



Early results w. NISAR, Sentinel-1c/d and ICEYE interferometric SARs in Antarctica



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Plan of presentation:

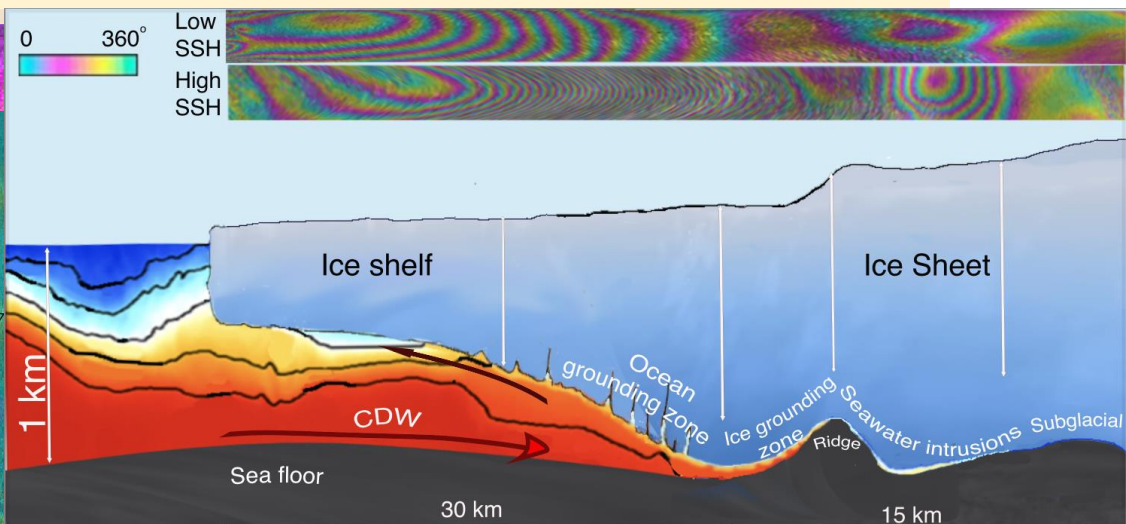
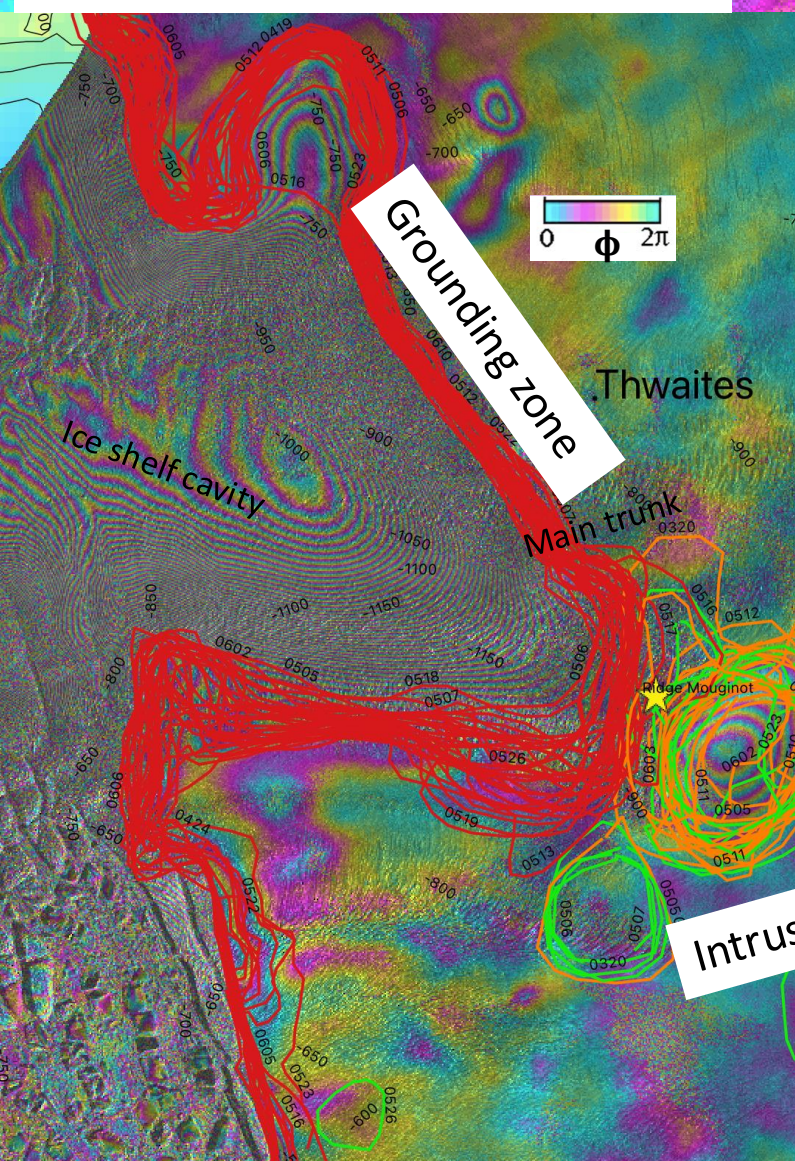
- Grounding line mapping 1992-2026
 - Example with ICEYE, NISAR, S1 1-d
- Velocity mapping 2000-2025
 - S1 monthly, NISAR phase-only velocity.



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Thwaites Glacier, ICEYE May 13, 2023 (2m pix)



GZ delineation with InSAR

$2\pi \sim 1.7 \text{ cm}$

$$\delta\phi_{12} = (\phi_{\text{motion}12} + \phi_{\text{tide}12} + \phi_{\text{Pw}12})$$

$$\delta\phi_{23} = (\phi_{\text{motion}23} + \phi_{\text{tide}23} + \phi_{\text{Pw}23})$$

$$\delta\phi_{12} - \delta\phi_{23} \propto \text{SSH}_1 - 2\text{SSH}_2 + \text{SSH}_3 + P_{w1} - 2P_{w2} + P_{w3}$$

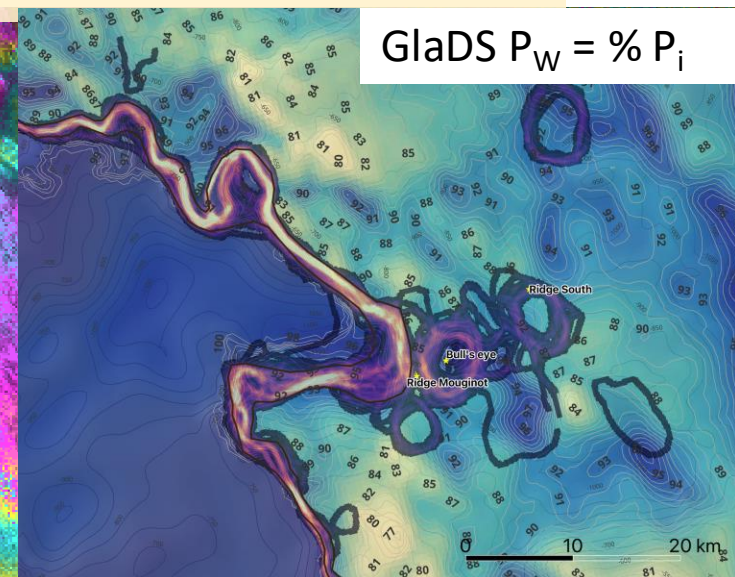
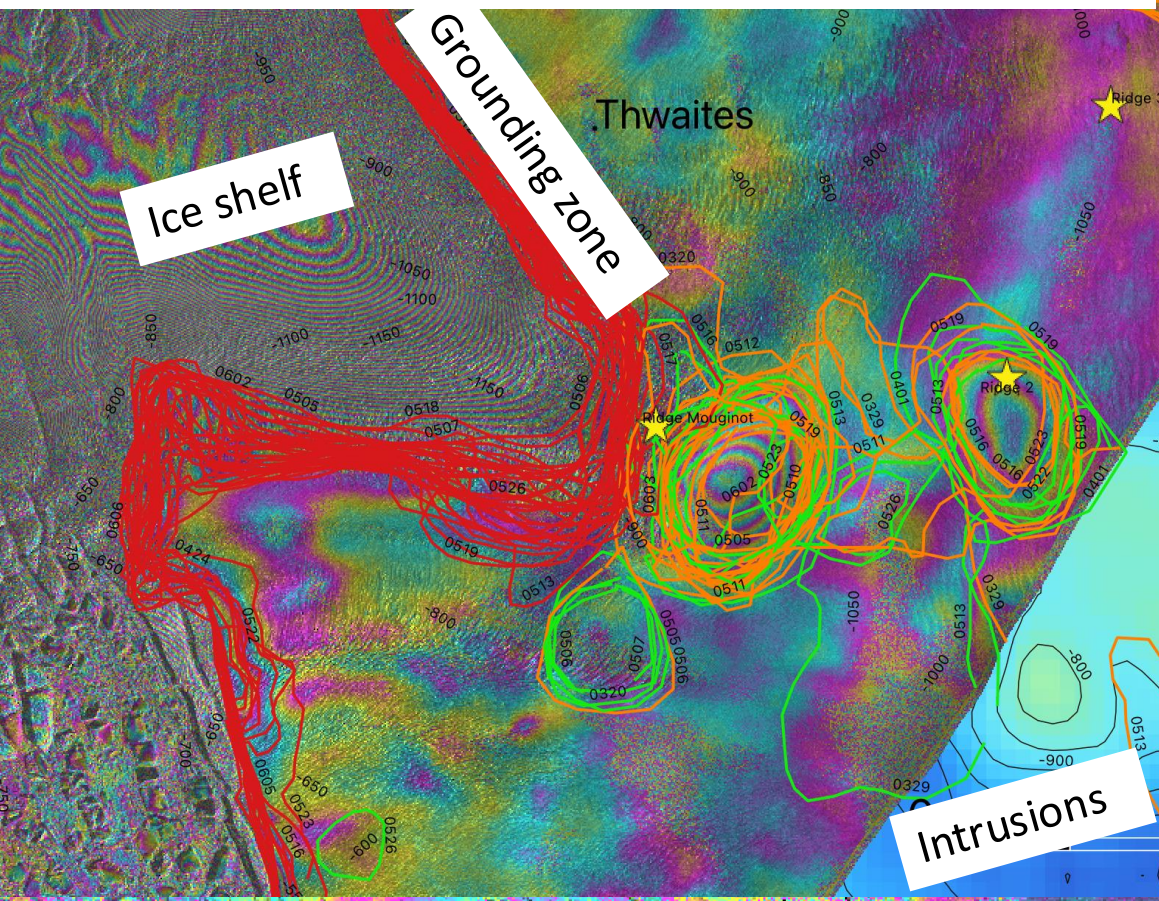
with changes in basal water pressure (P_w) above ice overburden pressure expressed as changes in surface height



