Relevance of the Four KISS Technical Foci to Glaciology

Prof. Slawek Tulaczyk, Department of Earth and Planetary Sciences,
University of California, Santa Cruz, CA

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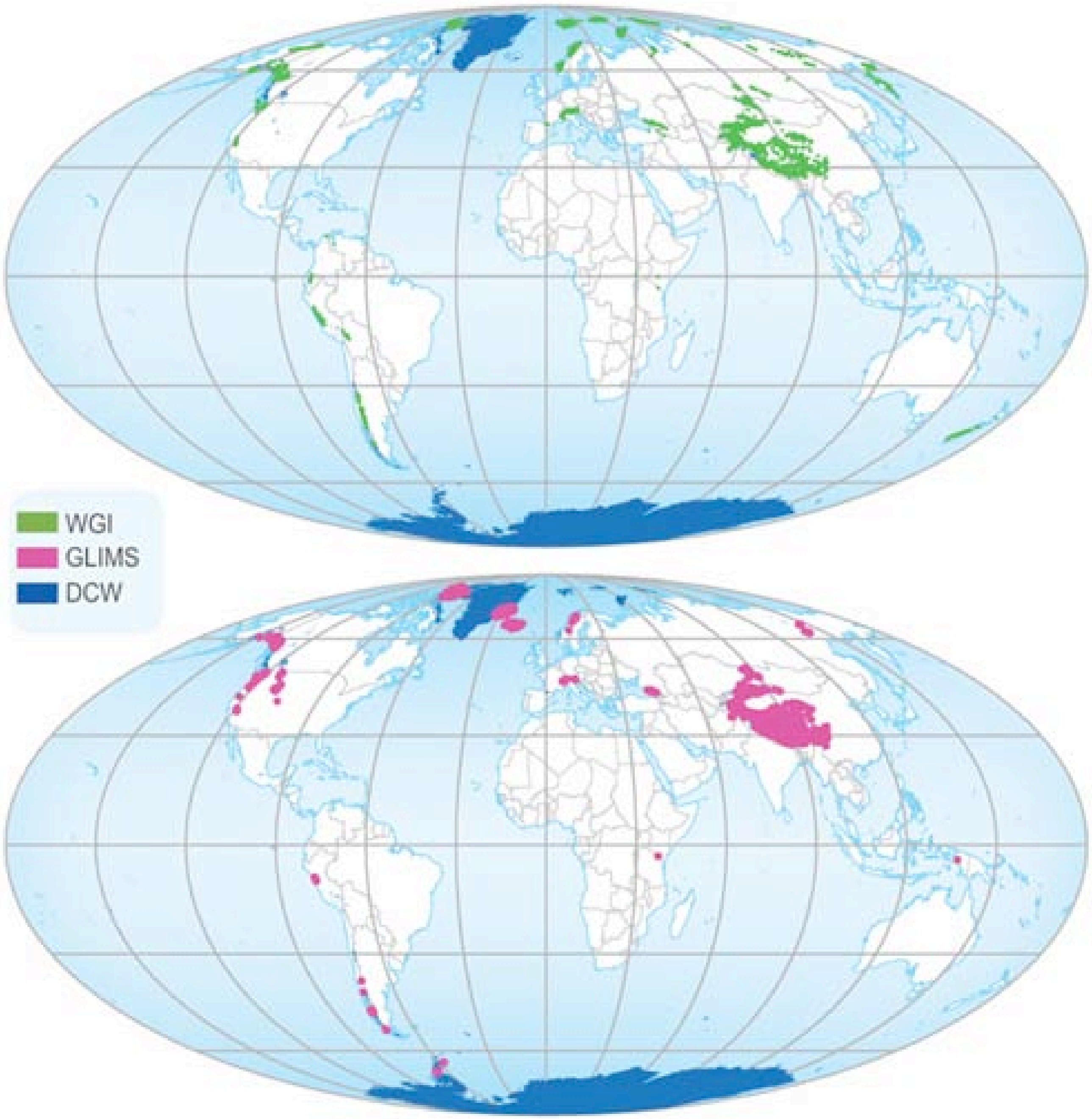
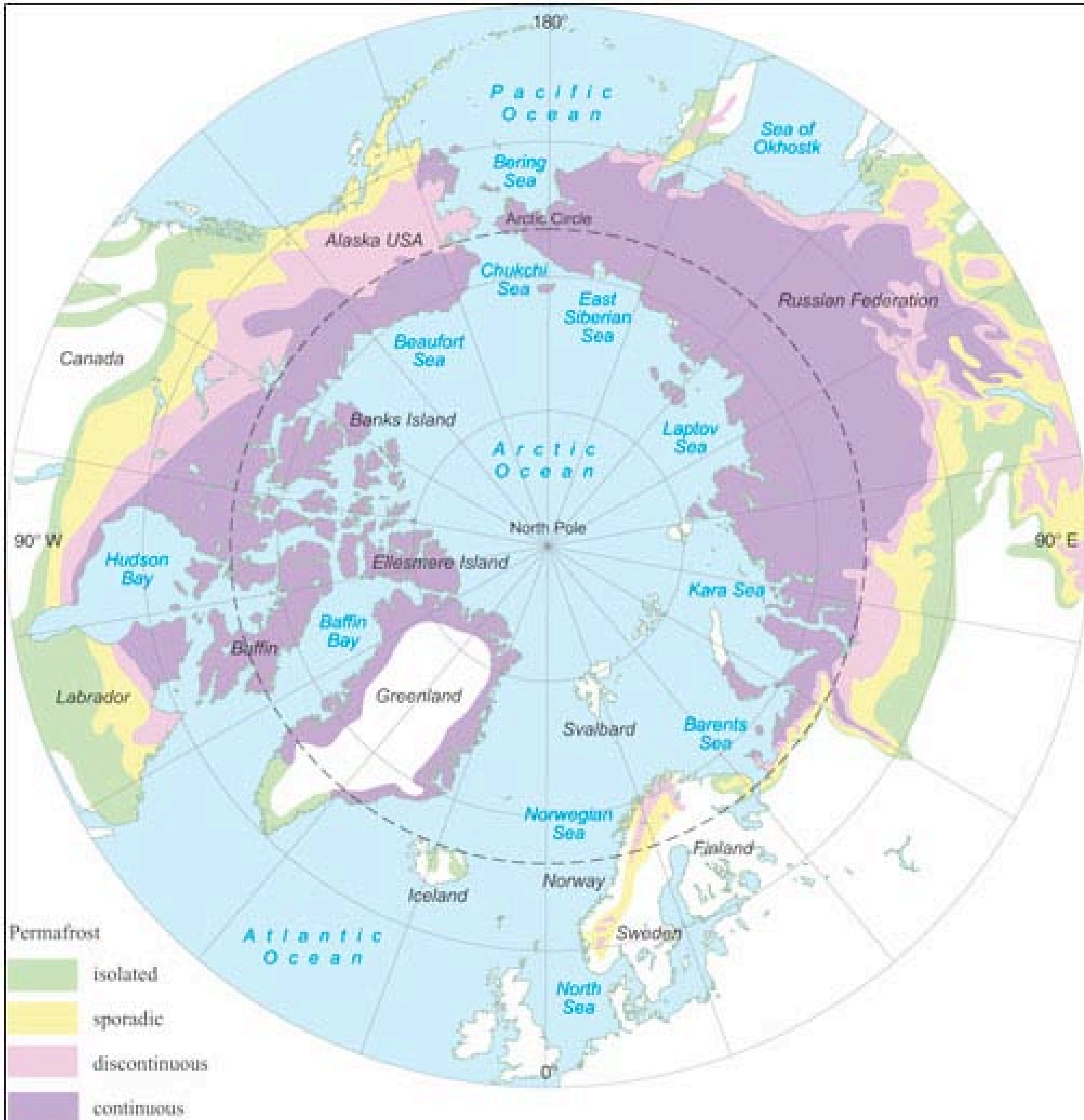
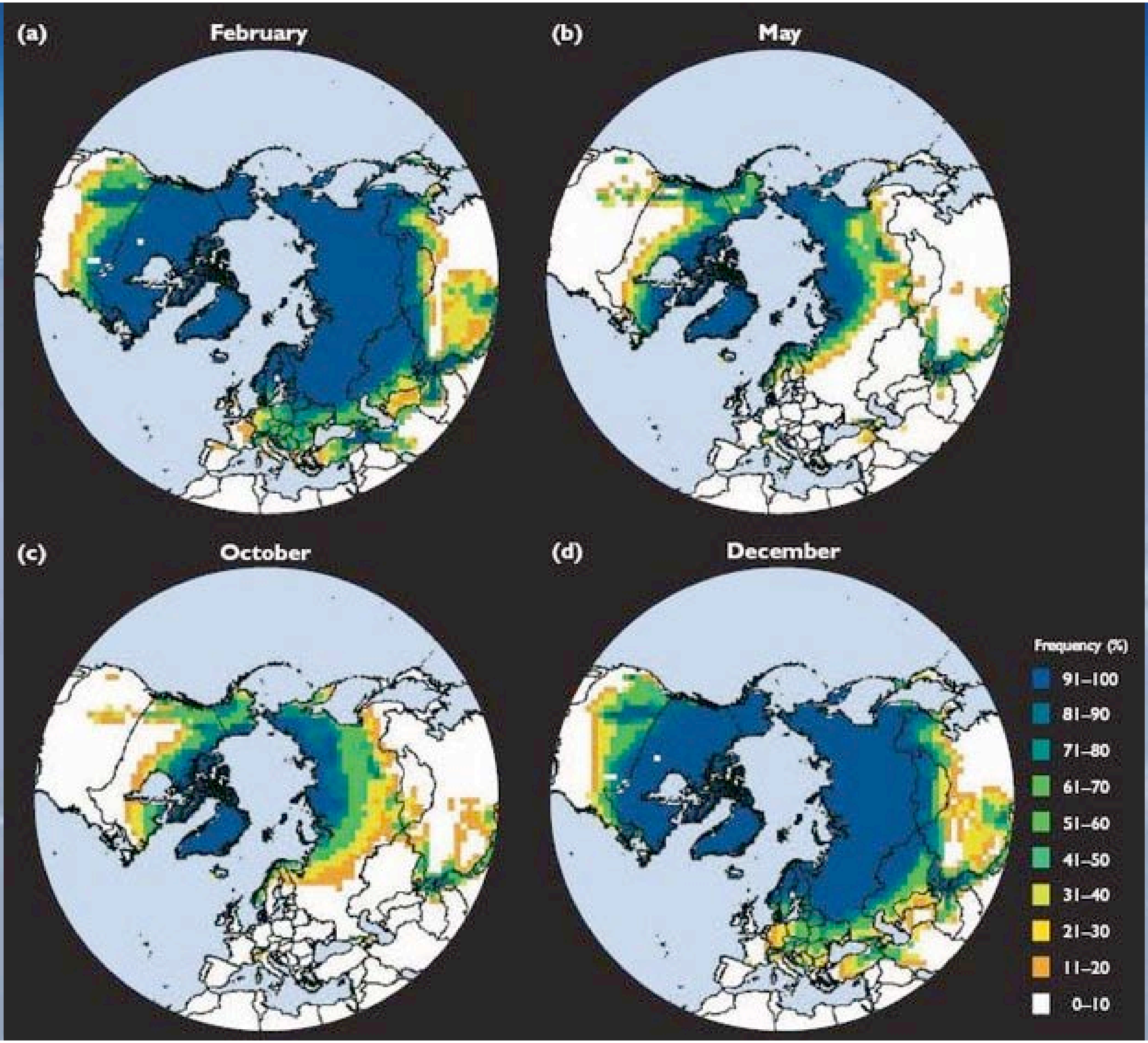
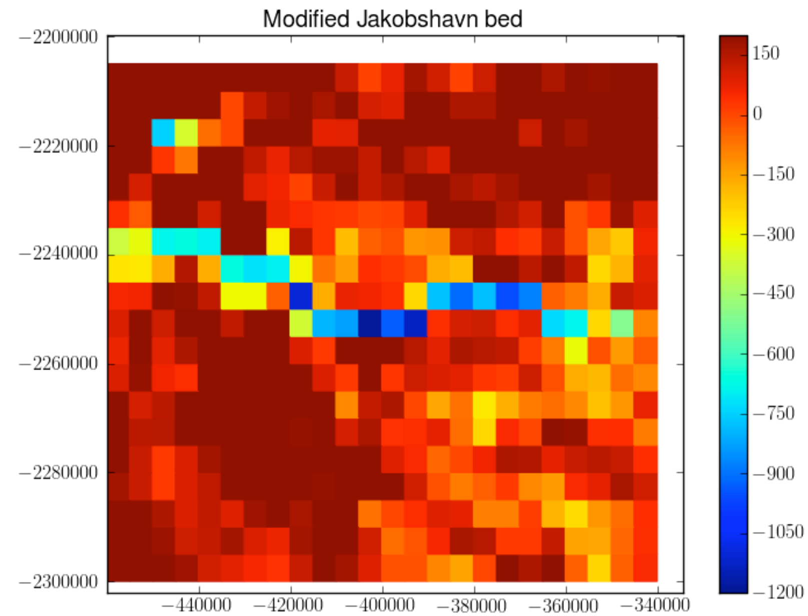


