Air-droppable geodetic-seismic ice penetrator for response studies of Antarctic ice shelves to ocean forcing

– **MIT Haystack**: Pedro Elosegui, Mike Hecht, Eryl Derome, Chris Eckert, Jason SooHoo, Ganesh Rajagopalan, and others

– **MIT AeroAstro**: Jeff Hoffman, Charlotte Lowry, Andy Guatemala, German Prieto (EAPS), and many others

In memoriam Gordon Hamilton

MIT HAYSTACK OBSERVATORY

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Research project in a nutshell

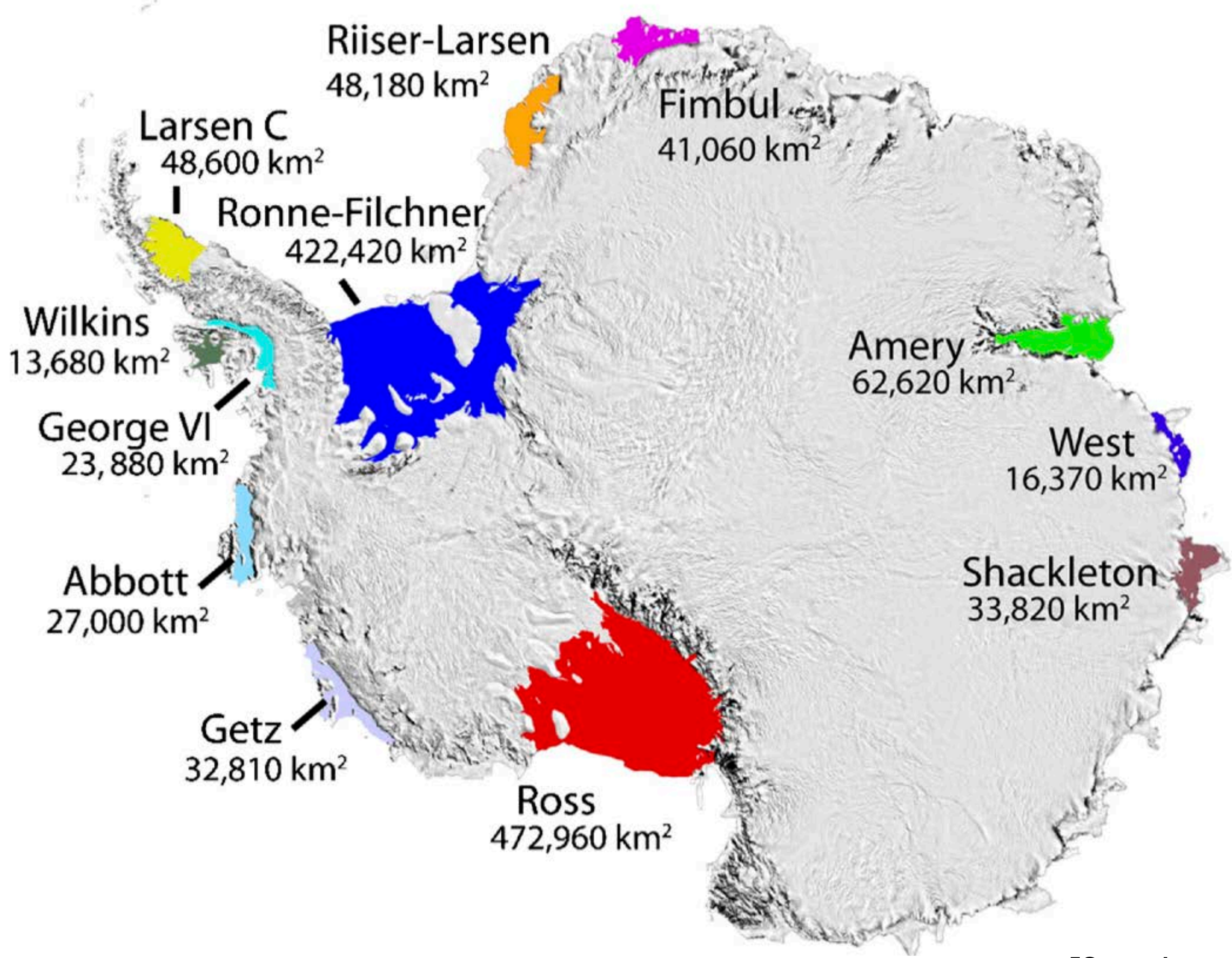
Address the question(s):

- What is the response of the Antarctic ice shelves to the ocean wave field?

- What technologies can be developed to best describe the relevant properties?

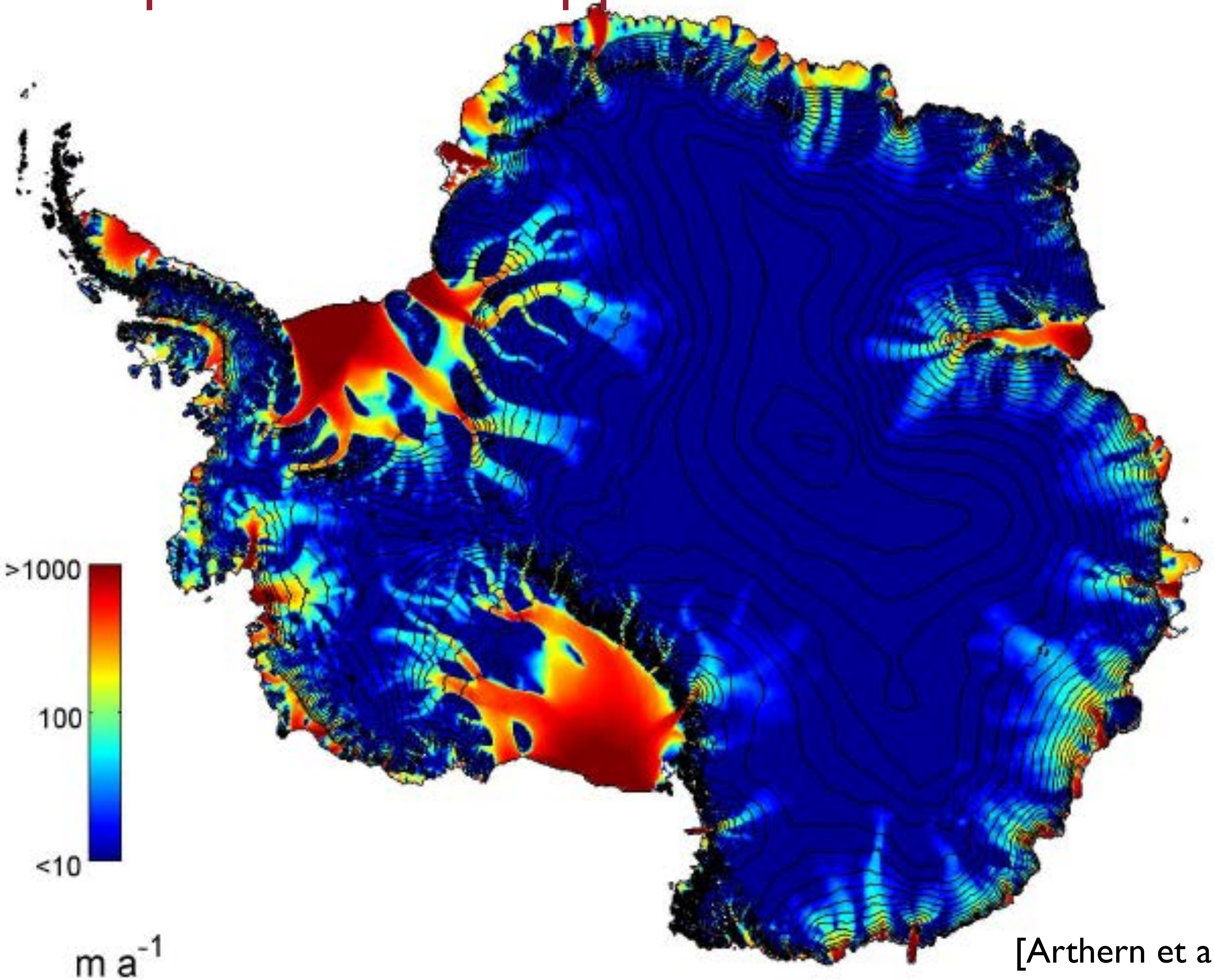
"Science through technology innovation"