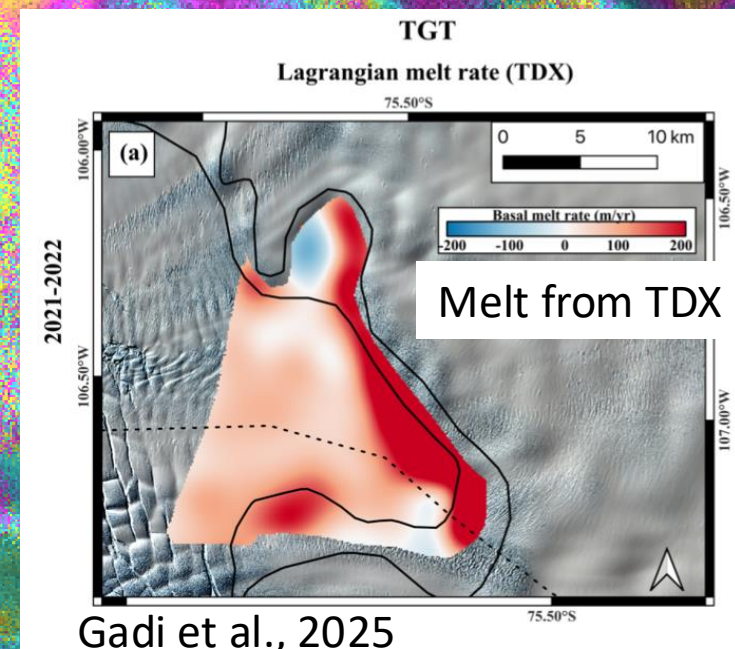
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- InSAR reveals km-sized seawater intrusions
- Intrusions cause rapid ice high melt (Gadi et al. 2025).
- **Intrusions increase the sensitivity of models to melt by a factor x 2** (Parizek et al., 2013; Seroussi and Morlighem, 2018; Robel et al., 2022)
- Intrusions in areas of high P_w (Rignot et al. 2024)



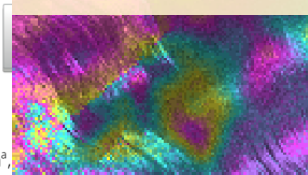
$$\text{GlaDS } P_w = \% P_i$$



Gadi et al., 2025

Thirty years of glacier grounding line retreat in Antarctica

Eric Rignot^{a,b,c,d,1}, Bernd Scheuch^a, Jean Baptiste Barre^d, Virginia Brancato^b, Laurene Charrier^d, Hanning Chen^e, Enrico Ciraci^a, Andy Dinh^e, Sam Herreid^b, Seongsu Jeong^b, Xin Li^a, Thomas Mitchell^e, Yara Mohajerani^f, Sina Shamsian^a, Valentyn Tolpekin^g, Isabella Velicogna^{a,b}, and Michael Wollersheim^g



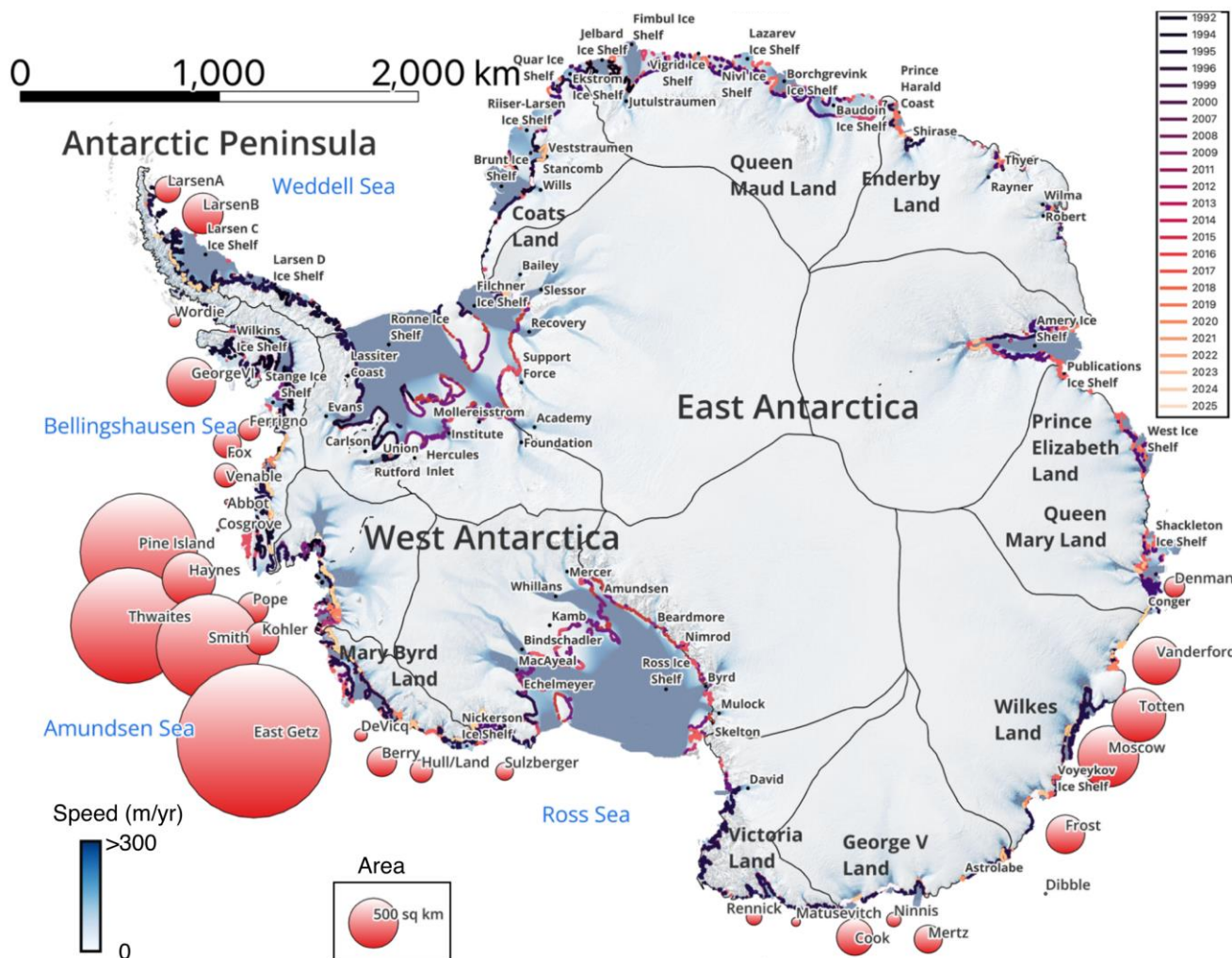
No migration for $77 \pm 10\%$ coast.

Retreat in **AP** (Larsen A-B (2-18 km) and George VI (2-6 km)), **Wilkes Land** (Denman, Totten, Moscow, Frost, Holmes, Mertz, Ninnis, and Cook (6-10 km), Vanderford (26 km)); and **West Antarctica** (Ferrigno, Fox, and Venable (5-7 km), and Pine Island 33 km, Thwaites 26 km, Haynes 20 km, Pope 23 km, Smith 42 km, Kohler 12 km, East Getz 9 km, Berry 18 km, Hull 14 km, and Land 5 km).