Fig. 3.6 Global glacier inventories

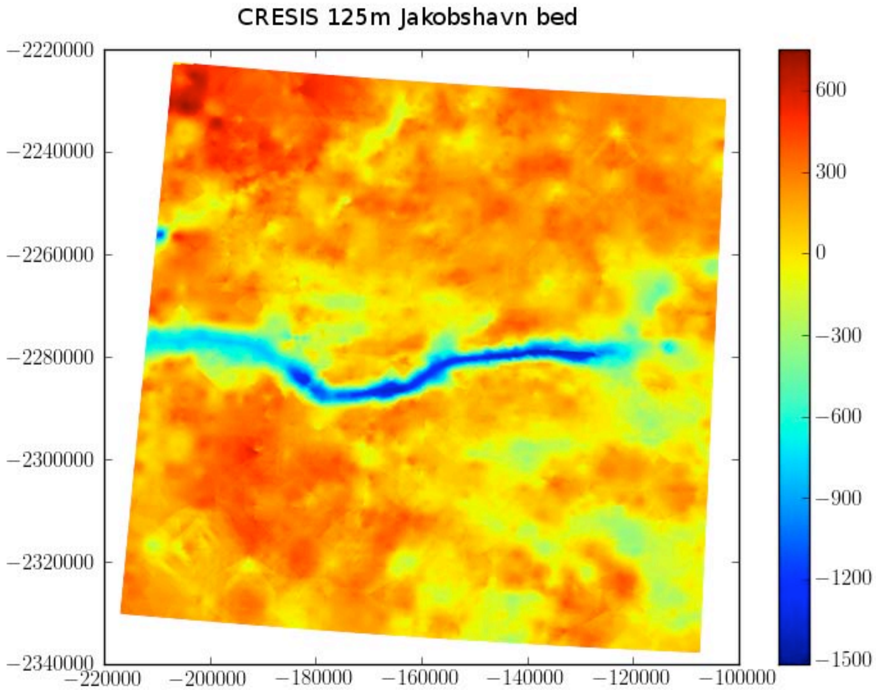

180°
Pacific Ocean
Sea of Okhostk
Bering Sea
Arctic Circle
Alaska USA
Chukchi Sea
East Siberian Sea
Russian Federation
Canada
Beaufort Sea
Banks Island
Laptov Sea
Arctic Ocean
North Pole
90° W
90° E
Hudson Bay
Ellesmere Island
Kara Sea
Baffin Bay
Buffin
Labrador
Greenland
Svalbard
Barents Sea
Norwegian Sea
Finland
Norway
Iceland
Sweden
Atlantic Ocean
North Sea
0°
Permafrost
isolated
sporadic
discontinuous
continuous


(a)
February
(b)
May
(c)
October
(d)
December
Frequency (%)
91–100
81–90
71–80
61–70
51–60
41–50
31–40
21–30
11–20
0–10

