Four Decades of Radar-Echo Sounding:

The past, present & future of radar applications for understanding subglacial environments

Winnie Chu

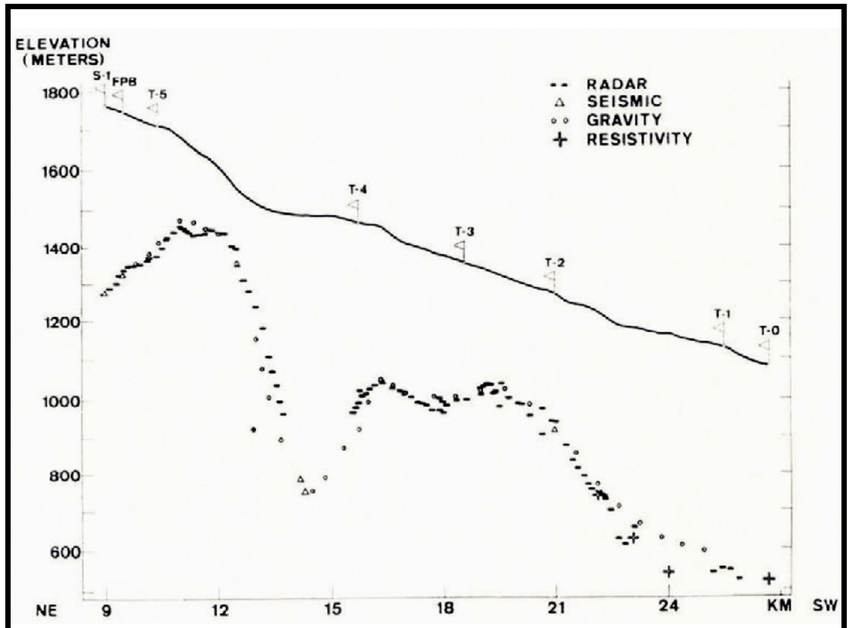
Georgia Institute of Technology

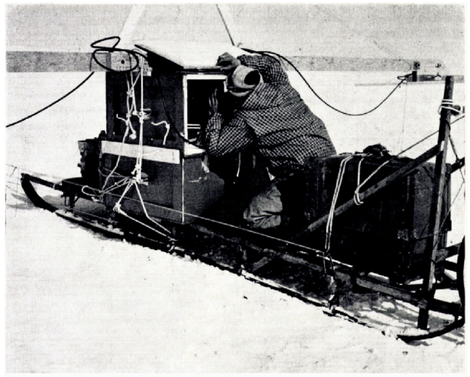
EGU General Assembly 2021



Early Ice-Penetrating Radar Sounding Experiments

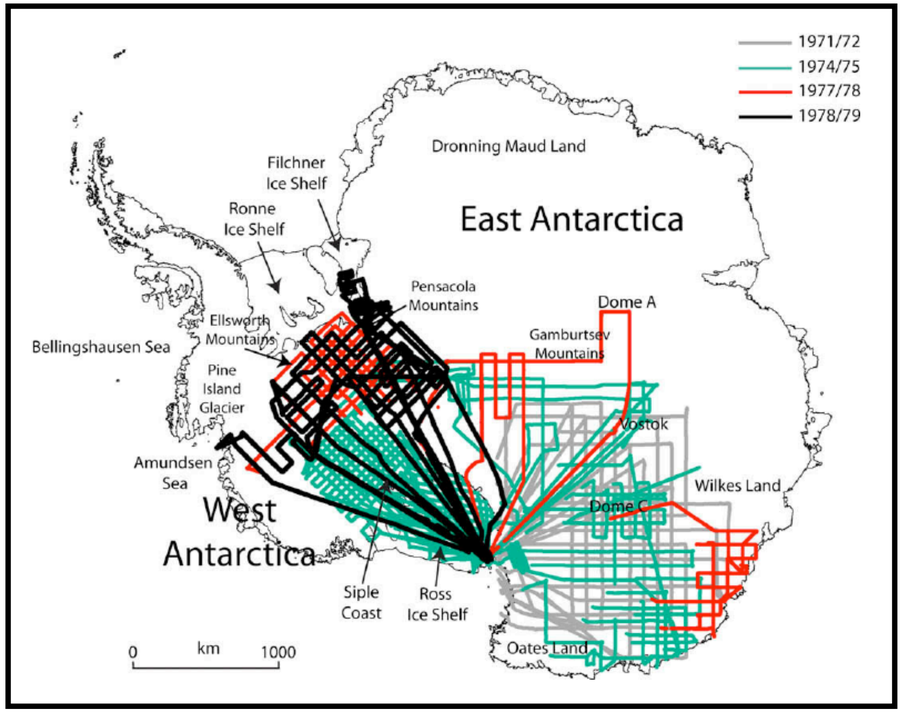
First Thickness Measurements





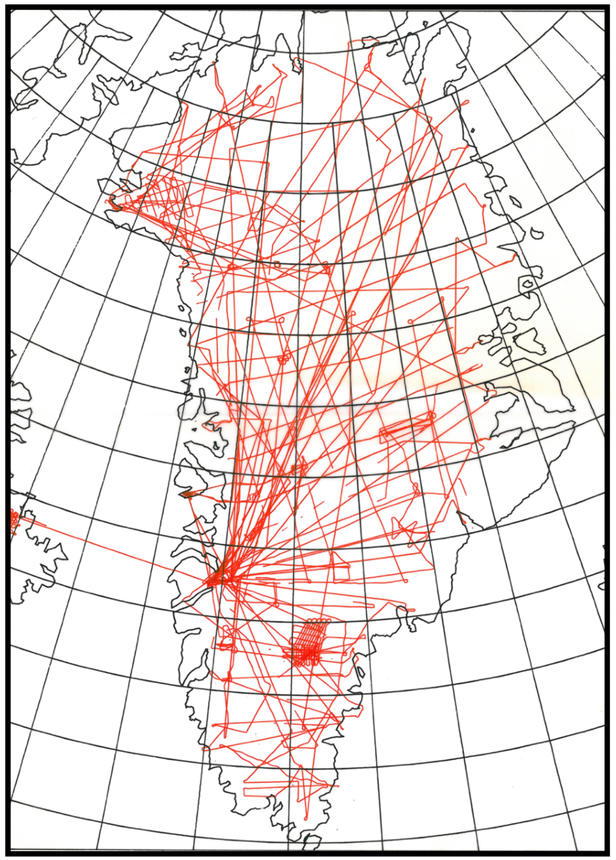
Weber & Andrieux, 1970

TUD/SPRI/NSF Airborne Survey



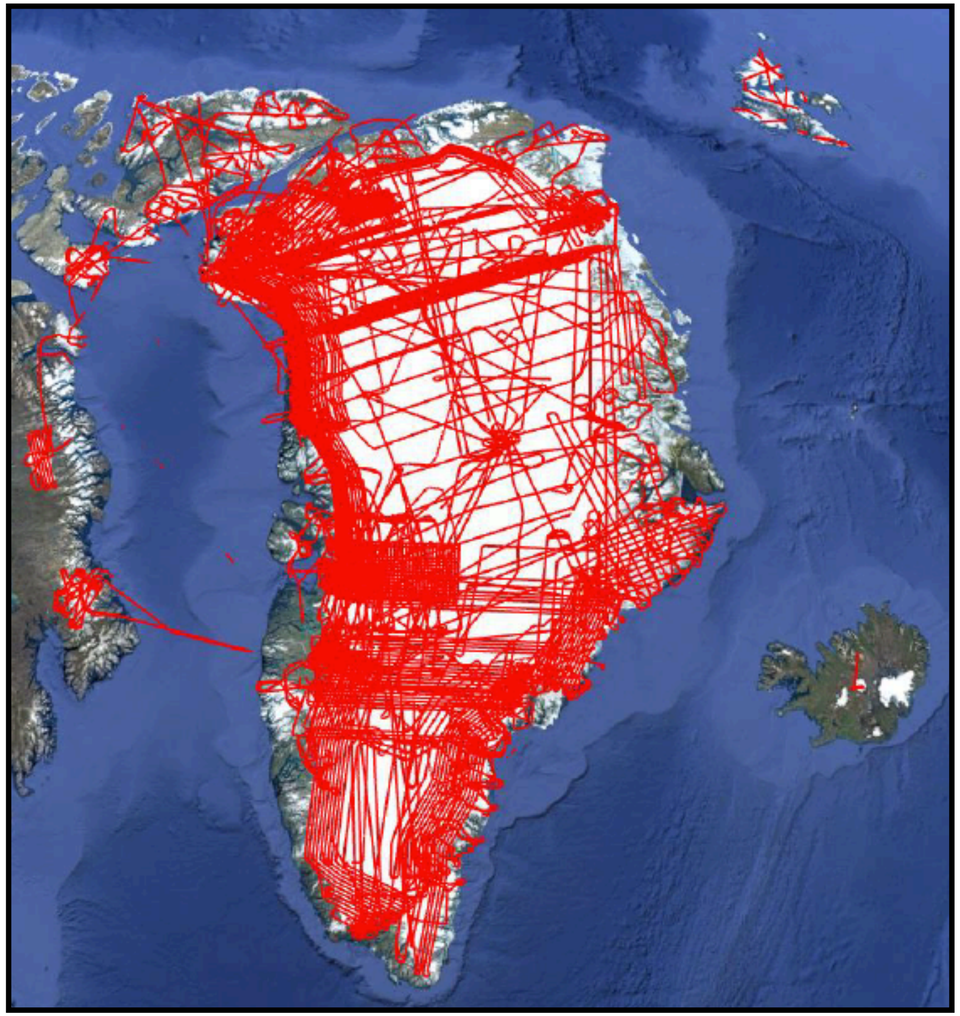
e.g. Bailey et al., 1964; Robin et al., 1977; Siegert, 1999

