ICWG Update

SAB/TAB Meeting
March 6, 2017
Madison, WI

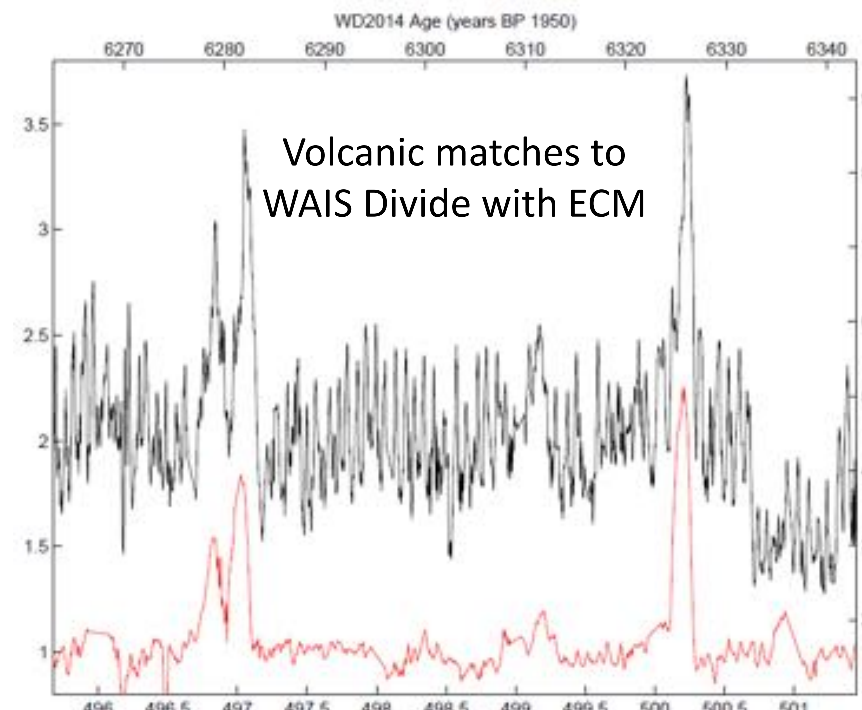
Foreman, Fudge, Kurbatov,
Osterberg, Petrenko, Severinghaus, Steig

ICWG Activities 2016-2017

- Significant updates and revisions to the 2016 LRSP
- Continued work with IDDO to draft science requirements for:
  - "Portable Firn Coring Drill" to 50-100 m
  - "Agile Ice Coring Drill" to 400-900 m
- Work with IDDO on comparison of DISC vs. IDD costs for potential Hercules Dome core
- Initial updates to technology priorities and planning matrix
- Remote ICWG annual meeting in the coming month

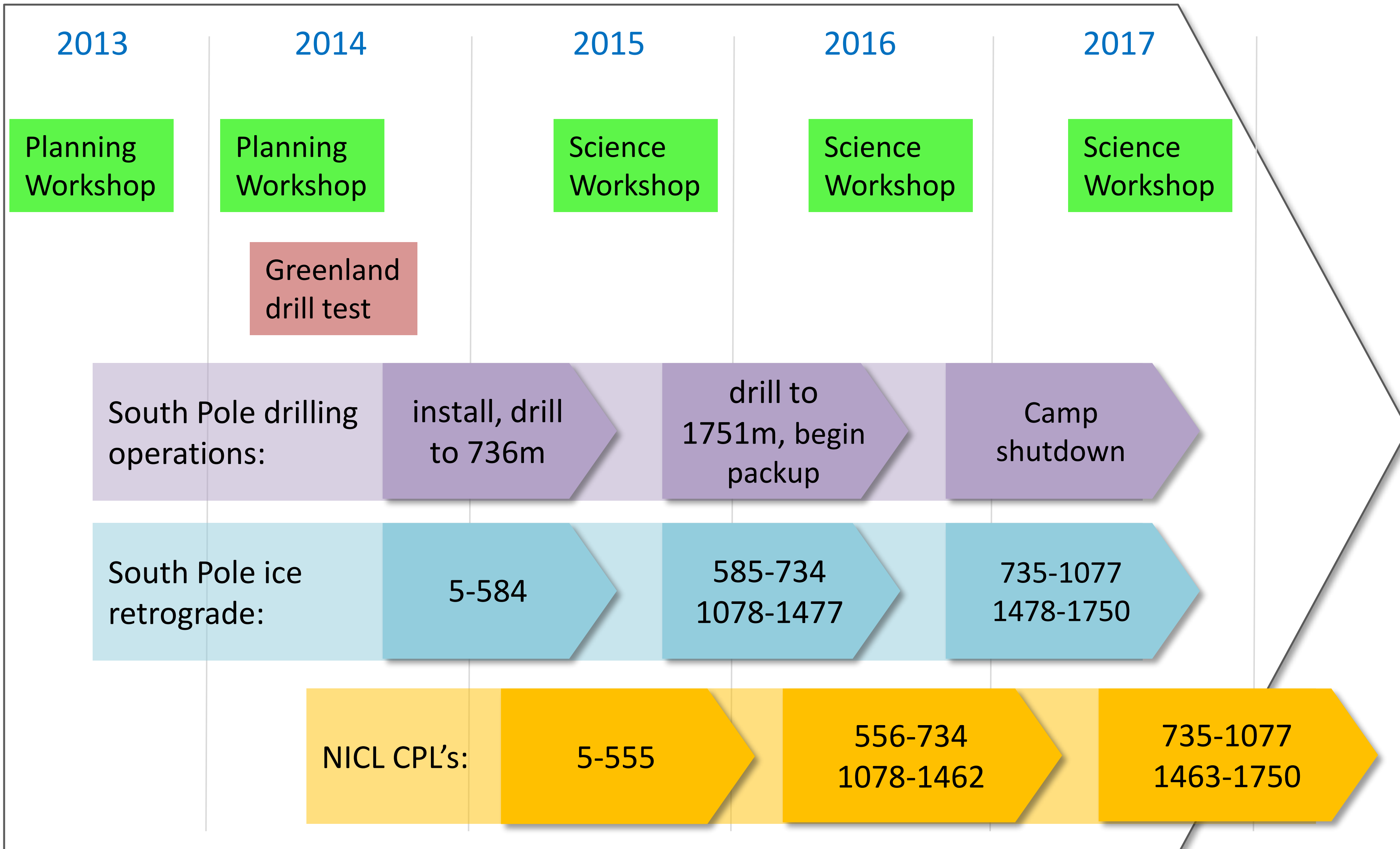
SPICEcore Update

- <u>2016-17 Field Season</u>: Remaining ice retroed. Borehole logging for temp, dust, video complete. Camp removed.
- <u>CPL</u>: 555-734 m and 1078-1462 m processed in 2016; 735-1077 m and 1463-1751 m will be processed in June
- 3rd Science Meeting in September (19th-20th) at UW



SPICECORE Timeline

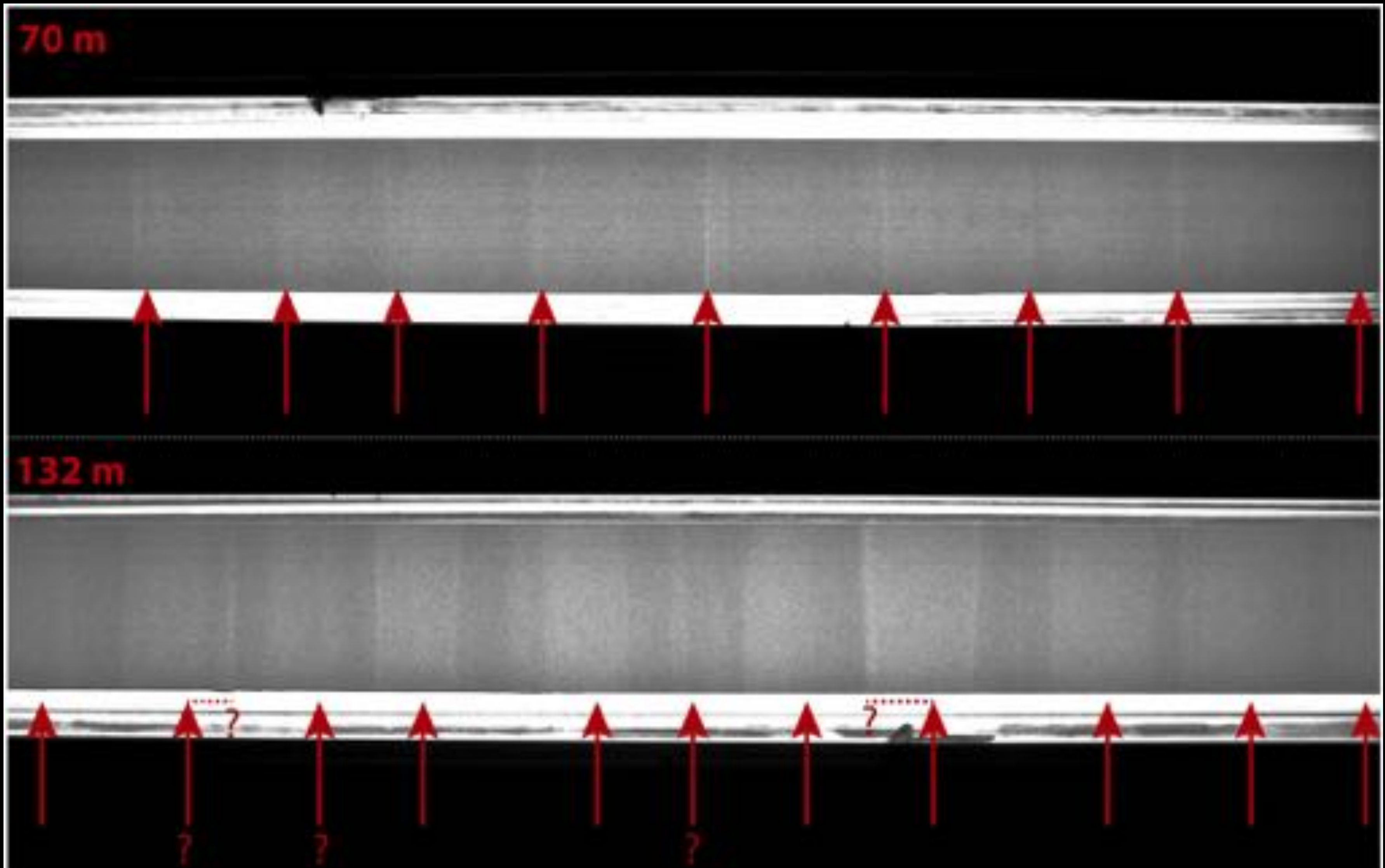
Collaborative project: U. New Hampshire (J. Souney, M. Twickler), UC Irvine (M. Aydin, E. Saltzman), U. Washington (T.J. Fudge, E. Steig), NASA – GSFC (T. Neumann)



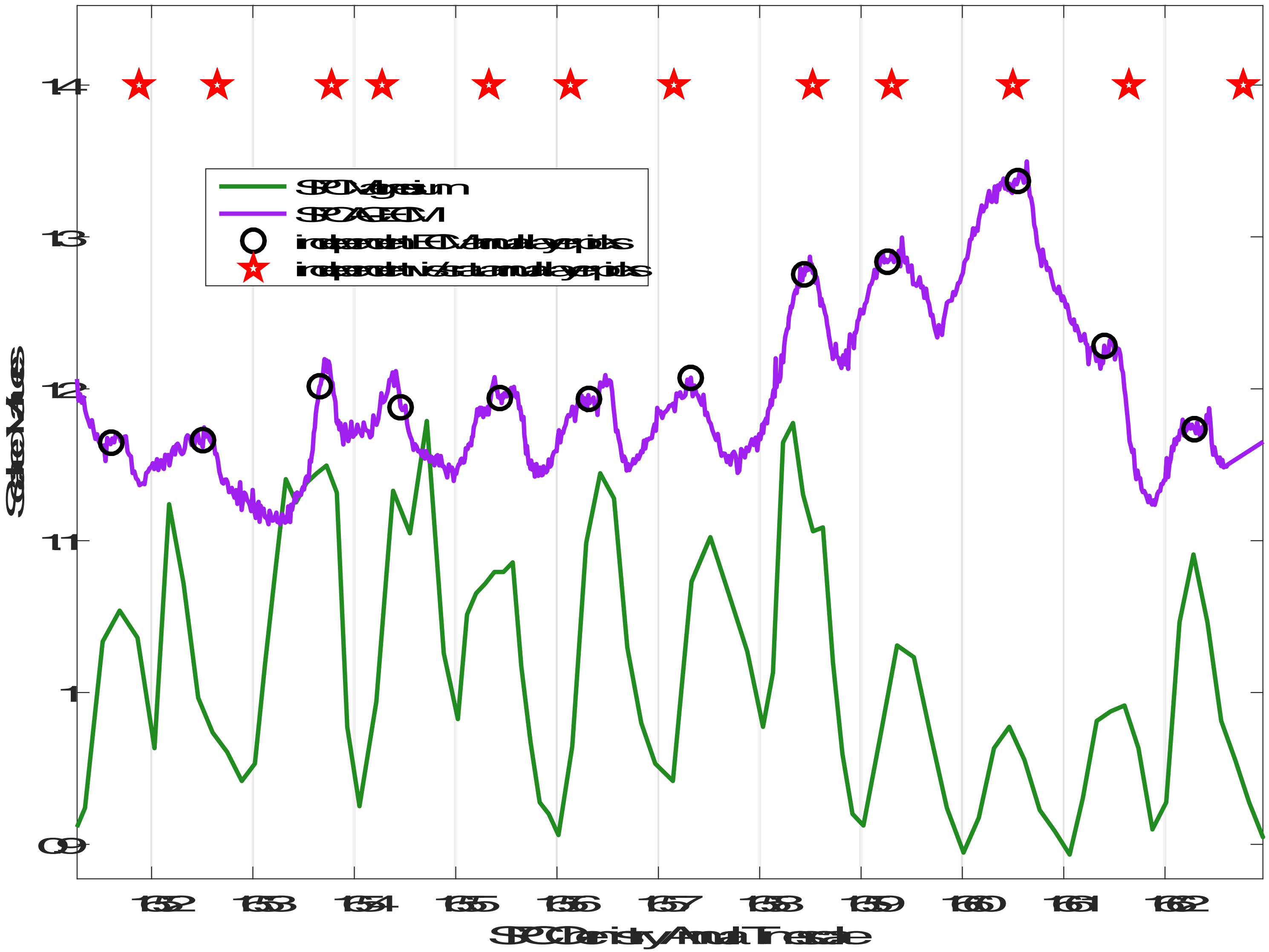
SPICECORE – Funded Science

- Isotopes: *U. Washington, U. Colorado*
- Chemistry: *Dartmouth, U. Maine, S.D. State*
- Gases: *Oregon State, Penn State, Scripps, UC Irvine, Rochester, Stony Brook*
- Phys props: *Penn State*
- 10Be: *Columbia, U. Washington*
- ECM: *U. Washington*
- Volcanic markers: *NM Tech, U. Maine*
- Dust log: *UC Berkeley*

