Ocean-driven basal melt channels and the stability of Amundsen and Bellingshausen Sea ice shelves

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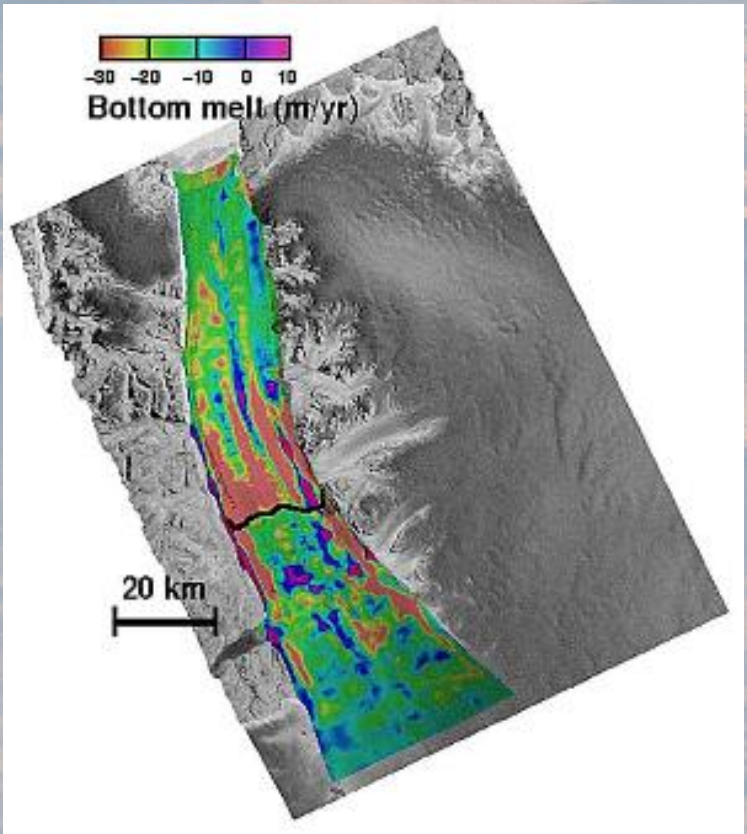
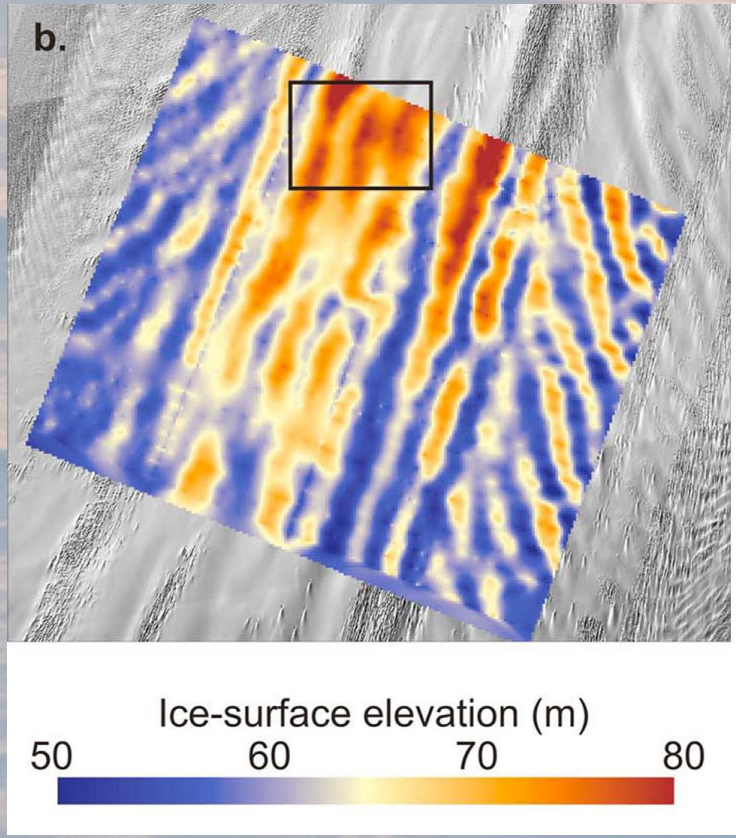
Funding:

Basal melt channels

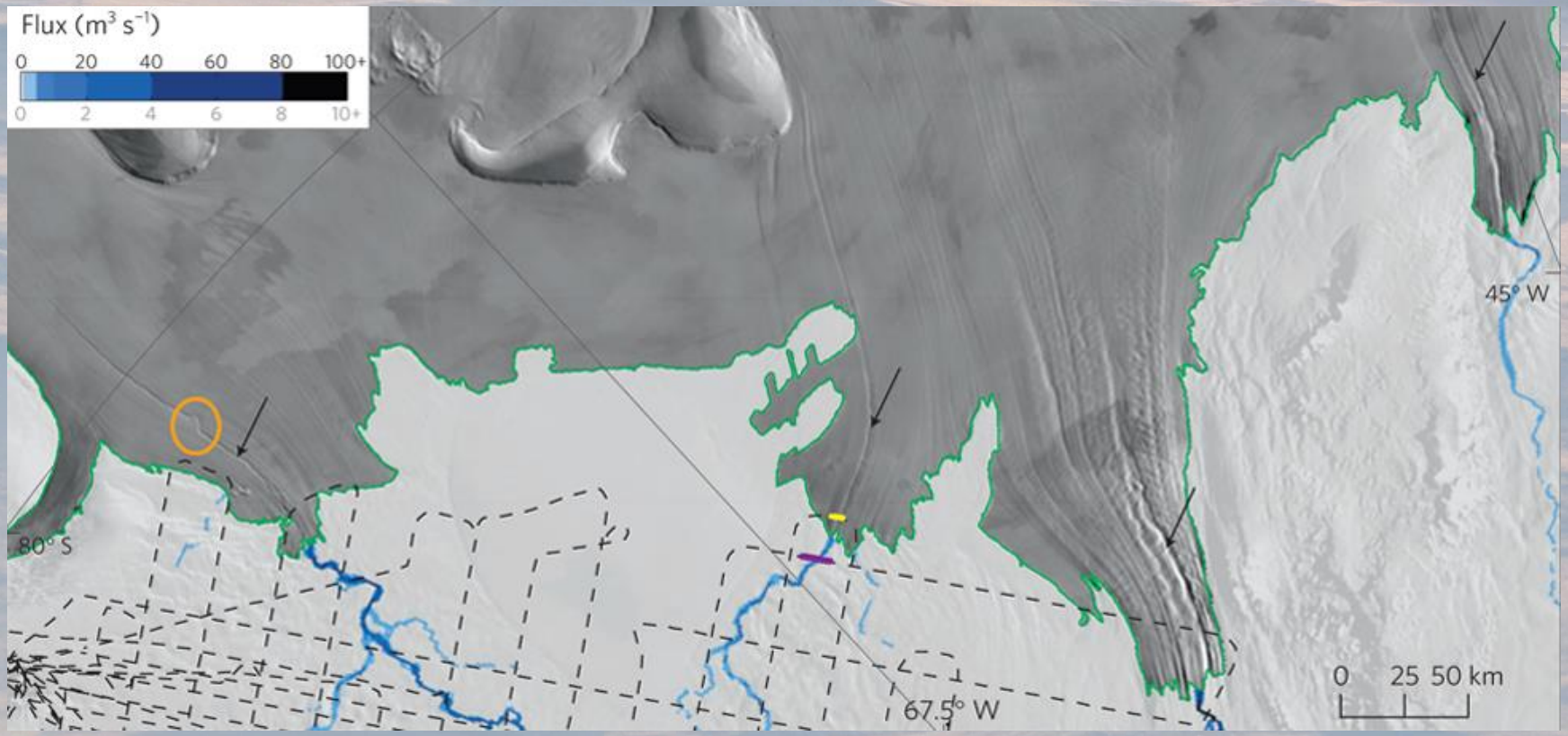
Petermann Glacier from Rignot and Steffen (2008)



