

Challenges in Monitoring Greenland's Surface Mass Balance

*(*psst*: it's about the water)*

Mike MacFerrin

Cooperative Institute for Research in Environmental Sciences (CIRES)

University of Colorado, Boulder, CO

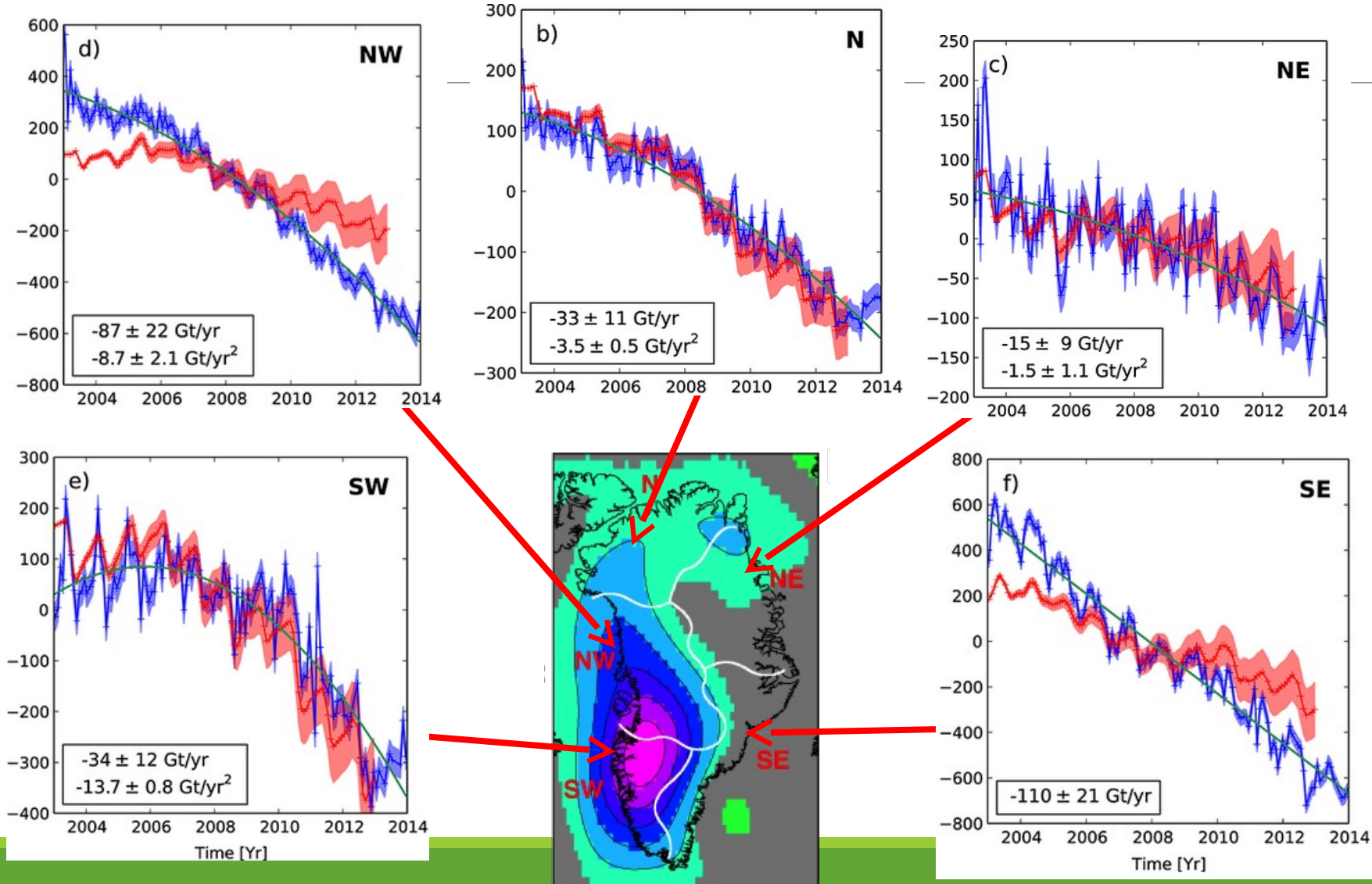
Polar Technology Conference (PTC-15), March 25, 2015



Greenland Mass Balance, 2002-2014

Surface Mass Balance (SMB) accounts for **68%** of mass loss and **79%** of acceleration in Greenland, 2002-2014

