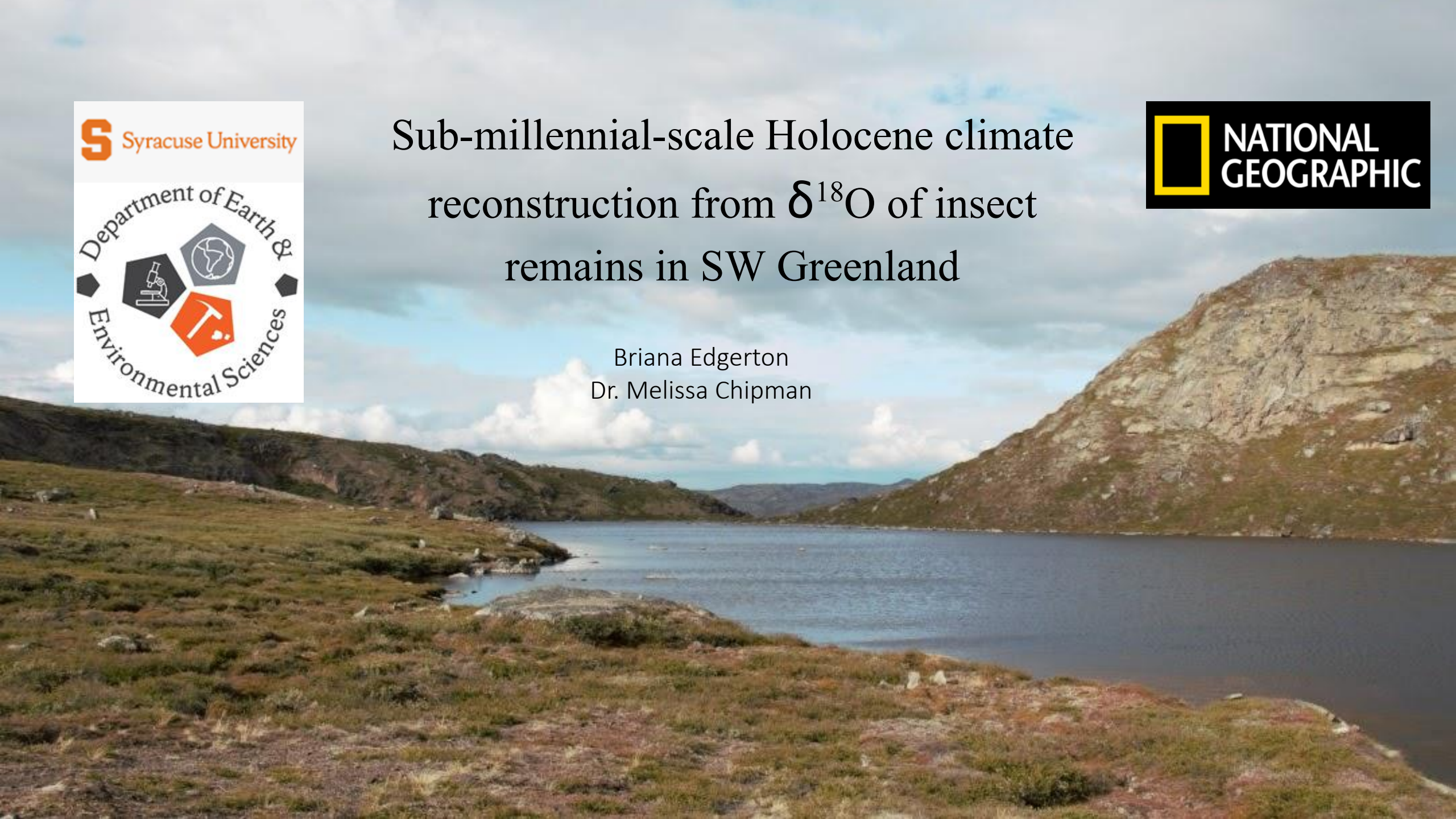
Sub-millennial-scale Holocene climate reconstruction from $\delta^{18}O$ of insect remains in SW Greenland

Briana Edgerton
Dr. Melissa Chipman



Article

Rate of mass loss from the Greenland Ice Sheet will exceed Holocene values this century

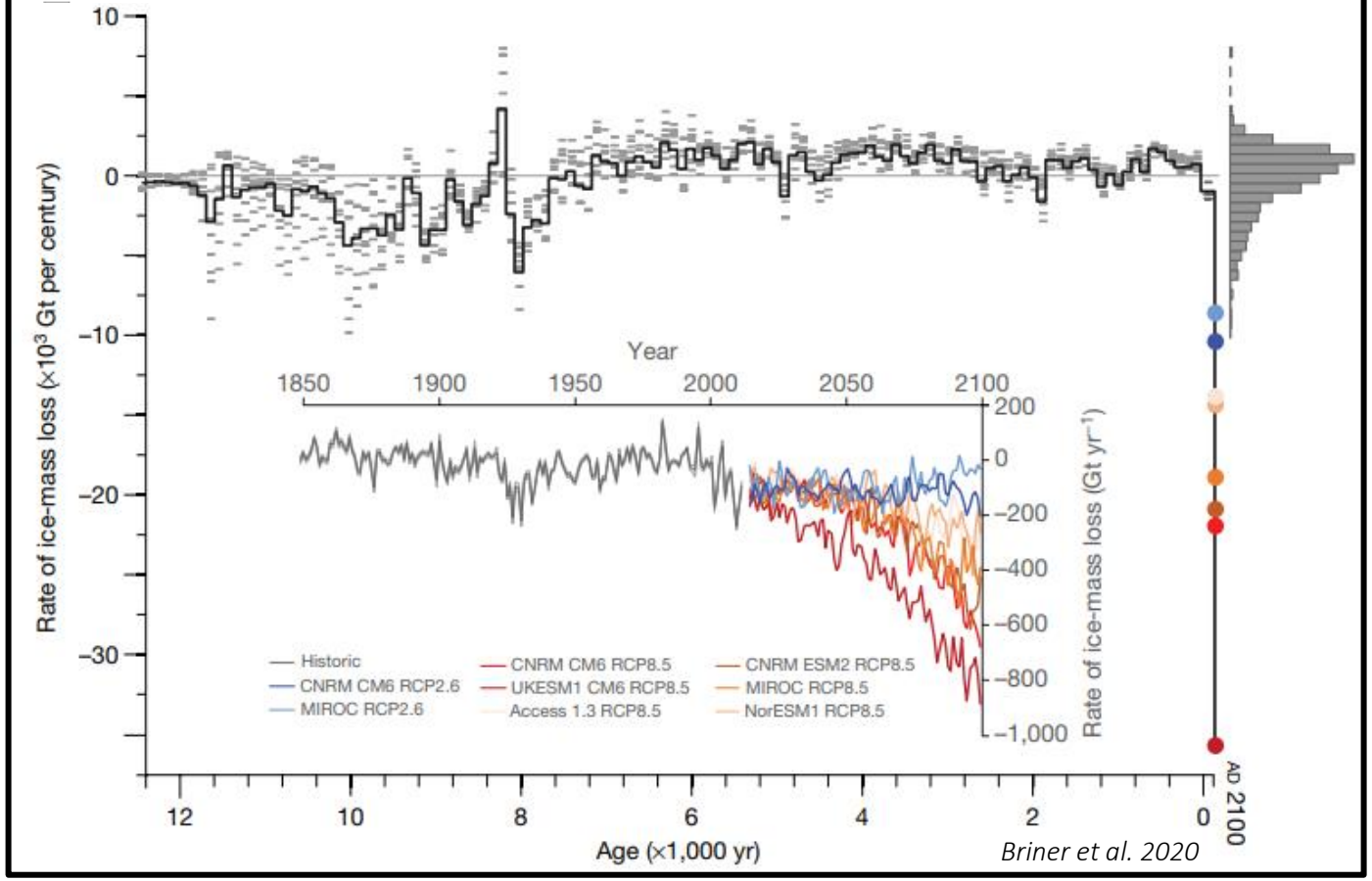
https://doi.org/10.1038/s41586-020-2742-6

Received: 30 December 2019

Accepted: 27 July 2020

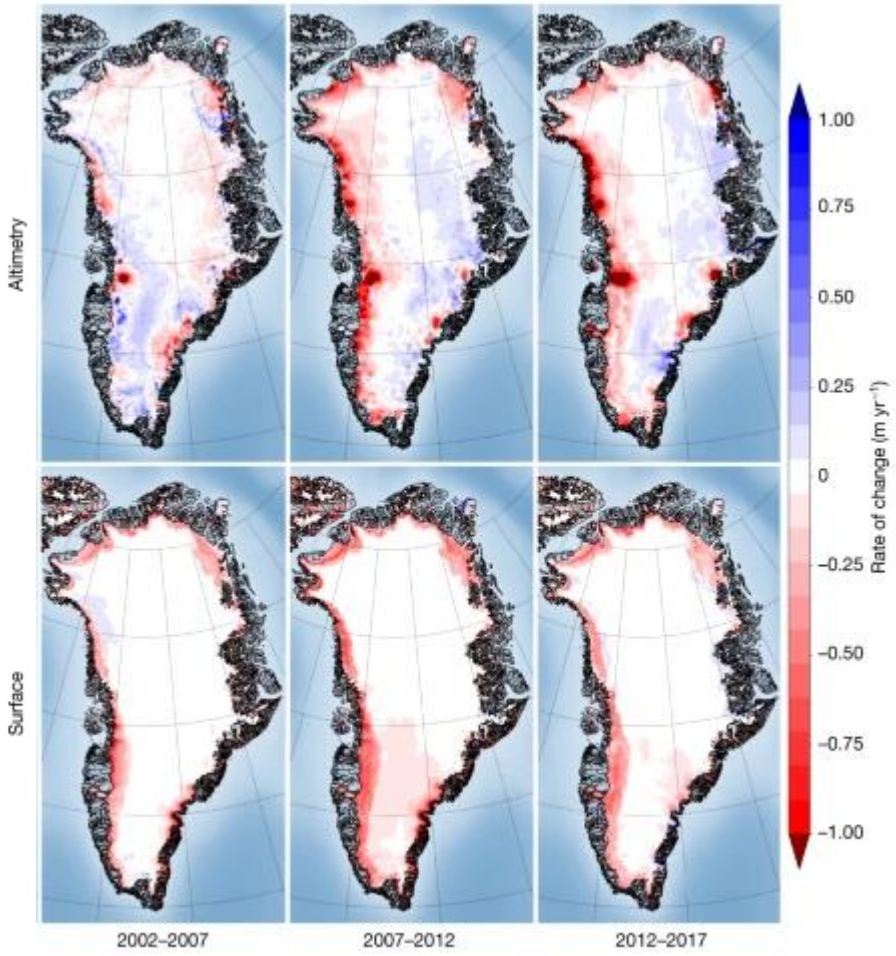
Published online: 30 September 2020

Jason P. Briner[1✉], Joshua K. Cuzzone[2,3], Jessica A. Badgeley[4], Nicolás E. Young[5], Eric J. Steig[4,6], Mathieu Morlighem[2], Nicole-Jeanne Schlegel[3], Gregory J. Hakim[6], Joerg M. Schaefer[5,7], Jesse V. Johnson[8], Alia J. Lesnek[1], Elizabeth K. Thomas[1], Estelle Allan[9], Ole Bennike[10], Allison A. Cluett[1], Beata Csatho[1], Anne de Vernal[9], Jacob Downs[8], Eric Larour[3] & Sophie Nowicki[11]

