSIDC-0498>

Grounding Zone:

<https://nsidc.org/data/NSIDC-0778>

Boundaries

<https://nsidc.org/data/NSIDC-0709>

Bedmachine Antarctica

<https://nsidc.org/data/NSIDC-0756>



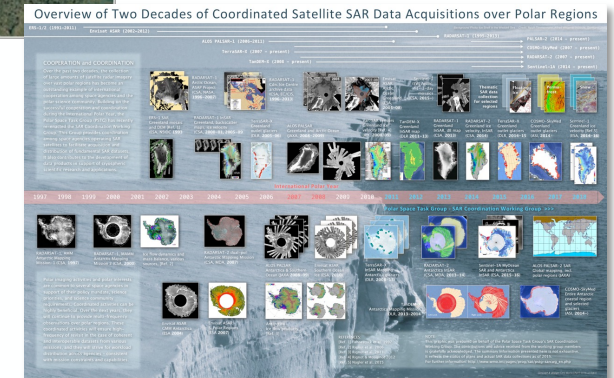
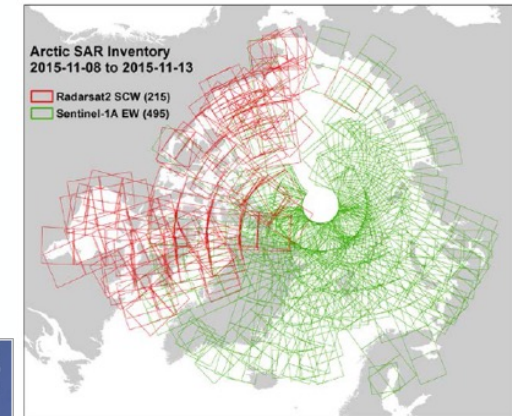
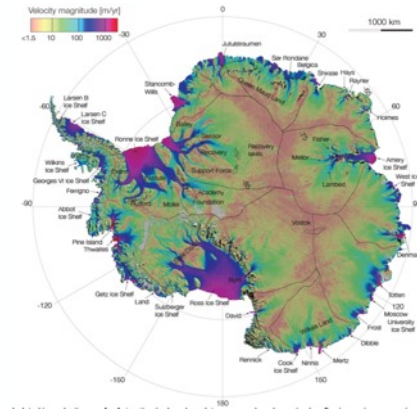
Polar Space Task Group



International coordination of satellite data acquisitions in support of Polar science.

Highlights

- First ever contiguous pole-to-coast **Antarctic ice sheet velocity and grounding line** maps.
- First evaluation of multi-sensor composite for estimating **melt onset** over Arctic sea ice; Multi-sensor examination of **seasonal snow melt on icecaps**.
- Dedicated coastal acquisitions implemented for **coastal erosion** studies. Multi-satellite seasonal **subsidence** studies.
- Established a multi-agency plan for acquiring **contiguous (seamless) six day repeat pan-Arctic SAR** imaging at consistent polarization combination



International Coordination Group for Spaceborne Synthetic Aperture Radar (SAR) Missions

<http://intl-sar-coord-group.space/>

Closer coordination and collaboration will significantly enhance the overall utility of the present and planned systems for the benefit of all.

Working Group 1: Present and Future Data - Visibility and Access (L0-L2)

Working Group 2: Future Imaging Systems - Goals, Plans, Challenges and Opportunities

Working Group 3: Data Exploration – Cal/Val, Fusion and Assimilation (L3-L4)

Thematic Area 1: Polarimetric and Multi-frequency SAR Applications

Thematic Area 2: Interferometric SAR Applications

Thematic Area 3: Program and Mission Coordination

The Polar Space Task Group (PSTG) constitutes a successful example of how such a science-led coordination activity can be organized.

Thematic Area recommendation related to PSTG:

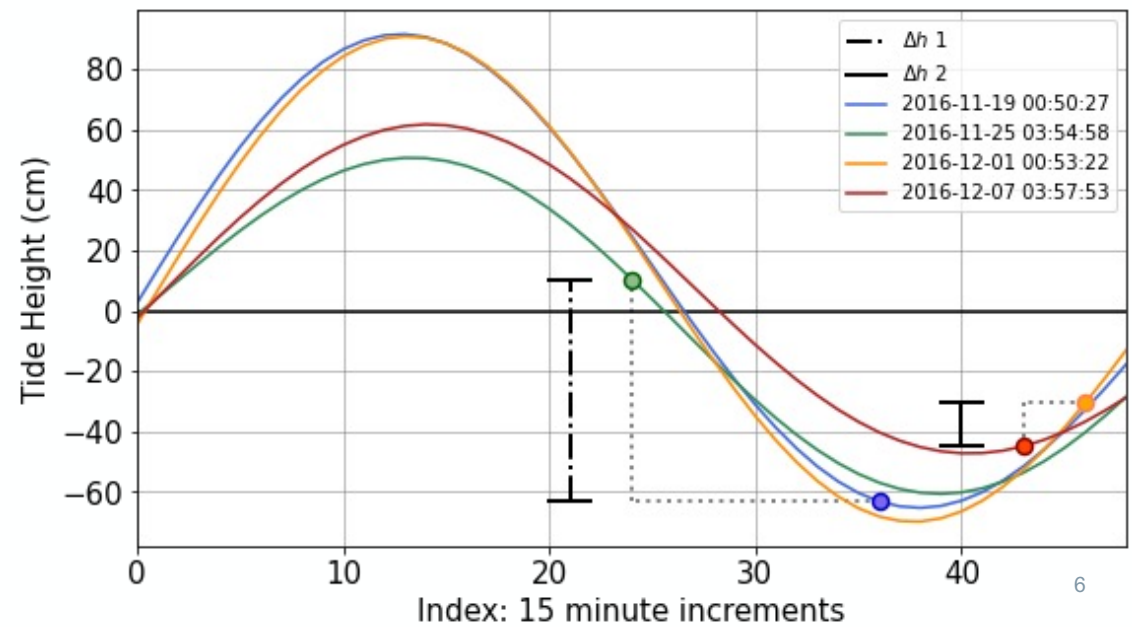
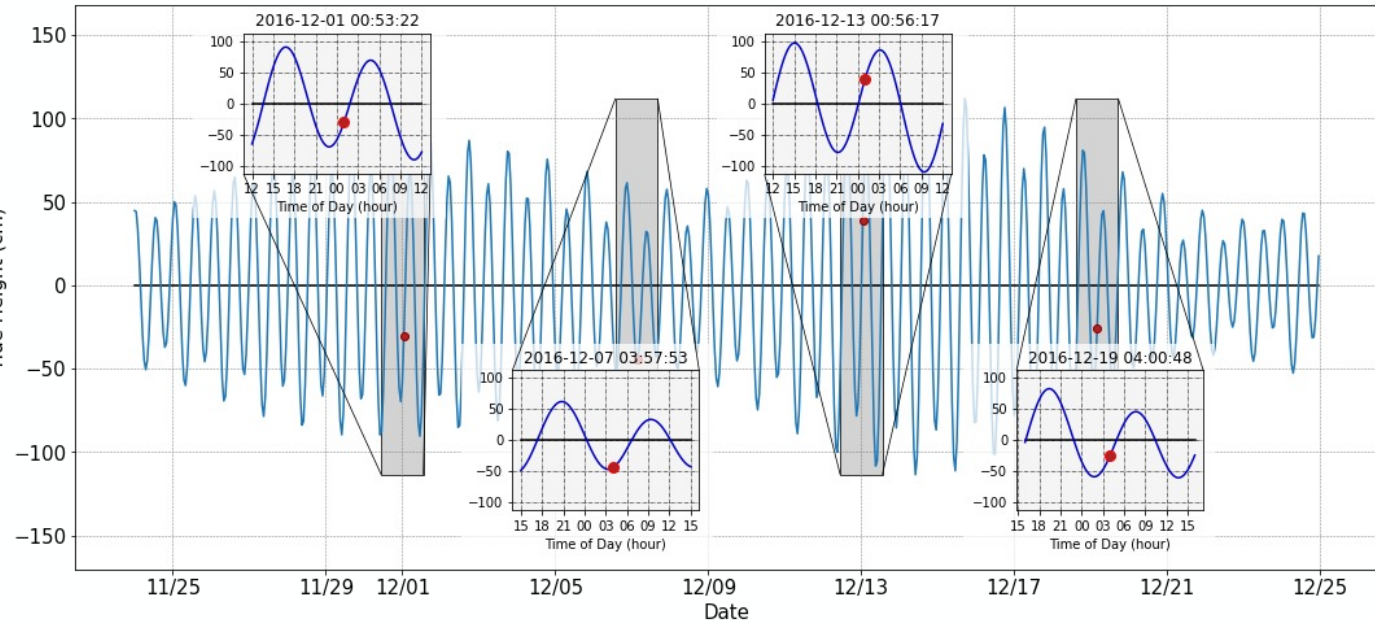
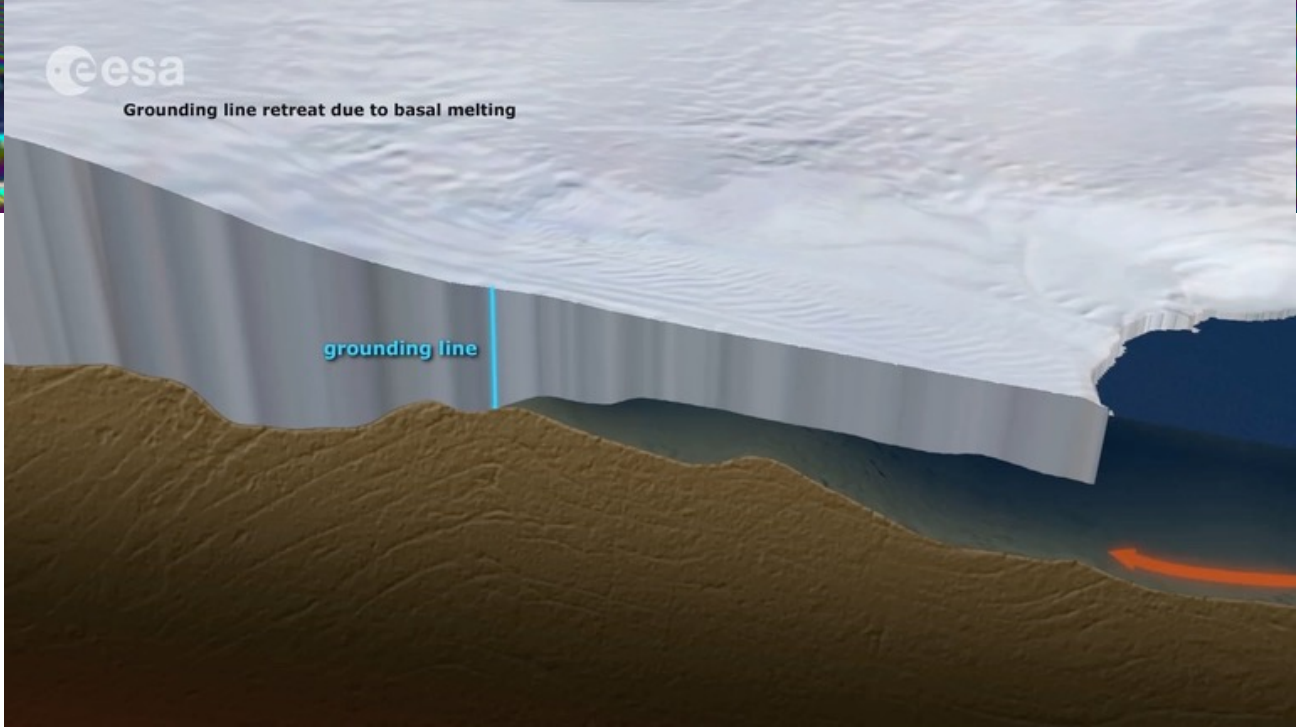
• Re-establish Polar Space Task Group to coordinate polar acquisitions from current & upcoming missions

