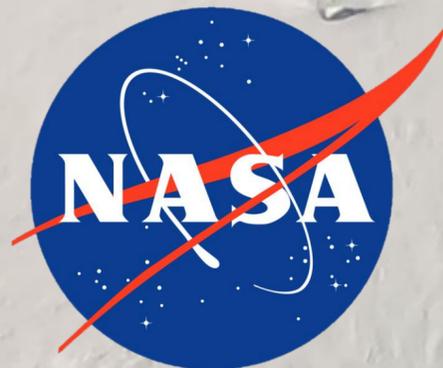
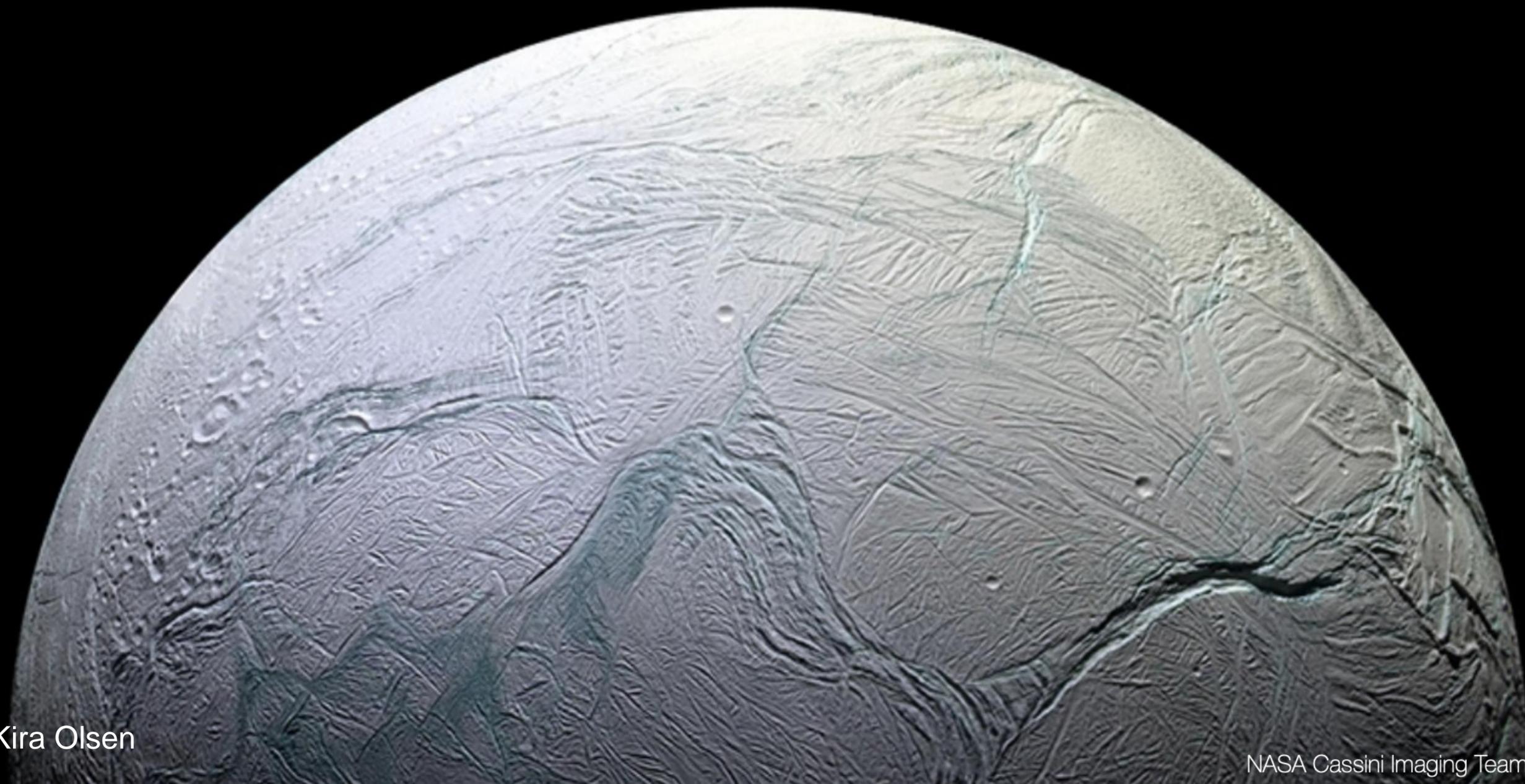


Deformation of a Ross Ice Shelf Rift measured through GPS and Seismic Observations



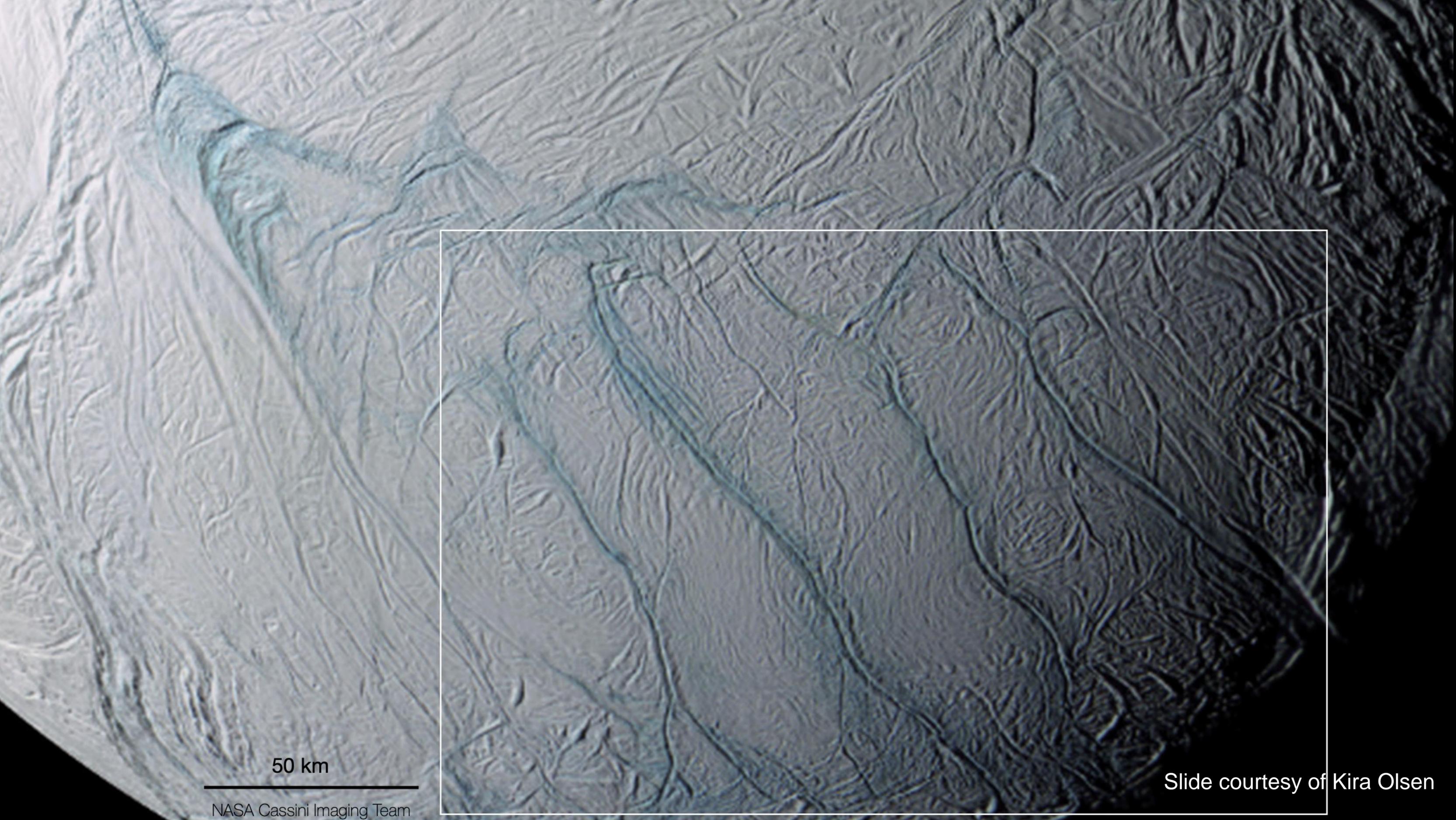
Mong-Han Huang
University of Maryland, College Park





Slide courtesy of Kira Olsen

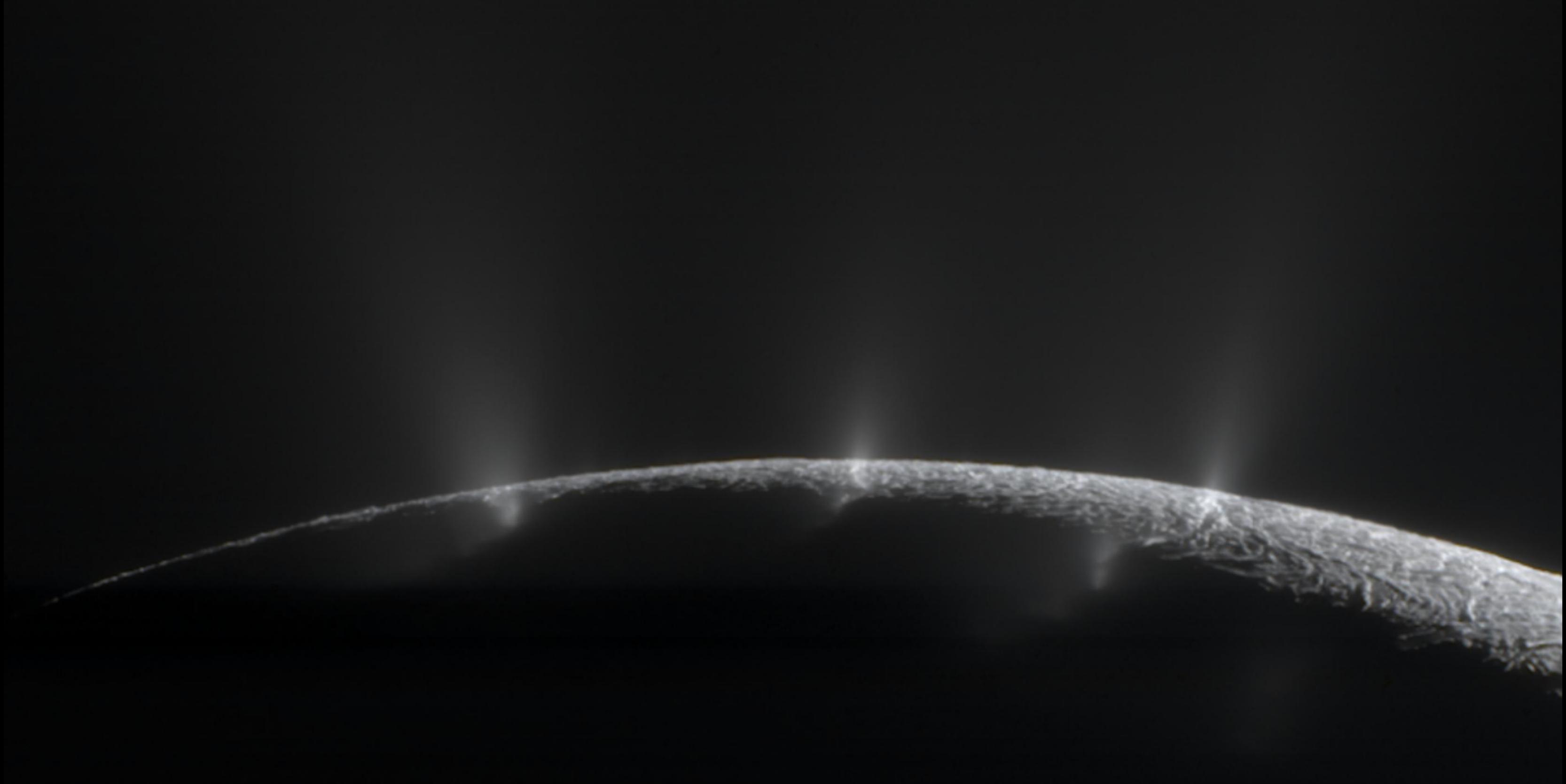
NASA Cassini Imaging Team



50 km

NASA Cassini Imaging Team

Slide courtesy of Kira Olsen

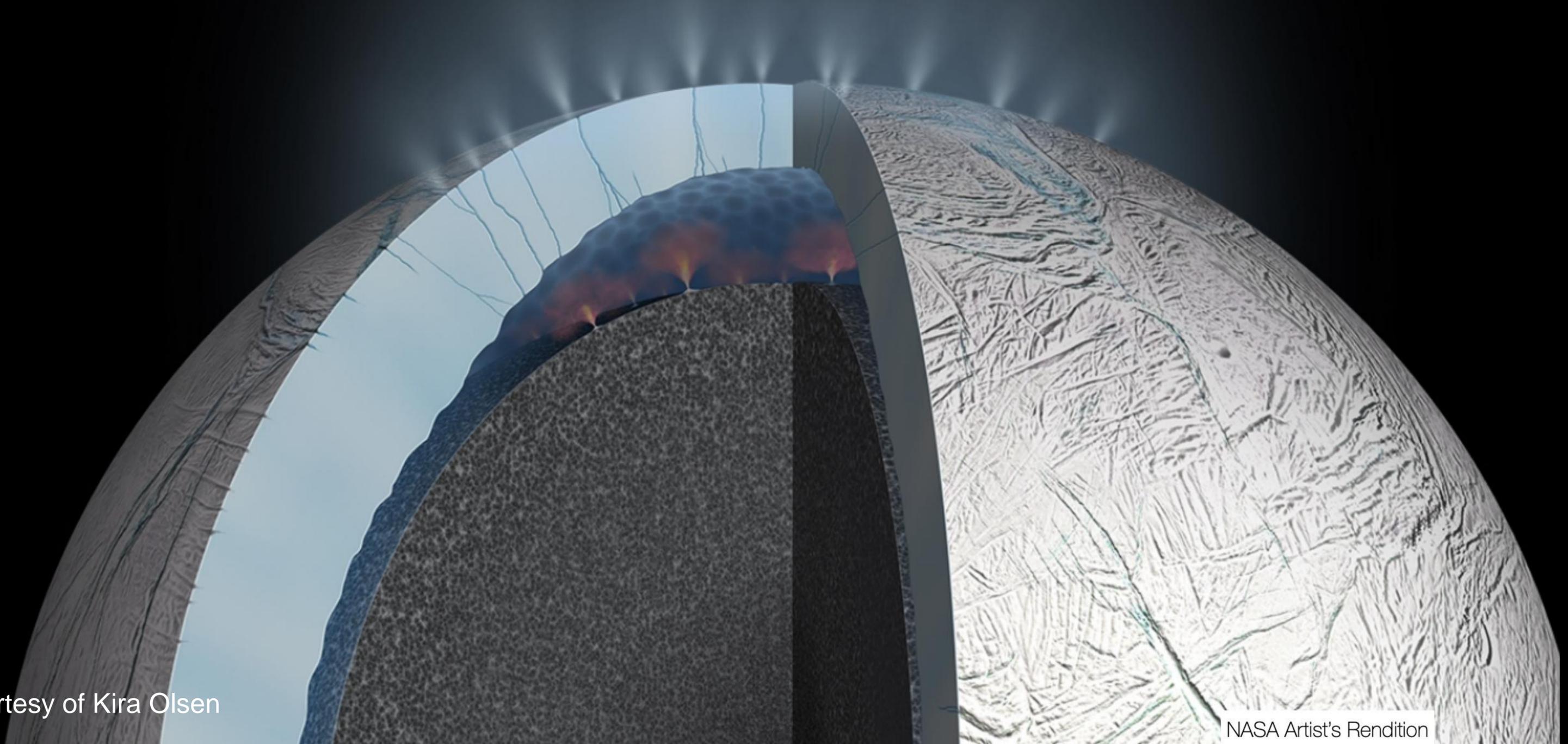


Slide courtesy of Kira Olsen

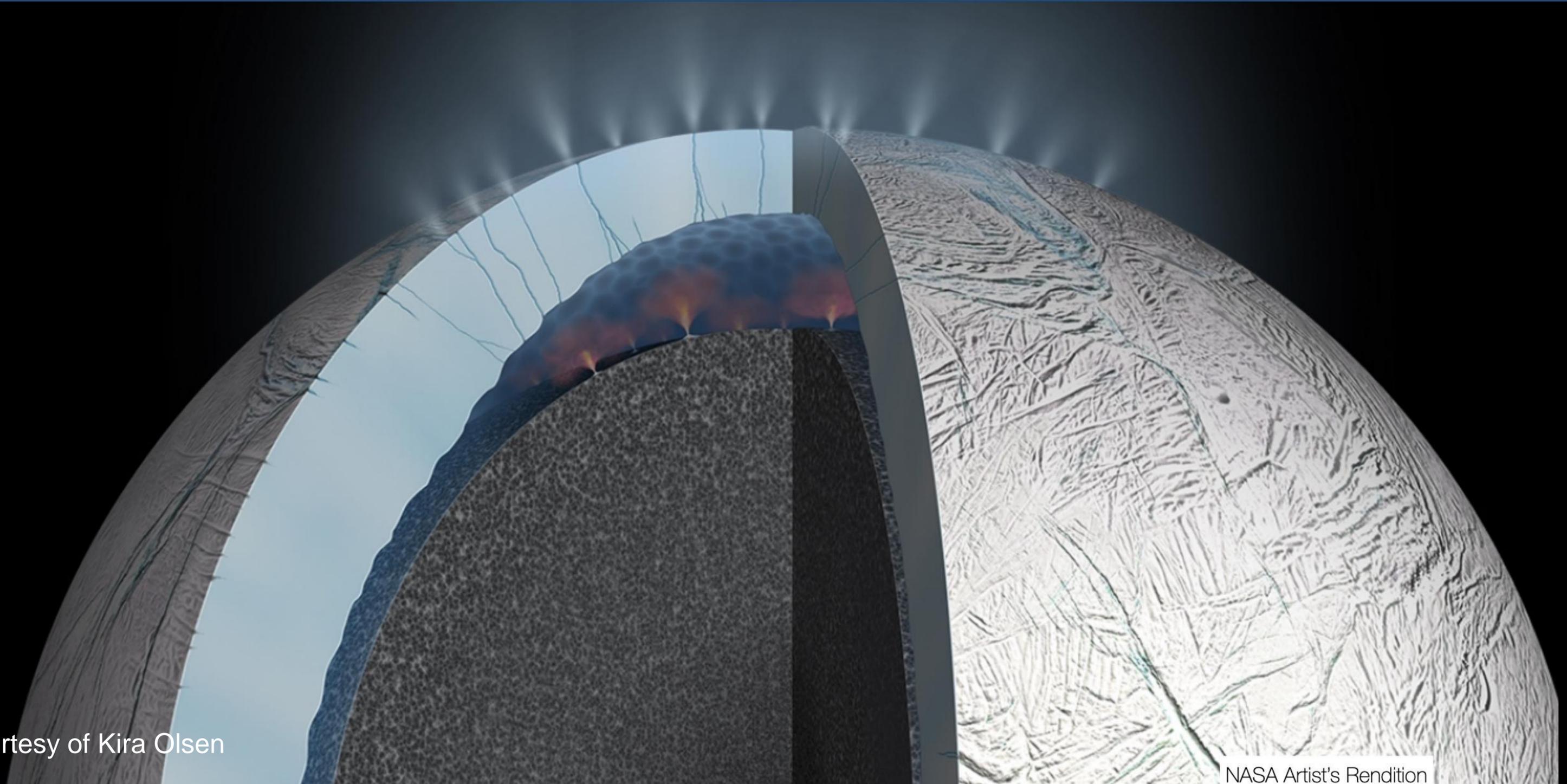
NASA Cassini Imaging Team

What is the **interior** structure?

Do fractures **span the full thickness** of the icy shell?