Antarctic Ice Shelves



[Scambos et al., 2007]

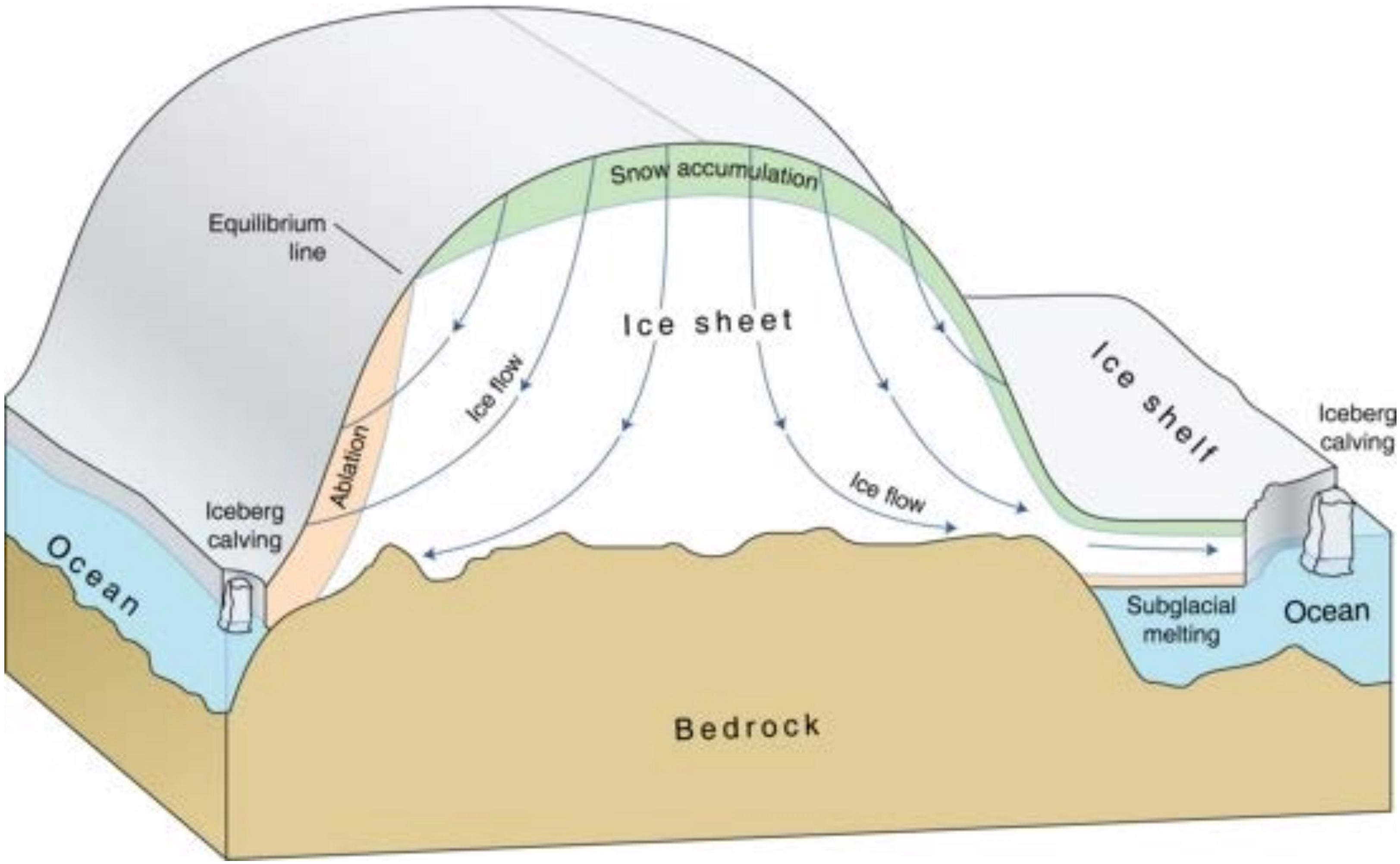
Flow Speed at the Upper Surface



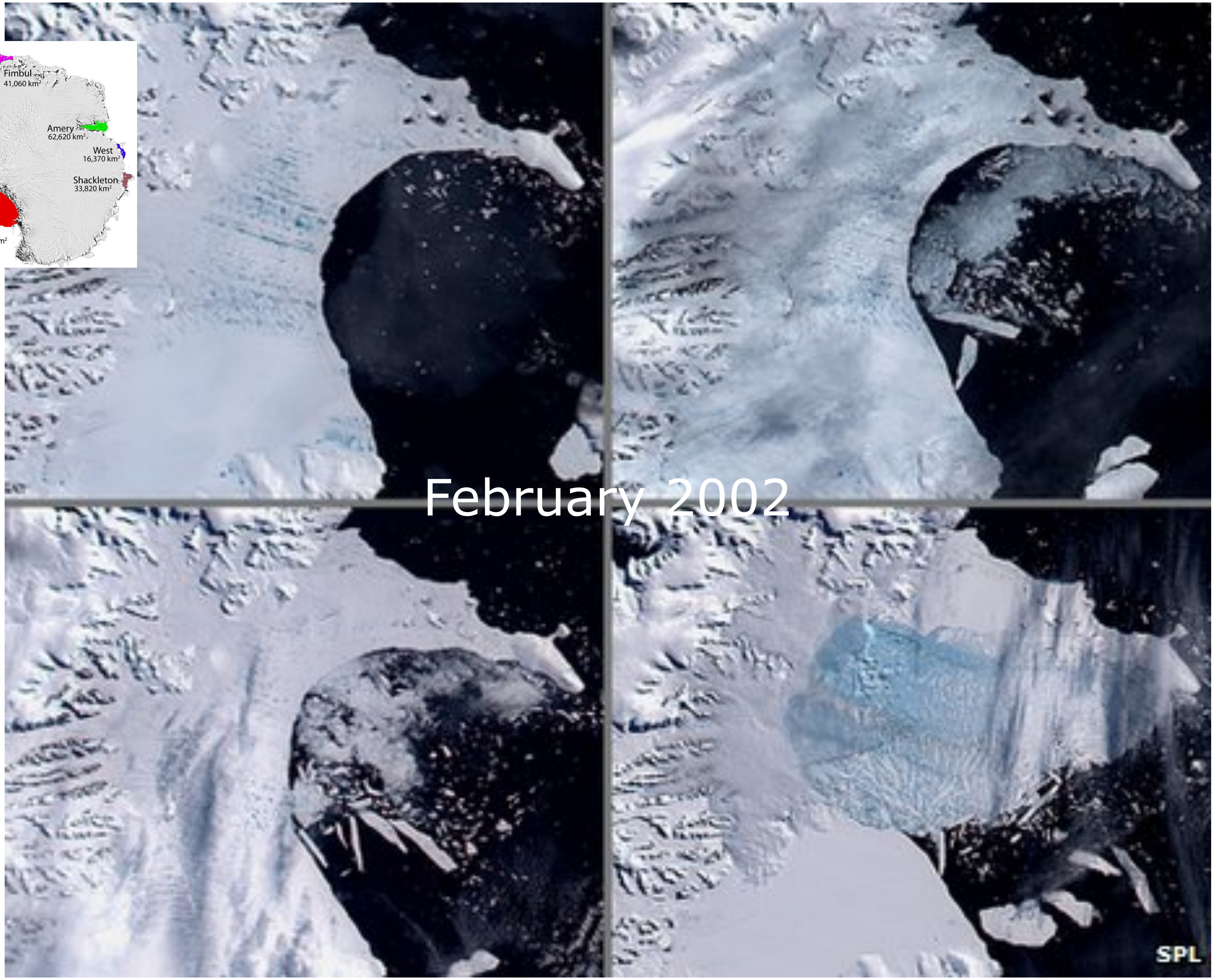
[Arthern et al., 2015]