Grounding Line GL

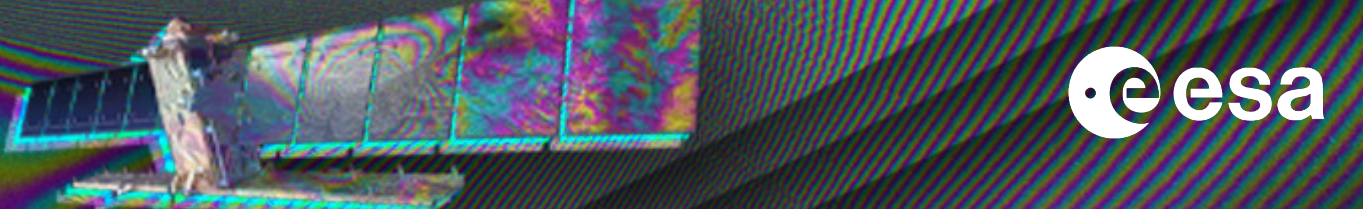
Location where ice detaches from the ground and starts to float.

The grounding line position is not static.

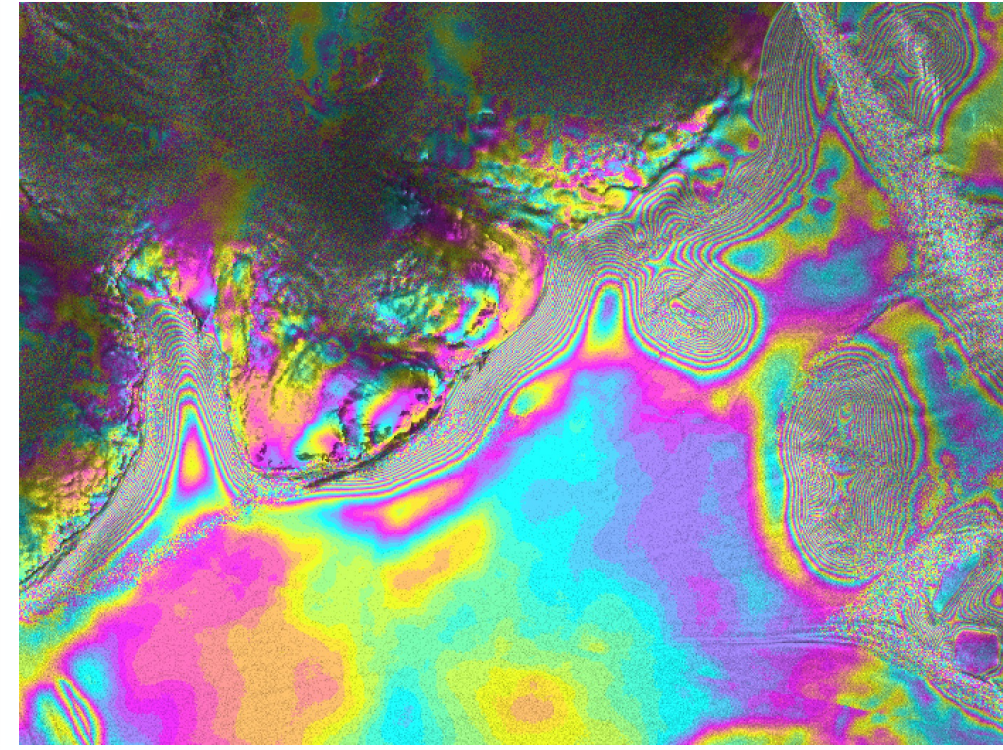
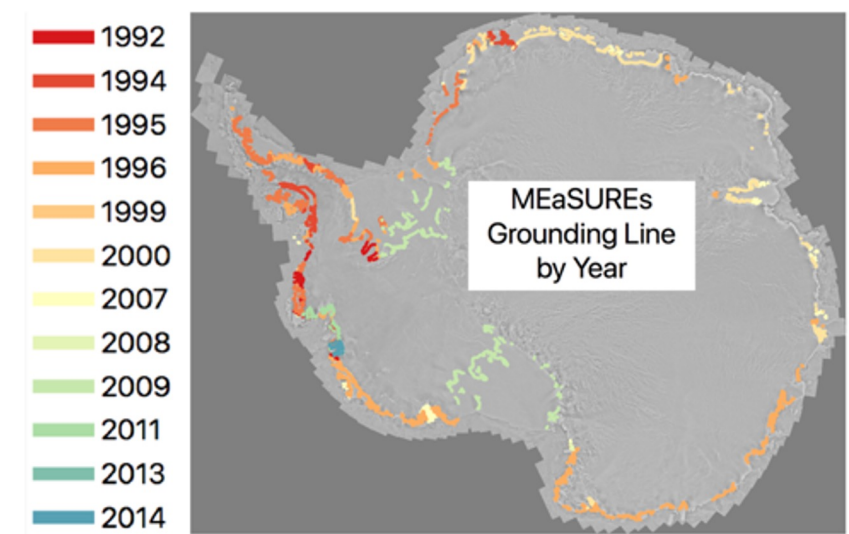
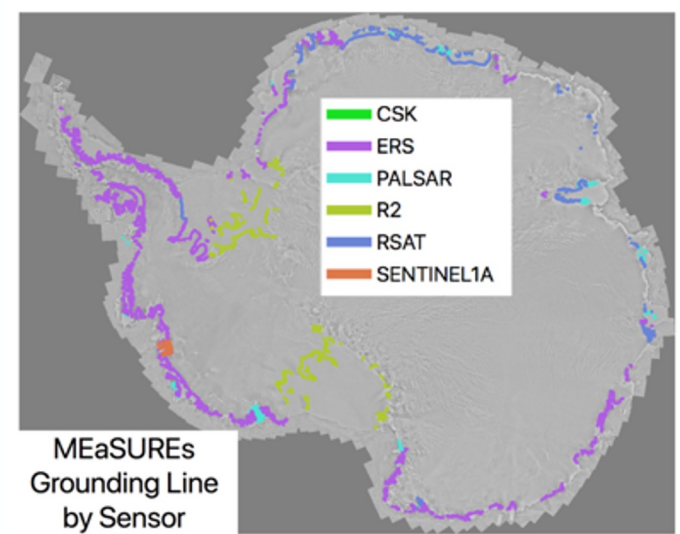
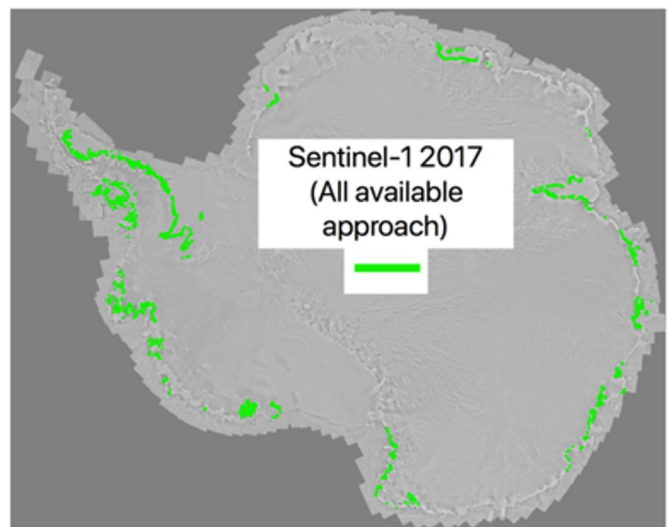
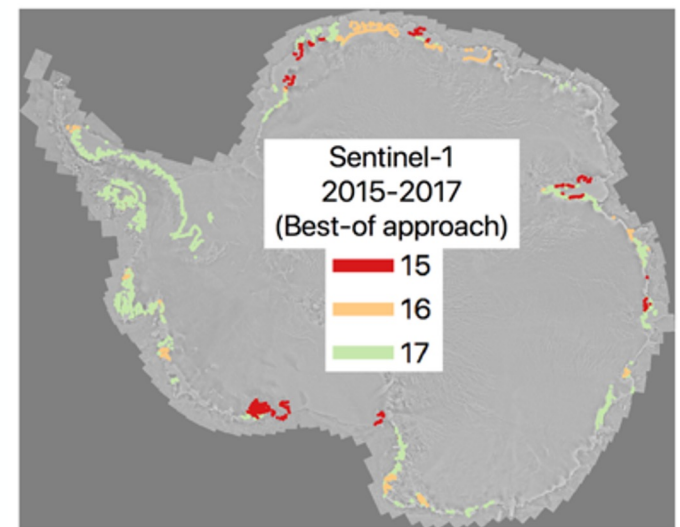
Measure the differential tidal displacement using SAR interferometry.