Pine Island Glacier from Vaughan et al. (2012)



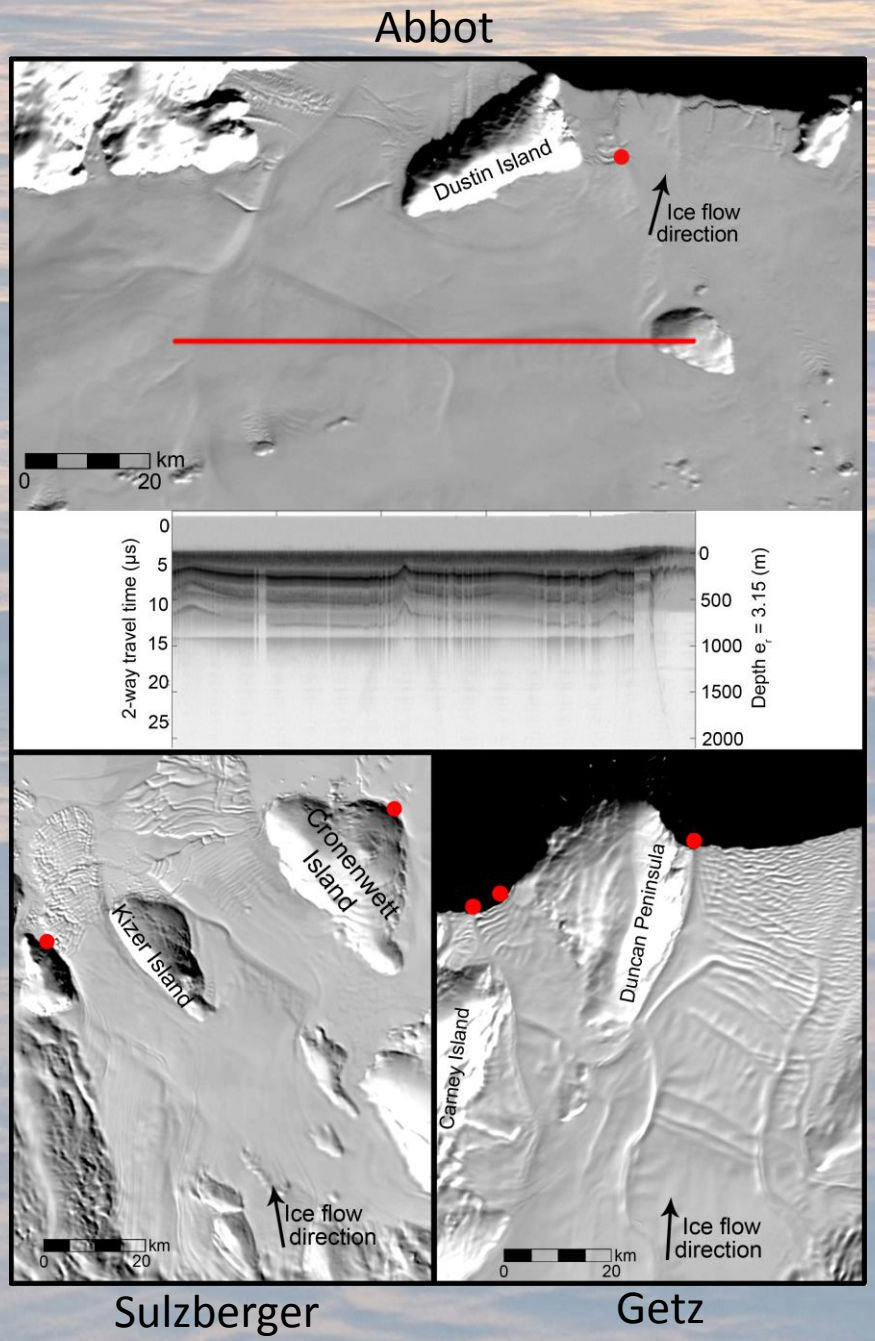
Meltwater-driven basal channels



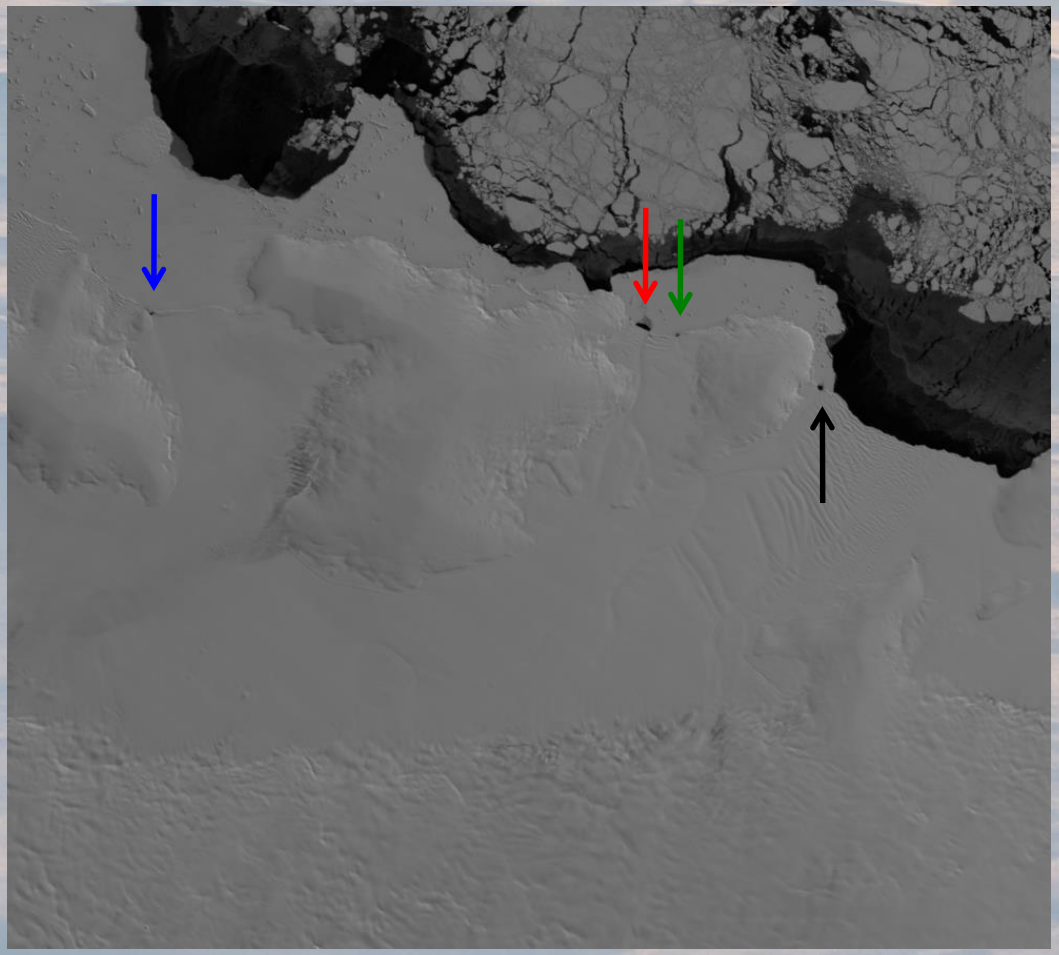
Le Brocq et al. 2013

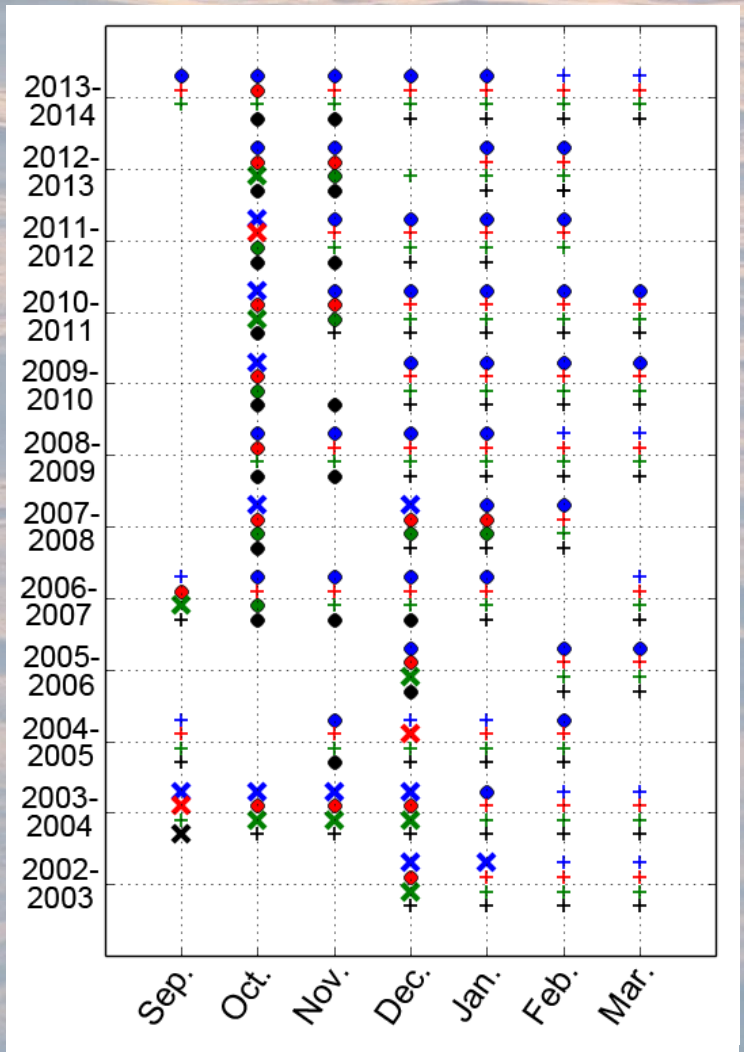
Ocean-driven melt channels

- Carved into shelf bases 1-5 km wide and 50-250 m high
- Visible at surface due to hydrostatic relaxation
- Identified through visible satellite imagery (MODIS Mosaic of Antarctica and Landsat) and, where possible, through IceBridge MCoRDS data