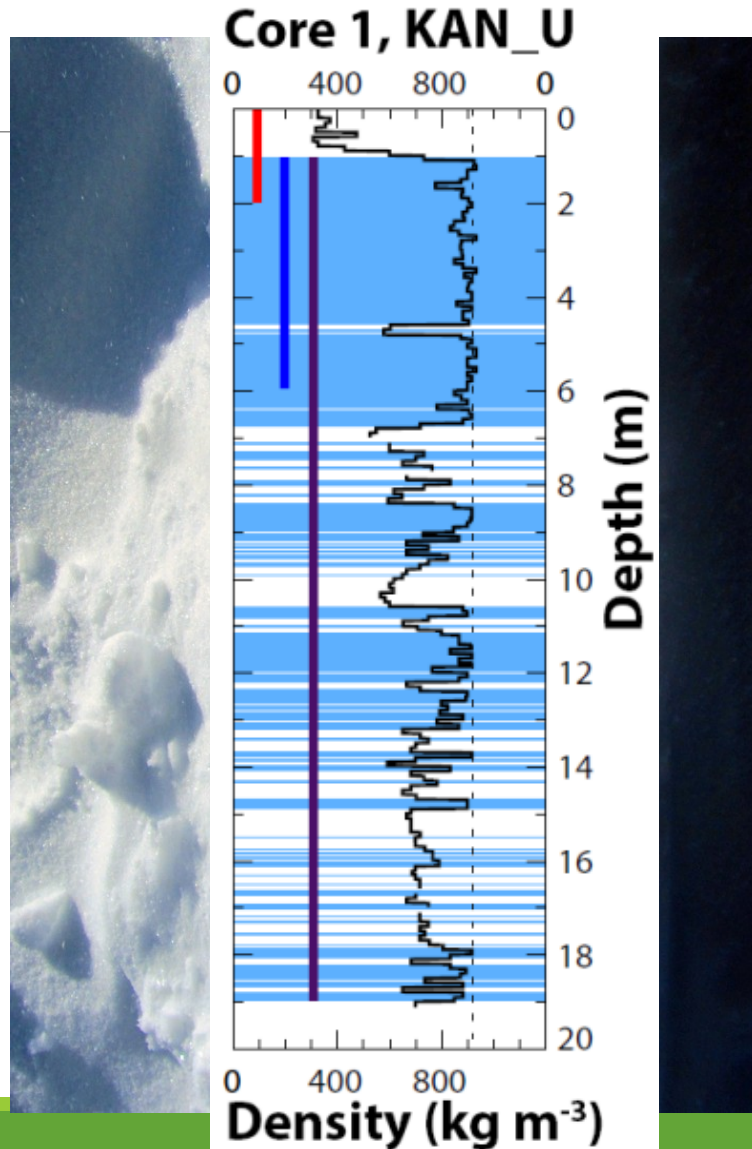
Velicogna I., T.C. Sutterley, M. van den Broeke. (2014). 'Regional acceleration in ice mass loss from Greenland and Antarctica using GRACE time-variable gravity data'. *Geophys. Res. Lett.*, 41 (22), 8130-8137