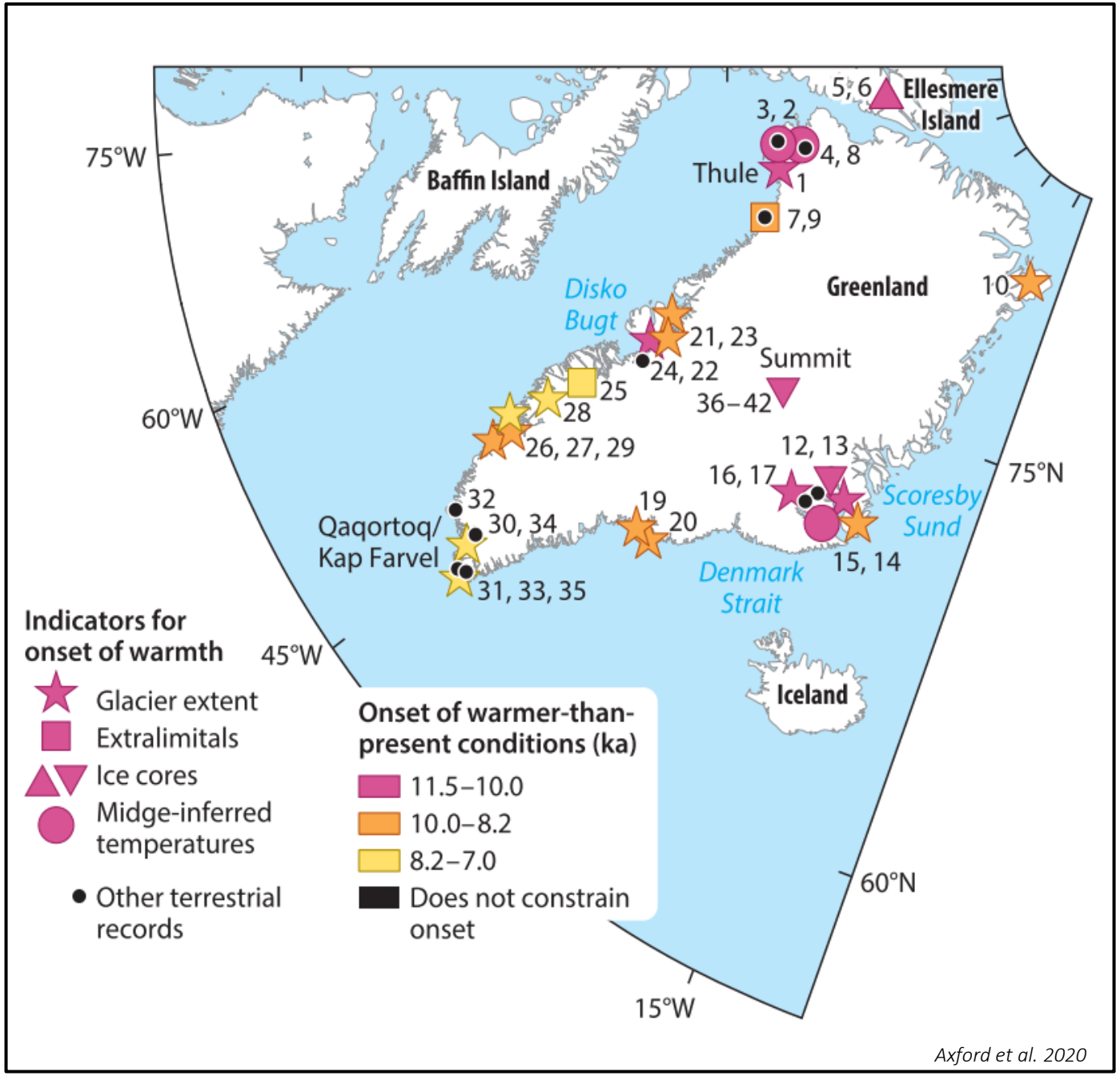


Briner et al. 2020

- We need to understand climate variability along ice sheet margins



Shepherd et al. 2020

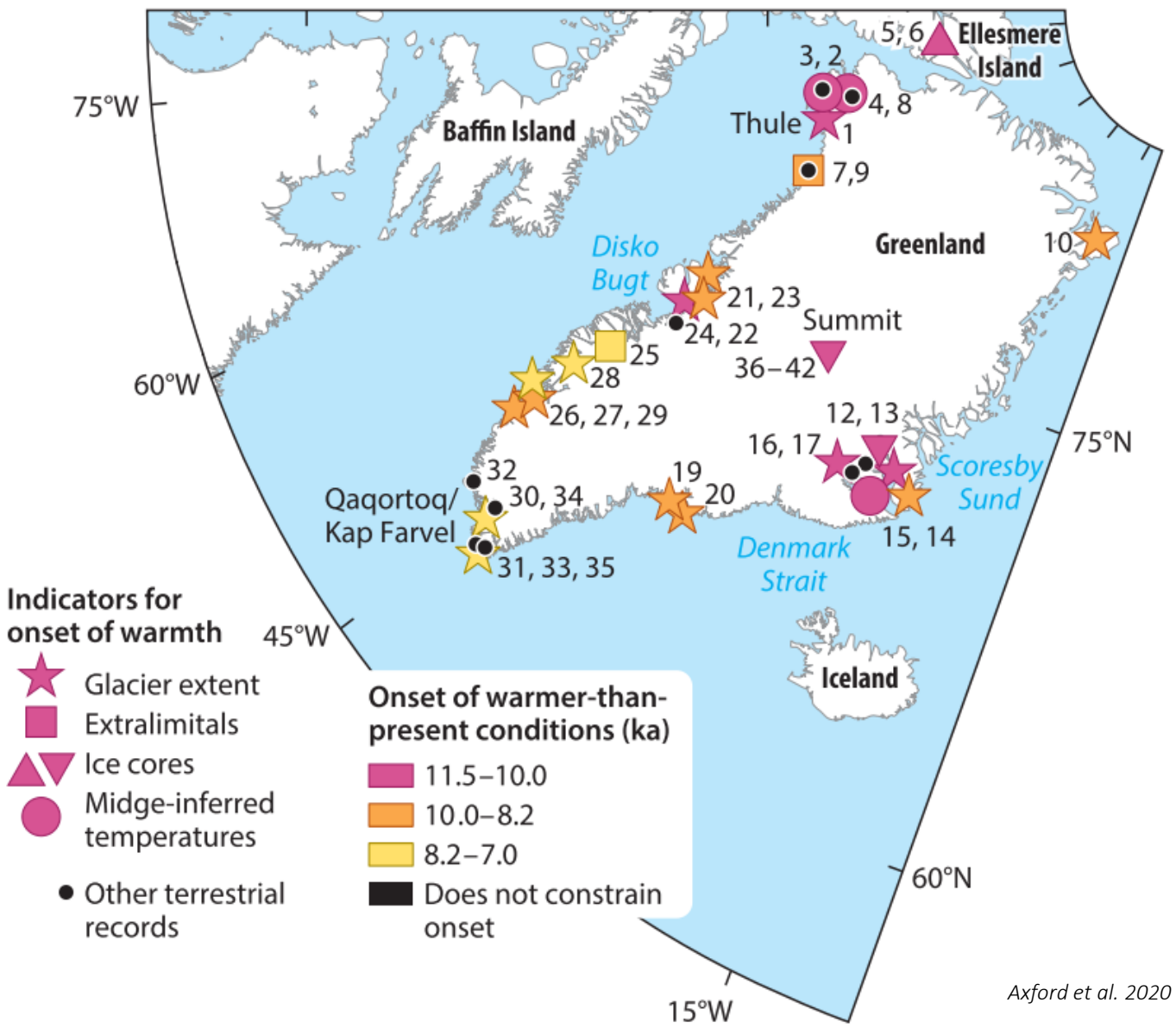


Axford et al. 2020

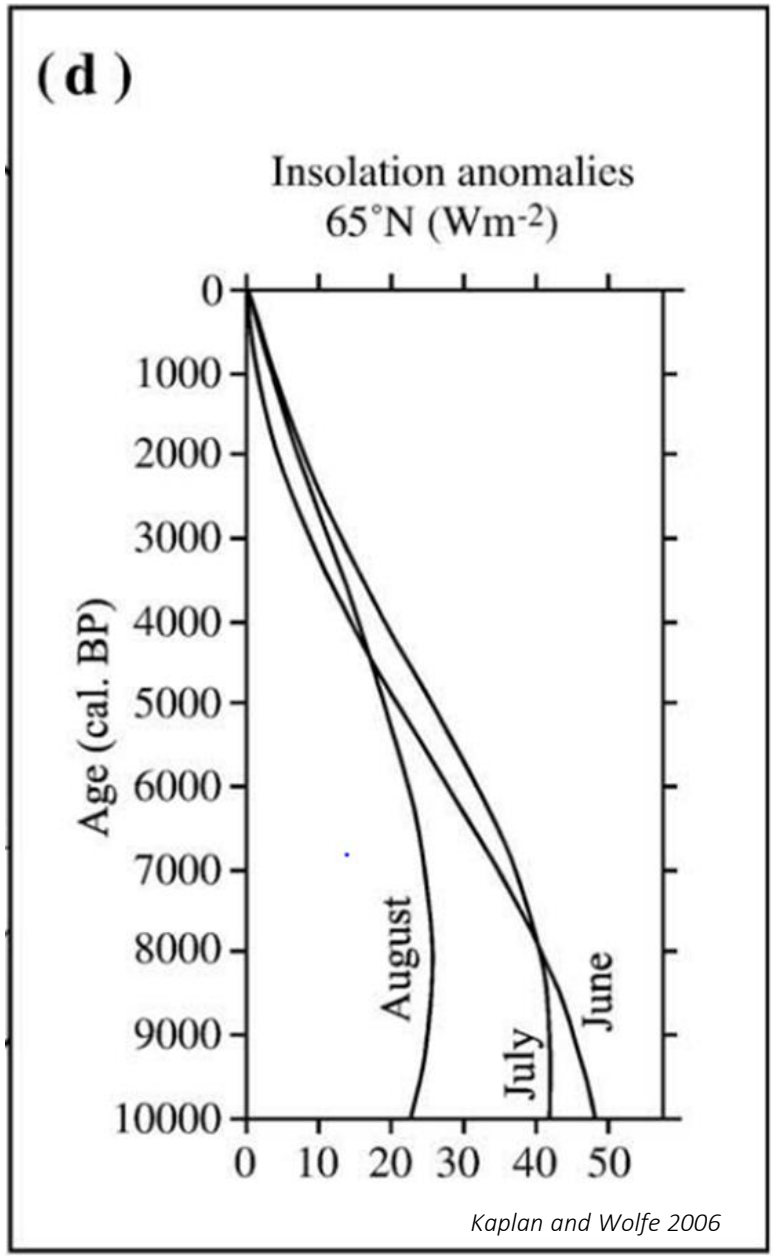
Introduction

- Greenland paleoclimate proxies show spatial and temporal heterogeneity in sub-millennial scale Holocene climate