Antarctic Grounding Line

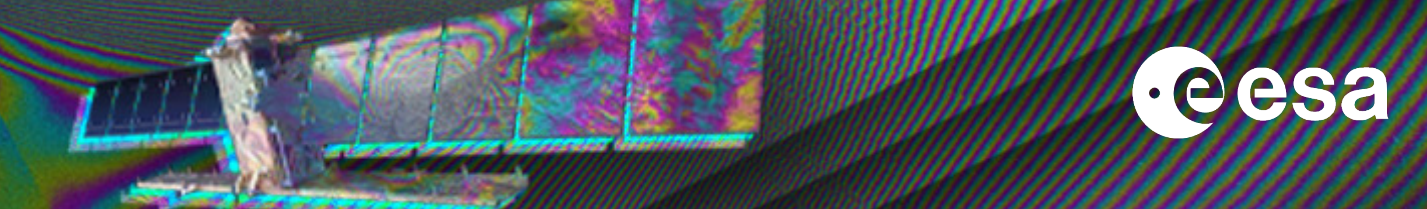


Rignot et al. 2011
 Rignot et al. 2014
 Li et al. 2015
 Scheuchl et al. 2016



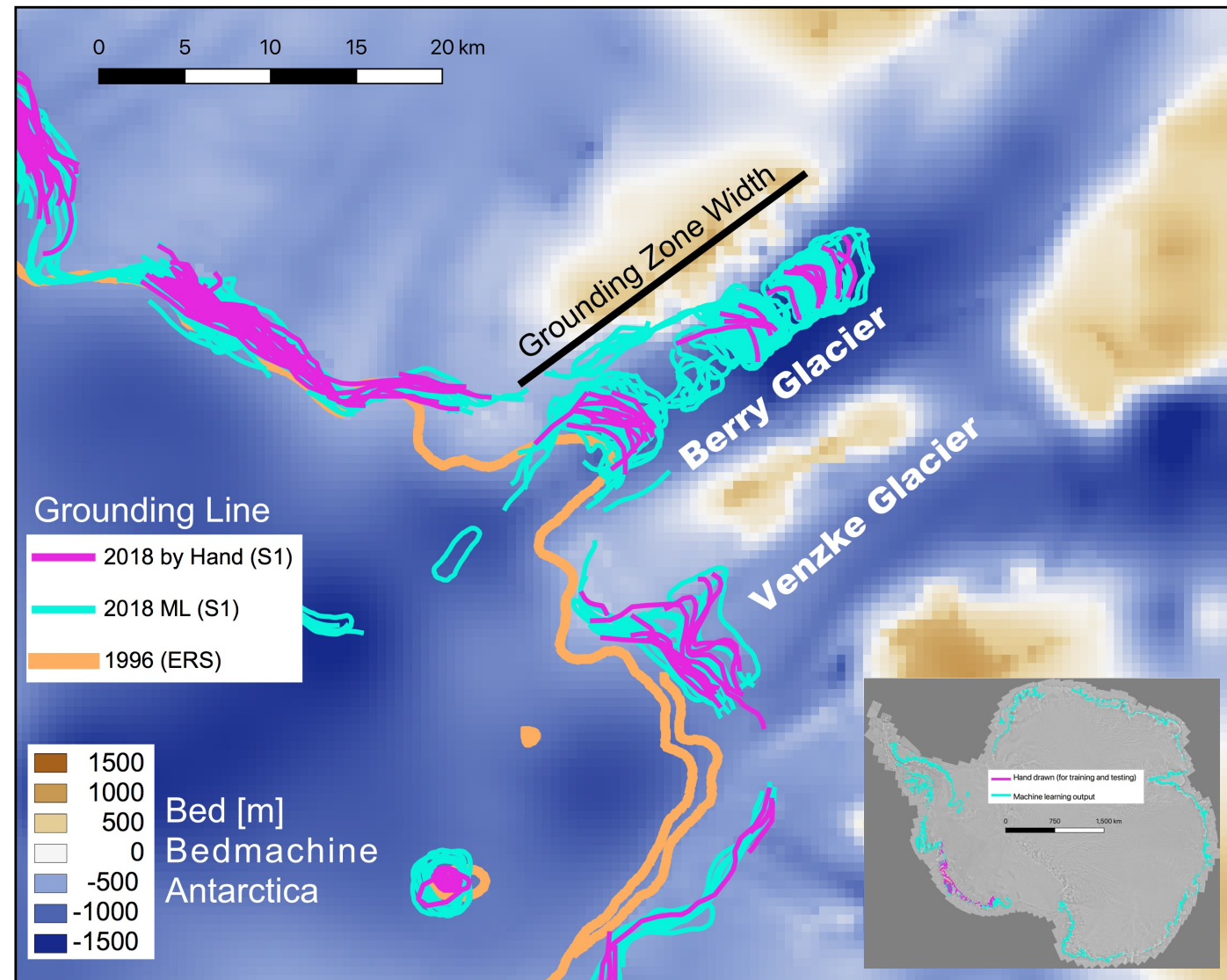
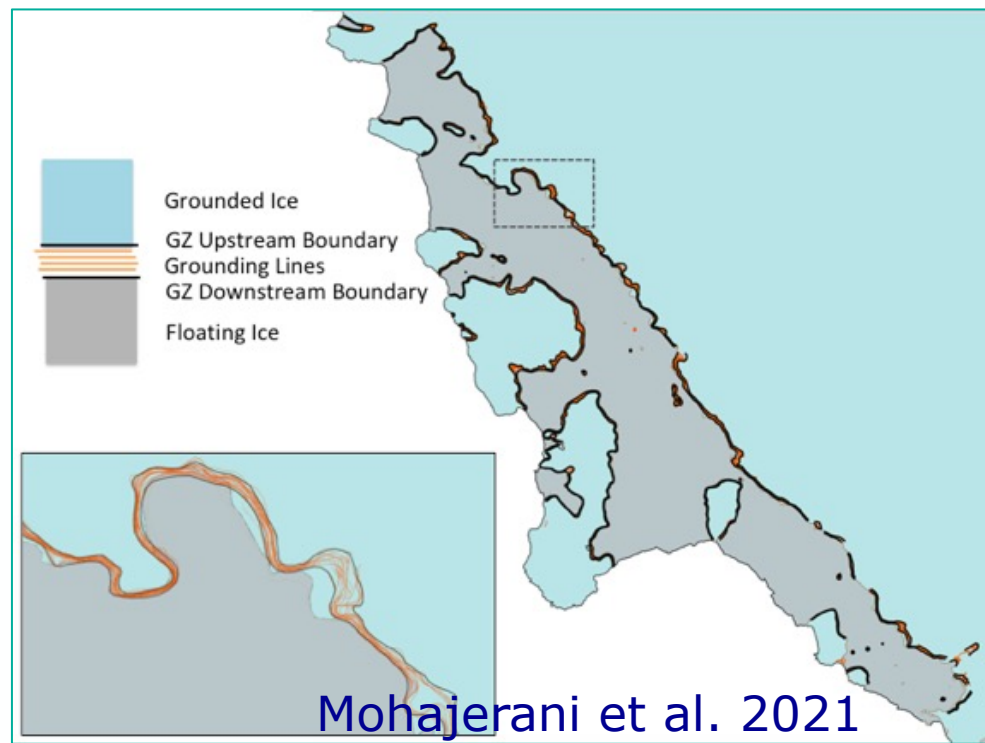
0 1,000 2,000 km <http://nsidc.org/data/NSIDC-0498/>