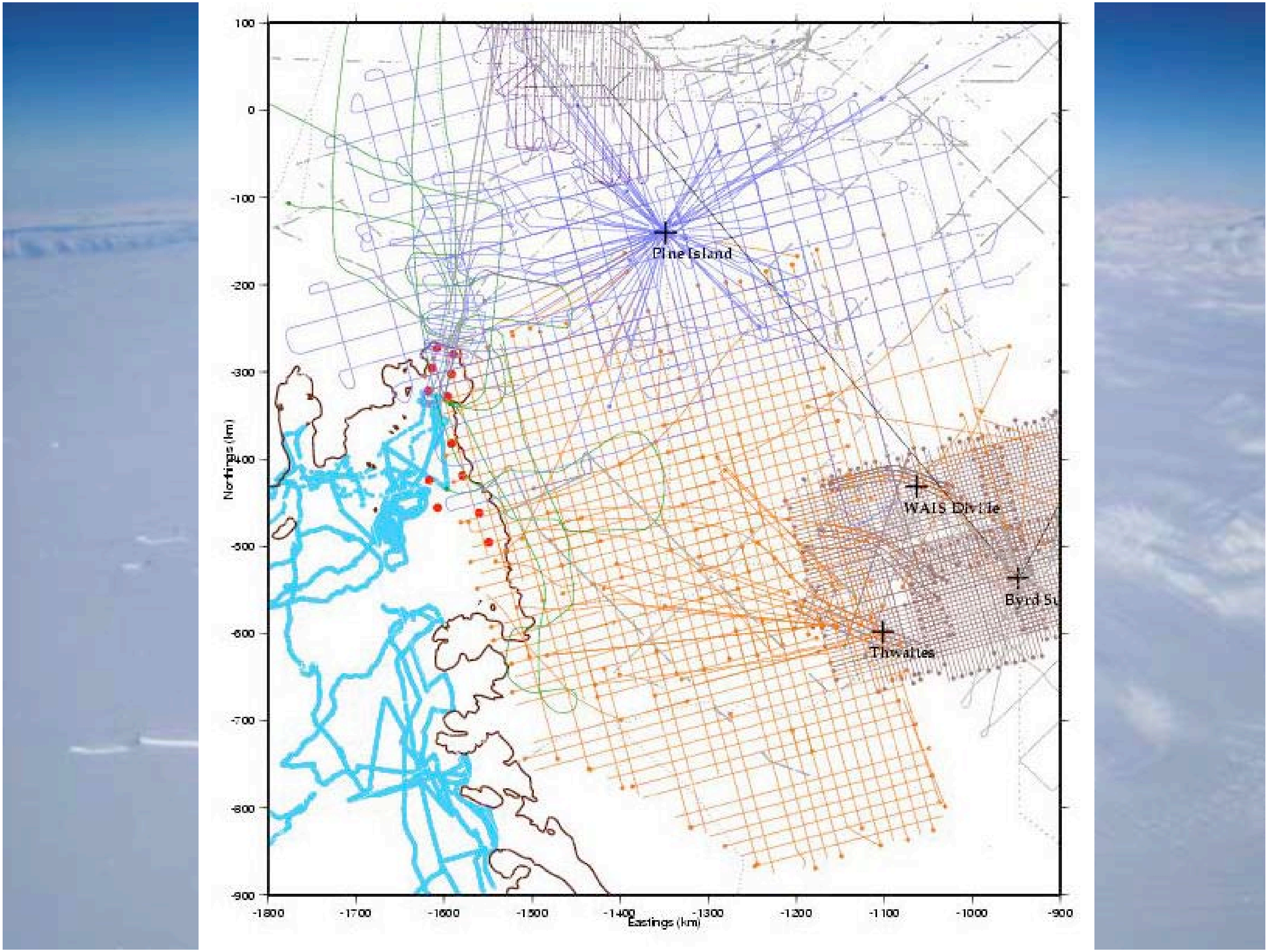
Far-reaching active microwave technology - coverage does not meet needs



Current Greenland and Antarctica bed maps posted at 5km - interpolated from sparse profiles.



Example from Dr. U. Hertzfeld


Pine Island
WAIS Divide
Byrd Su
Thwaites
Northings (km)
Eastings (km)
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1800
-1700
-1600
-1500
-1400
-1300
-1200
-1100
-1000
-900

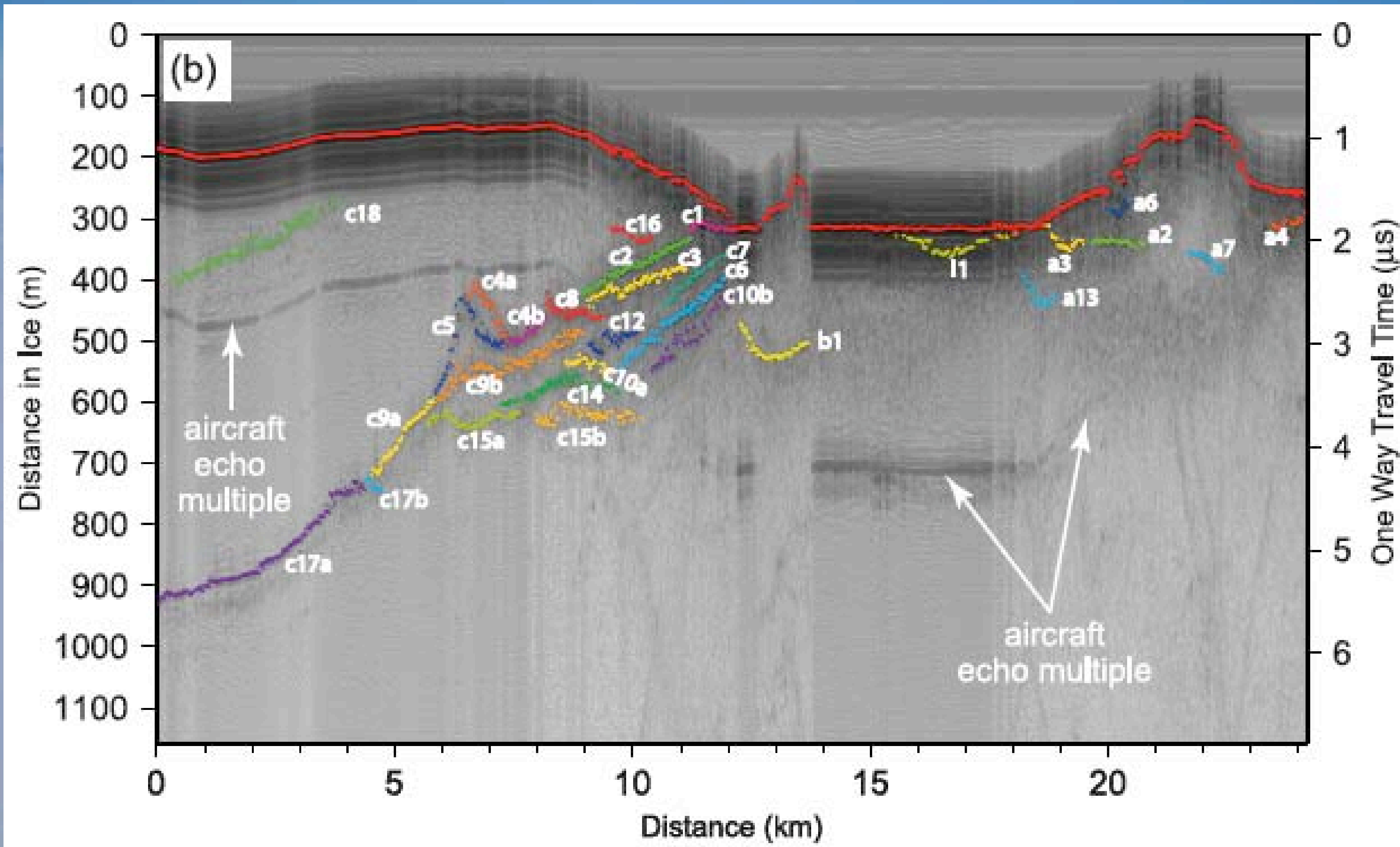
Far-reaching active microwave technology – penetration in ice >3km

Electrical Properties of Geological Media Material Dielectric constant Conductivity (mS/m) Velocity (m/ns) Attenuation (dB/m)