Seismic investigation will be
the way
future landed missions to **icy worlds**
answer these questions



Slide courtesy of Kira Olsen

NASA Artist's Rendition

Earth's Ross Ice Shelf as an analog



Credit: Josh Landis/NSF

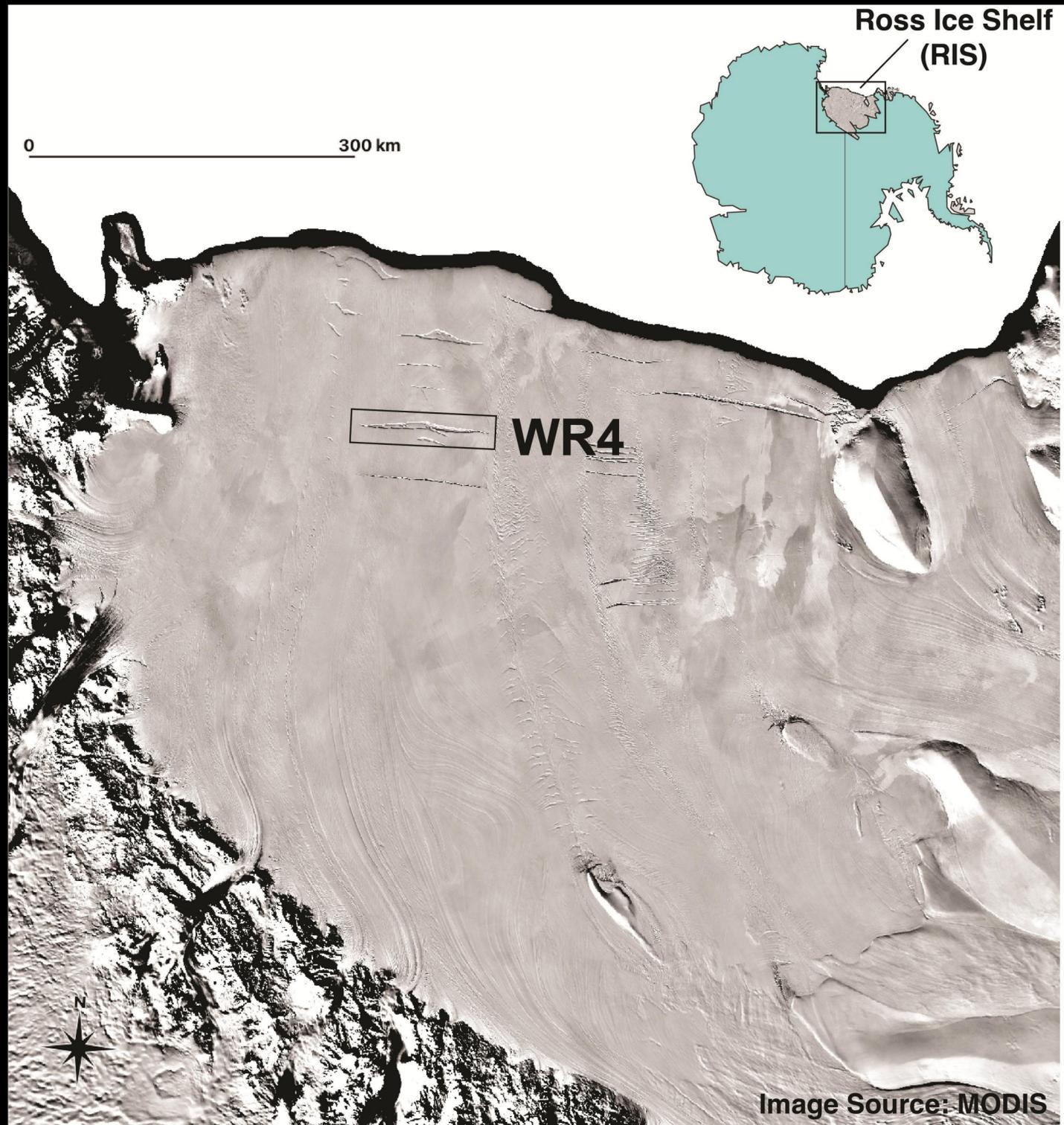
Antarctic Rift Research for Ocean Worlds

ARROW

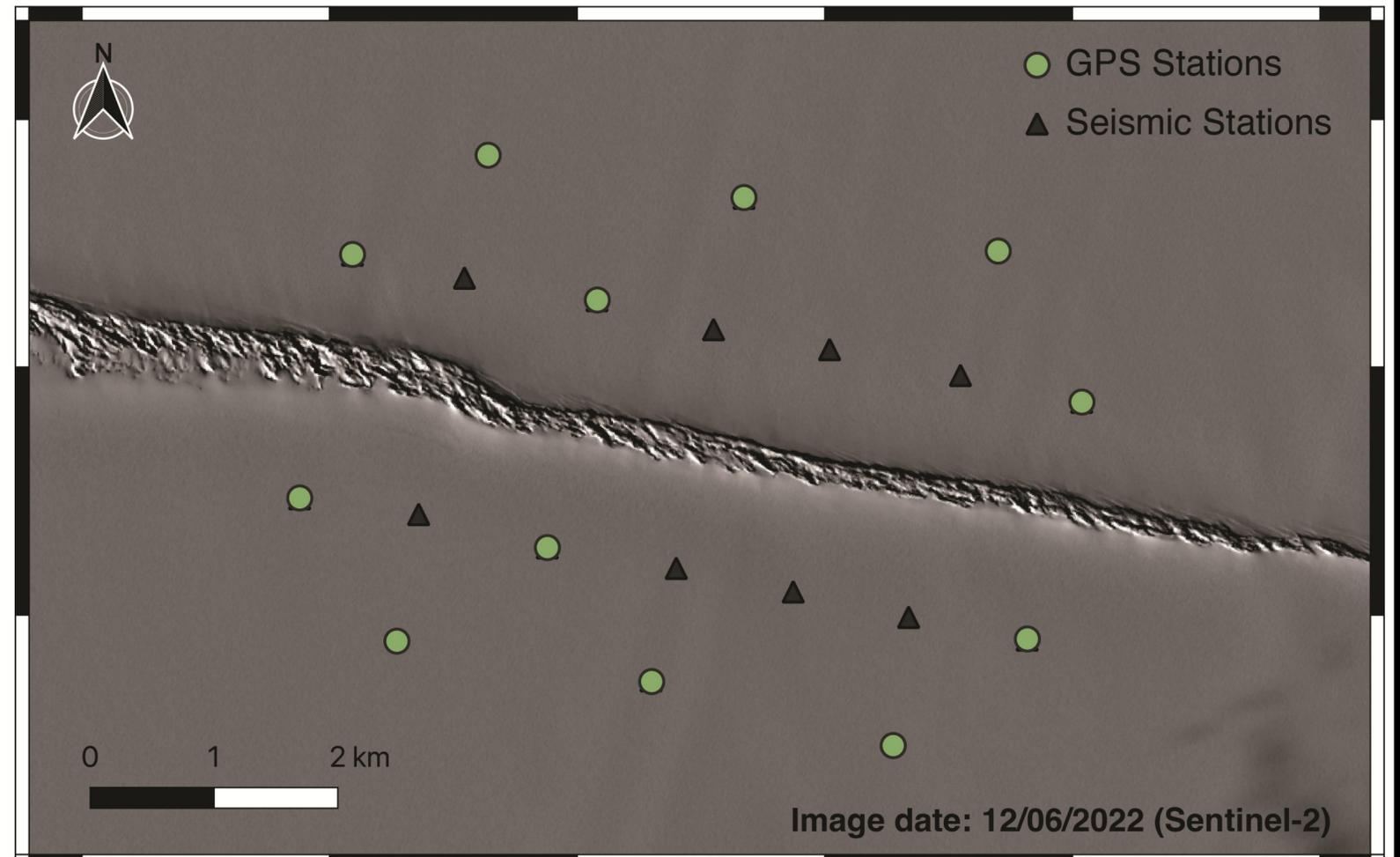
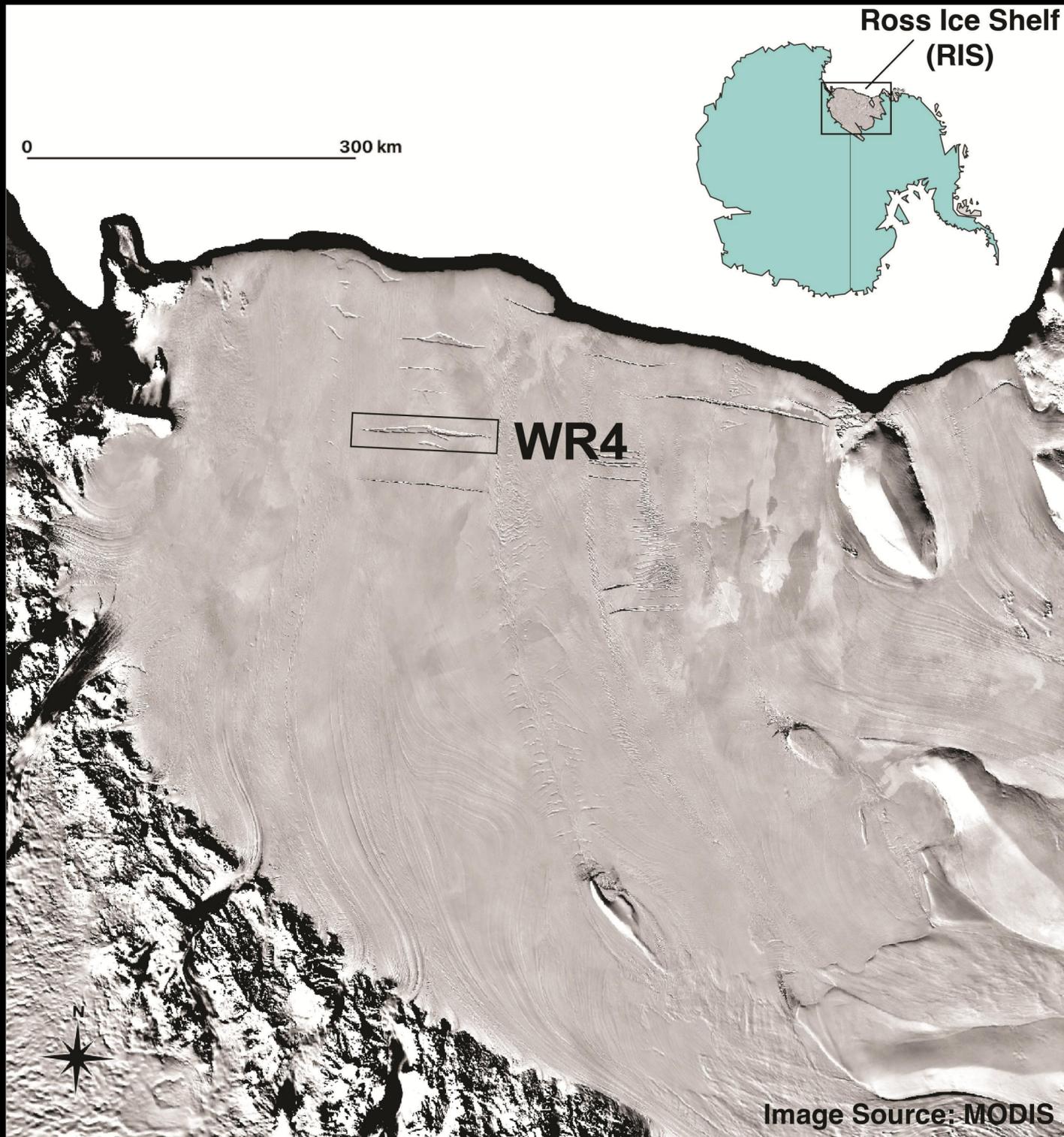
- Terry Hurford (NASA Goddard)
- Nicholas Schmerr (UMD)
- Kelly Brunt (NSF/NASA Goddard/UMD)
- Alyssa Rhoden (SwRI)
- Mong-Han Huang (UMD)
- Kathrine Udell Lopez (UMD)
- Kira Olsen (NASA Goddard/UMD)
- Emily Harkleroad, Simon Eisl, and Zoe Schlossnagle (Undergrads)
- Kat Dapr  (Postdoc)