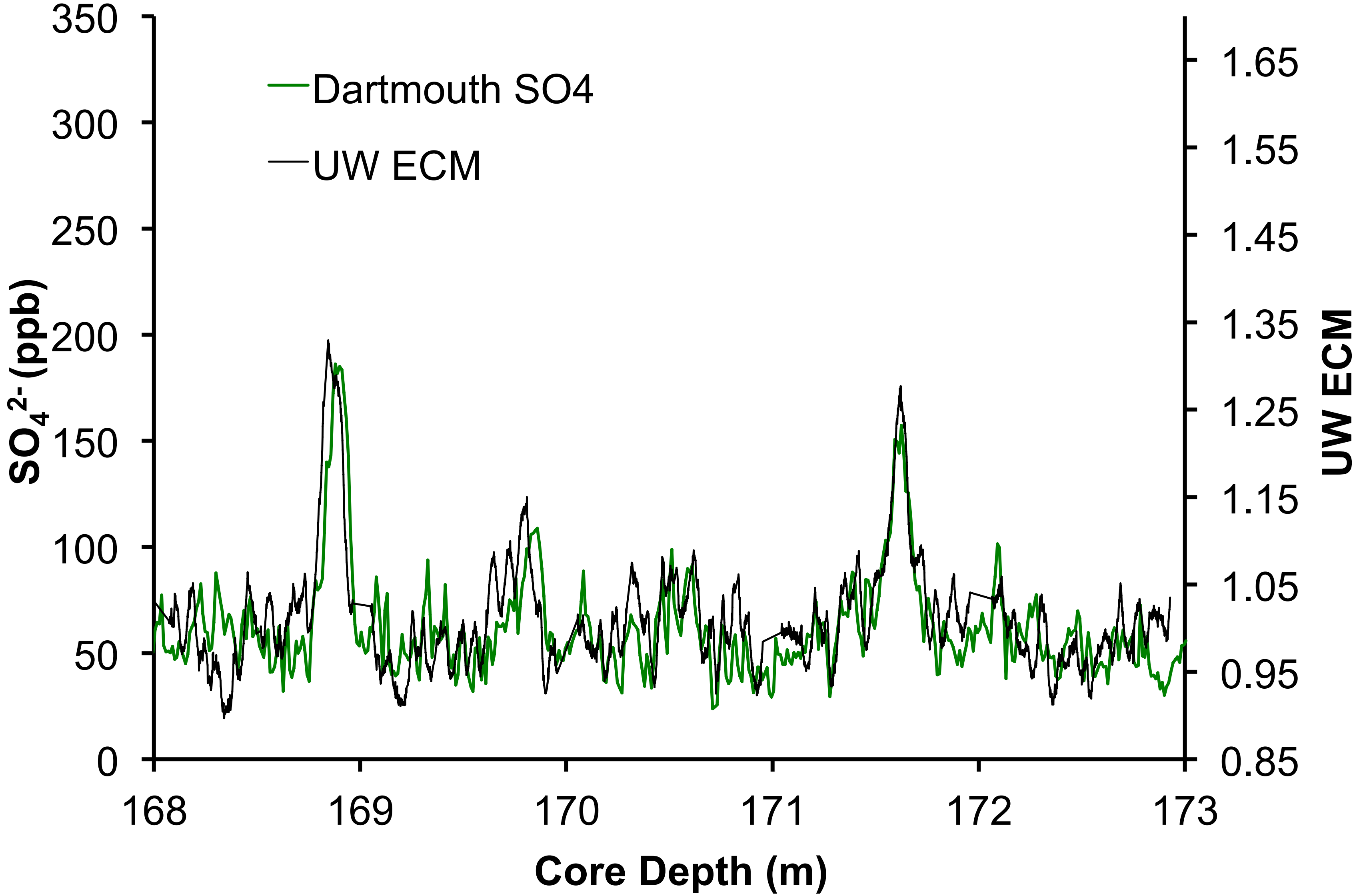
SPICECORE Visual stratigraphy (Penn State)



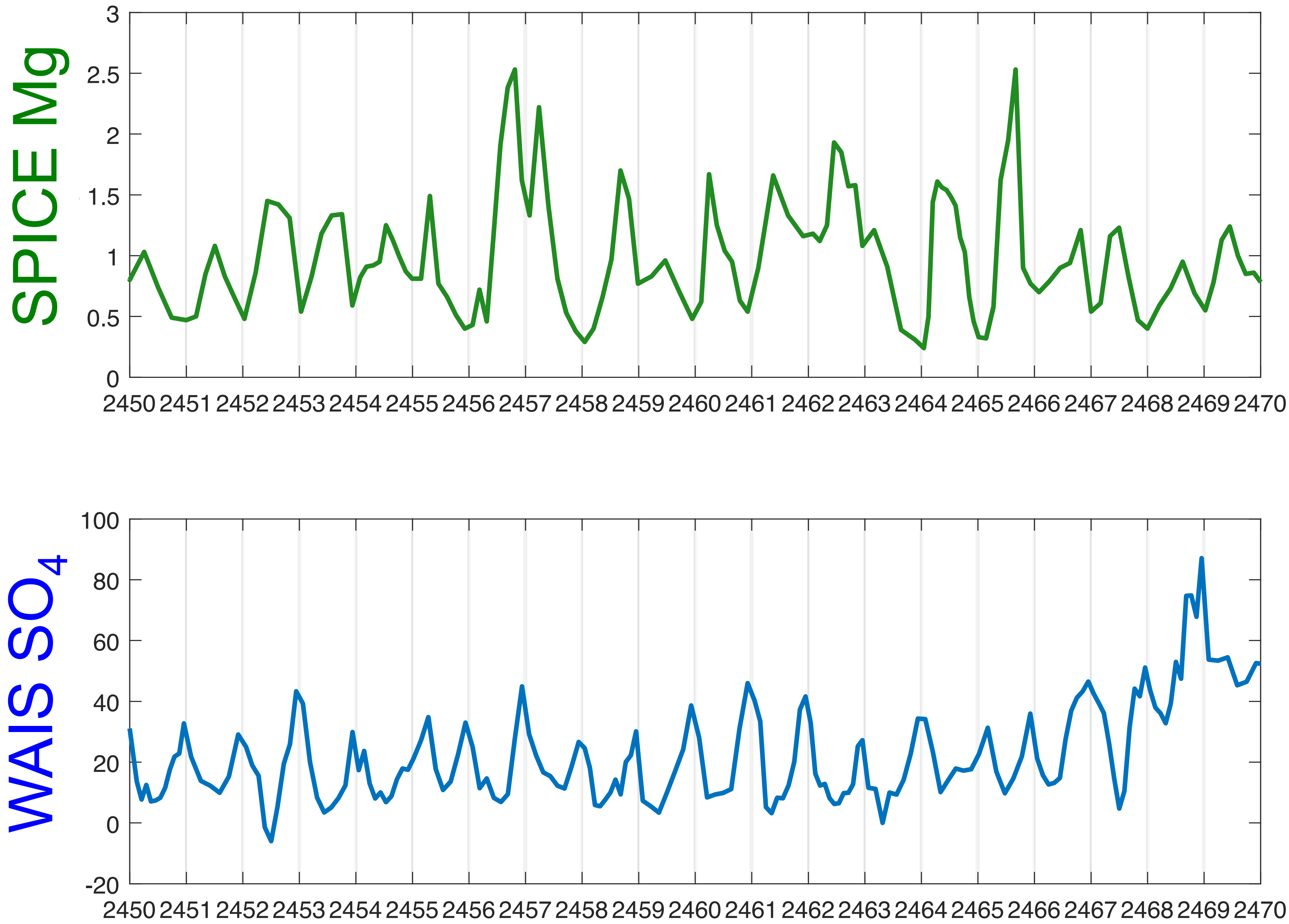
SPICE Annual Layers in Chemistry (Dartmouth) ECM (UW) & Vis-Strat (Penn St.)