Summer insolation forces millennial scale summer temperature in Greenland

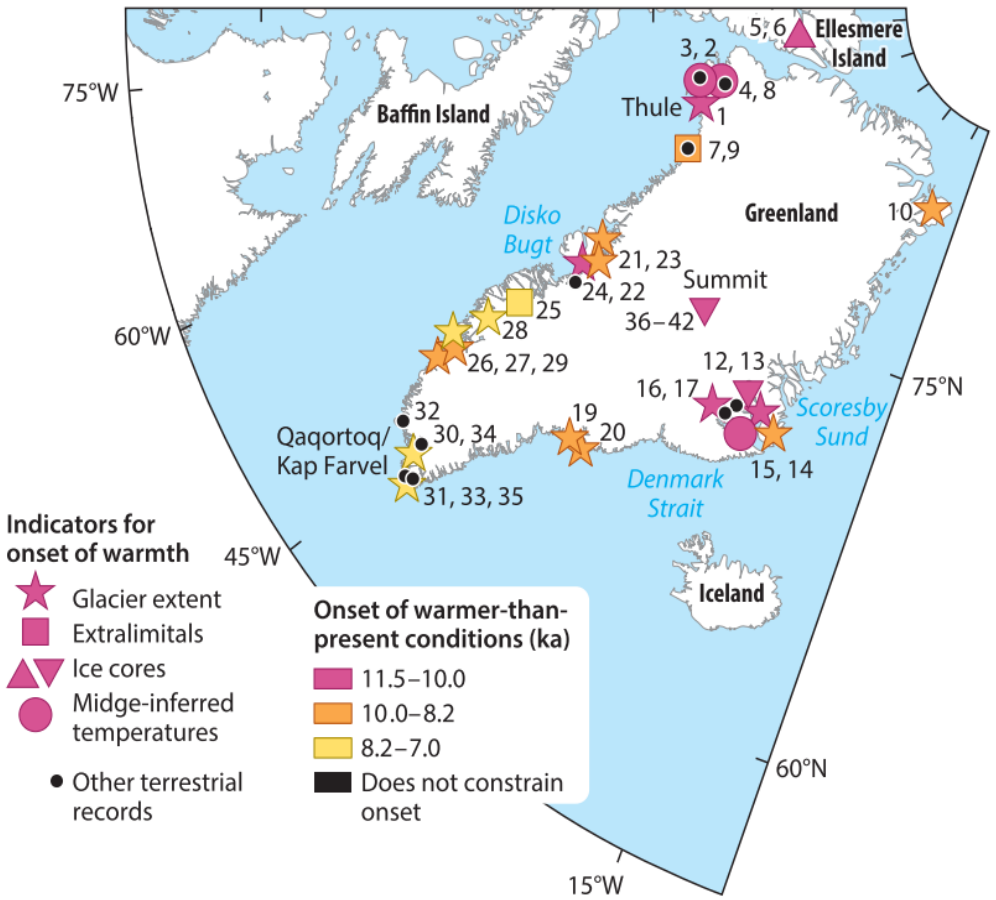


Axford et al. 2020

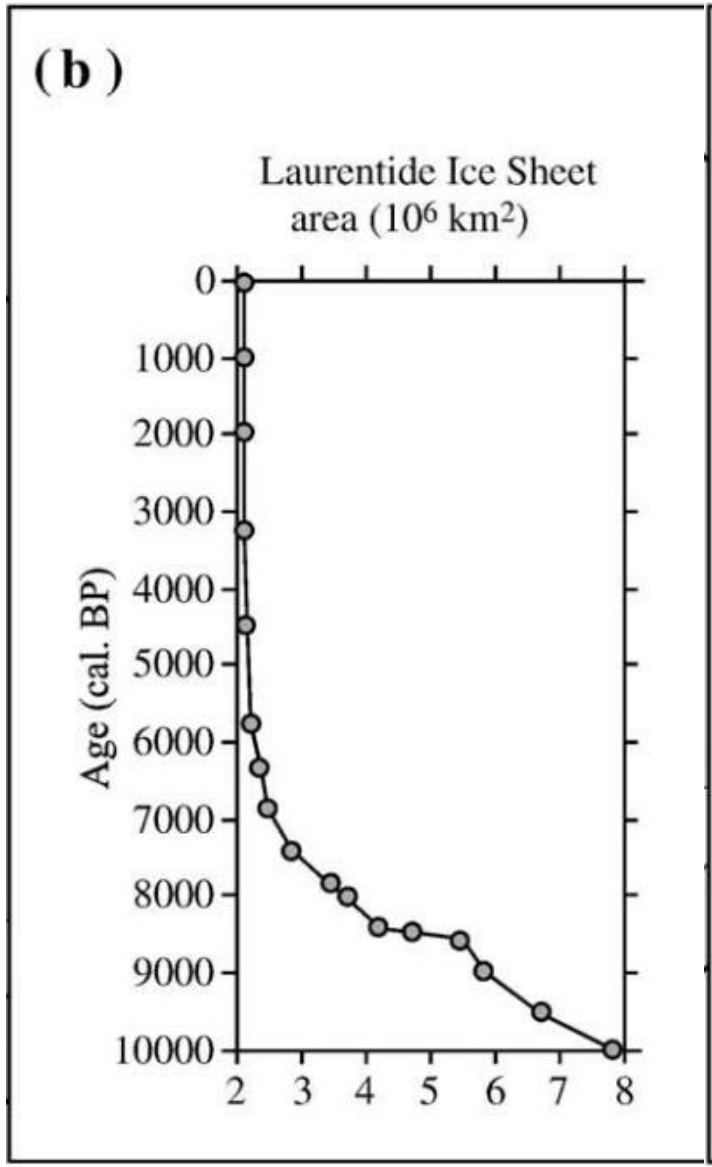


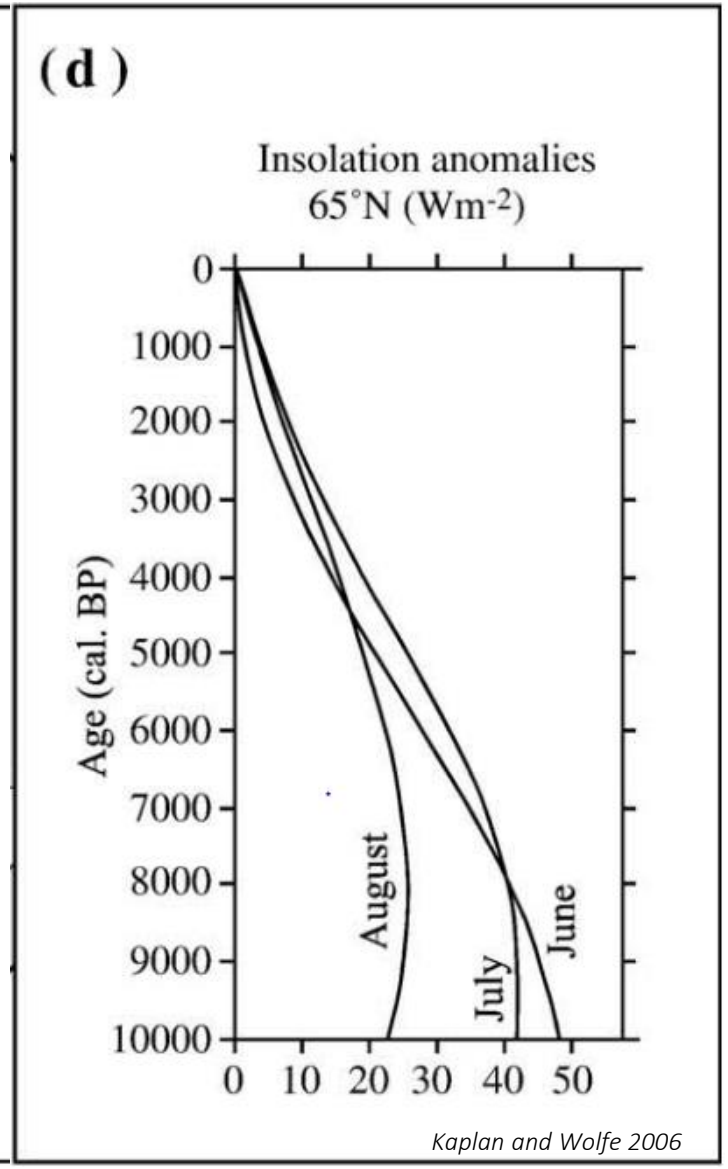
Kaplan and Wolfe 2006

Ice sheet thaw also impacted climate along the western margin of Greenland



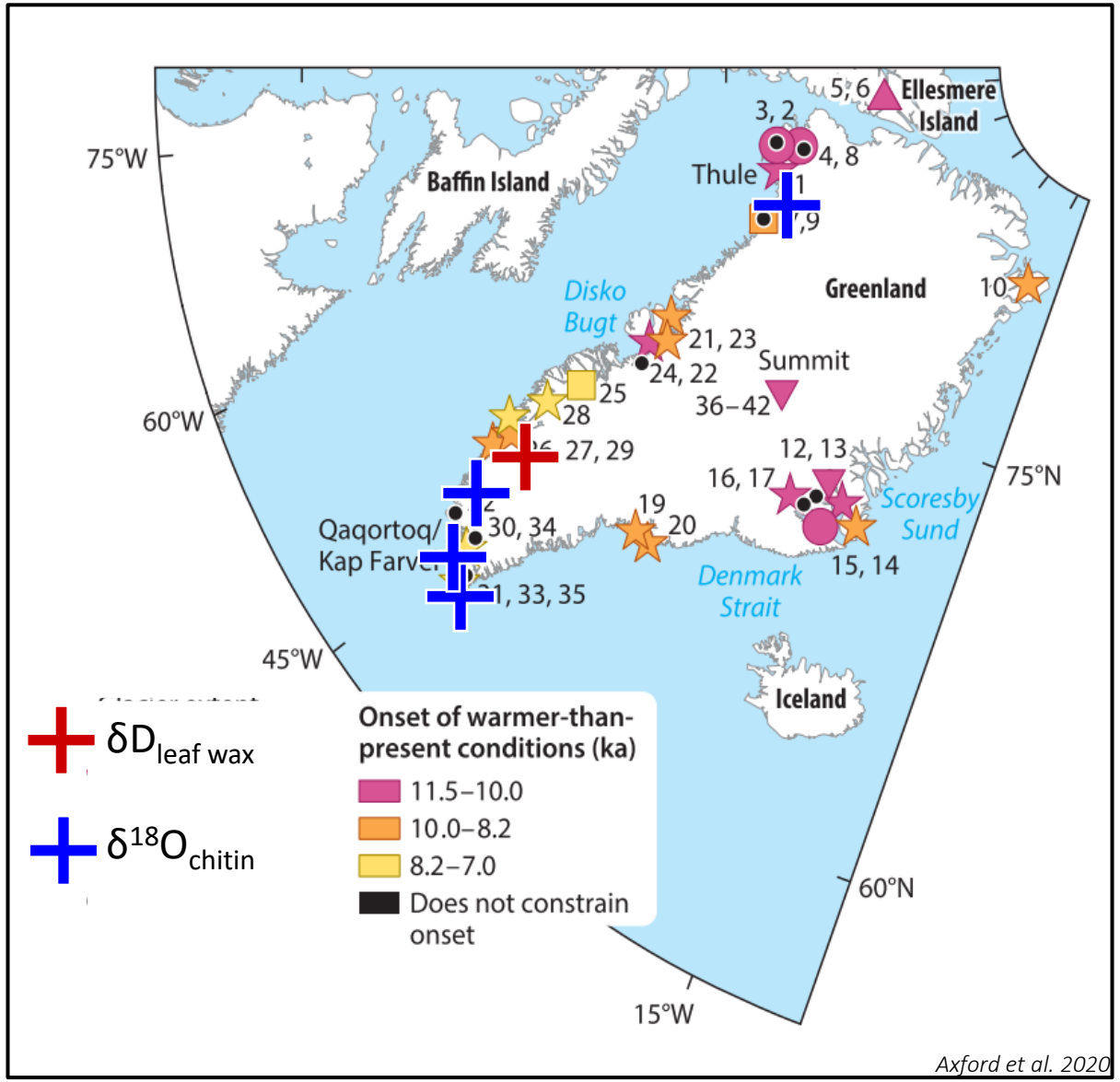
Axford et al. 2020



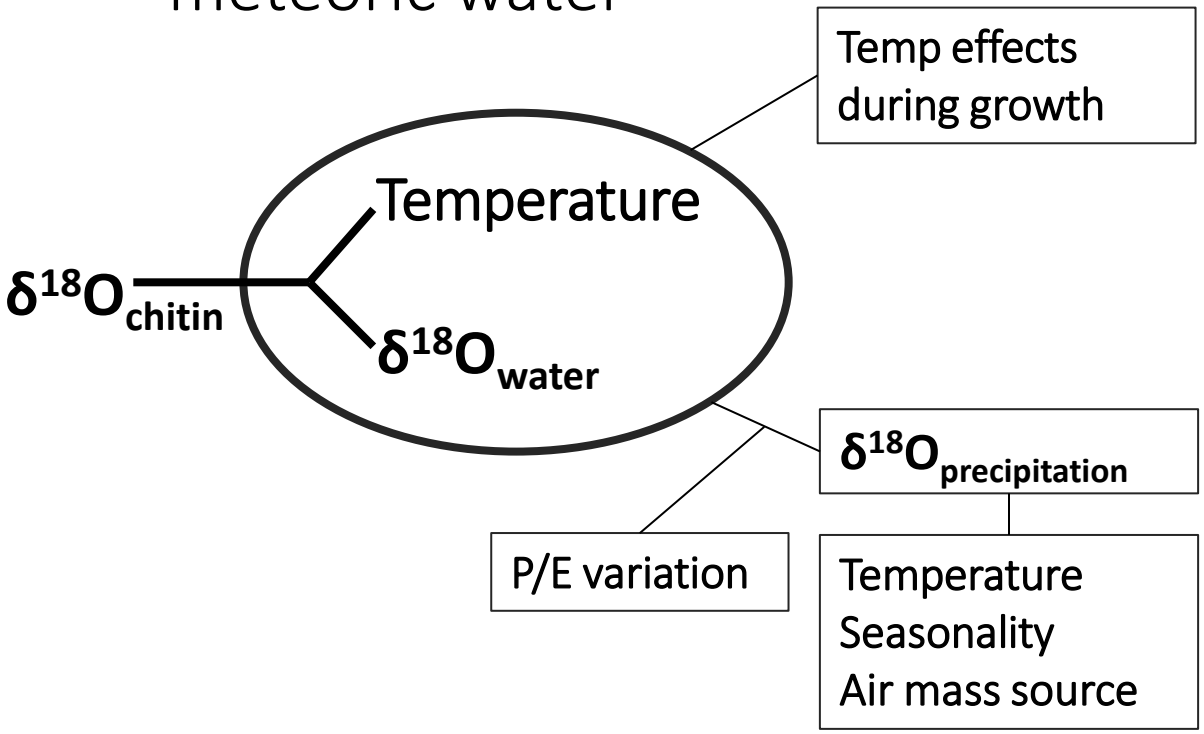


Kaplan and Wolfe 2006

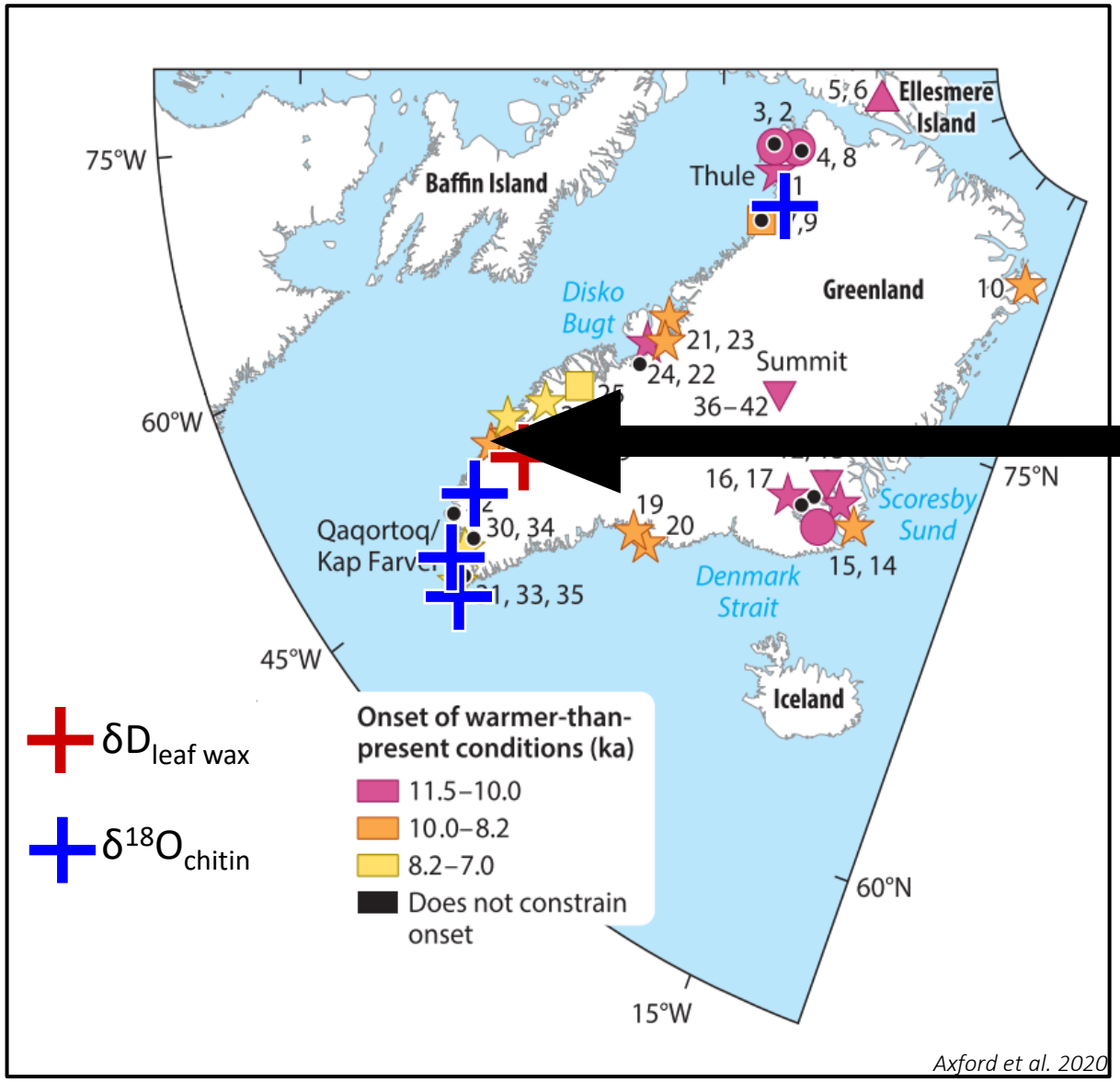
Isotope based records from Greenland



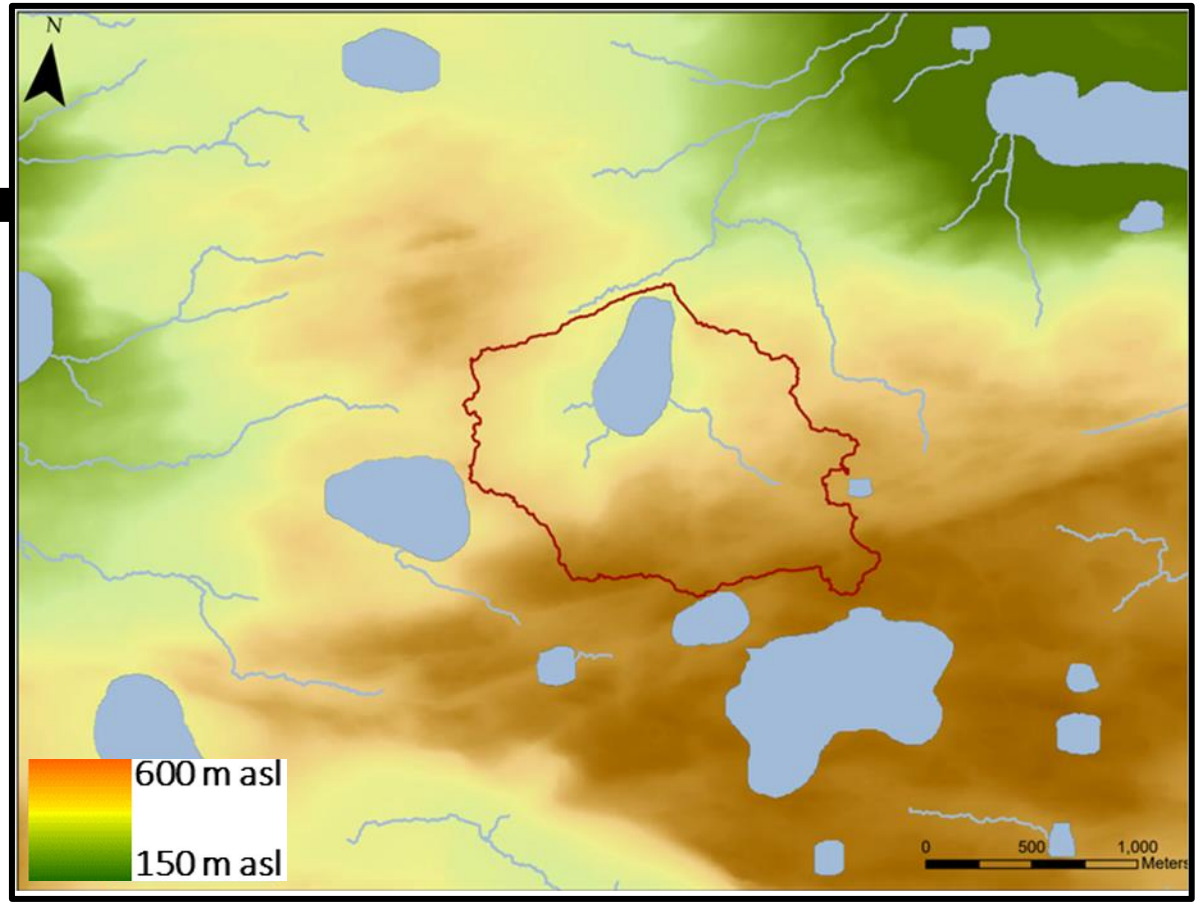
- Isotope records from beyond the ice sheet
- Indication of changes in meteoric water