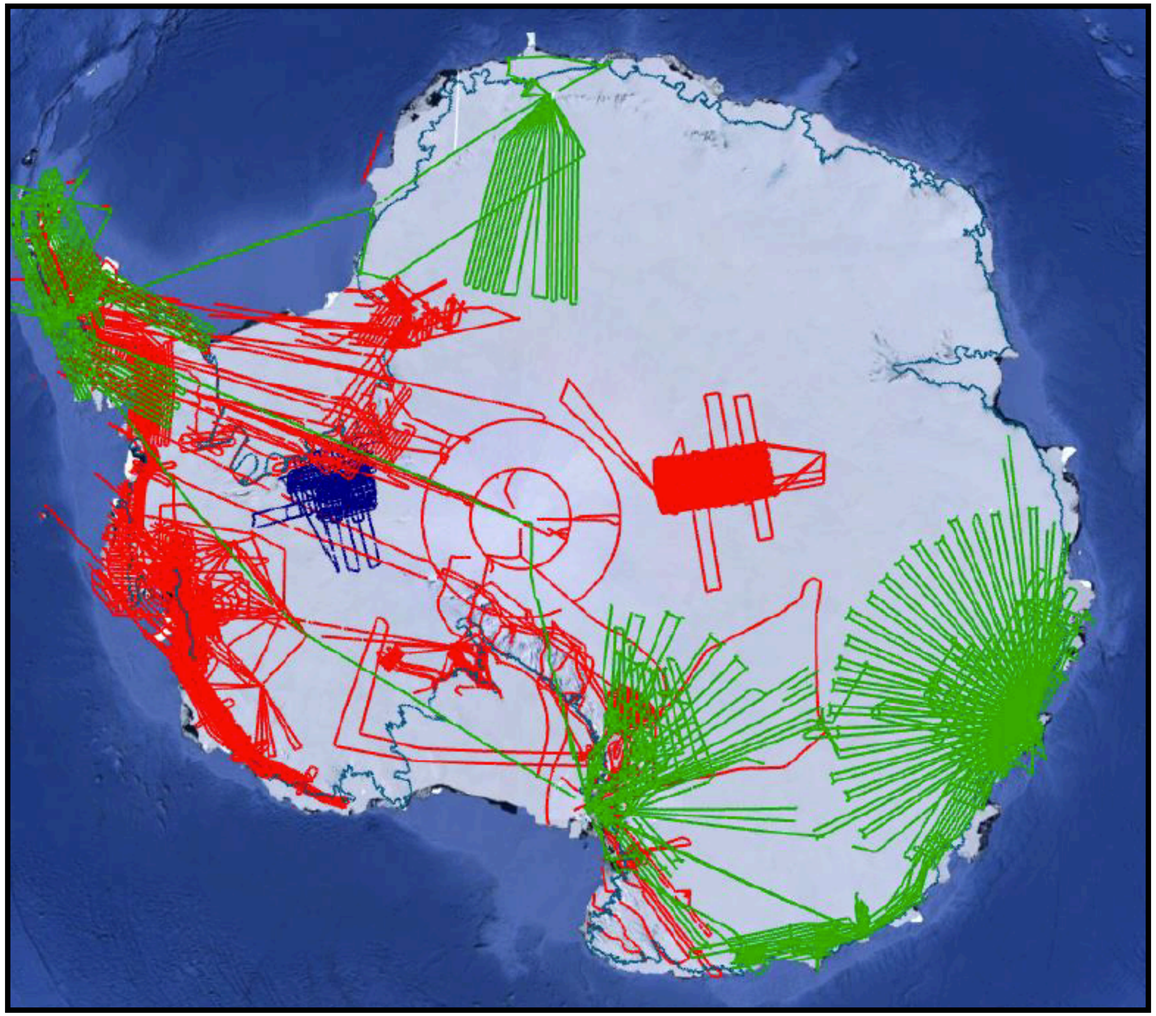
DTU 1978-79



e.g. Overgaard et al., 1984

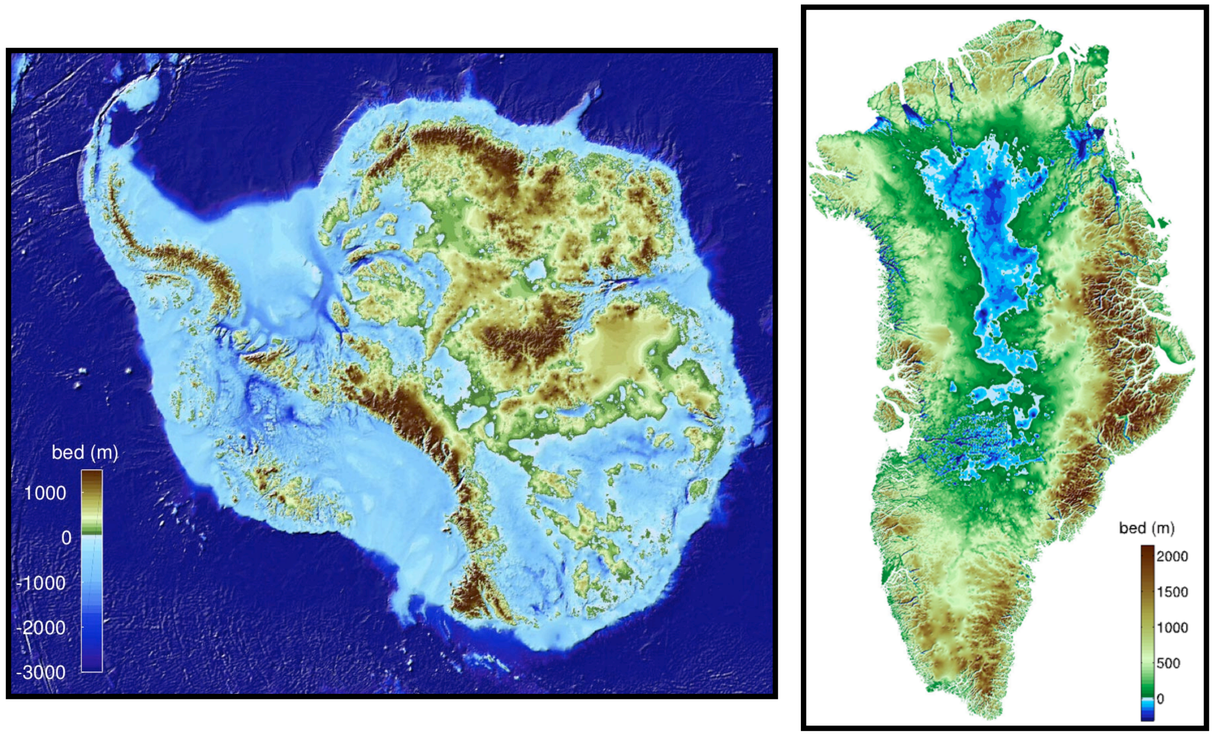
Modern Digital Radar Data Coverage





Expansion of Radar Data Interpretations

Subglacial Topography Mapping



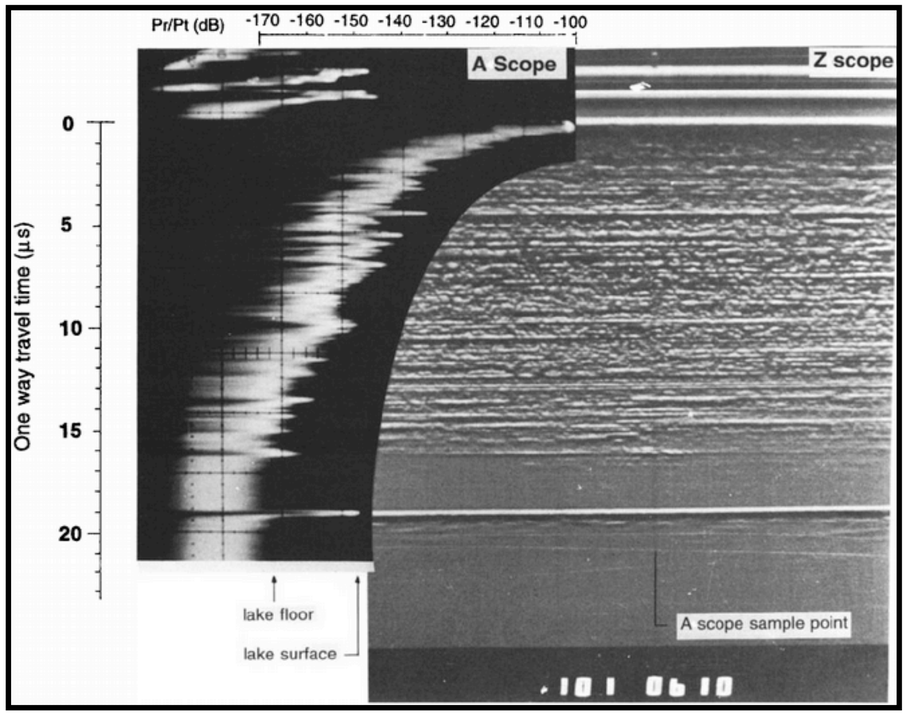
e.g. Lythe & Vaughan, 2001; Fretwell et al., 2013; Morlighem et al., 2017