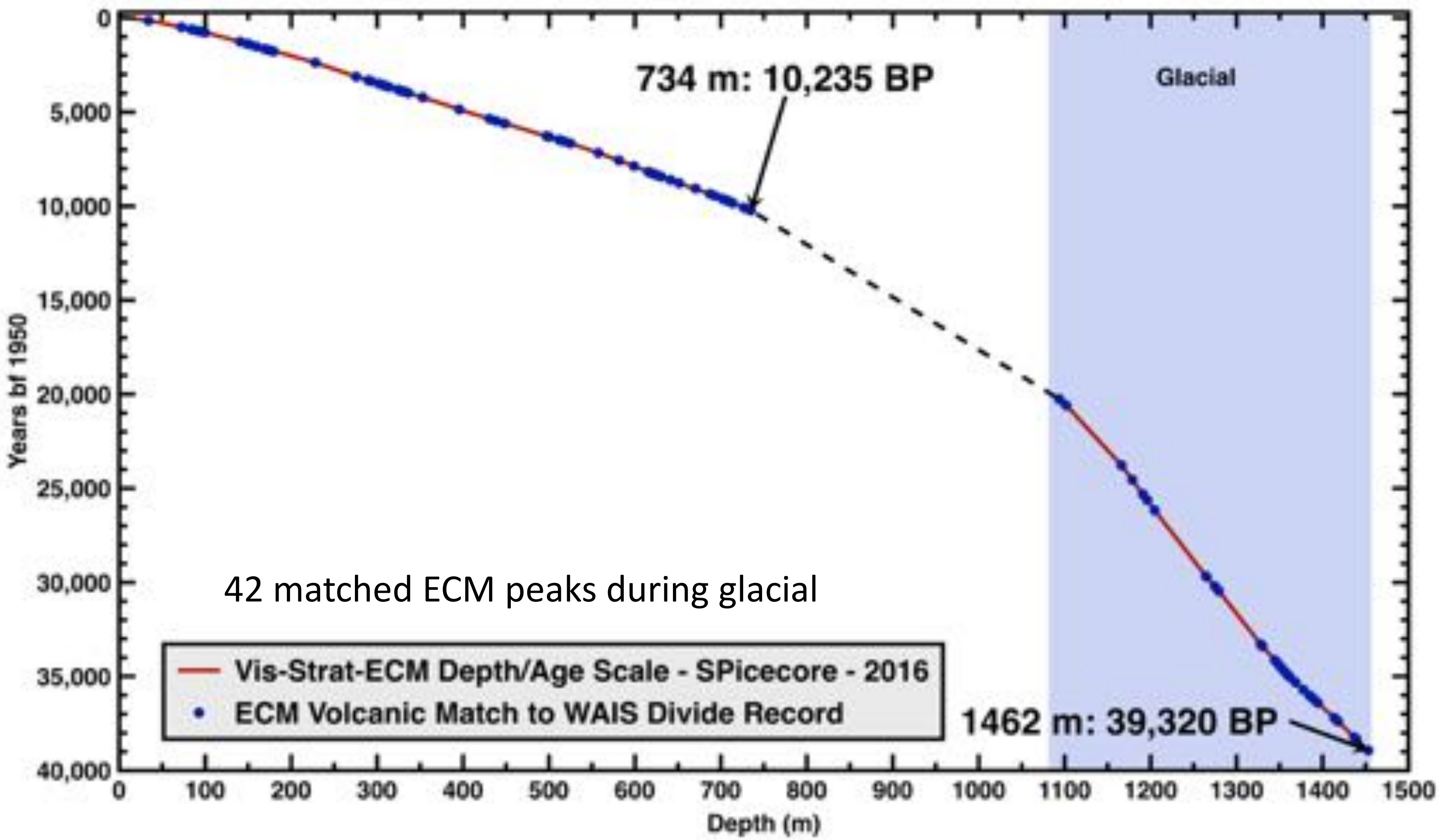
Dartmouth Sulfate vs. UW ECM



South Pole vs. WAIS Annual Layers



SPICECORE Chronology

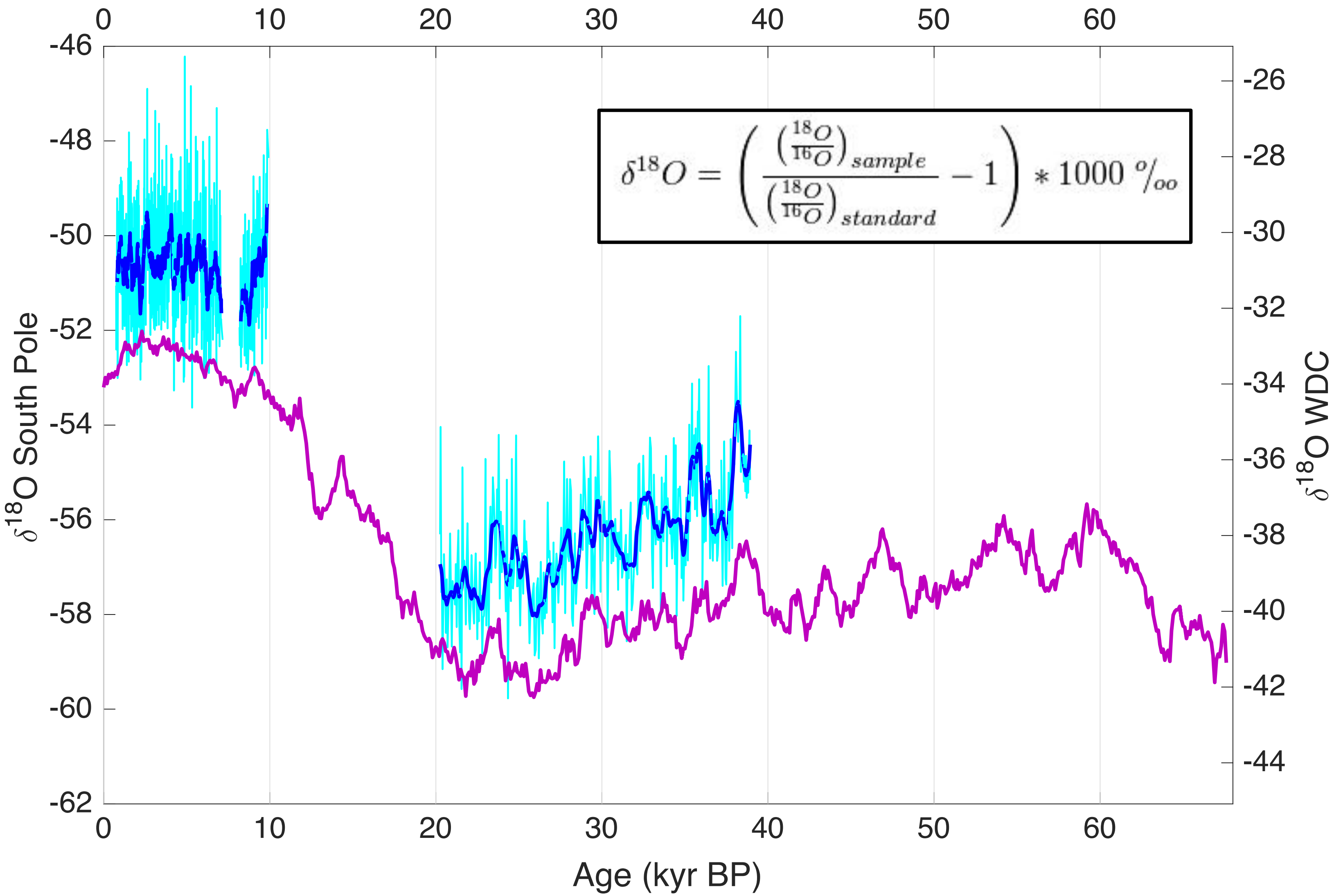


42 matched ECM peaks during glacial

From J. Fegyveresi

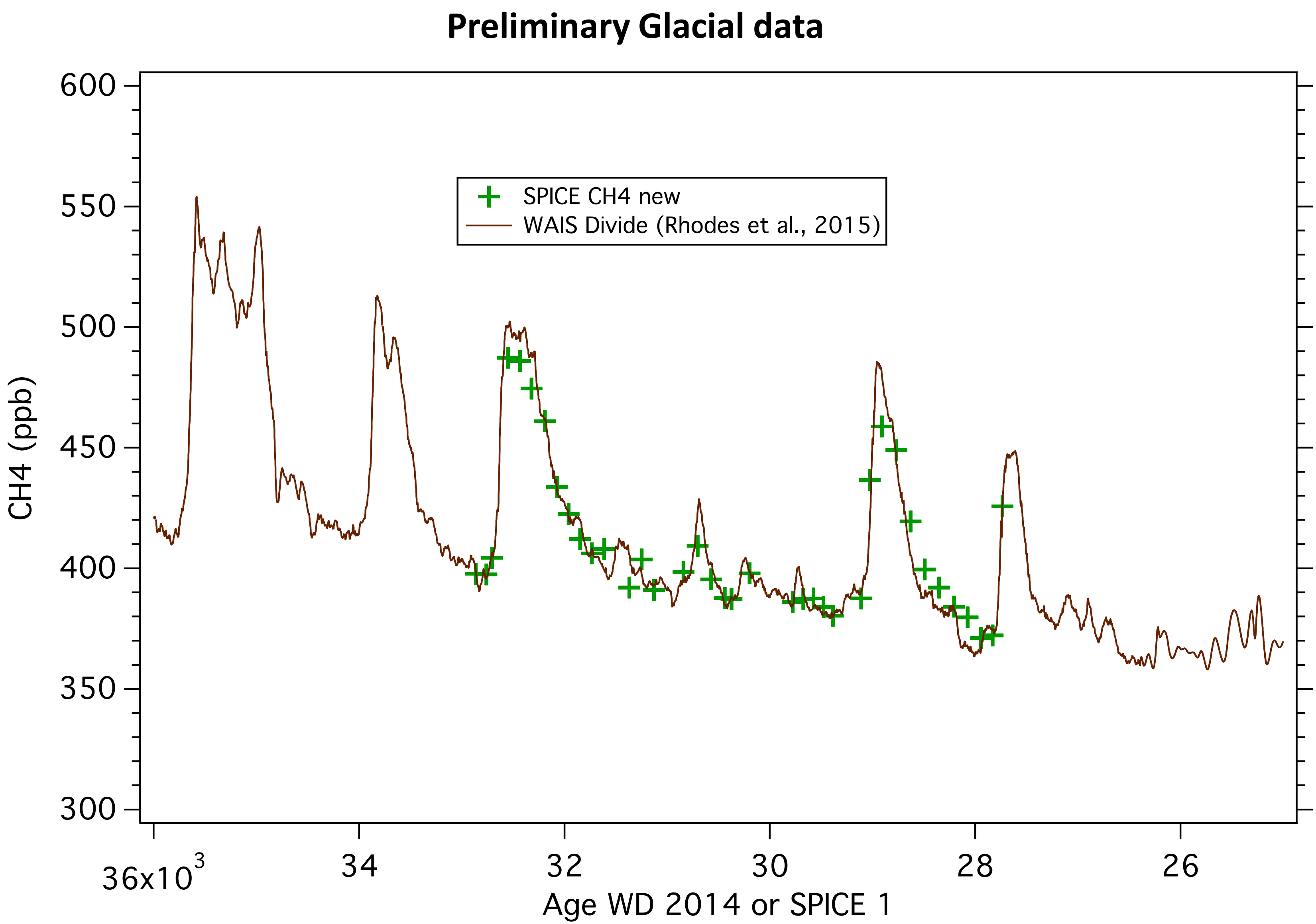
SPICECORE Water Isotopes (U. Washington and INSTAAR)

Comparison with WAIS Divide (West Antarctica) isotope record



$$\delta^{18}O = \left(\frac{\left(\frac{^{18}O}{^{16}O}\right)_{sample}}{\left(\frac{^{18}O}{^{16}O}\right)_{standard}} - 1 \right) * 1000\ ^{o}/_{oo}$$

SPICECORE Methane (Oregon State, Penn State)

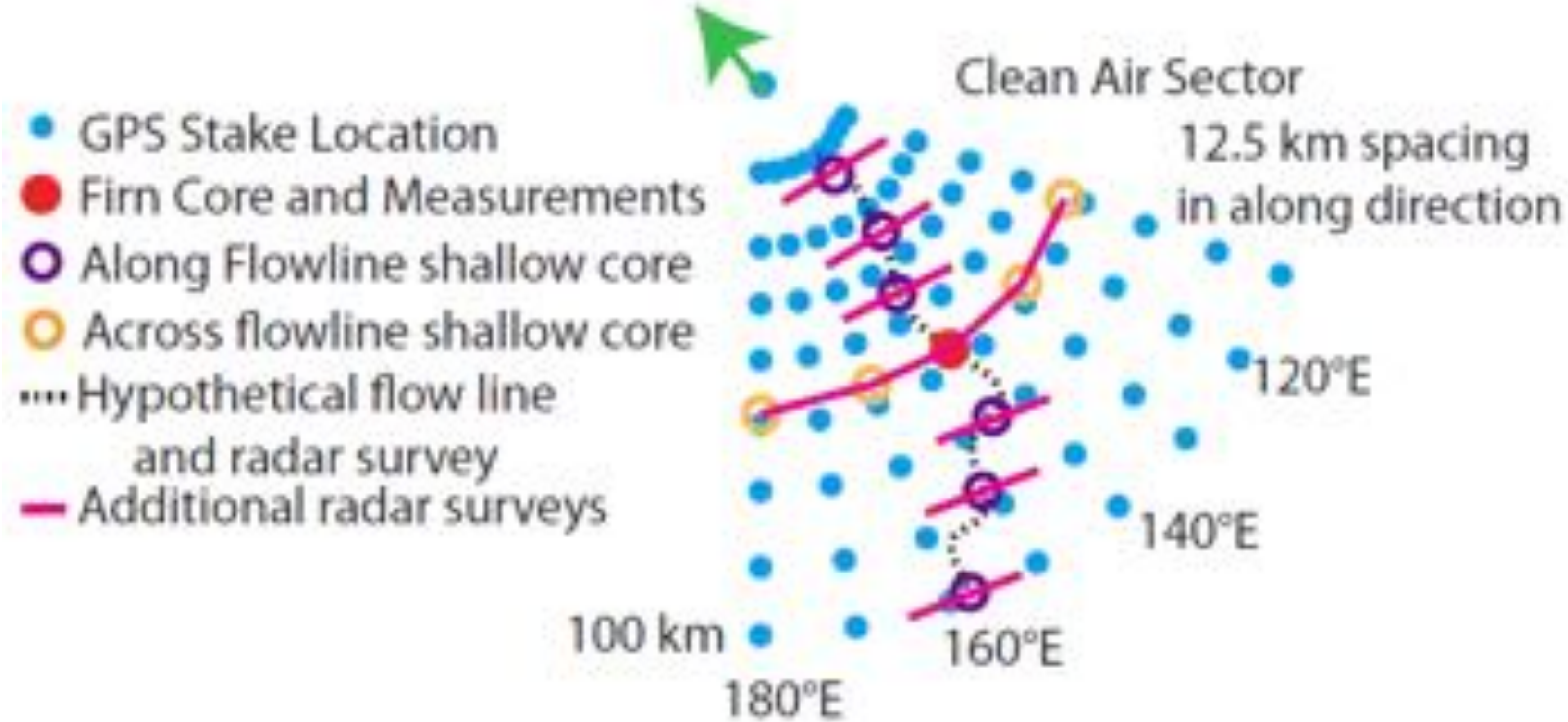


SPICECORE Other Gas Measurements

- CO_2 and $^{13}CO_2$: *Oregon State*
- $\delta^{15}N$ and $\delta^{18}O_{atm}$: *Scripps, Penn State*
- N_2O: *Oregon State*
- ^{86}Kr: *Scripps, OSU*
- CO and CO isotopes: *Rochester, Stony Brook*
- Carbonyl sulfide, methyl halides, light hydrocarbons: *UC Irvine*

SPICE Upstream Dynamics Project

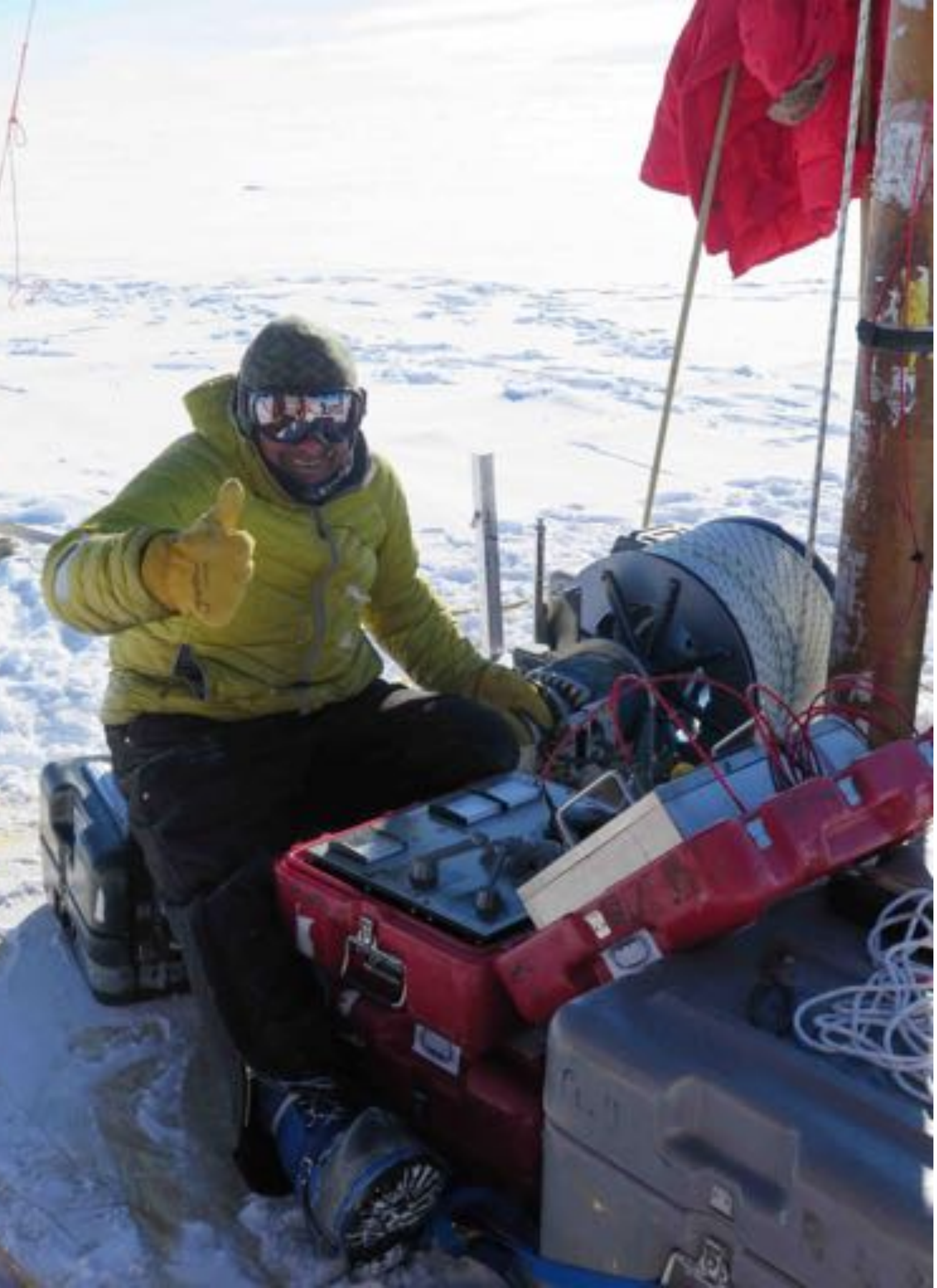
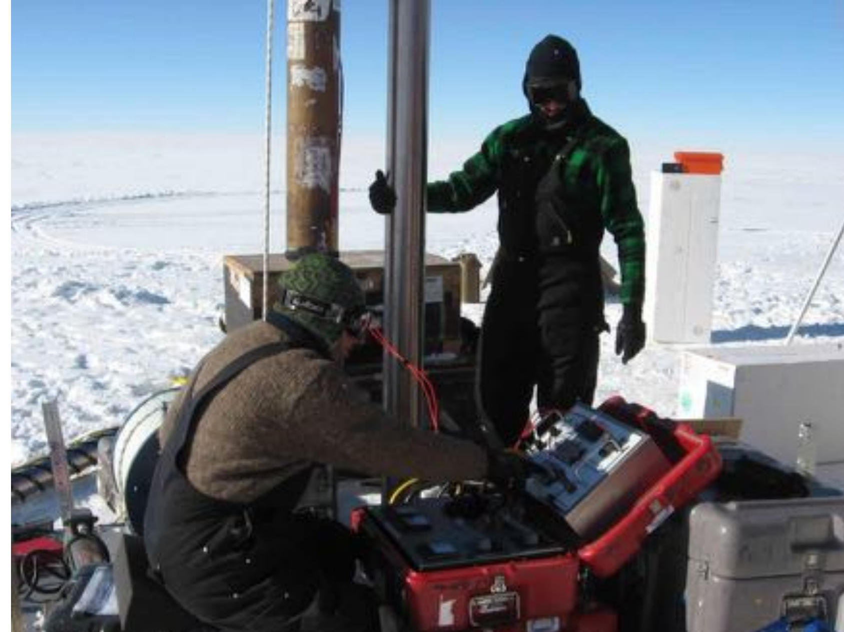
Michelle Koutnik, Ed Waddington, Howard Conway, TJ Fudge, Max Stevens (UW)
Bob Hawley, Erich Osterberg, Mary Albert (Dartmouth)