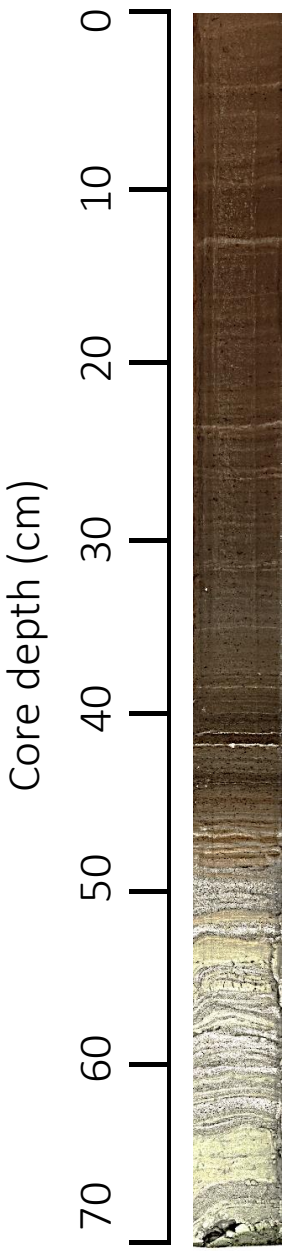
Study site: Arrowhead Lake

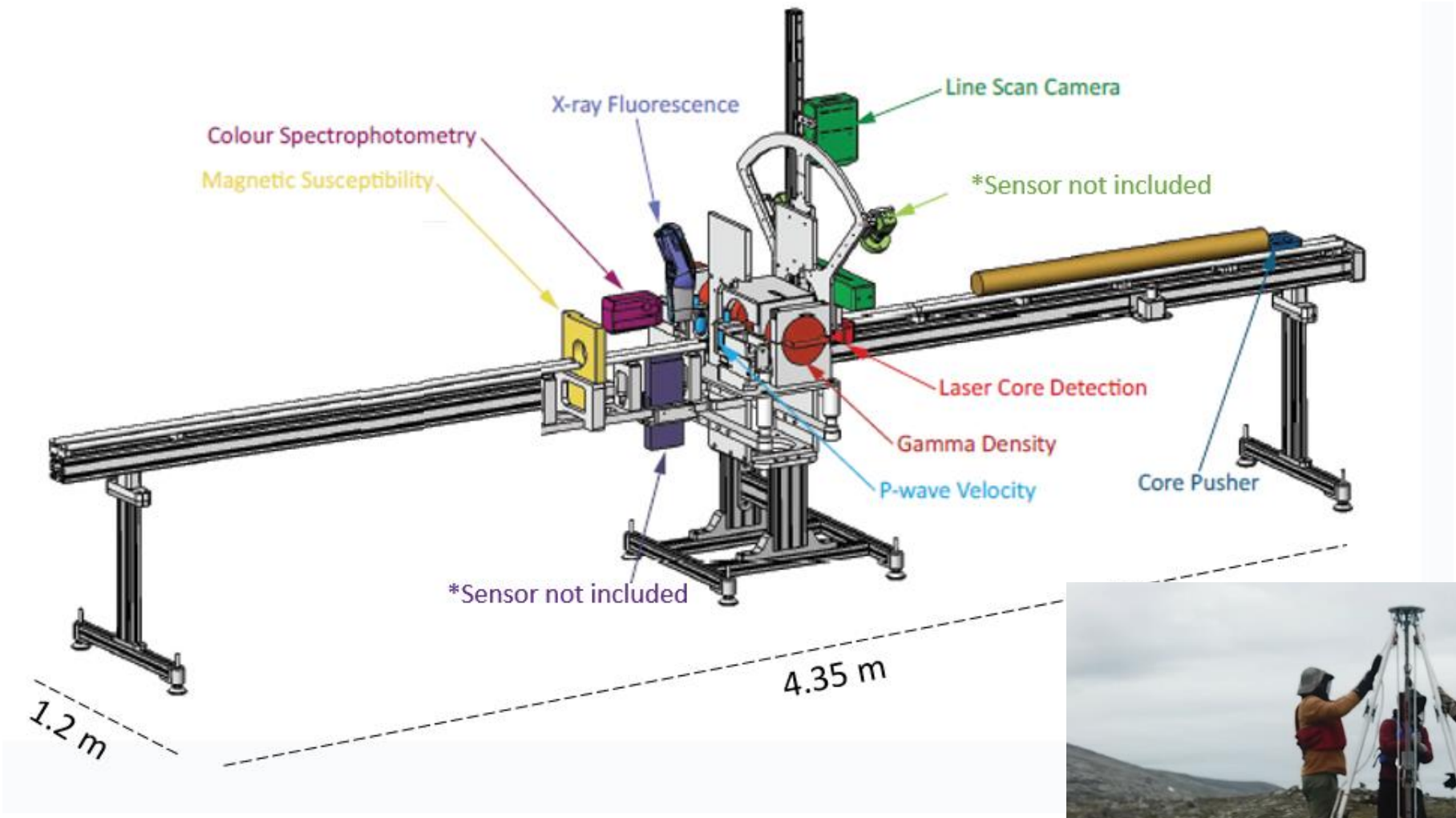


- New $\delta^{18}O$ record from lake sediment core in SW Greenland



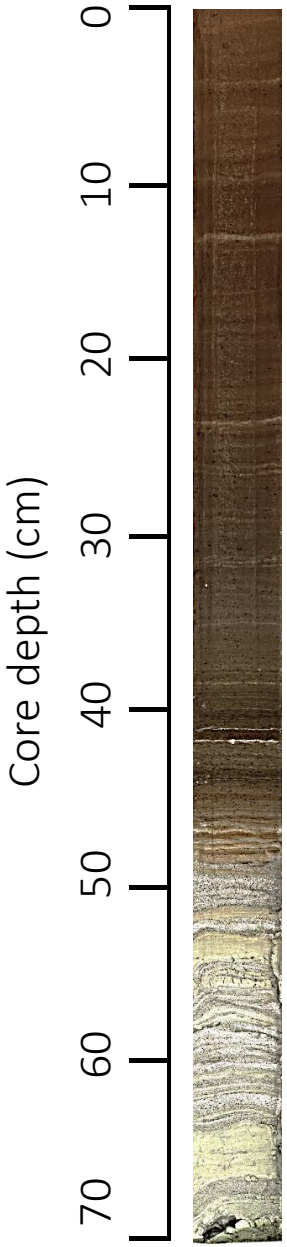
Methods

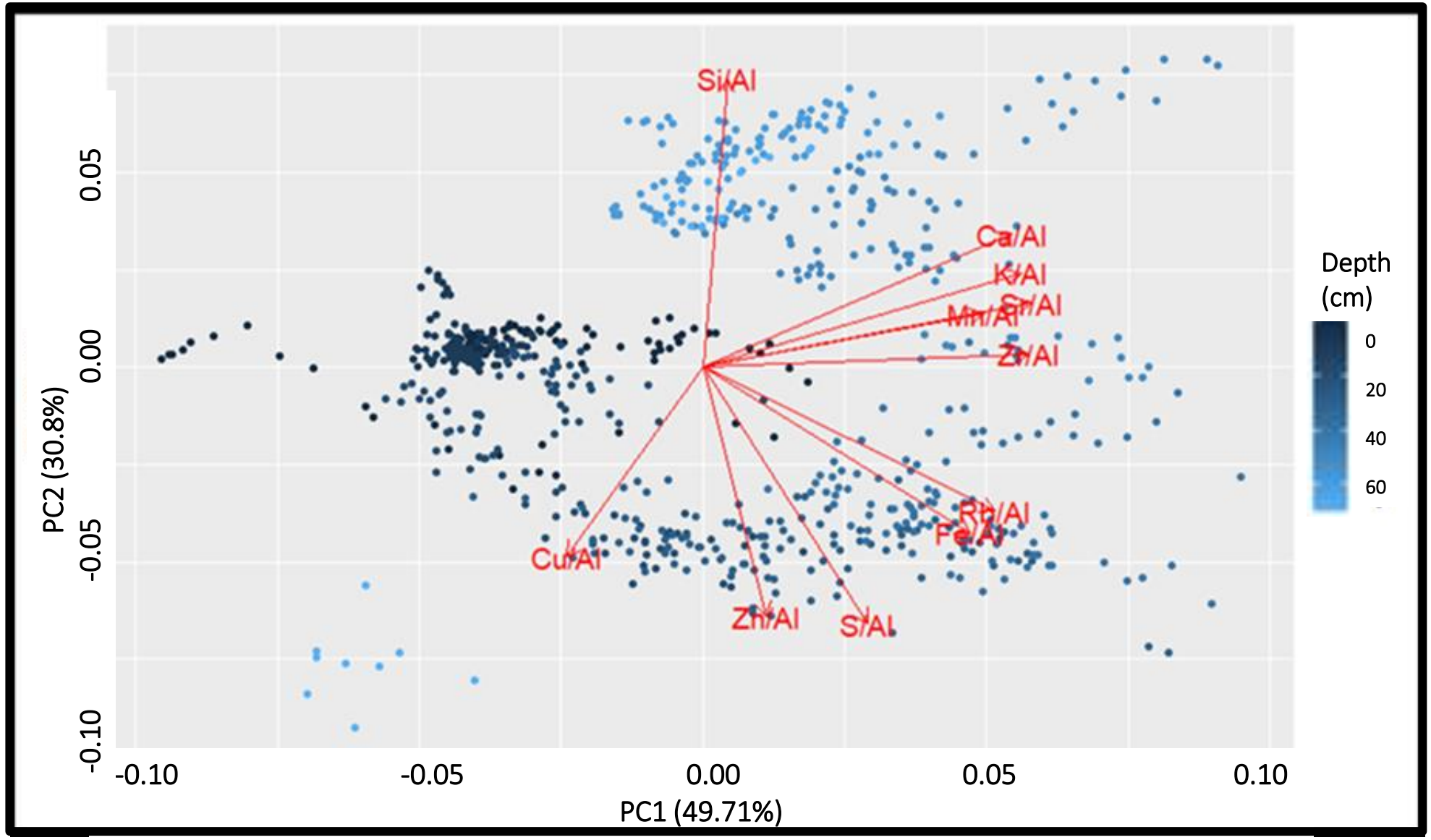


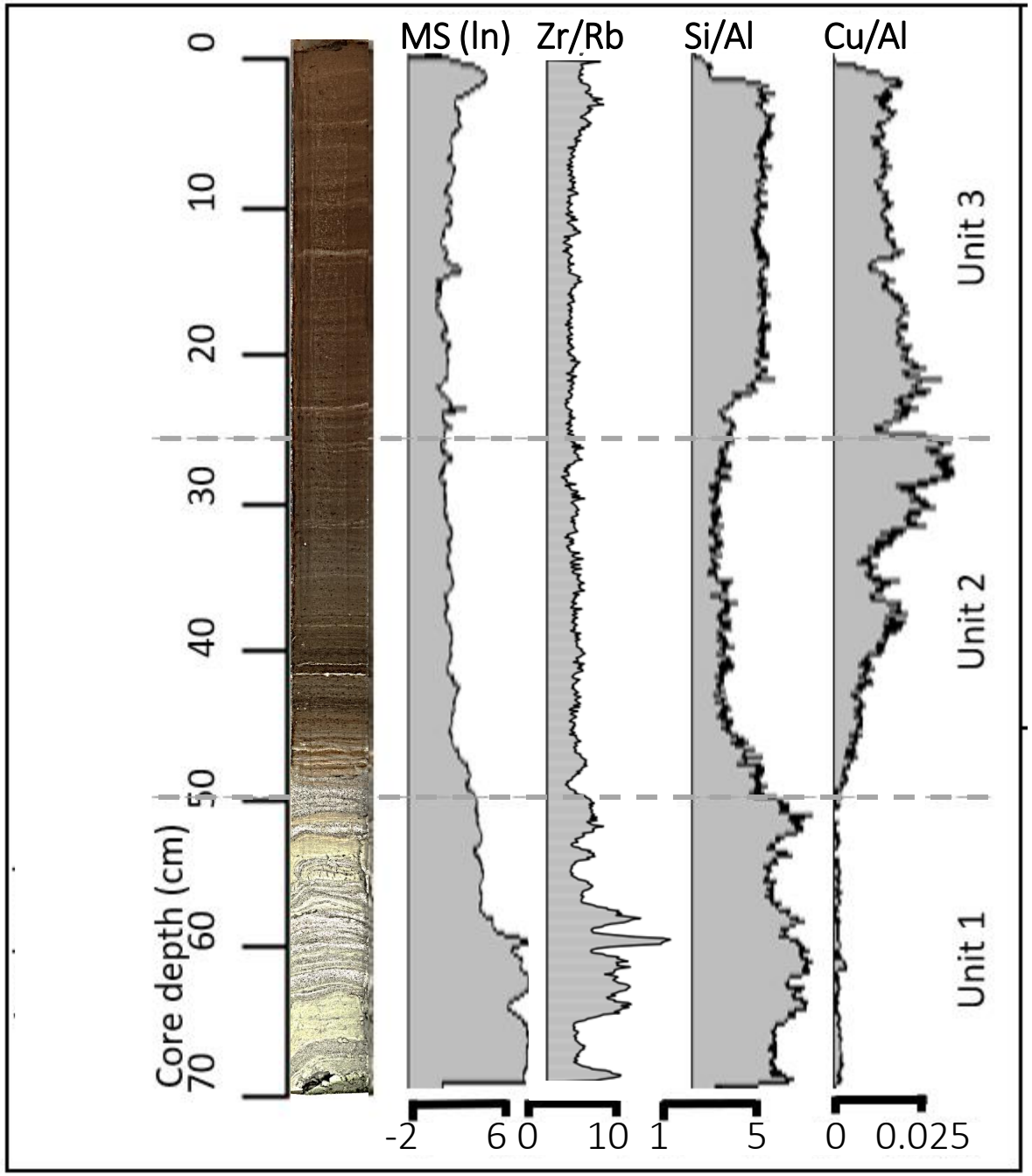


- Magnetic susceptibility and X-Ray Fluorescence for elemental composition

Arrowhead Lake sedimentology and geochemistry



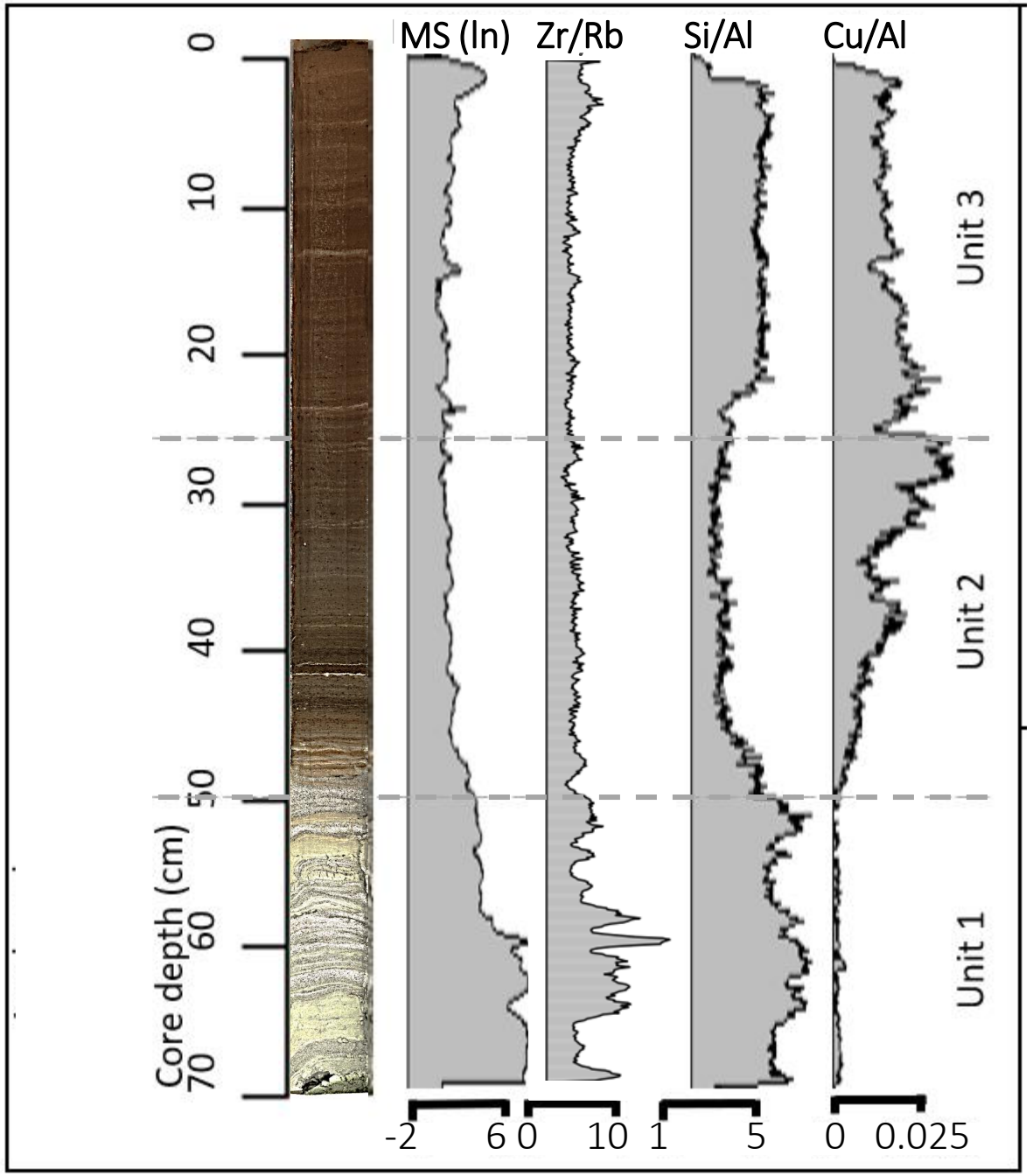




Arrowhead Lake sedimentology and geochemistry

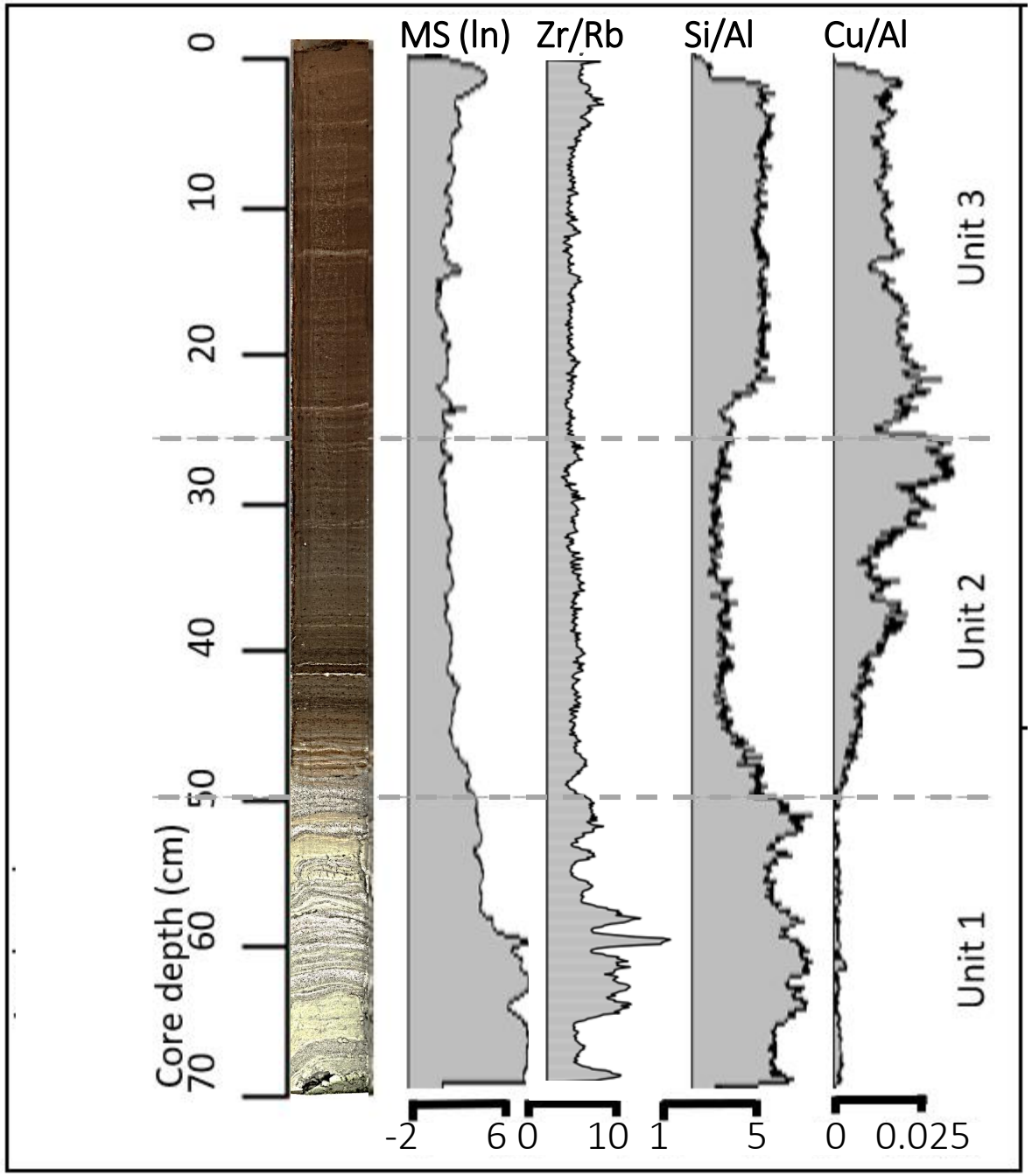
Unit 1:
Coarse-grained terrigenous sediments