Subglacial & Internal Ice Properties:

- Subglacial hydrology
- Basal roughness
- Grounding zone extent
- Crevasse formation
- Ice shelves melting/freezing
- Ice crystal fabrics
- Ice flow history
- Surface mass balance

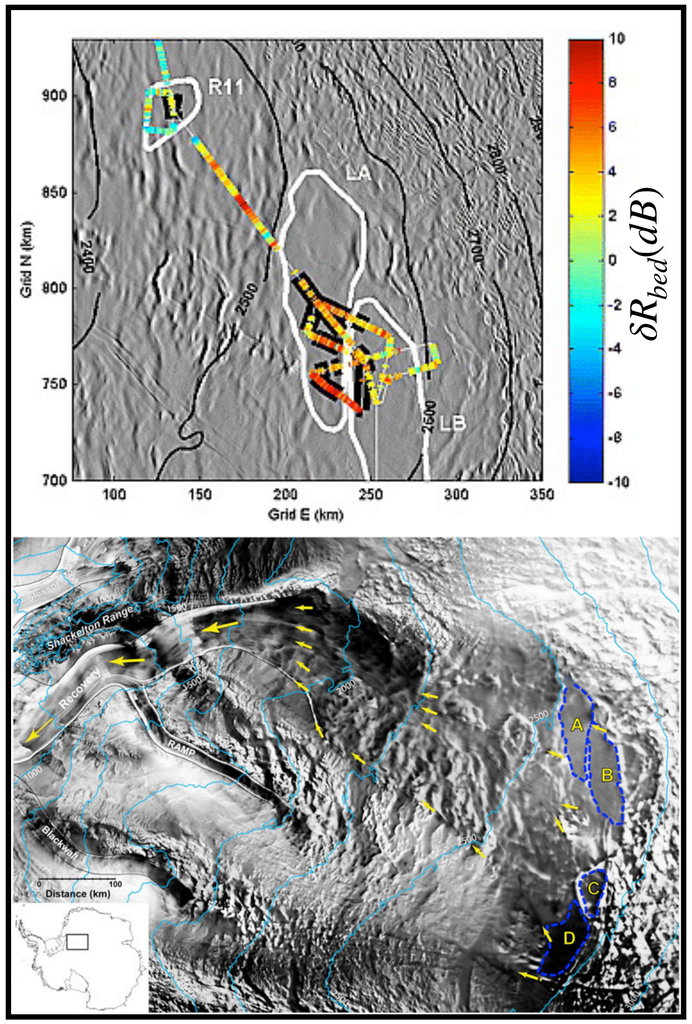
Subglacial Hydrology

Lake = Bright & Flat Returns



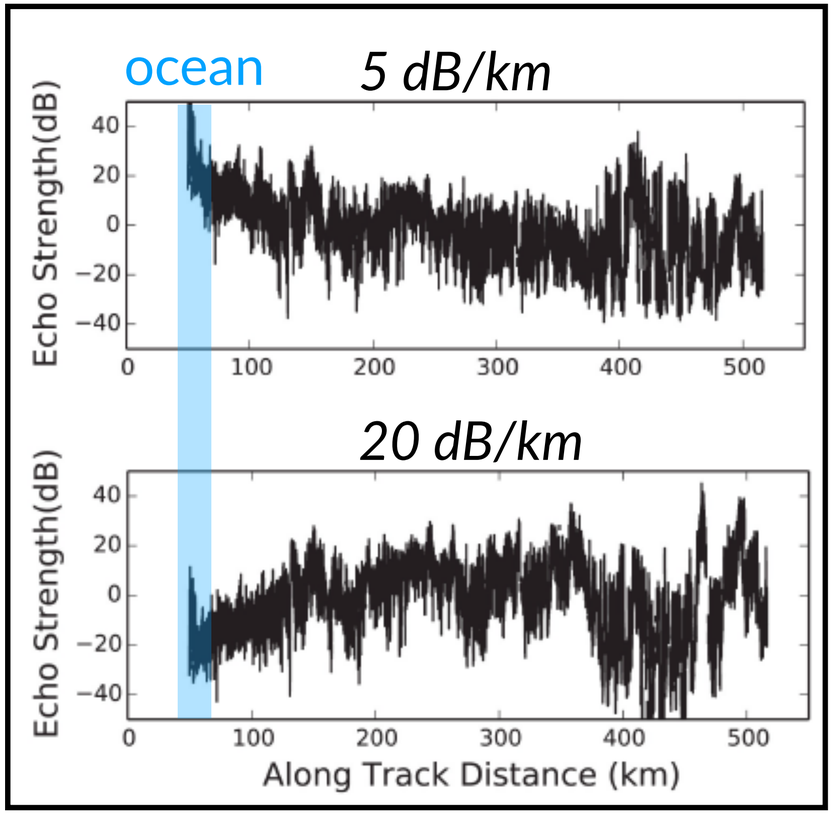
Gorman and Siegert, (1999)