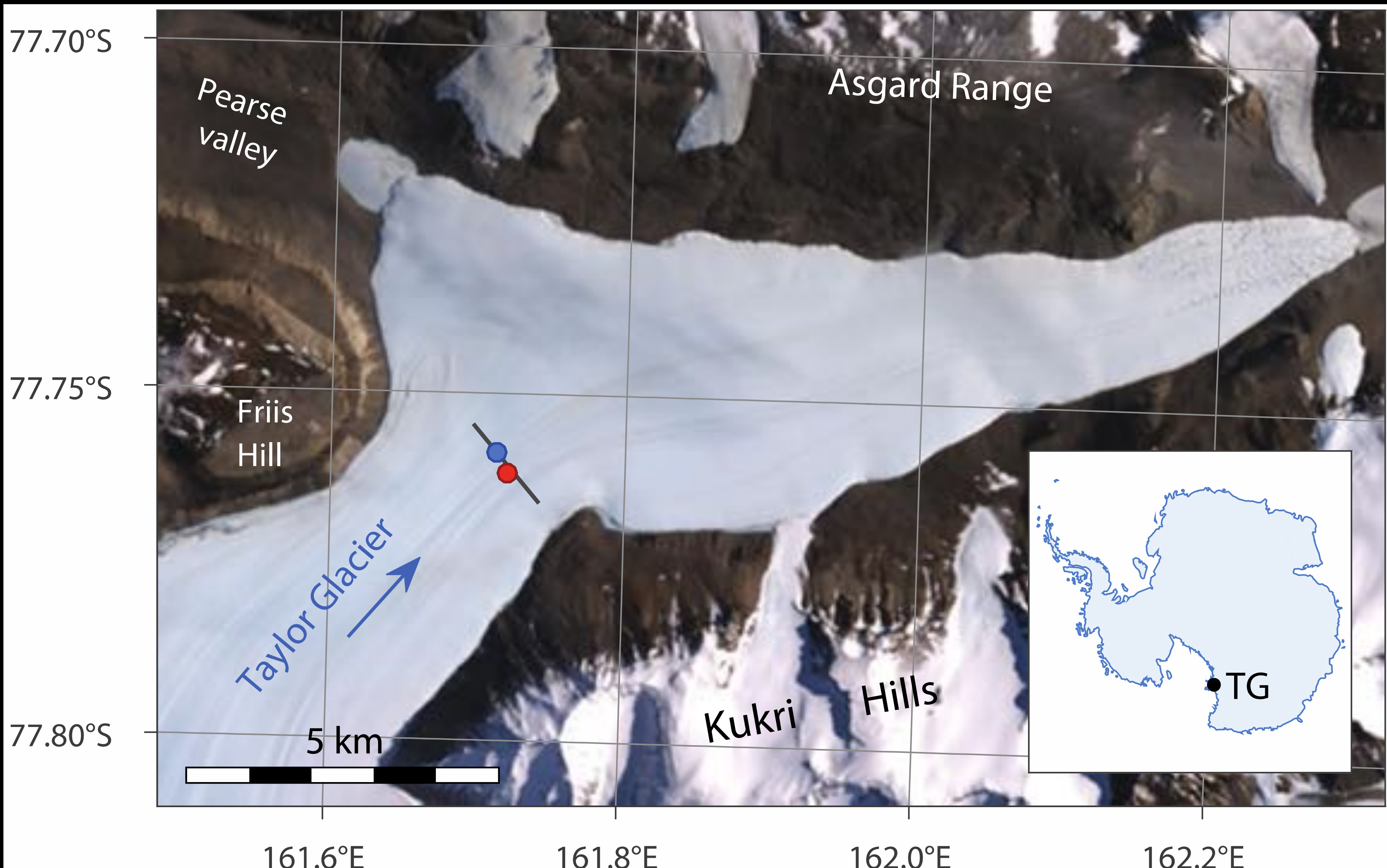
- ***Where did the SPICE ice originate?***
- ***What is the impact of ice advection on SPICE climate records?***
- ***What is the spatiotemporal accumulation history upstream?***
- ***Do current firn models accurately calculate compaction rates?***

SPICE Upstream Field Plan

- ✓ **15-16** – Install poles and conduct first year of GPS survey
- ✓ **16-17** – Resurvey GPS network to define flowline, then setup camp ~50 km from SP along the flowline:
  - Drill firn holes for $\delta^{18}O$; install firn-compaction sensors
  - Collect 2 x 100m cores for chemistry and micro-CT scanning, and log boreholes for density
  - Collect snow samples and radar data
- **17-18** – Monitor firn sensors; log boreholes
- **18-19** – Monitor firn sensors; log boreholes; take out all equipment


TAYLOR GLACIER PROJECT
Petrenko (lead), Brook, Severinghaus



TAYLOR GLACIER PROJECT

Pis: Petrenko (lead), Brook, Severinghaus

Field Work:
2013-14, 2014-15 and 2015-16. Drilling with BID and hand auger

Main Project Goals (Petrenko group):

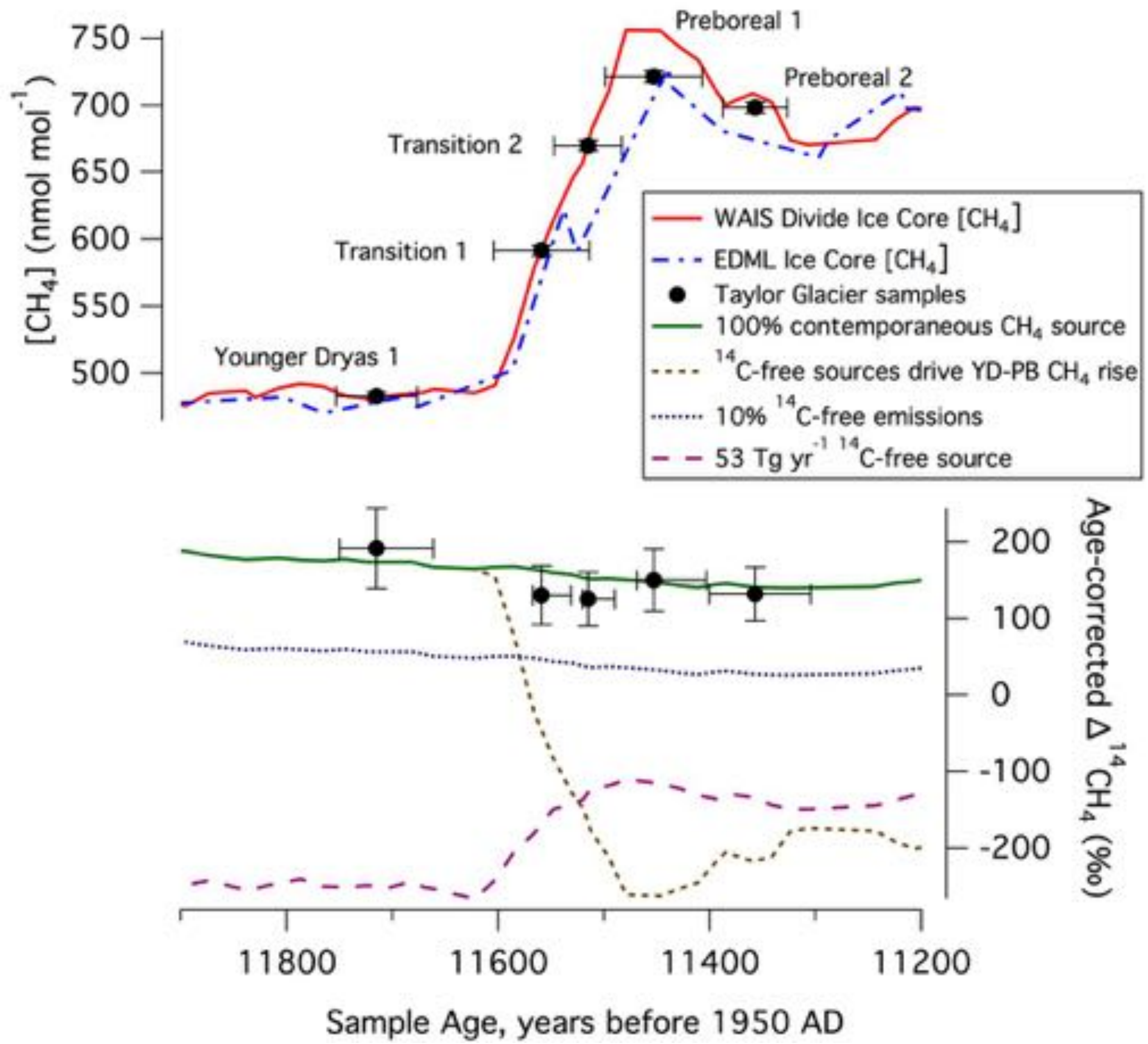
- Investigating in situ cosmogenic ^{14}C production in ice
- Investigating the involvement of old carbon reservoirs in the deglacial CH_4 budget

Results (Petrenko group):

Measurements of ^{14}C in ancient ice from Taylor Glacier, Antarctica constrain in situ cosmogenic $^{14}CH_4$ and ^{14}CO production rates

Vasilii V. Petrenko[a,*], Jeffrey P. Severinghaus[b], Hinrich Schaefer[c], Andrew M. Smith[d], Tanner Kuhl[e], Daniel Baggenstos[b], Quan Hua[d], Edward J. Brook[f], Paul Rose[g], Robb Kulin[e], Thomas Bauska[f], Christina Harth[b], Christo Buizert[f], Anais Orsi[b,h], Guy Emanuele[b], James E. Lee[f], Gordon Brailsford[c], Ralph Keeling[b], Ray F. Weiss[b]

TAYLOR GLACIER PROJECT – MORE RESULTS



Petrenko et al,
submitted

TAYLOR GLACIER PROJECT – MORE RESULTS

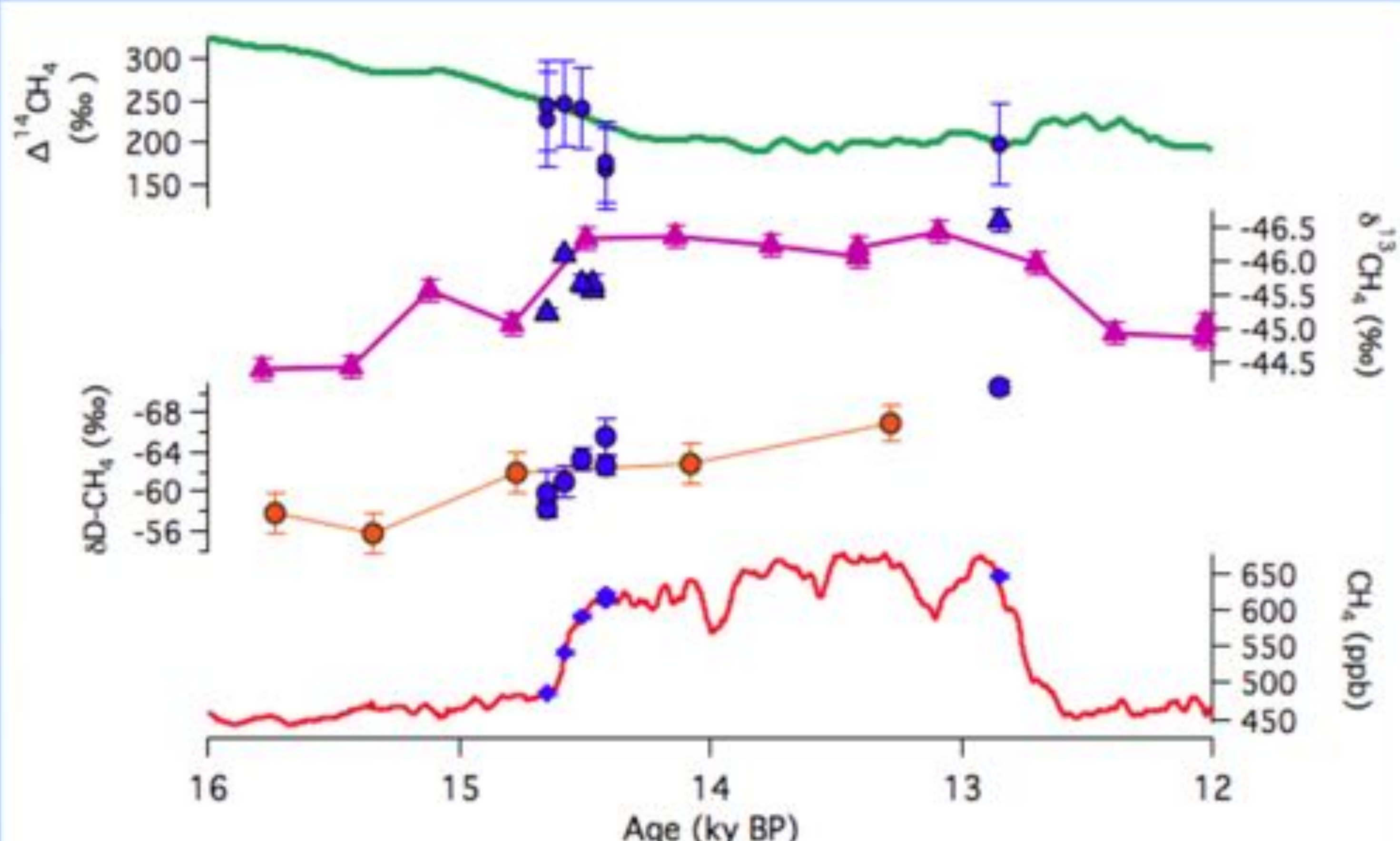
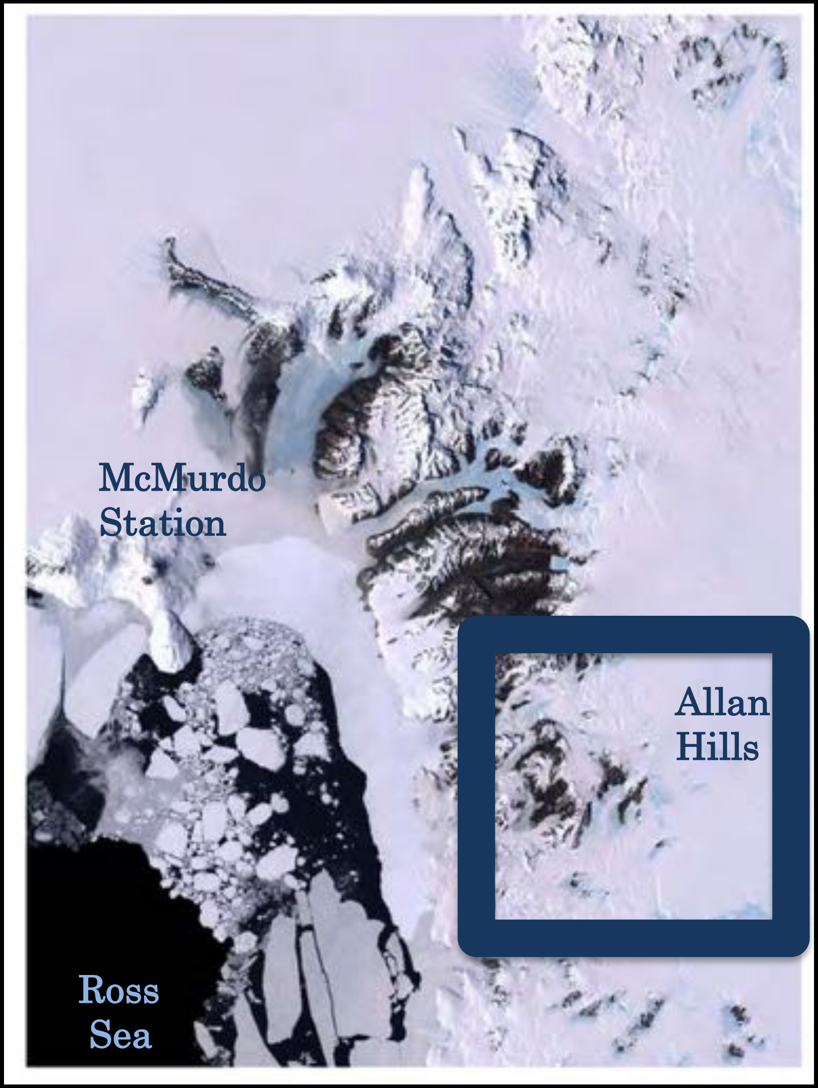


Figure 2. $\Delta^{14}CH_4$, $\delta^{13}C$-CH_4, δD-CH_4 and CH_4 measured in Taylor Glacier samples (blue markers, error bars represent 1-σ uncertainty) plotted against INTCAL13[9], EDML $\delta^{13}C$-CH_4[10], EDML δD-CH_4 (Bock et al. unpublished data) and WAIS Divide continuous CH_4[11] respectively. The Taylor Glacier $\Delta^{14}CH_4$ data has only undergone preliminary corrections for in-situ $^{14}CH_4$ production. The Taylor Glacier $\delta^{13}C$-CH_4 and δD-CH_4 data have not been corrected for firn column gravitational and diffusive fractionation.