The Setting

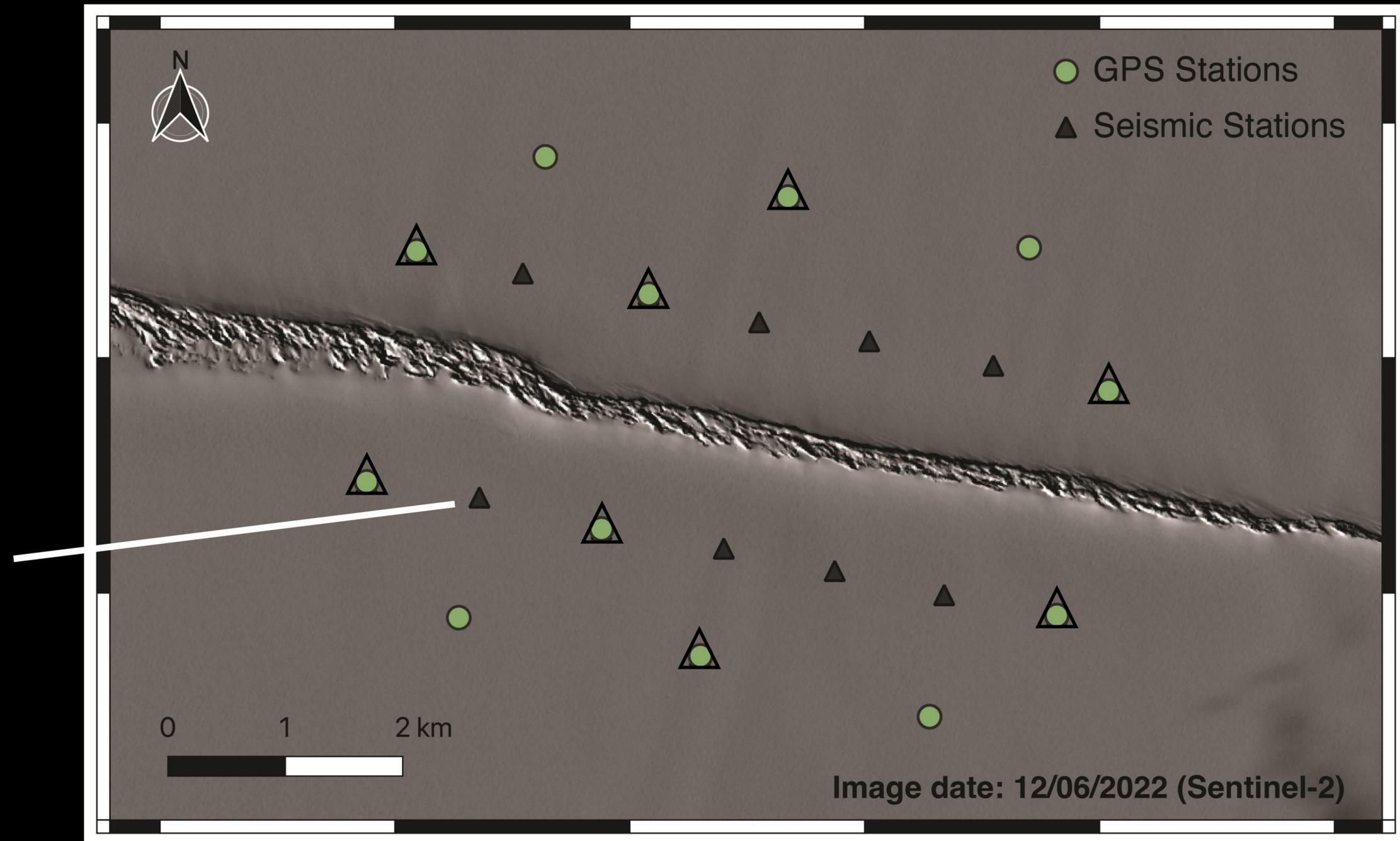


The Setting



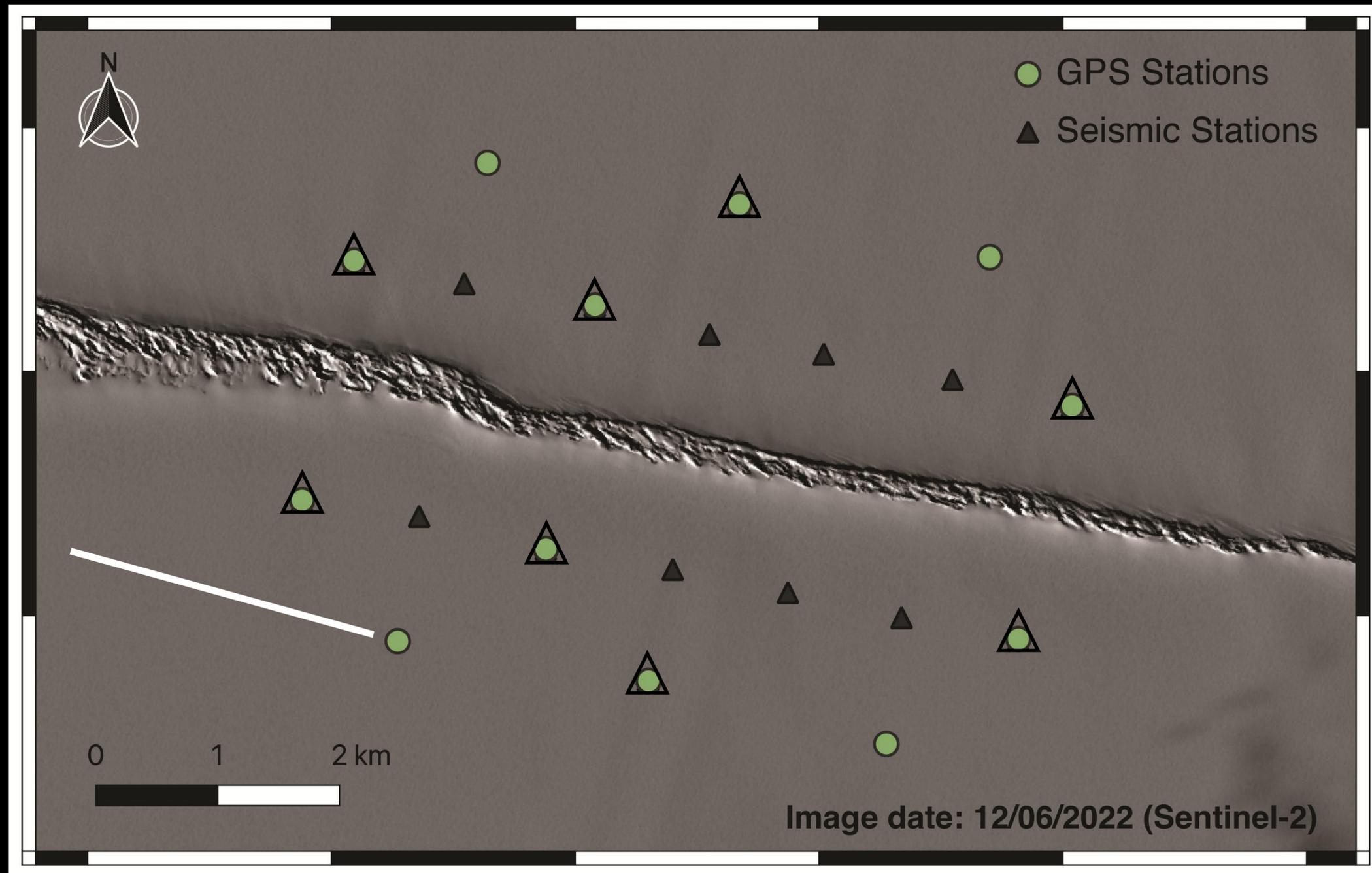
Our Deployment

- 16 seismic stations



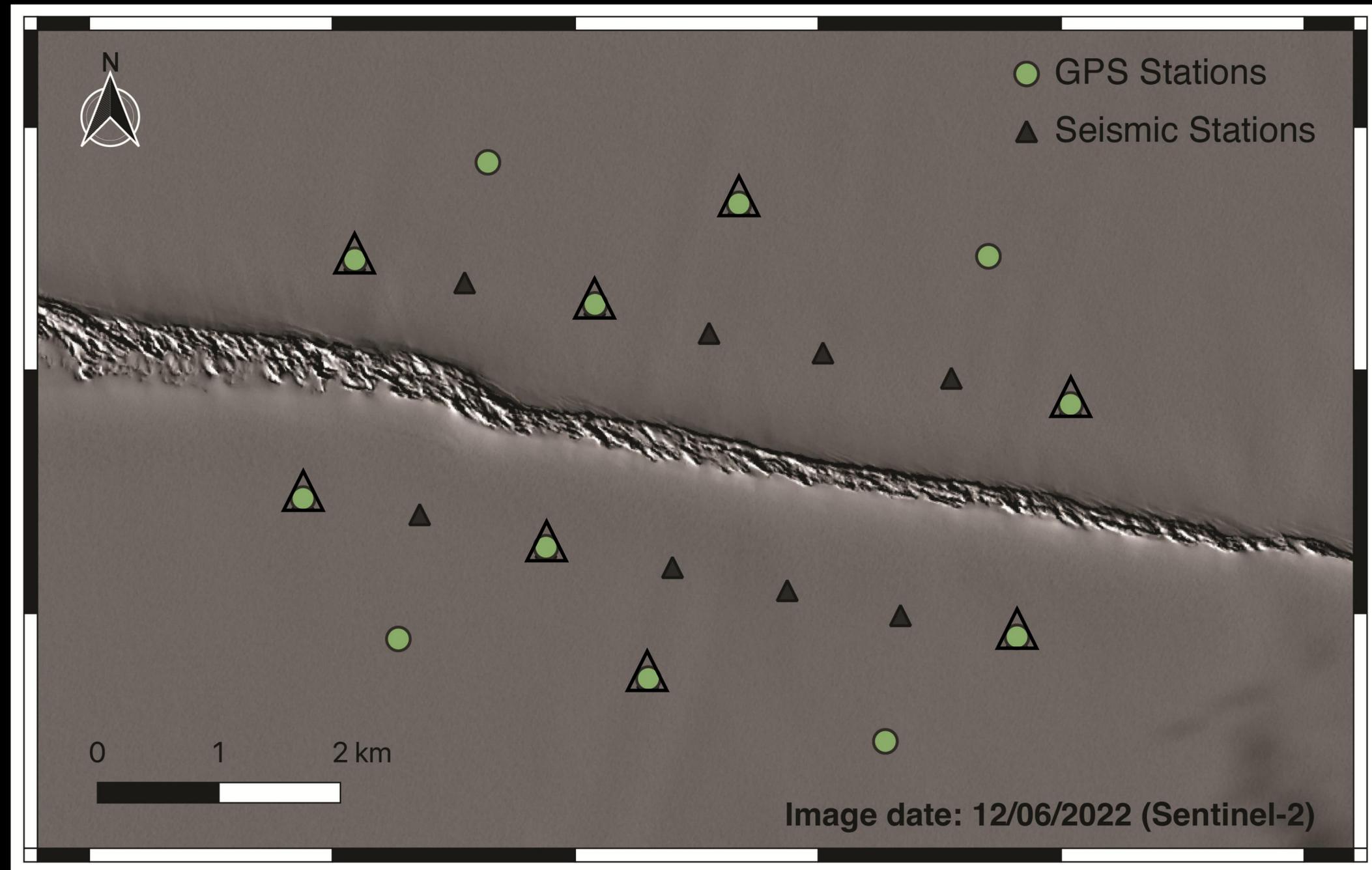
Our Deployment

- 16 seismic stations
- 12 GPS stations



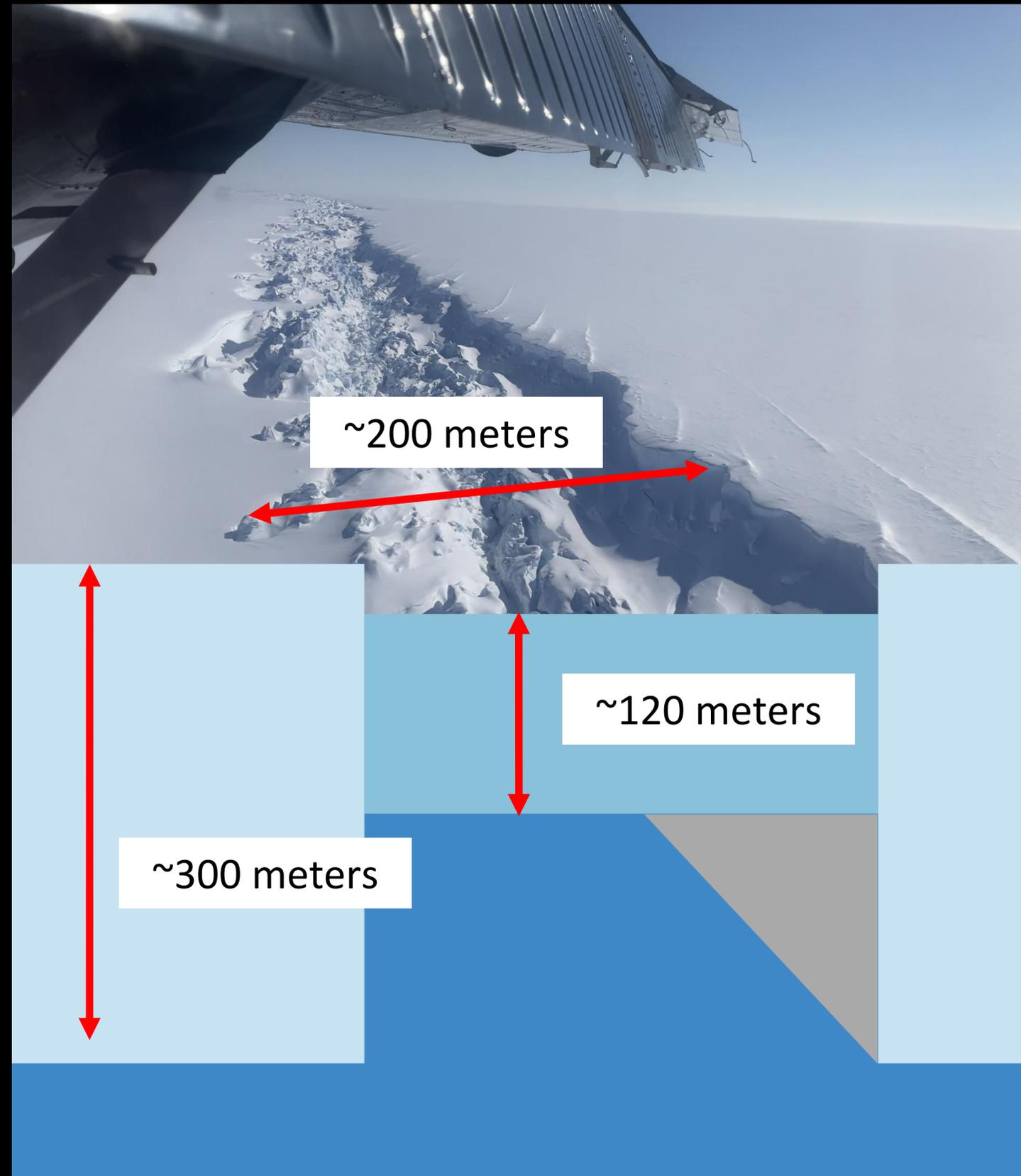
Our Deployment

- 16 seismic stations
- 12 GPS stations
- 5 active source lines

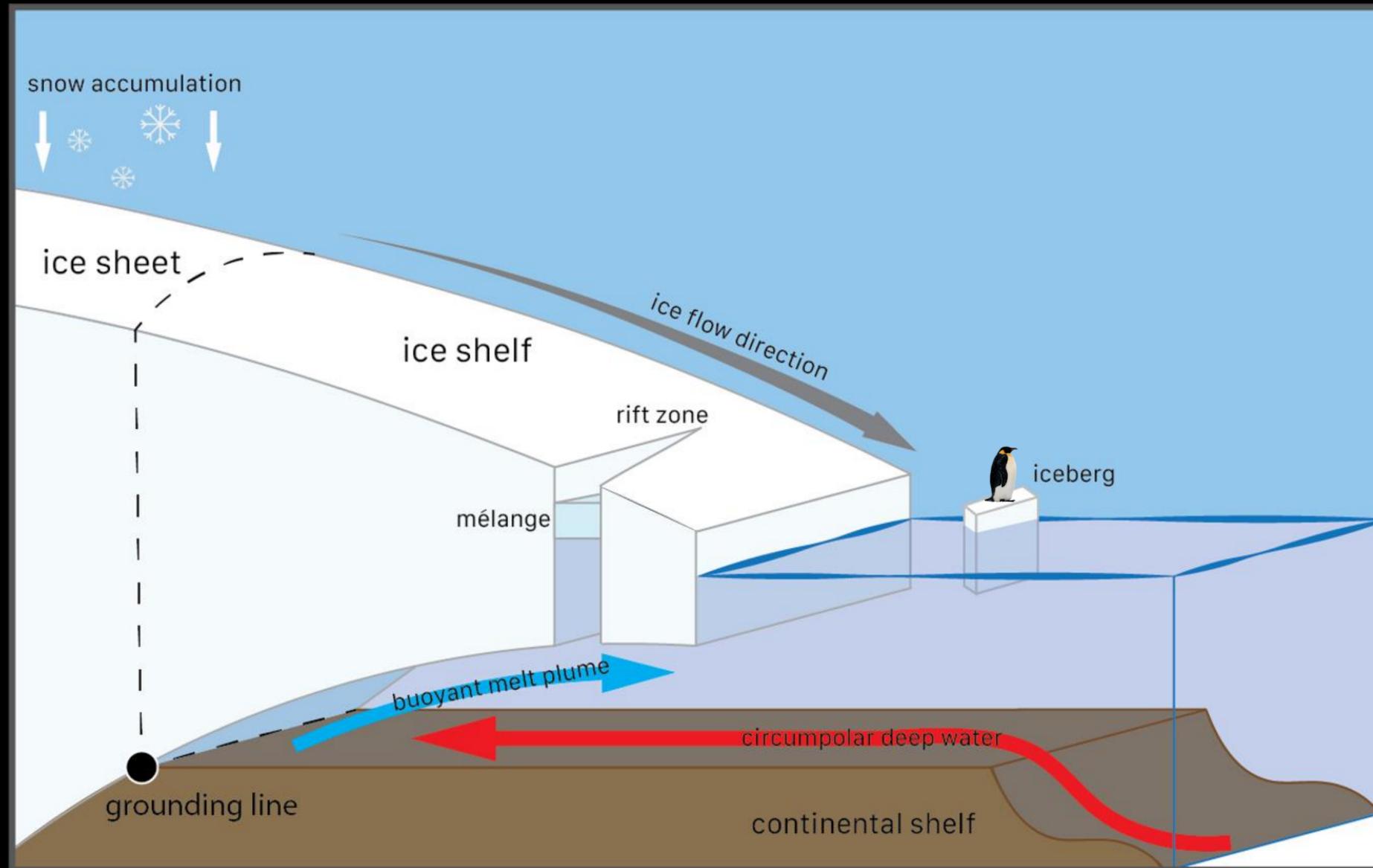


Our Deployment

- 16 seismic stations
- 12 GPS stations
- 5 active source lines
- ~30-day seismic record
- ~40-day GPS record



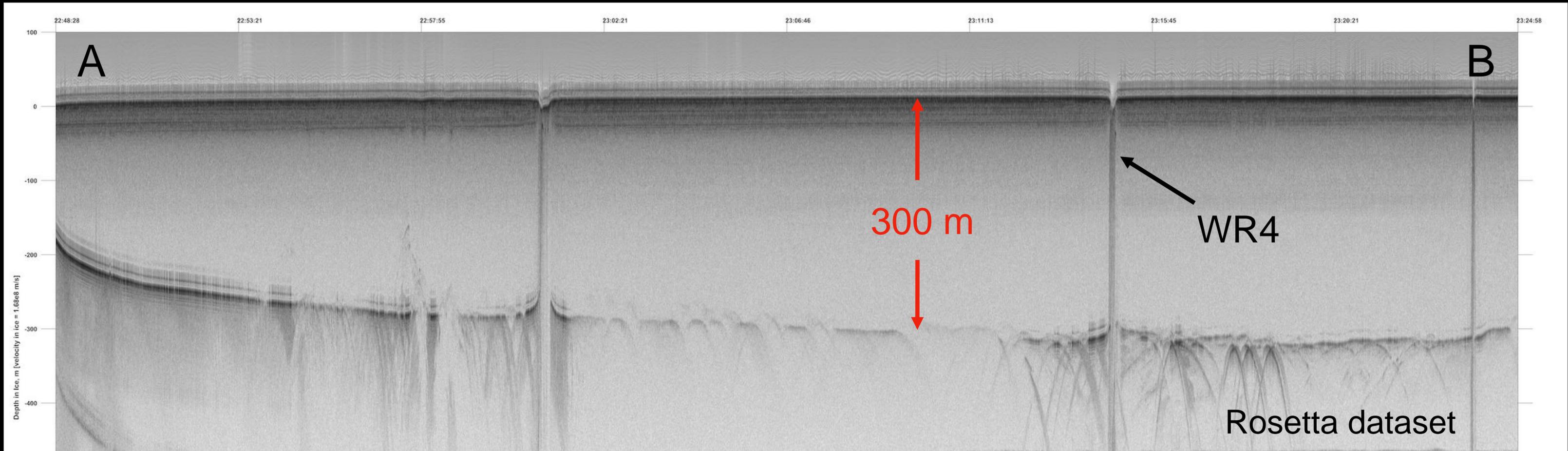
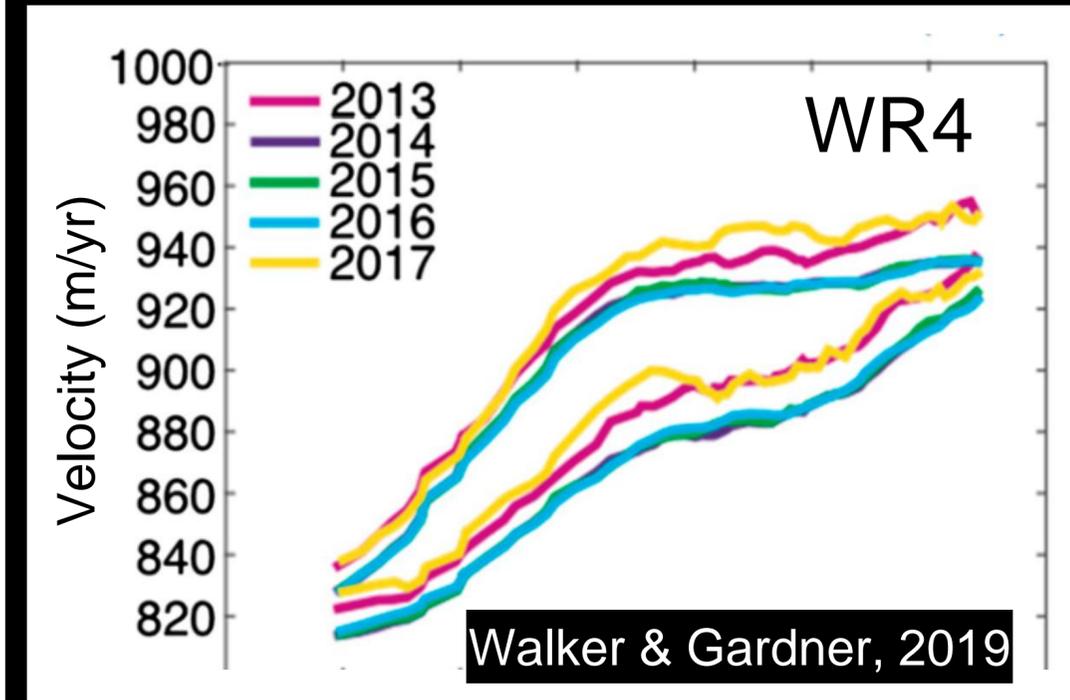
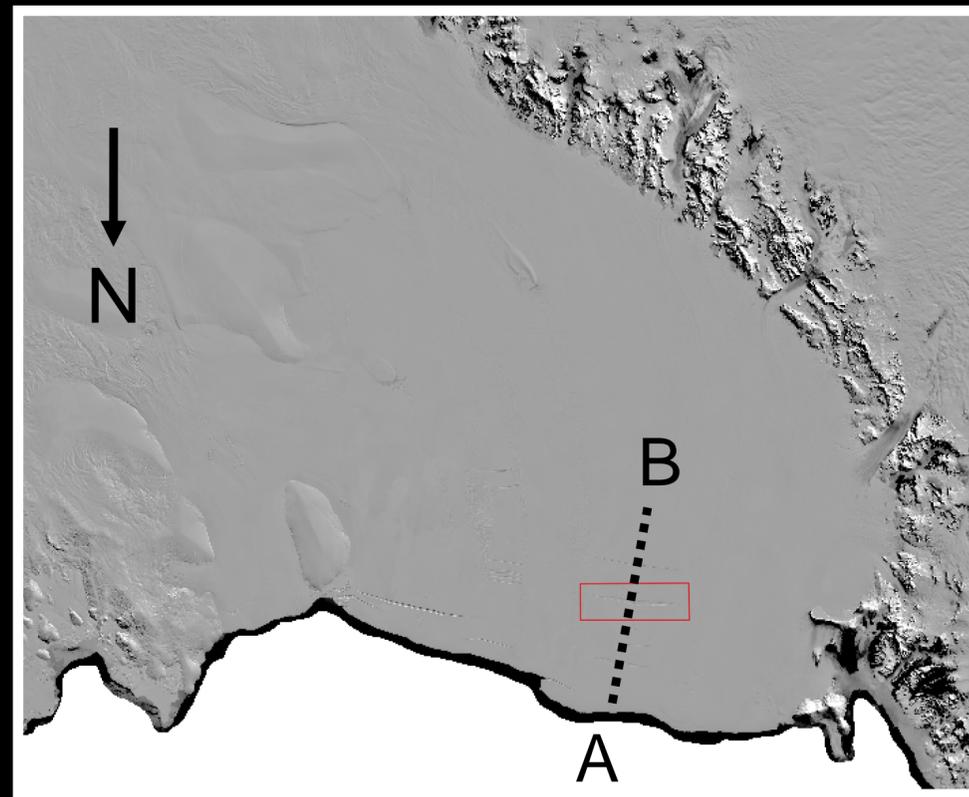
Ice Shelves



- Formed by ice flowing from the continent onto the ocean
- Rifts form from differences in flow speed that allow for opening

Ross Ice Shelf

- Thickness of ice shelf: ~300 m
- Thickness of rift: ~100 m
- WR 4 moves ~820 - 940 m/yr toward north



Deployment: Dec 2022 - Jan 2023



- 16 seismometers
- 12 GPS stations
- 1 active source seismic survey
- A few GPR lines