Arrowhead Lake sedimentology and geochemistry



Unit 2:
Decrease in grain size, increase in organic content

Unit 1:
Coarse grained terrigenous sediments

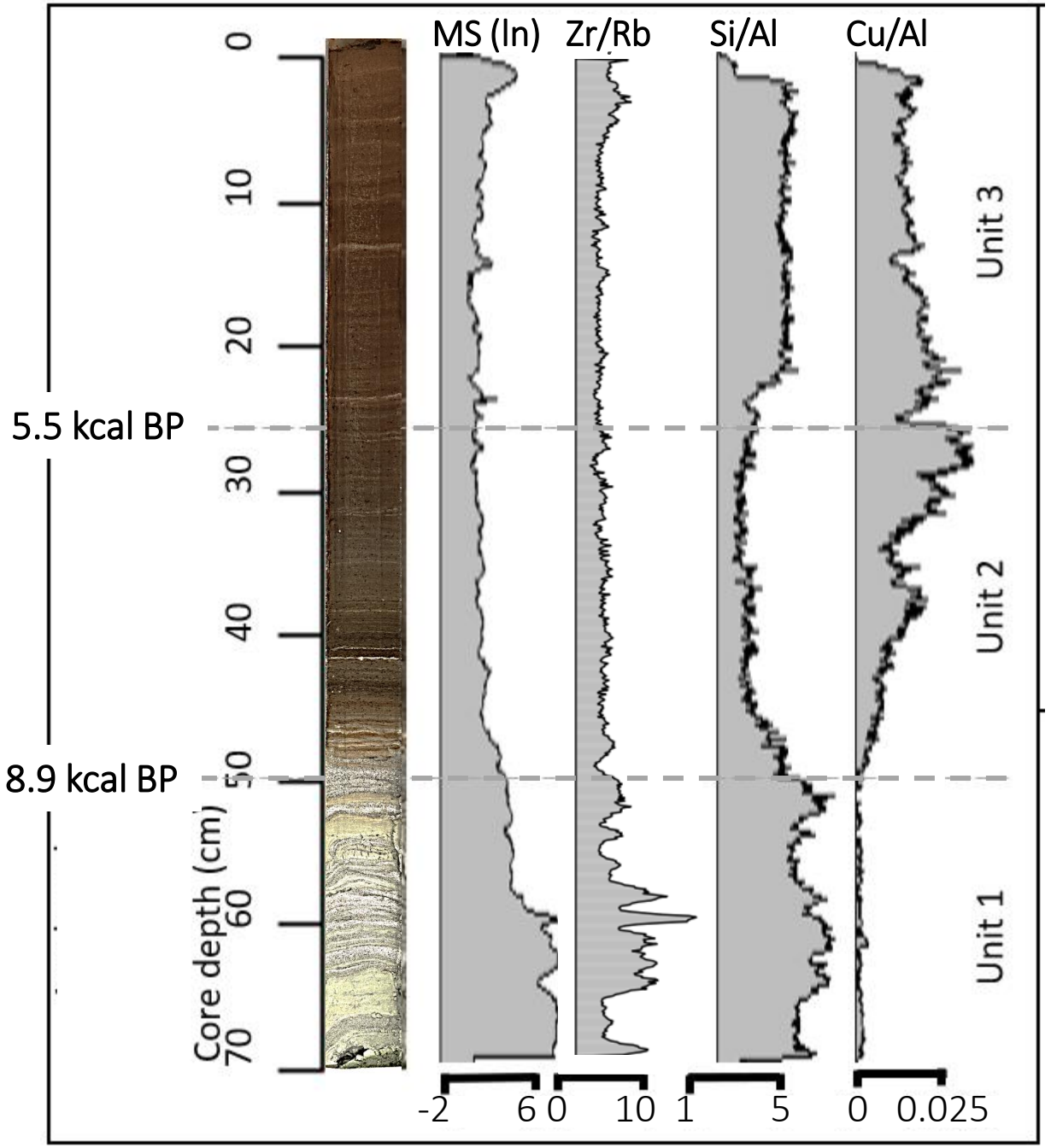


Arrowhead Lake sedimentology and geochemistry

Unit 3:
Increasing grain size, decreasing organics

Unit 2:
Decreased in grain size, increase in organic content

Unit 1:
Coarse grained terrigenous sediments



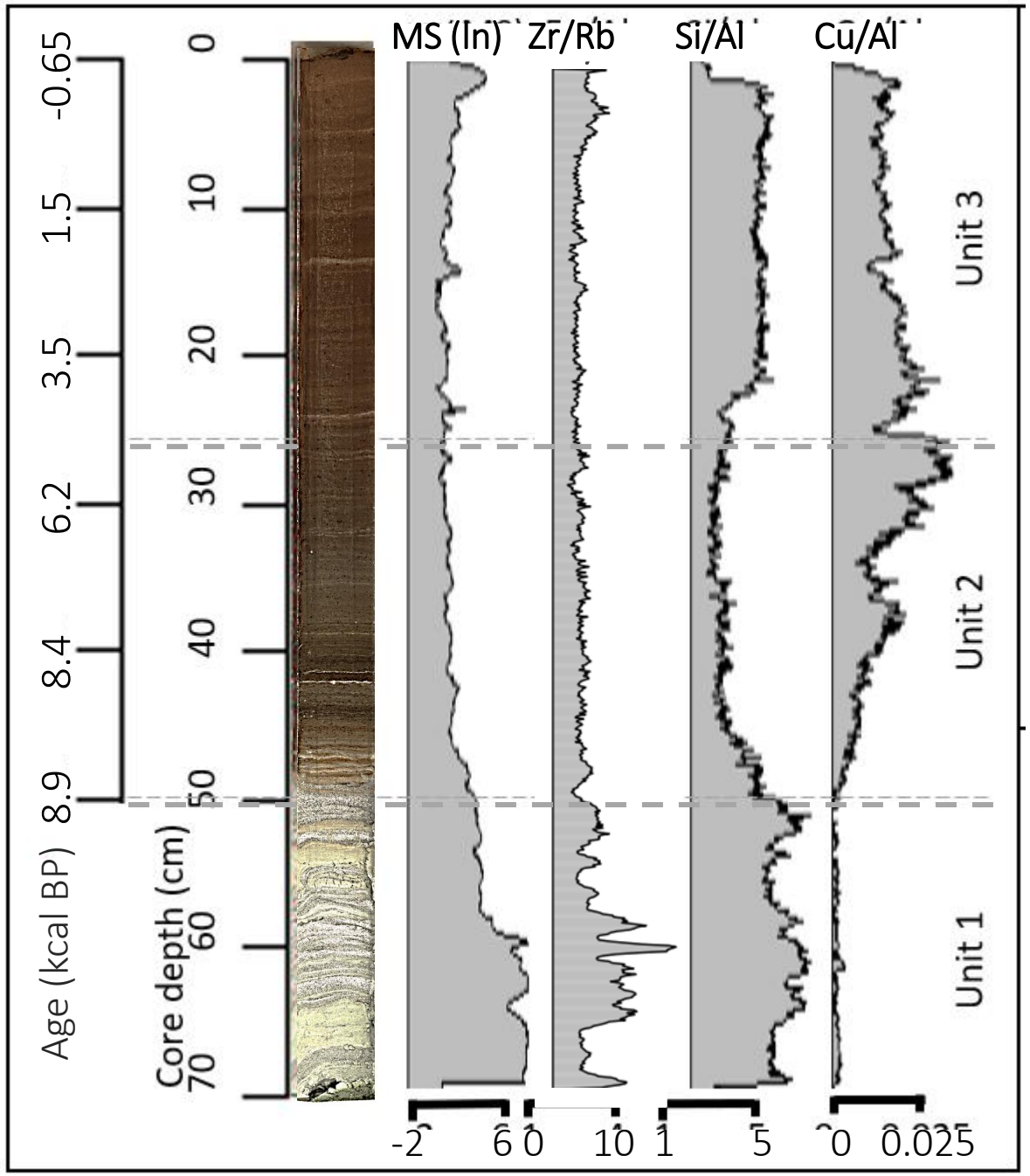
Arrowhead Lake sedimentology and geochemistry

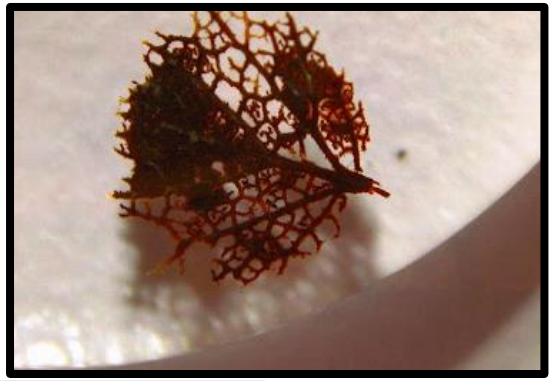
Unit 3:
Increasing grain size, decreasing organics

Unit 2:
Decreased in grain size, increase in organic content

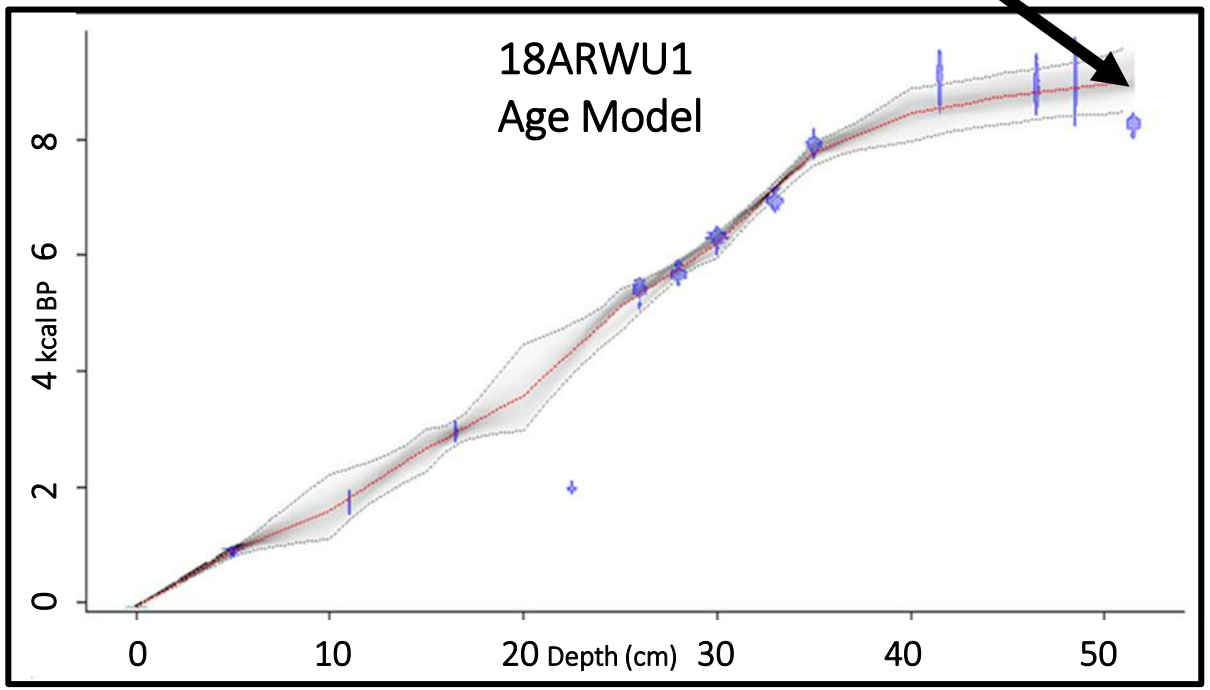
Unit 1:
Coarse grained terrigenous sediments

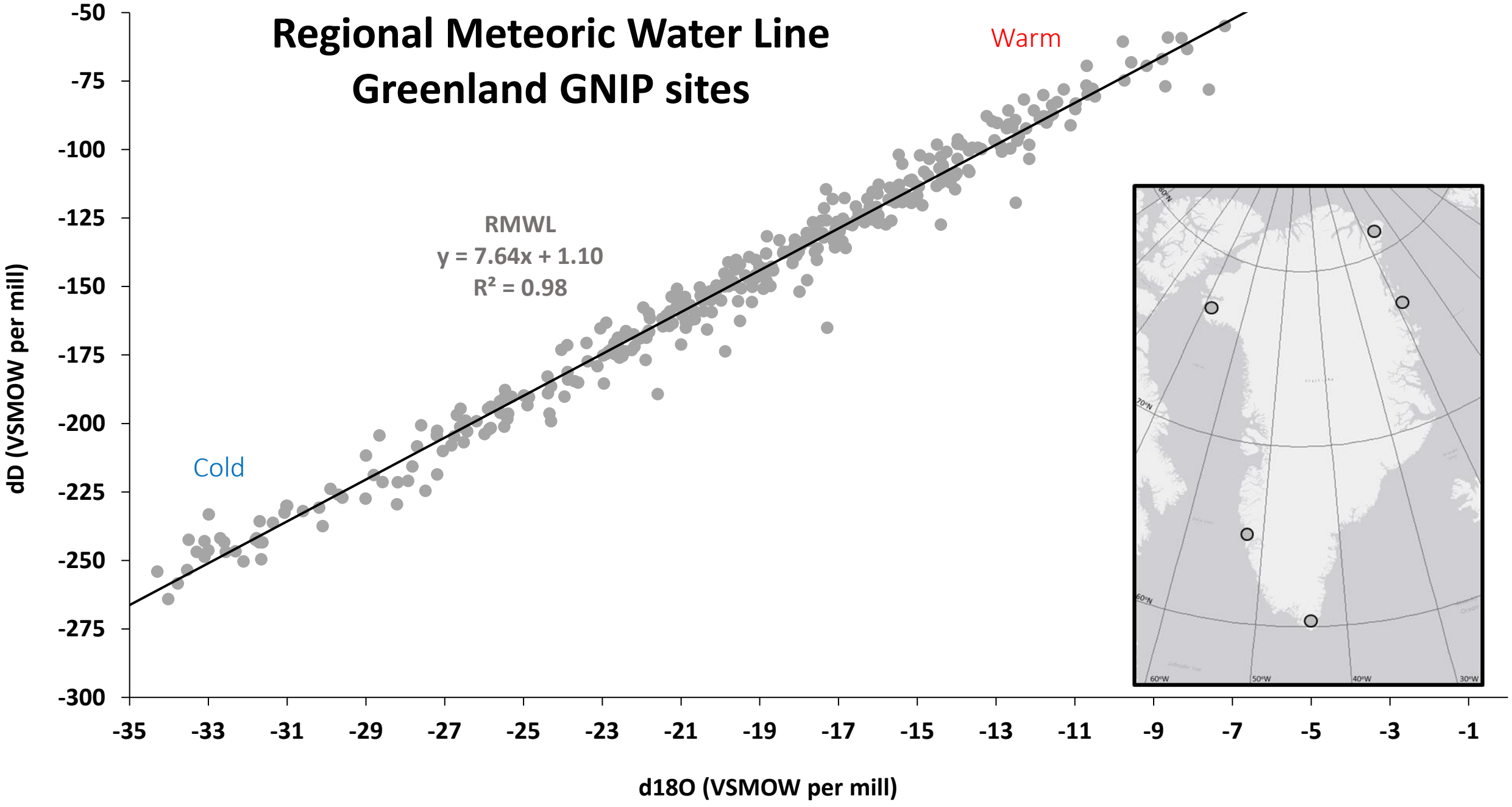
Age Model

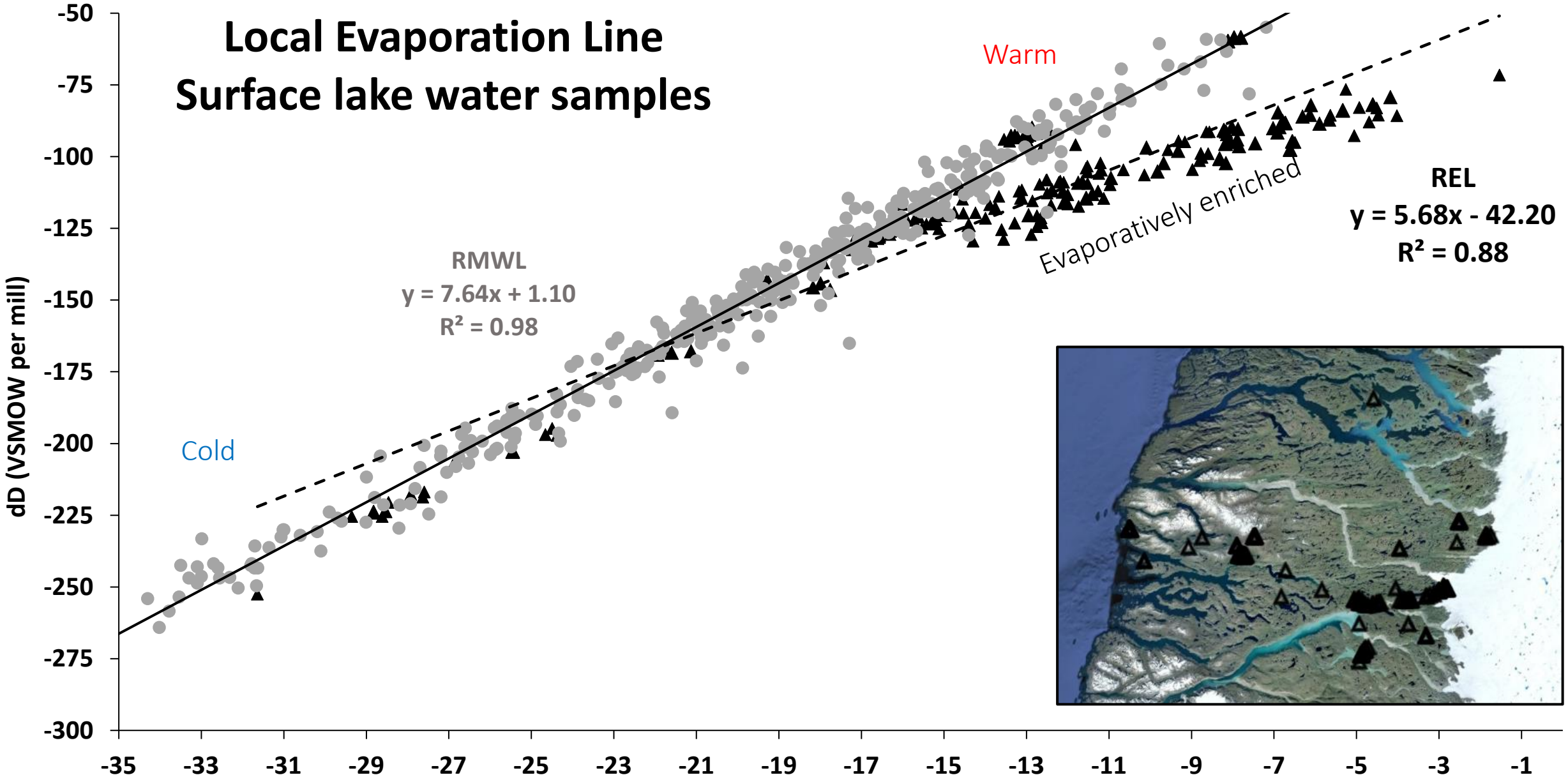




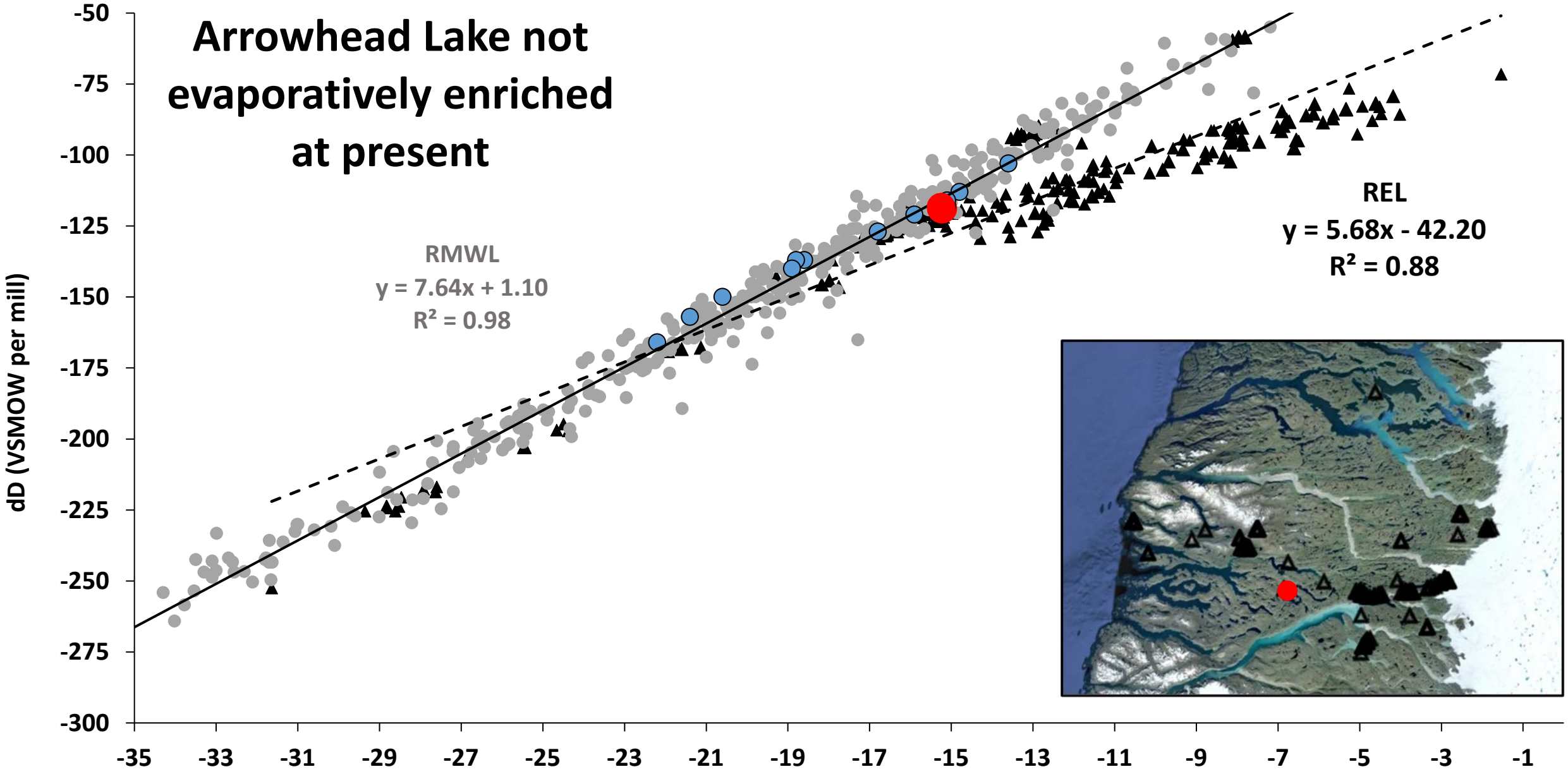
Local deglaciation ~9 kcal BP (Lecavalier et al. 2014)