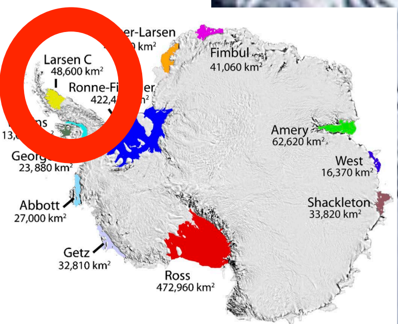
Antarctic Ice Cartoon:

ice sheet, ice streams, glaciers, ice shelves, icebergs, …

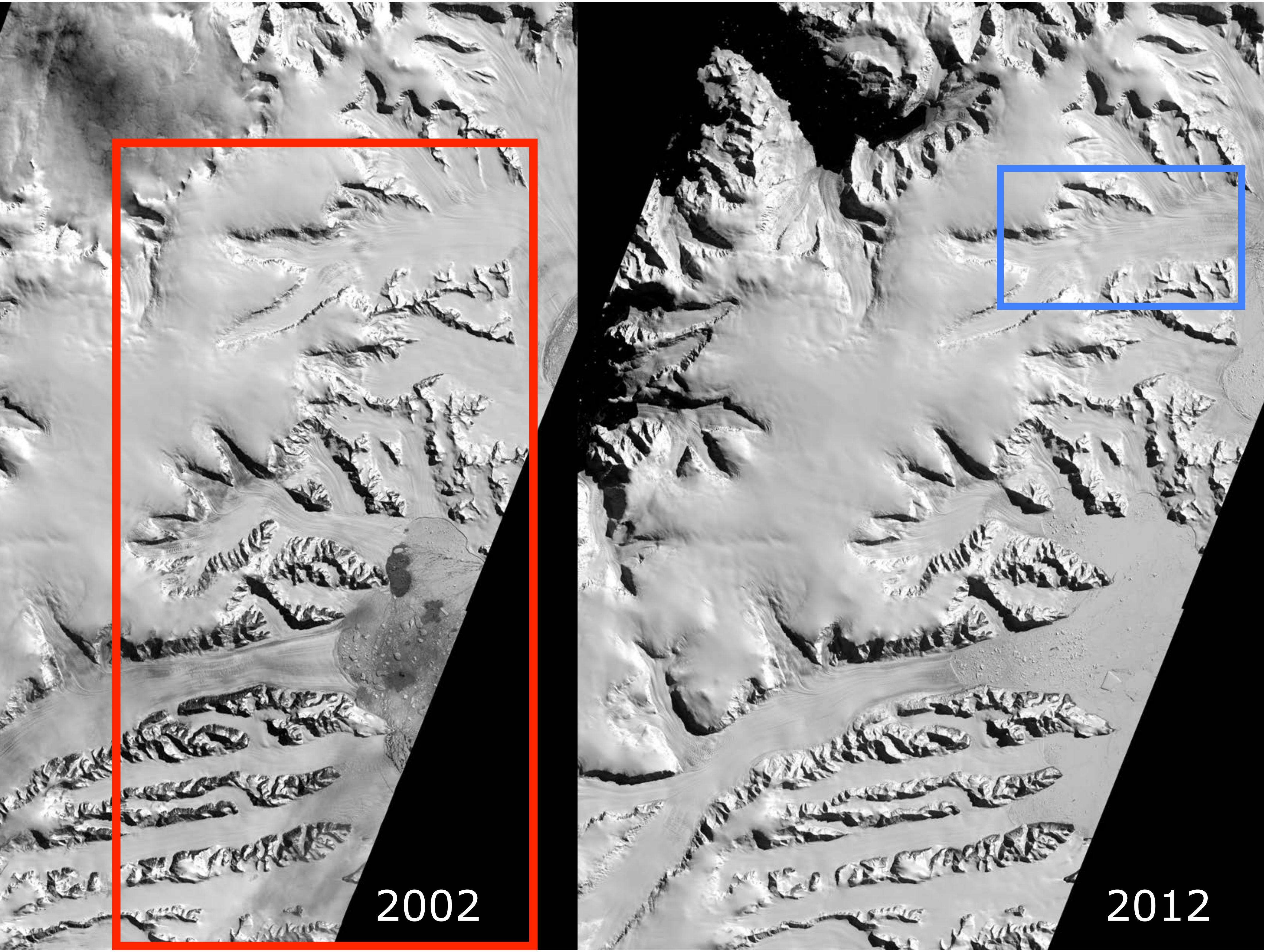


Collapse of the Larsen B Ice Shelf

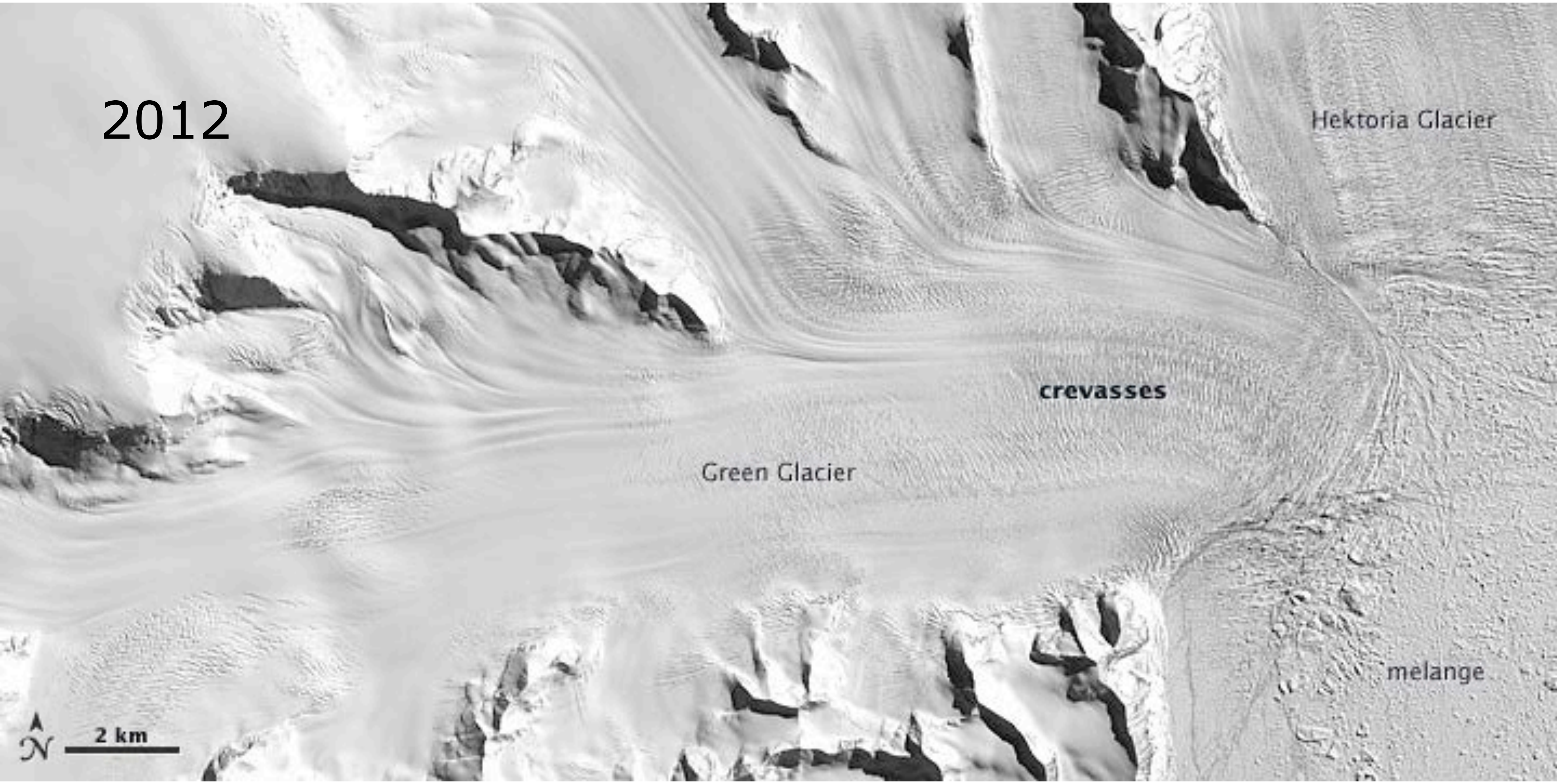




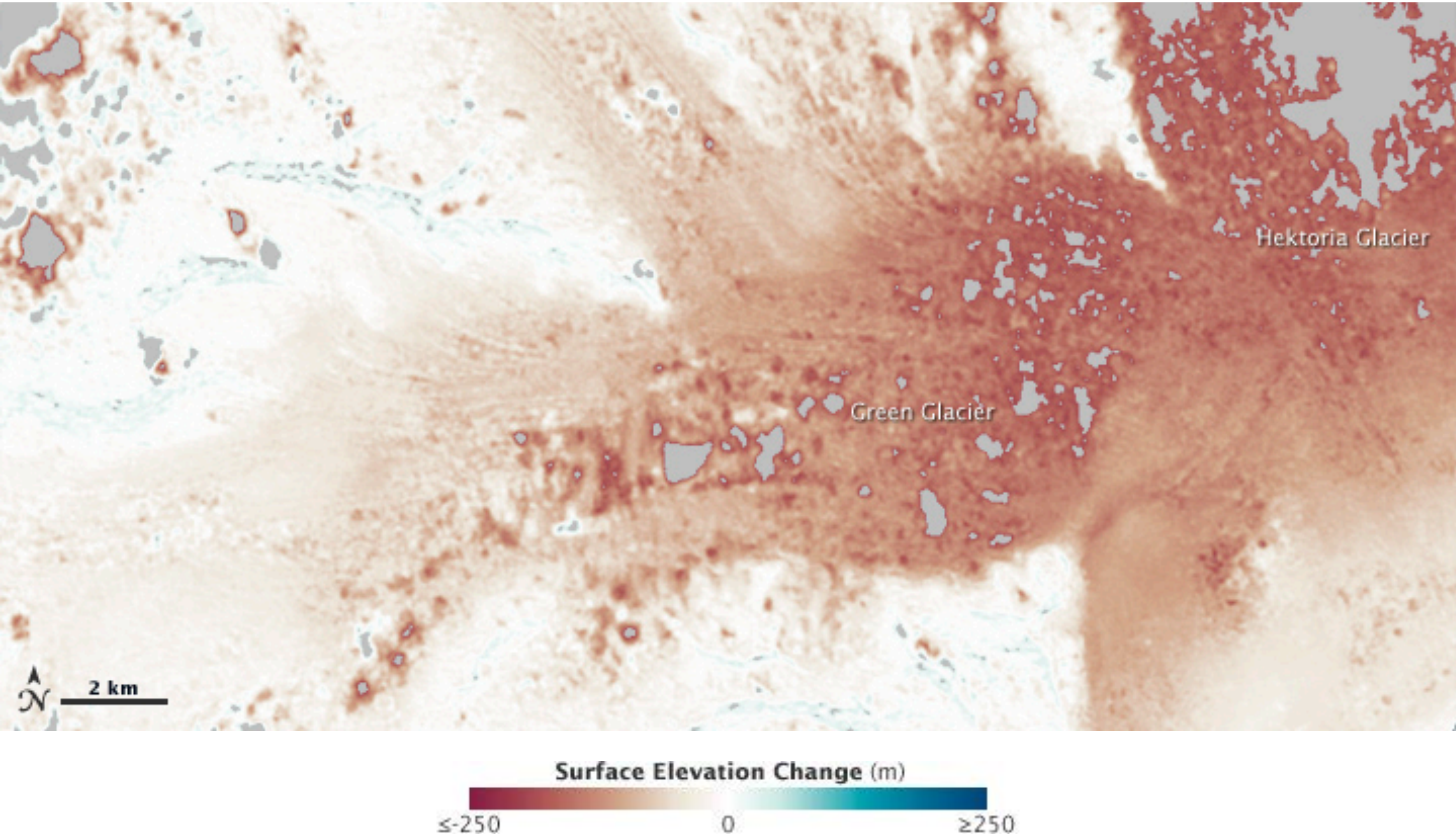