Grounding Zone (GZ)

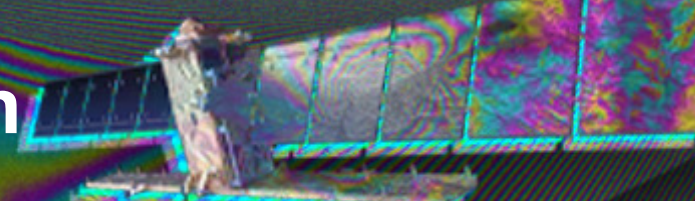


short term variation of the grounding line position over a set time

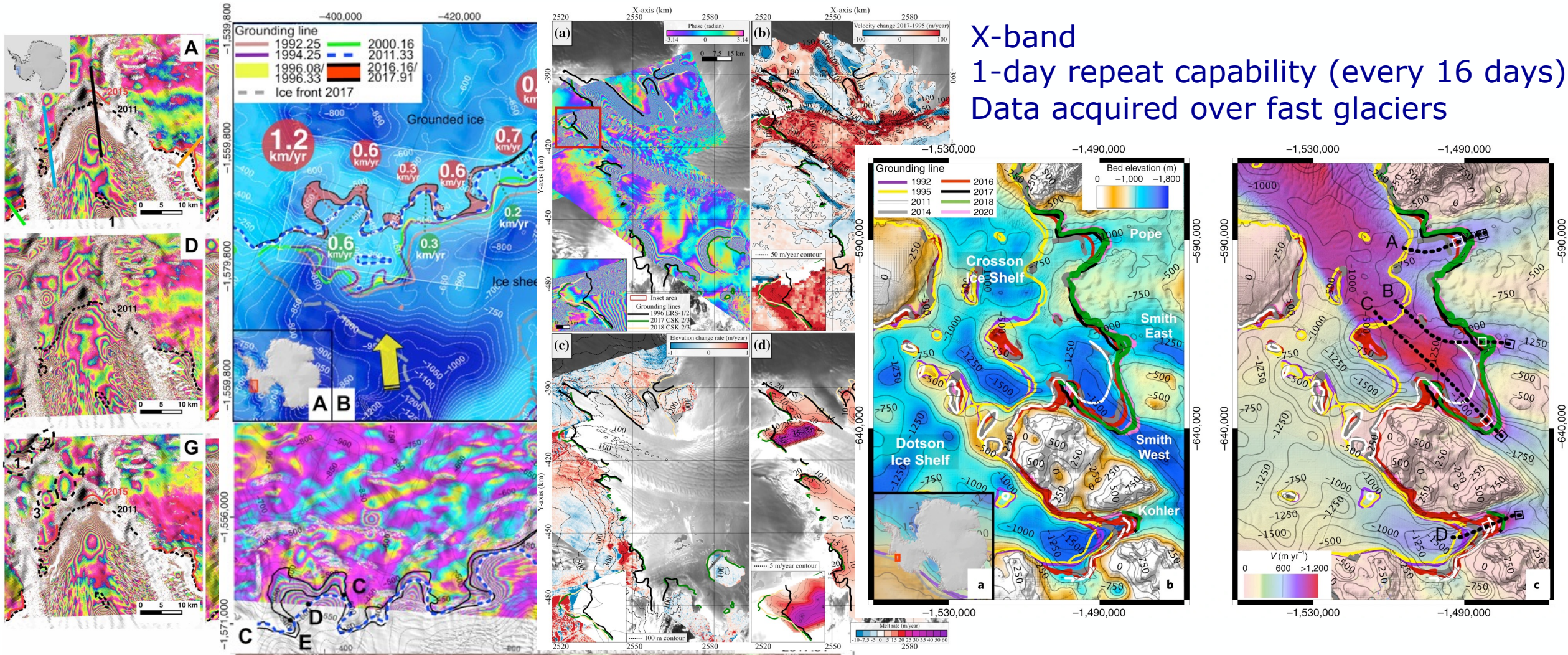
Machine learning approach to derive the GZ



COSMO SkyMed Constellation



X-band
1-day repeat capability (every 16 days)
Data acquired over fast glaciers

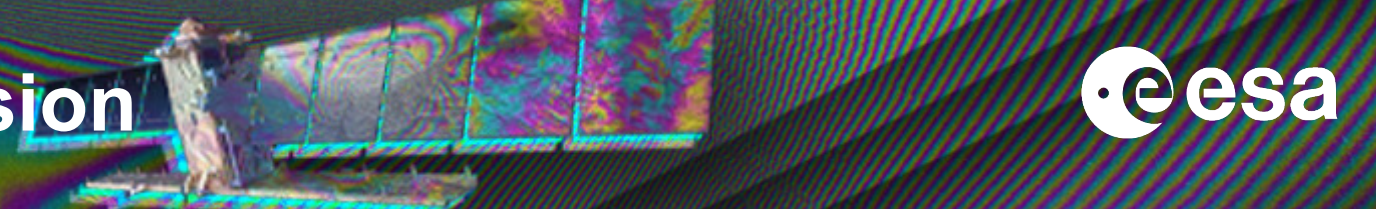


Milillo et al. 2017, Milillo et al. 2019, Brancato et al. 2020,
Pine Island Glacier Thwaites Glacier Denman Glacier

Milillo et al. 2022,
Pope, Smith, Kohler Glaciers



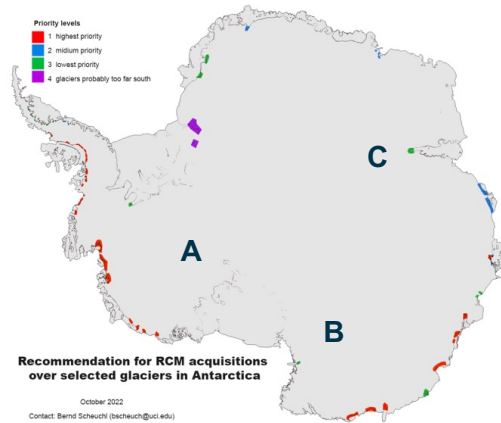
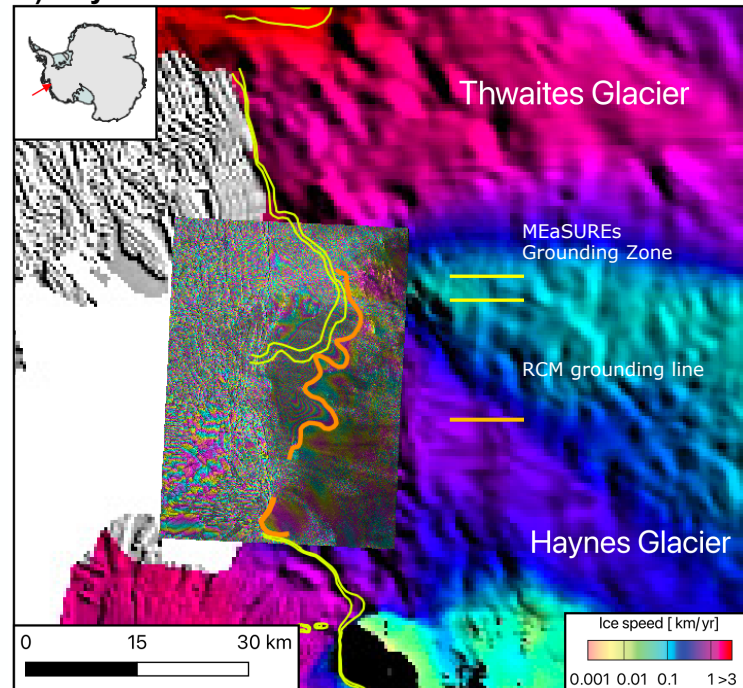
RADARSAT Constellation Mission