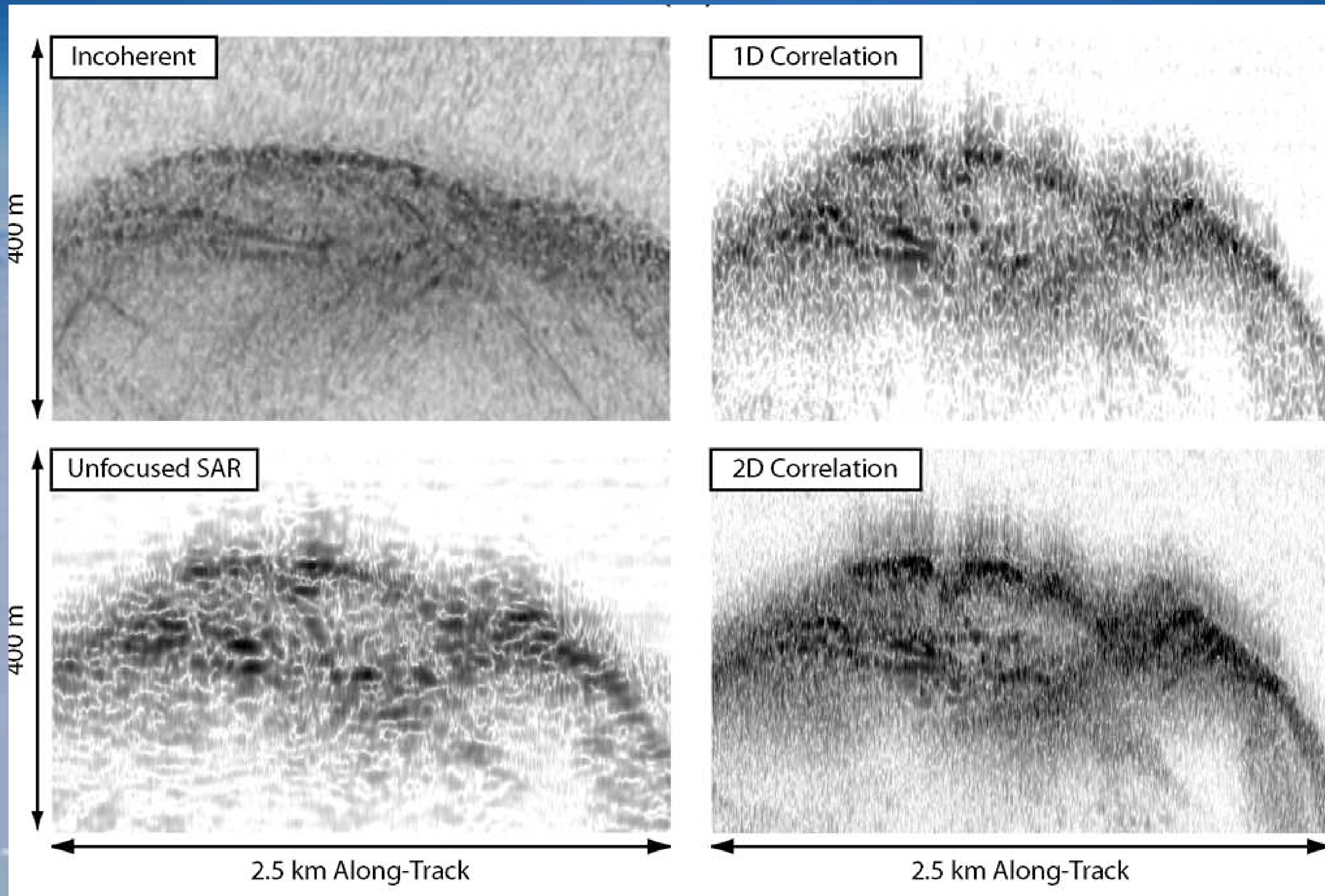
Material	Dielectric constant	Conductivity (mS/m)	Velocity (m/ns)	Attenuation (dB/m)
Air	1	0	0.3	0
Distilled water	80	0.01	0.033	0.002
Fresh water	80	0.5	0.033	0.1
Sea water	80	30,000	0.01	1,000
Dry sand	3-5	0.01	0.15	0.01
Saturated sand	20-30	0.1-1.0	0.06	0.03-0.3
Limestone	4-8	0.5-2	0.12	0.4-1
Shale	5-15	1-100	0.09	1-100
Silt	5-30	1-100	0.07	1-100
Clay	4-40	2-1,000	0.06	1-300
Granite	4-6	0.01-1	0.13	0.01-1
Salt (dry)	5-6	0.01-1	0.13	0.01-1
Ice	3-4	0.01	0.16	0.01

Table A.A: Electrical properties of geological media [after Davis et al., 1989]

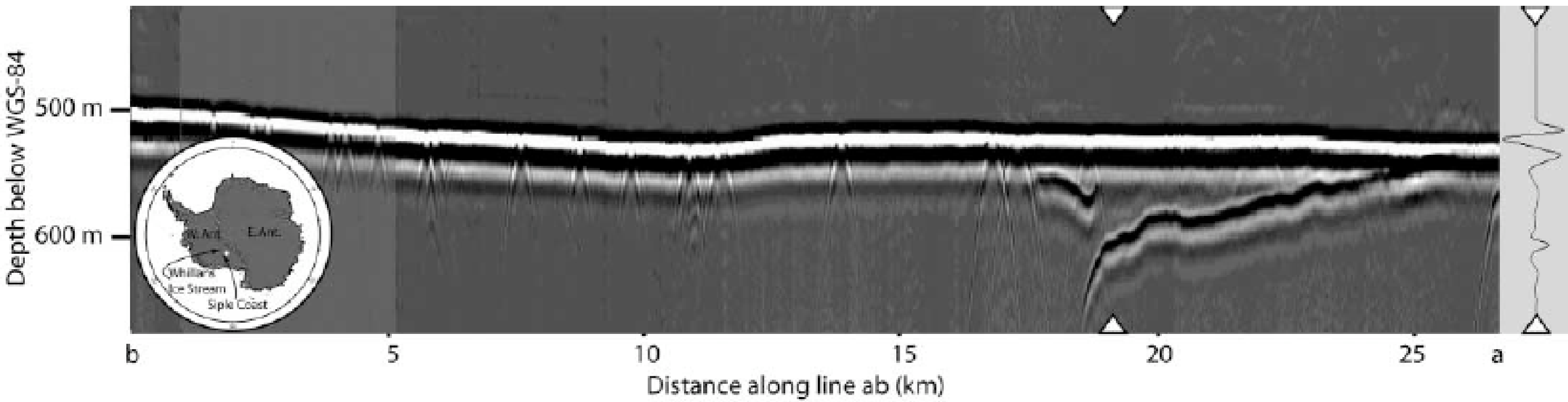
Active microwave technology - ground penetration around ice margins

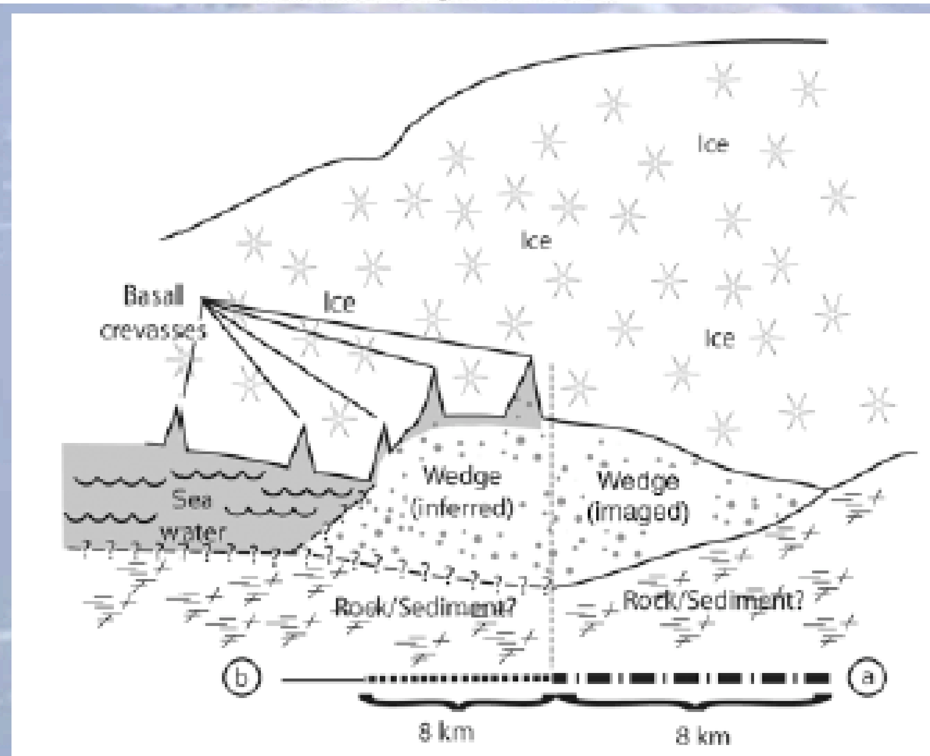


Holt et al. (2006) - airborne survey of Taylor Glacier. Even without penetration glaciologists use reflection strength to infer sub-ice properties