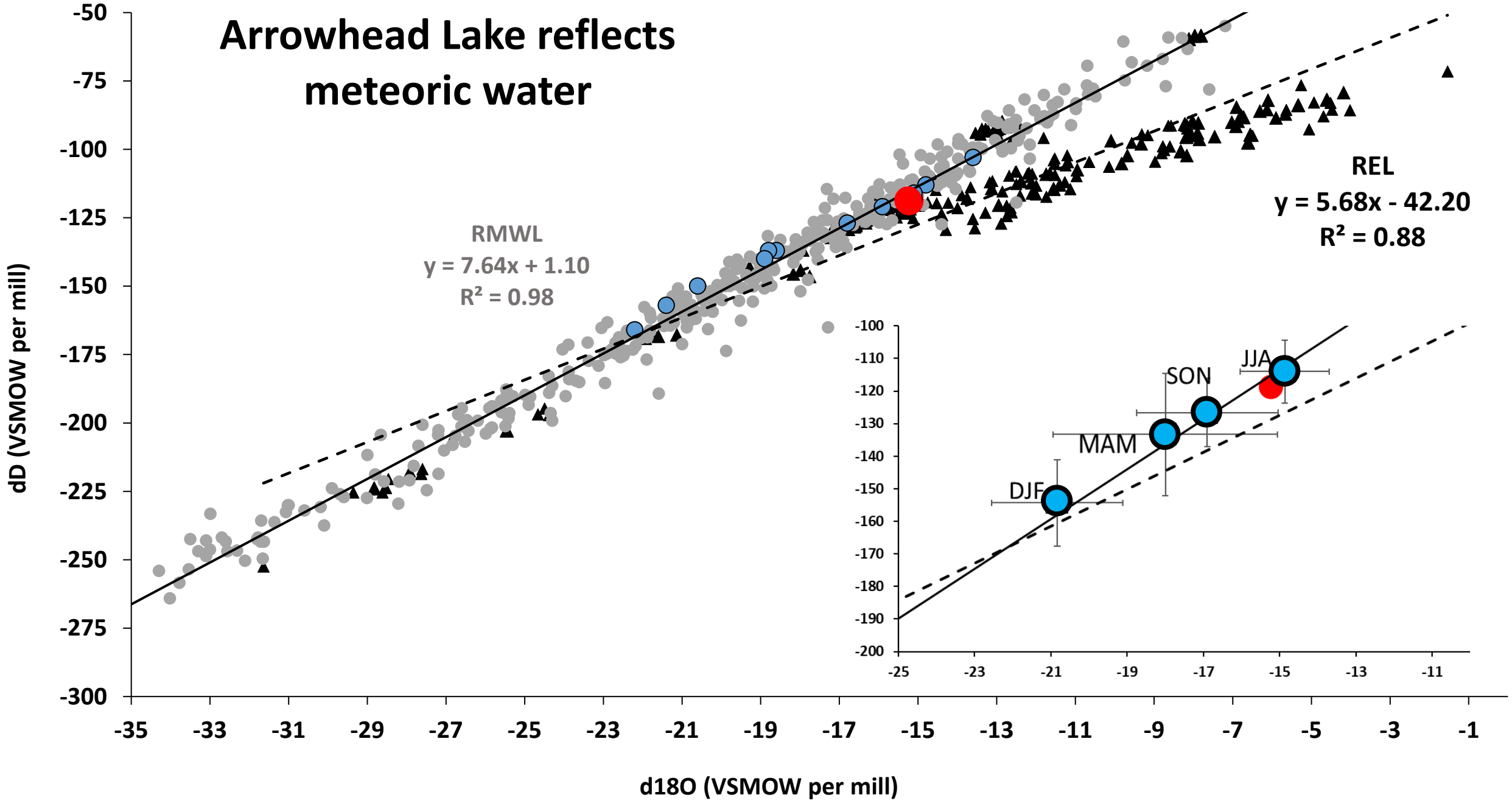

Regional Meteoric Water Line
Greenland GNIP sites
Warm
Cold
RMWL
y = 7.64x + 1.10
R² = 0.98
dD (VSMOW per mill)
d18O (VSMOW per mill)
-50
-75
-100
-125
-150
-175
-200
-225
-250
-275
-300
-35
-33
-31
-29
-27
-25
-23
-21
-19
-17
-15
-13
-11
-9
-7
-5
-3
-1
80°N
70°N
60°N
60°W
50°W
40°W
30°W



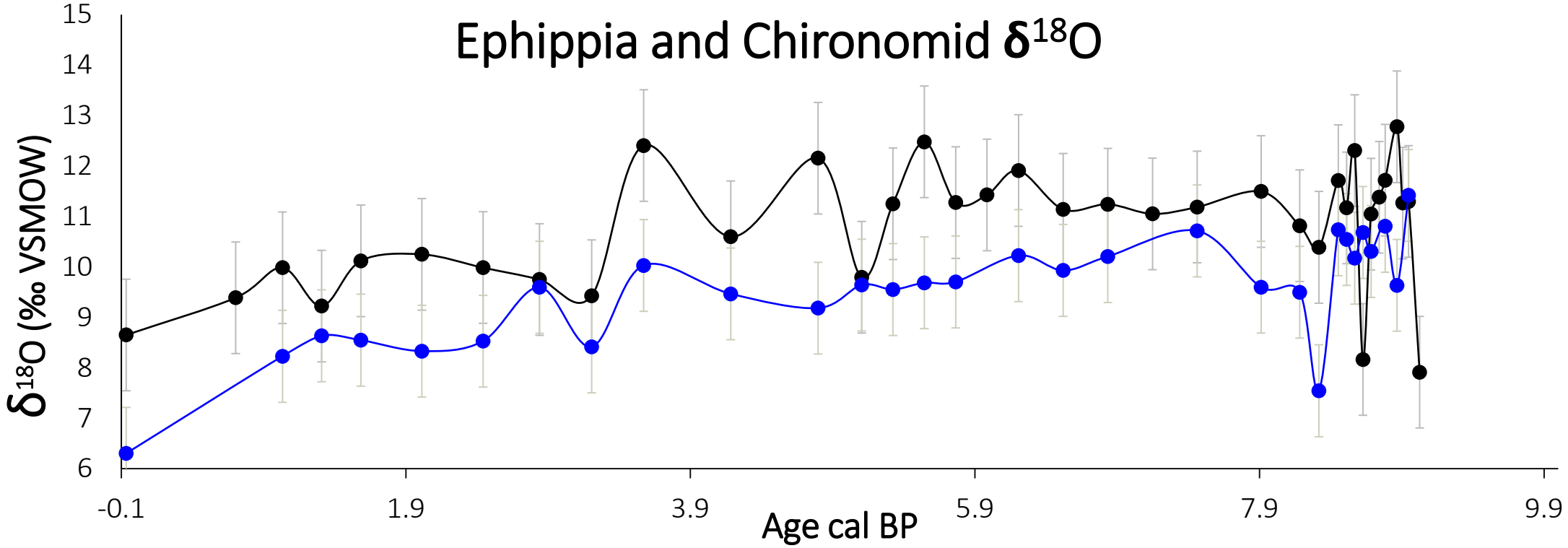
Modern water data from Cluett and Thomas 2020 and Axford Lab

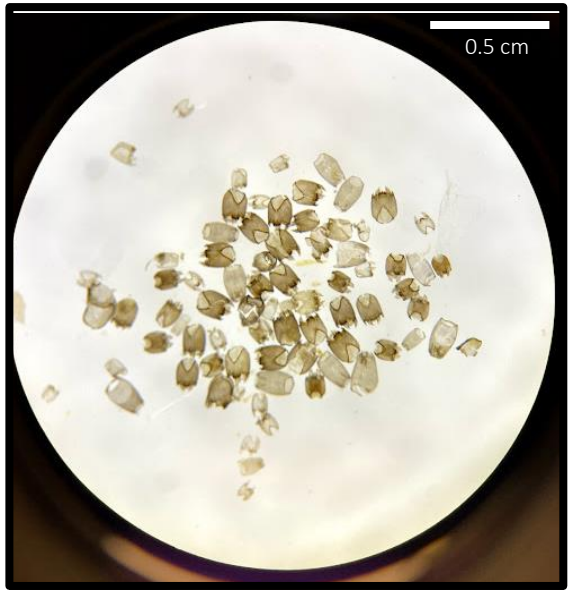


Modern water data from Cluett and Thomas, 2020 and Axford lab

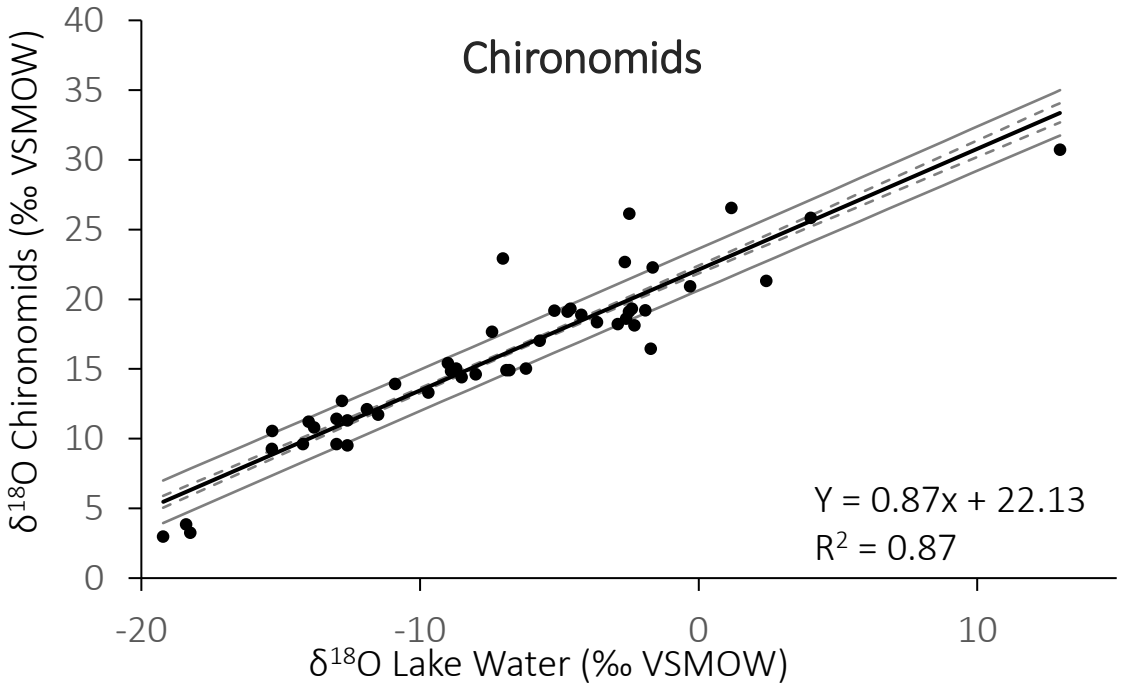

Arrowhead Lake reflects meteoric water
RMWL
y = 7.64x + 1.10
R² = 0.98
REL
y = 5.68x - 42.20
R² = 0.88
DJF
MAM
SON
JJA
dD (VSMOW per mill)
d18O (VSMOW per mill)
-50
-75
-100
-125
-150
-175
-200
-225
-250
-275
-300
-35
-33
-31
-29
-27
-25
-23
-21
-19
-17
-15
-13
-11
-9
-7
-5
-3
-1
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-25
-23
-21
-19
-17
-15
-13
-11