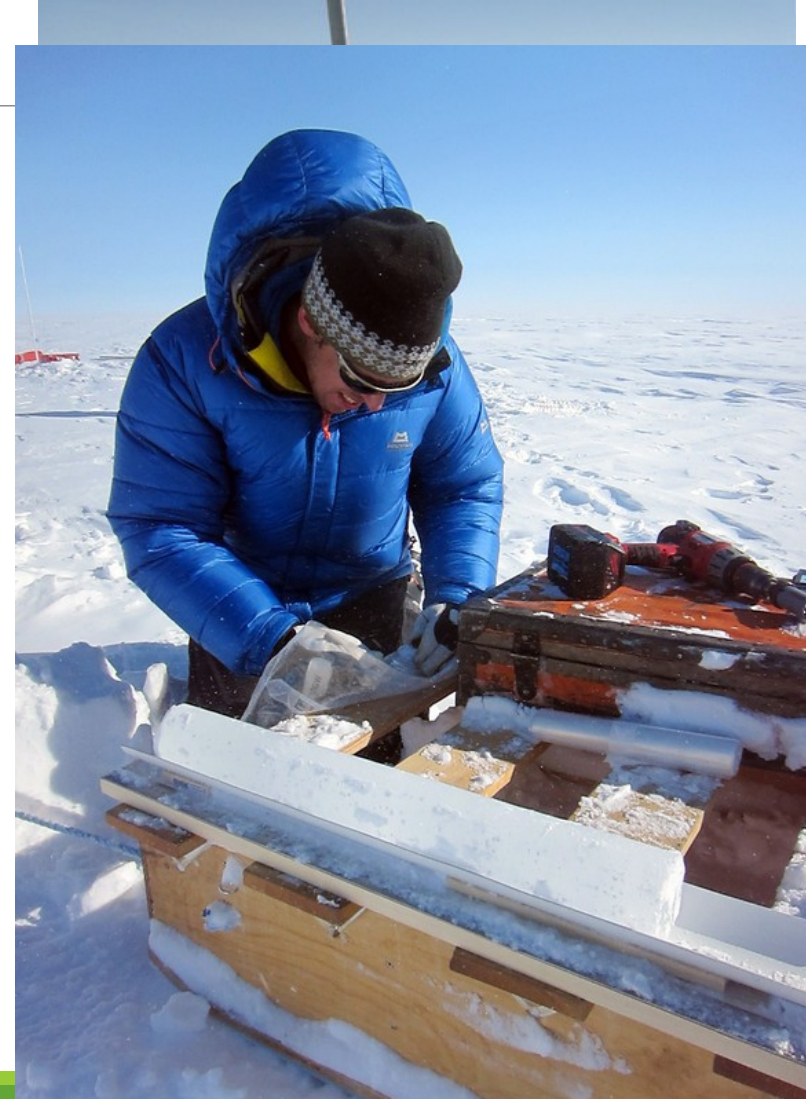
Ice Lenses at KAN-U, SW Greenland, 2012



67.0 N, 47.0 W
1860 m a.s.l.



Credit: Karen Alley, University of Colorado



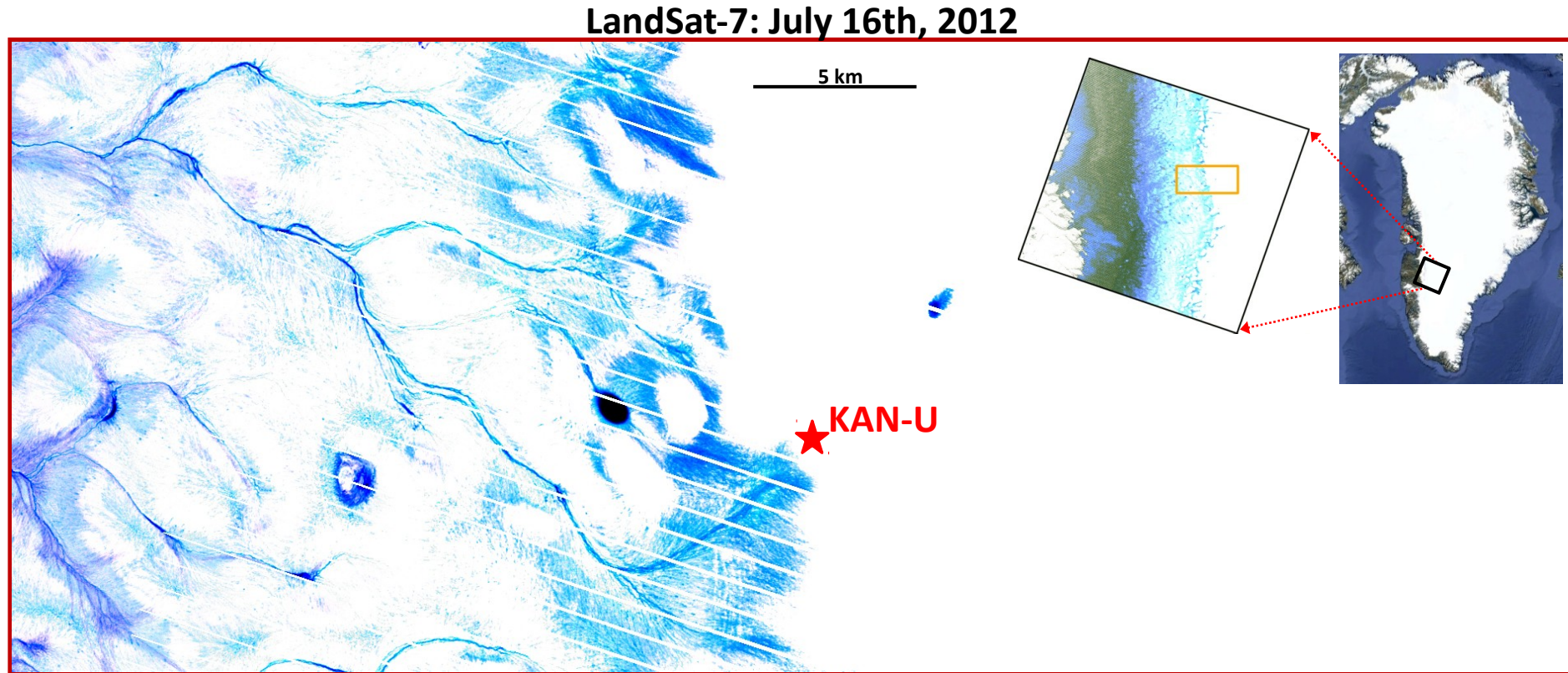
Credit: Babis Charalampidis, GEUS