Reflectivity Coefficient



Langley et al., (2011)

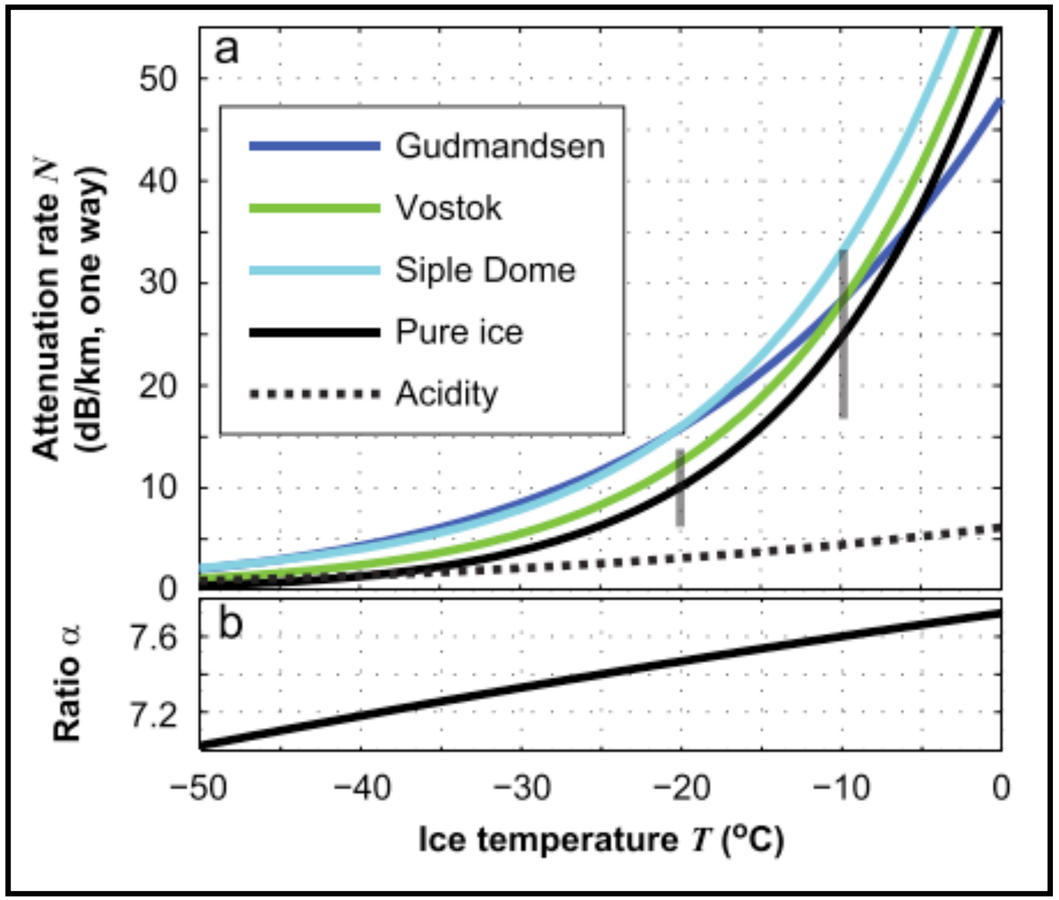
Attenuation Correction



Schroeder et al., (2016)

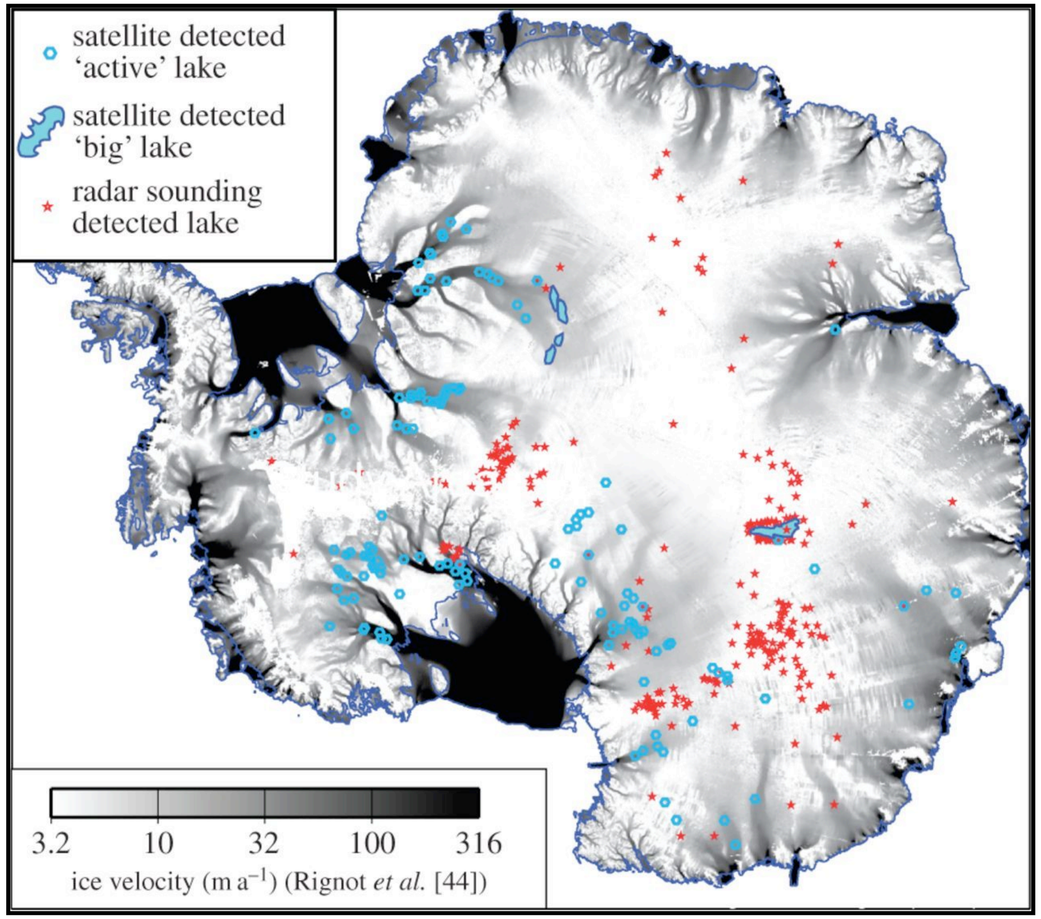
Uncertainties in Understanding Hydrology

Up to 50 dB/km From Changes in Ice Temperature



Matsuoka et al., (2012)