Fieldwork

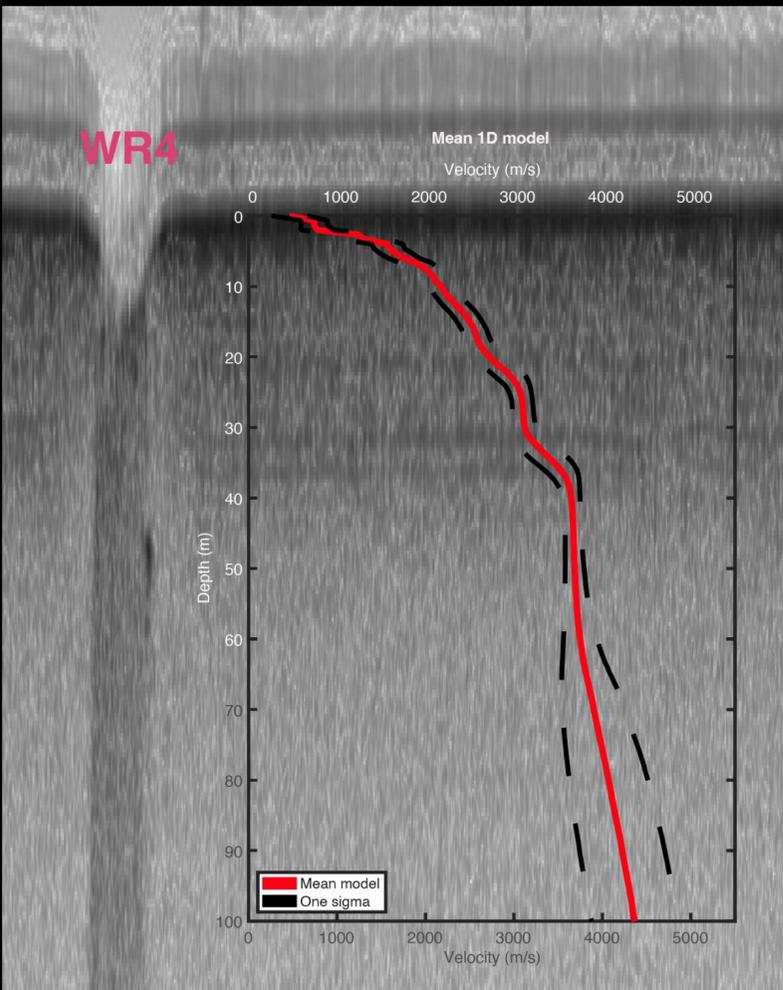
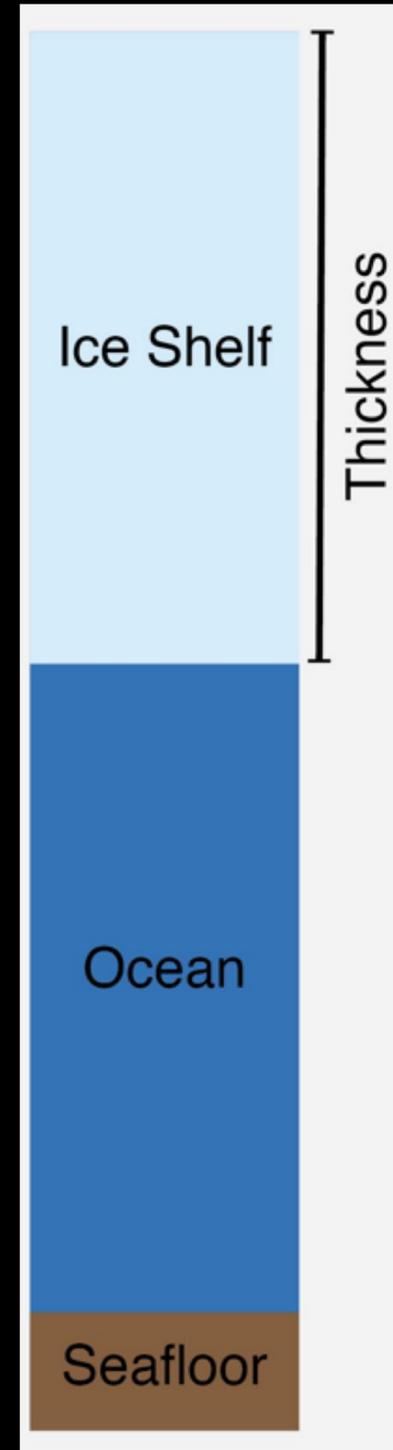
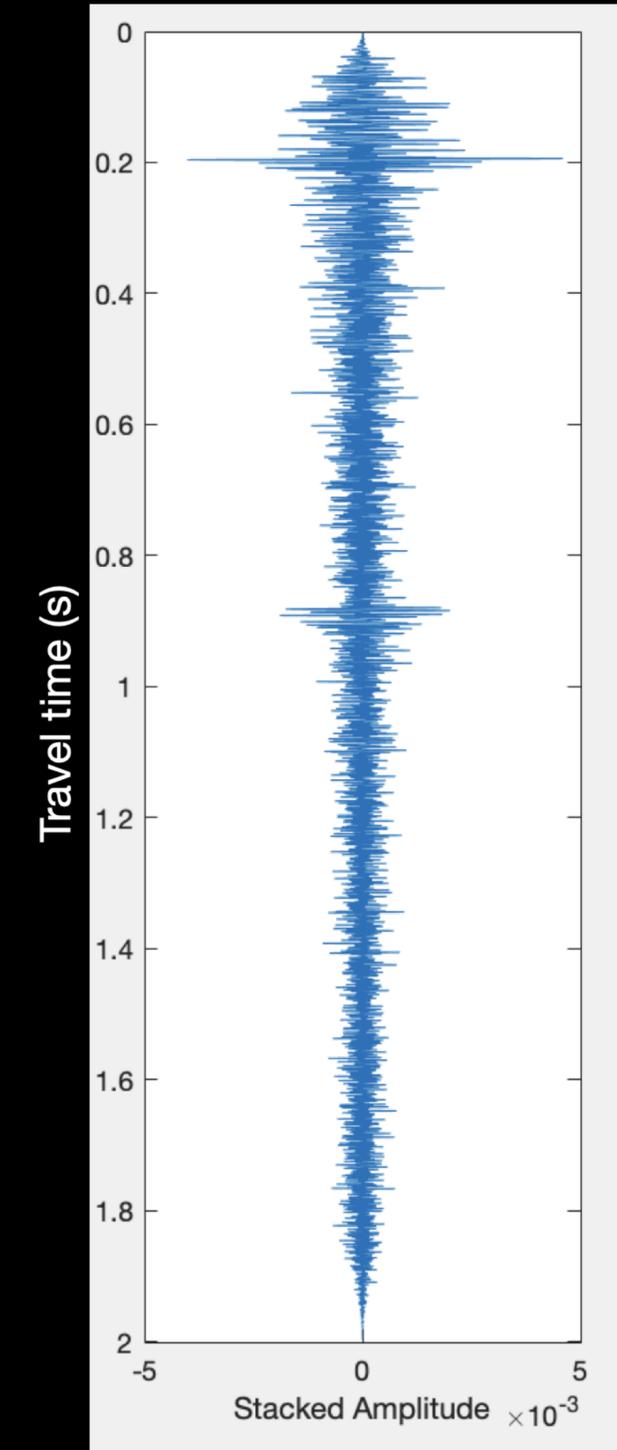
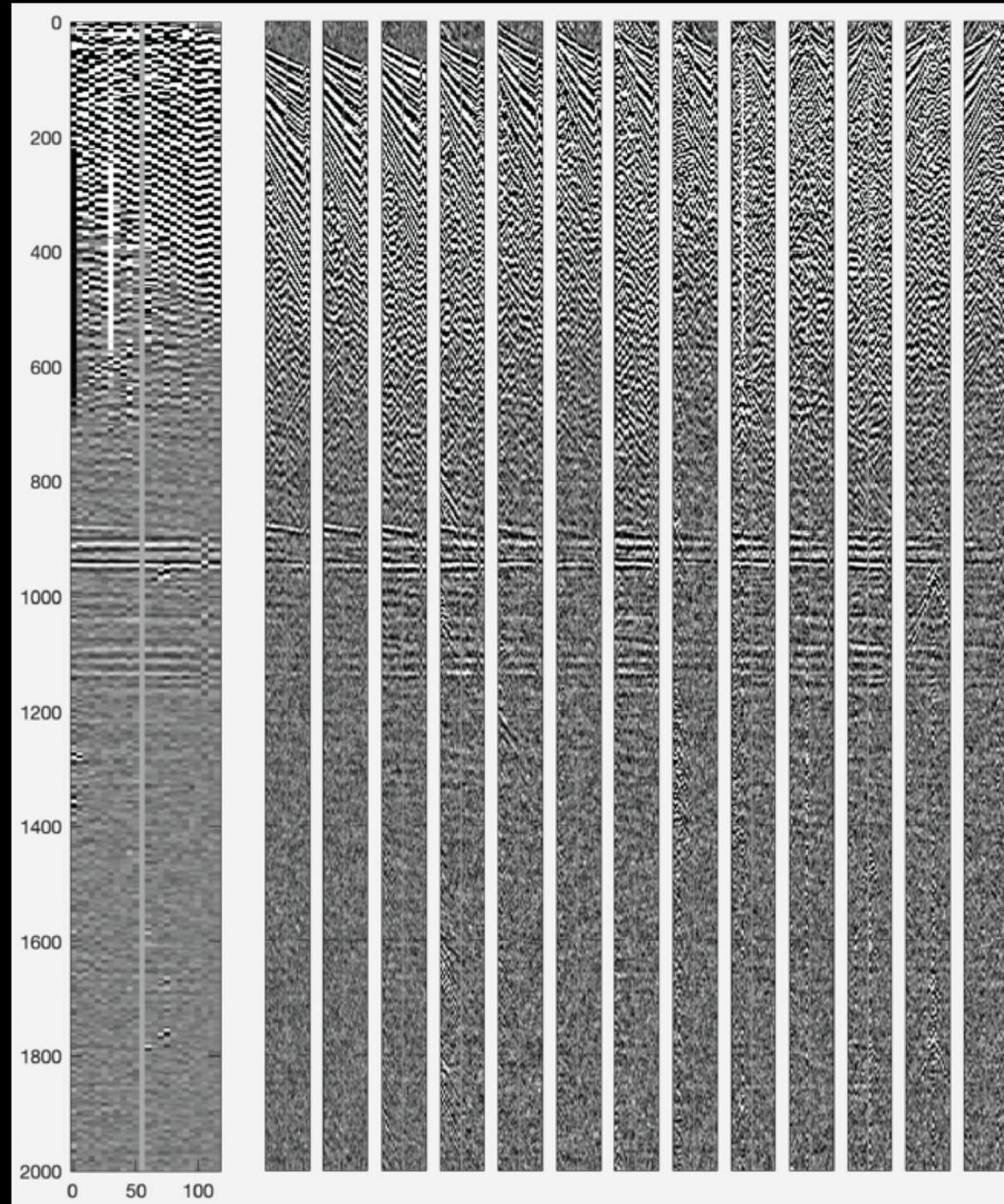
- Retrieving GPS & seismometer