Dyonisius et al., 2016, AGU meeting

Paleo Ice Project (PIP)
Field Location: Allan Hills Blue Ice Area



Logistic Advantages:

- Close proximity to McMurdo Station
- ~ 120 miles to Taylor Dome C-130 landing site

PIP Goals

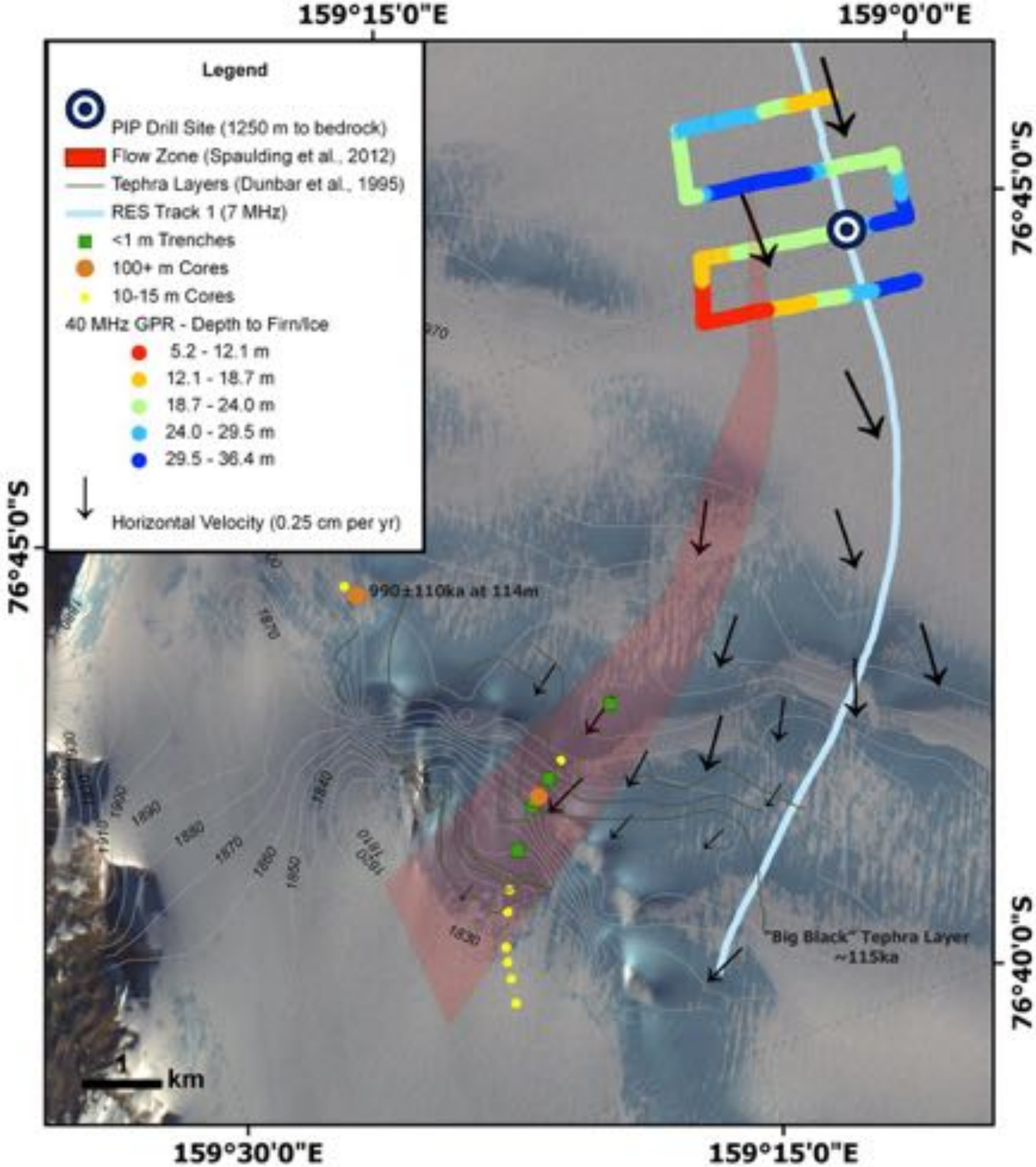
Collect a high quality 1250 m long ice core at a site where ice has not been disturbed by interaction with the bedrock.

Develop an ice core time scale and use that time scale to illuminate the spatial distribution of ice throughout the main ice field (ice park concept).

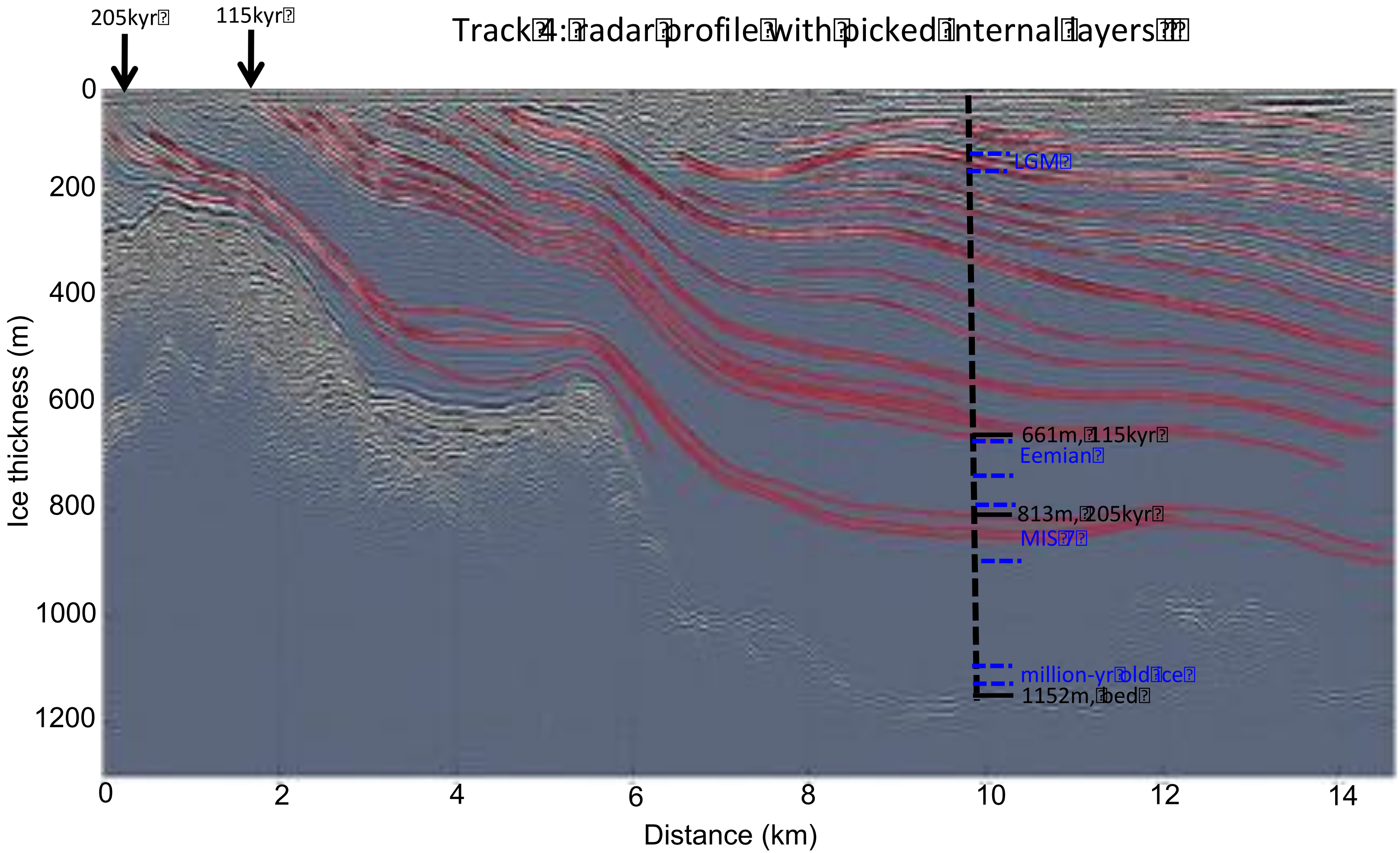
Develop a continuous, uniformly sampled glaciochemical, stable water isotope and trapped greenhouse gas record for the entire ice core.

Make 30% of the continuous ice core samples available to the community at the end of the project.

Expected time interval: Minimum last 250 ka (covering the Eemian interglacial), more likely at least 450 ka, ideally (as some evidence suggests) ~ 2.5 Ma years



159°15'0"E
159°0'0"E
Legend
PIP Drill Site (1250 m to bedrock)
Flow Zone (Spaulding et al., 2012)
Tephra Layers (Dunbar et al., 1995)
RES Track 1 (7 MHz)
<1 m Trenches
100+ m Cores
10-15 m Cores
40 MHz GPR - Depth to Firn/Ice
5.2 - 12.1 m
12.1 - 18.7 m
18.7 - 24.0 m
24.0 - 29.5 m
29.5 - 36.4 m
Horizontal Velocity (0.25 cm per yr)
76°45'0"S
76°45'0"S
990±110ka at 114m
"Big Black" Tephra Layer
~115ka
76°40'0"S
1 km
159°30'0"E
159°15'0"E



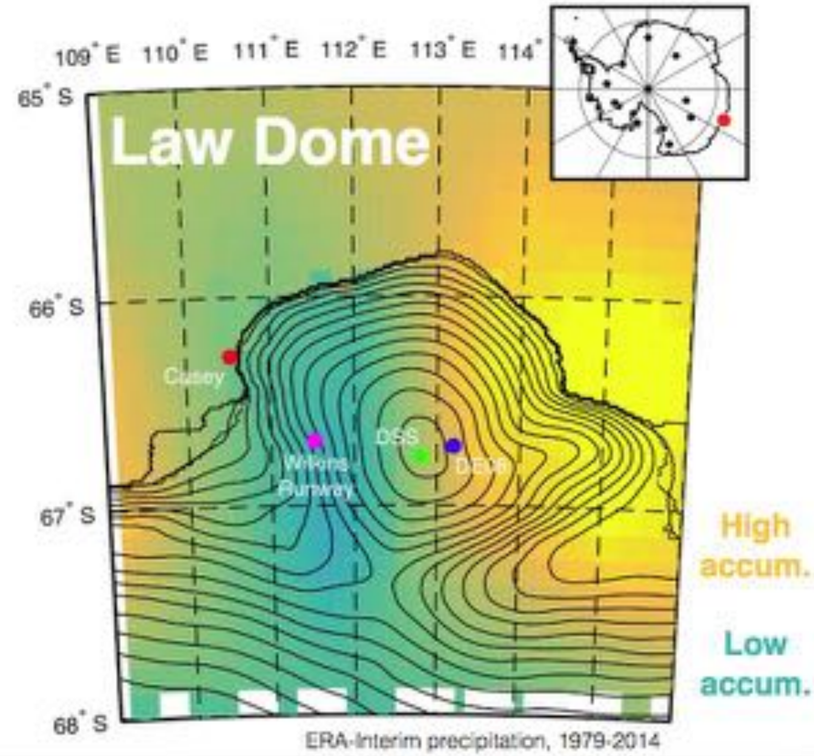
Track 4: Two dated tephra layers that outcrop at the surface in the ablation zone can be tracked up glacier, to provide powerful constraints on the age scale of the ice column. Depths and ages in black come from dated ash layers; preliminary epochs with depthrange in blue are from a Dansgaard-Johnsen age model.

unpublished 2015/2016 radar (Campbell , Conway, Spaulding)

PROPOSED LAW DOME PROJECT

PIs:
Petrenko (lead), Severinghaus, Buizert
Collaborative with Australia PIs Etheridge, Smith and Curran

Field Work:
2017-18, 2018-19. Drilling with 3” Eclipse, 4” drill and BID-Deep

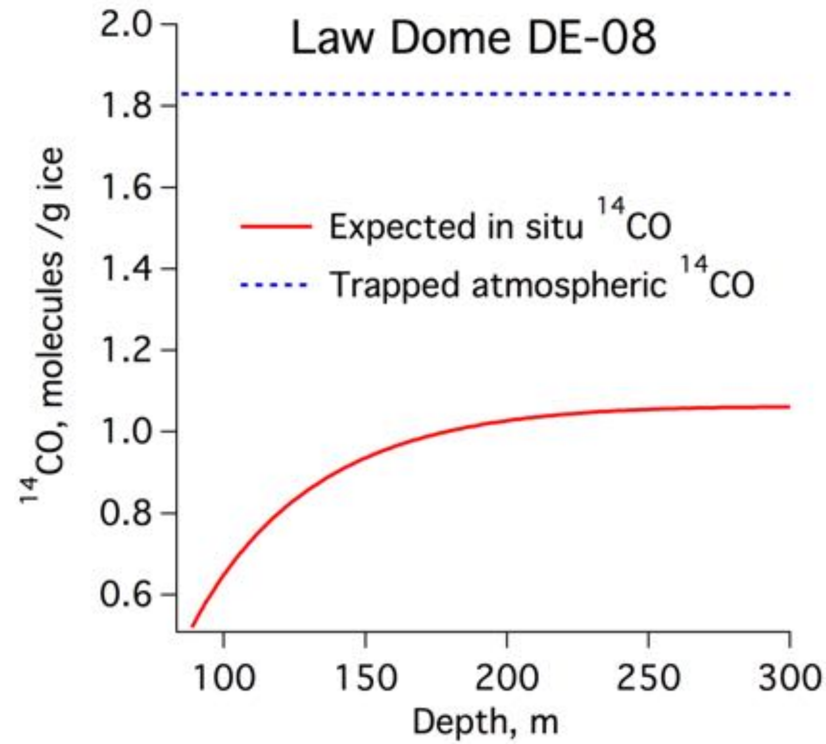


Main Project Goals:

- Constrain variations in atmospheric hydroxyl radical abundance for past ≈150 years using ^{14}CO measurements
- Explore the potential of $\delta^{86}Kr$ as a proxy for movement of Southern Hemisphere westerlies
- Improve understanding of in situ cosmogenic ^{14}C in ice

LAW DOME PROJECT KEY POINTS

- OH is a key parameter in chemical state of the troposphere
- Affects the lifetime of many radiatively important species (e.g., CH_4, aerosols)
- OH is unconstrained back in time beyond ≈1980
- ^{14}CO produced in atmosphere by cosmic rays; removed by OH
- ^{14}CO has been used to successfully monitor modern OH
- Atmospheric ^{14}CO in ice is complicated by in situ cosmogenic ^{14}CO
- Very high accumulation at Law Dome minimizes the in situ cosmogenic ^{14}CO component



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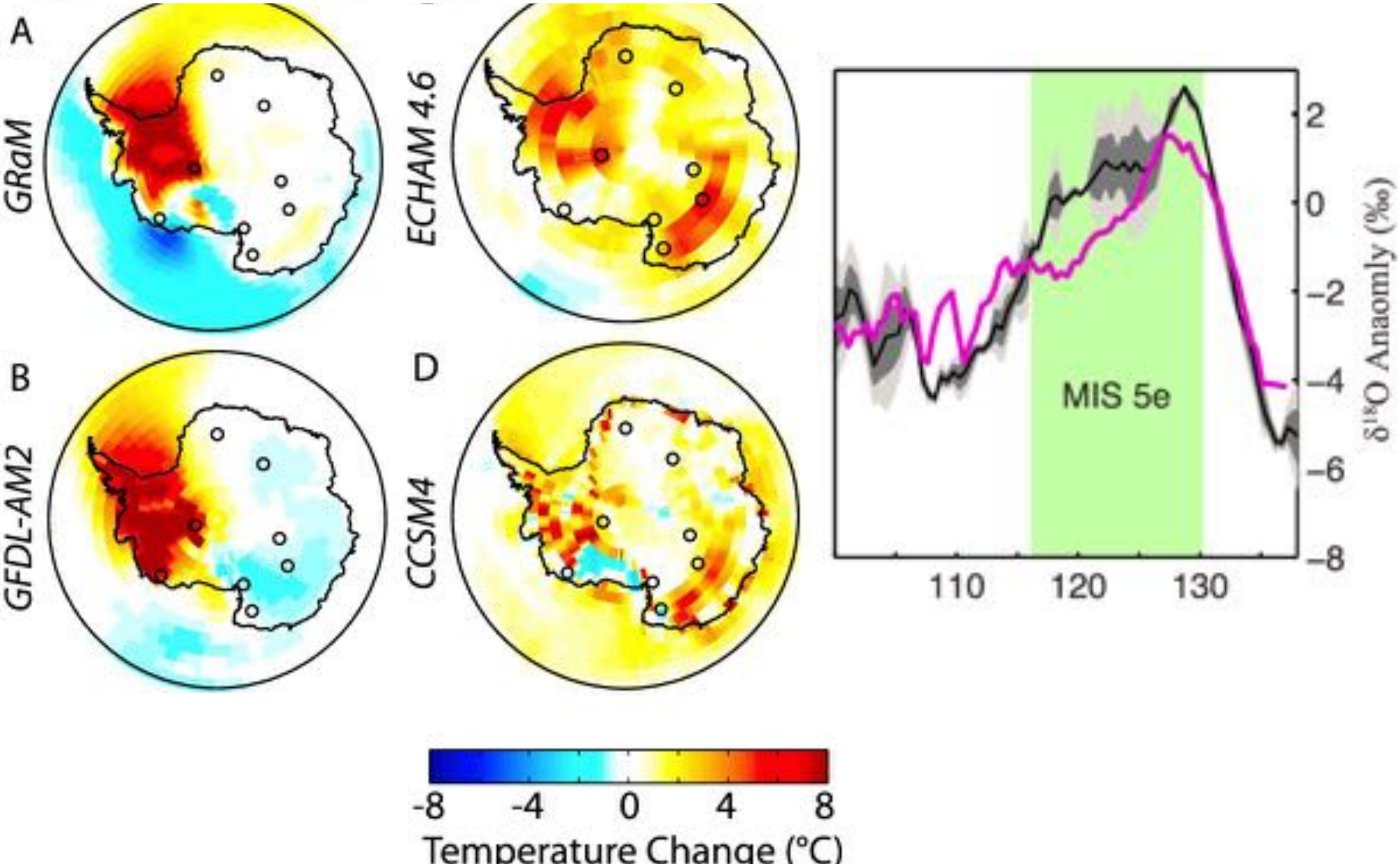
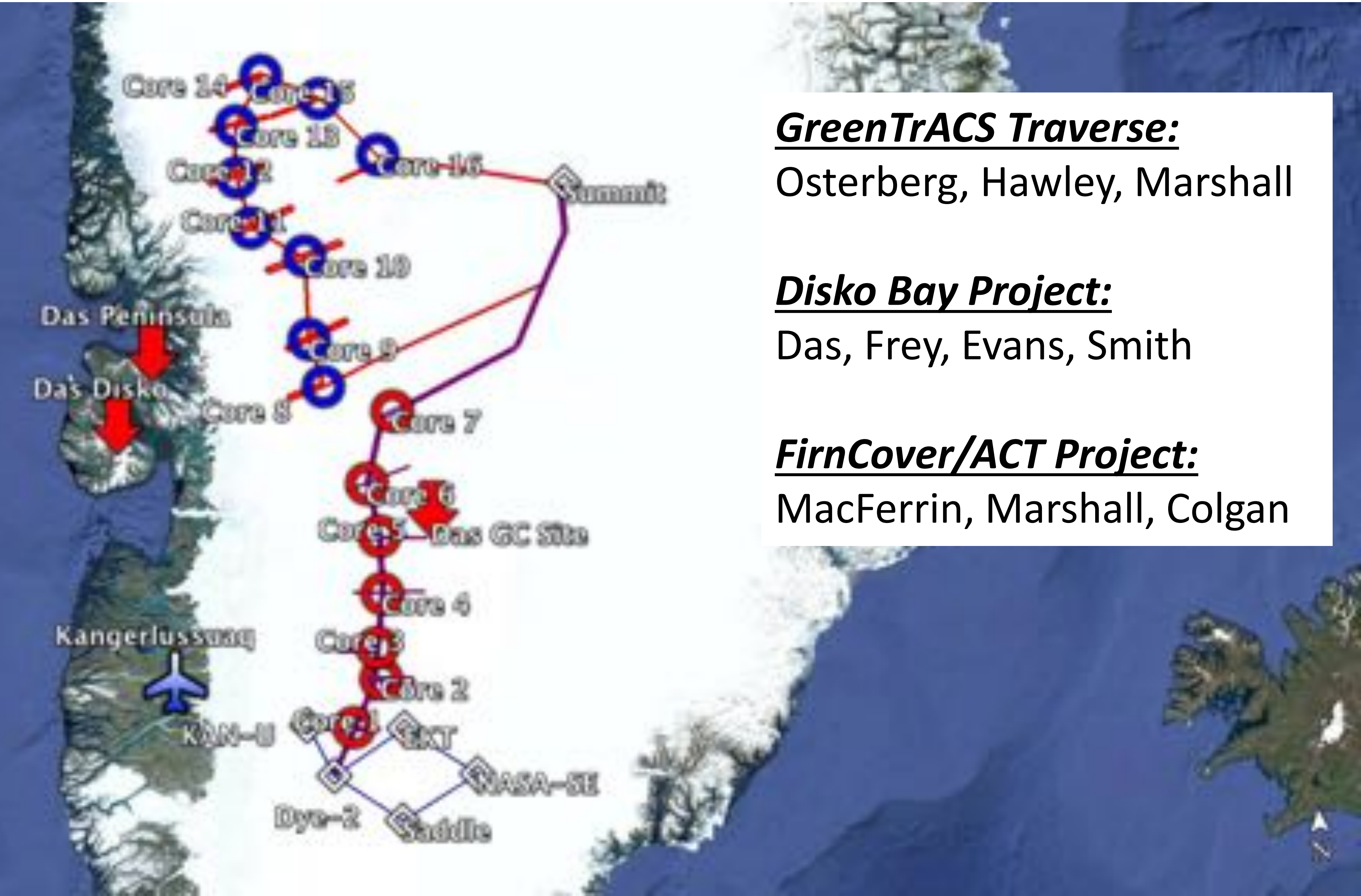
Influence of West Antarctic Ice Sheet collapse on Antarctic surface climate

Eric J. Steig[1,2], Kathleen Huybers[3], Hansi A. Singh[2], Nathan J. Steiger[2], Qinghua Ding[4], Dargan M. W. Frierson[2], Trevor Popp[5], and James W. C. White[6]



Greenland Mass Balance and Recent Climate Projects

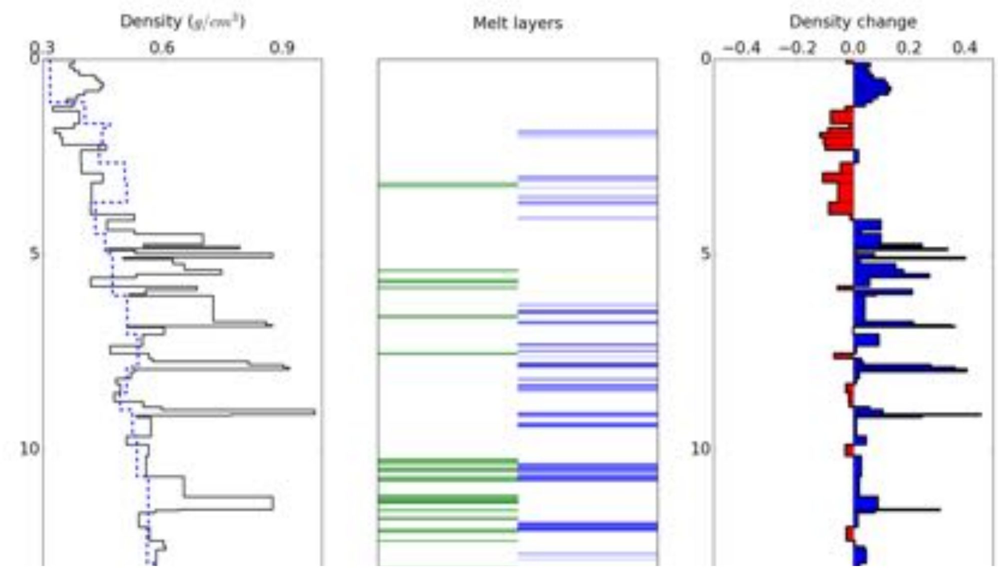


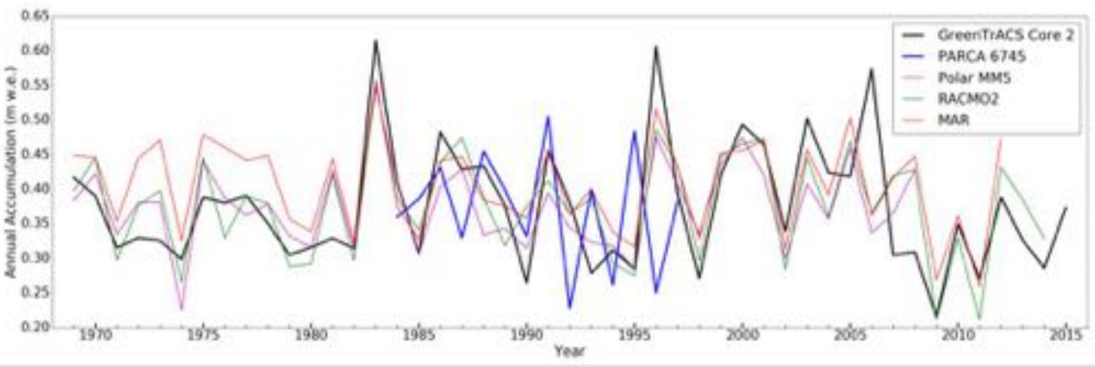
GreenTrACS Traverse:
Osterberg, Hawley, Marshall

Disko Bay Project:
Das, Frey, Evans, Smith

FirnCover/ACT Project:
MacFerrin, Marshall, Colgan

GreenTrACS Traverse Accumulation and Melt Studies





GREENLAND SUMMIT PROJECT

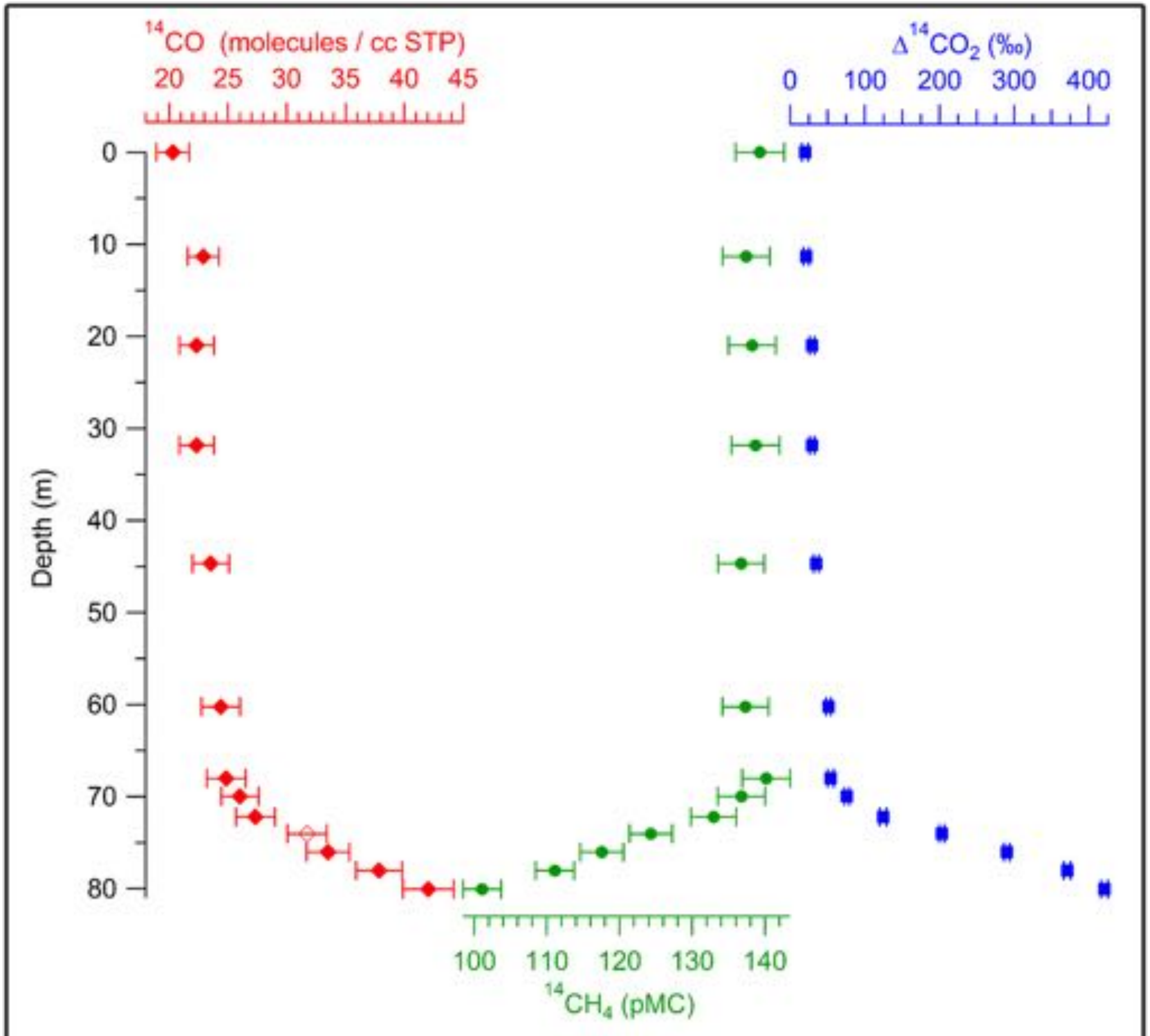
PIs:
Petrenko (lead), Brook, Severinghaus

