Antarctic landfast sea ice: Why it matters, what we know, and what's missing?

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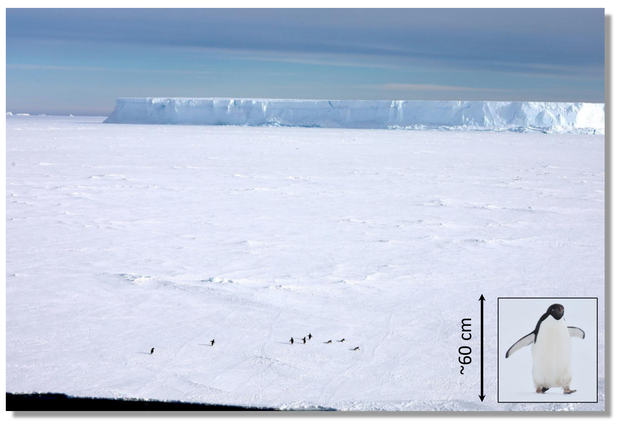
"The physics team" from forthcoming review paper: "Antarctic landfast sea ice: Physical, biogeochemical and ecological significance", to be submitted to *Reviews of Geophysics*, Sept 2022

"Landfast sea ice: Sea ice that is fixed horizontally

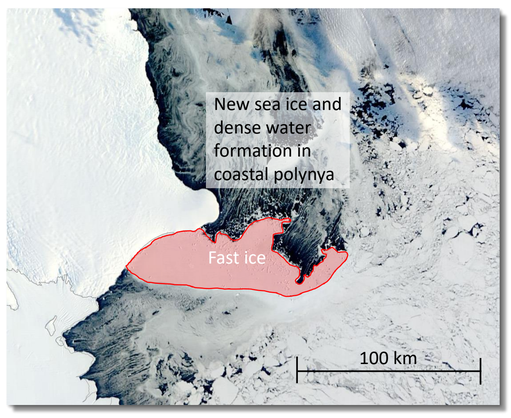


"Fast ice" remains horizontally stationary and attaches to the coastline or grounded icebergs.

Photo credit: Linda Welzenbach and Sarah Slack

"Fast ice is crucially important for various coastal processes

- Controls sea ice production in adjacent coastal polynyas (**drives global thermohaline circulation**)
- Provides a **stable breeding habitat for Emperor penguins**
- Forms a **reservoir of freshwate**r
- Releases accumulated iron into the upper water column during breakout, **fertilizing the Southern Ocean**
- **Isolates the ocean** from wind-induced stress
- Harbours and **promotes ice algae**
- **Stabilises ice shelves** and glacier tongues against breakout
- **Provides runways for aircraft; impedes shipping**