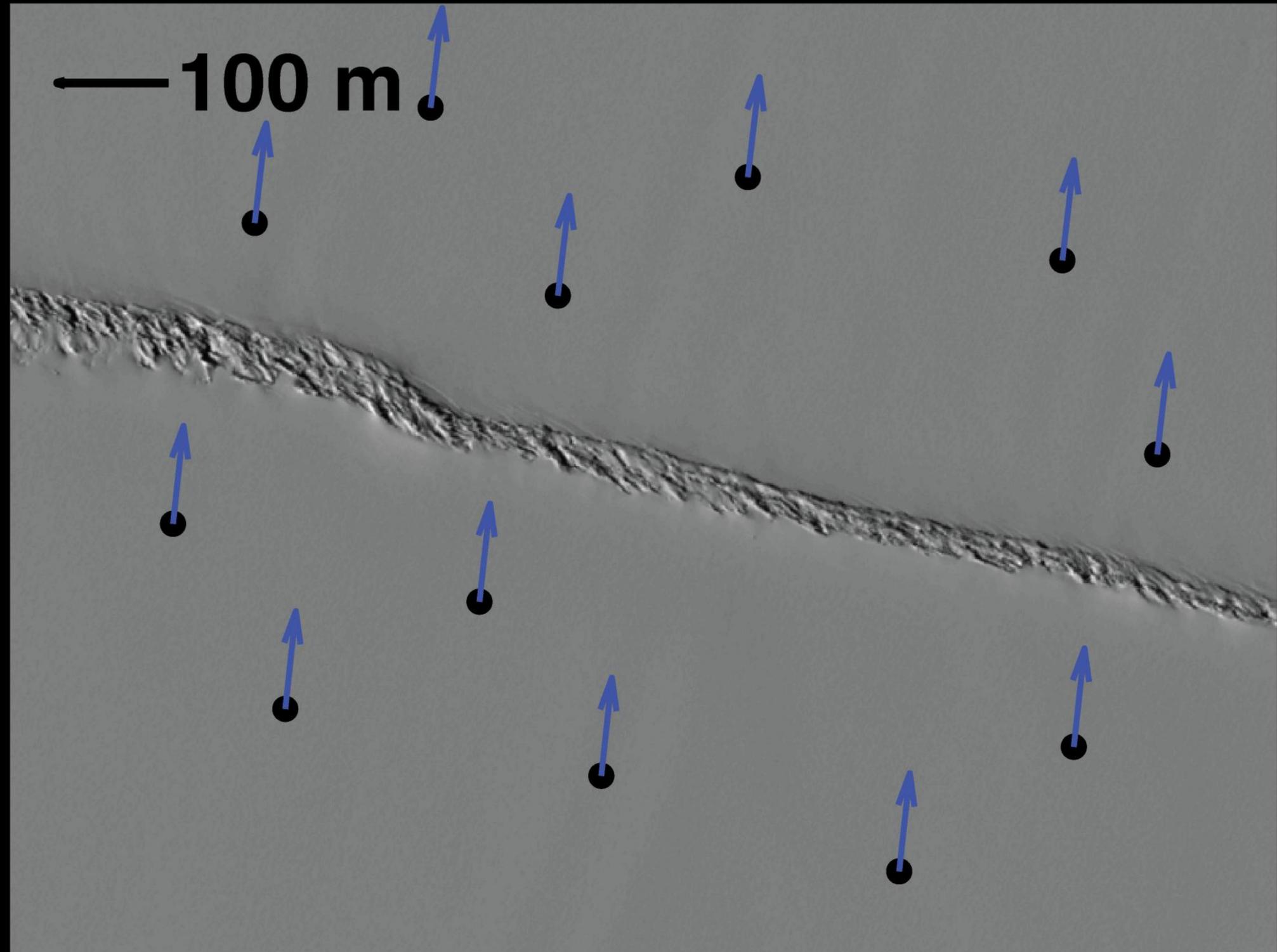


Active source seismic experiment



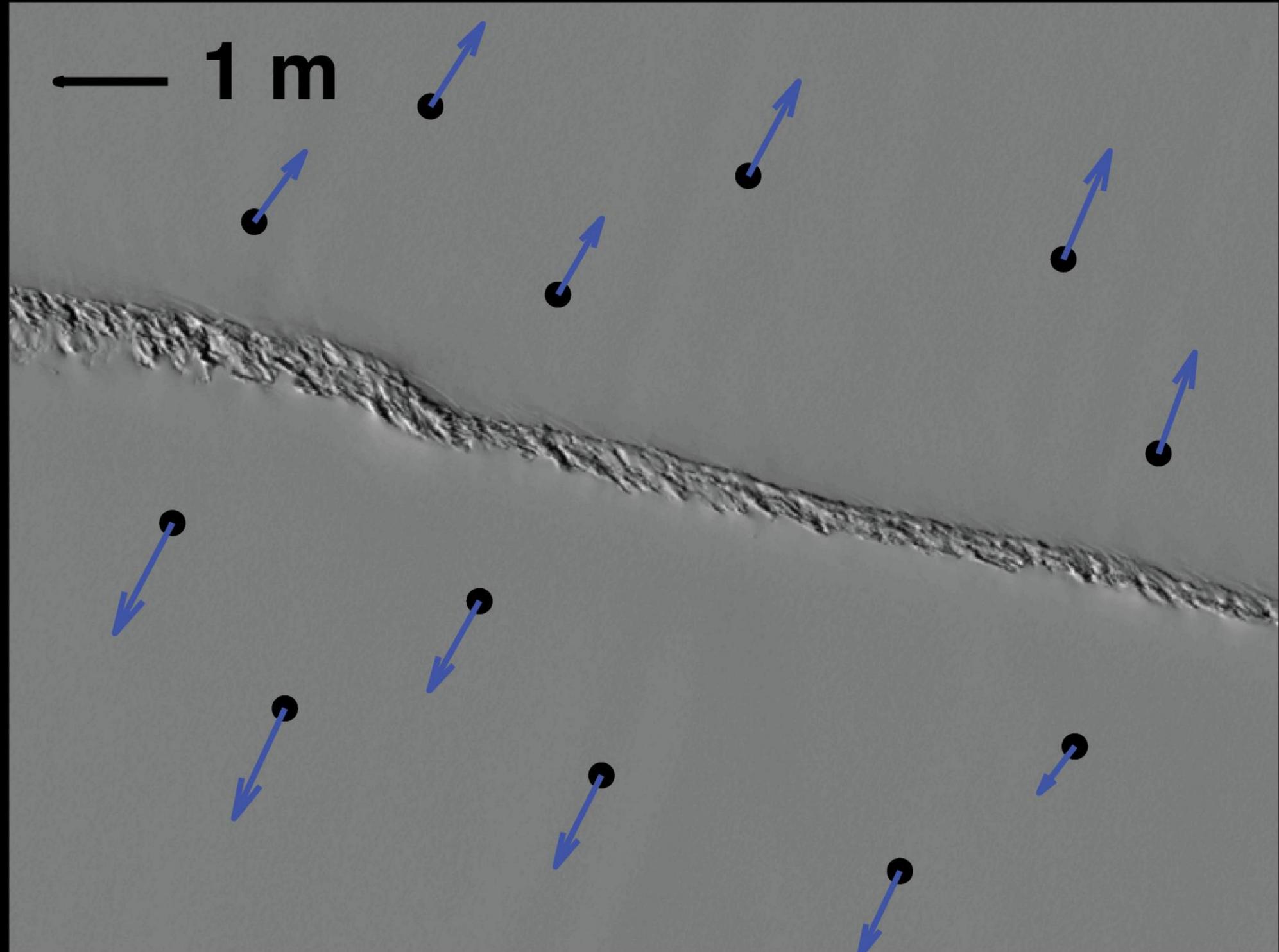
Long Term Deformation

- 2.6 m/day flow towards N10°E



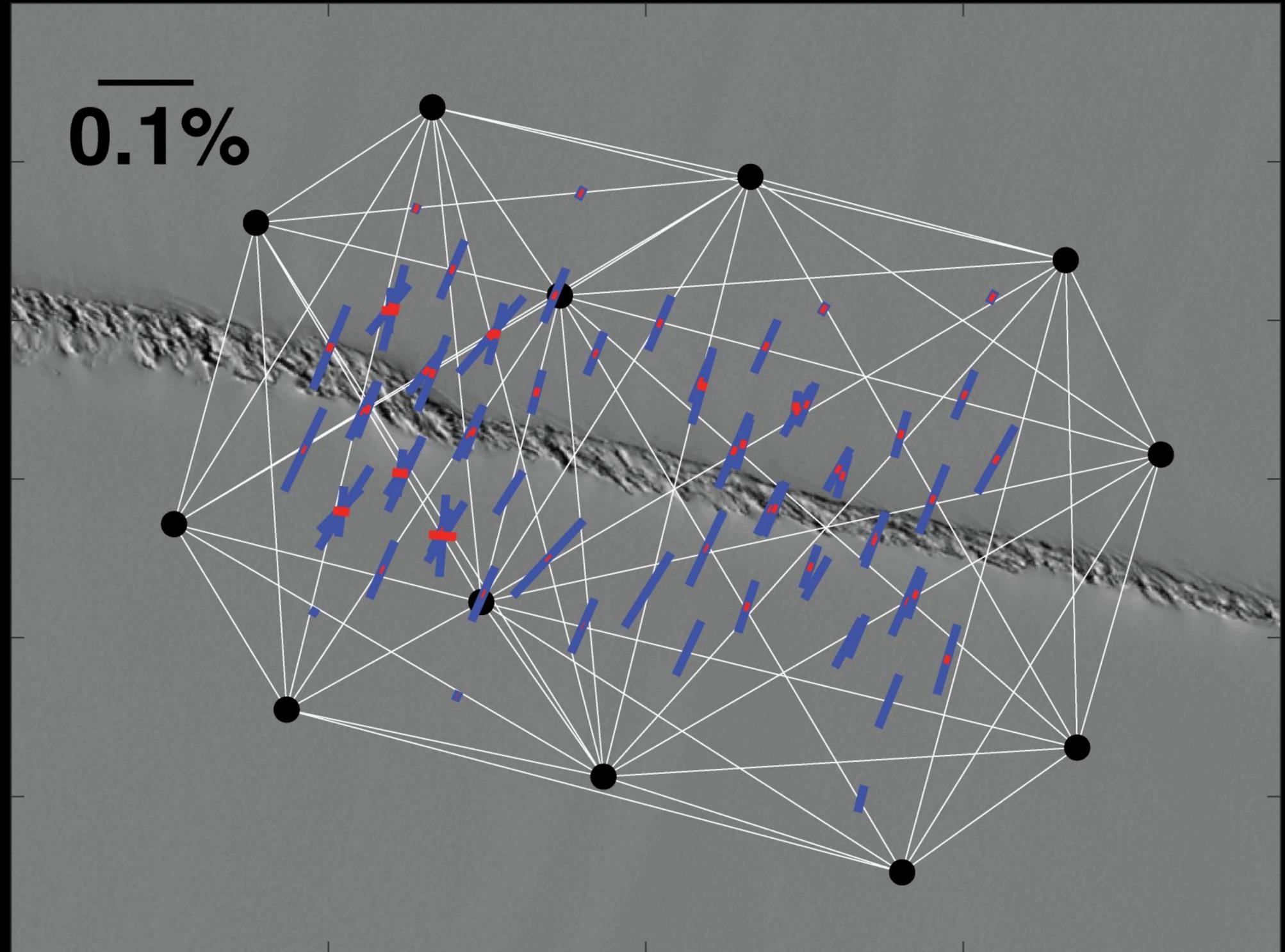
Long Term Deformation

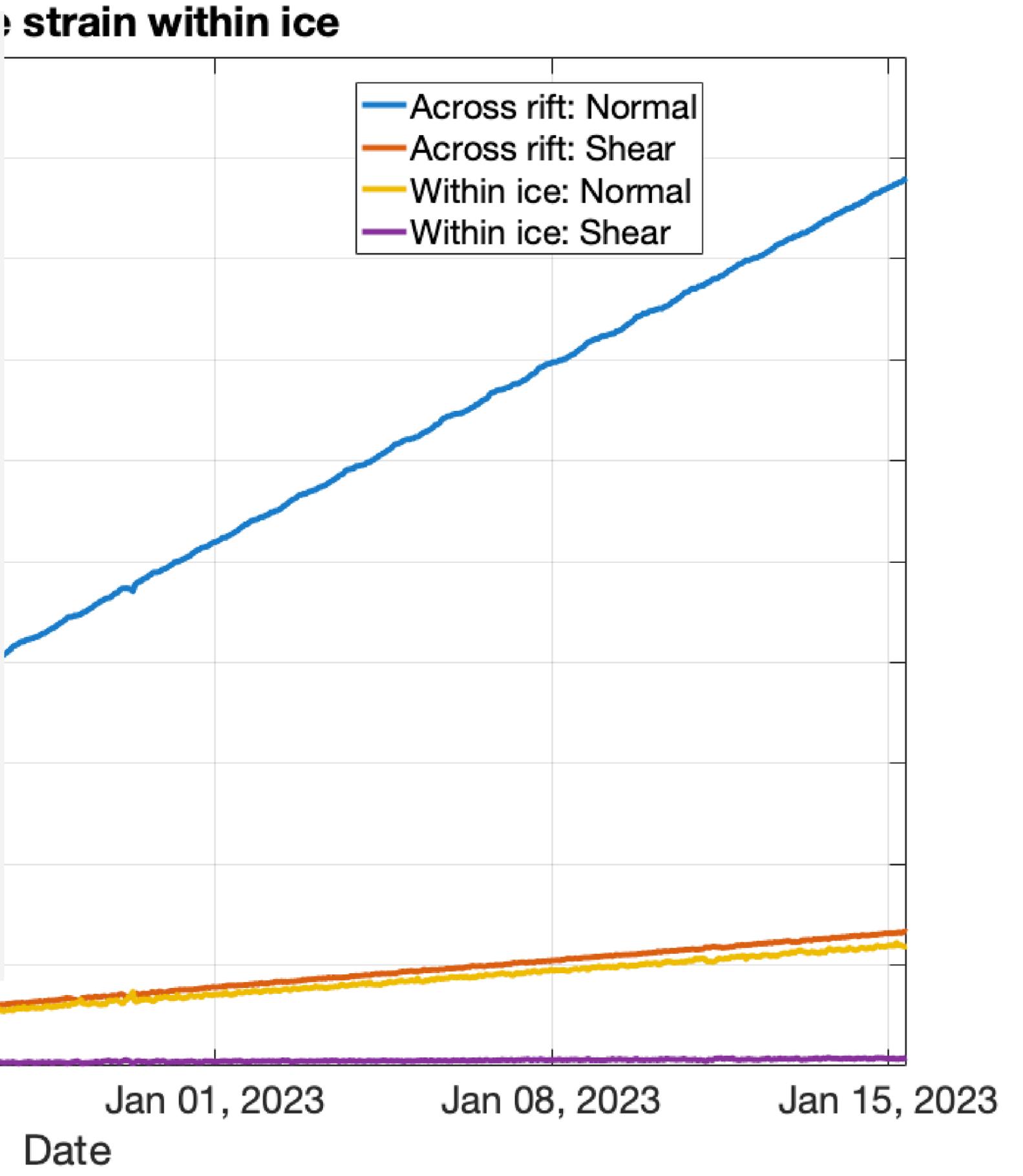
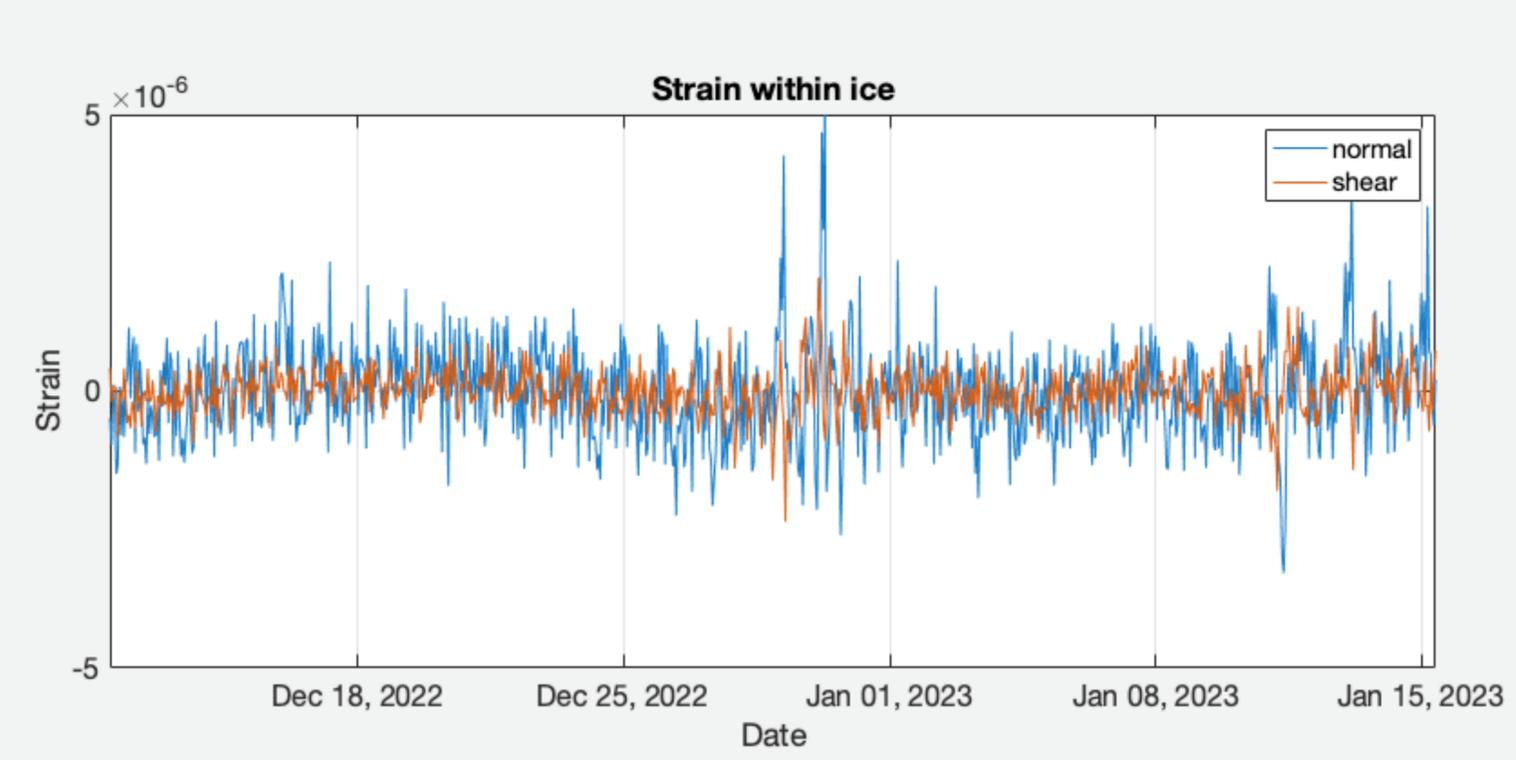
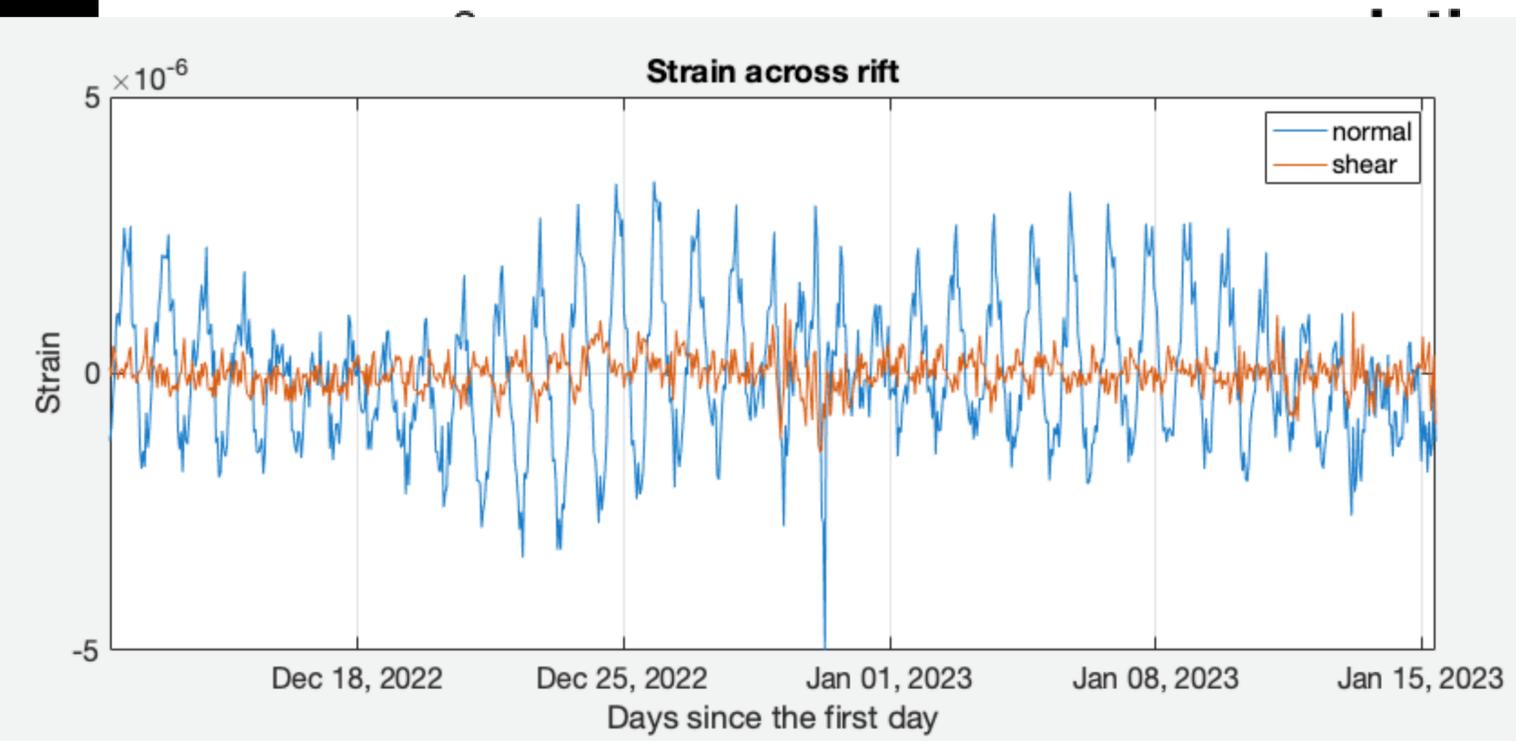
- 5 cm/day opening towards N30°E