Collapse of the Larsen B Ice Shelf


2002
2012

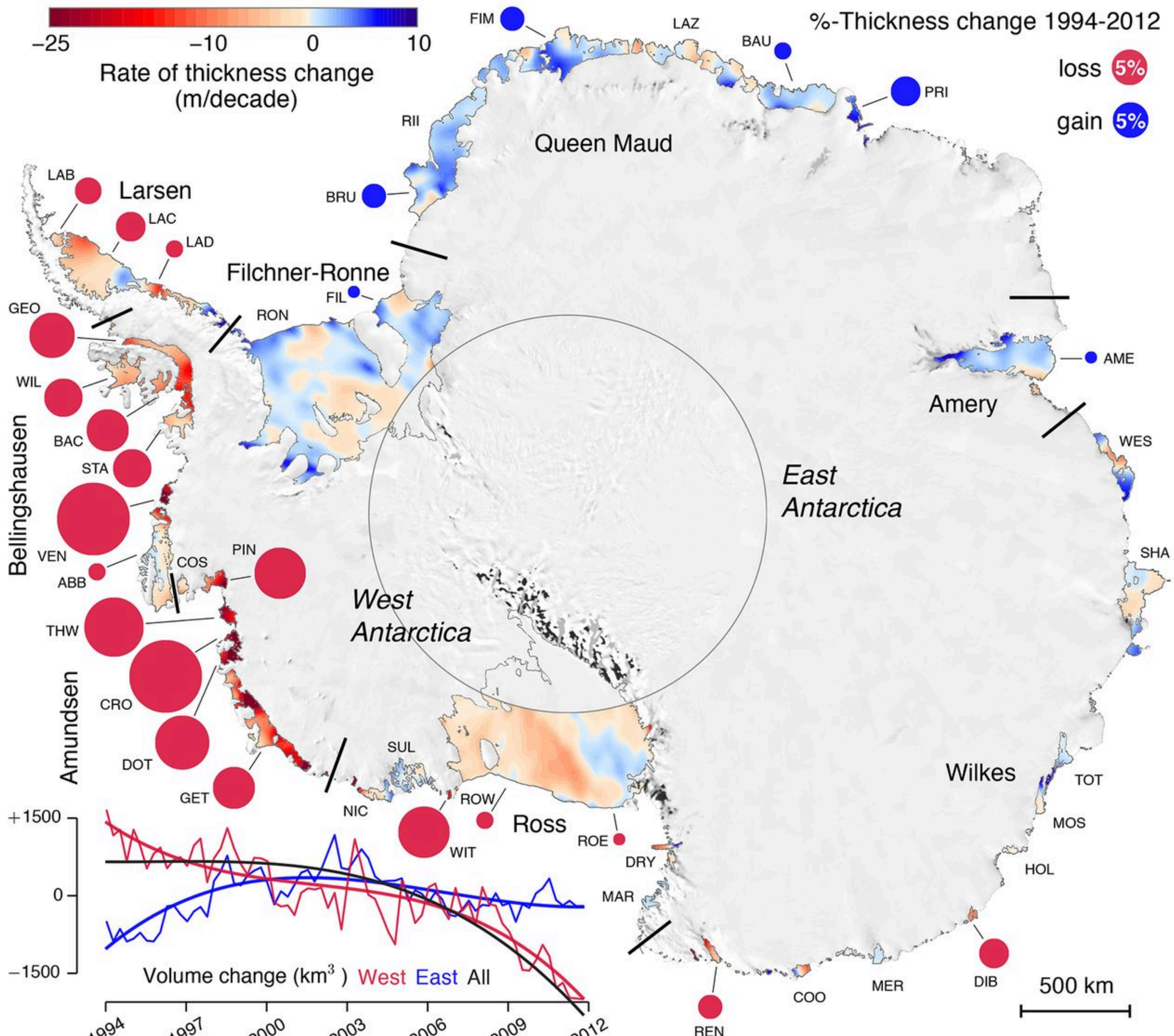
Collapse of the Larsen B Ice Shelf: Glacier Impact



Collapse of the Larsen B Ice Shelf: Rapid Glacier Thinning and Stretching



Accelerating Antarctic Ice Shelves Volume Loss



[Paolo et al., 2015]