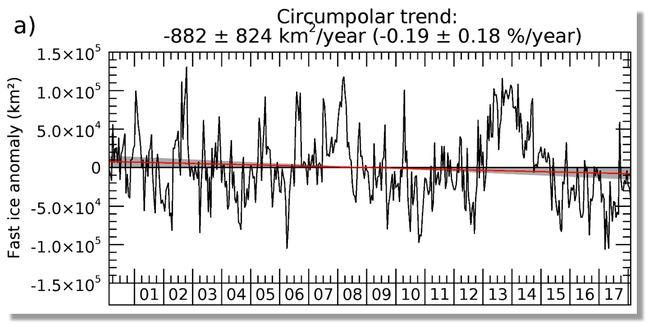


Satellite image: NASA MODIS

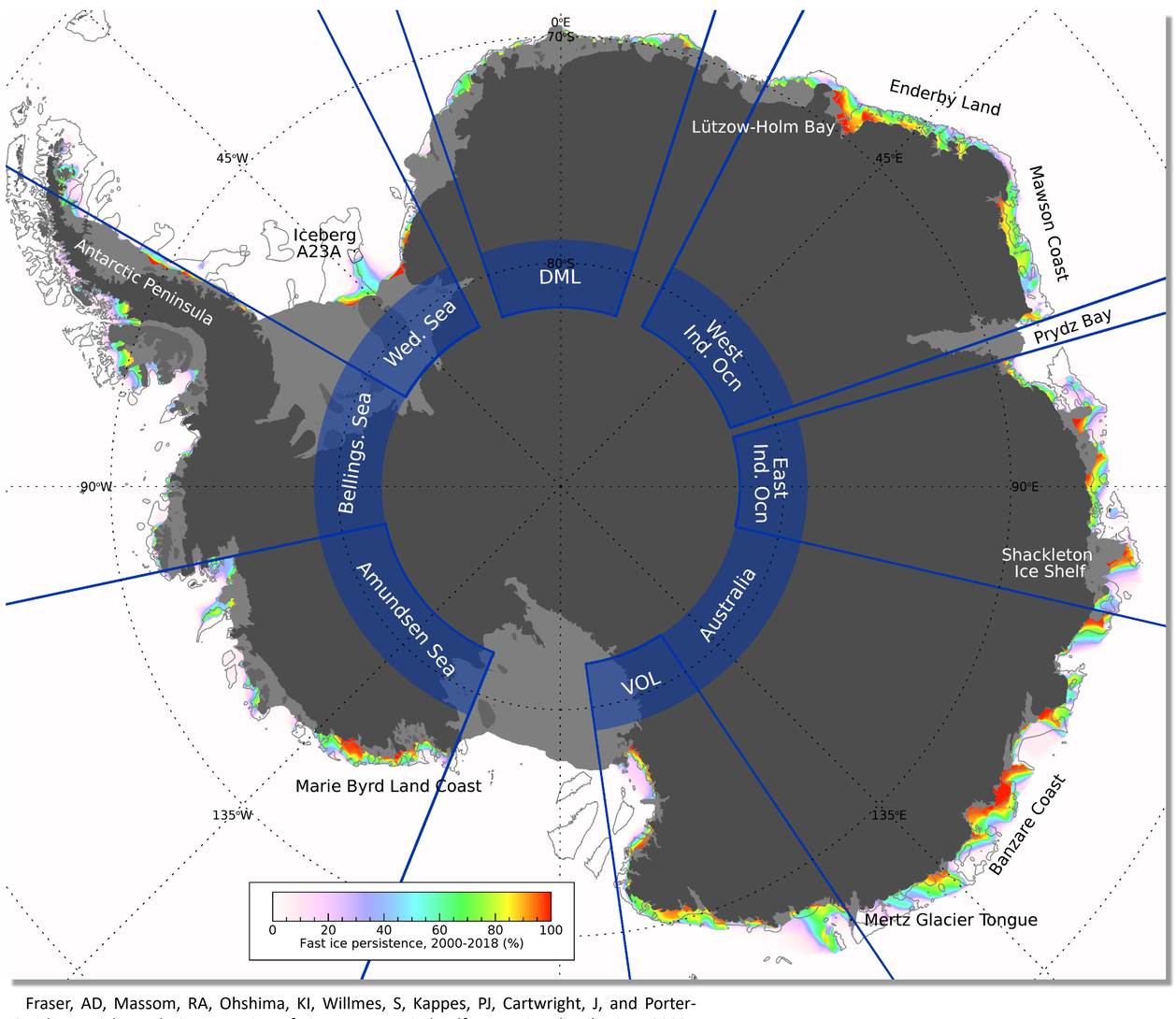
"A new fast ice dataset allows circum-Antarctic analysis of extent, distribution, variability

New dataset (Fraser et al., 2020):

- Longest time series (2000 to 2018)
- High resolution (15 days, 1 km)
- Published methodology
- Suitable for a variety of uses
  - Climate analysis, case studies
- Dataset reveals marginal decrease in fast-ice extent, strong regional variability



Figures above and below: Fraser et al. (2021)



Fraser, AD, Massom, RA, Ohshima, KI, Willmes, S, Kappes, PJ, Cartwright, J, and Porter-Smith, R: High-resolution mapping of circum-Antarctic landfast sea ice distribution, 2000–2018, *Earth Syst. Sci. Data*, 12, 2987–2999, 2020.

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Giles, AB, Massom, RA and Lytle, VI. Fast-ice distribution in East Antarctica during 1997 and 1999 determined using RADARSAT data. *Journal of Geophysical Research: Oceans*, 113(C2), 2008.