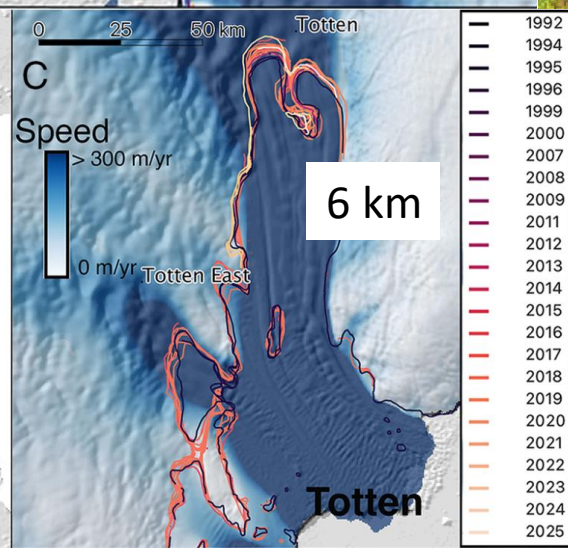
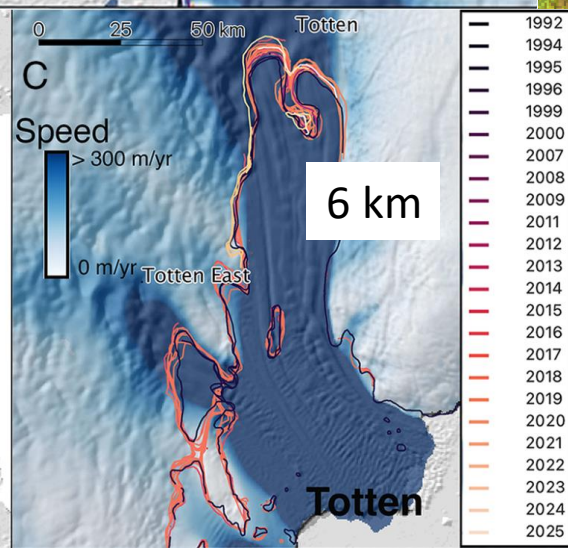
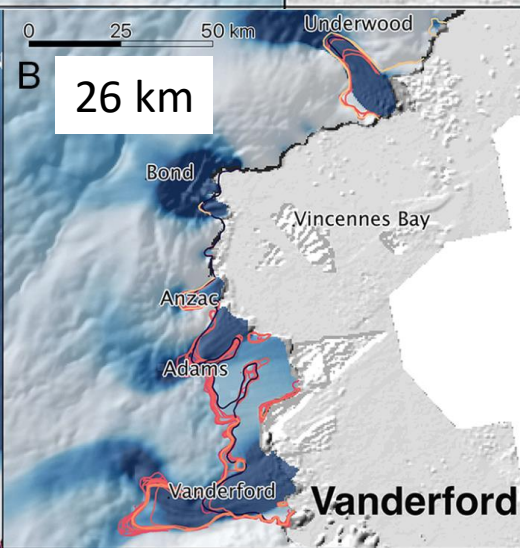
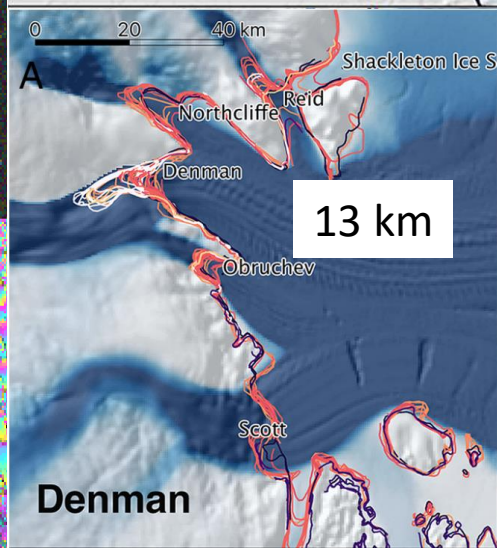
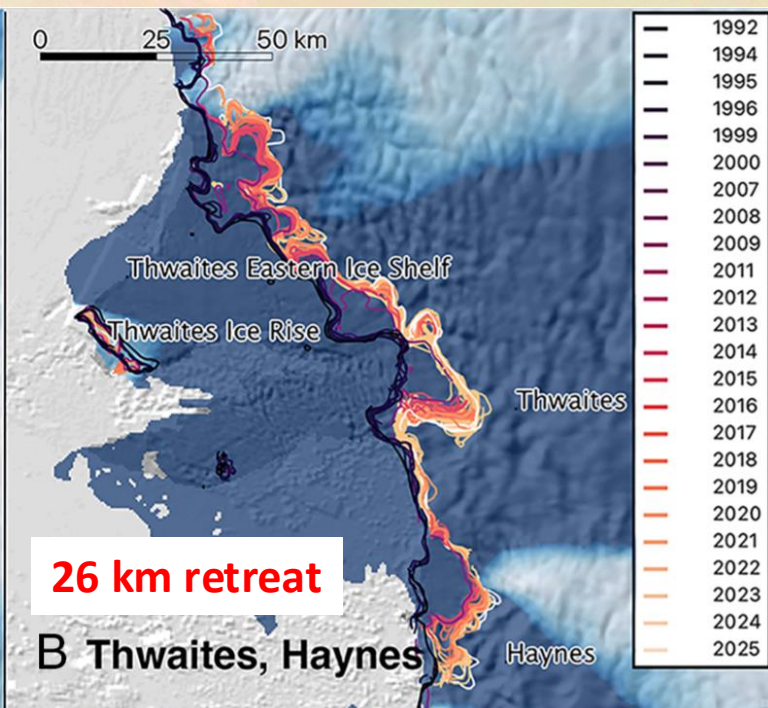
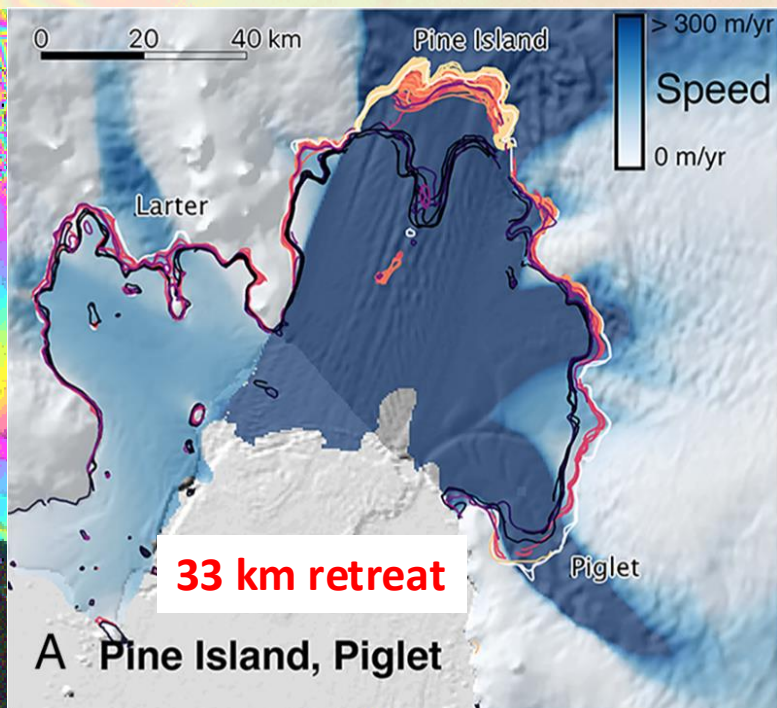
Ice sheet lost $12,820 \pm 1,873 \text{ km}^2$ of grounded ice, or $442 \pm 64 \text{ km}^2/\text{y}$, 62% from WAIS and 28% from EAIS.

GL (<https://nsidc.org/data/nsidc-0498/versions/2>)

GZ (<https://nsidc.org/data/nsidc-0778/versions/1>)) **harmonized benchmarks for ice grounding zone-based ice sheet models.**

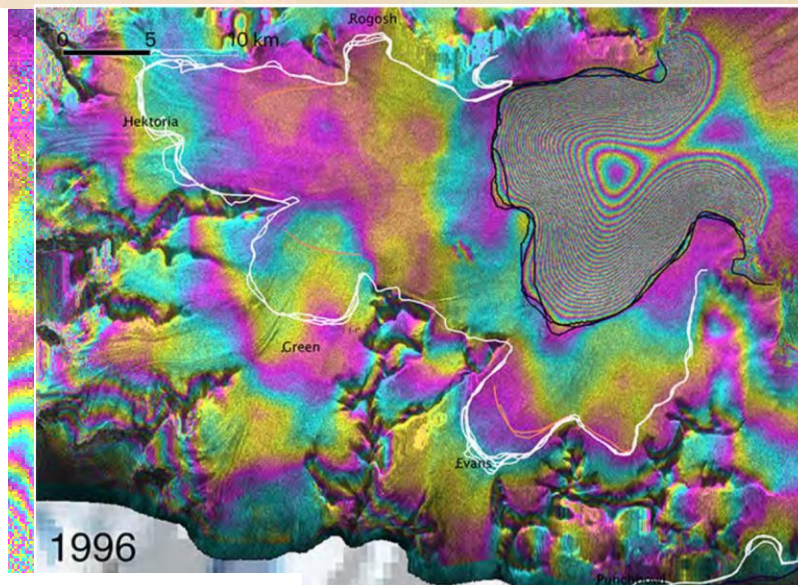
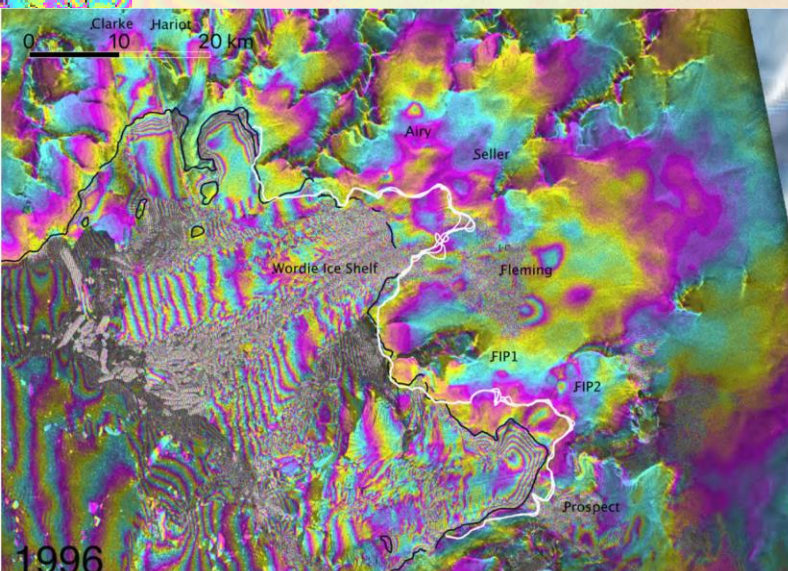


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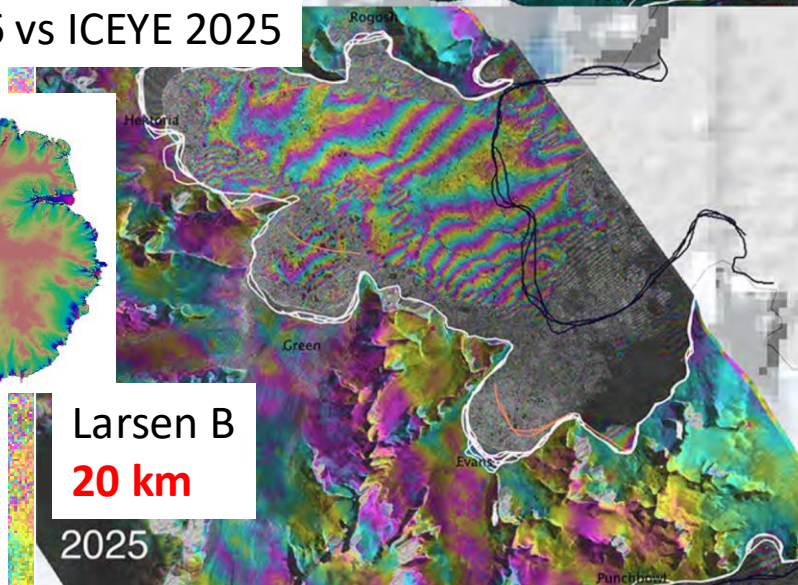
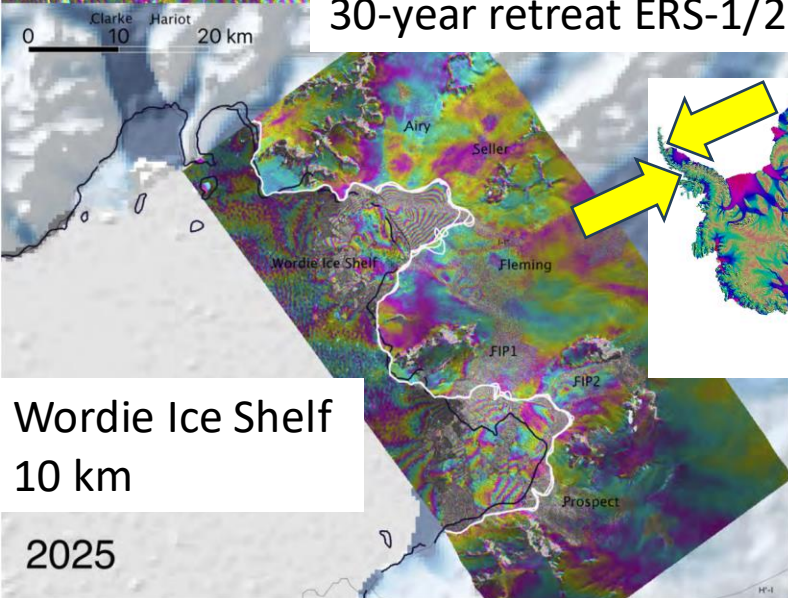