Persistent, stationary polynyas

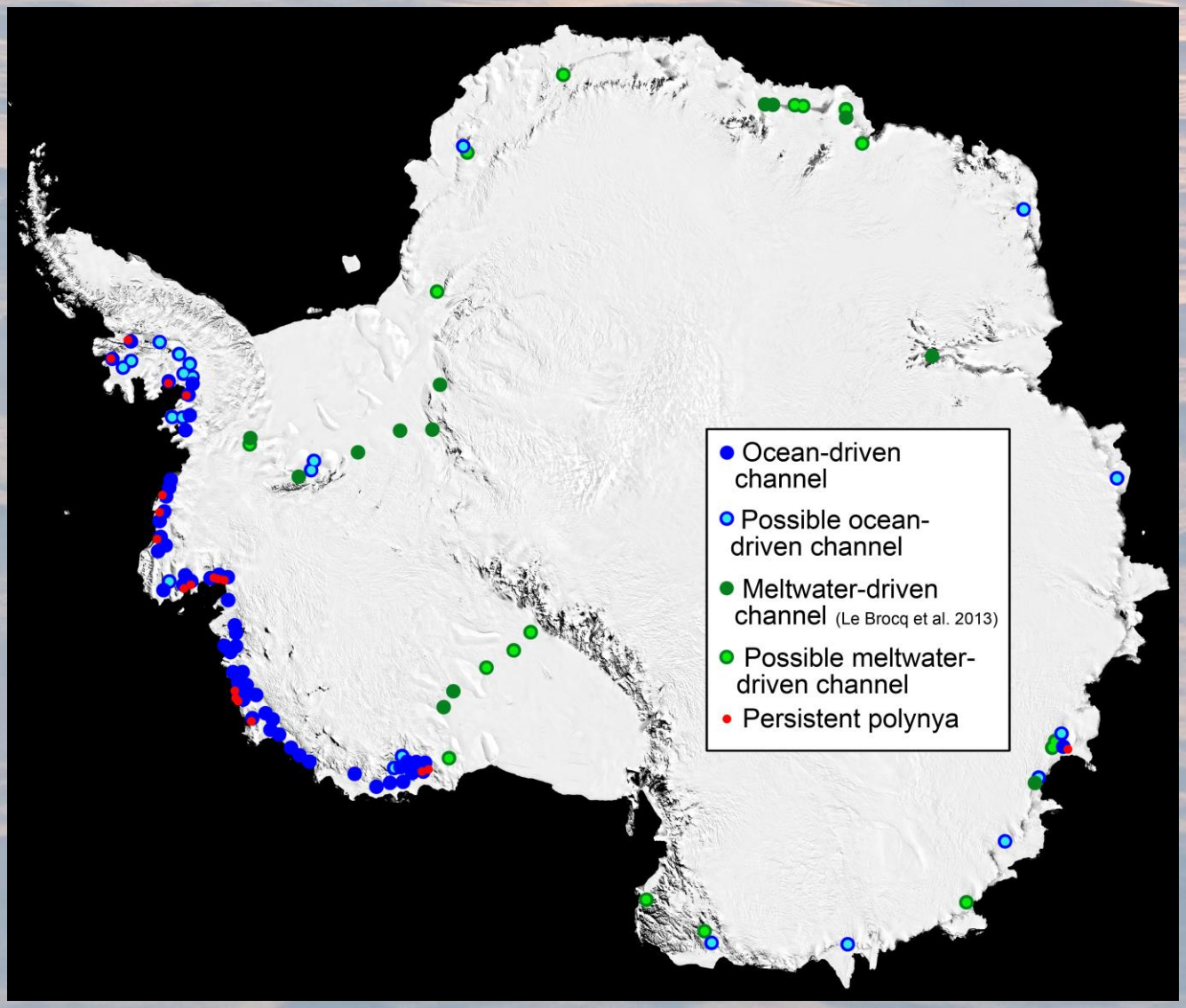




● = polynya **x** = fast ice but no polynya

+ = no fast ice

Distribution of melt channels and polynyas

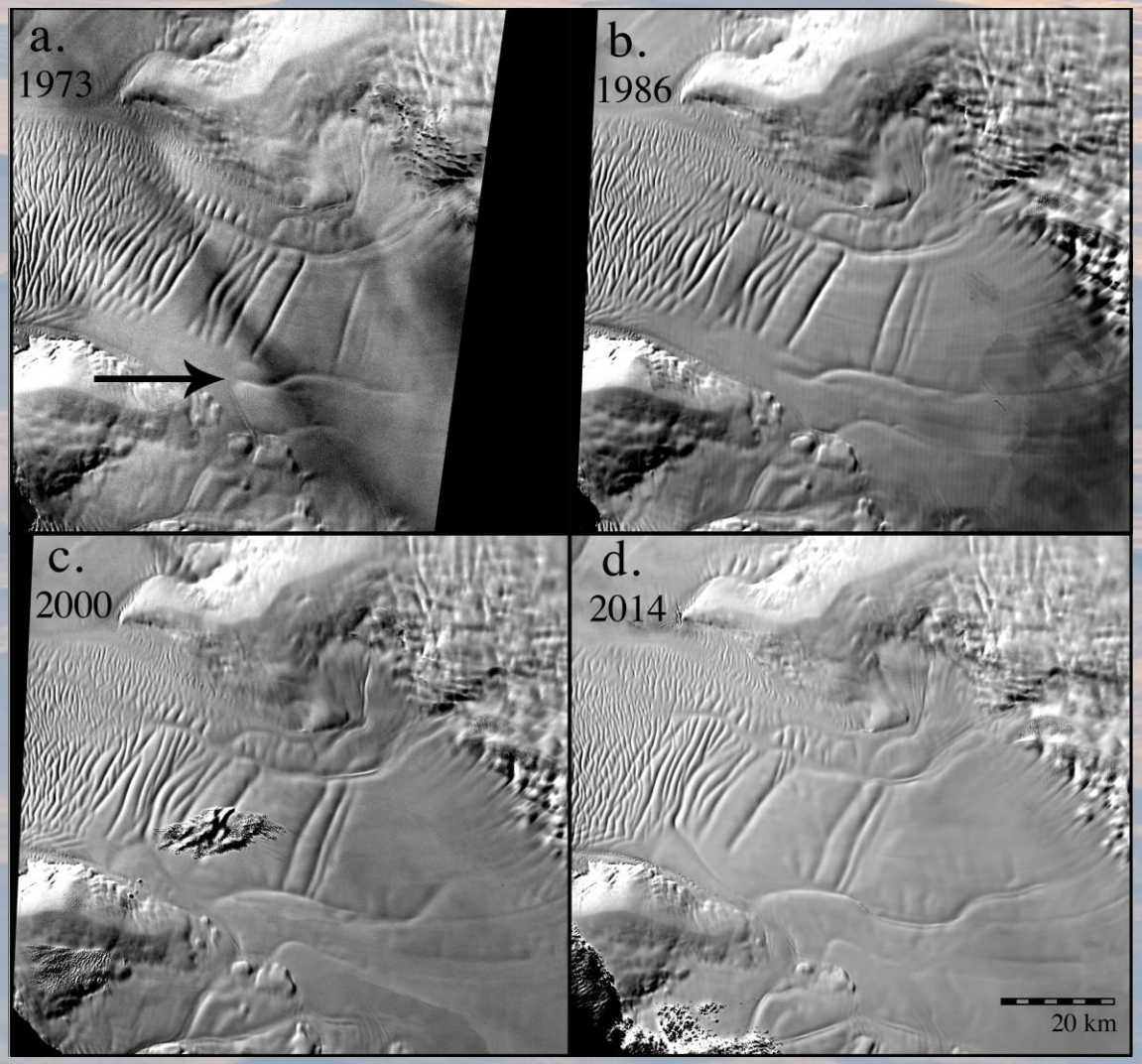


Key aspects of ocean-driven melt channels

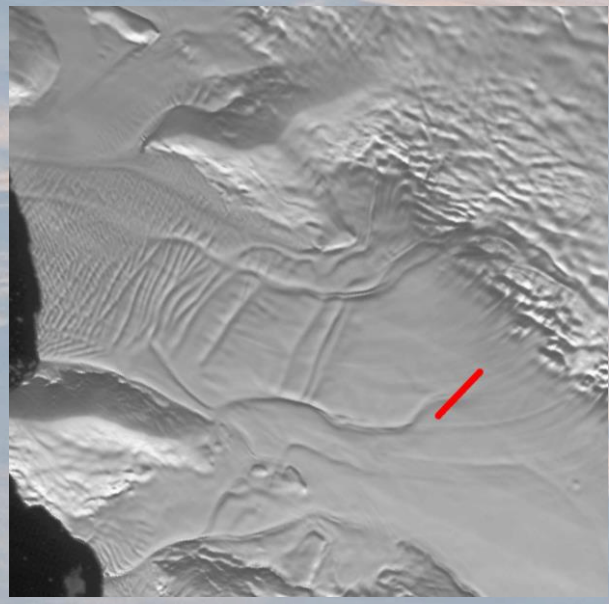
- Originate away from the grounding line