Objective

Augment Sentinel-1 coverage with 4-day InSAR repeat acquisitions in key areas of coastal Antarctica.
Test: Jan/Feb 2023

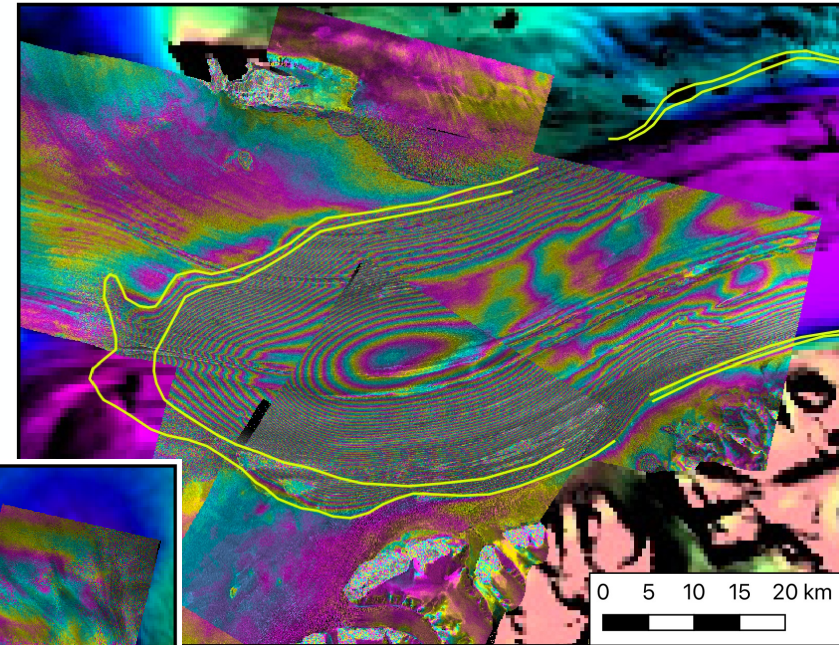
A) Haynes Glacier



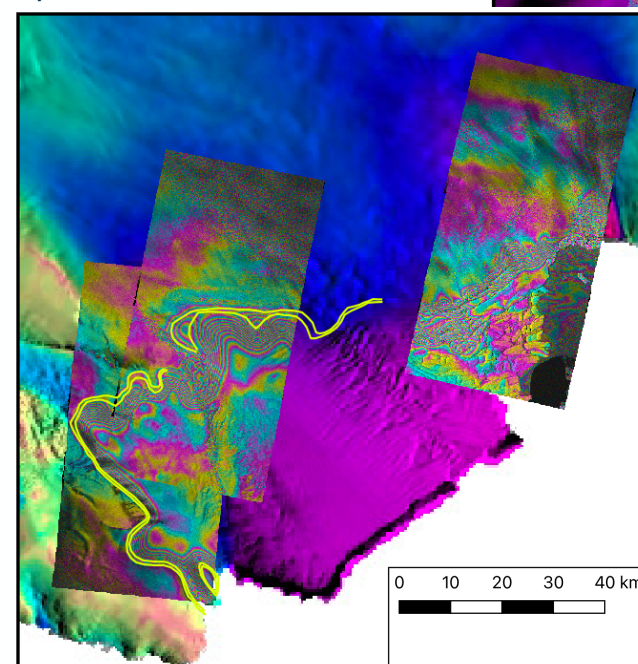
C) Lambert Glacier

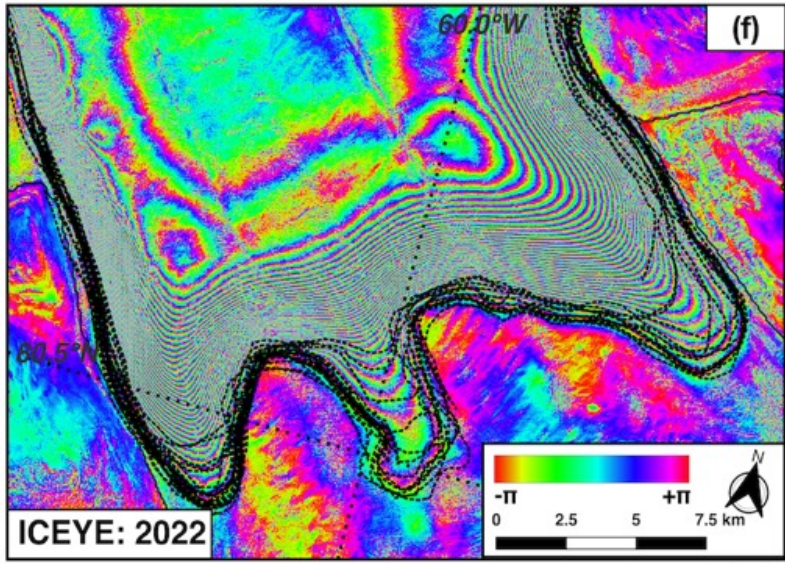
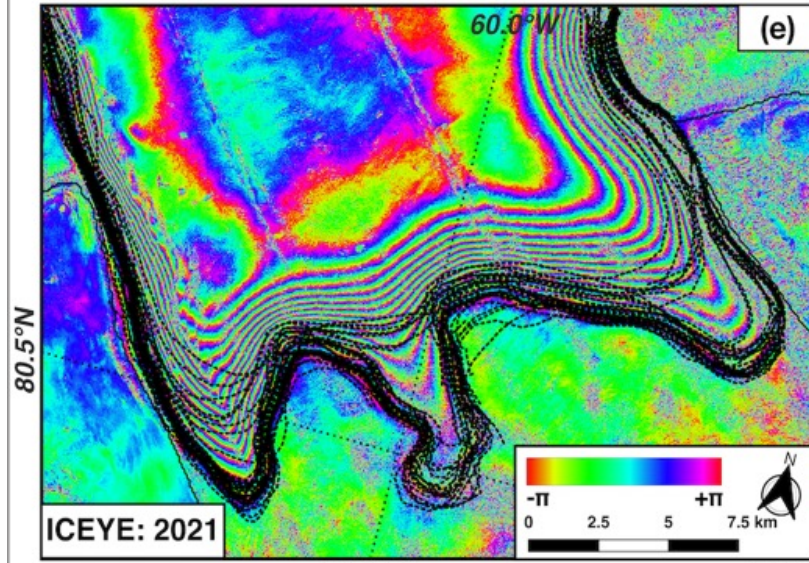
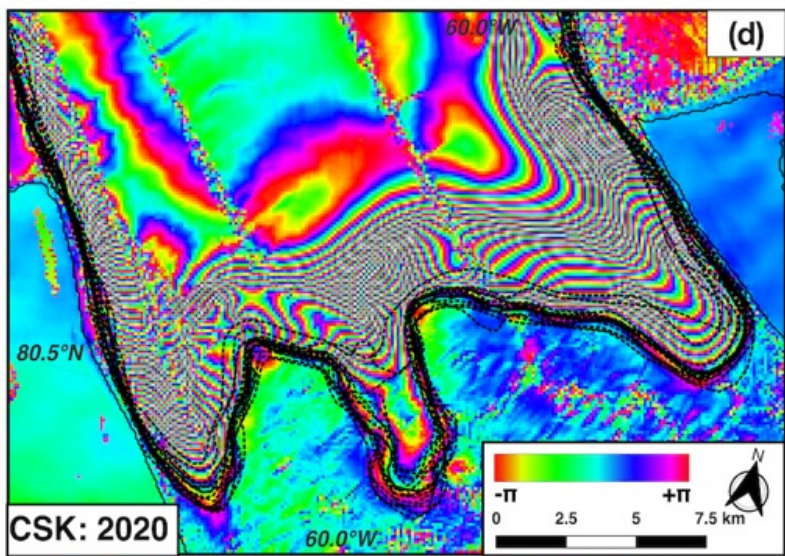
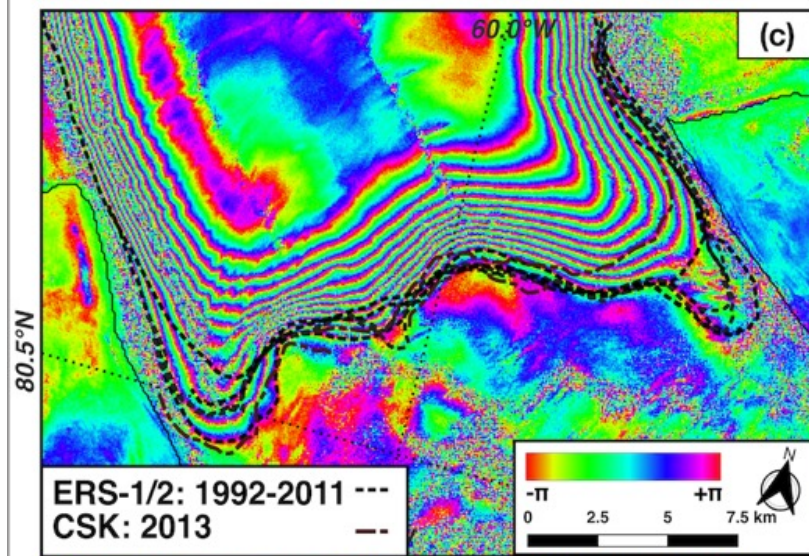
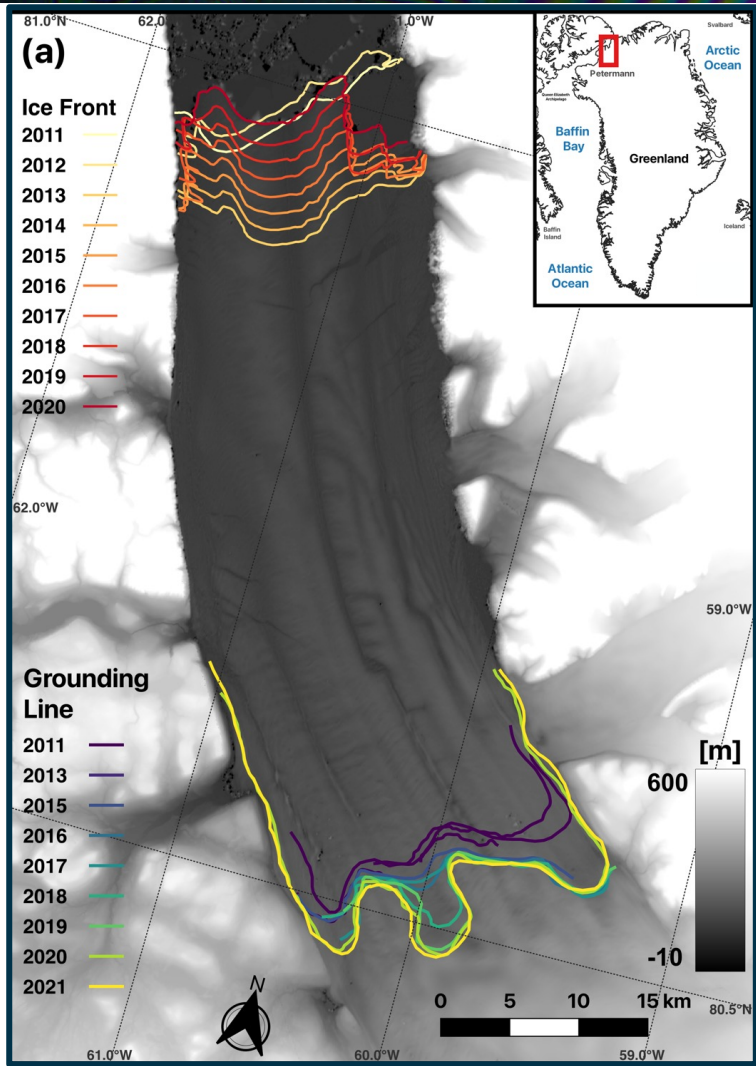
RCM coverage proposal