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30-year retreat ERS-1/2 1996 vs ICEYE 2025



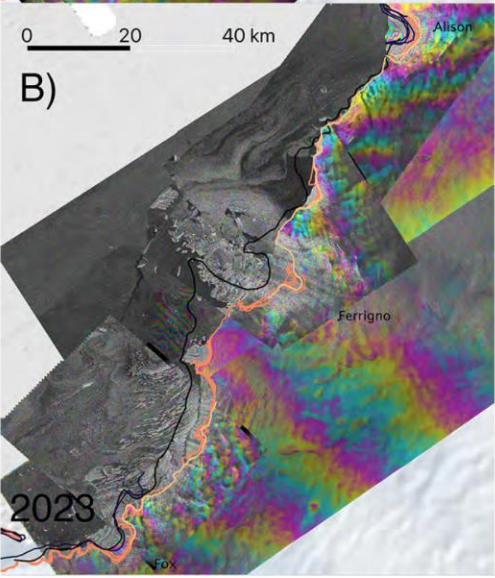
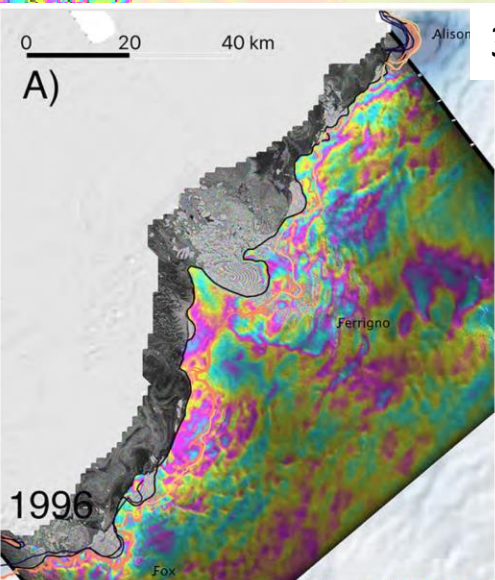
Wordie Ice Shelf
10 km
2025

Larsen B
20 km
2025

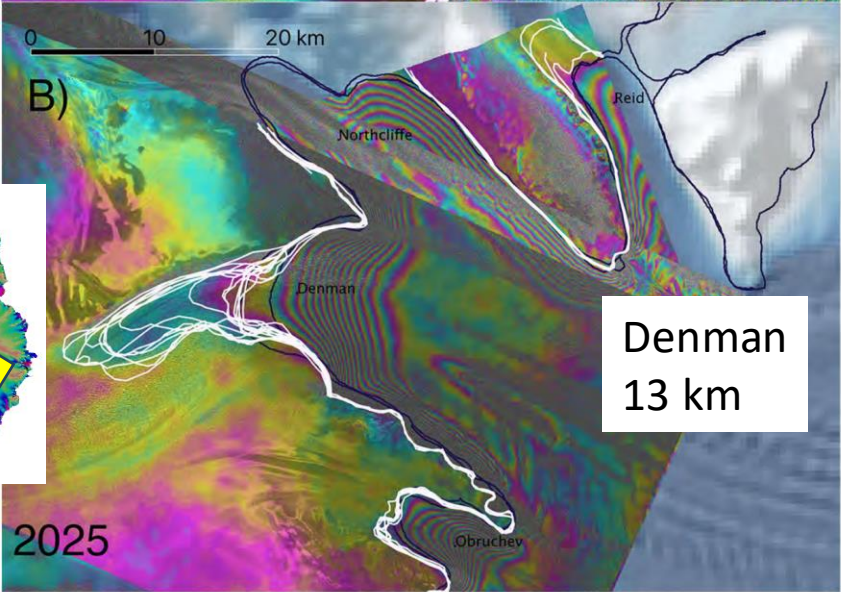
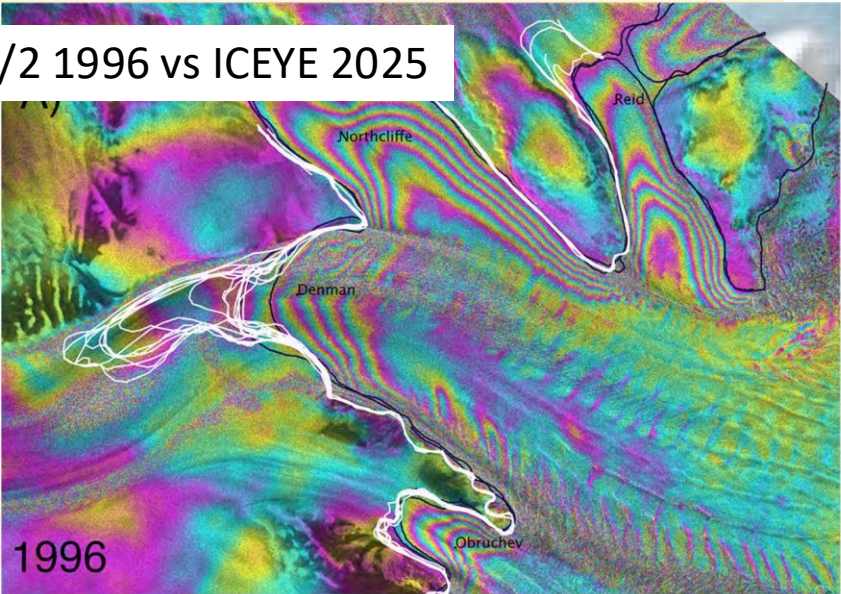
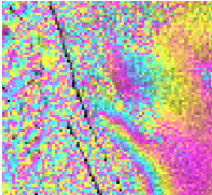
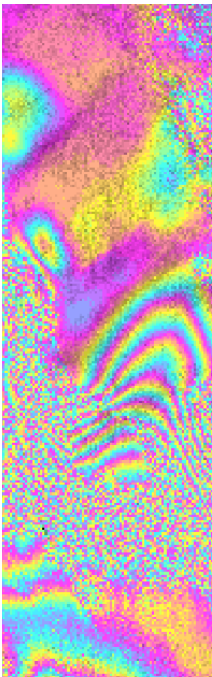
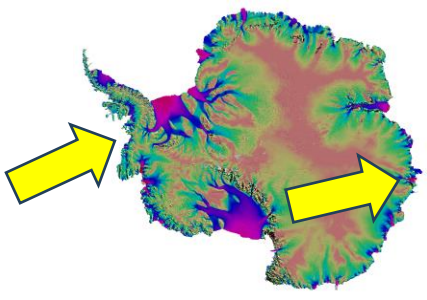


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30-year migration ERS-1/2 1996 vs ICEYE 2025



Ferrigno
8 km



Denman
13 km

Ferrigno ice streams, West Antarctica acquired by A) ERS-1 in 1992 from Track 038, Dates 1992/03/04-1992/03/07-1992/03/10
ADARSAT Constellation Mission (RCM) in 2023 from Track 080, Dates 2023/04/23-2023/04/27-2023/05/01, Track 077, Dates
21, Dates 2023/04/23-2023/04/27-2023/05/01, and the CosmoSkyMed (CSK) in 2020 from Track 111, Dates 2020/10/07-2020/10/08-
2020/10/02-2020/10/03-2020/11/03-2020/11/04, with GL positions in orange.

e DInSAR of Denman Glacier, East Antarctica acquired by A) ERS-1/2 in 1996 from Track 303, Dates 1996/03/11-1996/03/12-1996/02/05-1996/02/06,
in black (another GL position is from Track 303, Dates 1996/03/11-1996/03/12-1996/04/15-1996/04/16); B) by ICEYE in 2025 from Track 014, Dates
/01/24-2025/01/26-2025/01/27 with GL position in white (other GL positions from year 2025 are white).

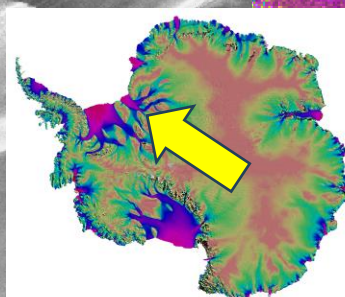
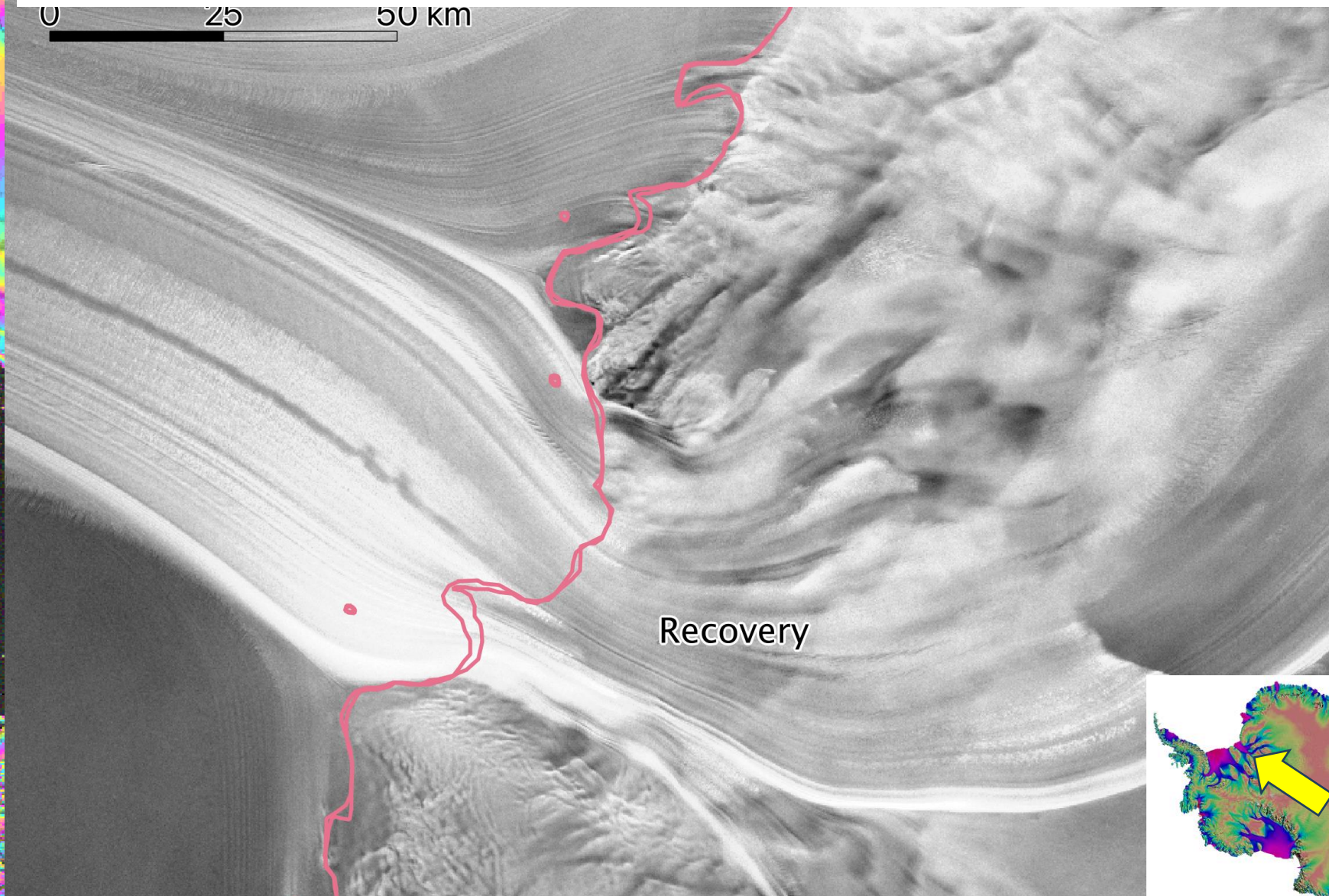