Field Work:
2013, 2014 and 2015. Drilling with 3” Eclipse and BID

Main Project Goals (Petrenko group):

- Investigating in situ cosmogenic ^{14}C production and retention in ice
- Investigating the potential of $^{14}CH_4$, ^{14}CO and $^{14}CO_2$ in ice as tracers

GREENLAND SUMMIT PROJECT -- RESULTS

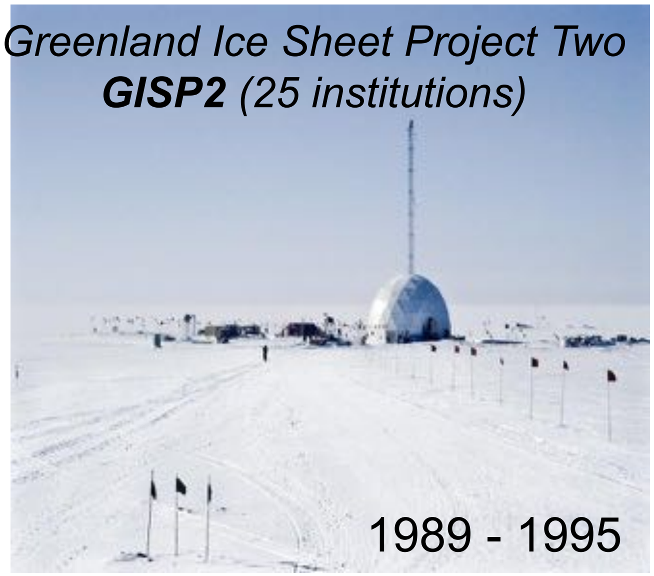


^{14}CO, $^{14}CH_4$ and $^{14}CO_2$ content vs. depth in the firn air samples.

Hmiel et al., 2016, AGU meeting

The first and most detailed record of the last 110,000 years of climate ever recovered – GISP2 (25 institutions)

It changed the way we think about climate!



(1) Why does climate change?

(2) How fast can climate change?

(3) Have humans impacted climate?

(4) How much of a change is needed to impact humans?

GISP 21 2019- 2022

Climate Change Institute | University of Maine

New 1600 m long, high resolution record that covers the last 13 ka:

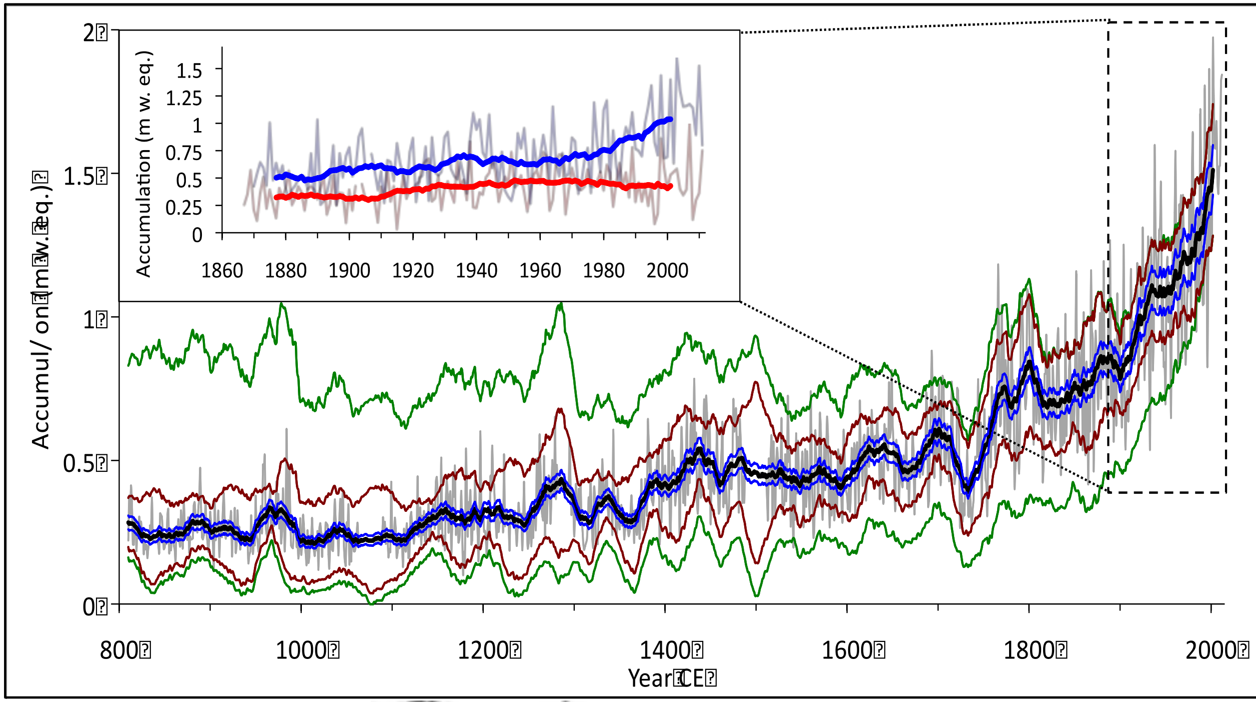
- Sea Ice
- History of anthropogenic emissions
- Volcanic forcing
- Dust storms and source areas
- Forest fires

Overlaps more with instrumental period.

North Pacific Ice Core Sites

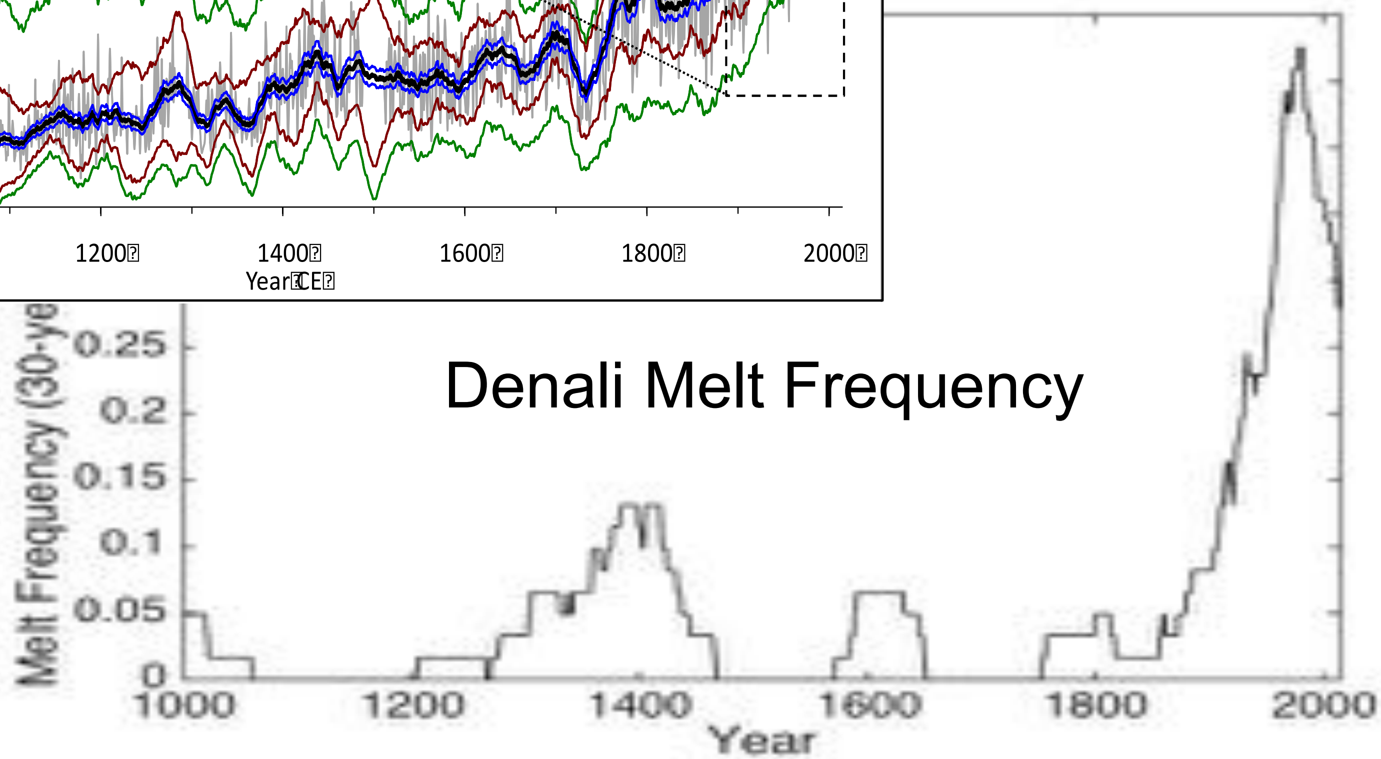
Denali Ice Core 1200-Year Annual Climate Record