for continent-wide science impact



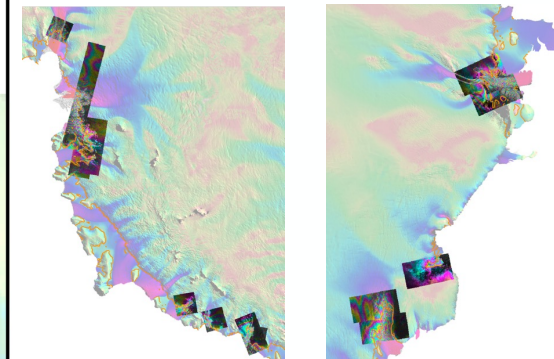
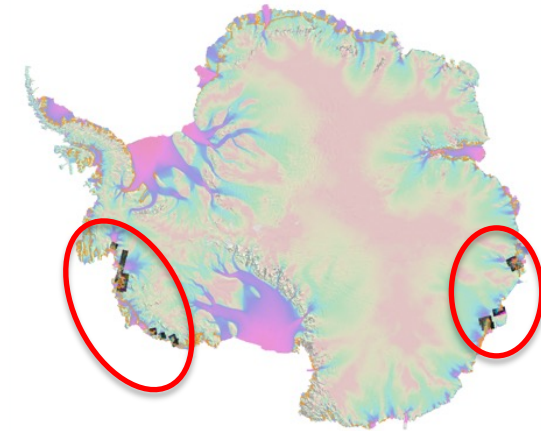
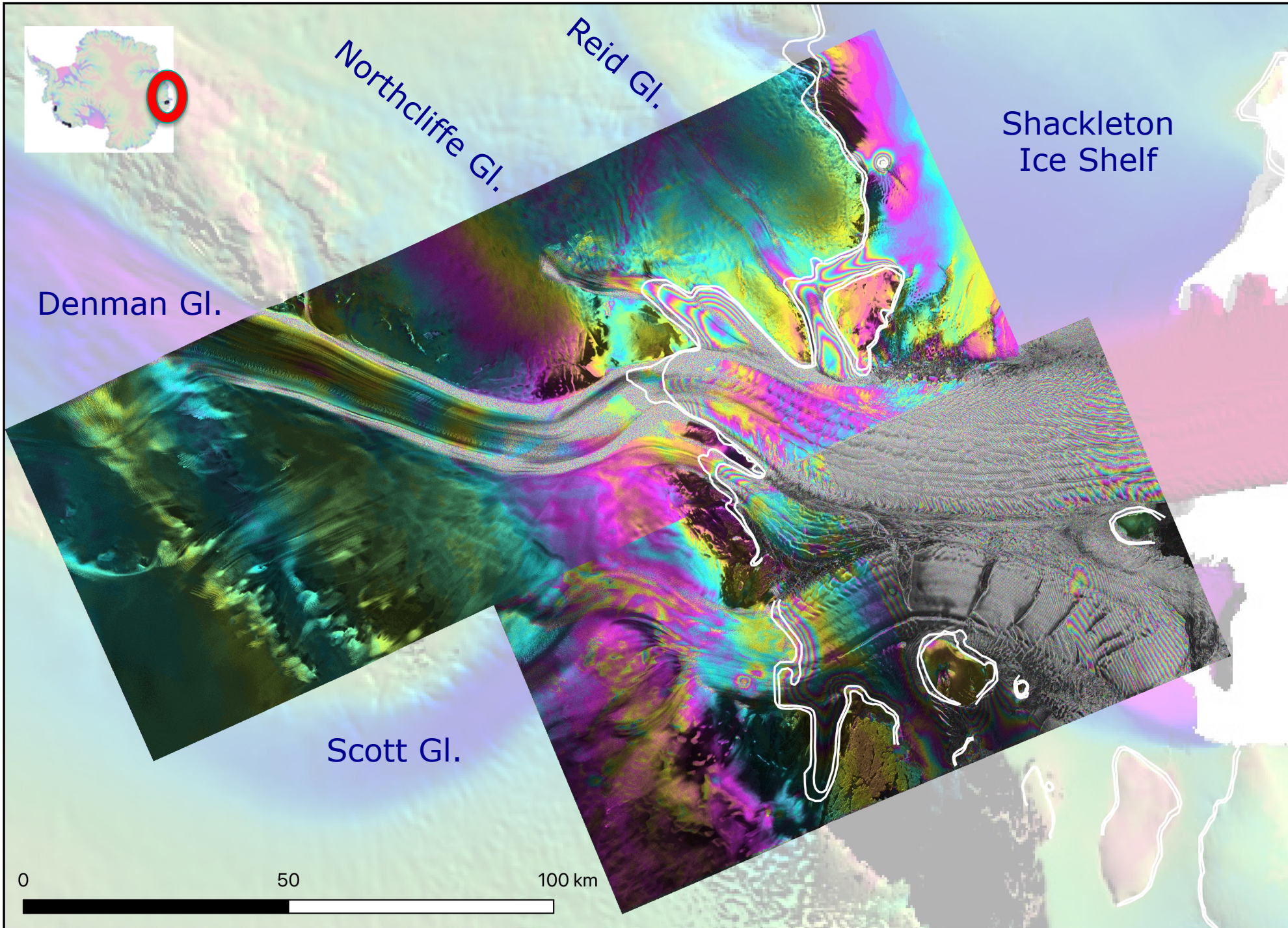
B) Cook Ice Shelf