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Recovery Ice Stream GL: **never mapped with InSAR** (too far south, decorrelation, bad luck)

0 25 50 km





Early results w. NISAR, Sentinel-1c/d and ICEYE interferometric SARs in Antarctica

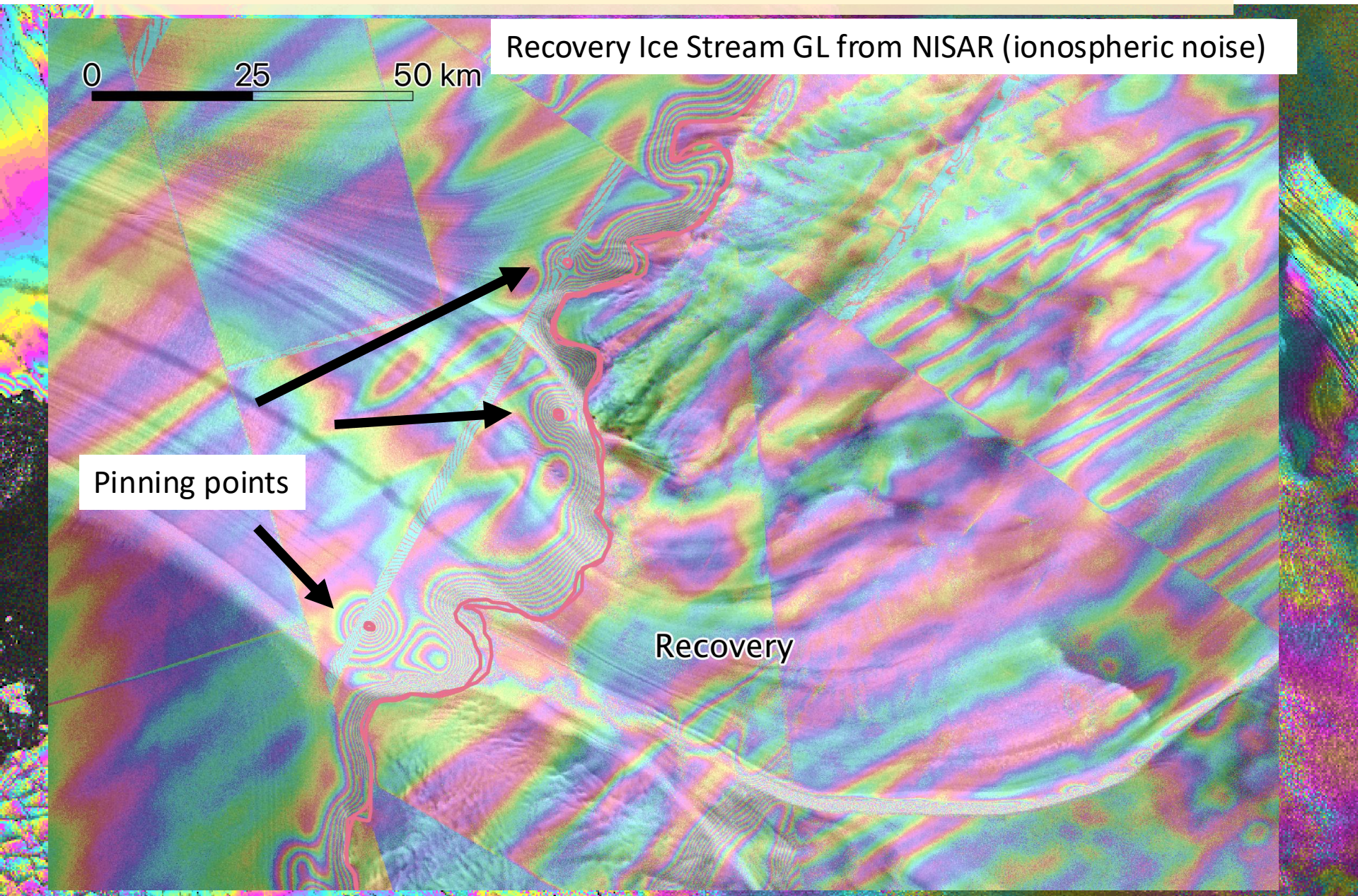


Recovery Ice Stream GL from NISAR (ionospheric noise)

0 25 50 km

Pinning points

Recovery

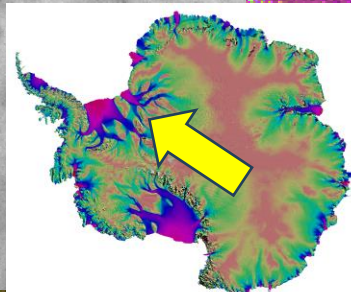
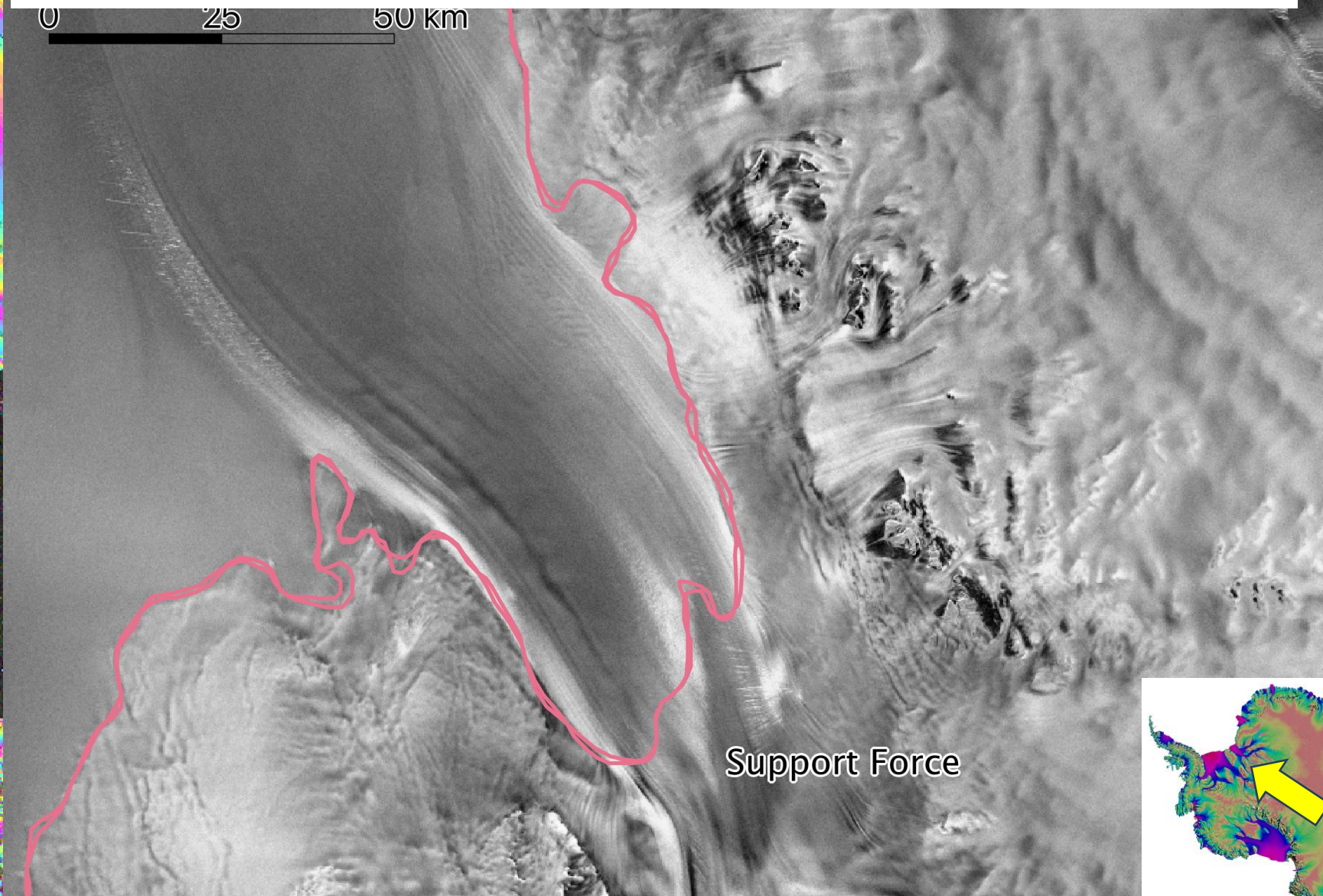




Early results w. NISAR, Sentinel-1c/d and ICEYE interferometric SARs in Antarctica

Support-Force Ice Stream GL: **never mapped** (too far south, decorrelation, bad luck)