KAN-U, Spring 2012

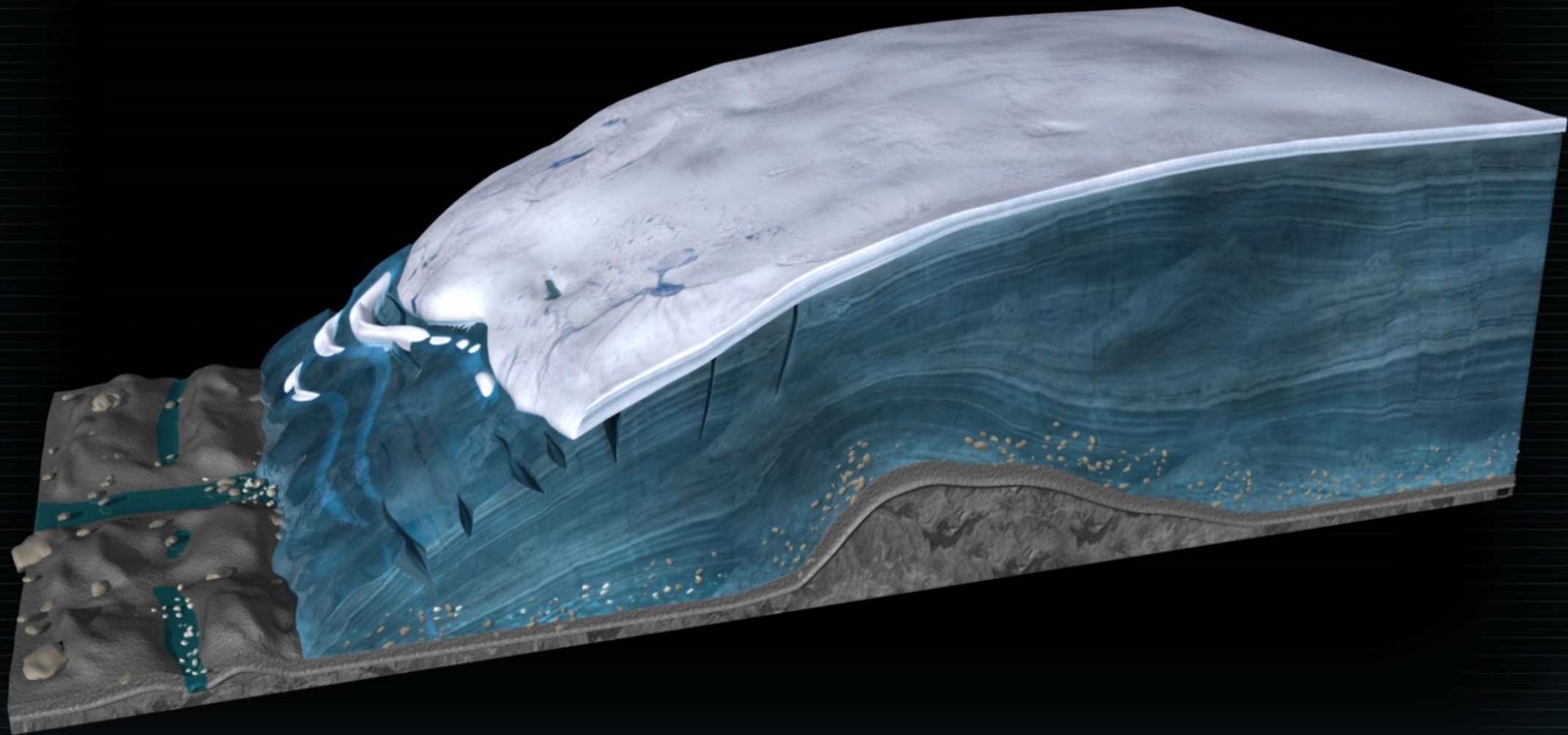


Credit: Horst Machguth, DTU

Summer 2012 Runoff Reaches KAN-U



Runoff had not previously been witnessed this high in southwest Greenland (up to 1900+ m a.s.l.)