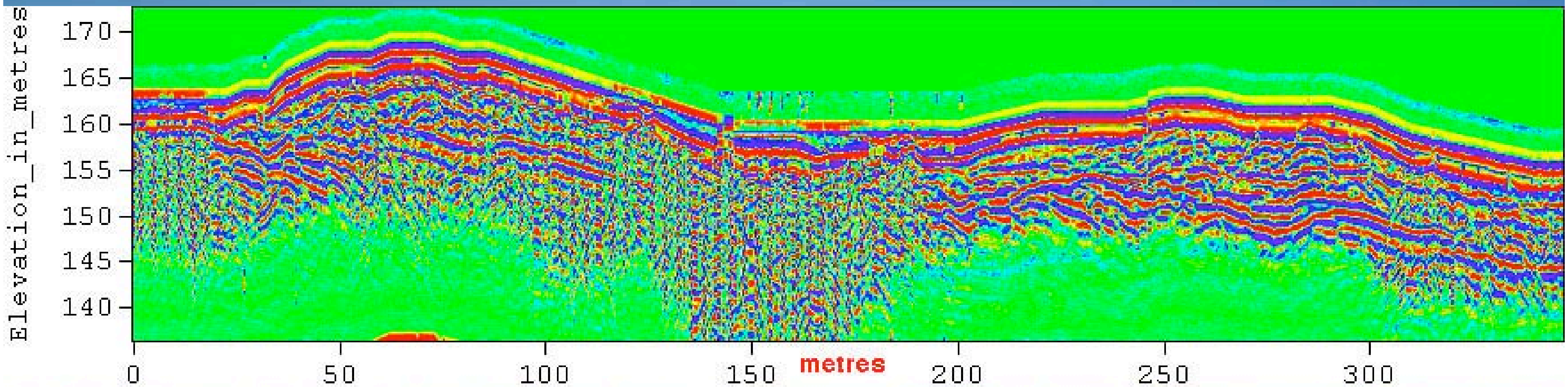
Peters et al. (2007) - Bed penetration beneath Kamb Ice Stream (under ~1.5 km of ice) - use of phase info in addition to magnitude

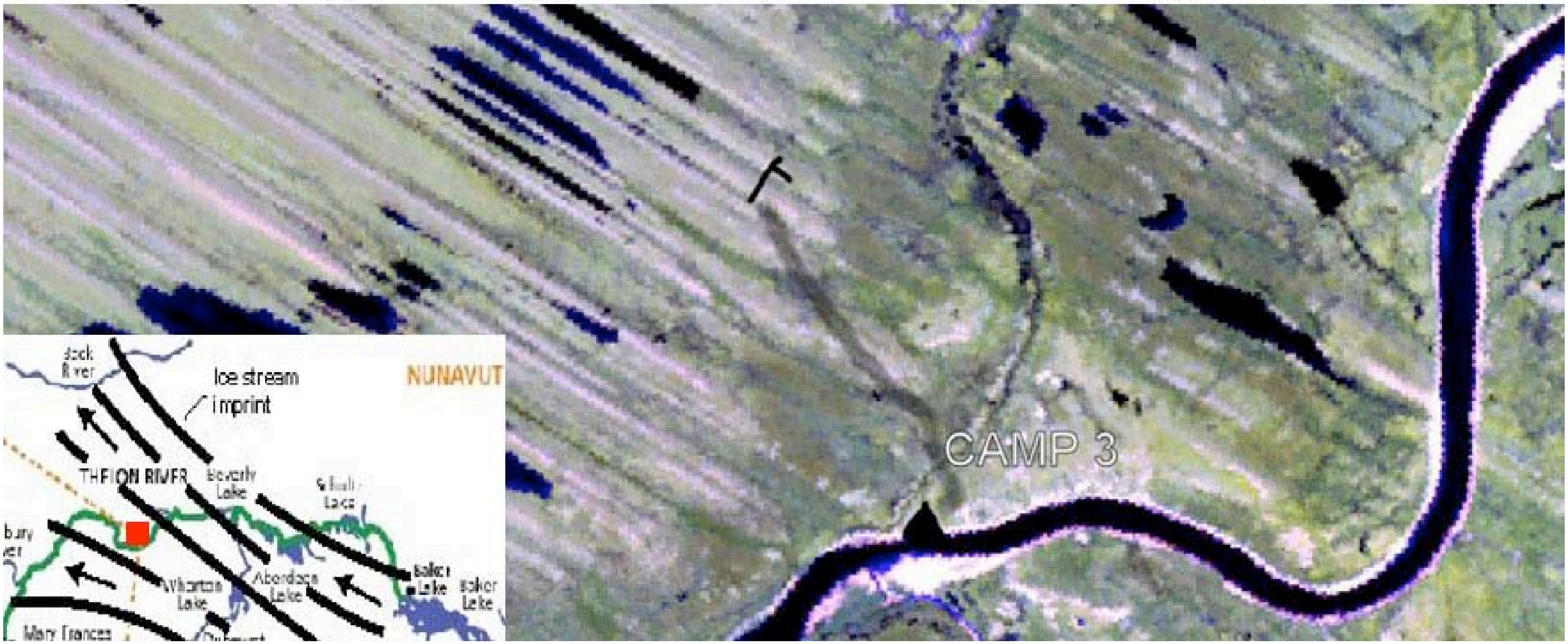




Anandakrishnan et al. (2007) - sub-ice sedimentary wedge imaged with ground-based IPR (700m thick ice).

Ground-based GPR (100 MHz) penetrates to 20-30m in permafrost





Conclusions on far-reaching active microwave technologies:

- There is still huge need for mapping out thickness, bed topography, internal accumulation layers for glaciers and ice sheets (interpolation of profiles thus far).
- Temporal variability of interest to catch ice thickness changes and because we have observed (with spatio-temporally sparse data) changes in bed properties (e.g. accumulation or drainage of water, erosion and accumulation of sediments).
- Technical challenges are huge but not hopeless and scientific/societal pay-offs are immense (glaciology, geomorphology, hydro(geo)logy, seismic hazard assessment, agriculture, land management, coastal management, military).
- Recent polar missions may provide a good place to start in terms of technology/processing (WISE, GISMO, CReSIS, UTIG, LDEO).
- Multifrequency!

InSAR and GPS Time Series

- For glaciology much of the need in the area of repeat velocity measurements will be met (?) by DESDynI, if it launches and works as planned and has high resolution/accuracy.

- High frequency repeat velocity measurements (‘seismic InSAR’) would be of interest (calving events, transient glacier response to calving events or to water drainage events).

- Improved processing approaches to integrating various displacement measurements (InSAR, GPS, feature matching) into 4D data sets.