0 25 50 km



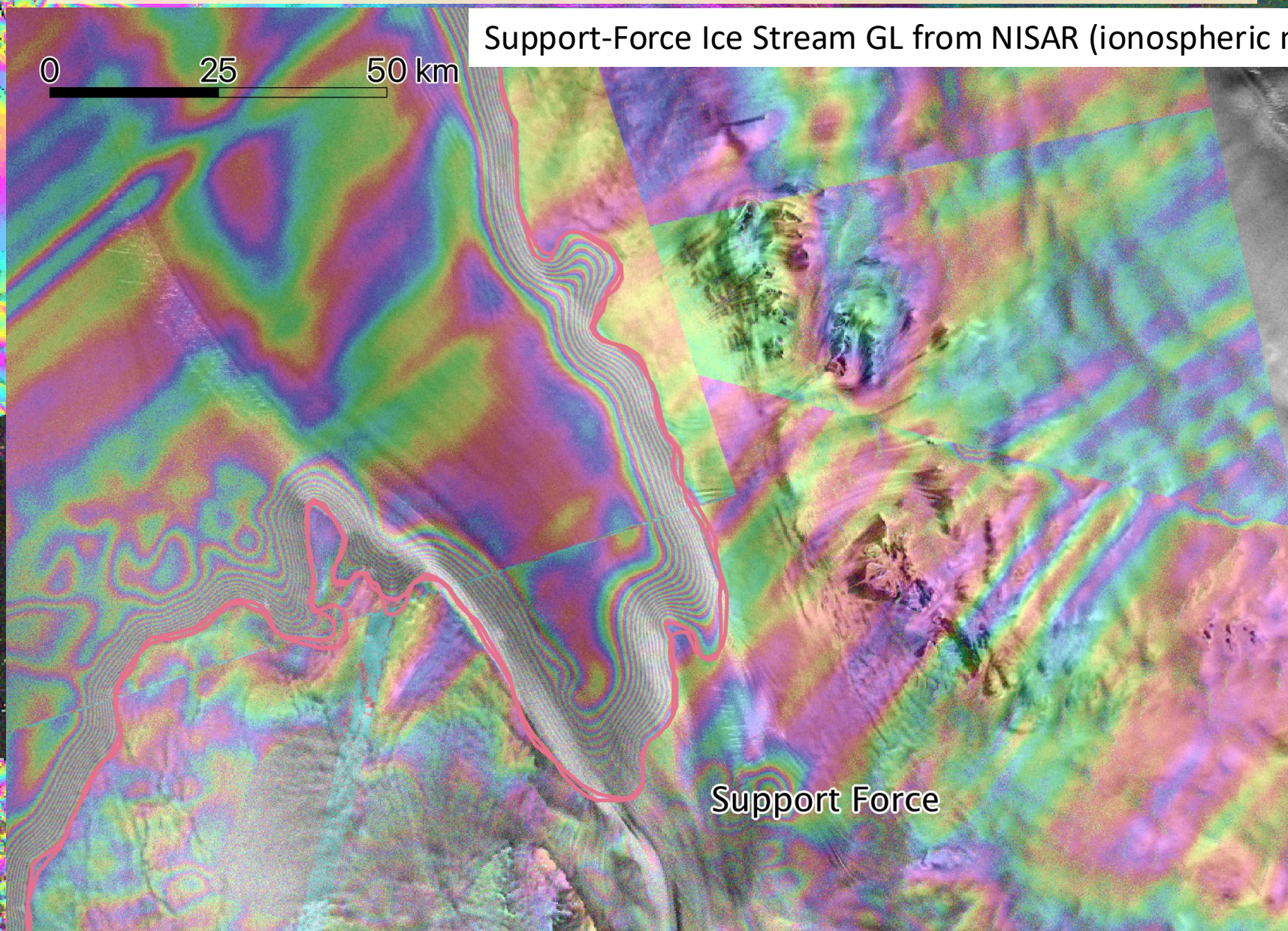


Early results w. NISAR, Sentinel-1c/d and ICEYE interferometric SARs in Antarctica



Support-Force Ice Stream GL from NISAR (ionospheric noise)

0 25 50 km



Support Force



Early results w. NISAR, Sentinel-1c/d and ICEYE interferometric SARs in Antarctica

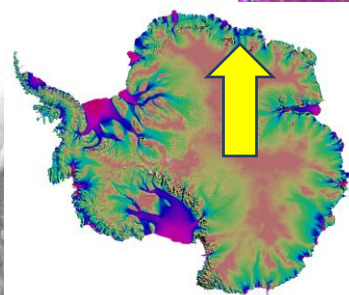


Roi Baudoin Ice Shelf from NISAR

0 20 40 km

NIT7 GNSS

Baudoin Ice S

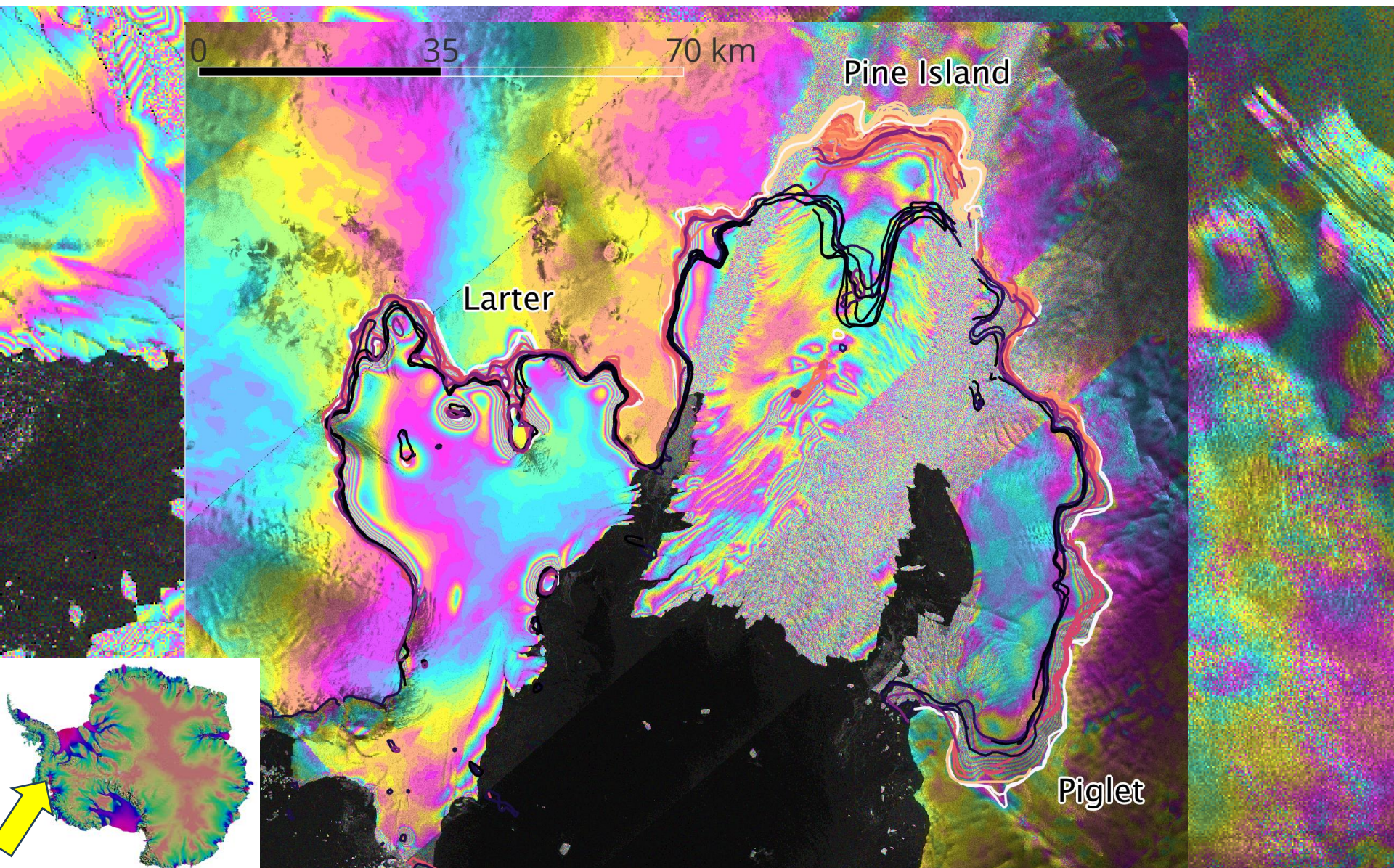




Early results w. NISAR, Sentinel-1c/d and ICEYE interferometric SARs in Antarctica



Largest contributors to sea level: No GL with 12-/6-day repeat; but GL with 1-day repeat