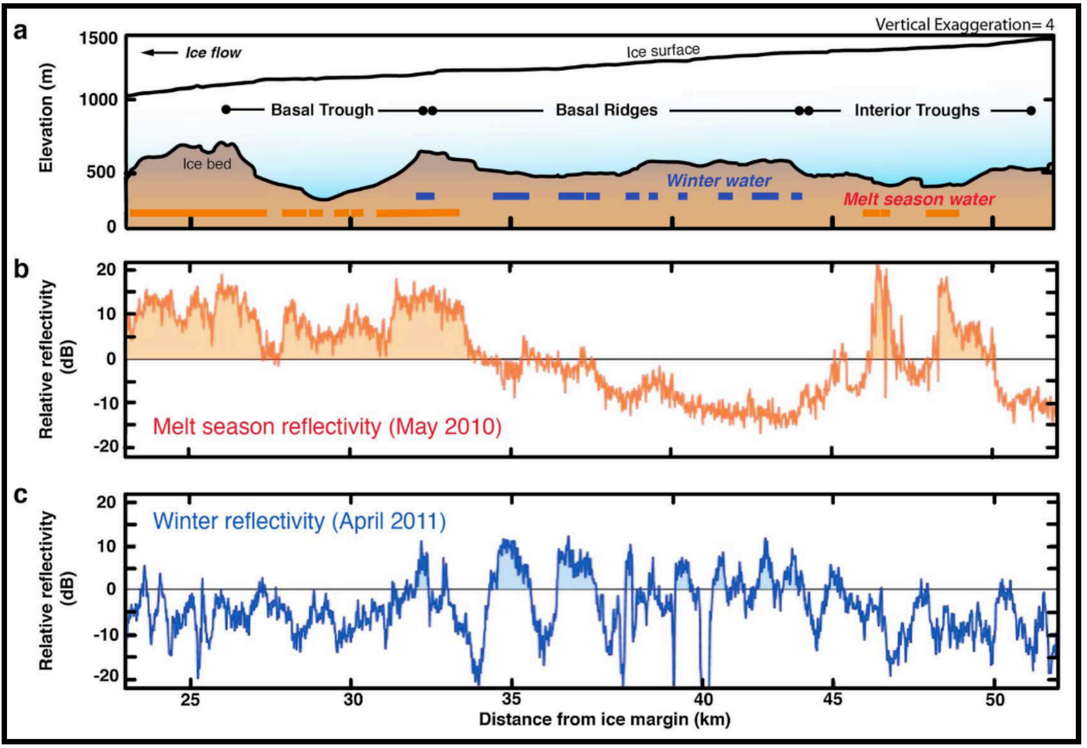
Discrepancies Between Sounding & Altimetry Lakes



Pattyn et al., (2016)

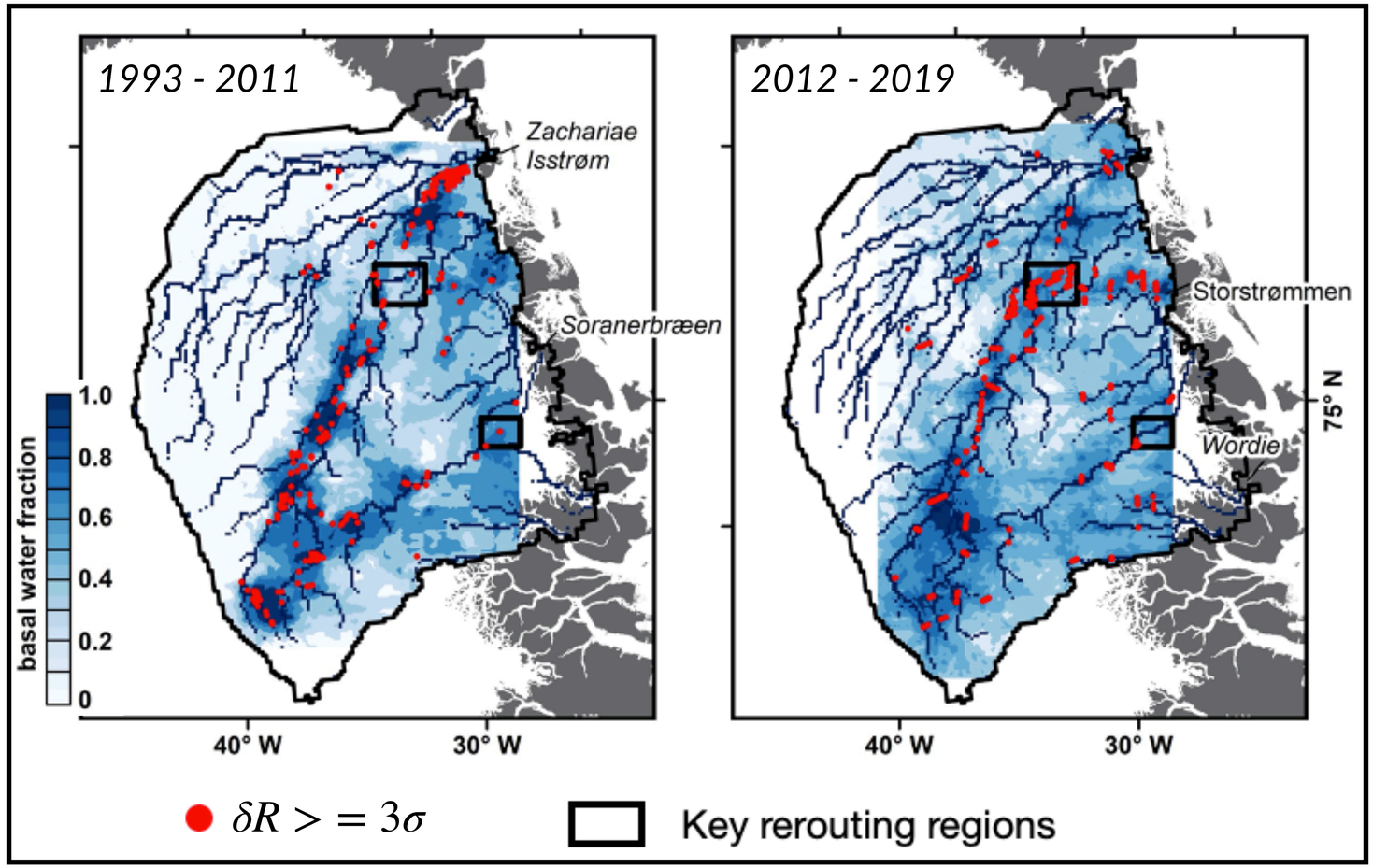
Temporal Changes in Subglacial Hydrology

Seasonal Changes in Storage



Chu et al., (2016)

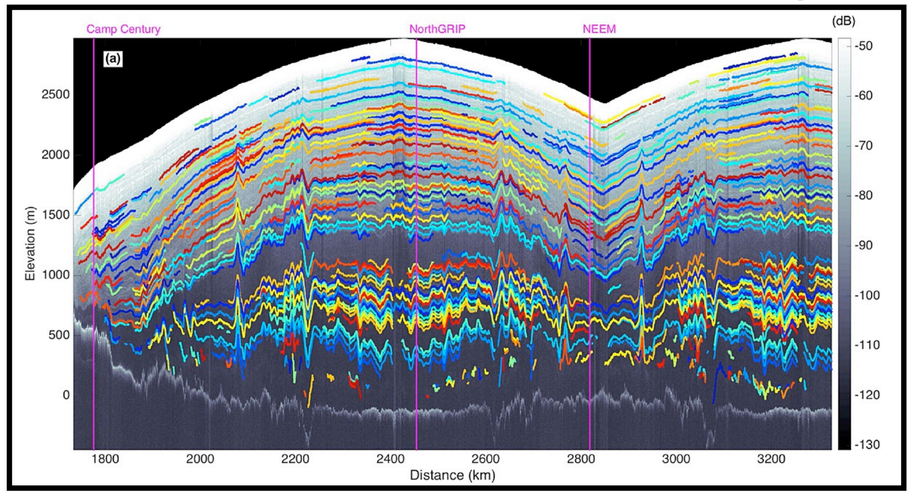
Inter-annual Subglacial Water Piracy



Chu et al., (in prep)