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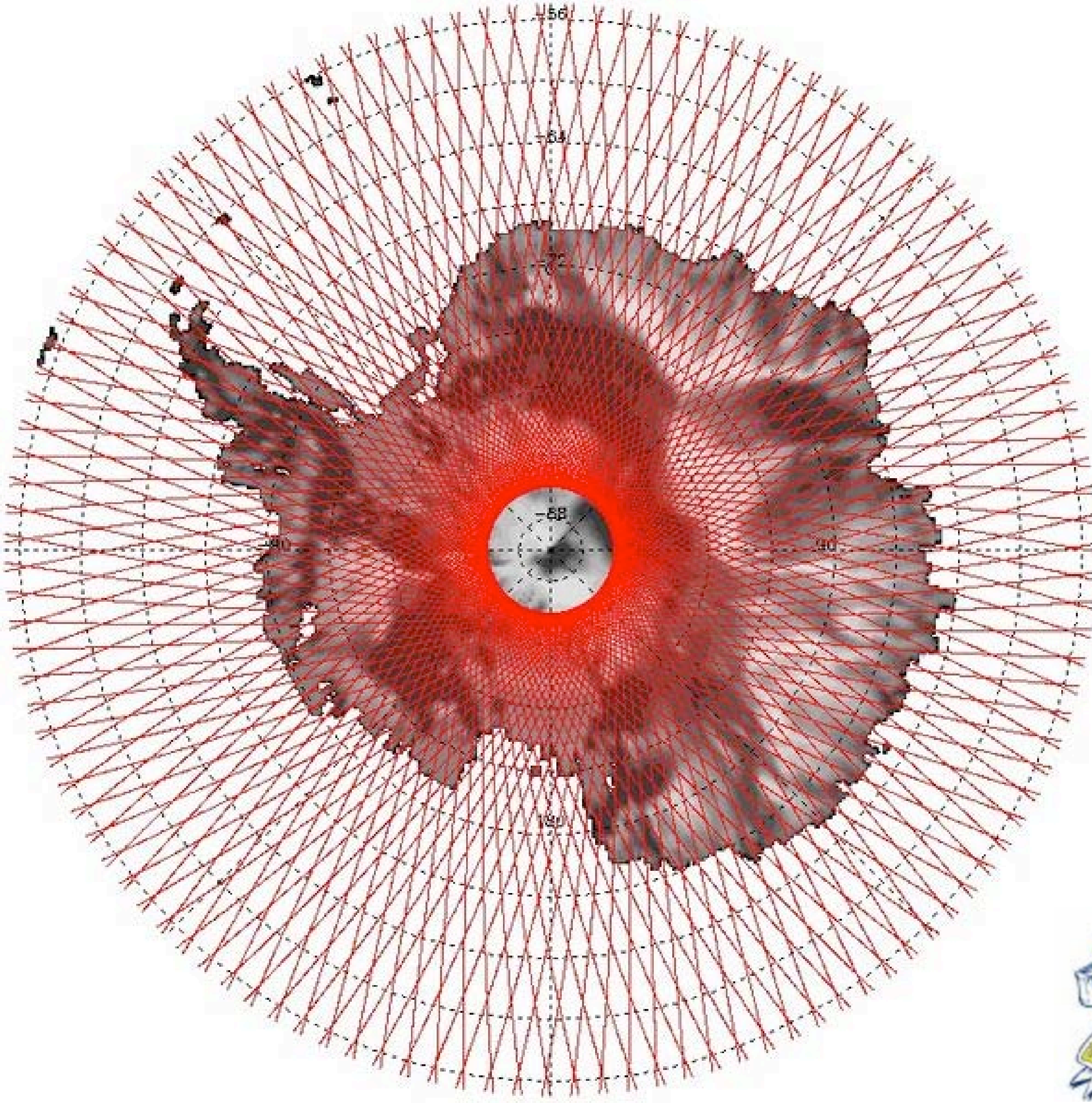
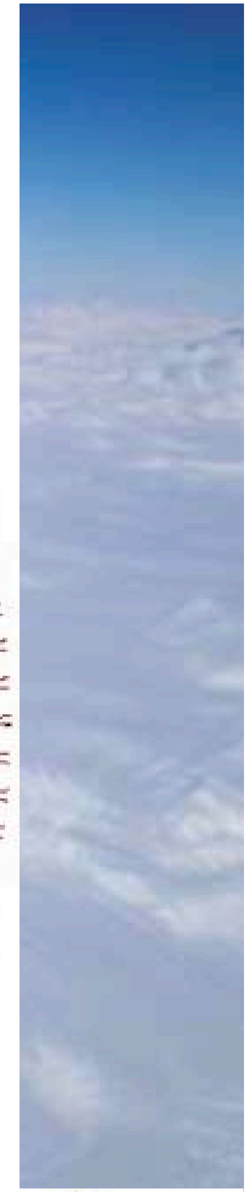
Distributed Optical Telescope

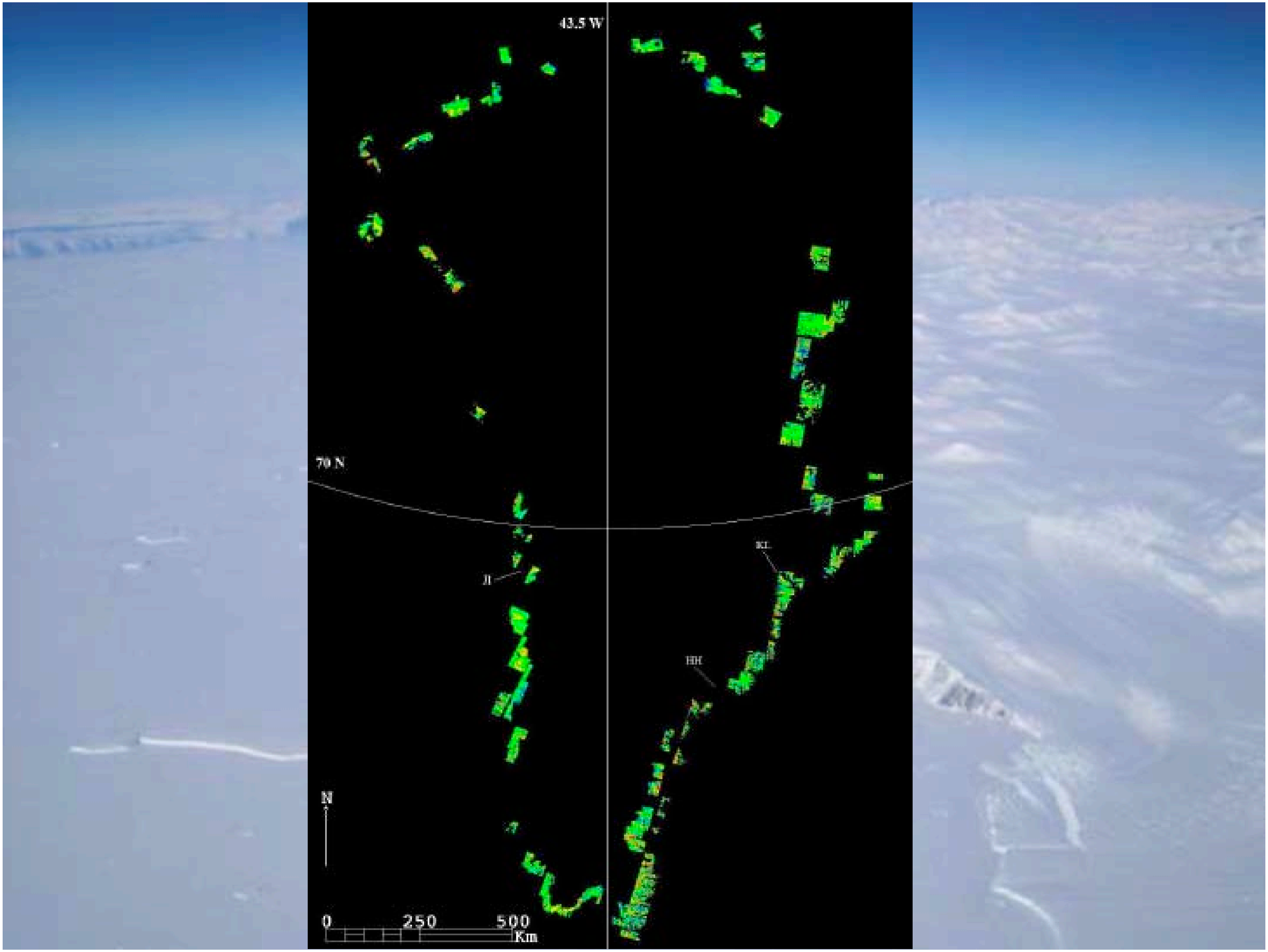
- Use of (past and future) optical data to measure ice volume changes and displacement. Before ~1990s archival satellite and airborne data provide the only high-resolution/accuracy sources of information.