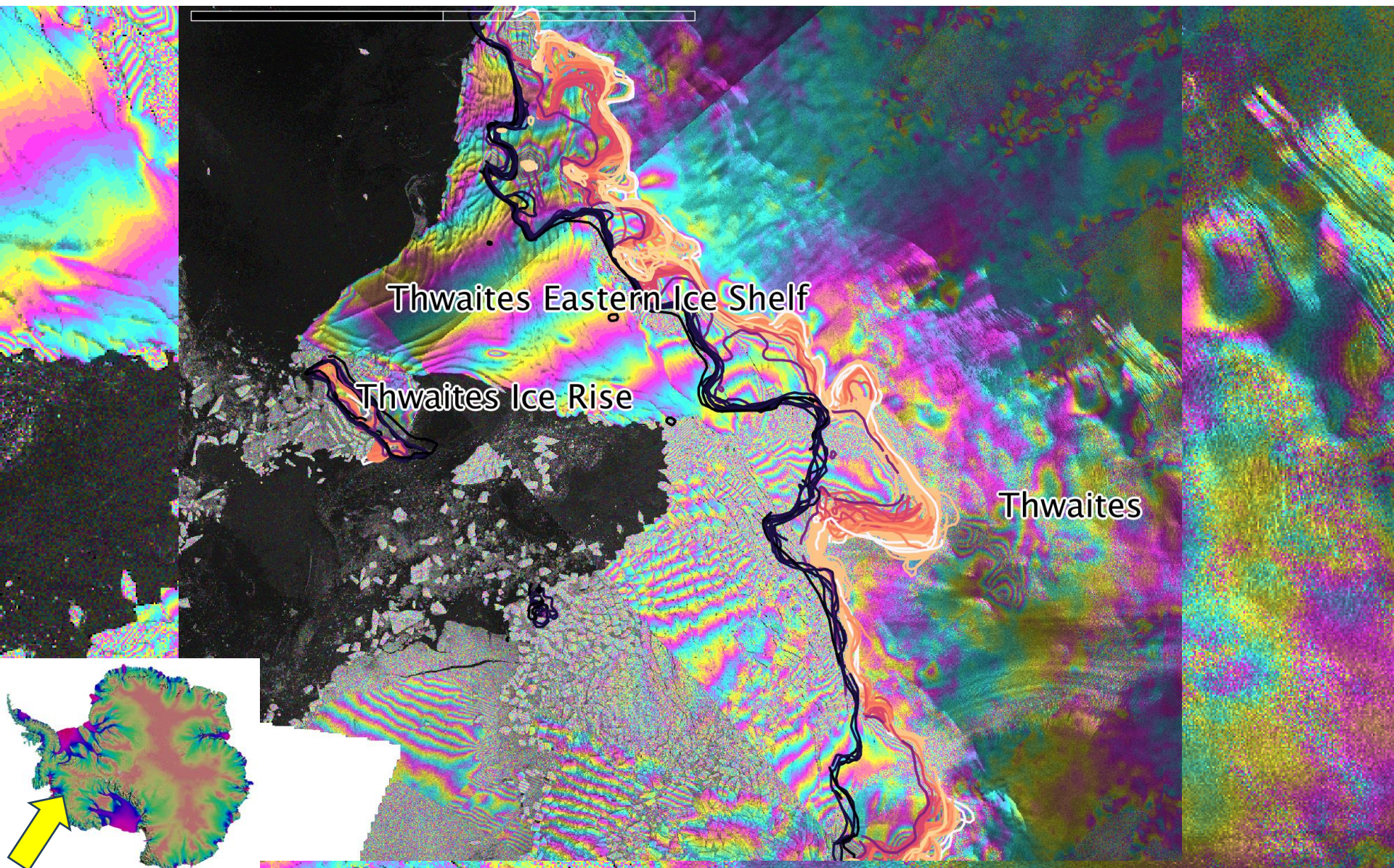




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Largest contributors to sea level: No GL with 12-/6-day repeat; but GL with 1-day repeat

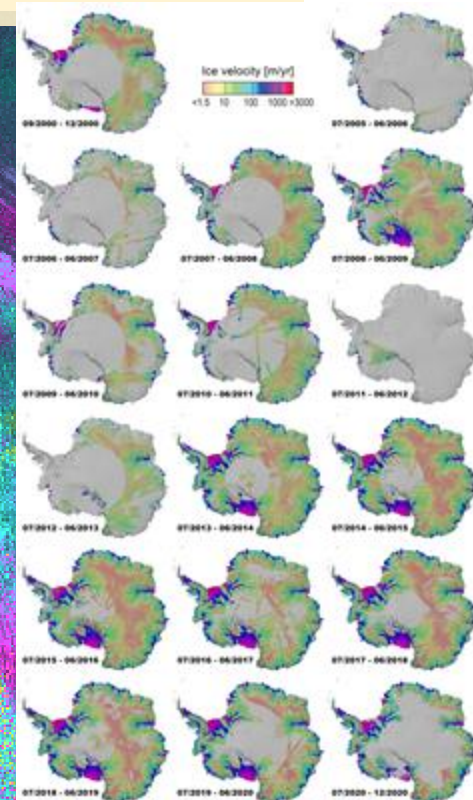




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- **Annual maps of ice velocity mosaics (2000-2025)** from MEaSUREs-4 (to be discontinued and replaced)
<https://nsidc.org/data/nsidc-0720/versions/1>
- **Multi-year reference velocity mosaics:** 1 July 1995 to 30 June 2001; 1 July 2007 to 30 June 2009; 1 July 2014 to 30 June 2017; 1 July 2020 to 30 June 2022 <https://nsidc.org/data/nsidc-0761/versions/1>
- **Monthly velocity maps:** 2015-2025 to be released. **New in 2026.**



Ice velocities (ref/annual):

<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>

Grounding lines/zones:

<https://nsidc.org/data/NSIDC-0498>
<https://nsidc.org/data/NSIDC-0778>

Multi-year mosaics:

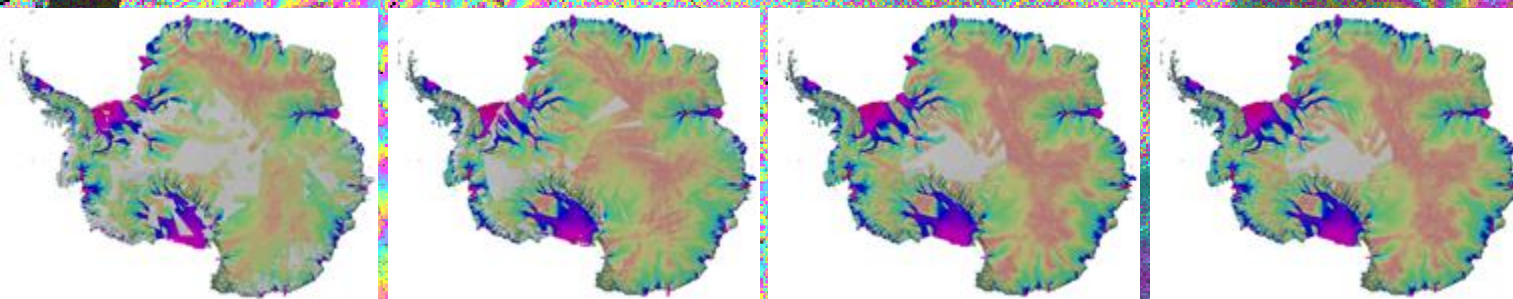
<https://nsidc.org/data/NSIDC-0761>

Boundaries:

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

Bedmachine Antarctica:

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





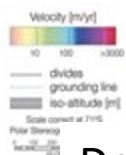
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Version 3.0 phase-only velocity map will include NISAR data, i.e. 10 x times more precise across Version 2.0 with than speckle tracking.

Ice Velocity and Grounding Line in Antarctica

International
Coordination:
PSTG

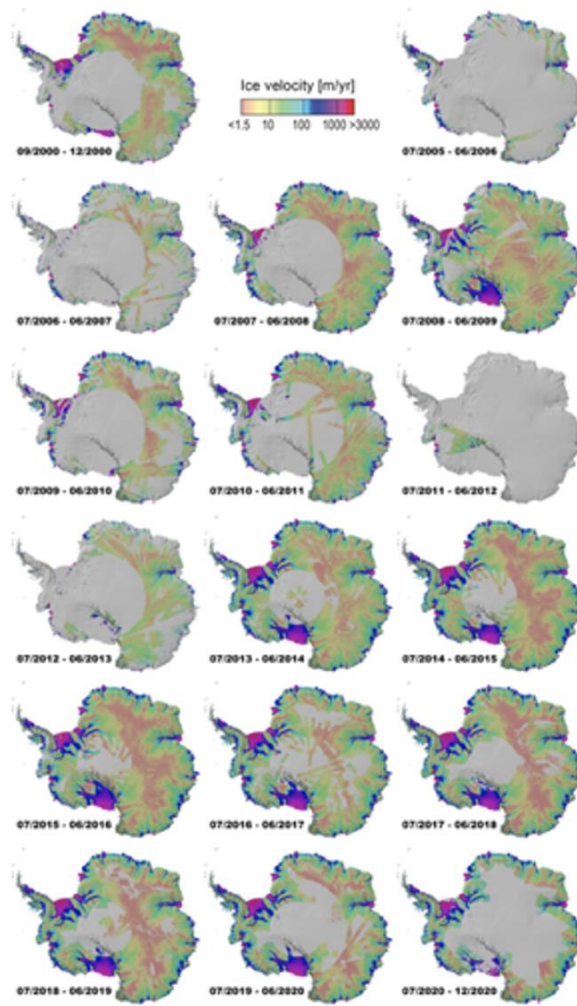


Denman

13 km

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

Funding:
NASA MEaSUREs

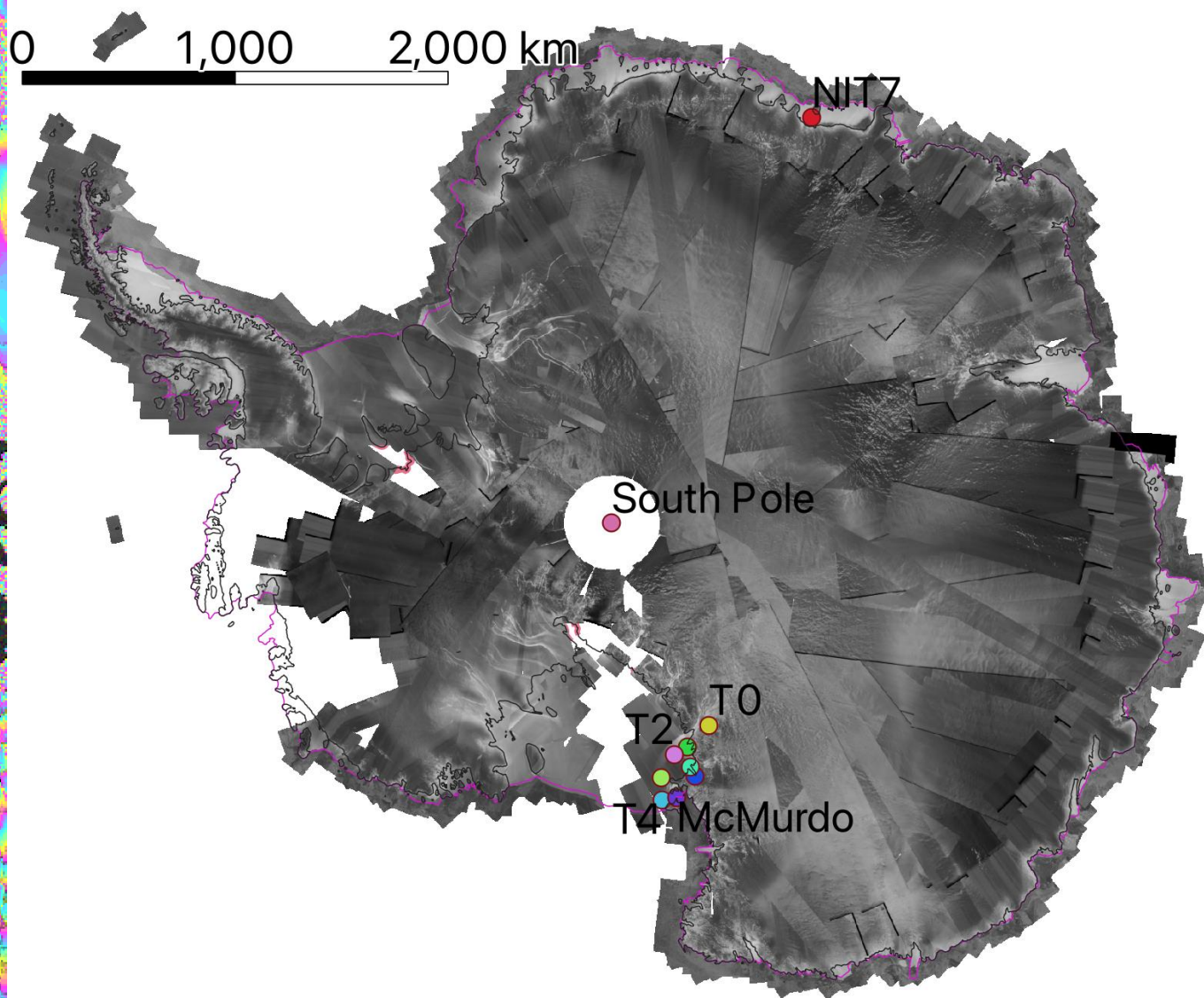




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Amplitude mosaic; cycle 018 (late April); NISAR L-band data; Processor 5012