Watson River in early May



Credit: Karen Alley, Univ. Colorado

Watson River in July 2012

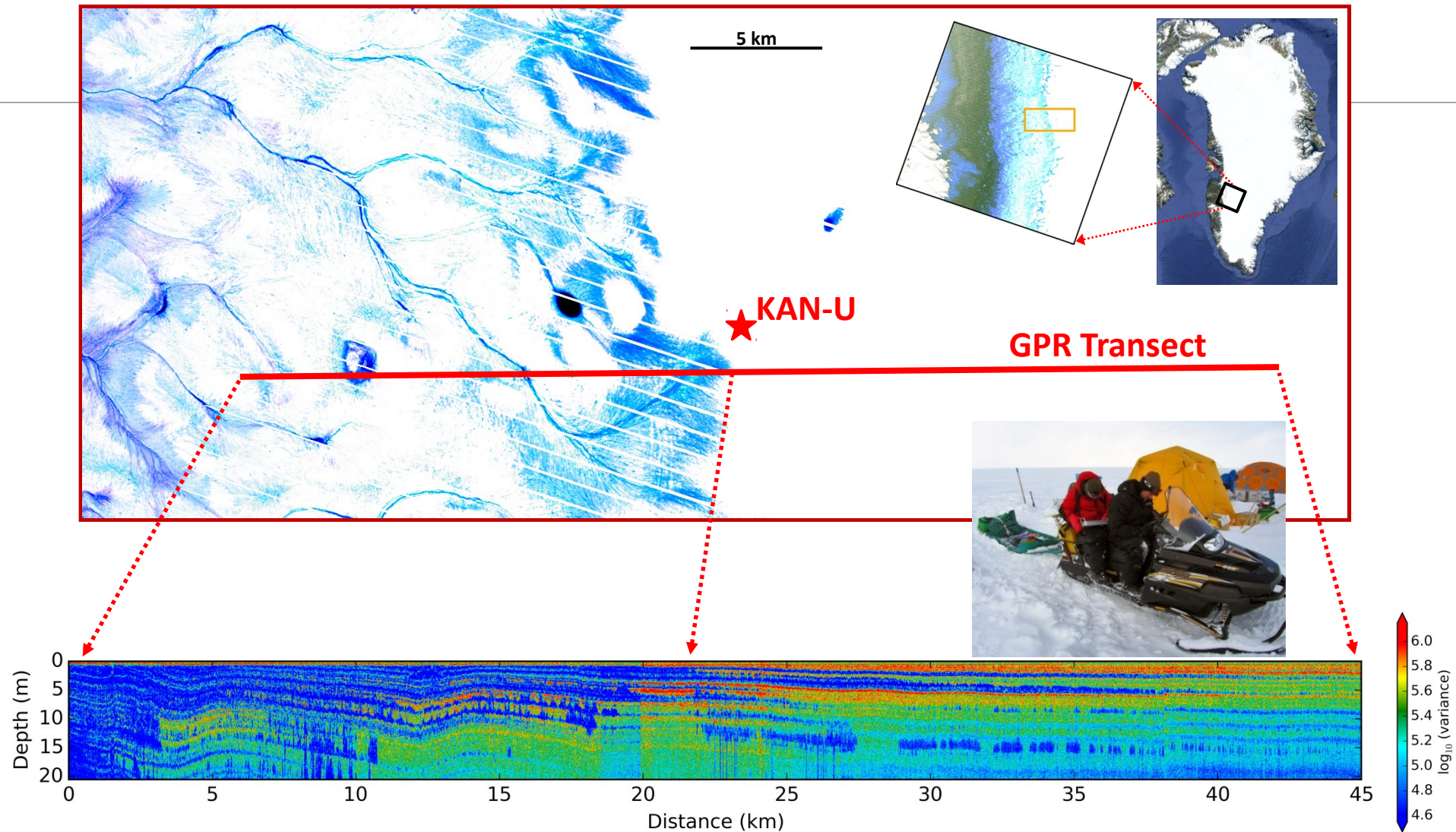


10±3% of 2012 Watson River area runoff came from “perched layer” zones at high elevation

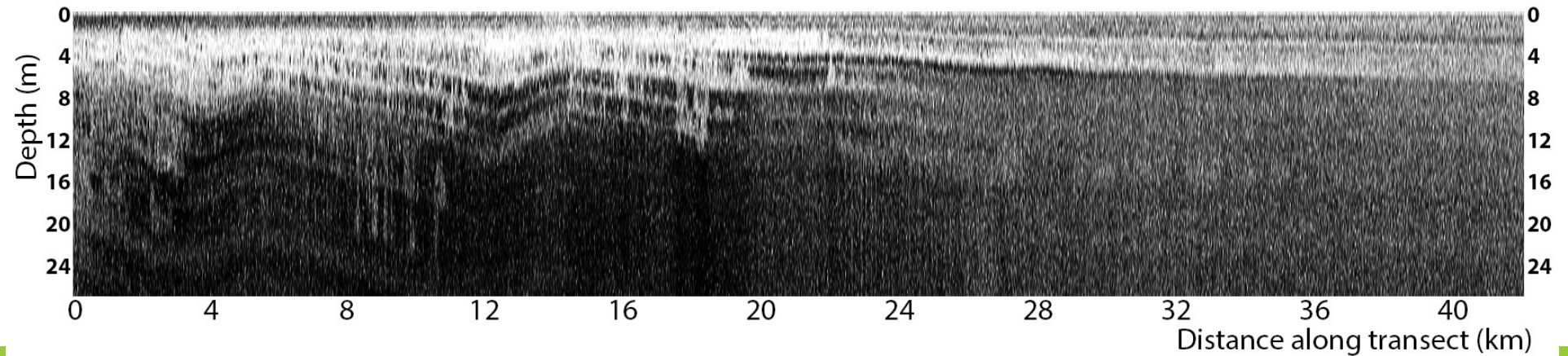
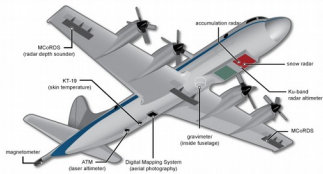
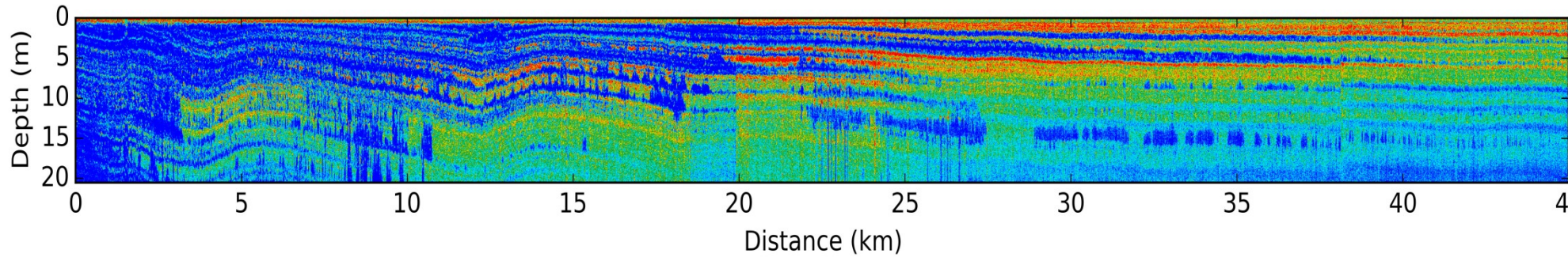
Machguth H., M. MacFerrin, D. van As, J. Box, C. Charalampidis, W. Colgan, R. Fausto. “Succession of melt events is key to abrupt Greenland ice sheet surface mass loss”. *Nature (in review)*. 2015