- May remain constant or deepen instead of tapering towards ice edge
- Often roughly follow ice flow direction, but can be highly sinuous
- Frequently end in persistent polynyas
- Tendency to form along the edges of islands and peninsulas
- Strong presence in the Amundsen/Bellingshausen Sea regions, but not much elsewhere

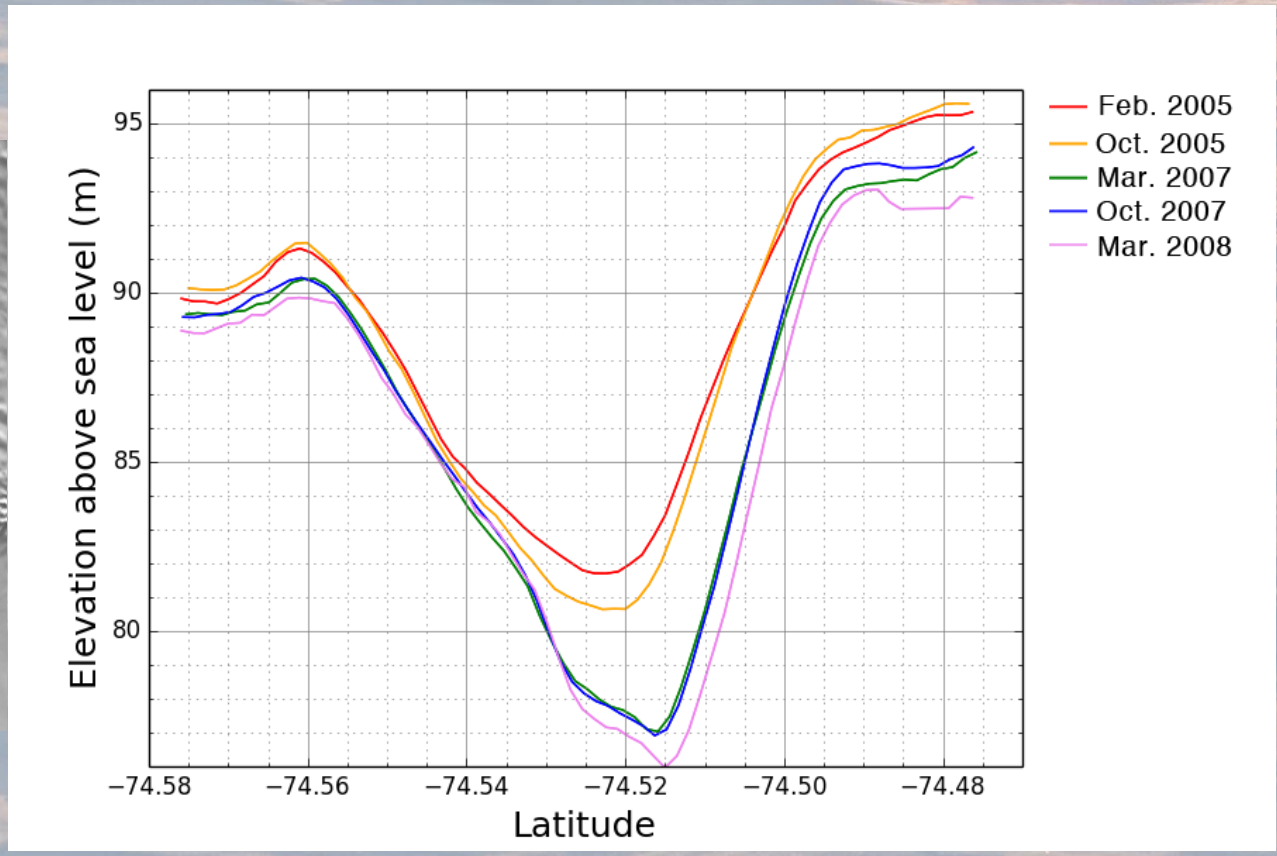
Hypothesis: primarily created by warm CDW