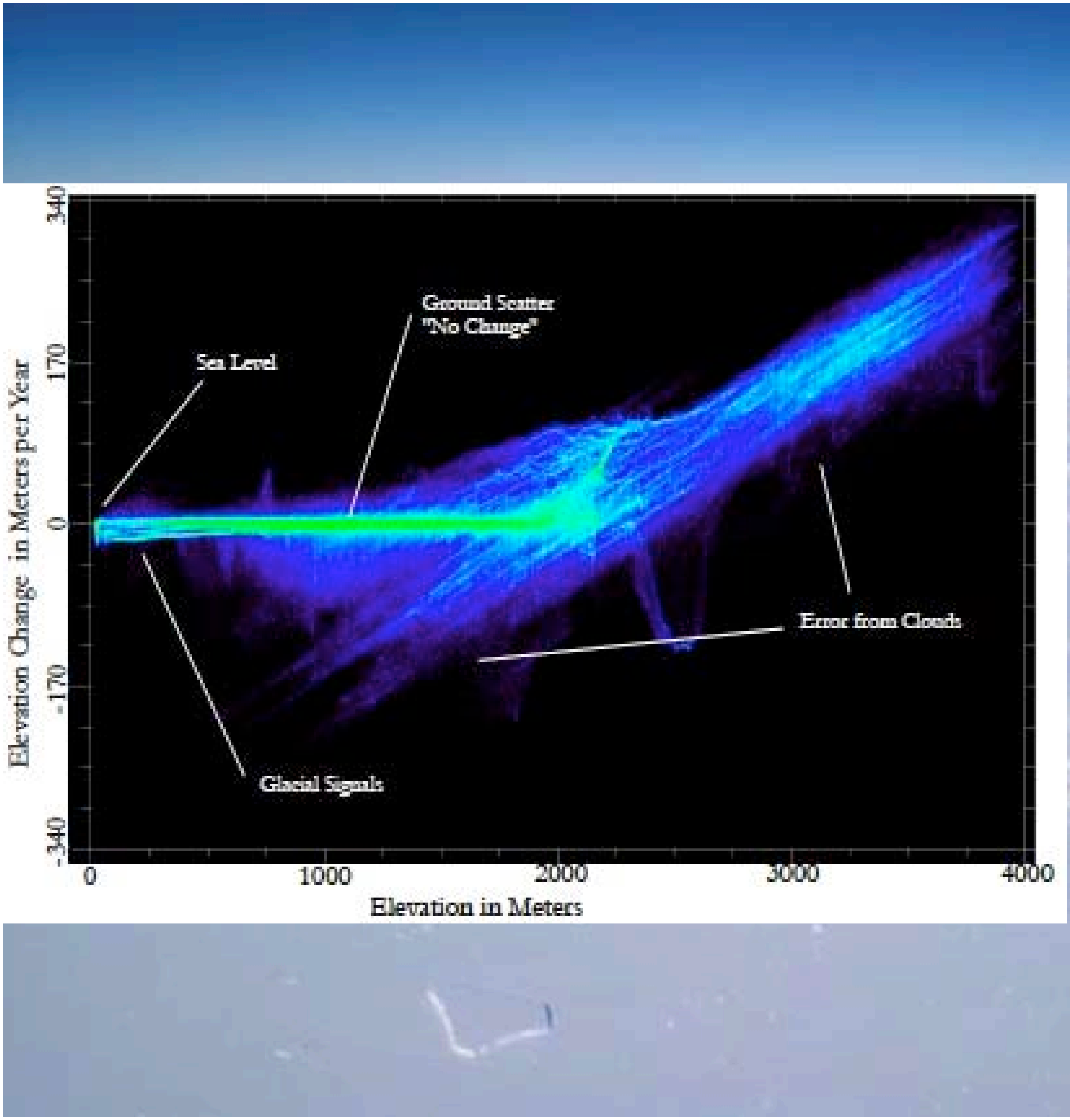
- DESDynI will help map out ice velocities starting in 2017 but there is no ice elevation mapper (just profiler) planned (ICESat 2 in 2015). Optical data will still be the only source of elevation information at scales less than dozens of km (track spacing).

- Will there be need for high-resolution glaciological data? Ice models are improving their resolution (1990s: 20-40km, 2000s: 5-10km, 2010s: down to ~1km, ultimately to ~0.1km).

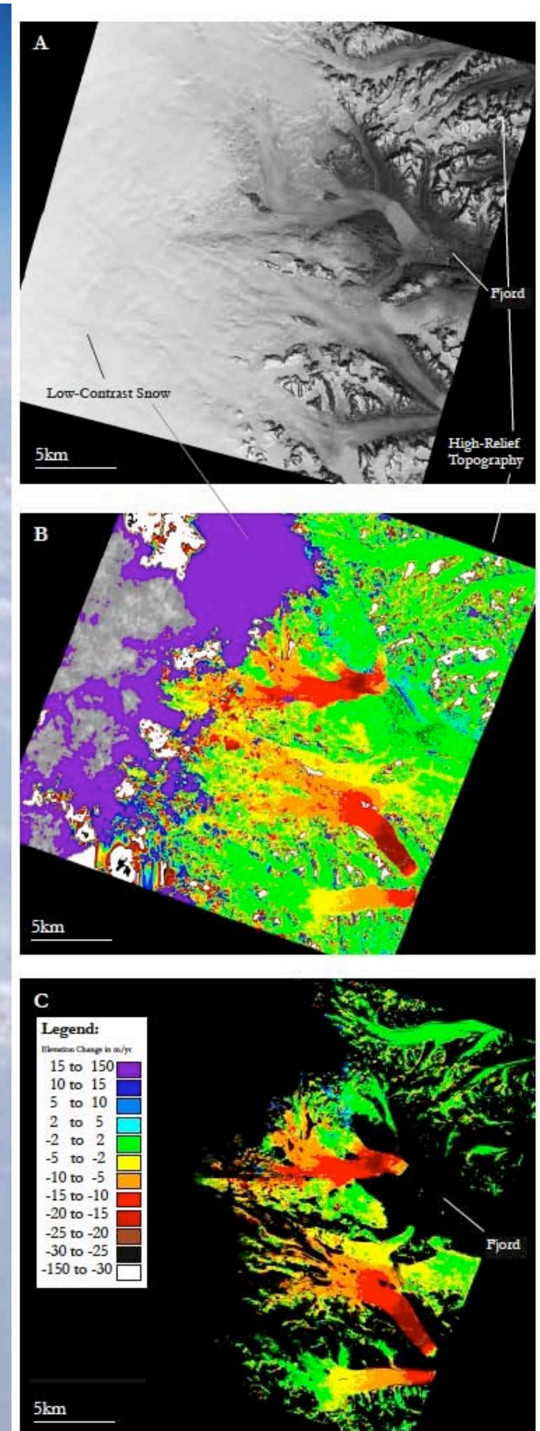
- Biggest challenges have to do with getting access to data, data quality control, processing large data volumes, maximizing quality of processed products, integrating with ancillary data, etc.



-56
-64
-72
-88
-90
90
180



43.5 W
70 N
JI
KL
HH
N
0
250
500
Km



Ground Scatter
"No Change"
Sea Level
Error from Clouds
Glacial Signals
Elevation Change in Meters per Year
Elevation in Meters
340
170
0
-170
-340
0
1000
2000
3000
4000



A
Fjord
Low-Contrast Snow
High-Relief Topography
5km
B
5km
C
Legend:
15 to 150
10 to 15
5 to 10
2 to 5
-2 to 2
-5 to -2
-10 to -5
-15 to -10
-20 to -15
-25 to -20
-30 to -25
-150 to -30
Fjord
5km

Geostationary Optical Seismometer

- Amazing idea, if over CA it may image changes in snow cover.