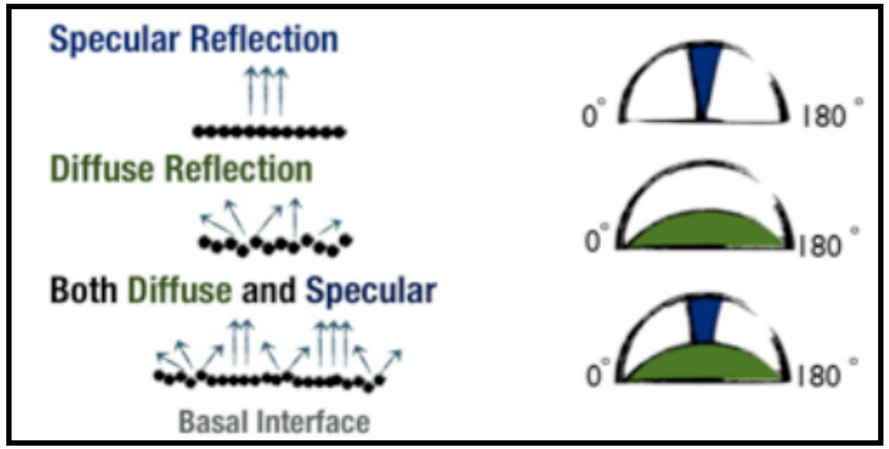
Improvements in Understanding Hydrology

Variable Ice Chemistry



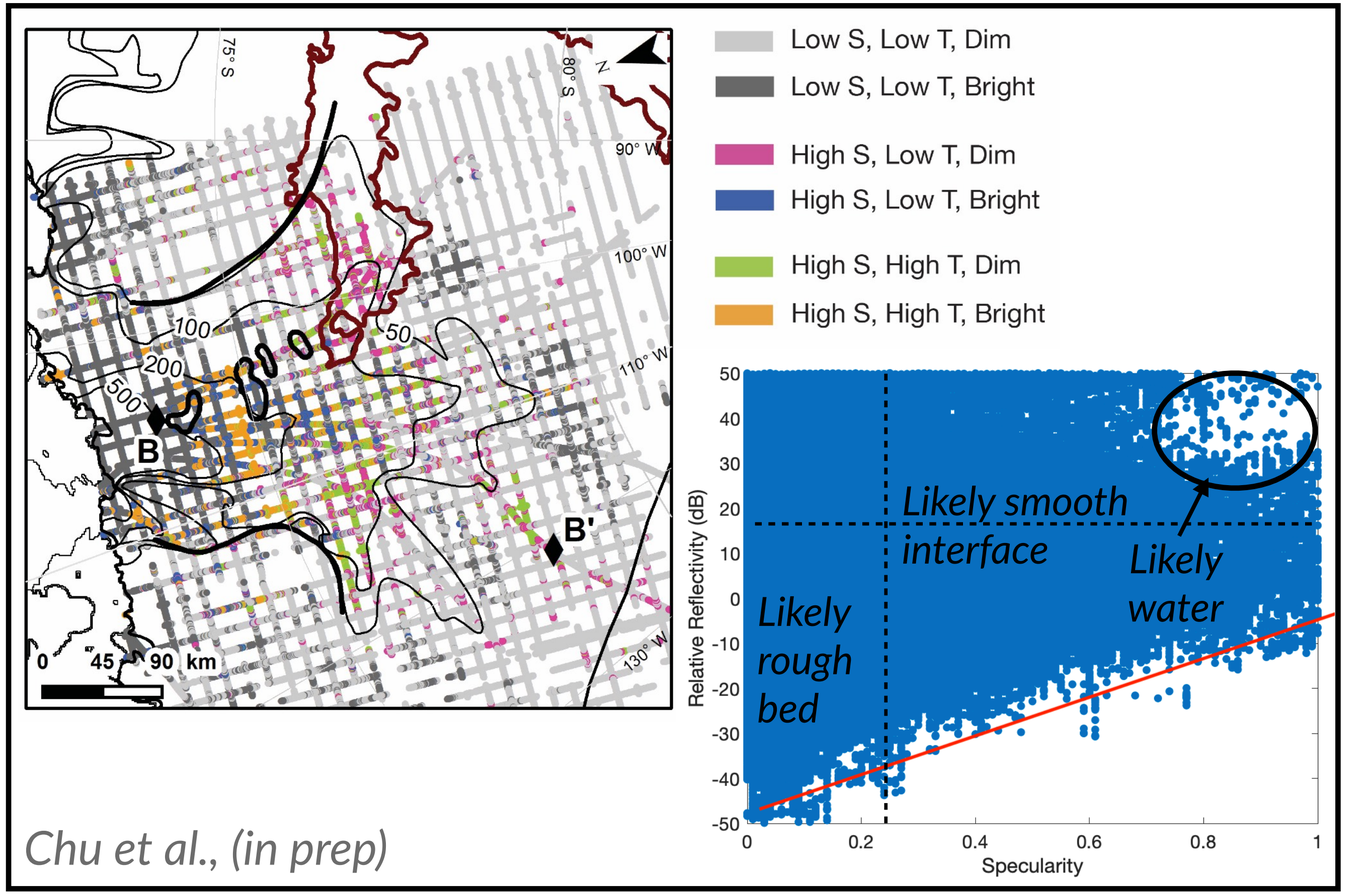
MacGregor et al., (2015)

Spatially Varying Basal Roughness



Schroeder et al., (2015)

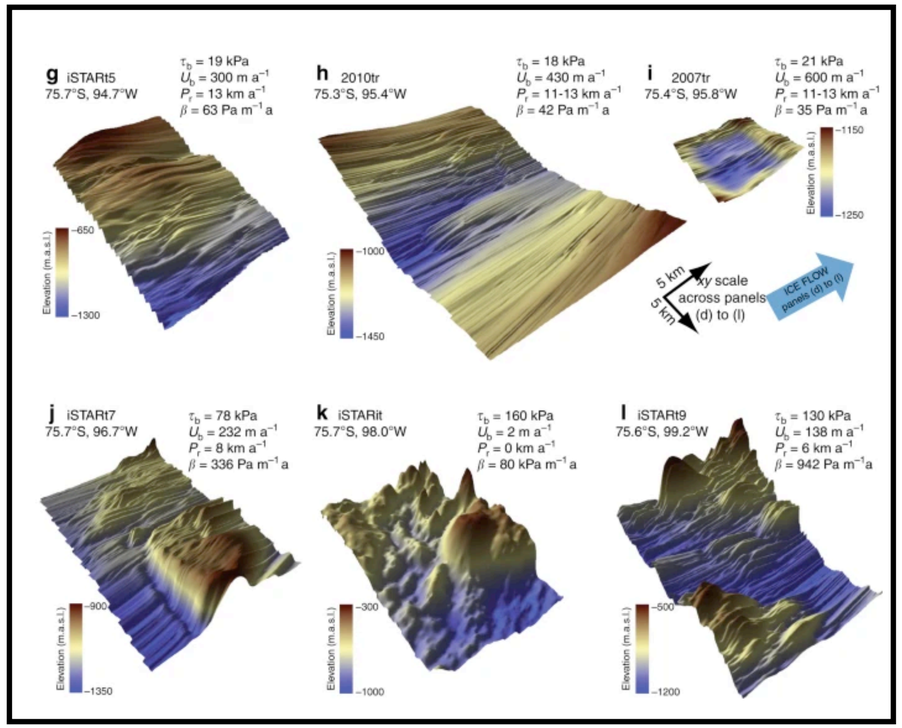
Combining Reflectivity & Bed Echo Character



Chu et al., (in prep)