An accurate Terrestrial Reference Frame is key

Next Generation VLBI = VGOS

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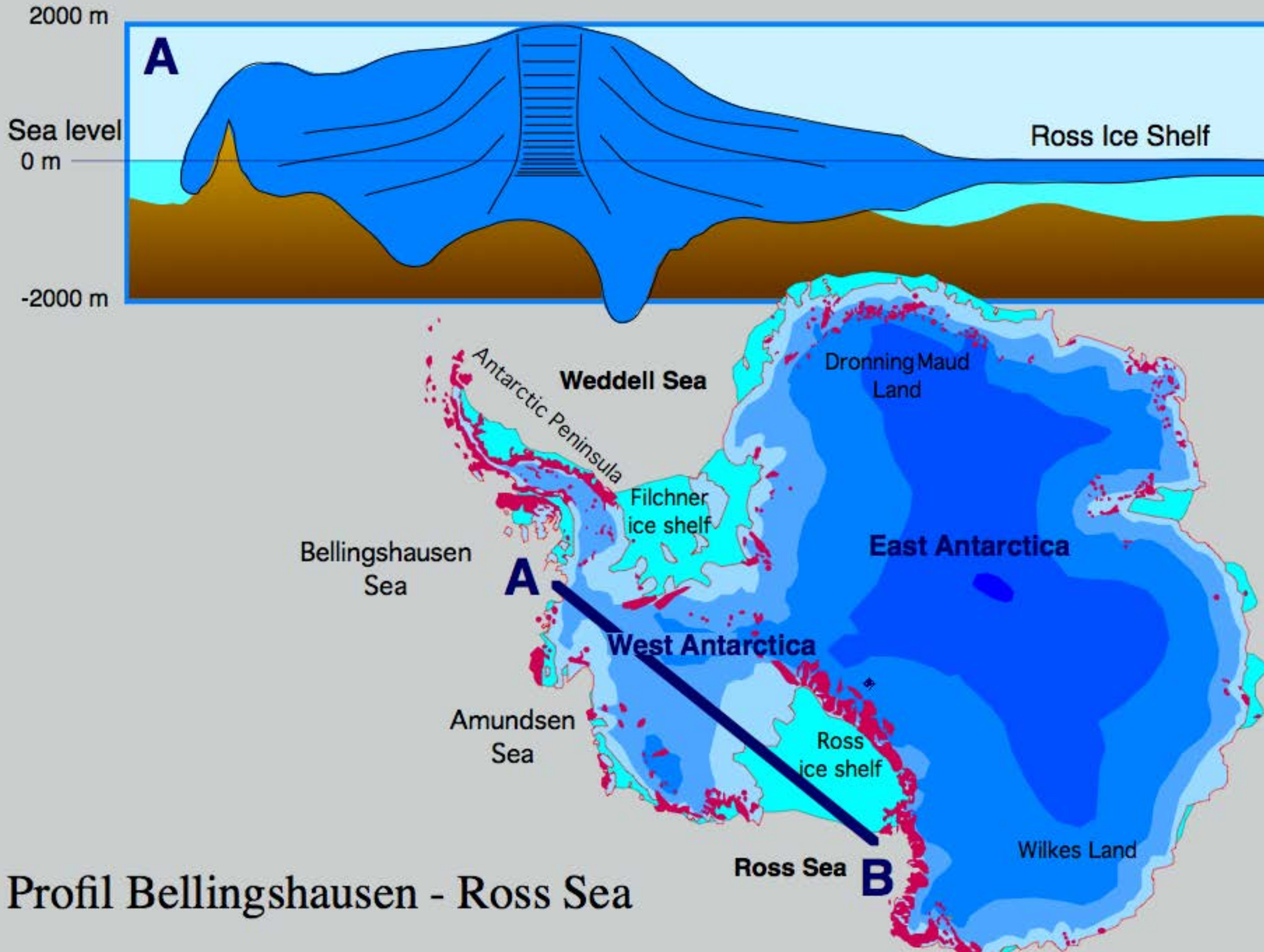
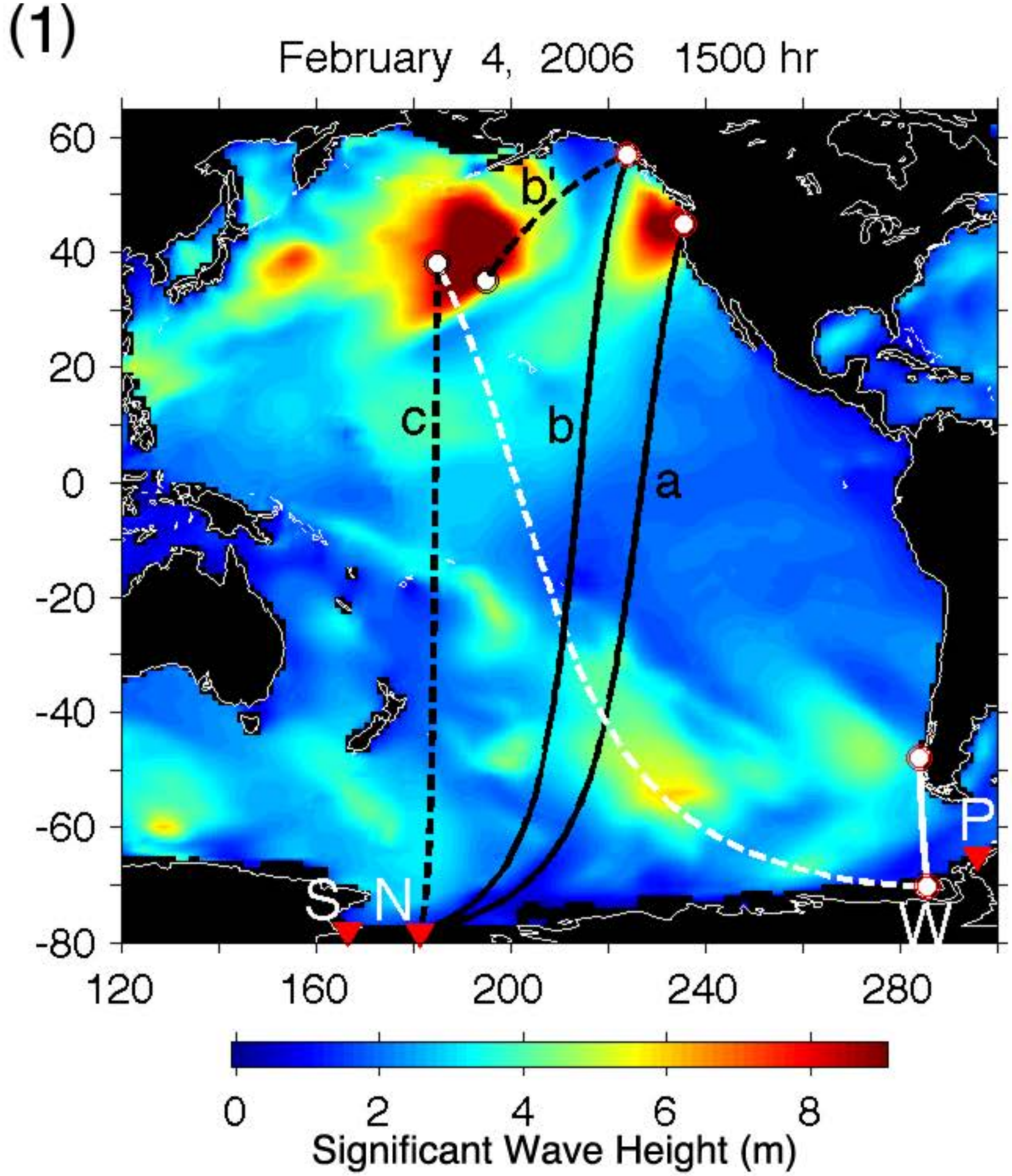
Antarctic ice sheet and ice shelves