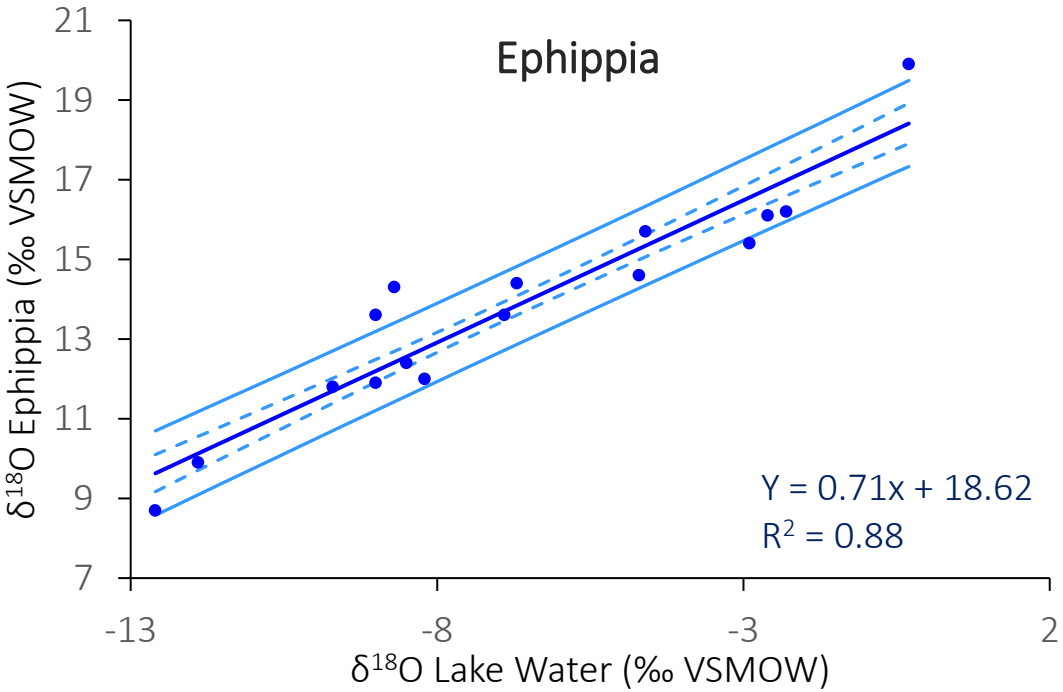
Ephippia and Chironomid $\delta^{18}O$

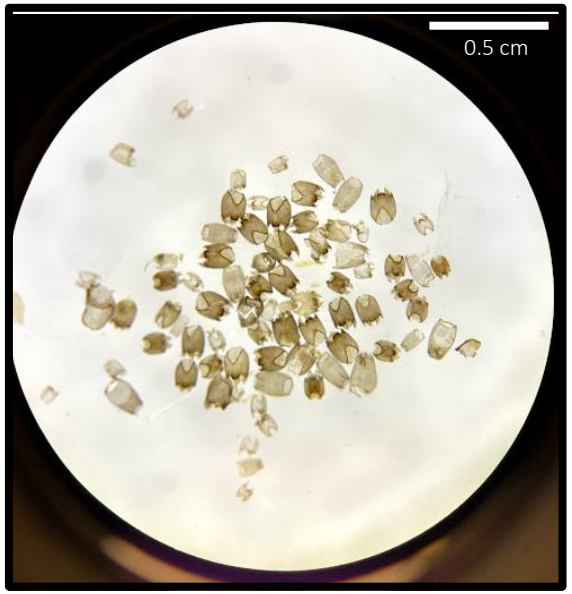




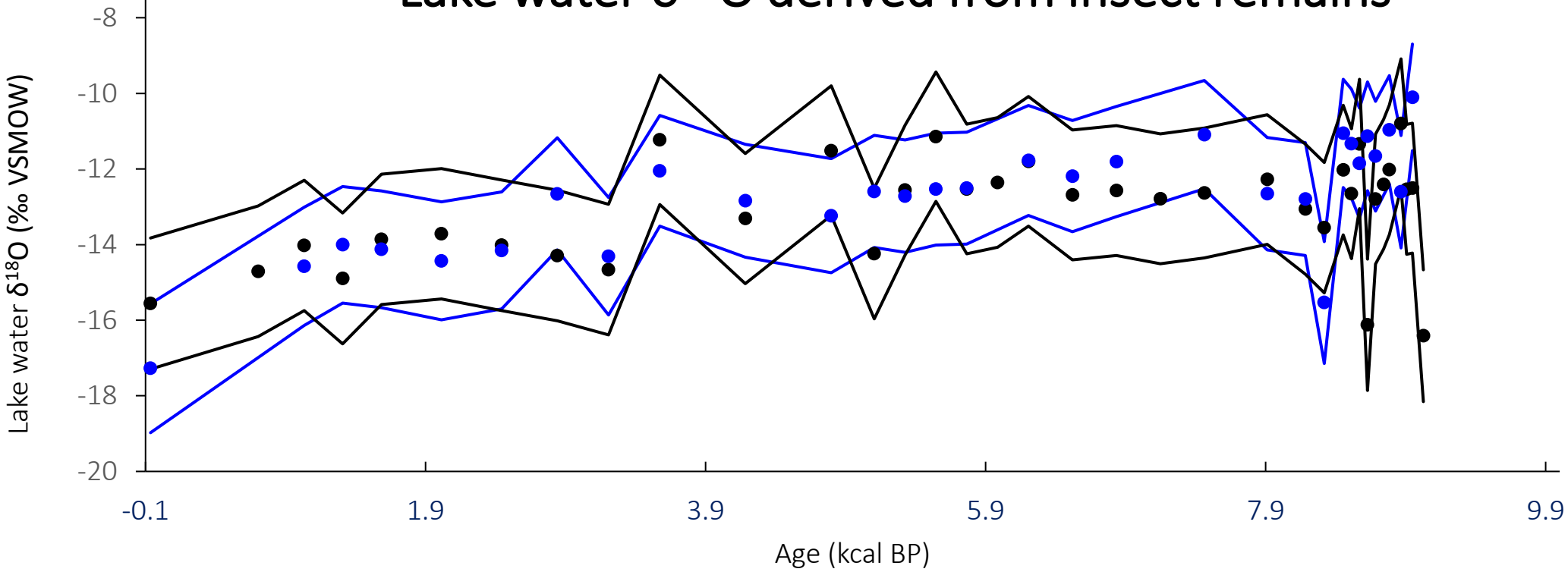
$\delta^{18}O$ conversion to lake water

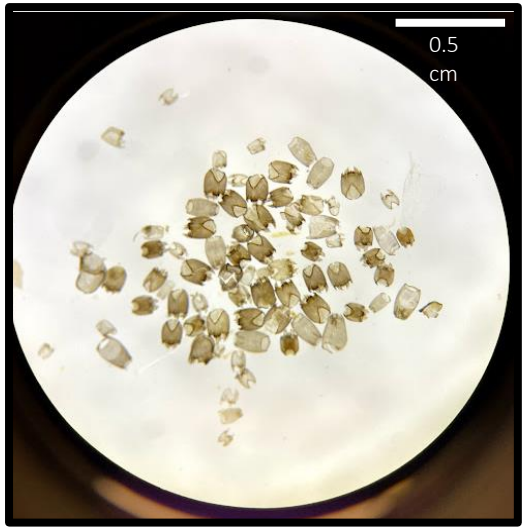




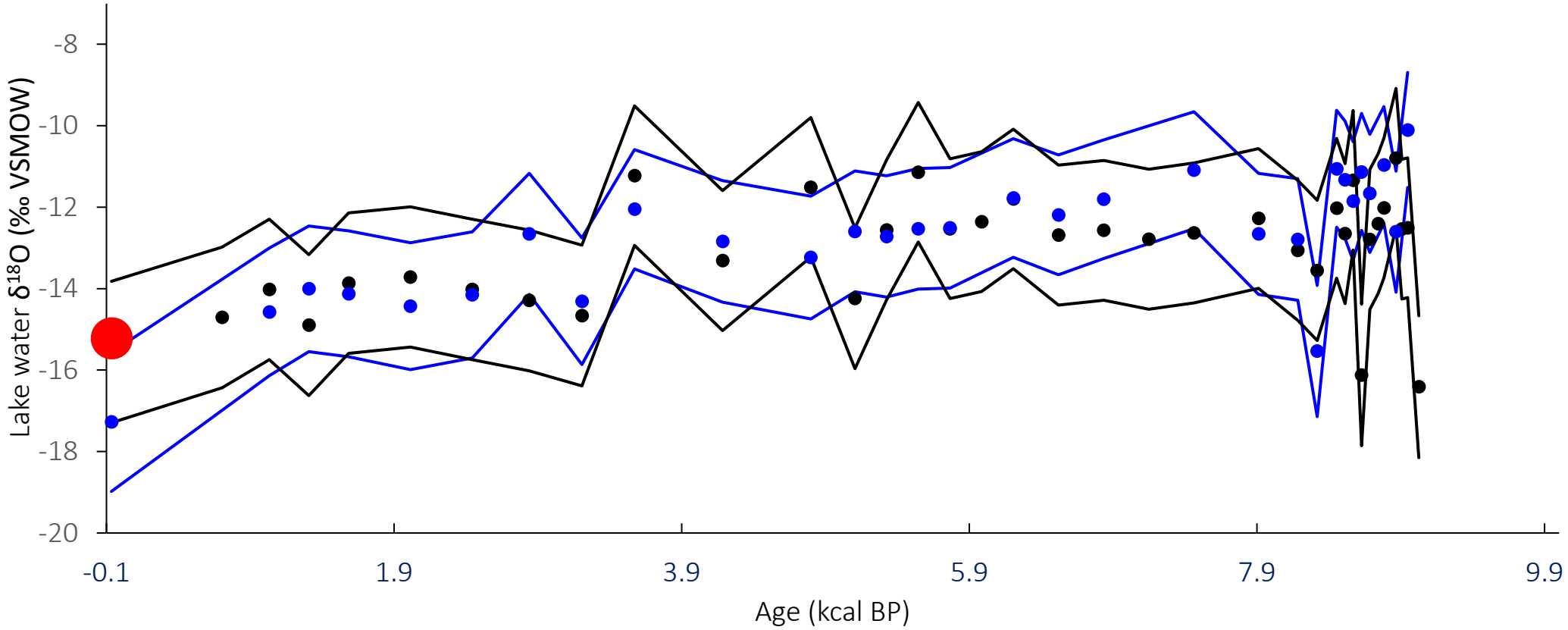


Lake water $\delta^{18}O$ derived from insect remains

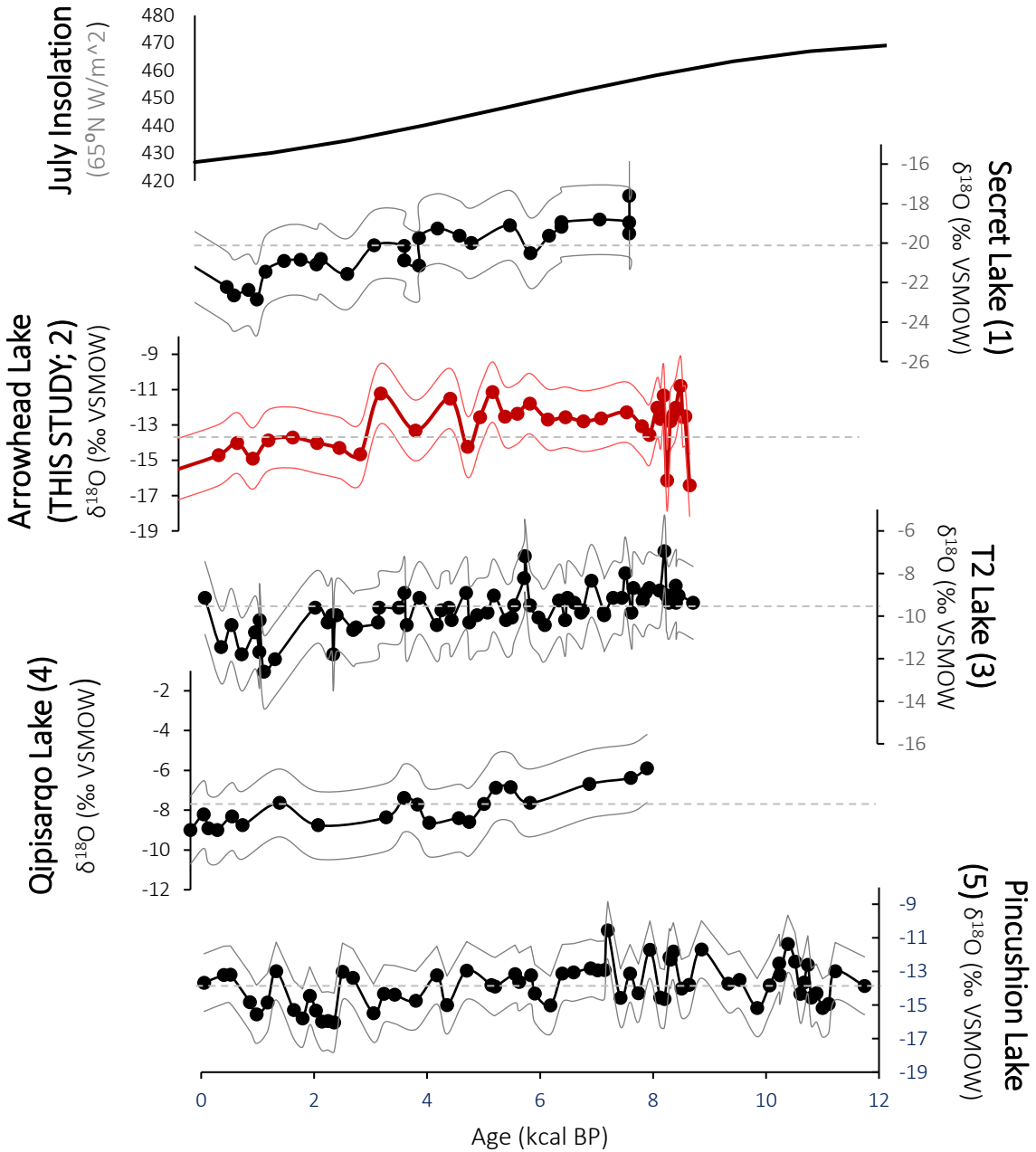


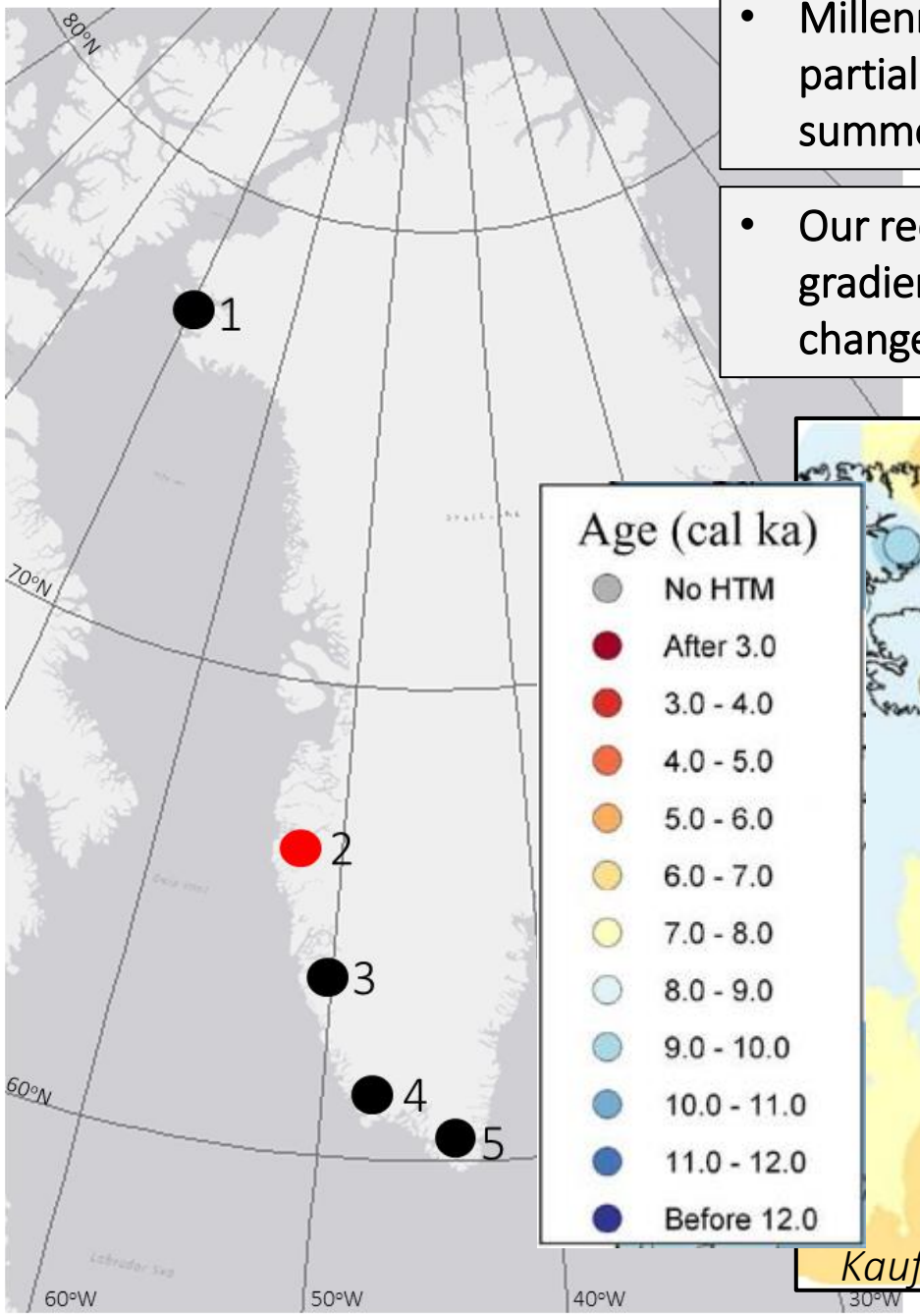


Modern lake water $\delta^{18}O$ correlates with adjusted $\delta^{18}O$ from top chironomid sample