Long Term Deformation

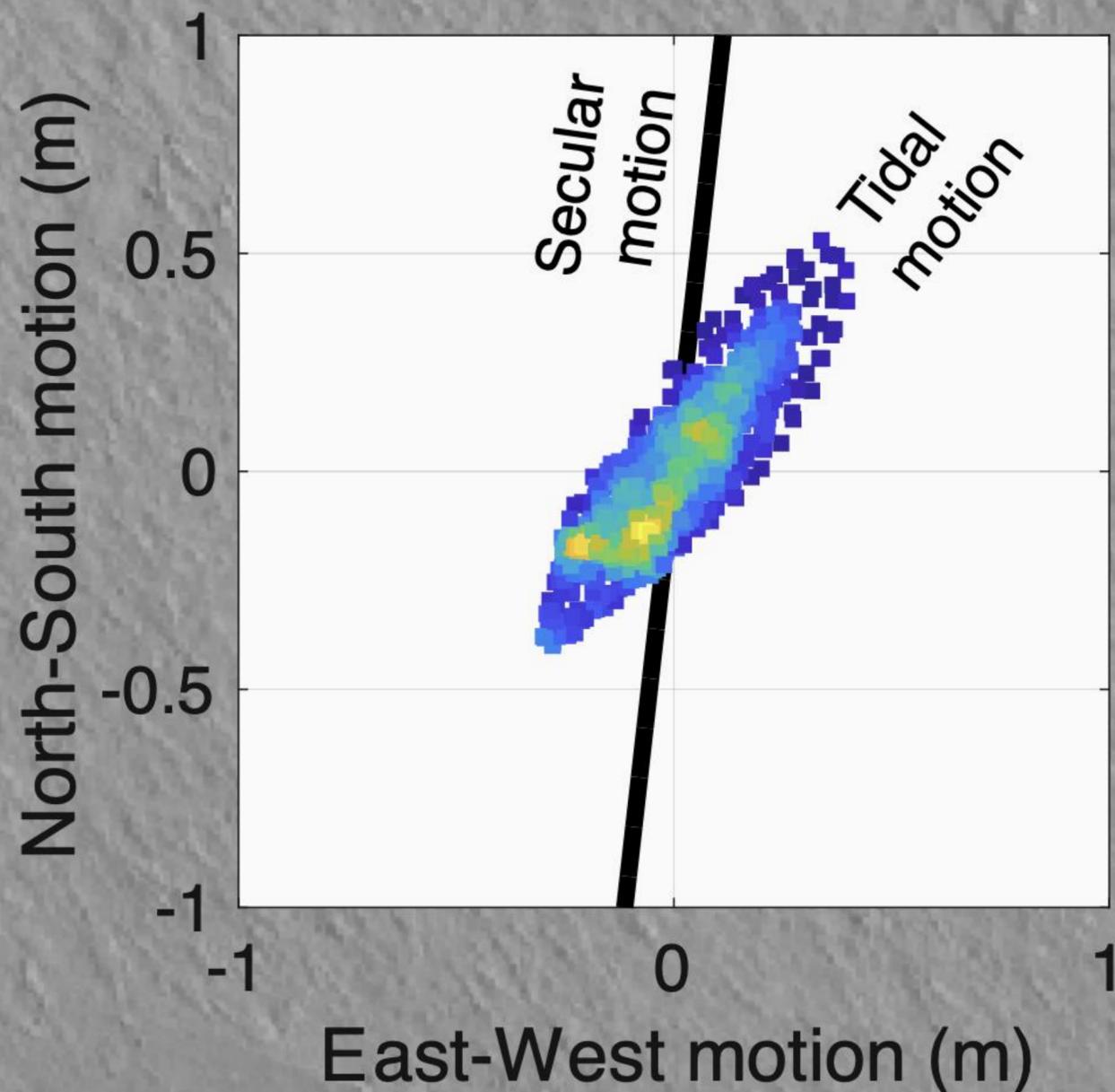
- Strain rate perpendicular to rift



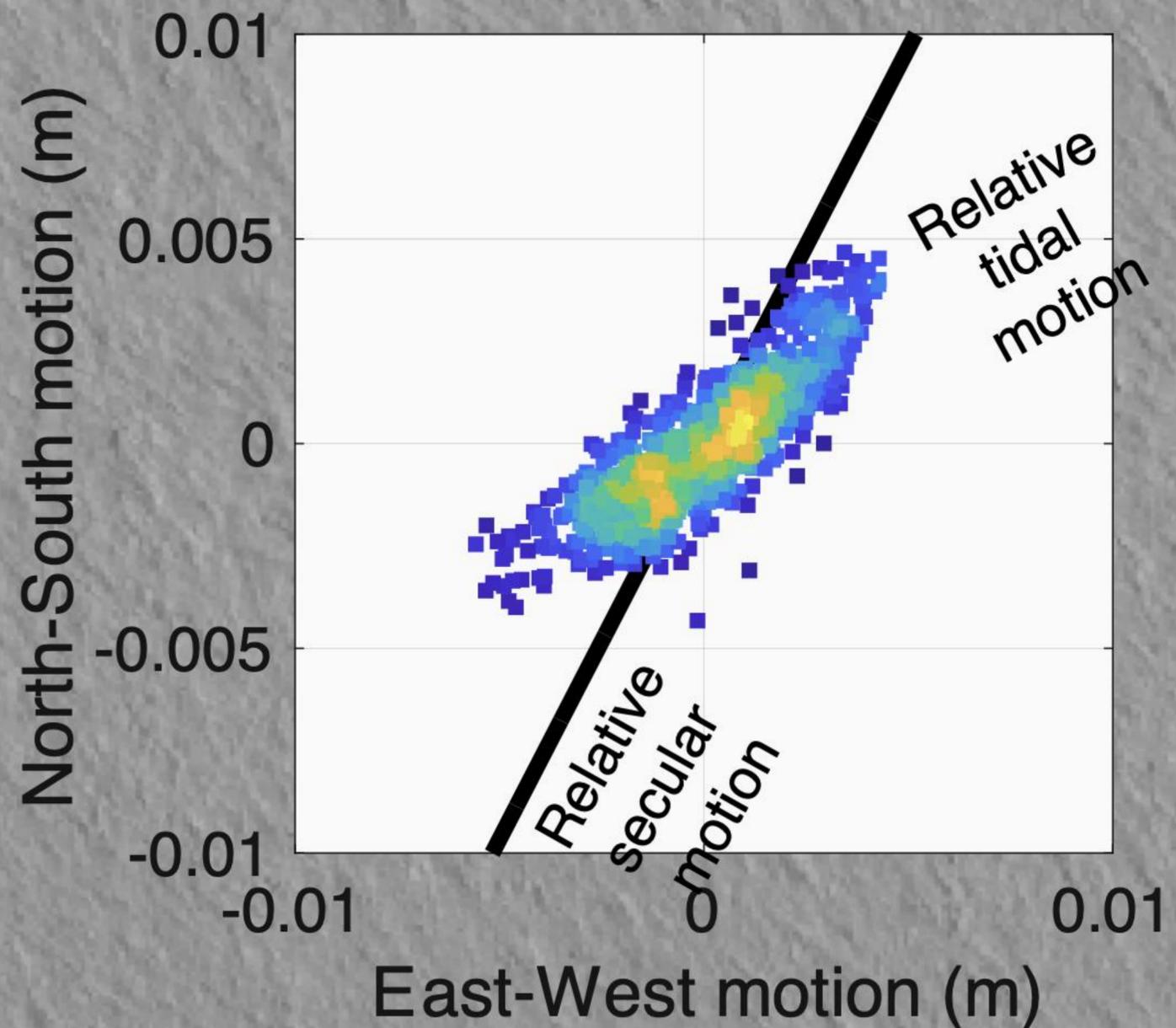


Secular vs Diurnal motions across the rift

Average motion of GPS stations

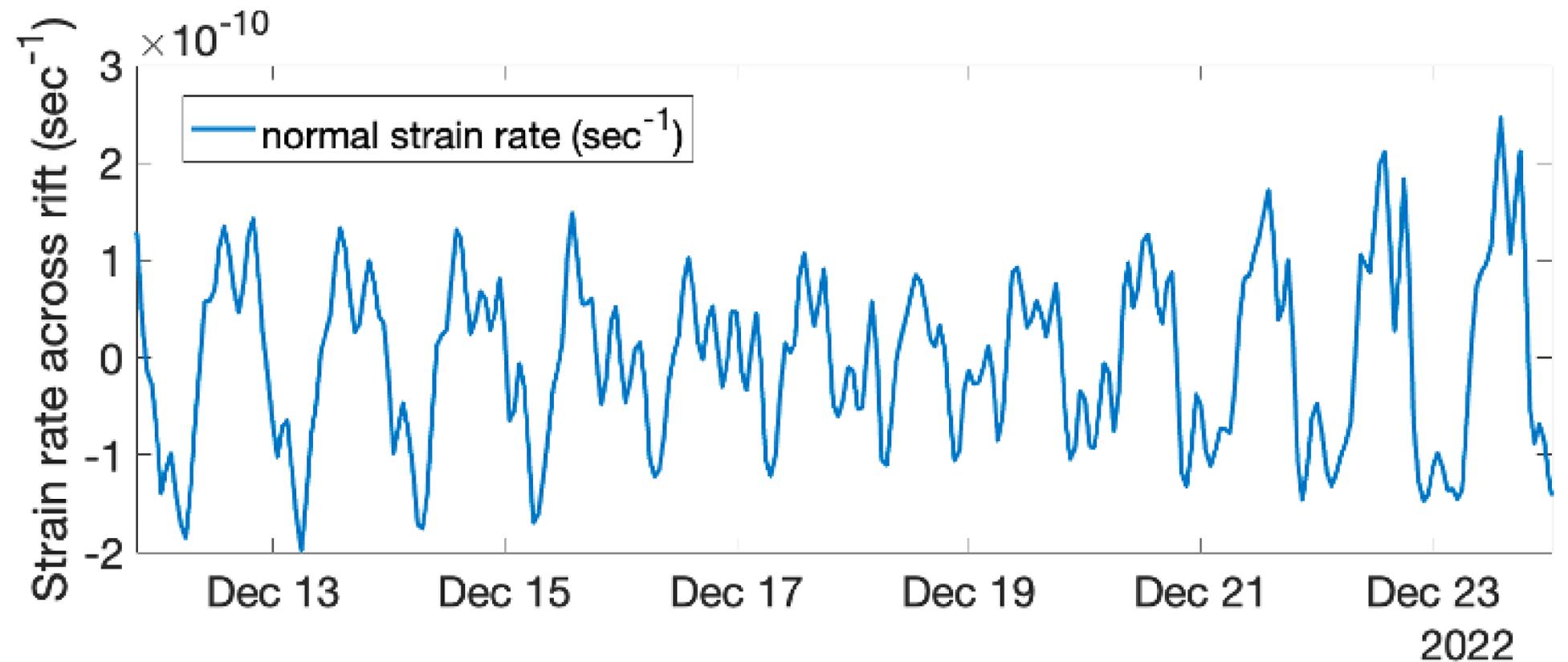
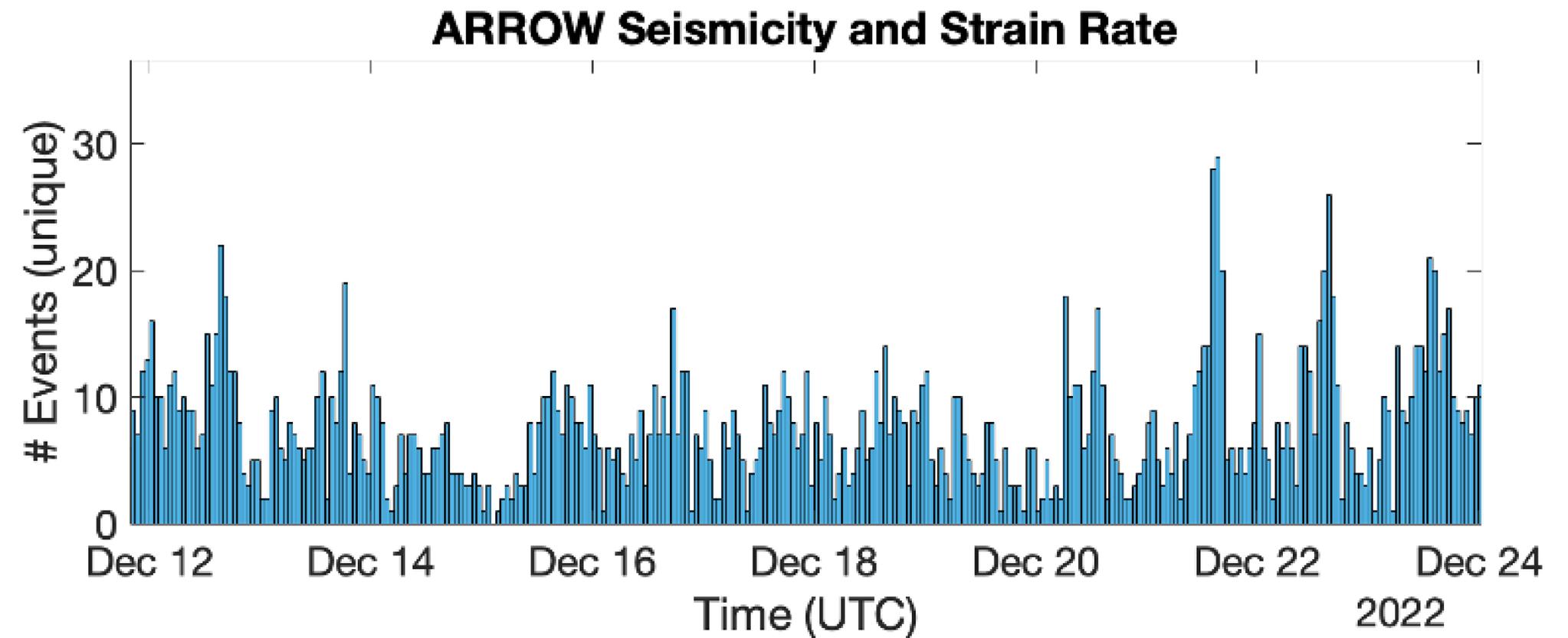


Relative motion across the rift



Icequakes

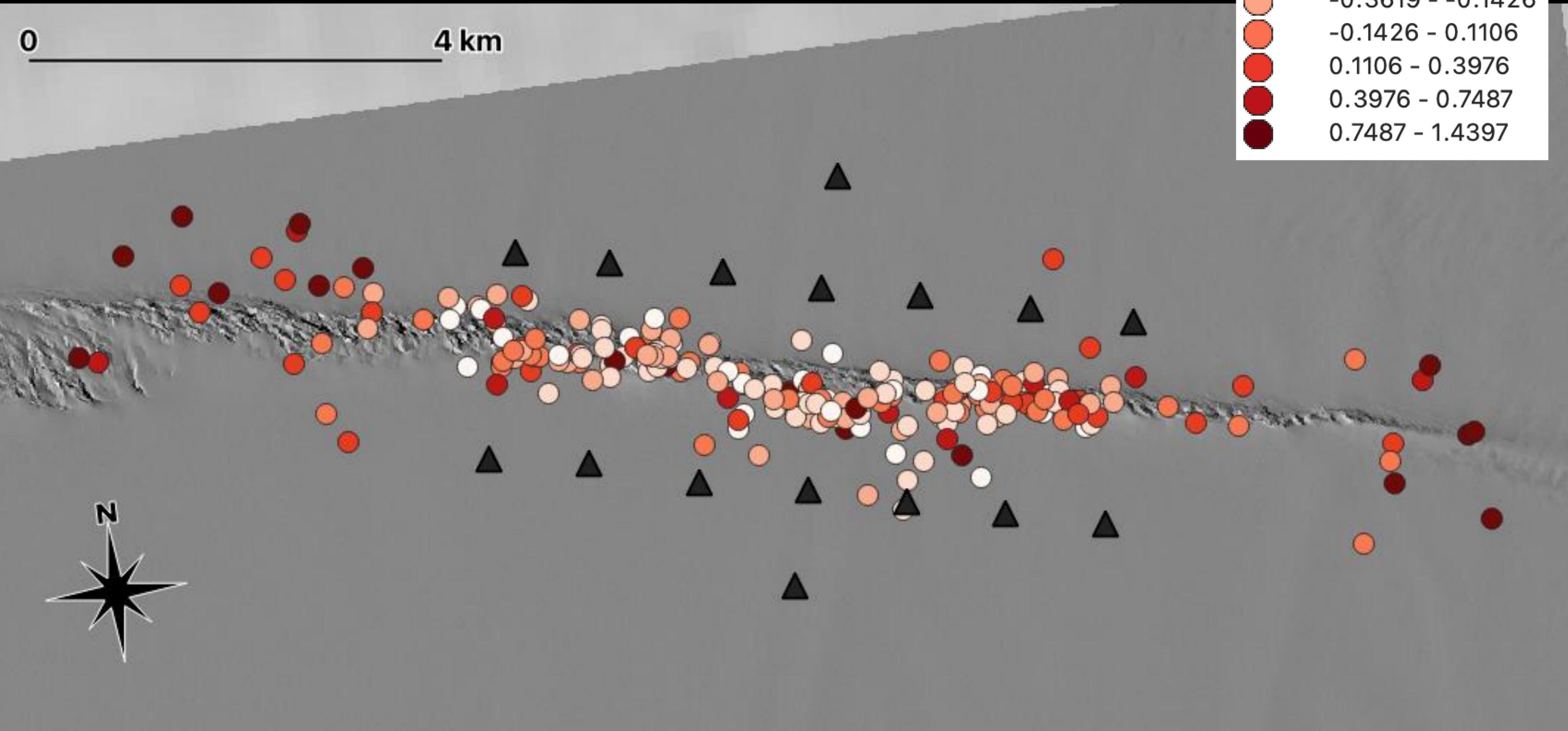
- Events identified manually
- About 6000 events
- Also based on ML
 - EQT
- Events associated and located using GaMMA



Icequake locations

0 4 km

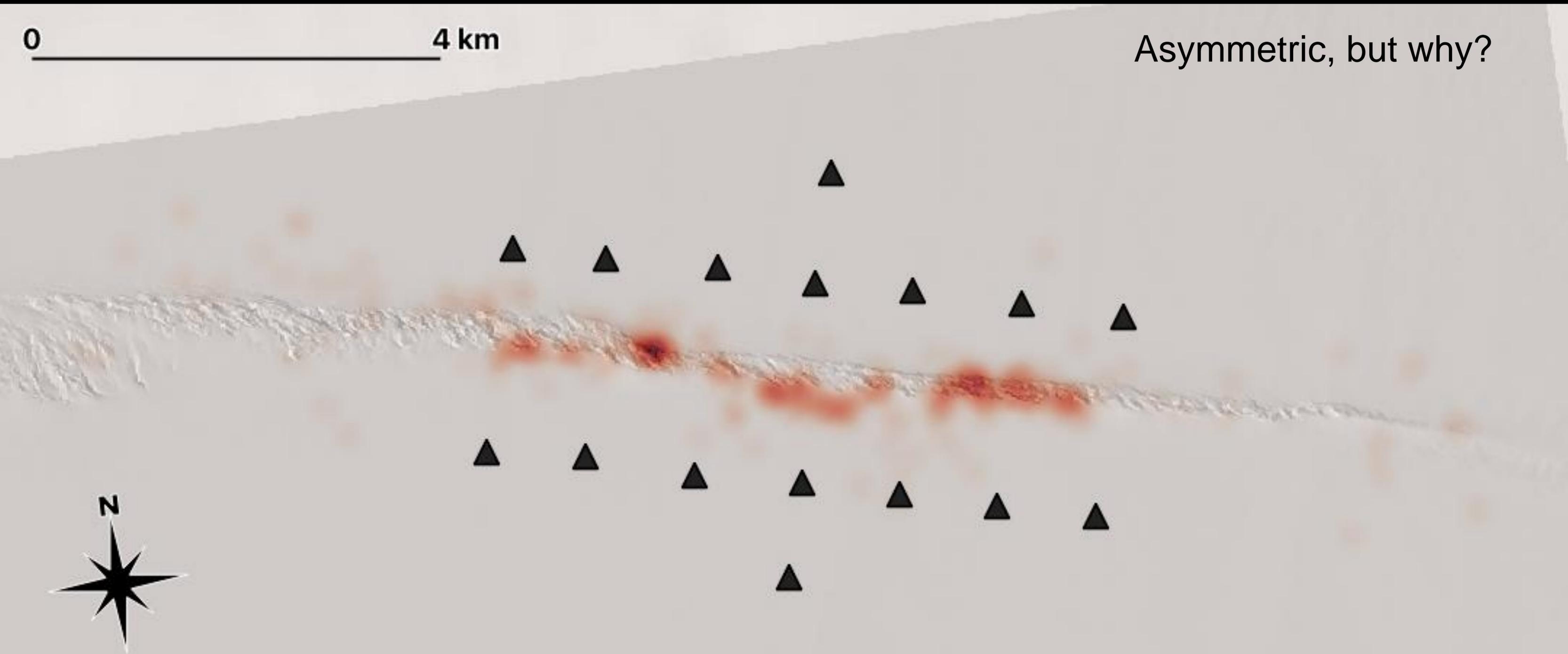
Symbol	Values
	-0.8657 - -0.5661
	-0.5661 - -0.3619
	-0.3619 - -0.1426
	-0.1426 - 0.1106
	0.1106 - 0.3976
	0.3976 - 0.7487
	0.7487 - 1.4397



Icequake locations

0 4 km

Asymmetric, but why?



Icequake locations

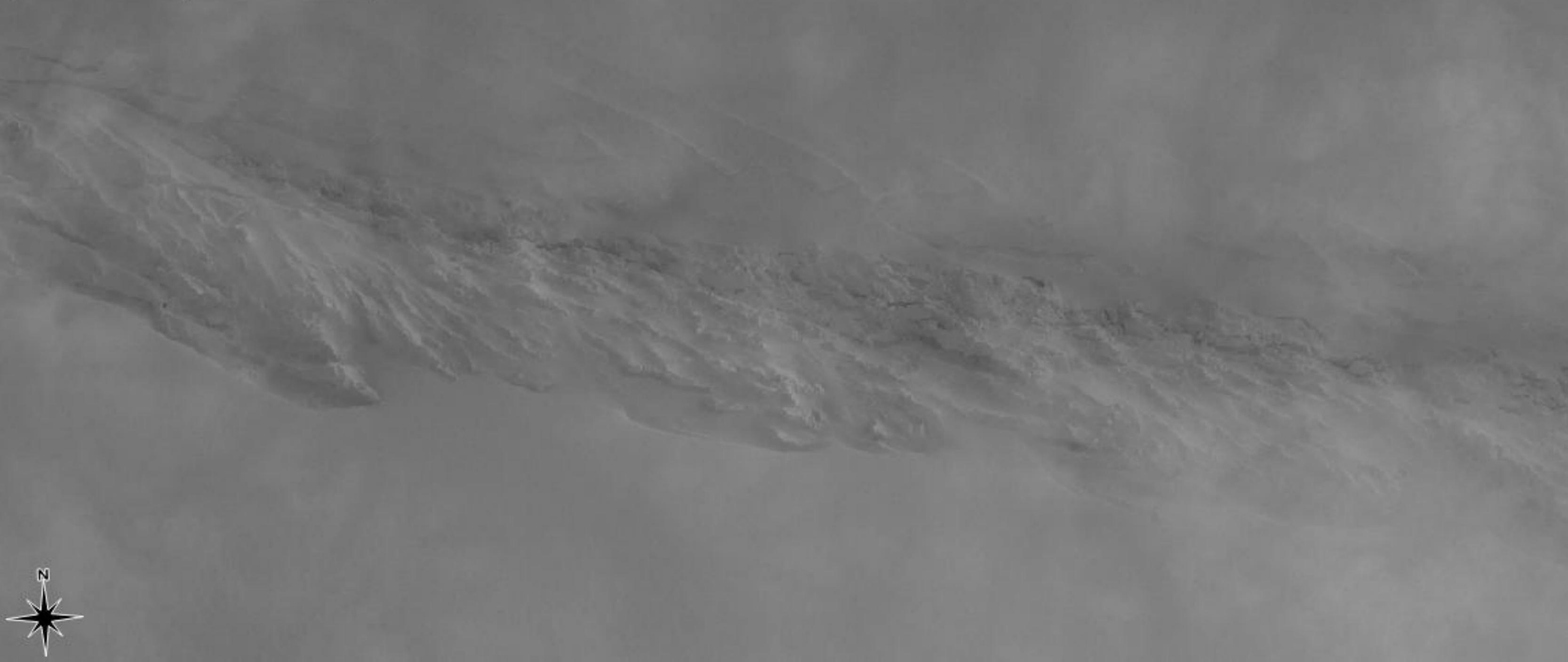
0 1.5 3 km

Low contrast, high resolution imagery provides a clue



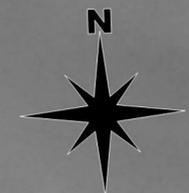
Icequake locations

0 150 300 m

A horizontal scale bar with a black bar and white tick marks. The numbers 0, 150, and 300 m are positioned above the bar.