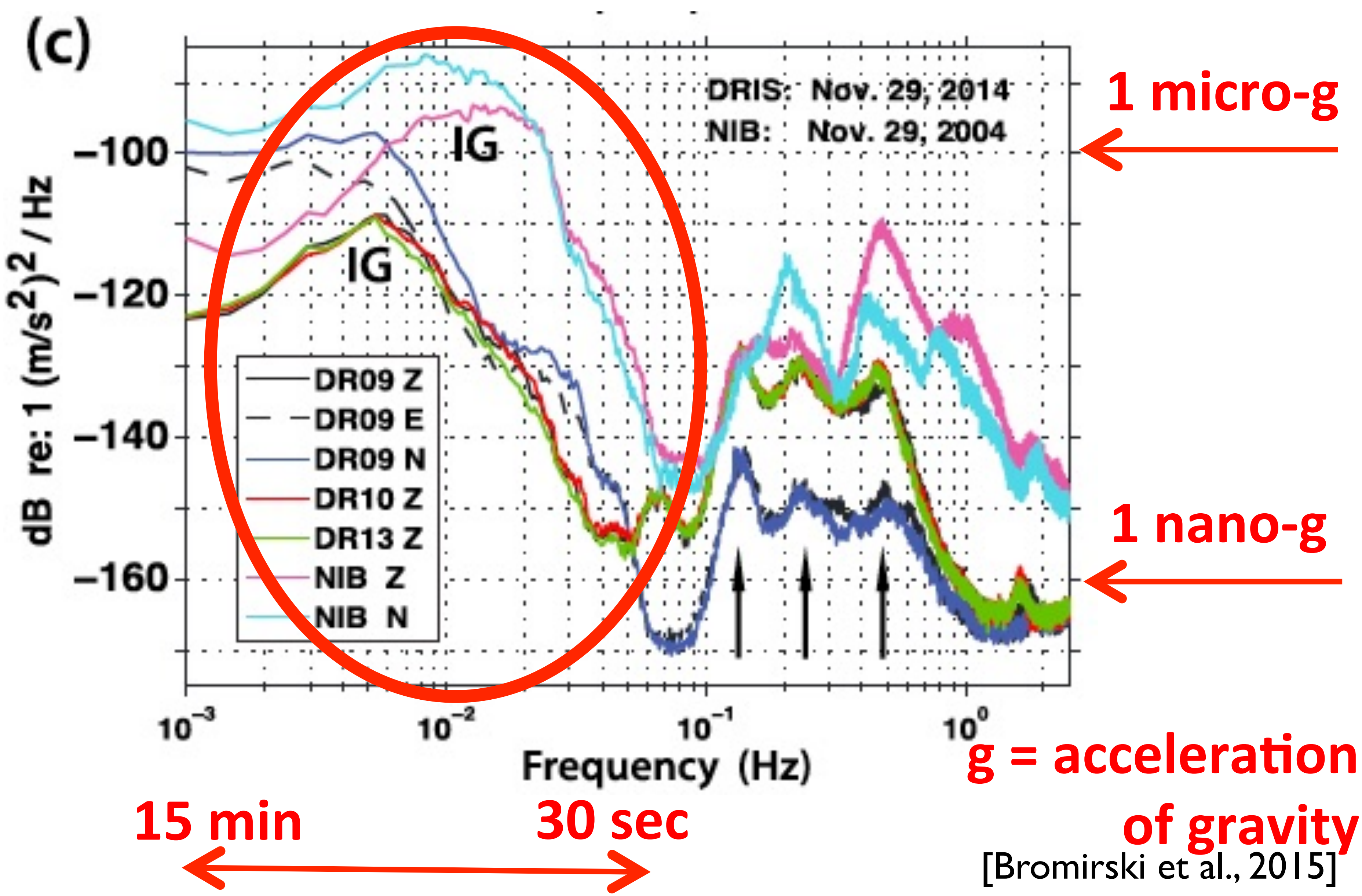
[Grobe, CreativeCommons]

Transocean Long-period Infragravity Waves



[MacAyeal et al., 2010]

Example of Infragravity Waves



[Bromirski et al., 2015]

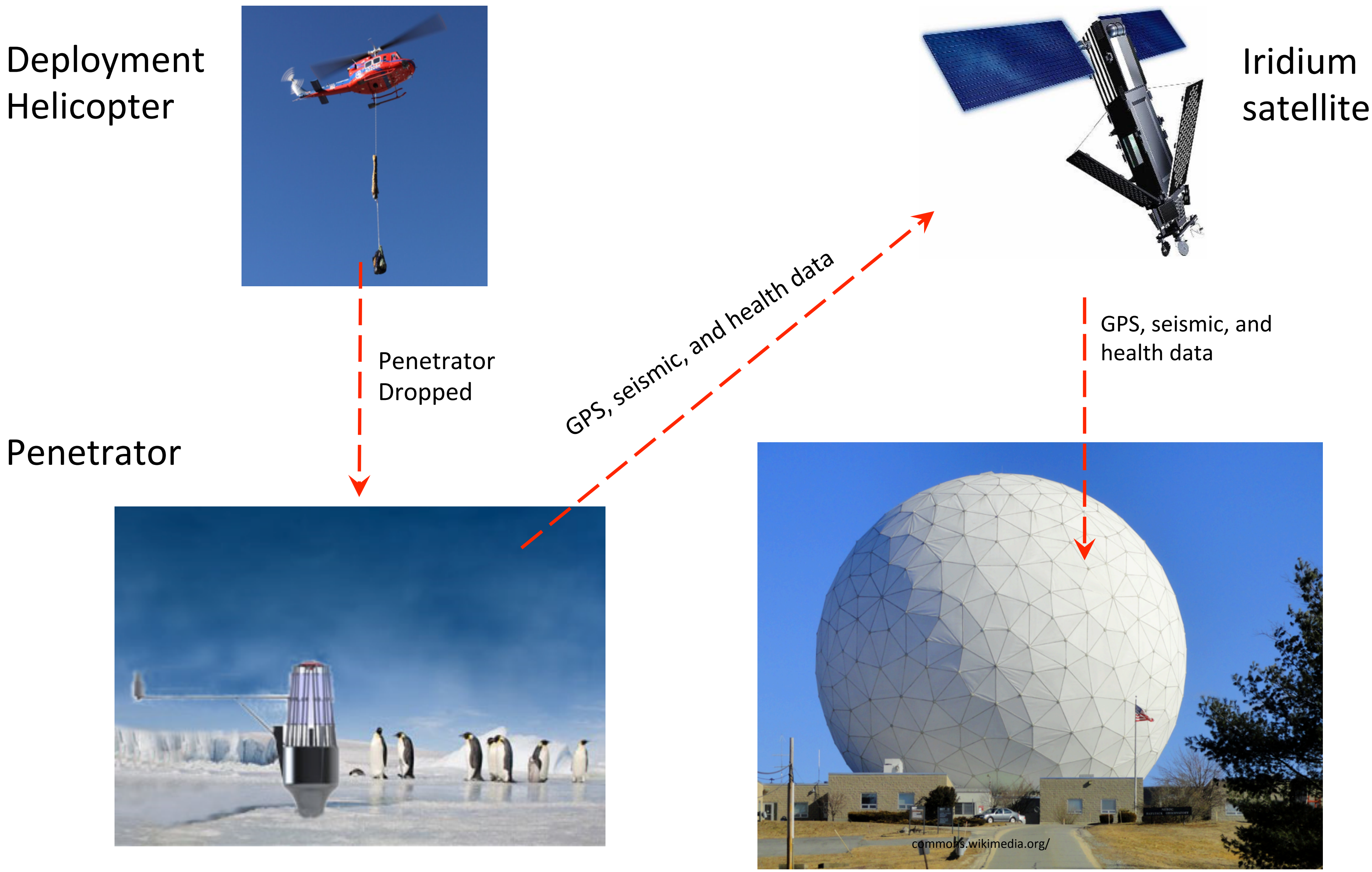
Geodesy and Seismology on the Ross Ice Shelf

[Image: Harrigan and Sergienko]