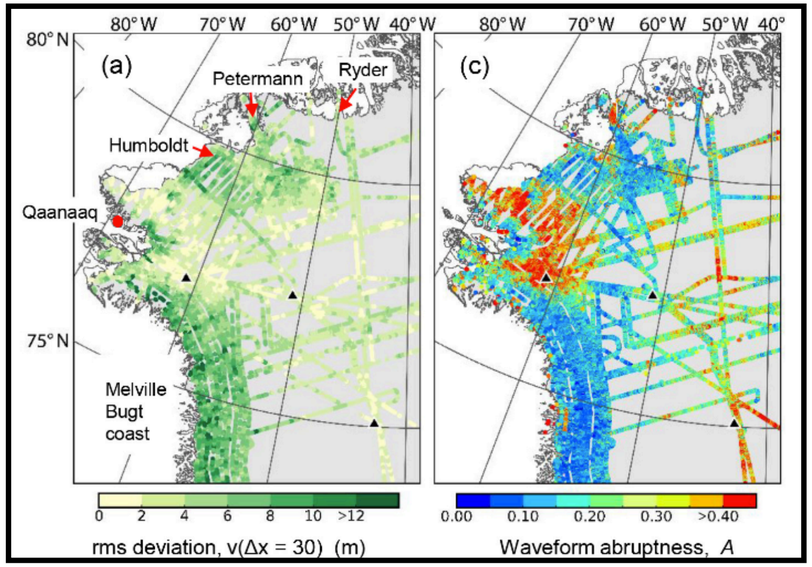
Fine-Scale Basal Roughness

Kilometer-scale Roughness



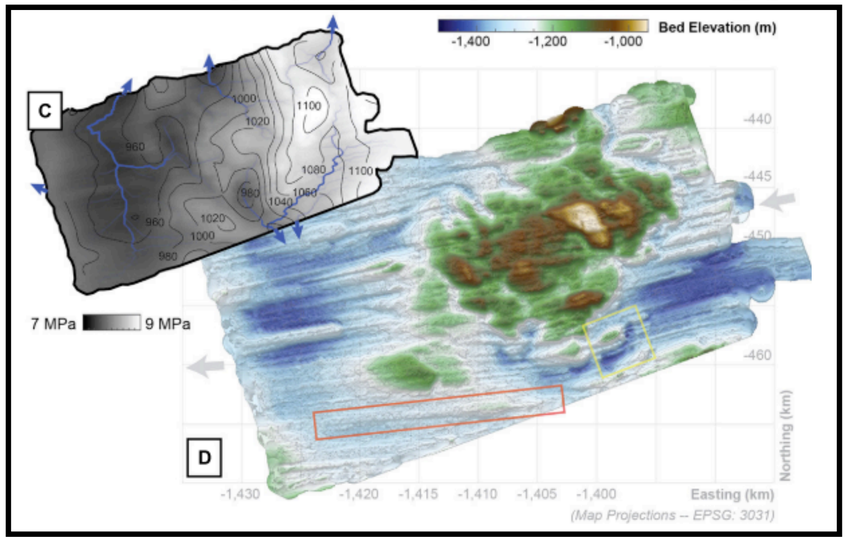
Bingham et al., (2017)

Waveform Abruptness



Jordan et al., (2017)

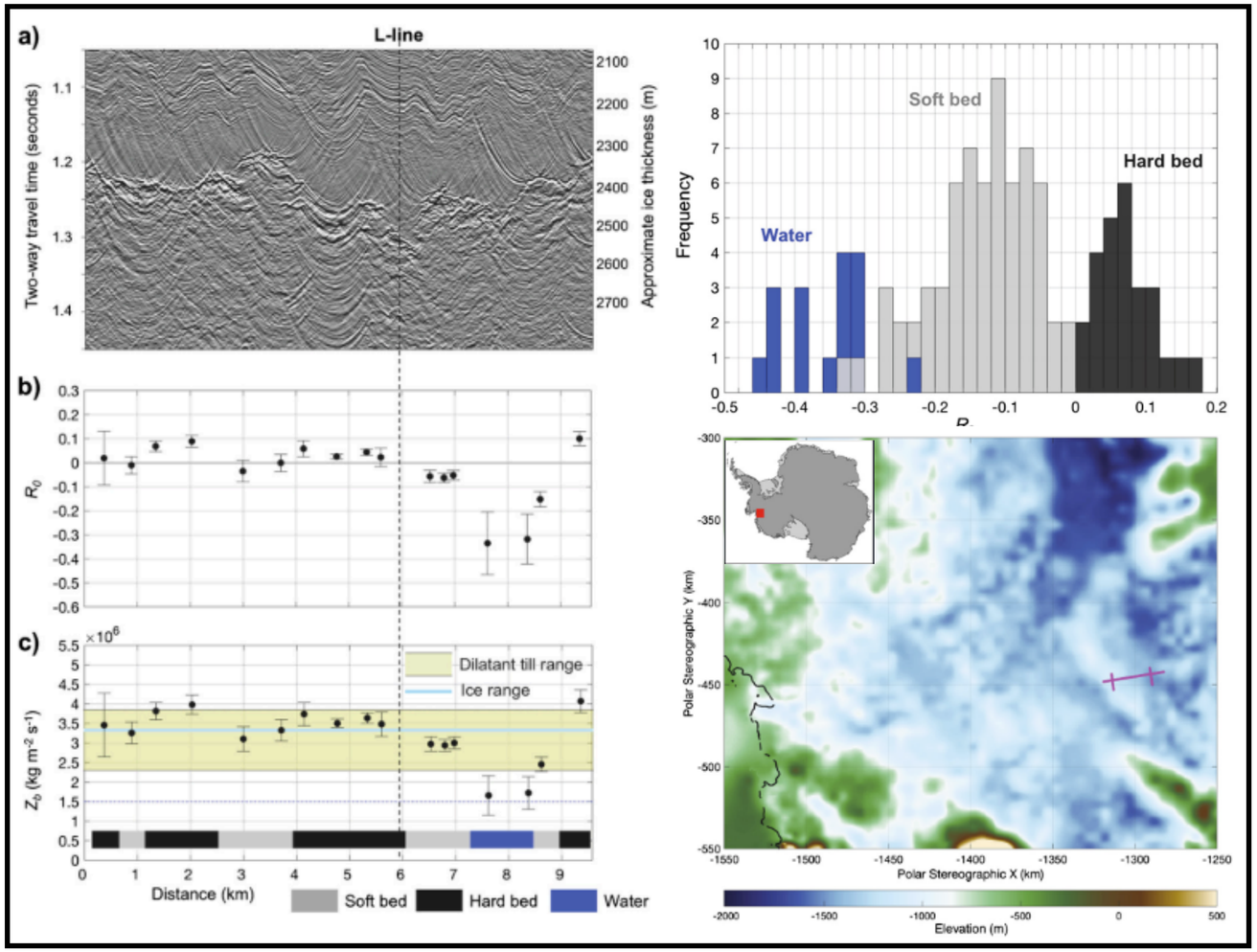
Tomographic Swath Imaging



Holschuh et al., (2020)