Melt channel growth on the Getz Ice Shelf

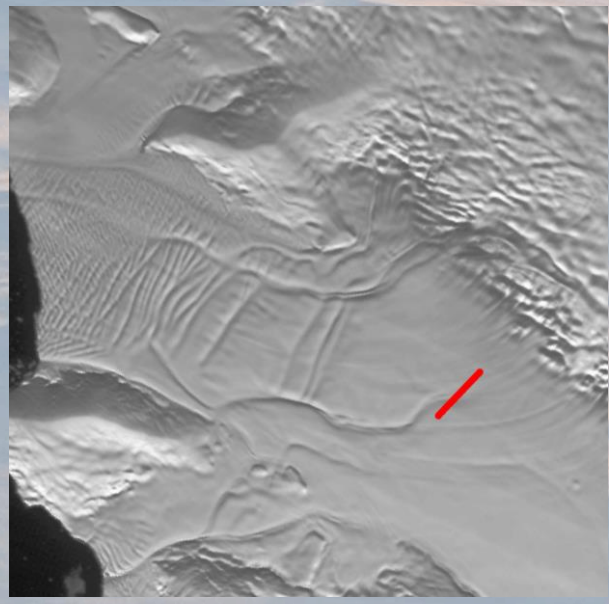


Growing melt channel from IceSat

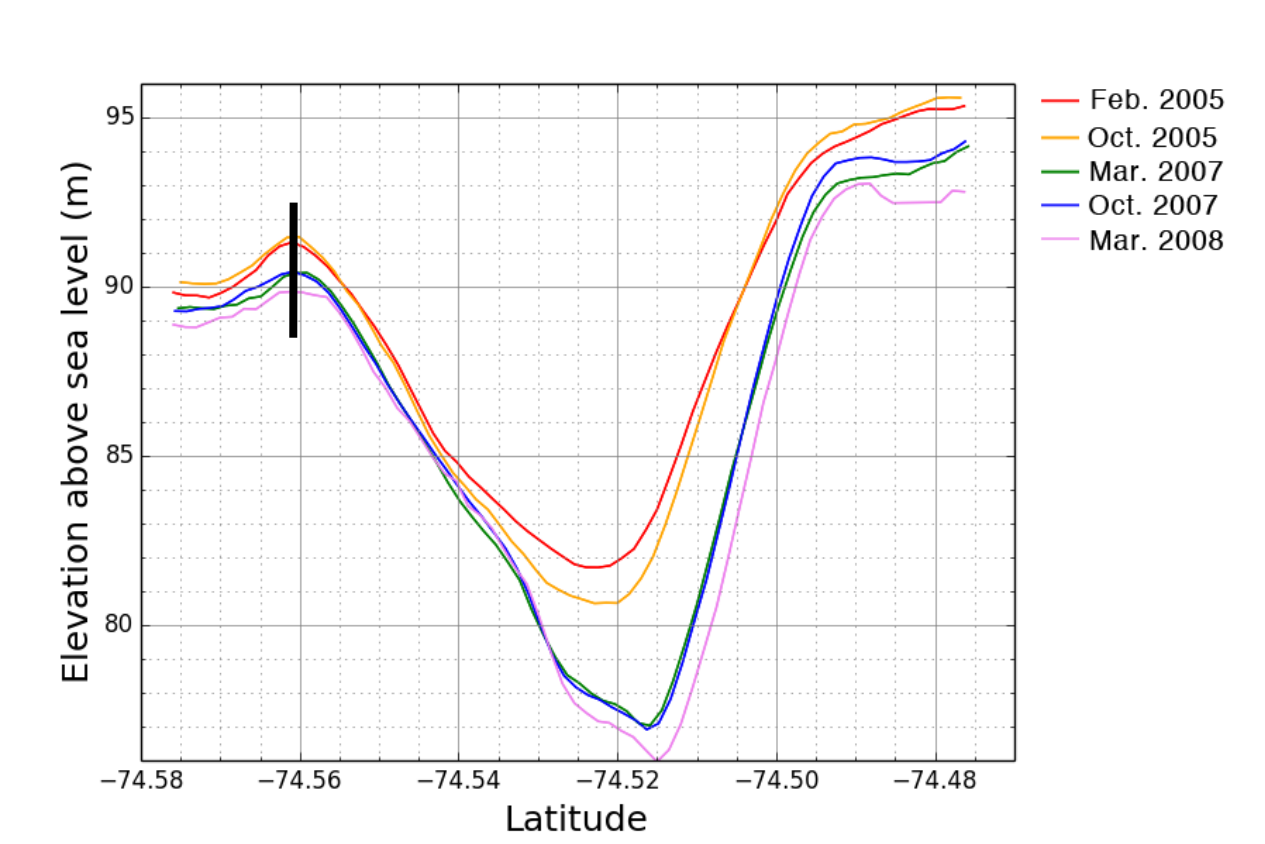




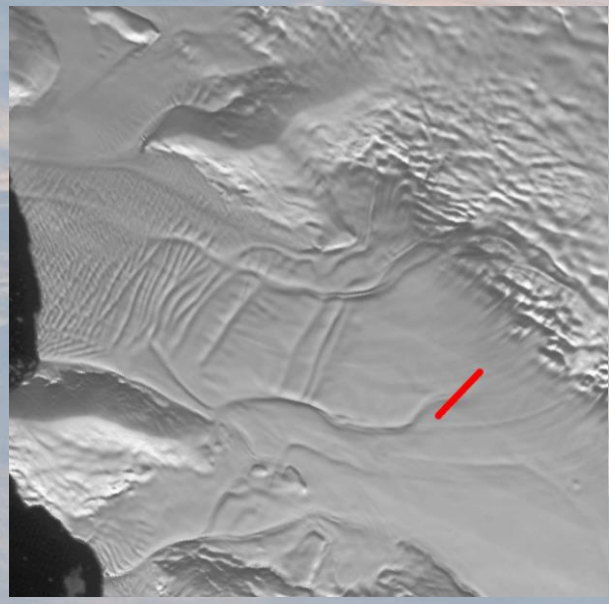
Growing melt channel from IceSat

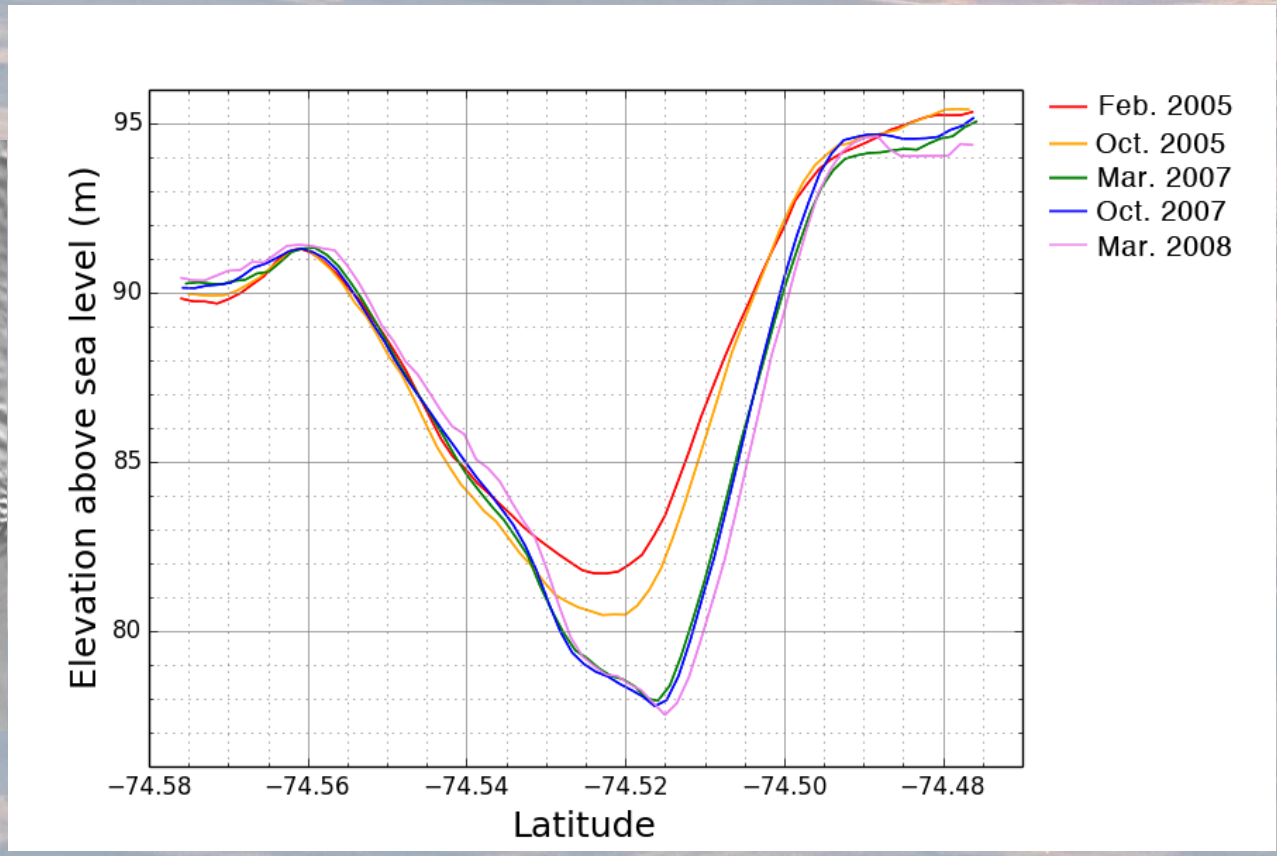


Background thinning rate on the Getz Ice Shelf: ~2 m/yr (Rignot et al. 2013)