Icequake locations

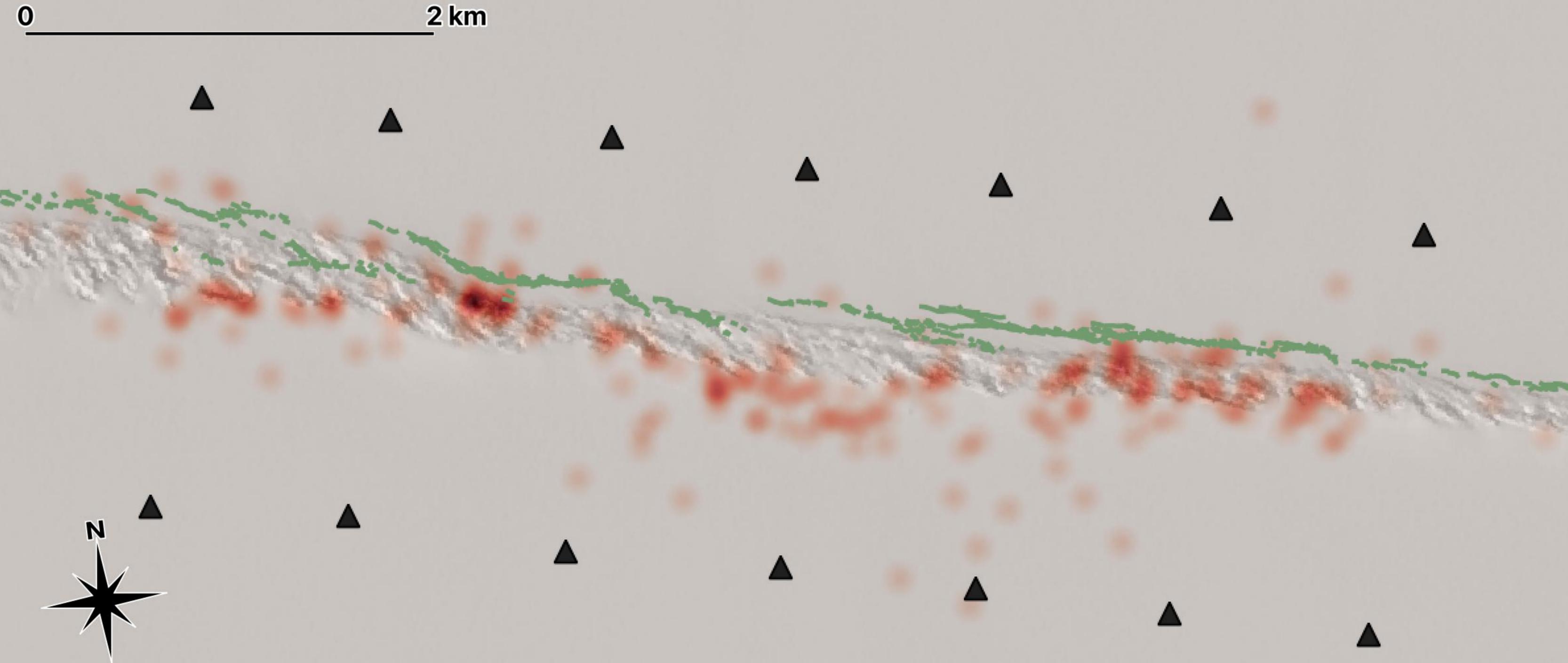
0 15 30 m



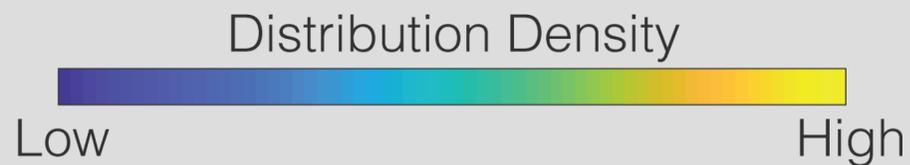
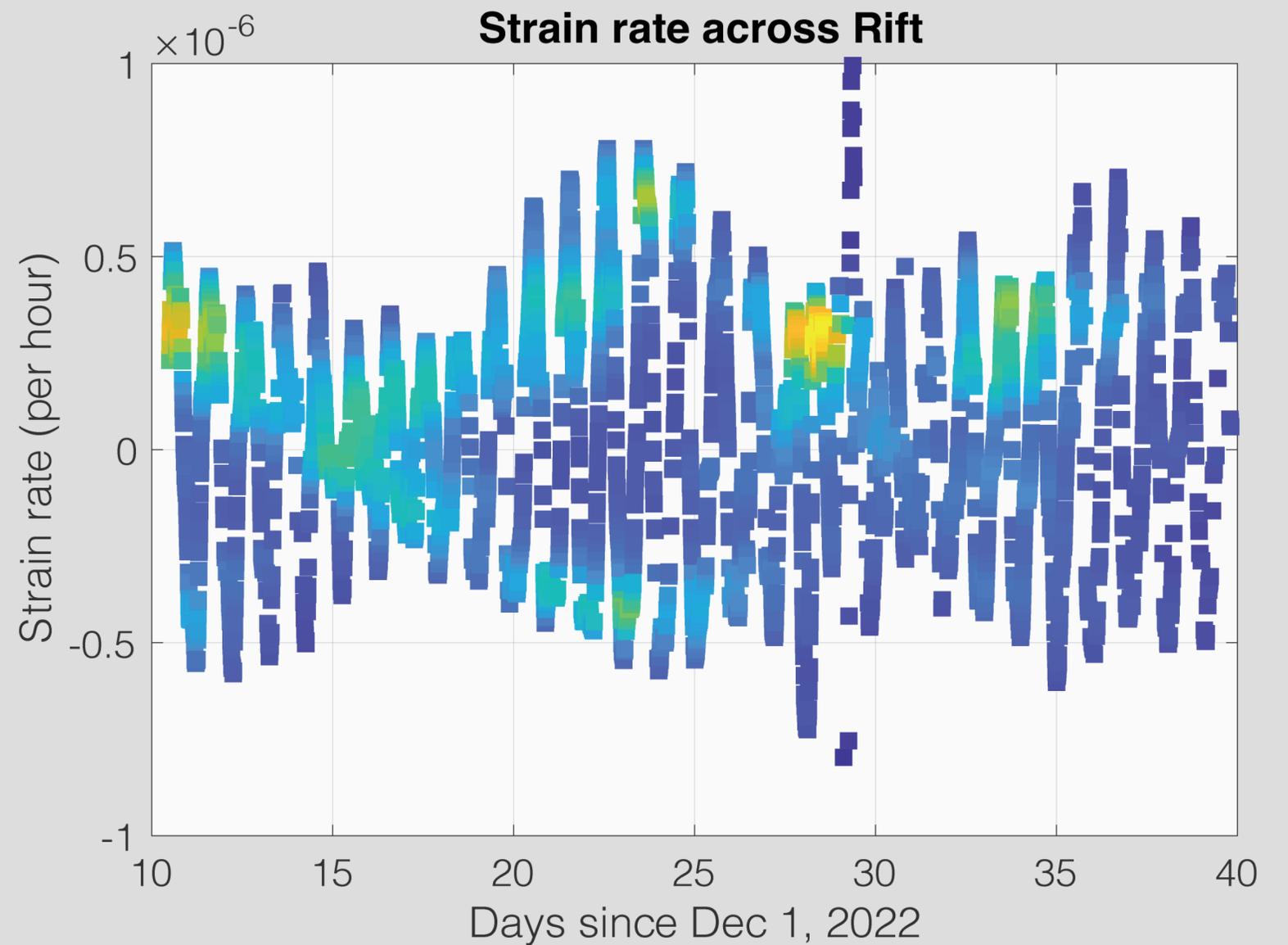
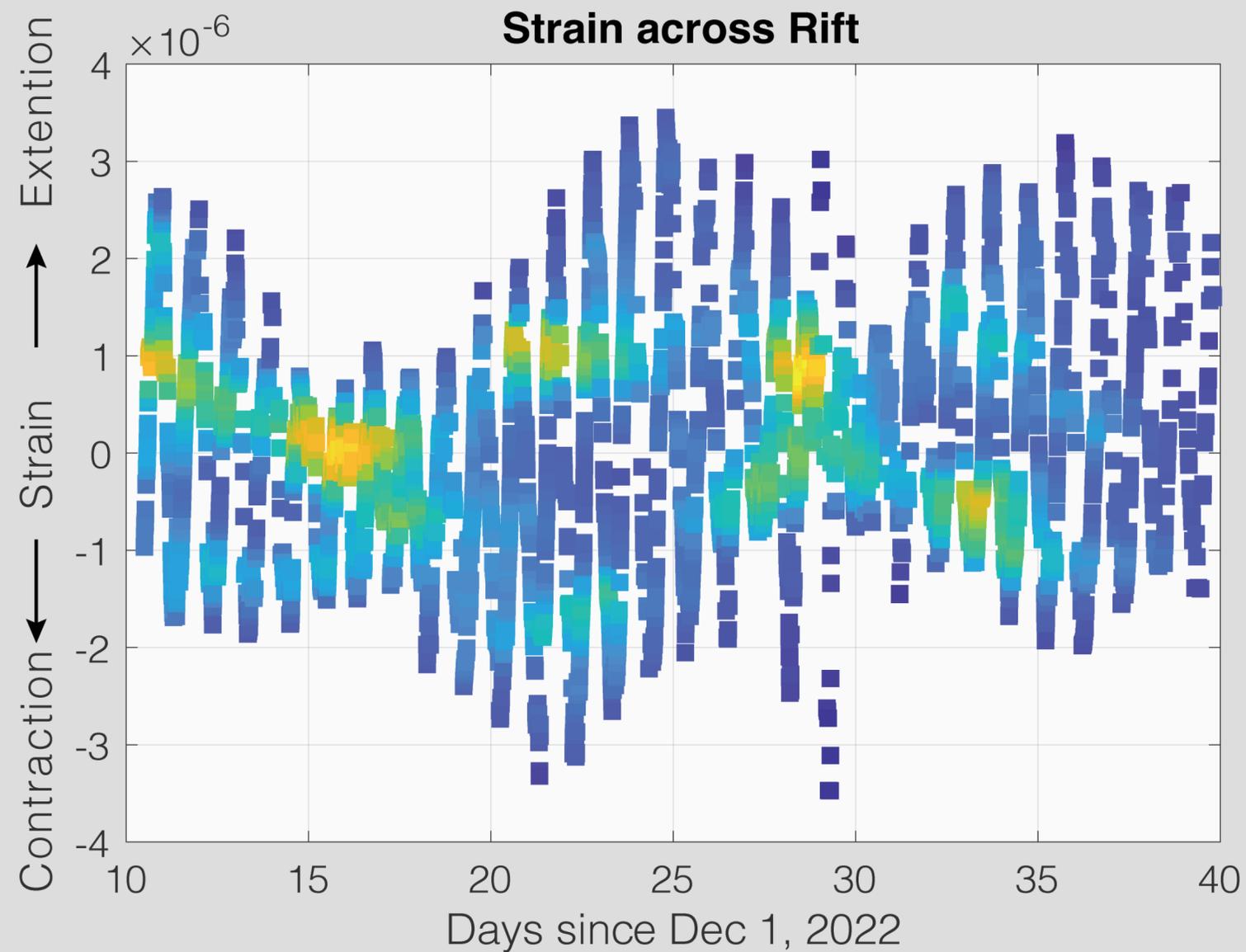
Icequake locations



Icequake locations

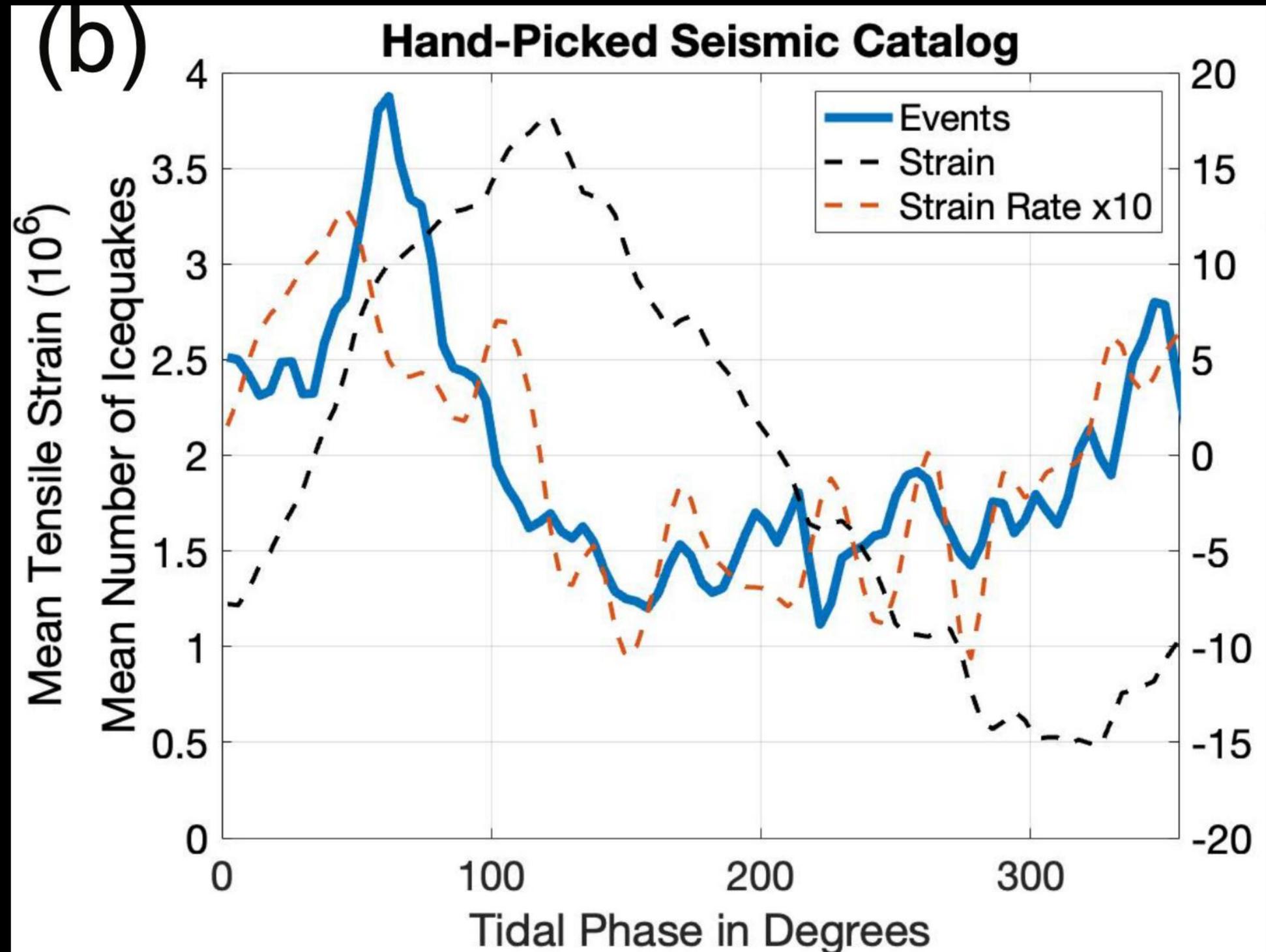


Seismic Activity



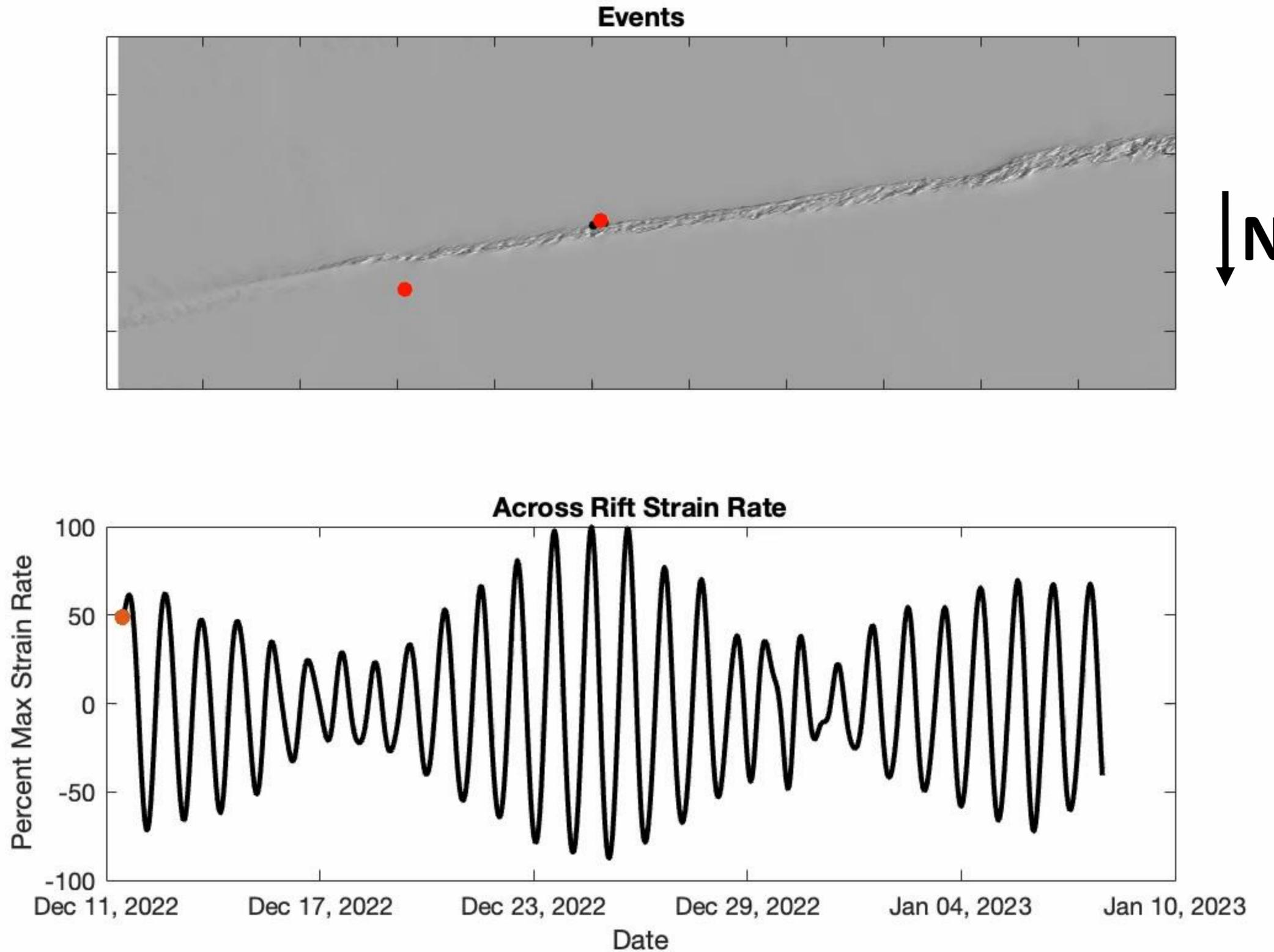
Seismic Activity

- Seismicity driven by across rift tidal strain rate
- Assuming stress and strain are in phase
- Icequakes production rate is modeled by the tidal stressing rate

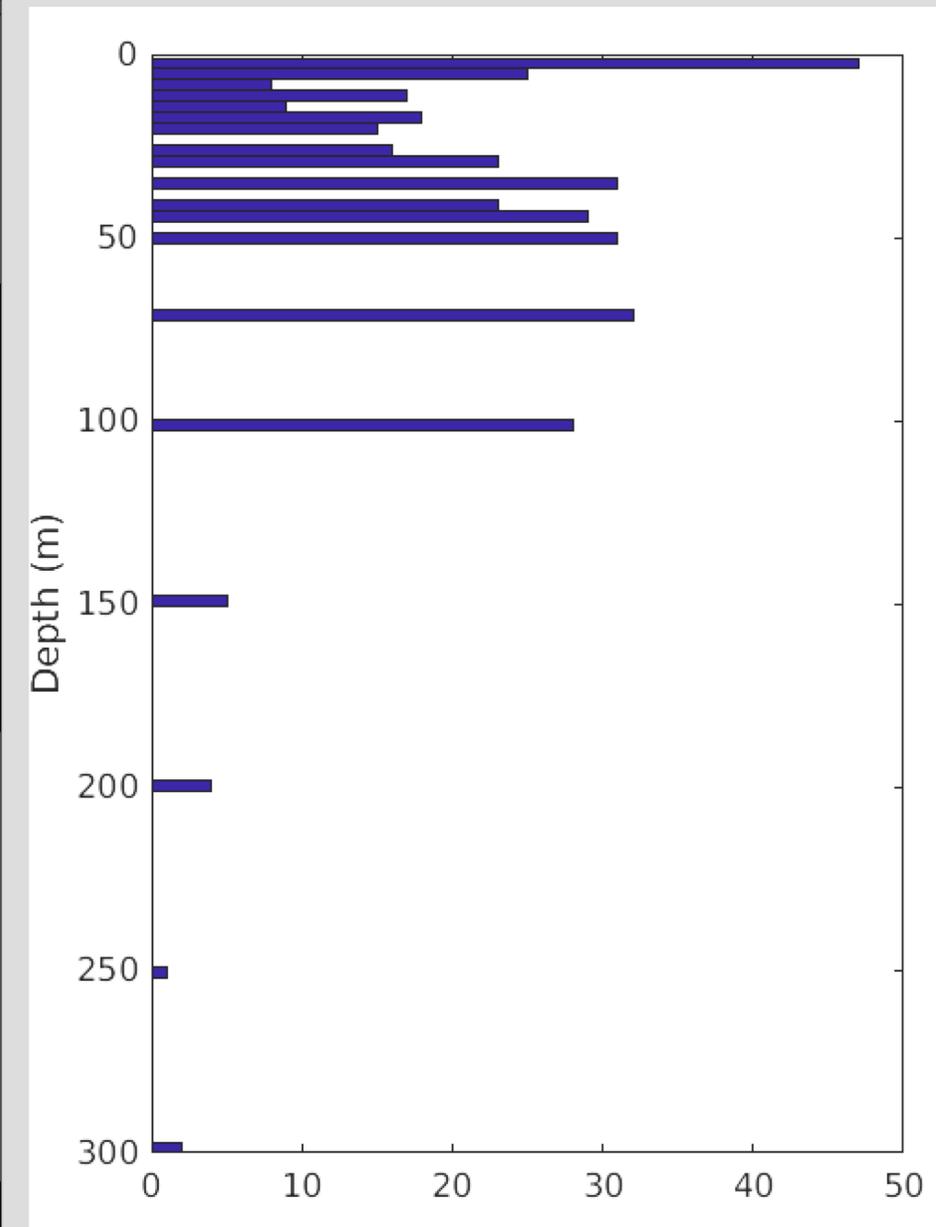
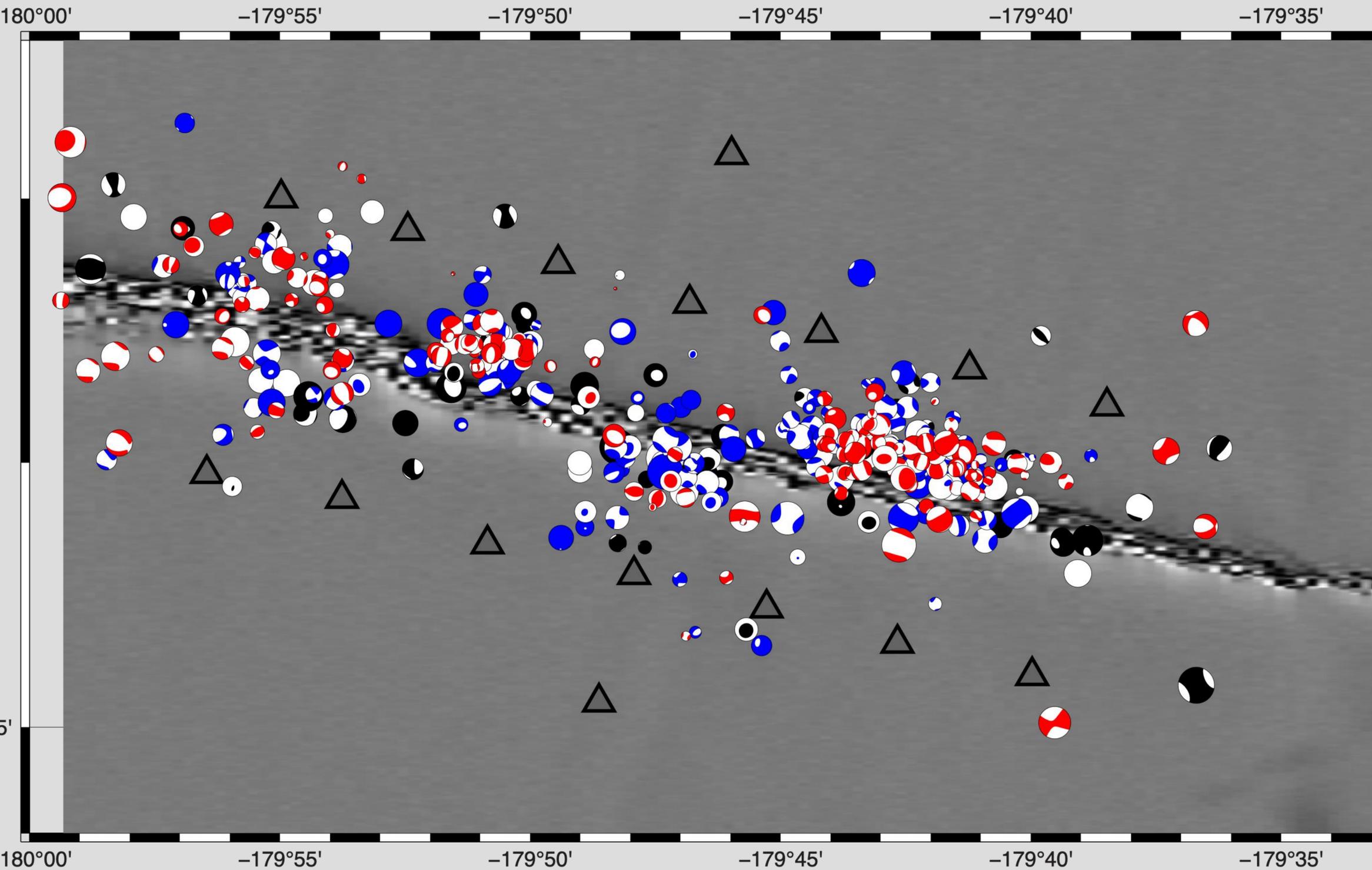