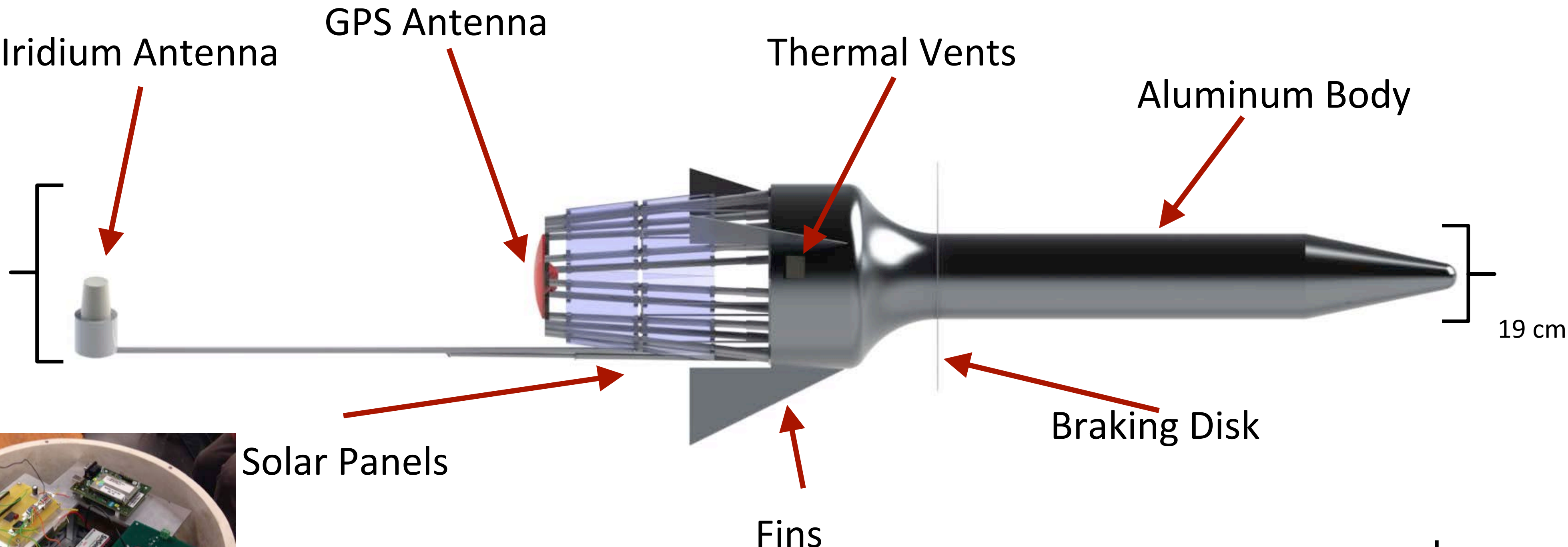
So what do we need?

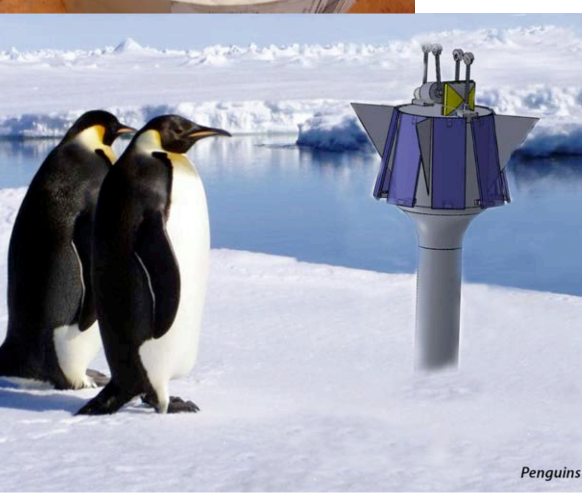
- Collect continuous geodetic and seismic observations to monitor the response of ice shelves to ocean forcing
- Package the sensors into an instrument that can be air dropped to the hard-to-land, inaccessible, unsafe polar marine environment
- Operate autonomously for extended periods with near-real time two-way communications for science and engineering data download and control

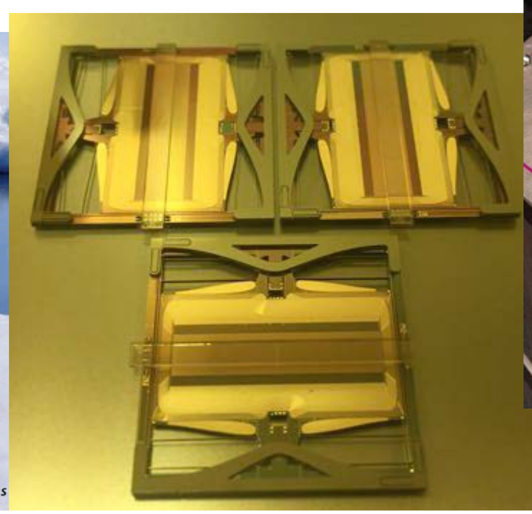
Geodetic-Seismic Ice Penetrator Concept



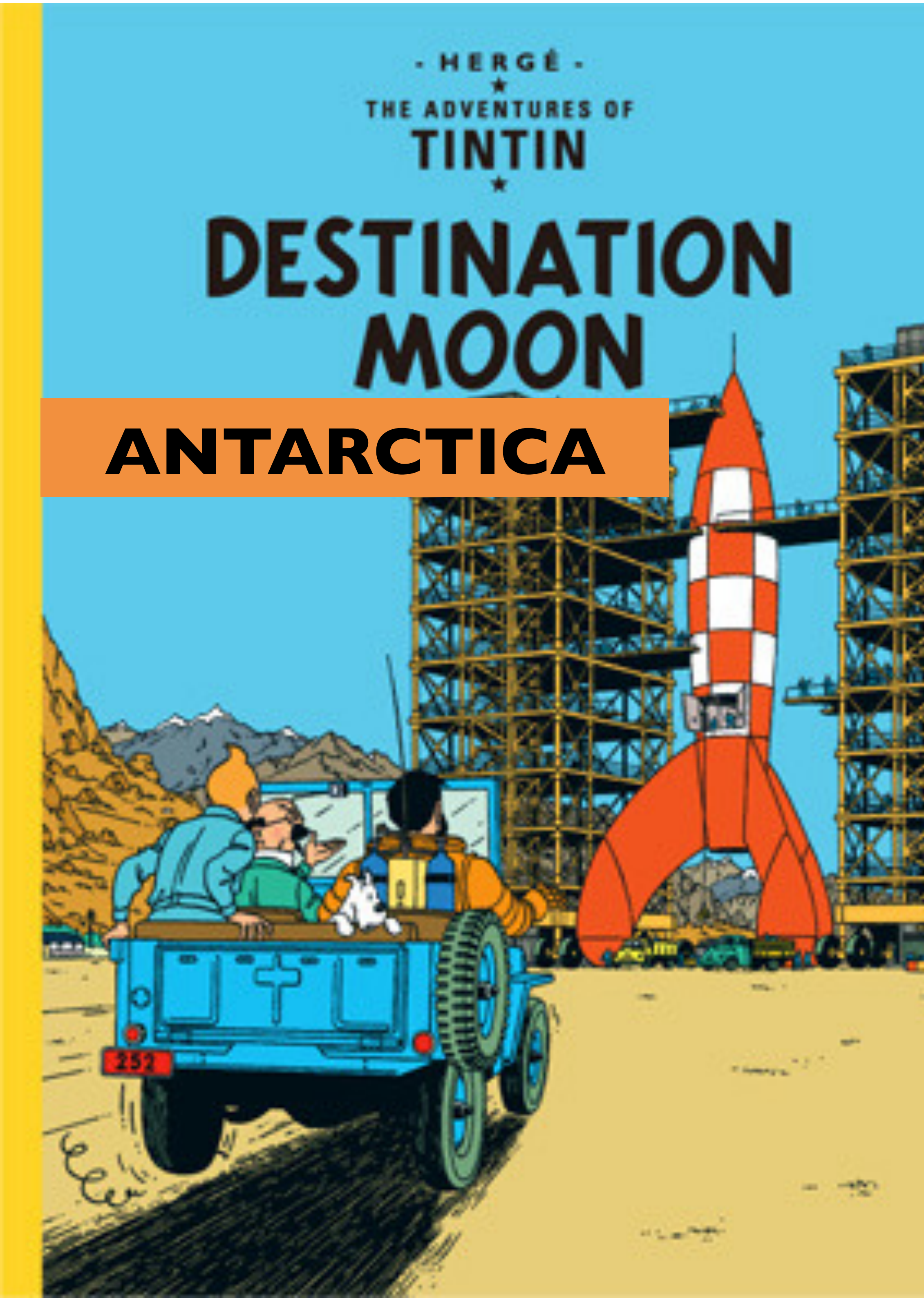
MIT AeroAstro Capstone Course
Space Penetrators