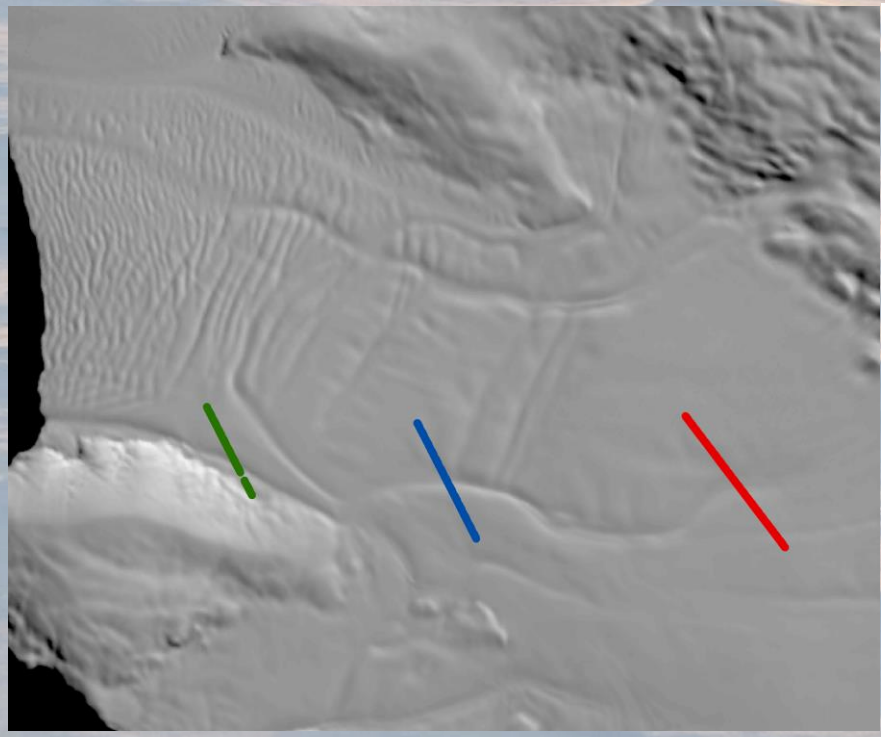


Growing melt channel from IceSat

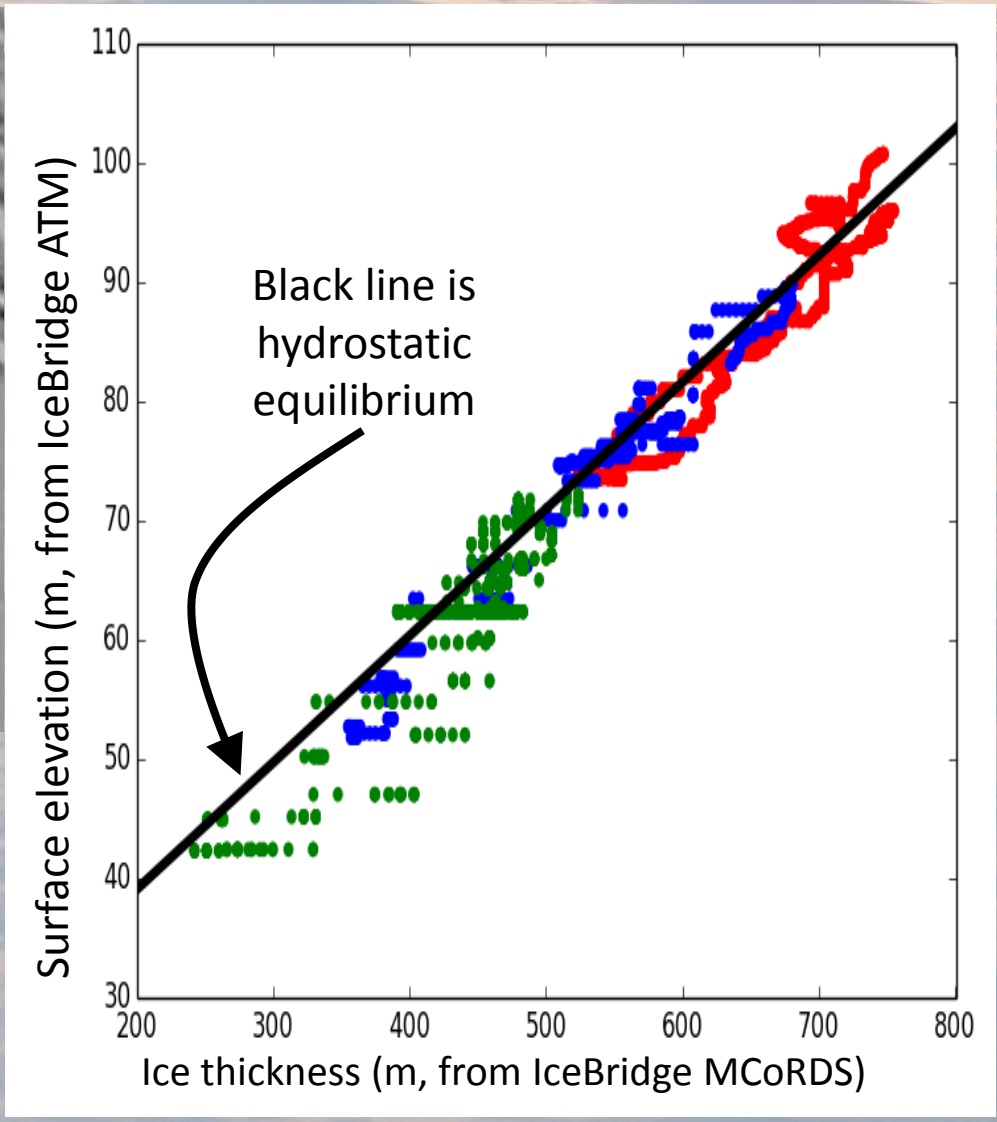




Growing melt channel deepening rate



Equivalent air thickness: ~20 m
(Van den Broeke 2008)