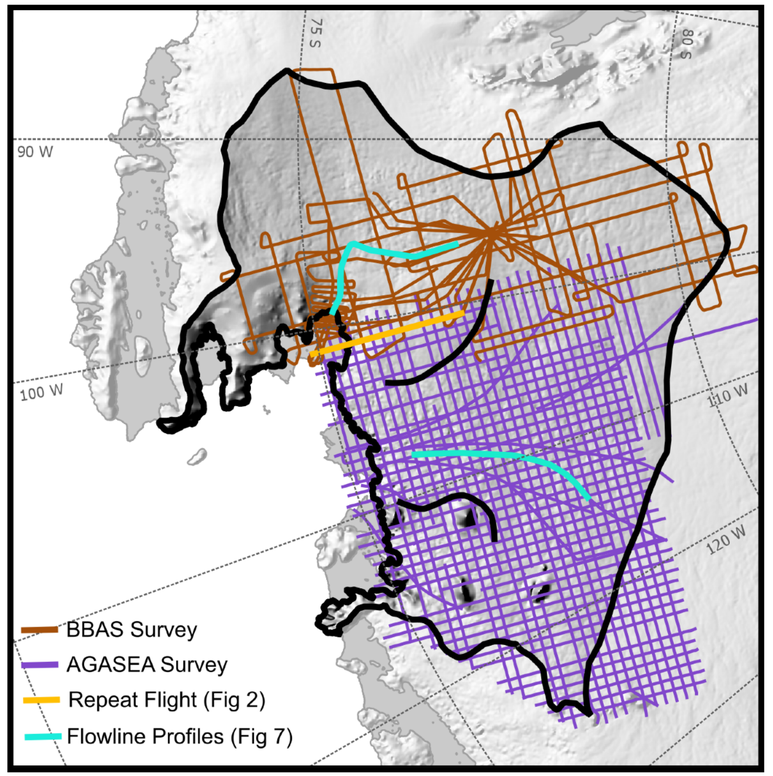
From Roughness to Glacial Geomorphology

Bed Morphology From Reflection Seismic



Muto et al., (2019)

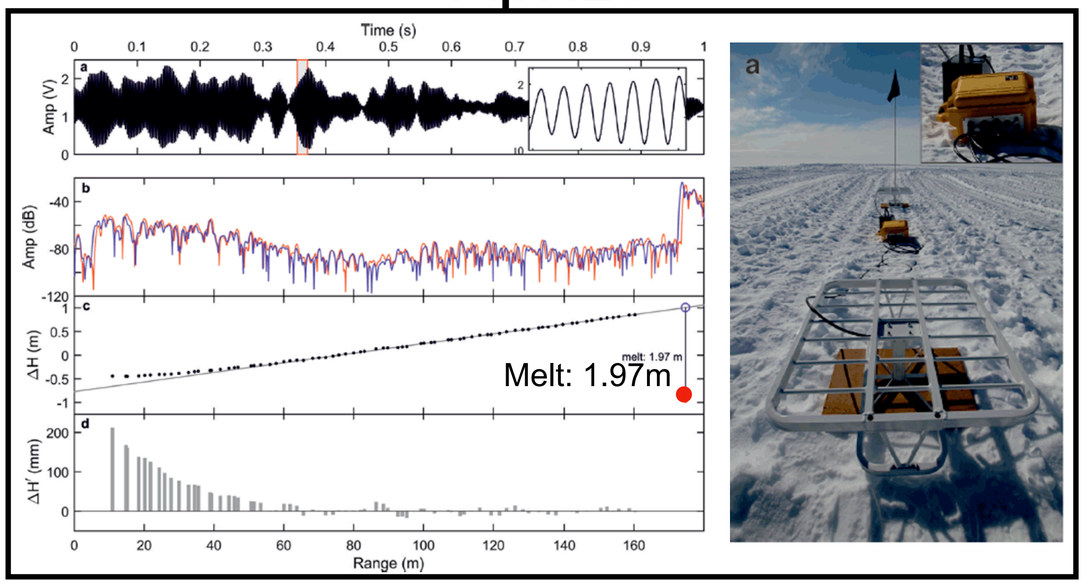
Radar Basal Reflectivity & Specularity



Chu et al., (in prep)

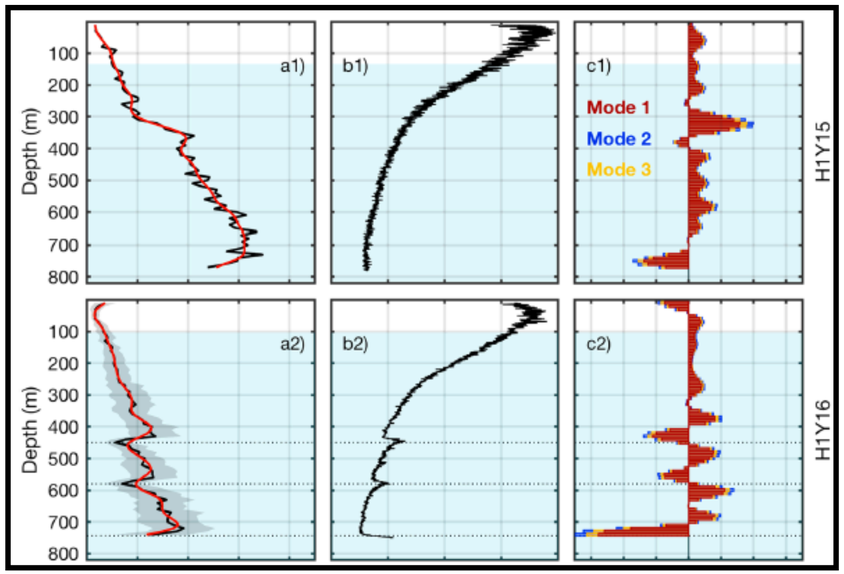
Ground-Based Platforms

ApRES



Internal Layer Motion

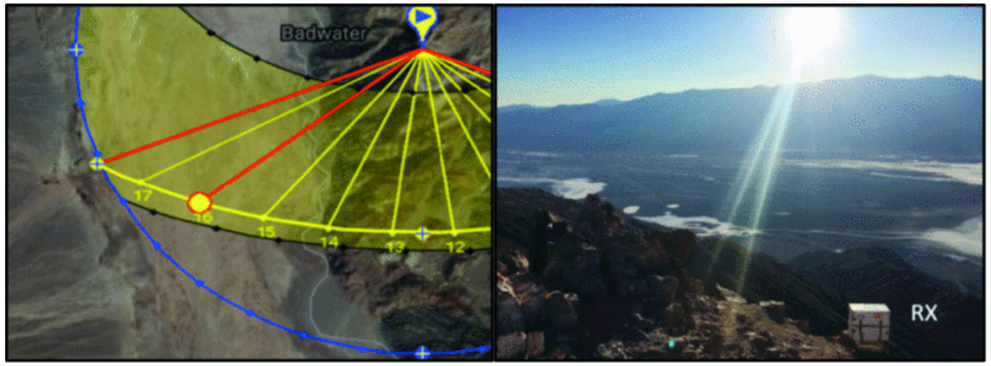
Nicholls et al., (2017)

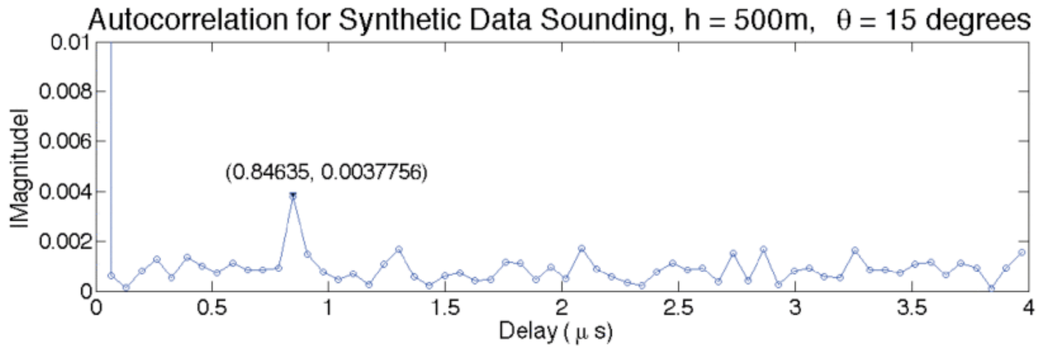


Phase Velocity

Vaňková et al., (2018)

Passive Radar Sounding





Peters et al., (2018)

Thank You