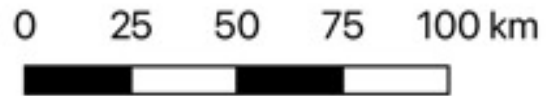
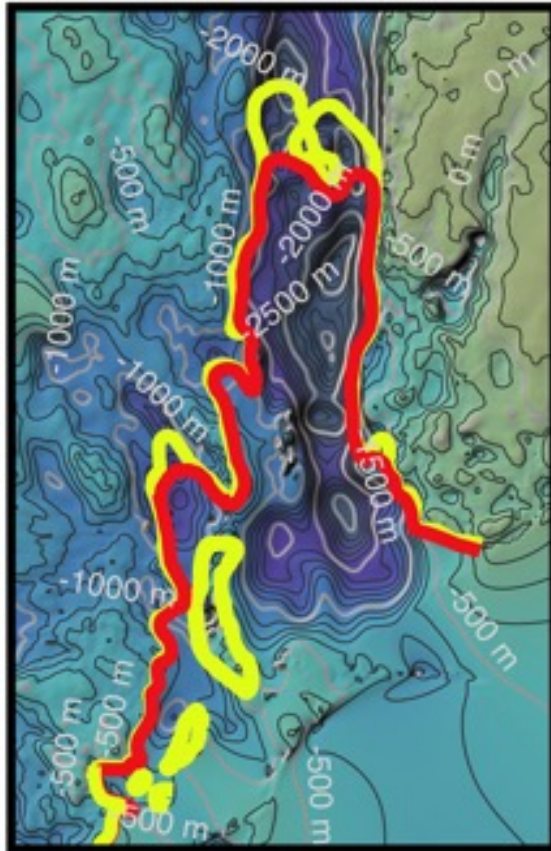
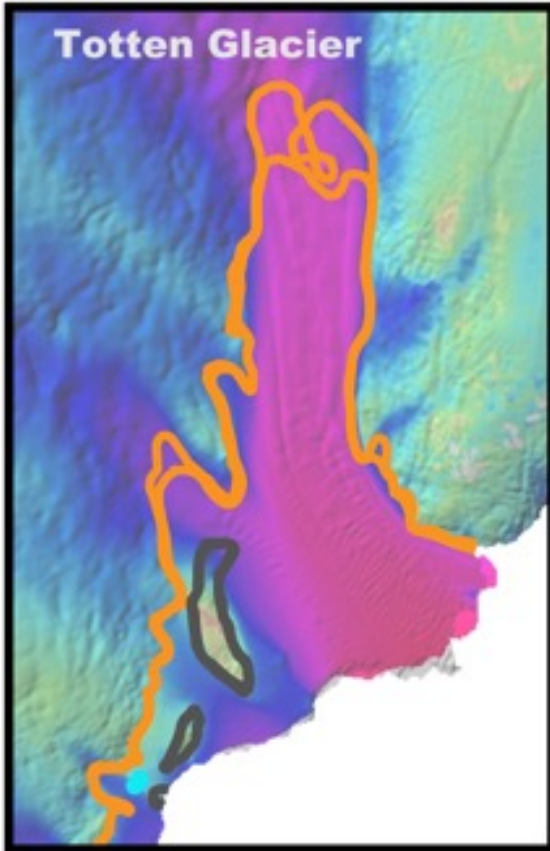


Ciraci et al. PNAS 2023; 10.1073/pnas.22209241

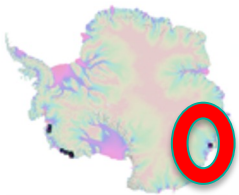
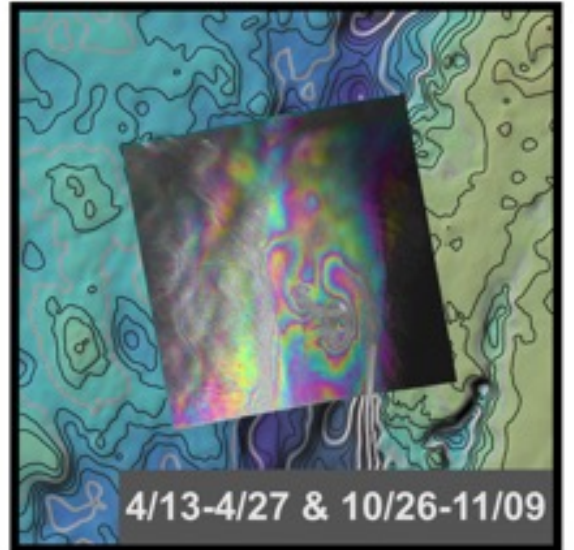
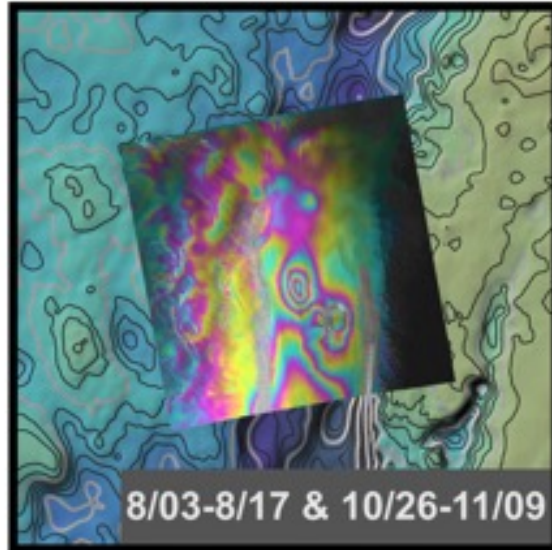
ALOS-2 PALSAR-2



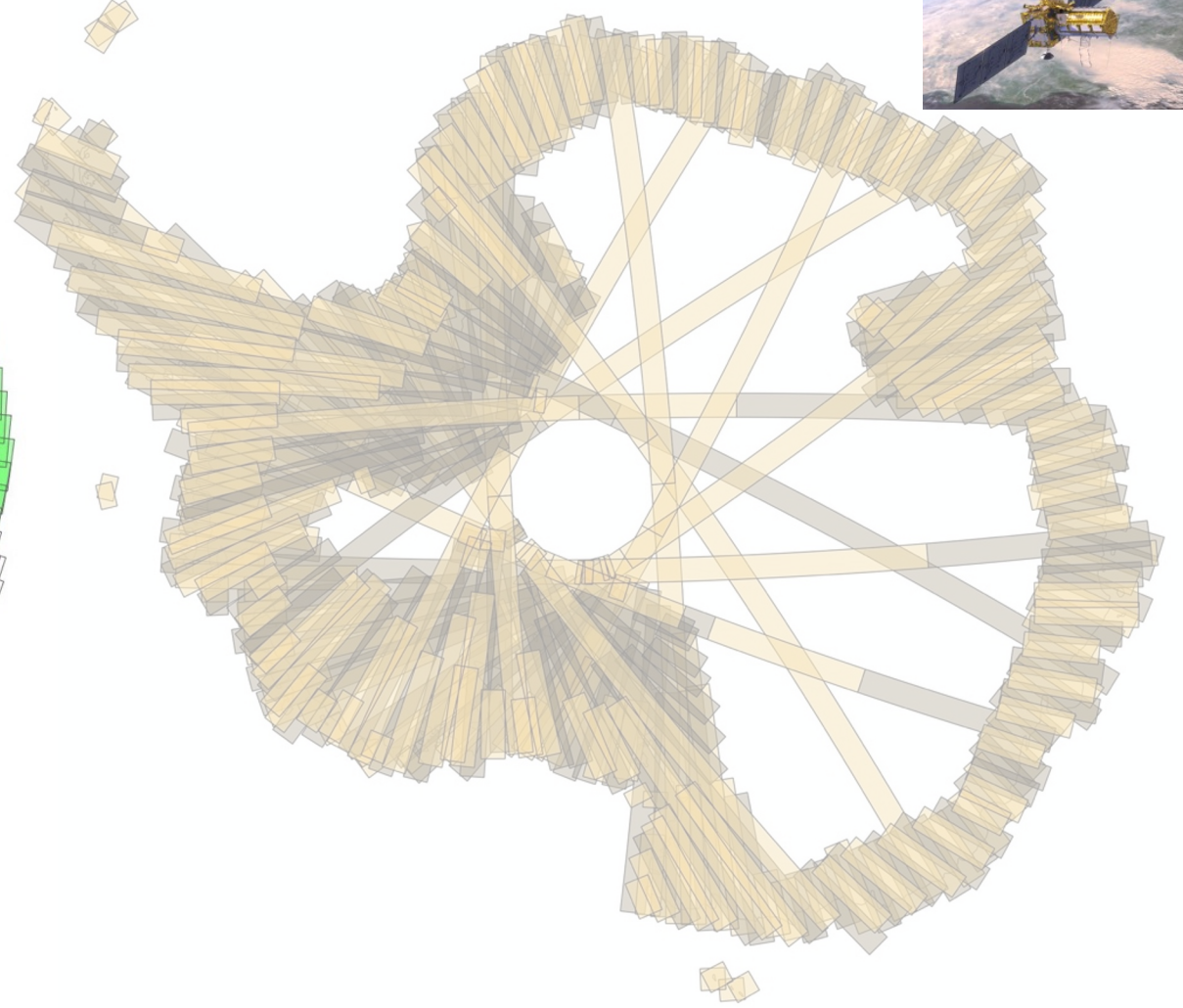
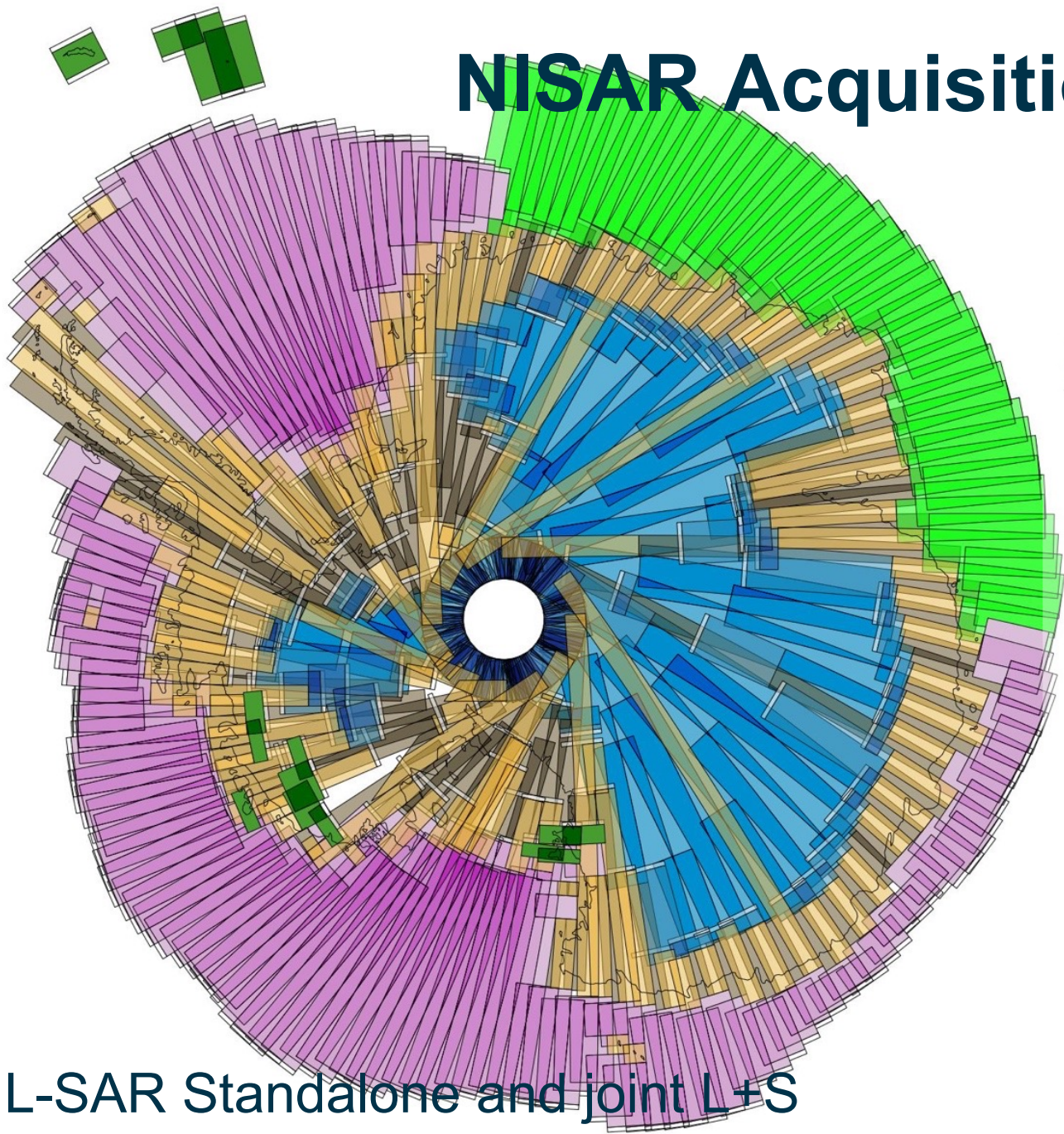
ALOS-2 PALSAR-2