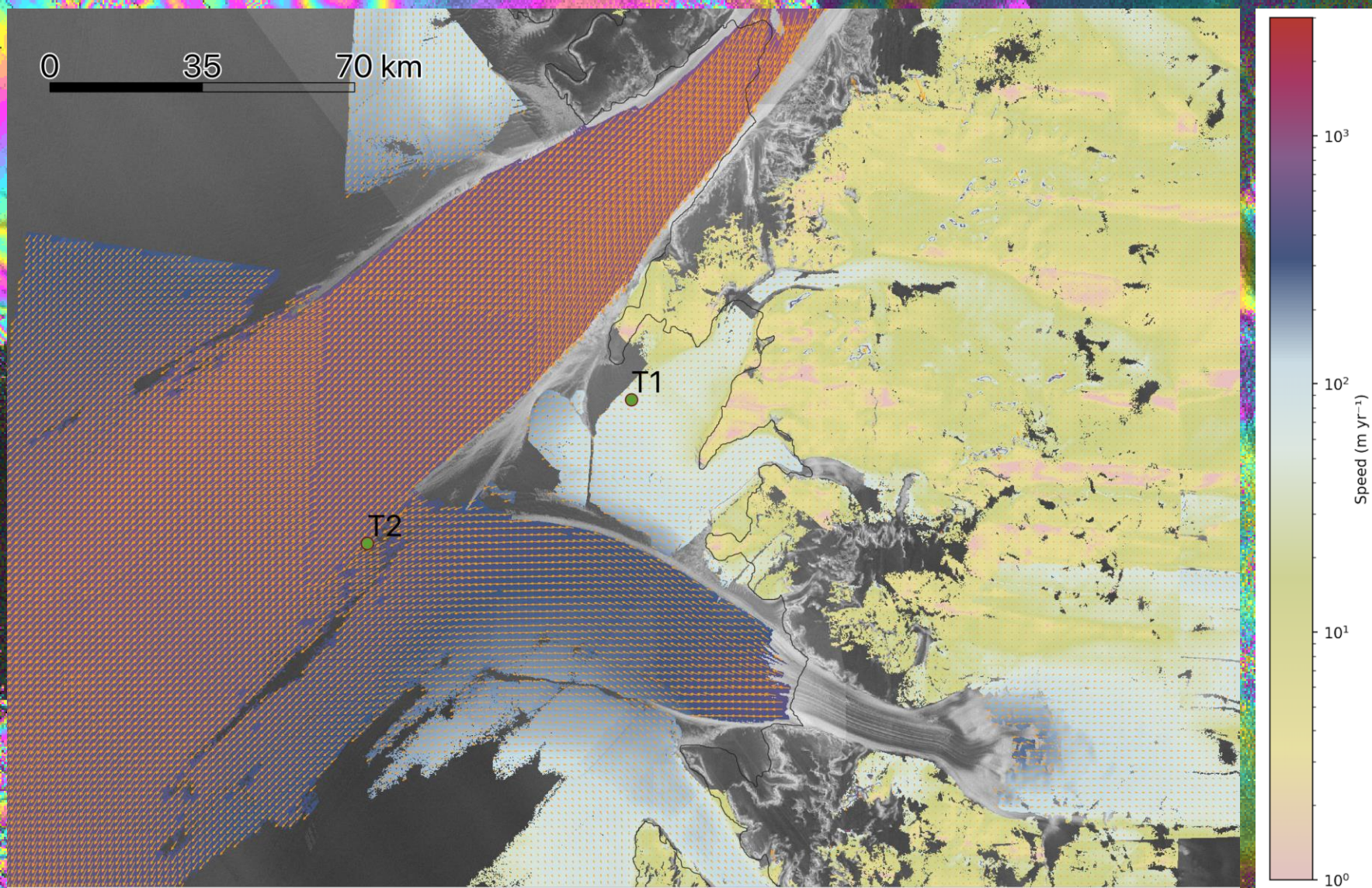




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Byrd Glacier, East Antarctica 80.3° S; 2D phase velocity from NISAR asc/desc pair



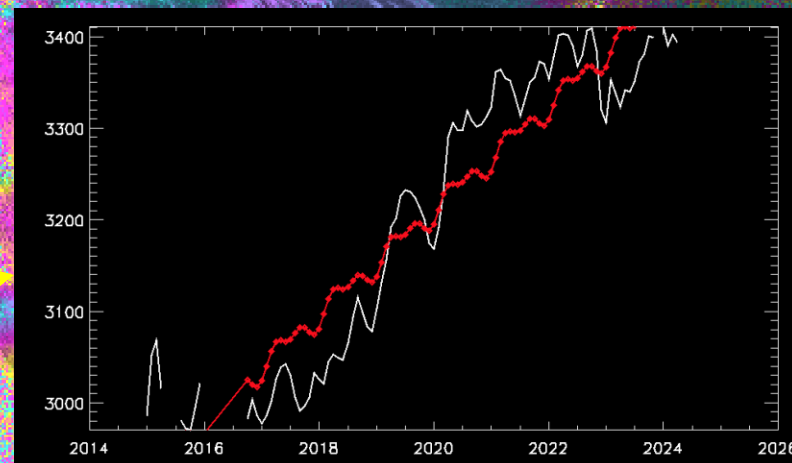


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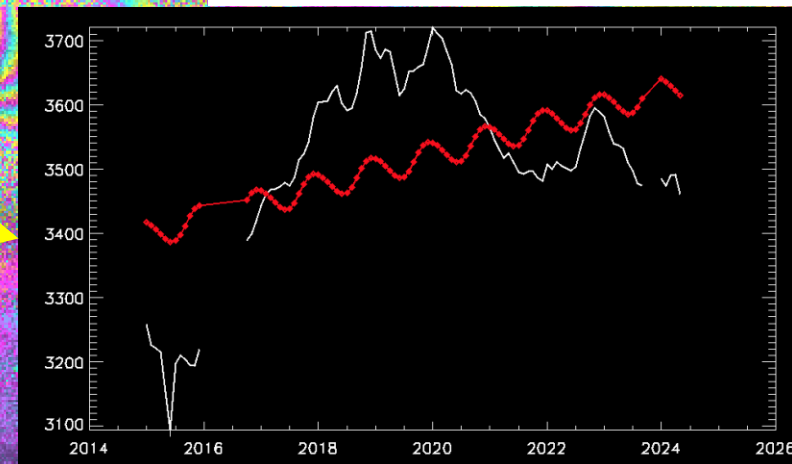


Monthly product

Some seasonal variability

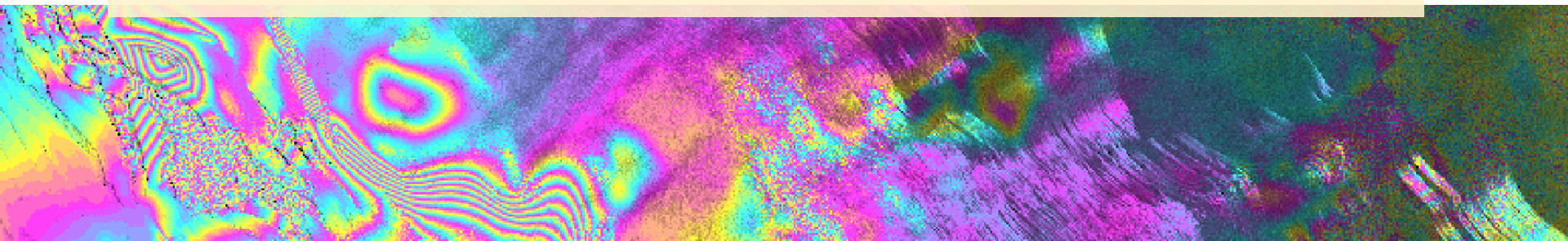


Mostly interannual variability

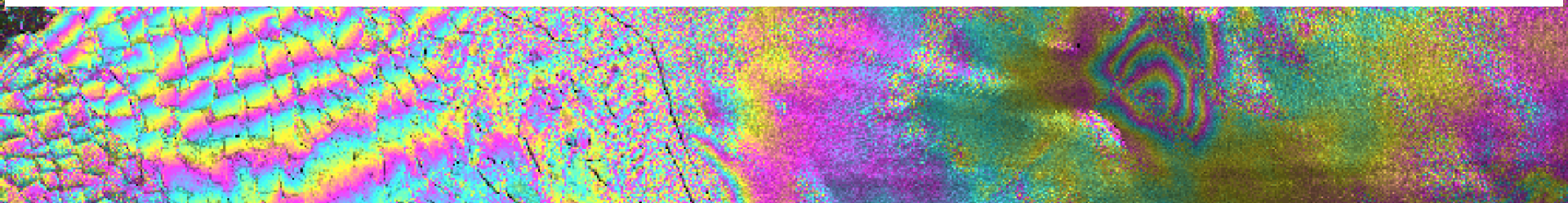




Early results w. NISAR, Sentinel-1c/d and ICEYE interferometric SARs in Antarctica



- Antarctica lost 442 sq km of continental ice per year in 1992-2025.
- 70% of the coastline is remarkably stable.
- Sentinel-1 1-day repeat great for GL mapping and phase unwrapping of fast glaciers.
- ICEYE provides essential information on the fastest moving/retreating glaciers (Peninsula, WAIS) at a daily repeat to reveal km-size seawater intrusions.
- NISAR provides continent-wide coverage and already unveiled never-mapped before GL.
- NISAR+S1+ICEYE+others will provide a phase-only coverage of Antarctica, which will be 10 x times more accurate than ever produced with speckle tracking.
- Monthly phase-only data will help unveil short term variability in velocity and its relationship with forcing like never before.





Early results w. NISAR, Sentinel-1c/d and ICEYE interferometric SARs in Antarctica



Thank you

Thwaites GL in 2026 from Sentinel-1 1-day repeat