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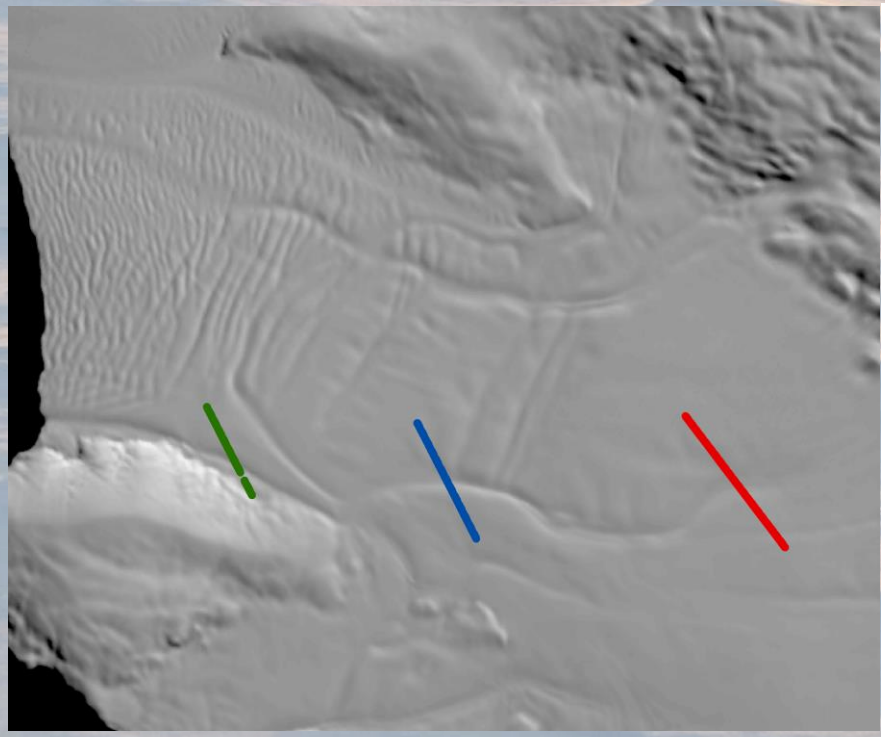
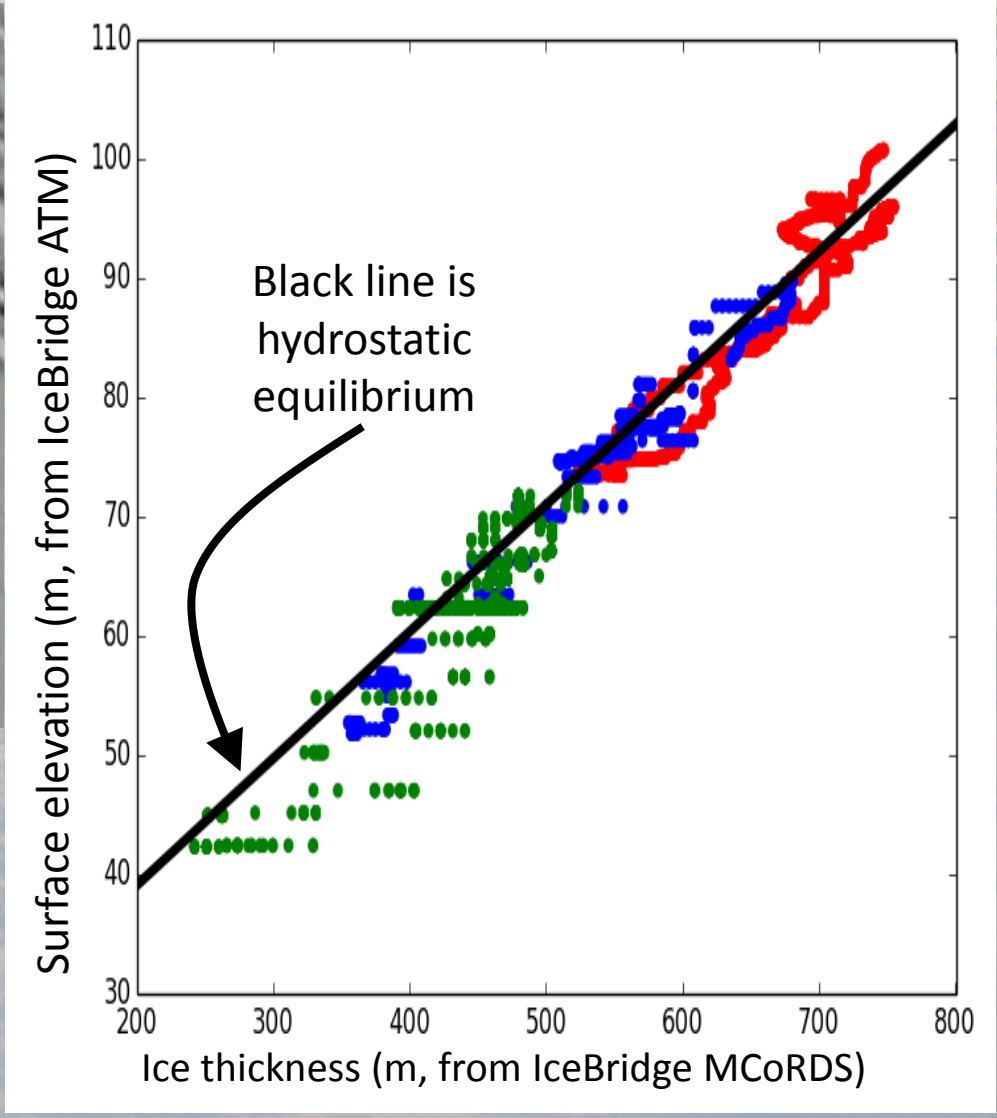
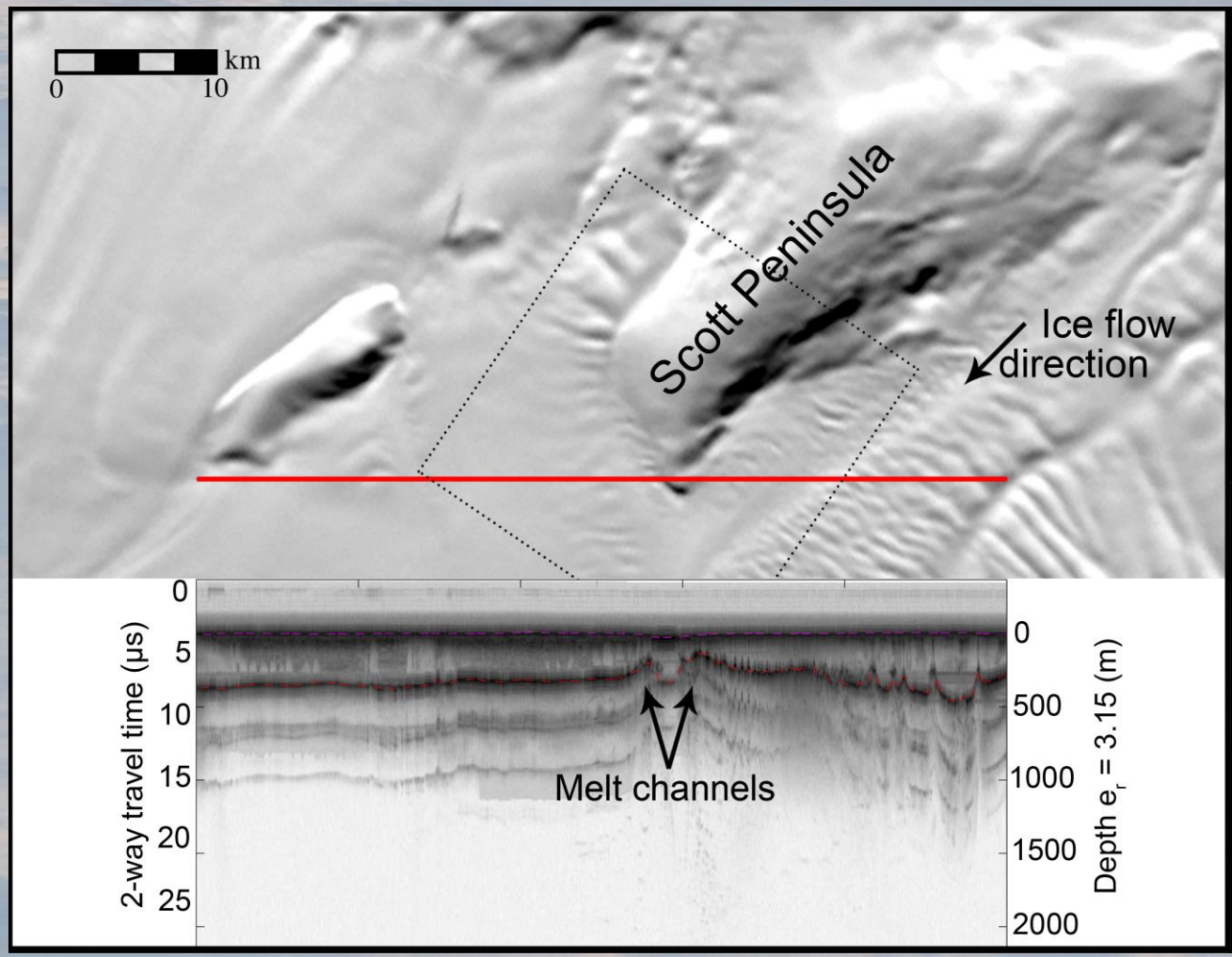
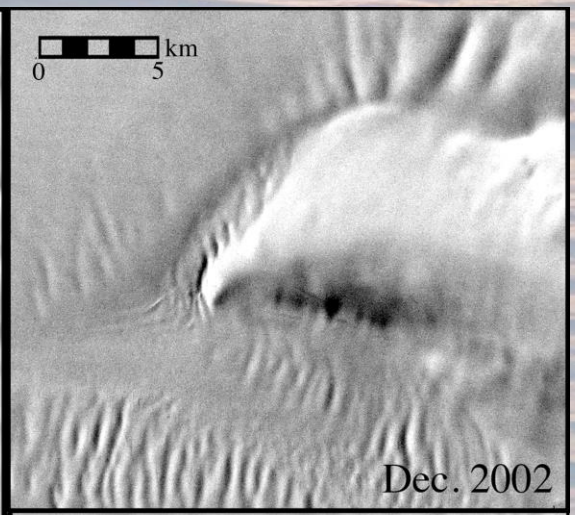


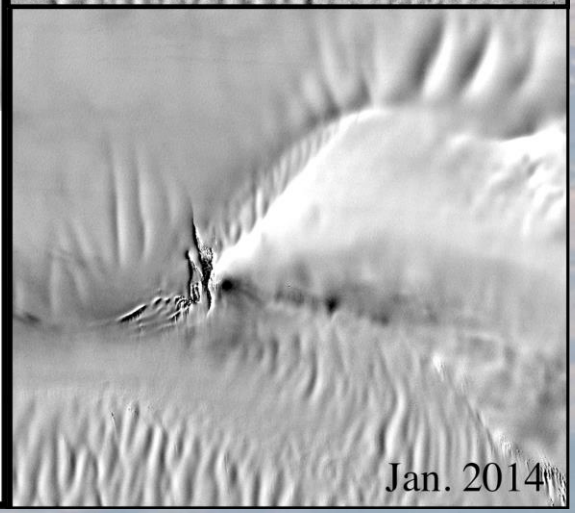
Assuming hydrostatic equilibrium:
4.2 m of surface lowering between Feb. 2005 and Mar. 2008 = **12.8 m deepening/year** (at the head of the channel)



Potential consequences of melt channels







Further research

- Why do melt channels tend to form along islands and peninsulas? Tidal mixing or other mechanisms?
- Could extensive channel melting, particularly along shear margins, lead to significant ice shelf retreat? How much melting would it take for that to happen?

Acknowledgements

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