14 day repeat



NISAR Acquisition Plan - Antarctica



L-SAR Standalone and joint L+S

L-SAR 80MHz Half-Swath



While not formally coordinated, recommendations are based on results and experiences during PSTG science coordination work as well as on our MEaSURES project results.

No single mission to date is capable of providing the information content of this virtual constellation. Coordination allows responsible use of valuable assets.

Sentinel-1: crucial baseline for GL – primary coverage motivator is ice velocity.

RCM: augment S1 coverage over fast glaciers. Primary motivator is GL/GZ.

NISAR: generous coverage, but expect decorrelation over some fast glaciers.

**To date, we are unable to reliably monitor key critical areas!
Pine Island Glacier and Thwaites Glacier still pose a challenge.**

X-band fast repeat (1-day or shorter):

CSK: 1-day repeat every 16 days; data not openly available

ICEYE: Experimental 1-day repeat time series successfully collected

Commercial data – need agency support for access (e.g. third party provider)

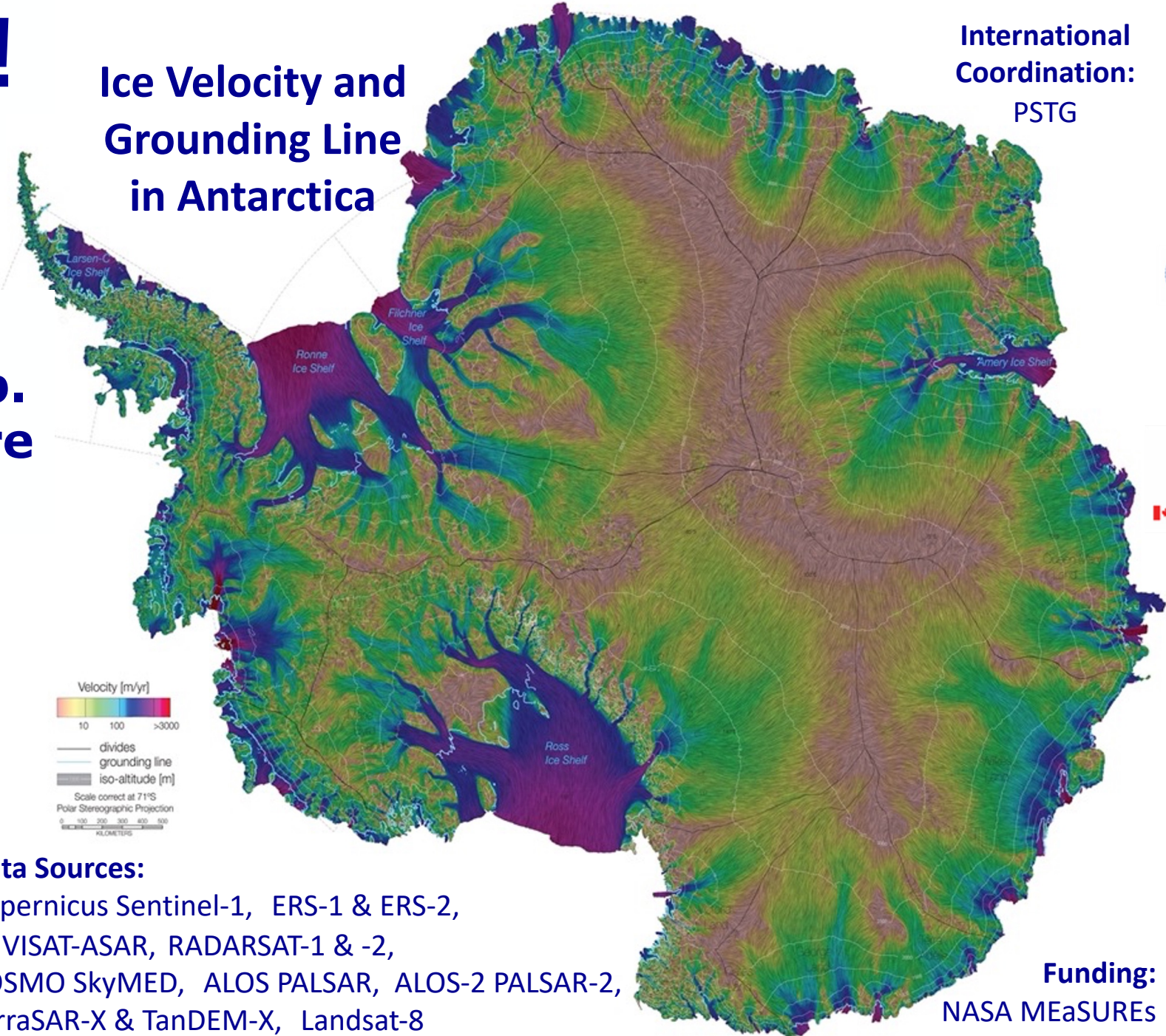
Thank you!

Bernd Scheuchl
bscheuch@uci.edu

Postdoctoral position
available in our group.
Scan QR code for more
information.



Ice Velocity and Grounding Line in Antarctica



Data Sources:

Copernicus Sentinel-1, ERS-1 & ERS-2,
ENVISAT-ASAR, RADARSAT-1 & -2,
COSMO SkyMED, ALOS PALSAR, ALOS-2 PALSAR-2,
TerraSAR-X & TanDEM-X, Landsat-8

International
Coordination:
PSTG



Funding:
NASA MEaSUREs