Mapping thick ice lenses with radar

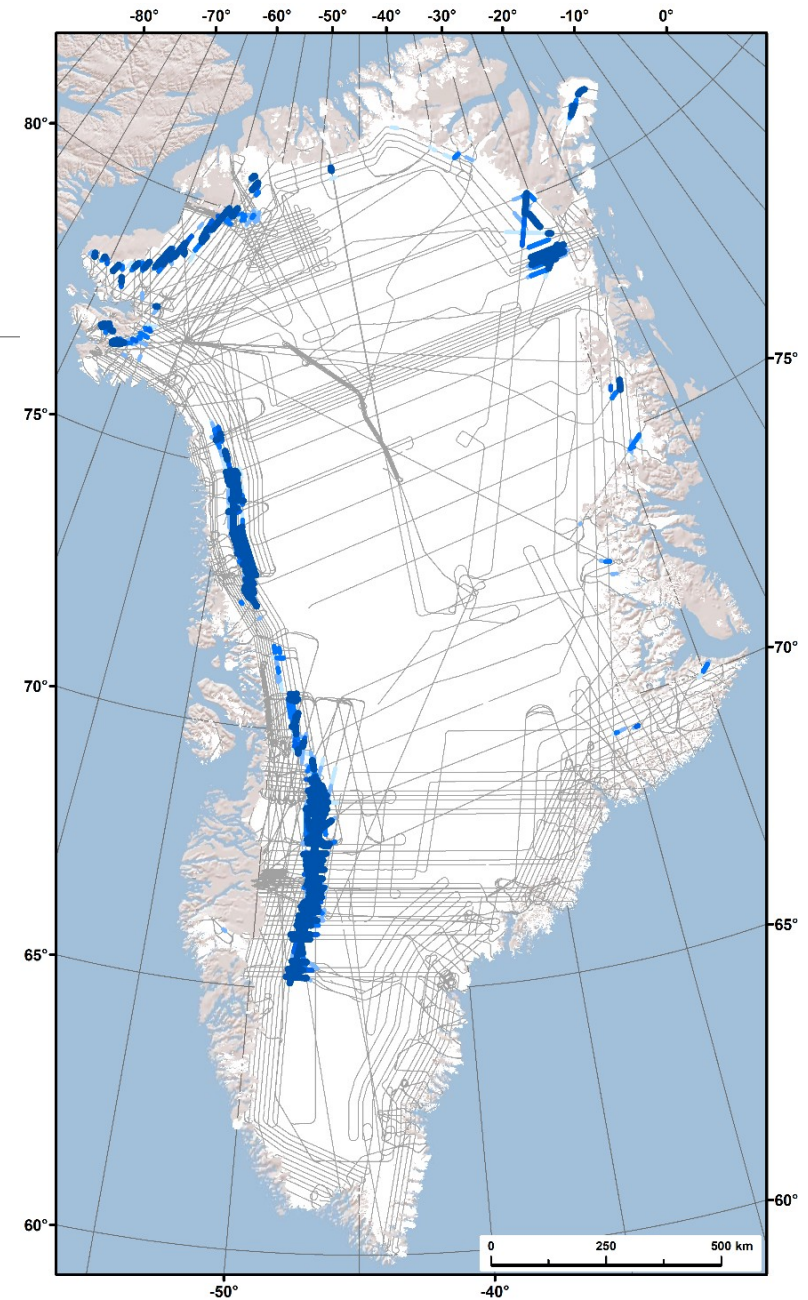


Ground radar \Rightarrow IceBridge radar

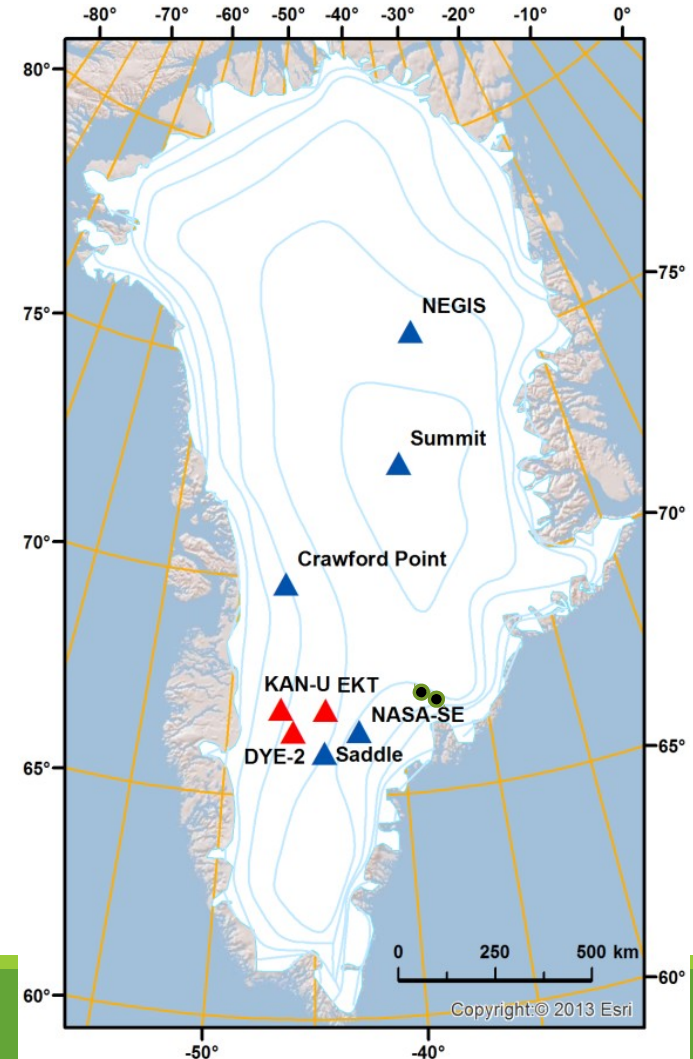
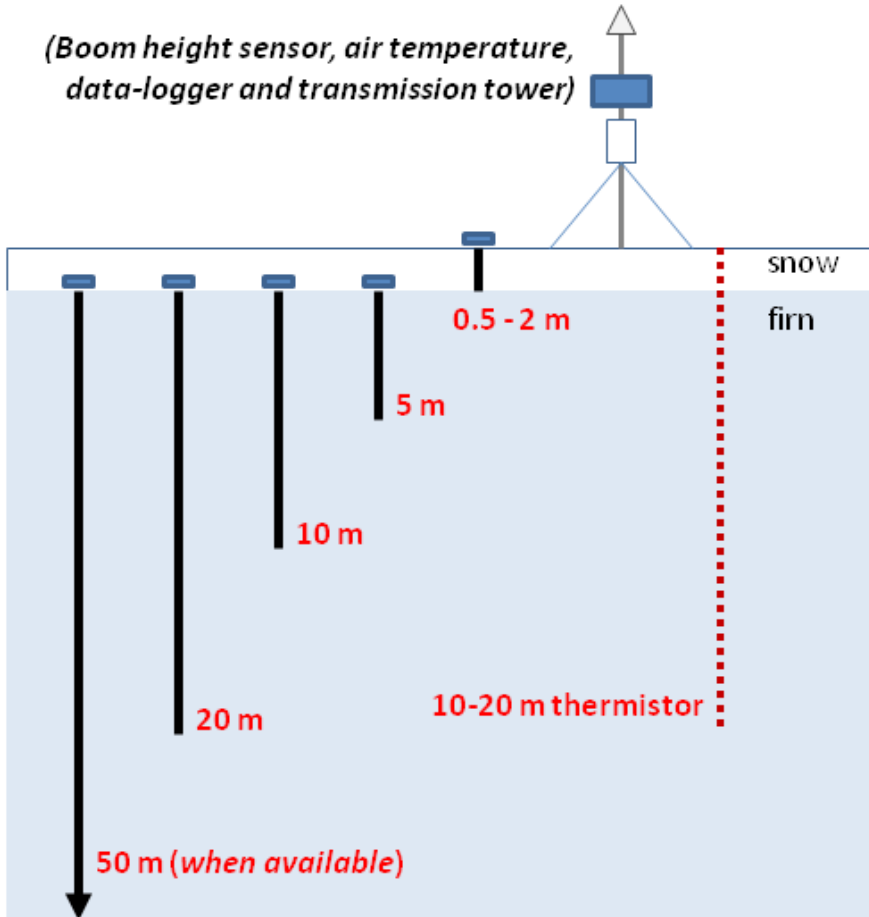


Perched Ice Layers across Greenland

- Extensive “perched” ice layers ≥ 1.5 meters (~ 5 feet) atop porous firn
- Perched layer zone spans $\sim 60,000$ km² (*West Virginia*)
- Near-surface firn can saturate **rapidly** (decadal)