FAIRGATE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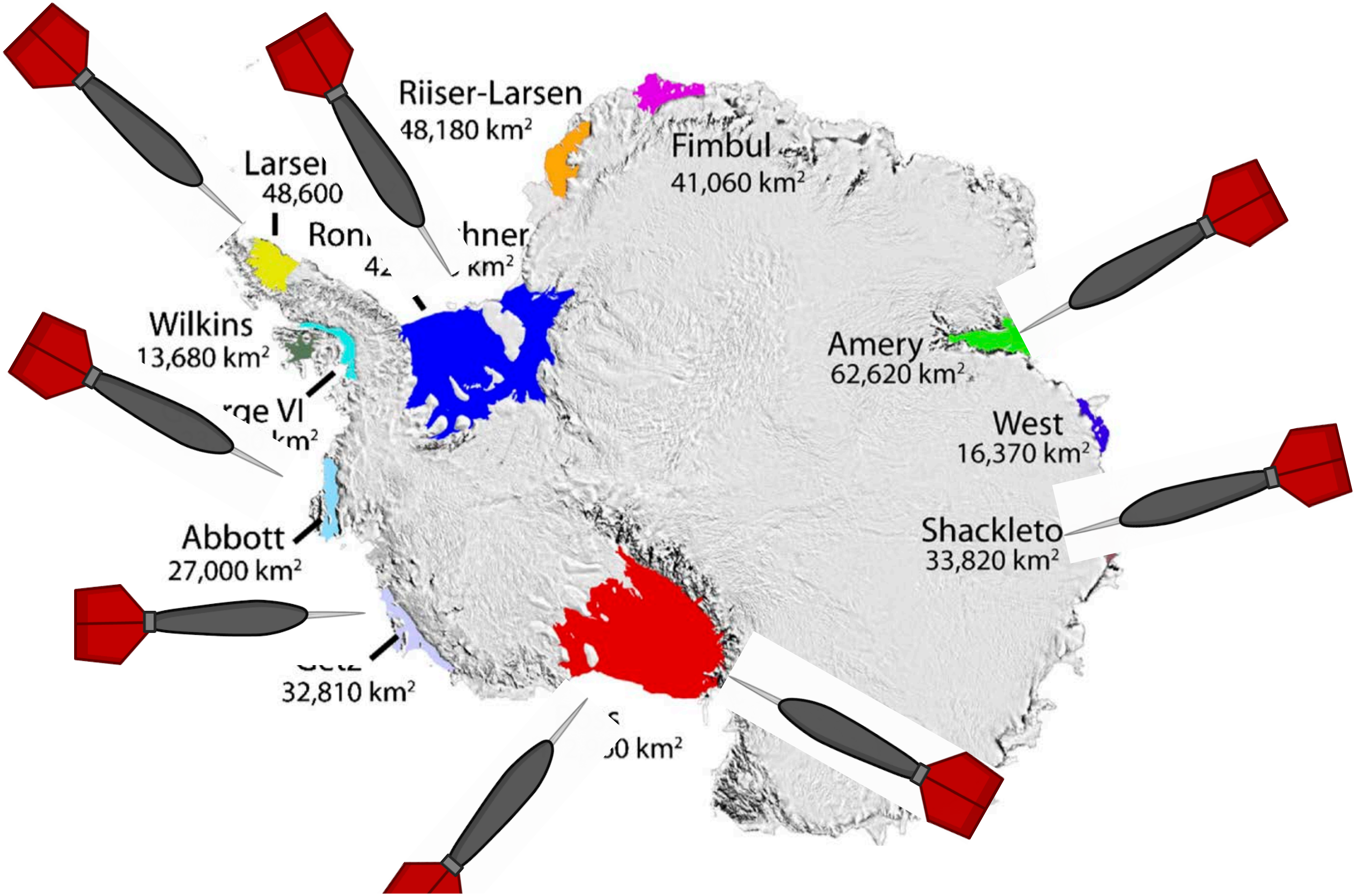
HAYSTACK OBSERVATORY

Long-Term Vision:
Antarctic ice Shelves Monitoring Observatory (ASMO)

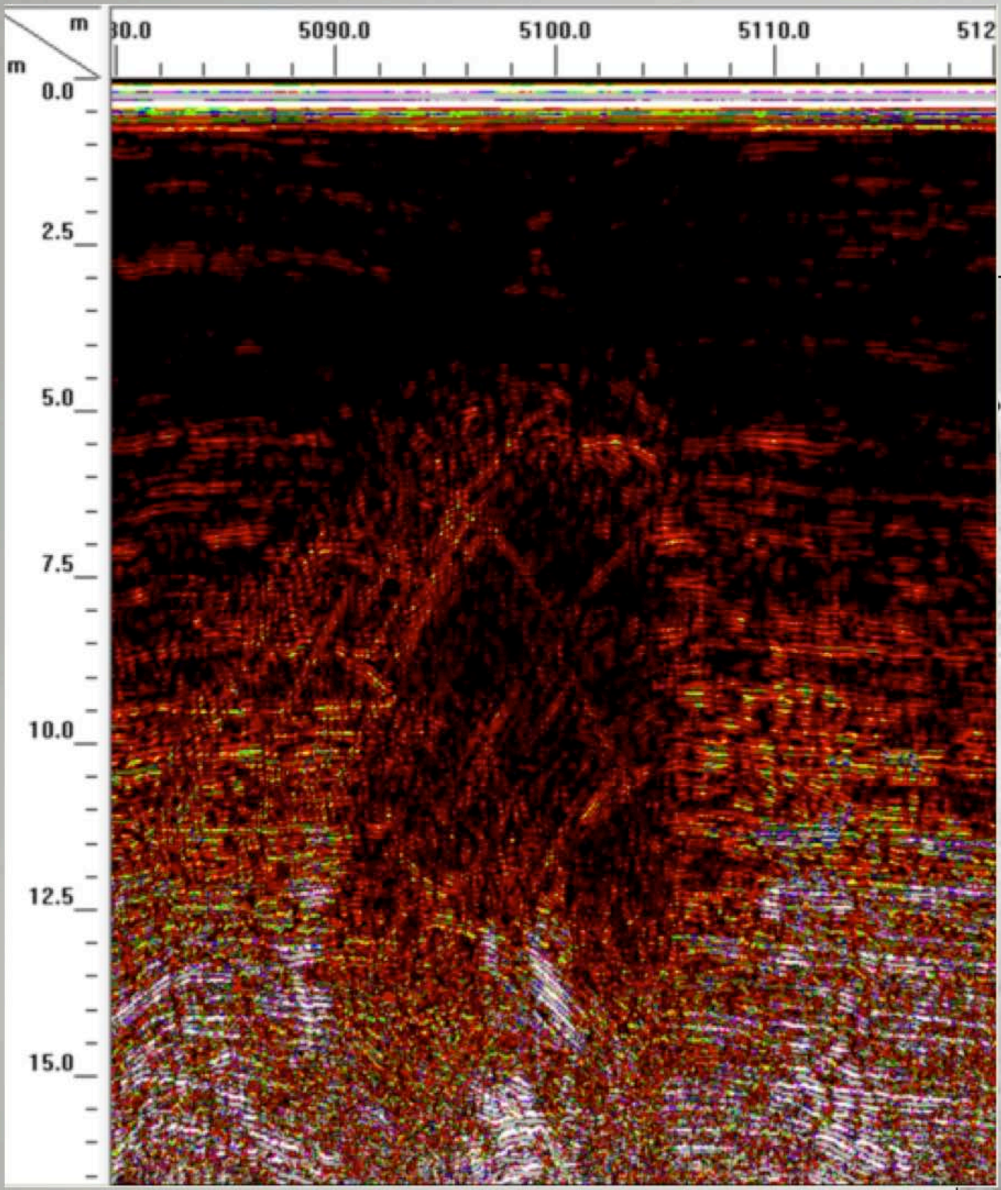


Great Progress but … TO DO?

- Pretty much everything

- Demonstrate:
  - seismic sensor performance
  - autonomous science operations
  - penetrator drop-ability
  - instrument survivability

In memoriam Gordon Hamilton



[Arcone et al., 2016]