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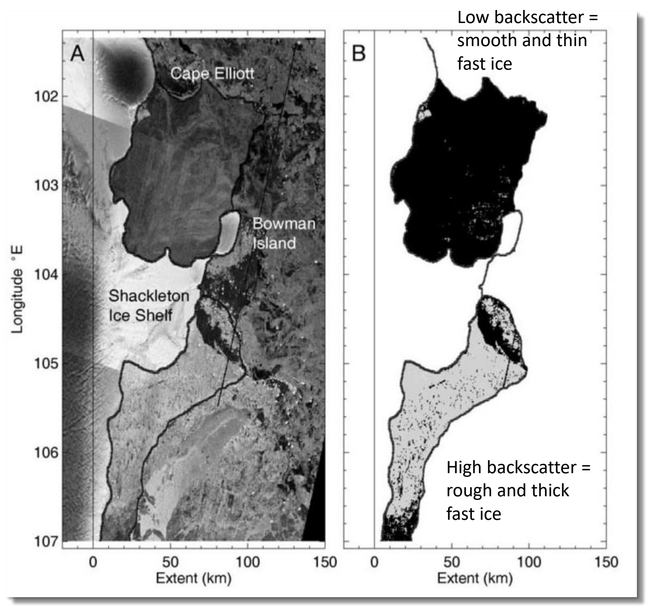
"New knowledge of distribution, but many gaps remain

Still no large-scale knowledge of…

- Fast-ice thickness
- Fast-ice roughness
- Snow on fast ice

Remote sensing can provide these

Figure below illustrates how Synthetic Aperture Radar can remotely retrieve fast ice thickness via roughness proxy (Giles et al., 2008)

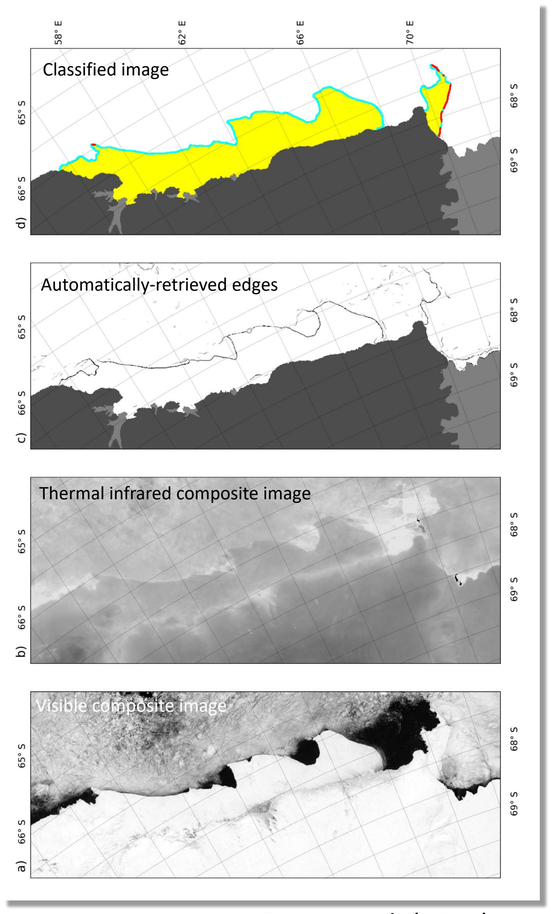


Giles et al. (2008)

Current dataset lacks…

- Objectivity (manual classification still needed)
- Frequent updates (2000-2018 only)

Figure below illustrates the semi-automated approach to fast ice edge retrieval used by Fraser et al (2020). Cyan edges are automatically-retrieved but red edges are manually chosen.



Fraser et al. (2020)

"We lack overall understanding of the drivers of Antarctic fast ice

- Drivers are complex and region-specific
  - A mix of oceanic and atmospheric drivers
  - Icebreaker passage can also cause fast-ice breakout
- Arctic measurement techniques yet to be implemented in Antarctica
  - Coastal radar (to study fine scale dynamics of fast ice attachment/breakout)
  - Studies of stability and microstrain (in situ and remote sensing-based)
- We need Antarctic fast ice to be prognostically modelled in high-resolution coupled ocean/sea ice models
  - Recent publications have incorporated fast ice for the first time (Huot et al., 2021; van Achter et al, 2022)
  - Accurate model representation of fast ice is essential for many coastal processes
  - Limited ability to project future fast ice extent without modelled fast ice
- Baseline knowledge of fast ice thickness, roughness and snow depth are lacking

The Australian Antarctic Program Partnership is led by the University of Tasmania, and includes the following partner agencies

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