“FirnCover” Compaction Stations (v3), 2015



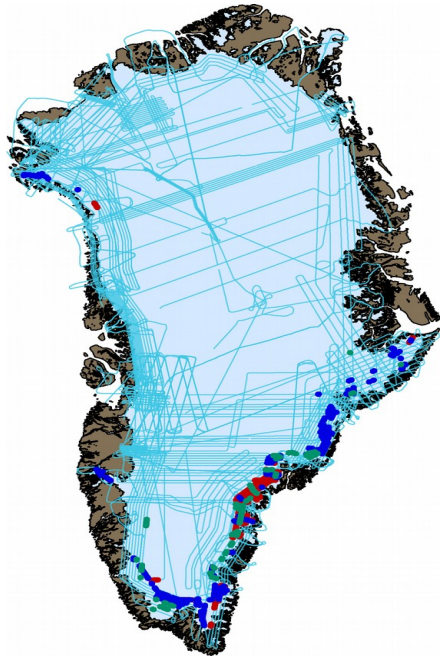
Open Questions in Greenland's SMB

- **Volume** of melt water and **trends in volume**?
- How does meltwater route **on, within, and under** the ice sheet?
- How are accumulation rates changing (SWE)?
- Accurate outlines of drainage basins?
- “Runoff” vs. “Outflow”?
- Outflow from tidewater glaciers?
- How does water percolate through snow?
- How does meltwater change firn density?
- How does meltwater change firn porosity?



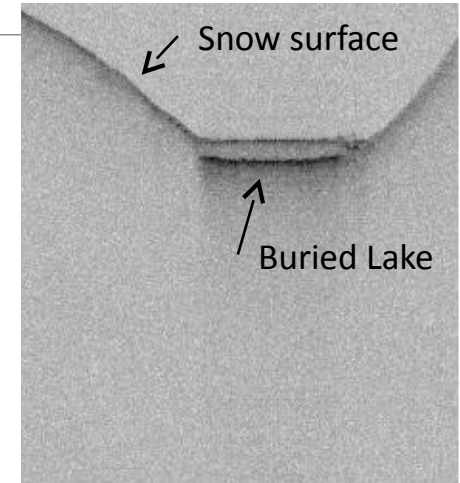
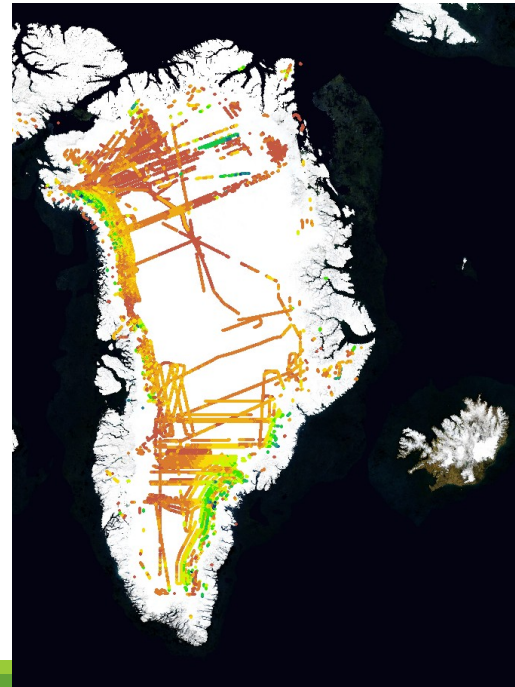
Radar Technologies

Aquifer Mapping



GROVER transport

Accumulation Mapping



Buried Lake Mapping

Water Percolating/Sloshing in Core



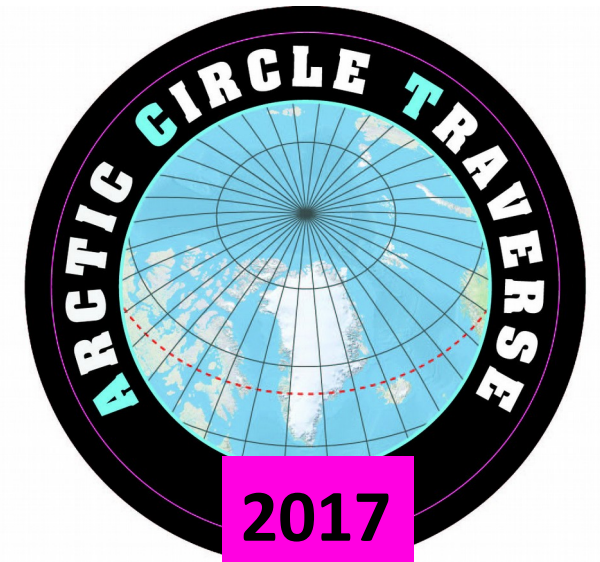
Water content has proven extremely difficult to measure in snow and firn (in situ *or* remotely sensed)

NASA is very interested in Greenland SMB



Pay attention to:

- Upscaling
- Spatial heterogeneity
- Link measurements to remote sensing & modeling, on ice-sheet scales



Questions? Ideas?

- Accumulation
- Compaction
- Melt
- Percolation
- Refreezing
- Water Routing
- Runoff & Outflow
- Water Content
- Spatial Upscaling