- Could be used as a prototype for future deployments over glaciated mountain ranges and/or Greenland/Antarctic ice margins

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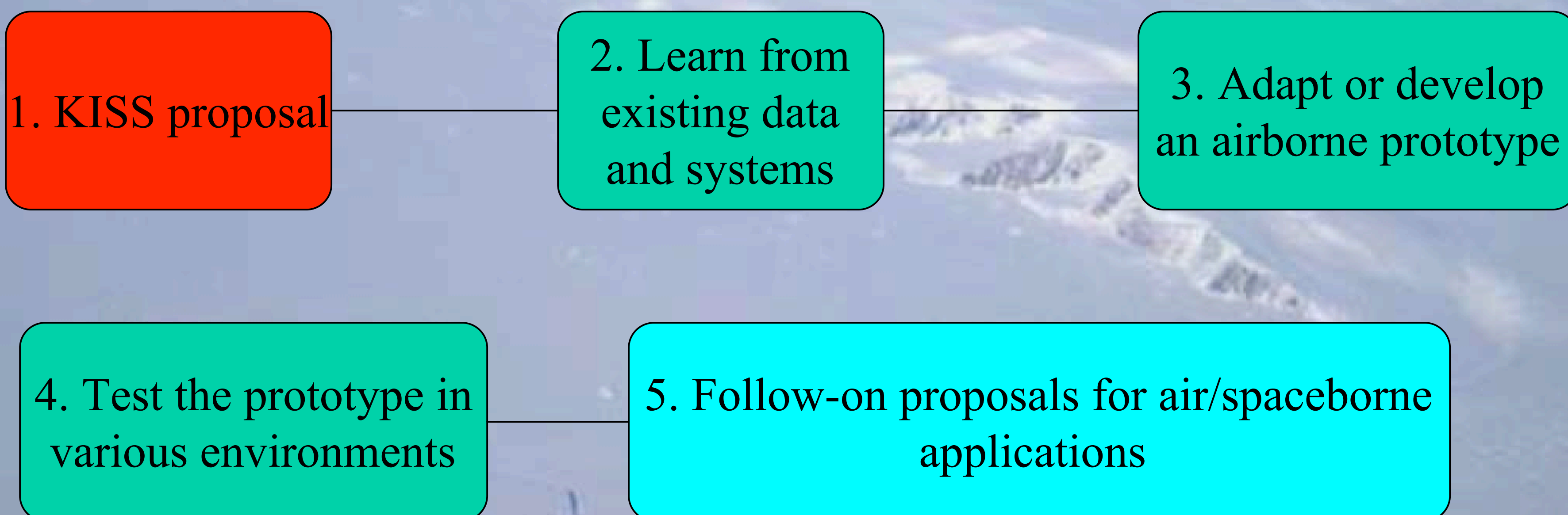
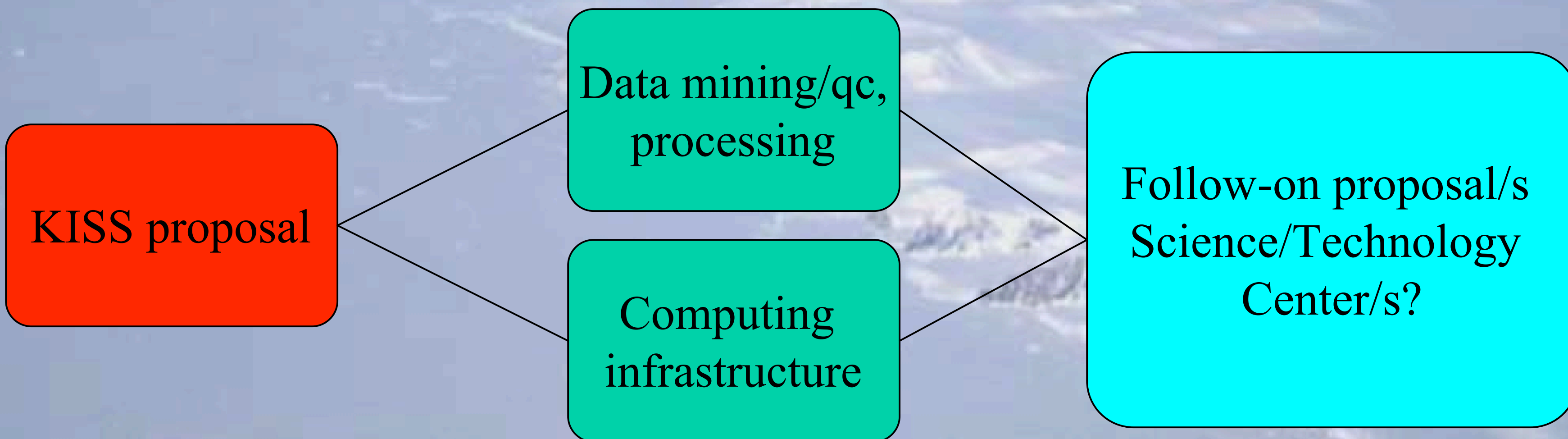
Summary of glaciological relevance of this KISS 'think tank':

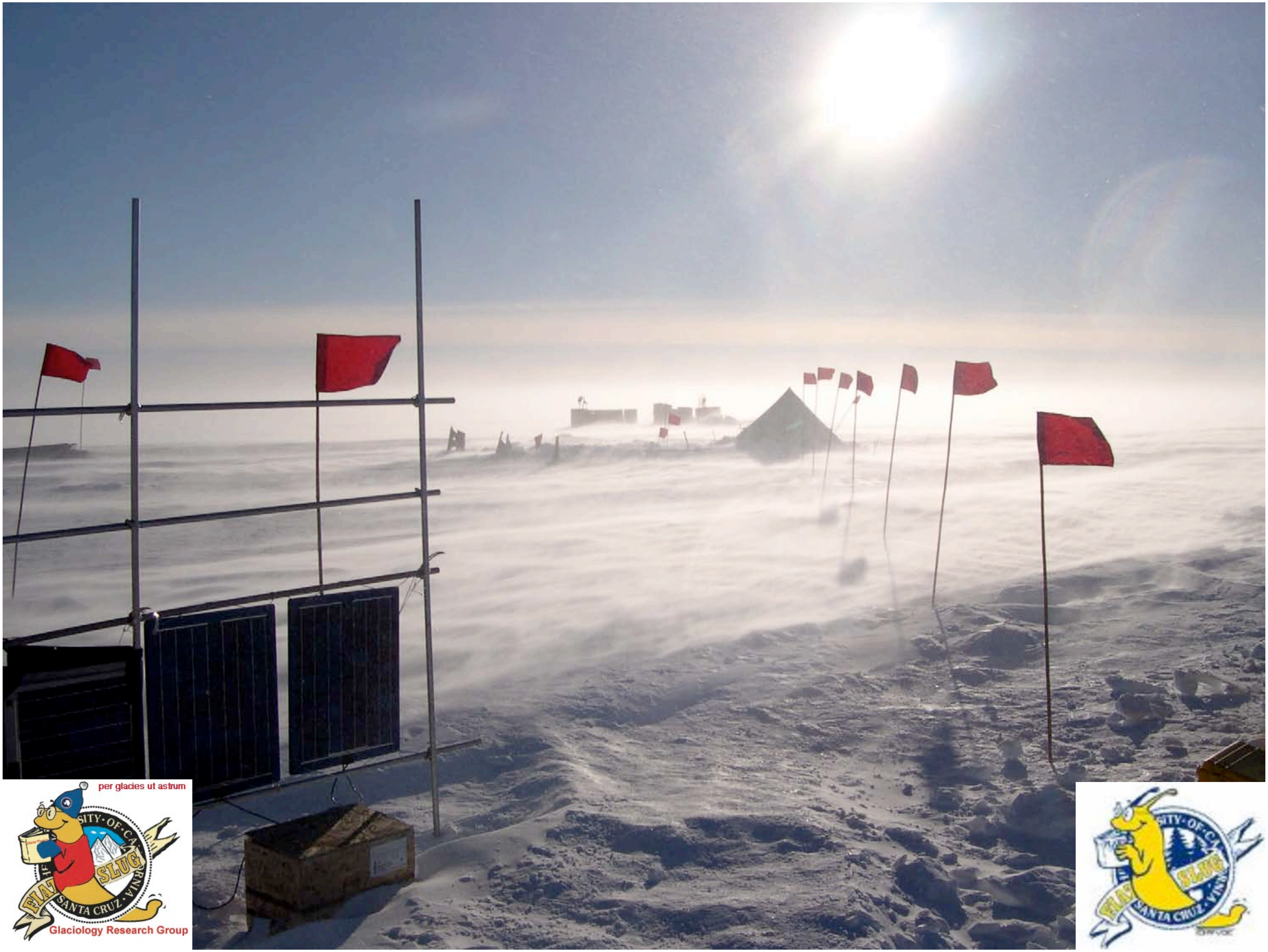
1. New sensor development - ice/ground multifrequency radar mapper (high value / high risk, high cost, long term).



Summary of glaciological relevance of this KISS 'think tank':

2. Advances in (optical and InSAR) data mining and processing techniques needed to cover Earth's Cryosphere (study area of >10 mln km^2, high value / low risk, short tem, low cost).





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