Seismic Activity

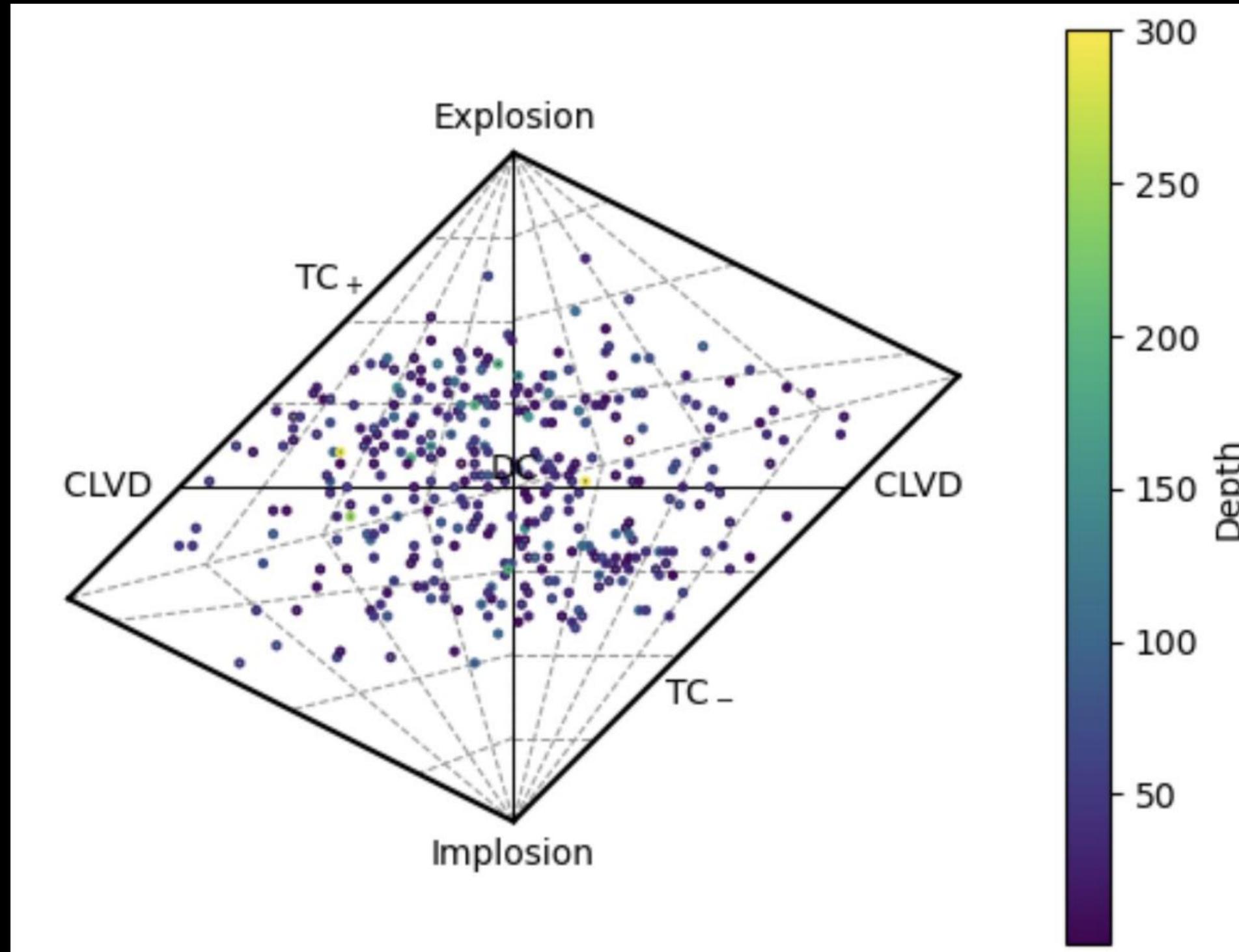
- Human located events
- New events in red
- Smoothed average across rift strain rate



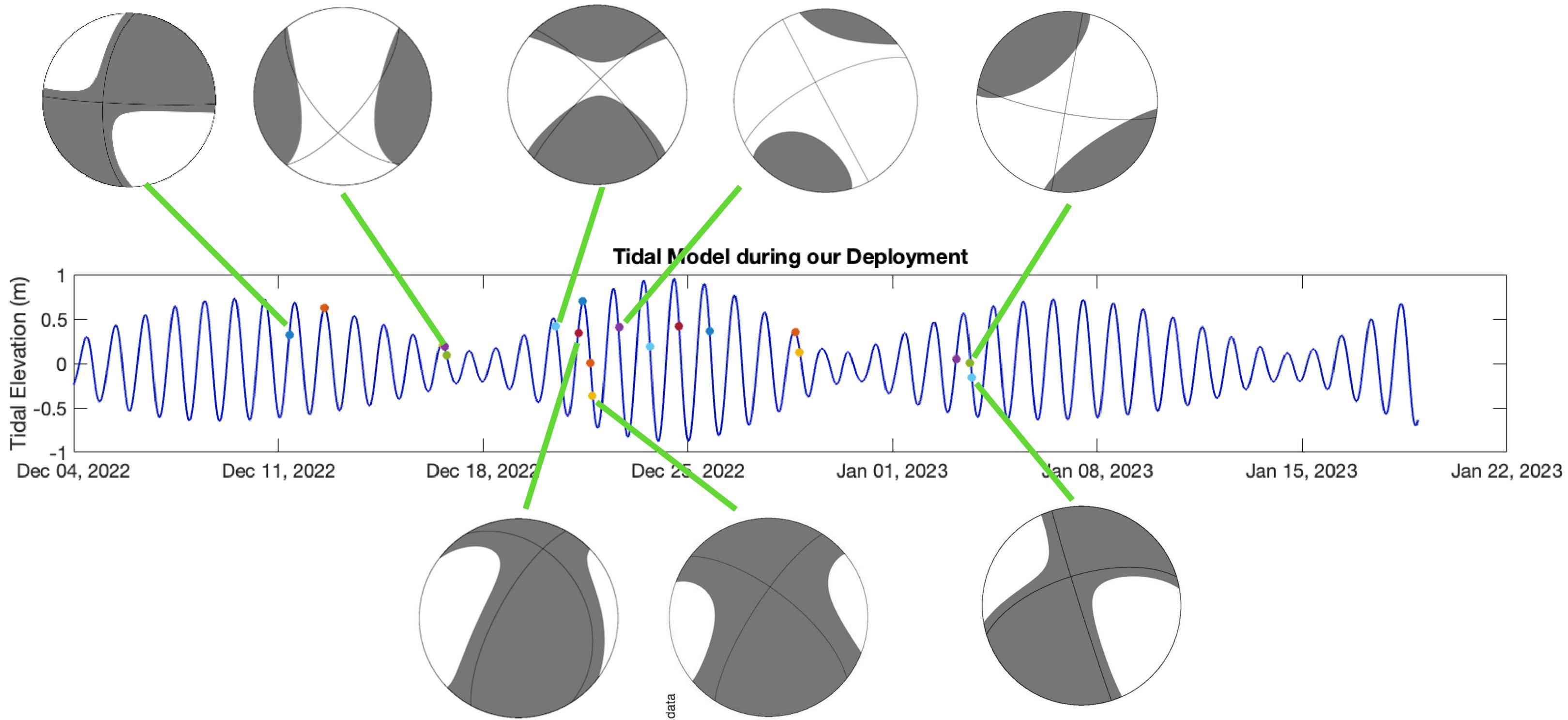
Icequake focal mechanism



Icequake focal mechanism



Selected focal mechanisms

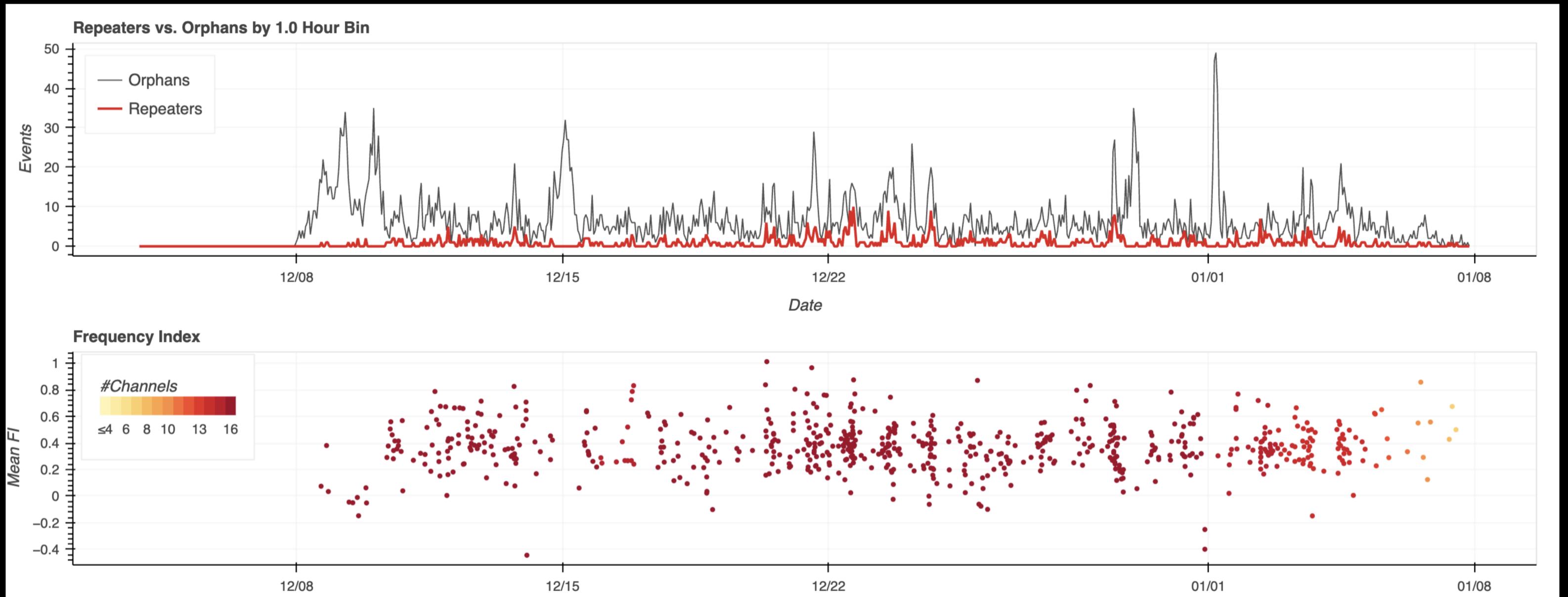


Summary

- Active source experiments indicate a ~40 m thick firm layer with soft snow, followed by ~350 m thick of solid ice.
- GPS data indicates a 5 cm/day secular opening across the rift
- There is a up to 5 mm opening/closing during a tidal cycle.
- Most icequakes are located on both sides of the rift, but there are more events on the north side.
- Icequakes are modulated with tidal stressing rate (or strain rate).
- Icequakes appear to occur along the active rifting portion of the rift
- Icequake focal mechanisms indicate a common T-axis along N-S

Ongoing and future research

Repeating events and their families



Ongoing and future research

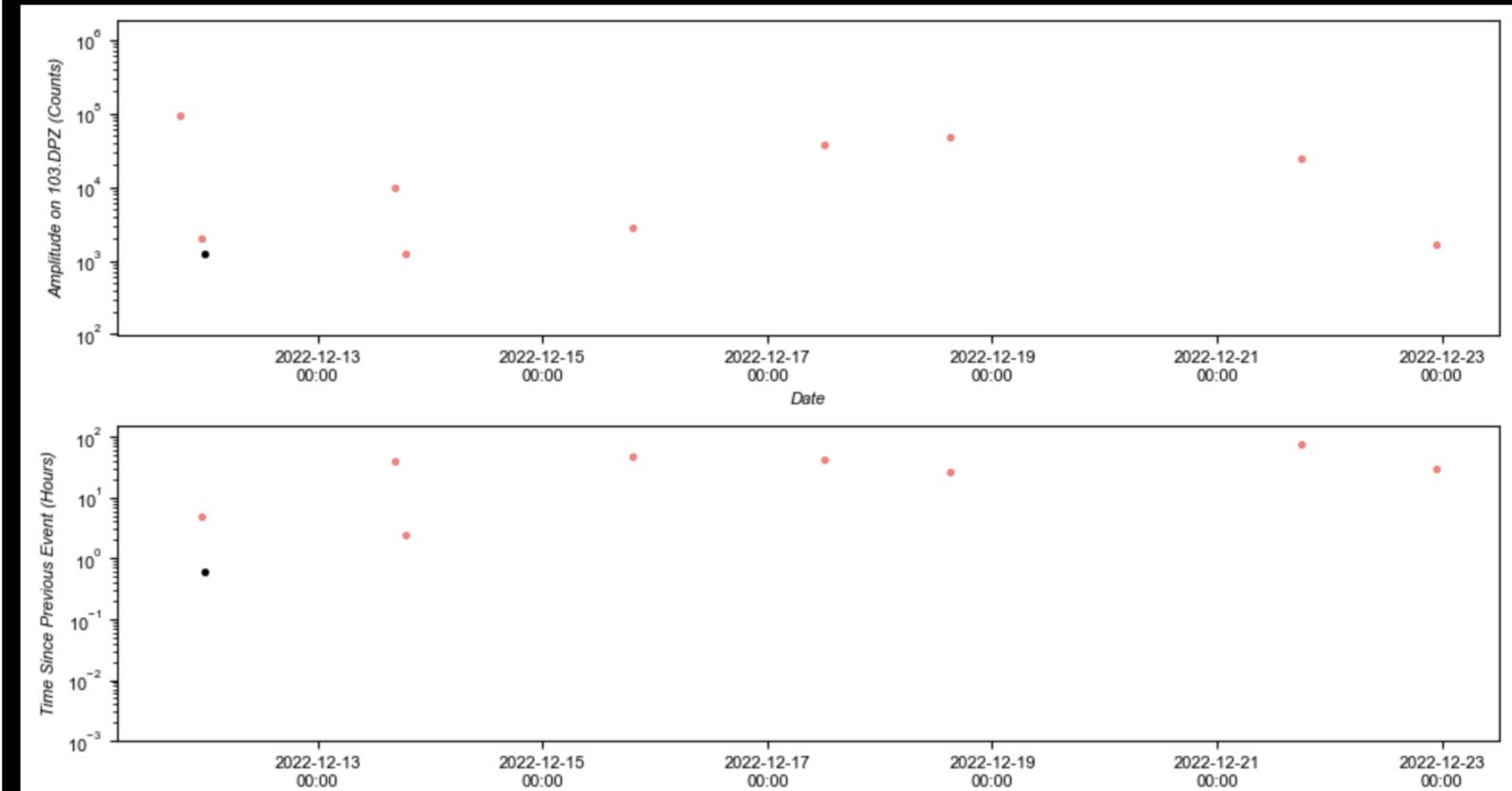
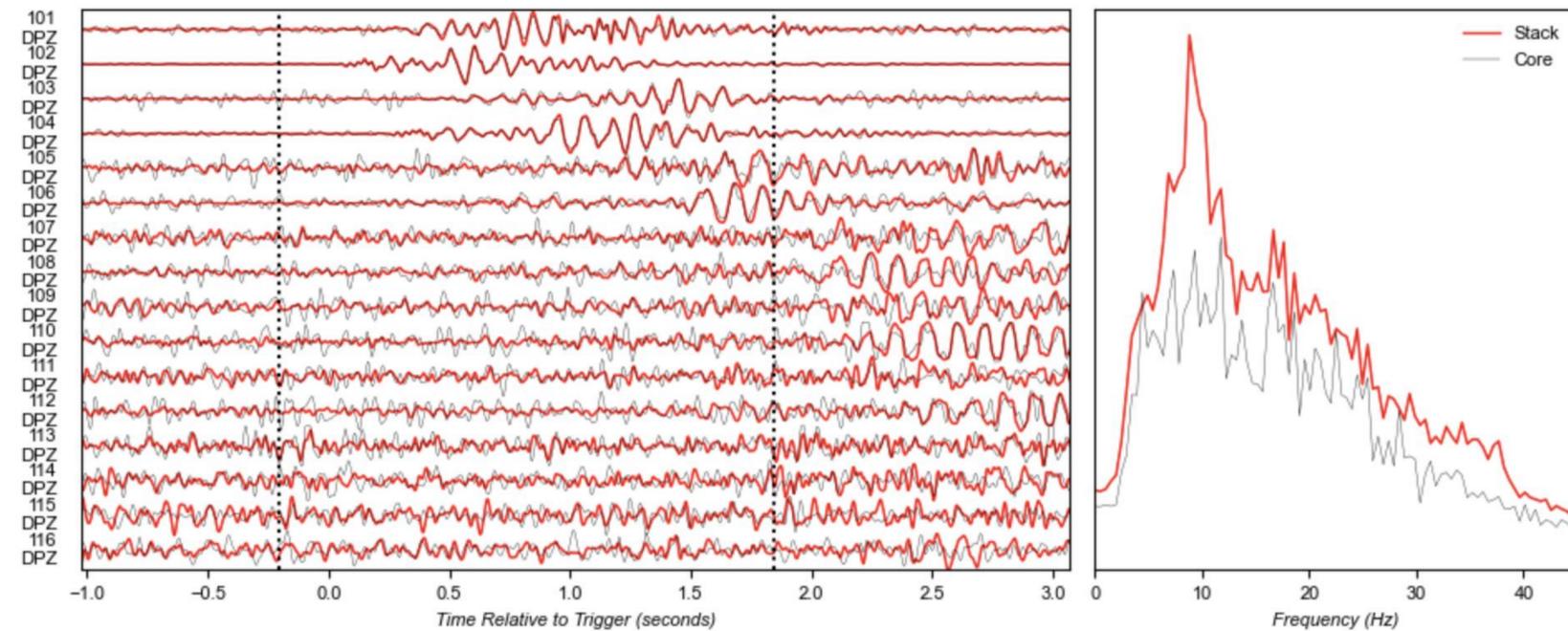
Repeating events and their families

Family 18



Number of events: 10
Longevity: 11.17 days
Mean event spacing: 29.80 hours
Median event spacing: 28.89 hours
Mean frequency index: 0.28

First event: 2022-12-11T18:32:43.258000
Core event: 2022-12-11T23:58:06.162000
Last event: 2022-12-22T22:44:04.476000











				7	8	9	10	11	12	13	14
U.S.L. Cary L.	talk 1930	1500 Nikko	0900 Flight org. Zoom								
1530 Madeline Pasoral	0900 James R242	GPS UNAVCO 1630 Scott's Base									
✓	✓	✓	✓								
			MH House Morse Trash								

7	18	19	20
	Departure		Departure

謝謝
謝謝

Day
8/21
巫凱
班



Thank you!





**WHAT I ATE IN A
MONTH IN
ANTARCTICA**