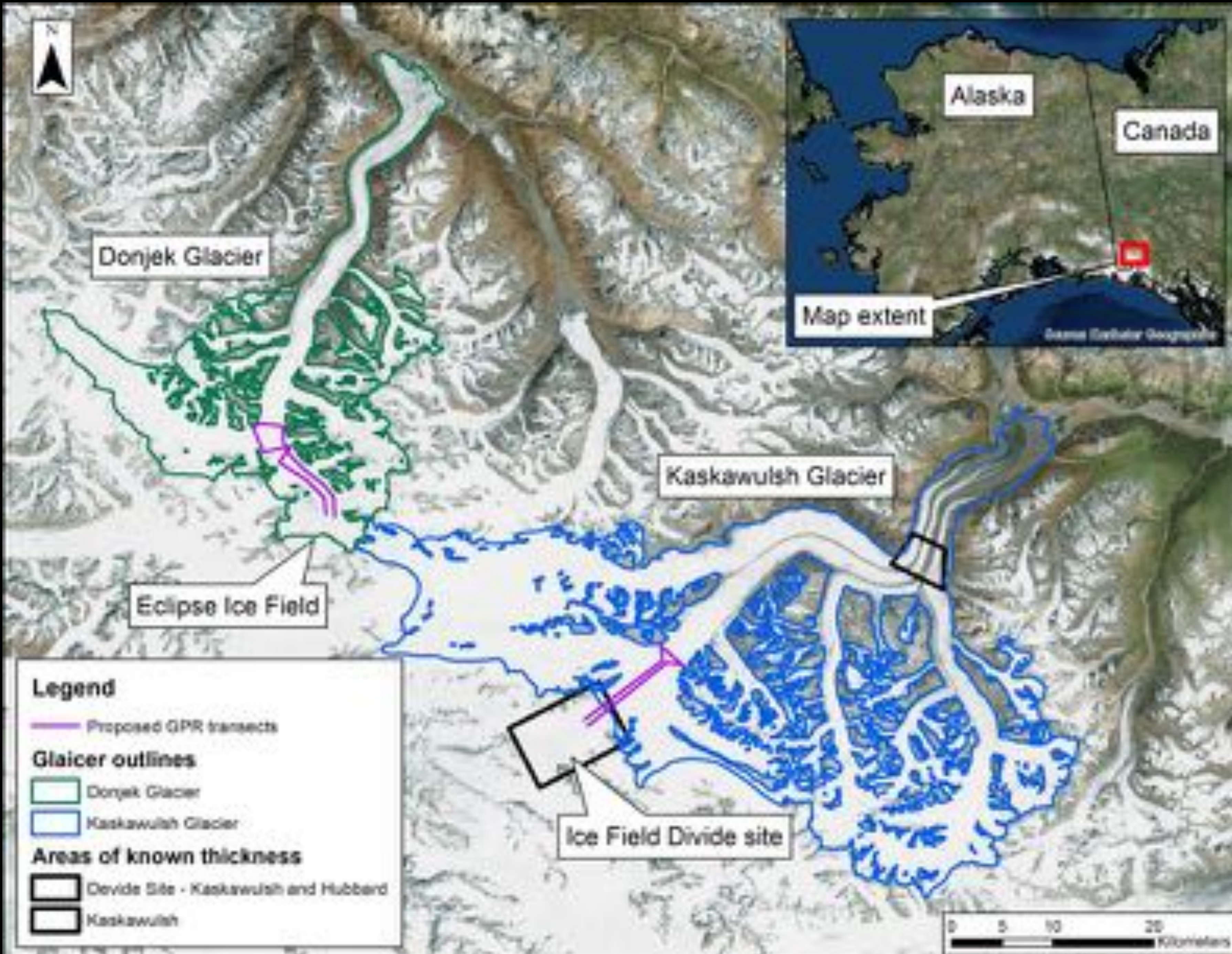
Denali Annual Accumulation



Recent doubling of accumulation
PNAS in review

Denali Melt Frequency





N
Alaska
Canada
Map extent
Donjek Glacier
Kaskawulsh Glacier
Eclipse Ice Field
Ice Field Divide site
Legend
Proposed GPR transects
Glaicer outlines
Donjek Glacier
Kaskawulsh Glacier
Areas of known thickness
Devide Site - Kaskawulsh and Hubbard
Kaskawulsh
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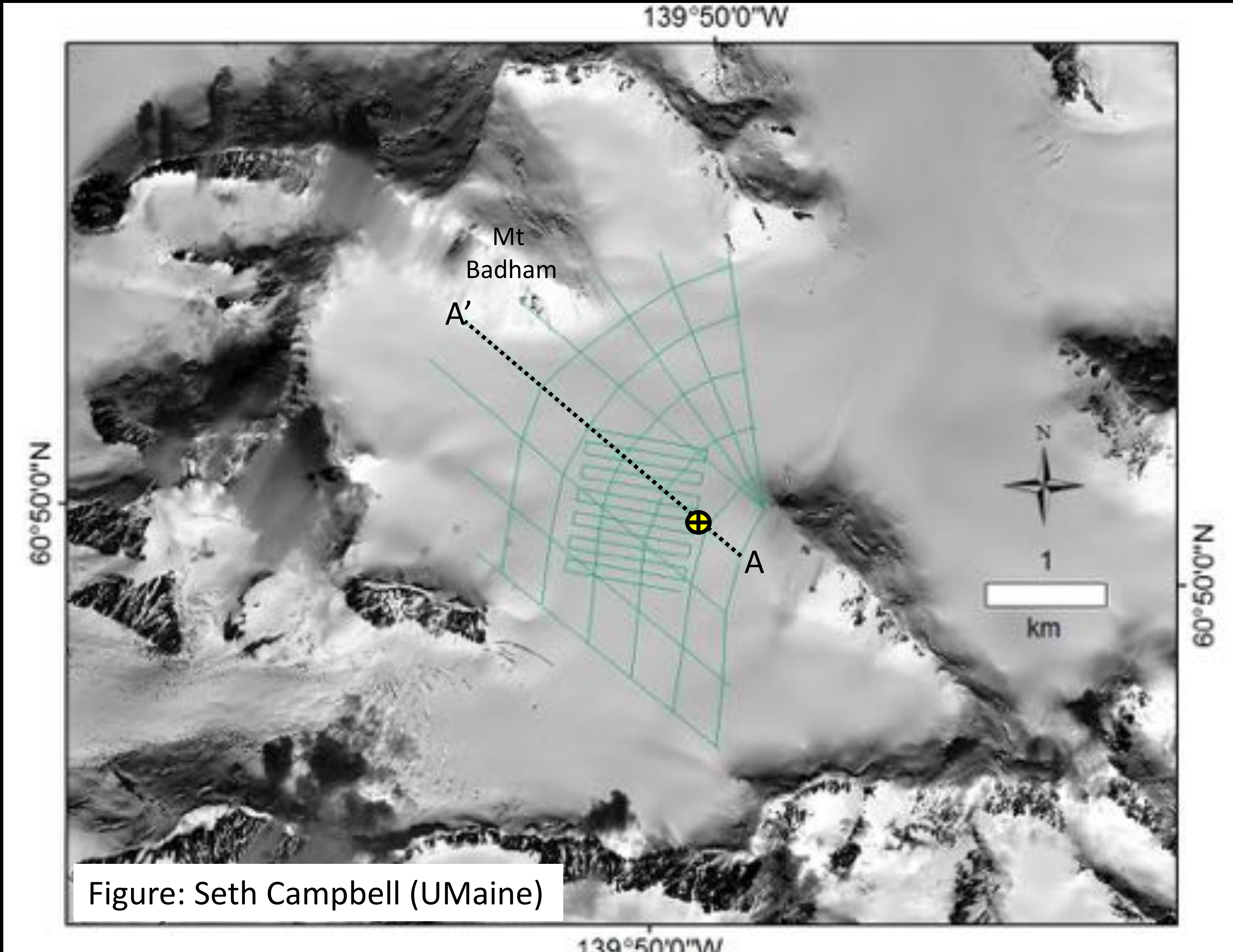
Kilometers

Eclipse Icefield Project: Kreutz and Campbell



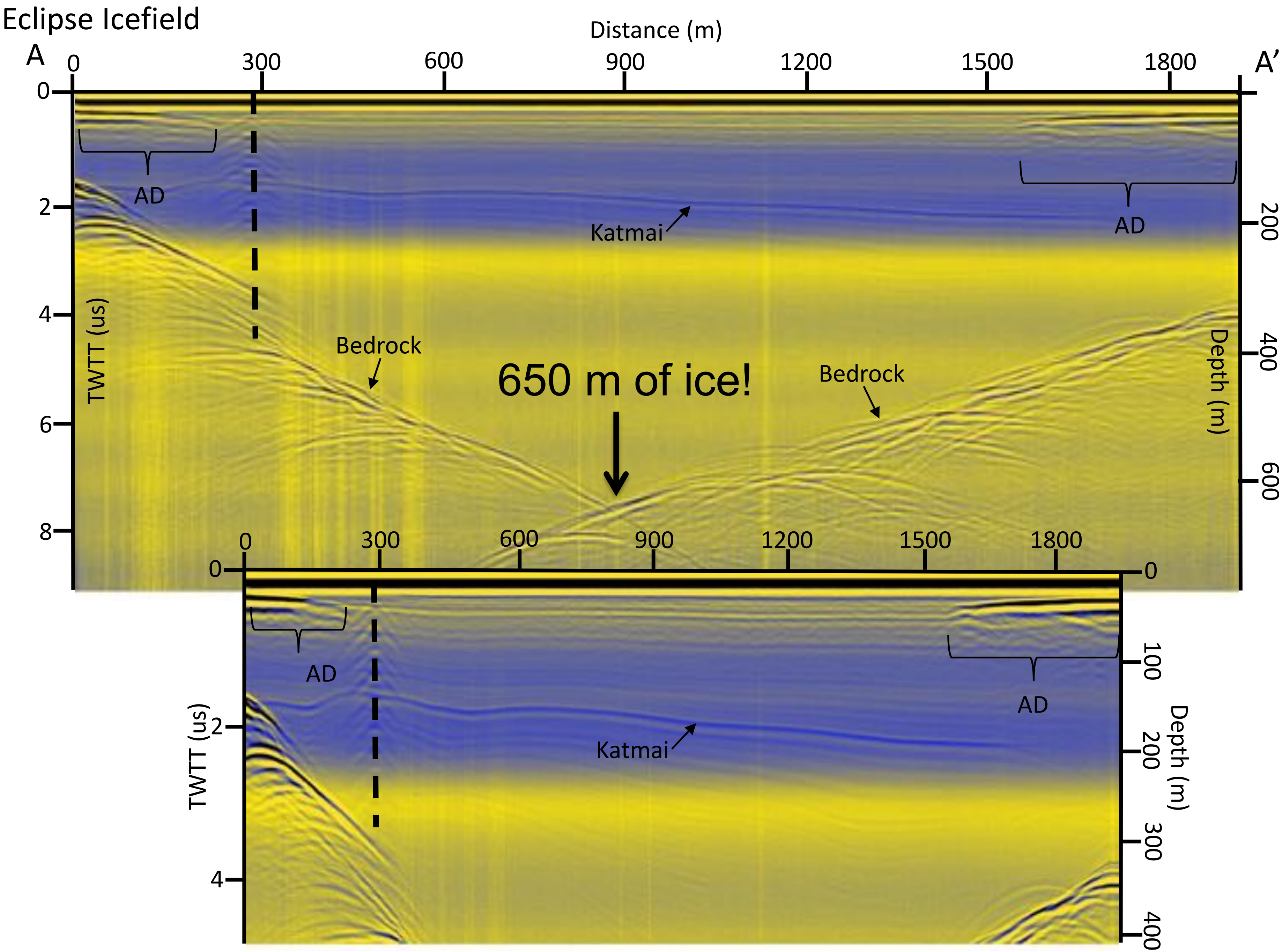
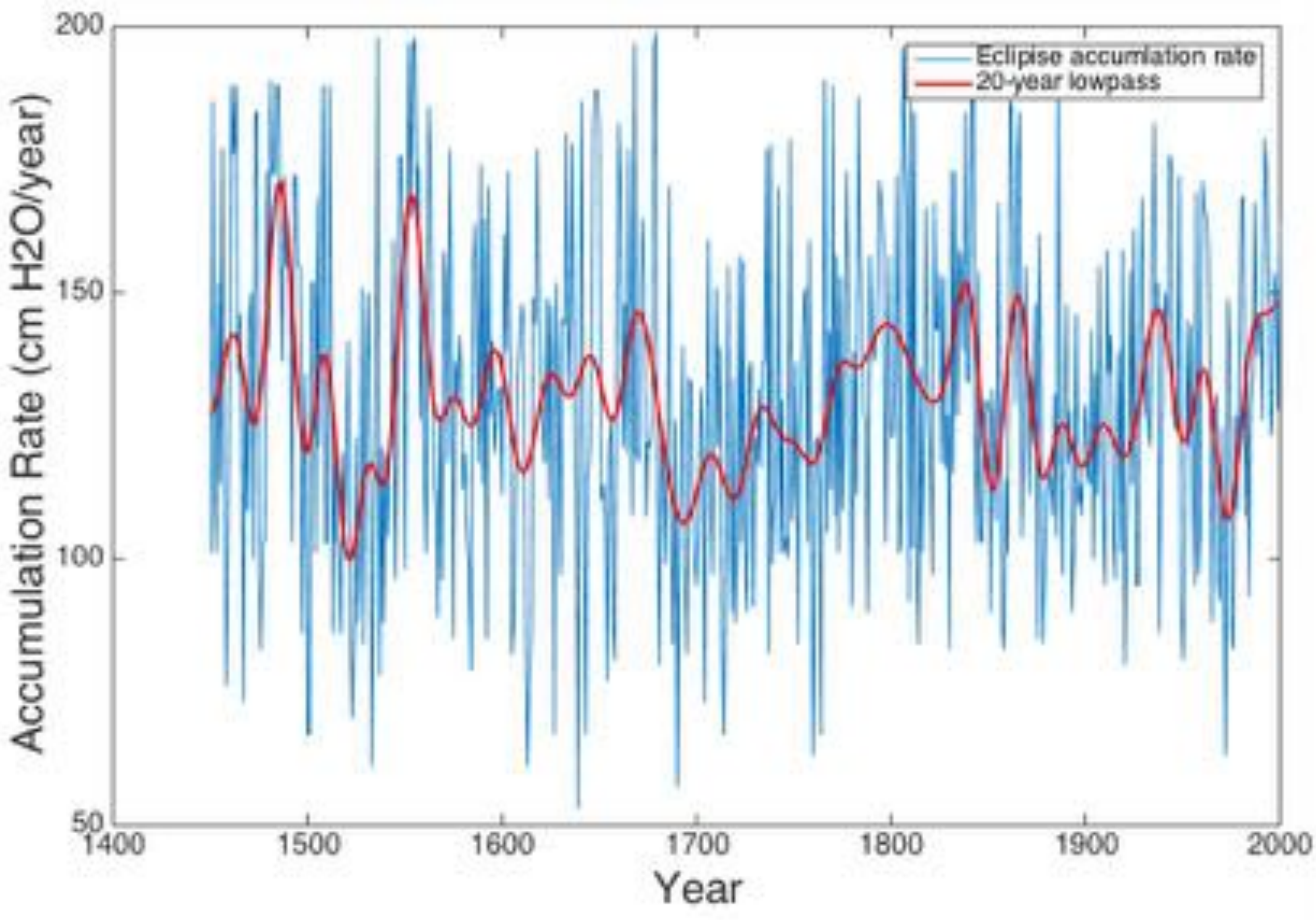
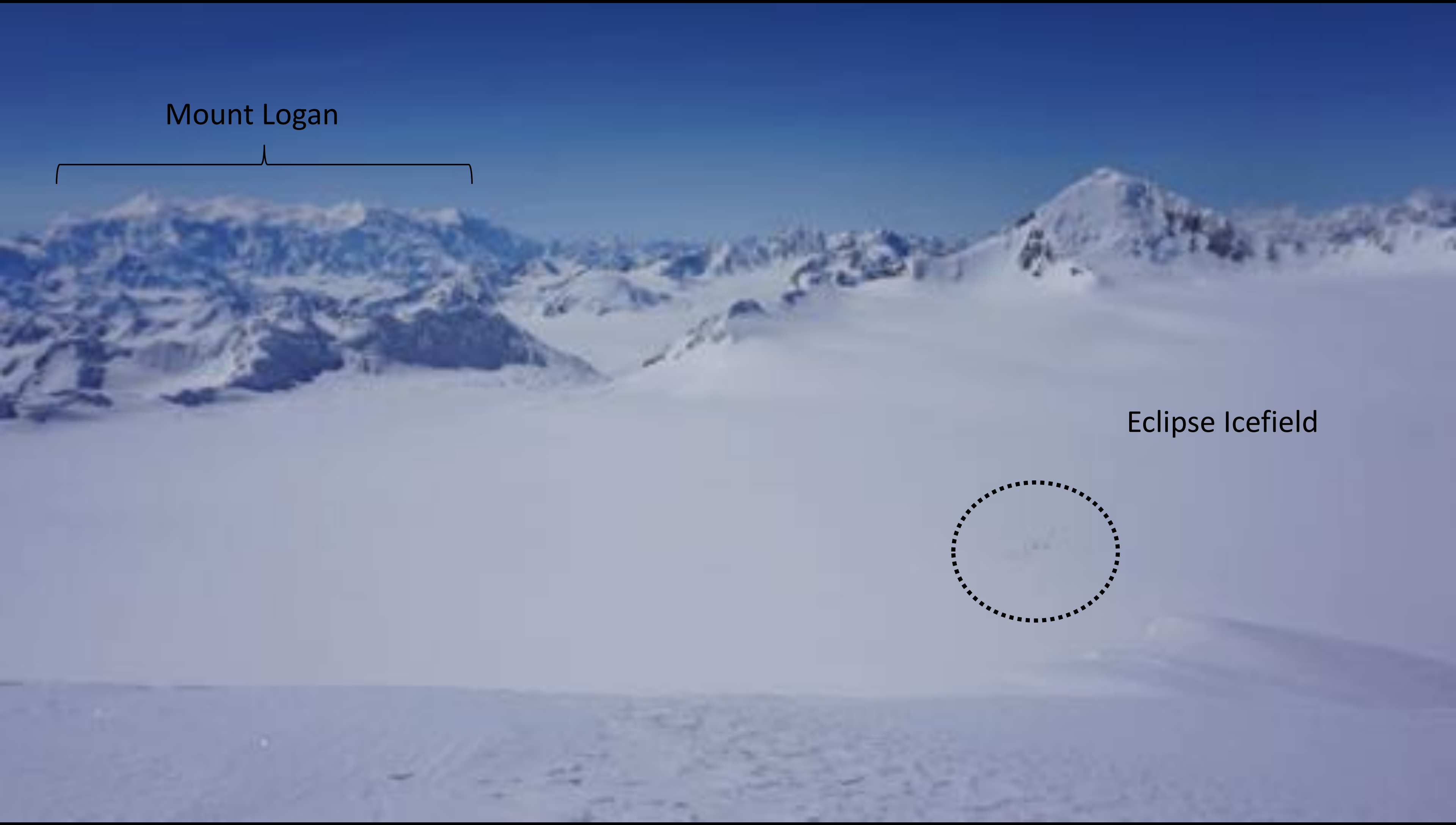


Figure: Seth Campbell (UMaine)

Eclipse Icefield Accumulation Record



Eclipse Icefield



Field Season at Mount Logan and Eclipse: May-June 2017

Photo: Karl Kreutz (UMaine)

ICWG Tech Investment Discussions

- Build the Agile Ice Coring Drill capable of drilling to 400-900 m depth
- Build a replica of the IDD drill for Arctic & Antarctic work
- Consider a hot water coring system capable of drilling to ~200 m in warm sites like Chile, NZ, Asia