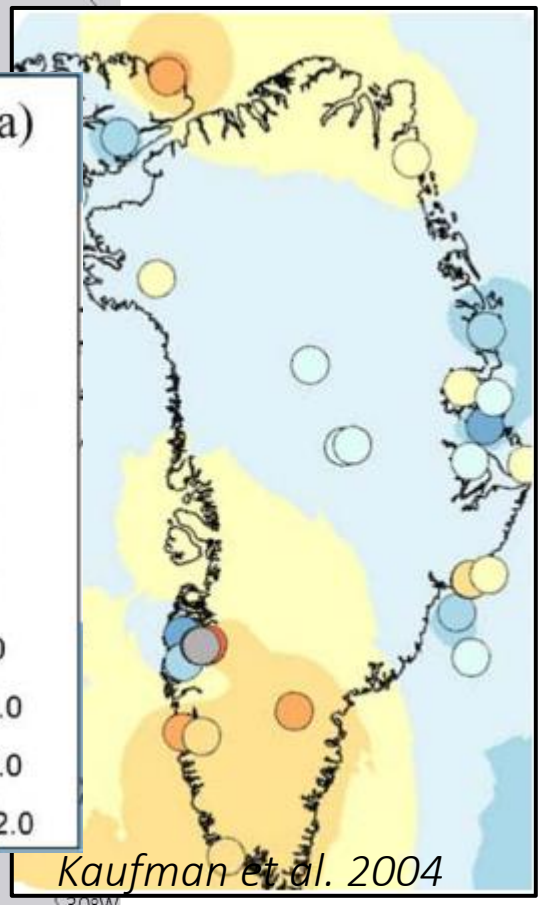


Regional comparison



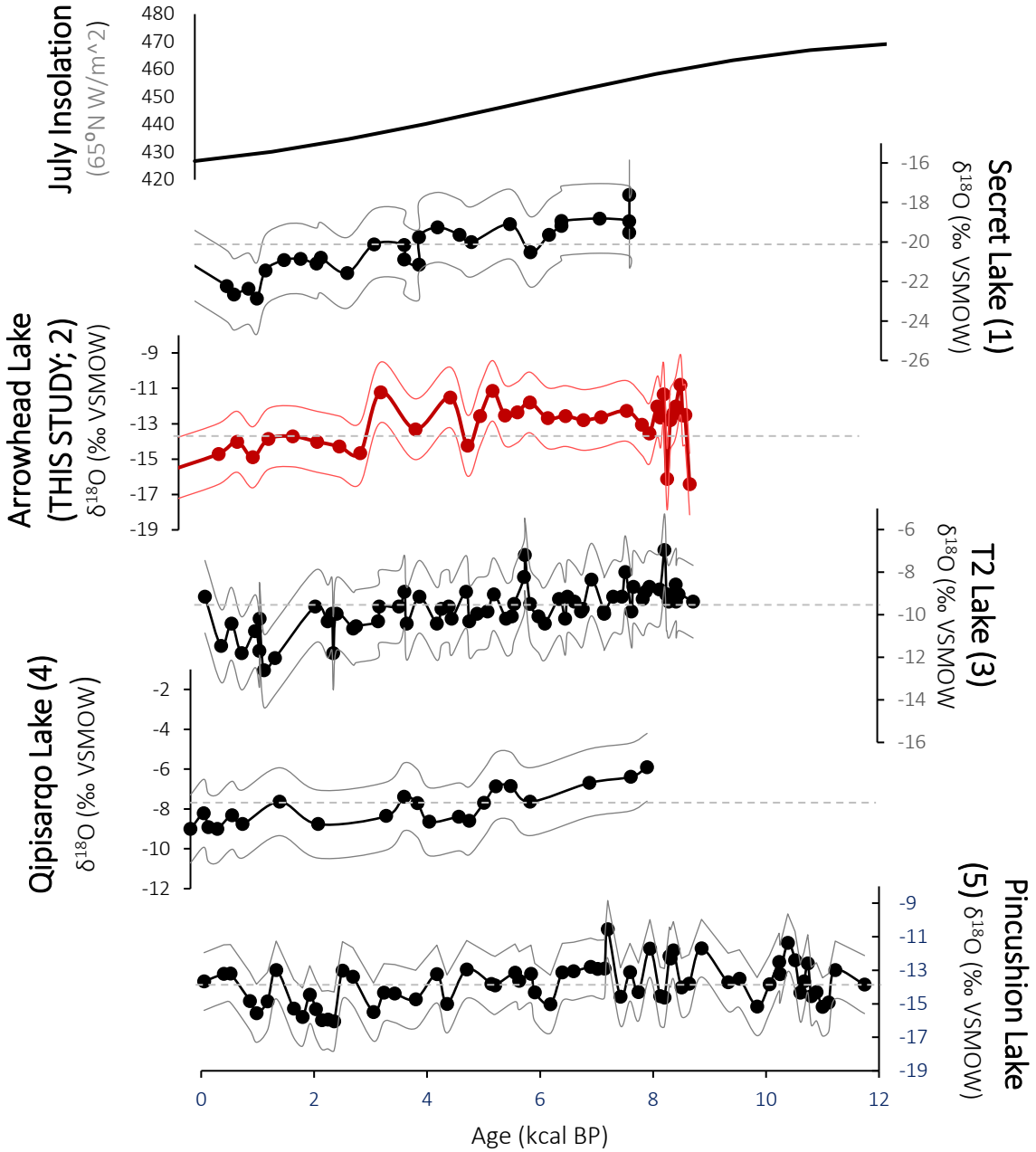


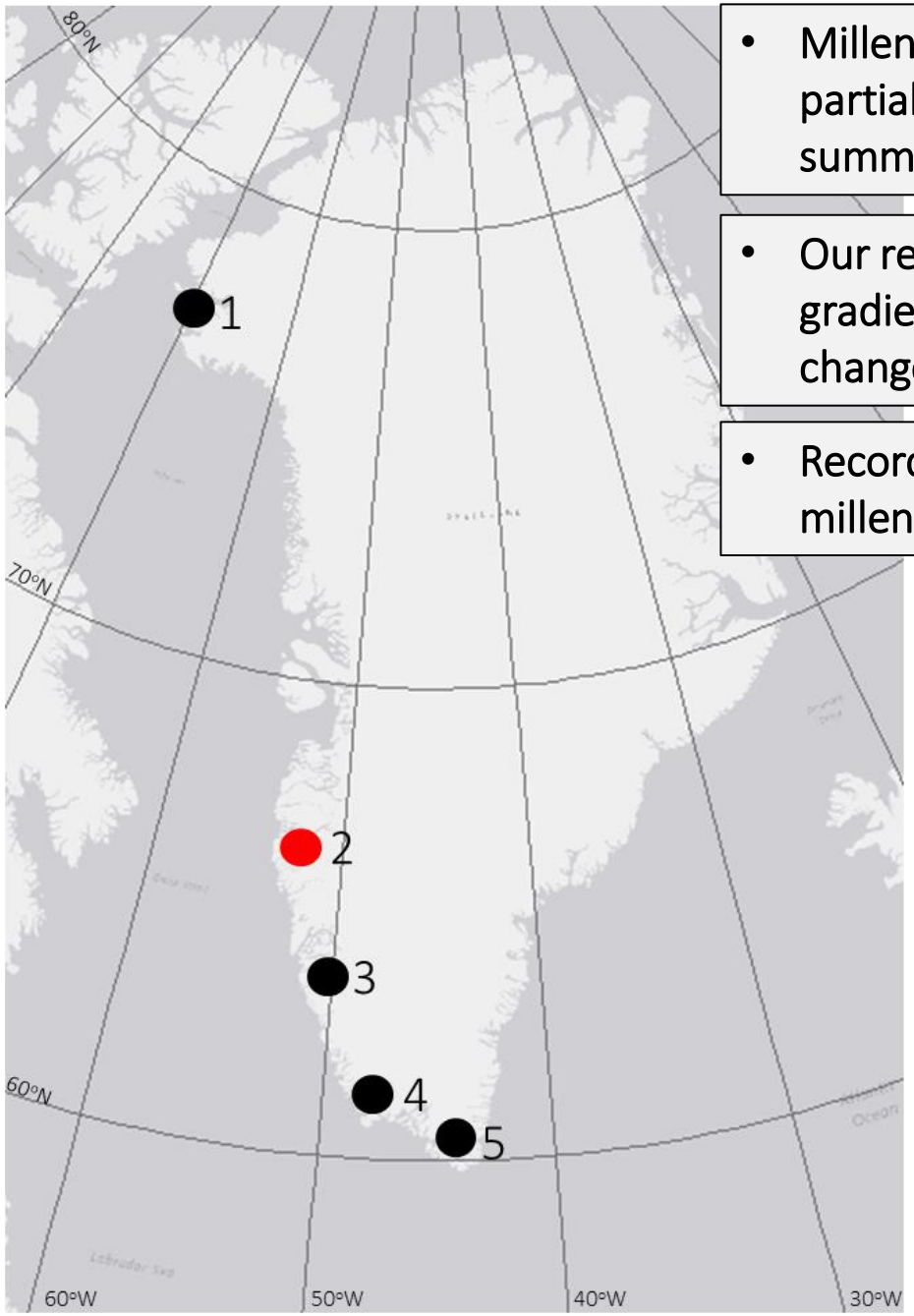
- Millennial scale climate partially driven by summer insolation
- Our record supports N-S gradient in magnitude change



Kaufman et al. 2004

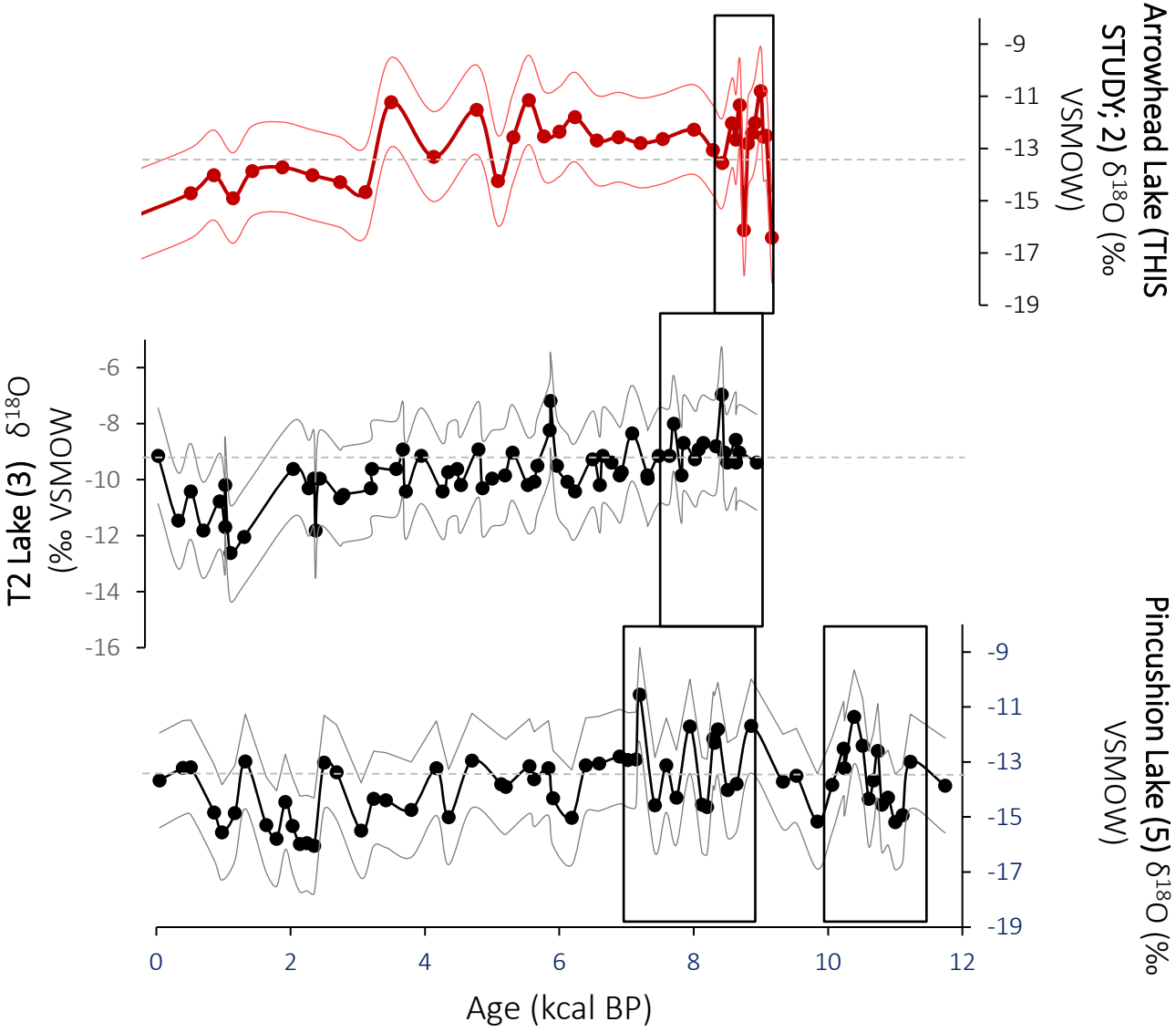
Regional comparison

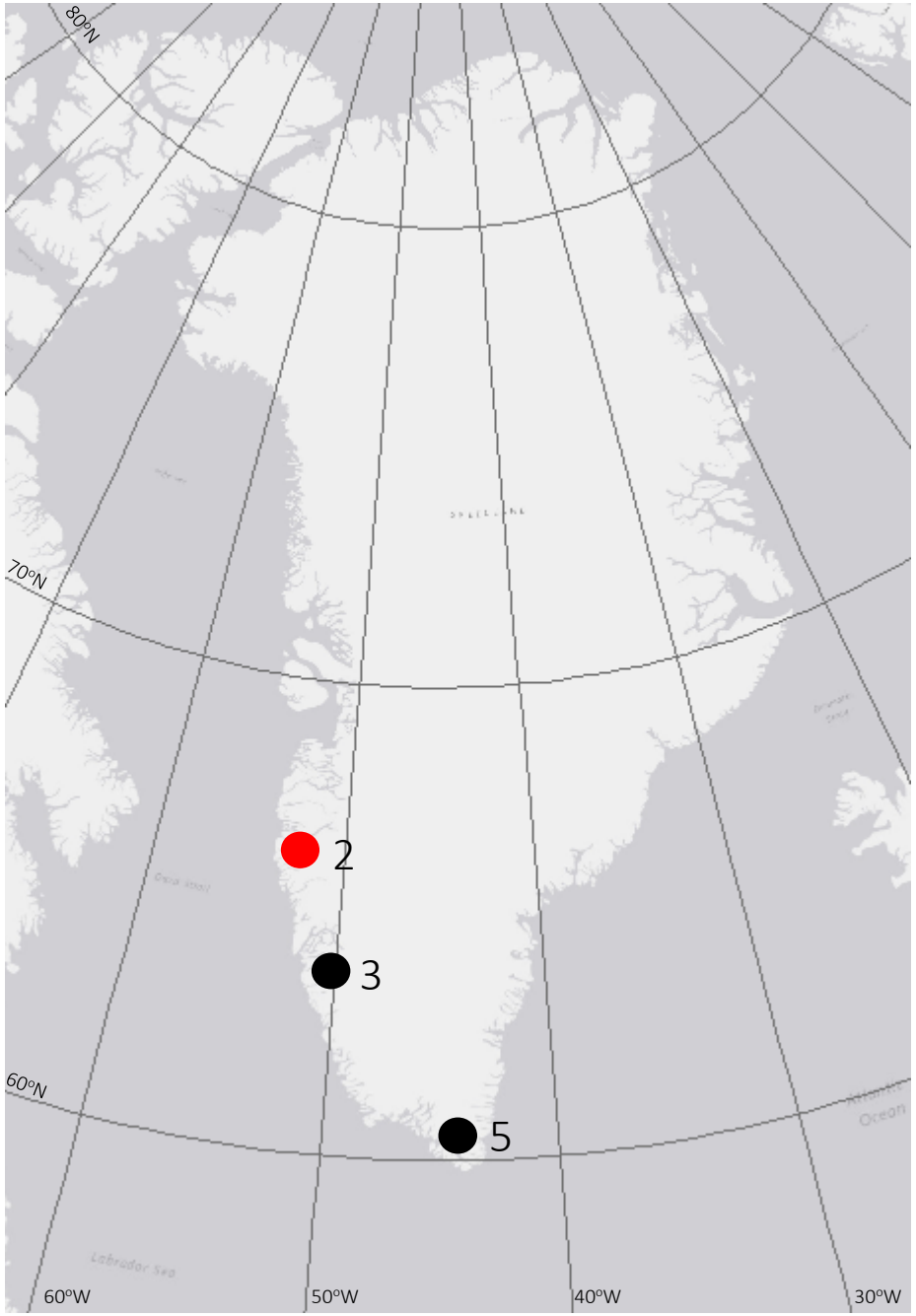




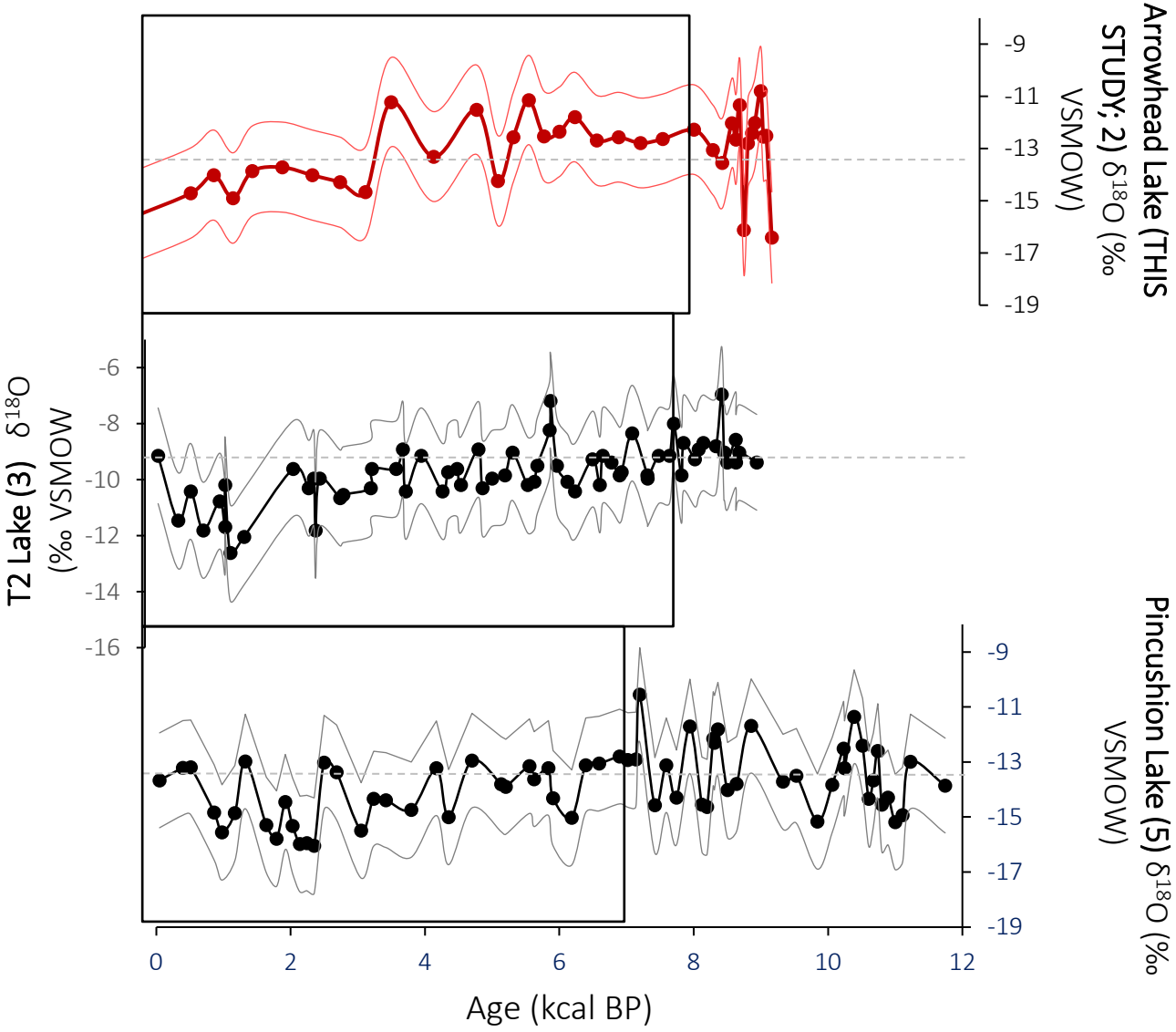
- Millennial scale climate partially driven by summer insolation
- Our record supports N-S gradient in magnitude change
- Records capture sub-millennial scale variability

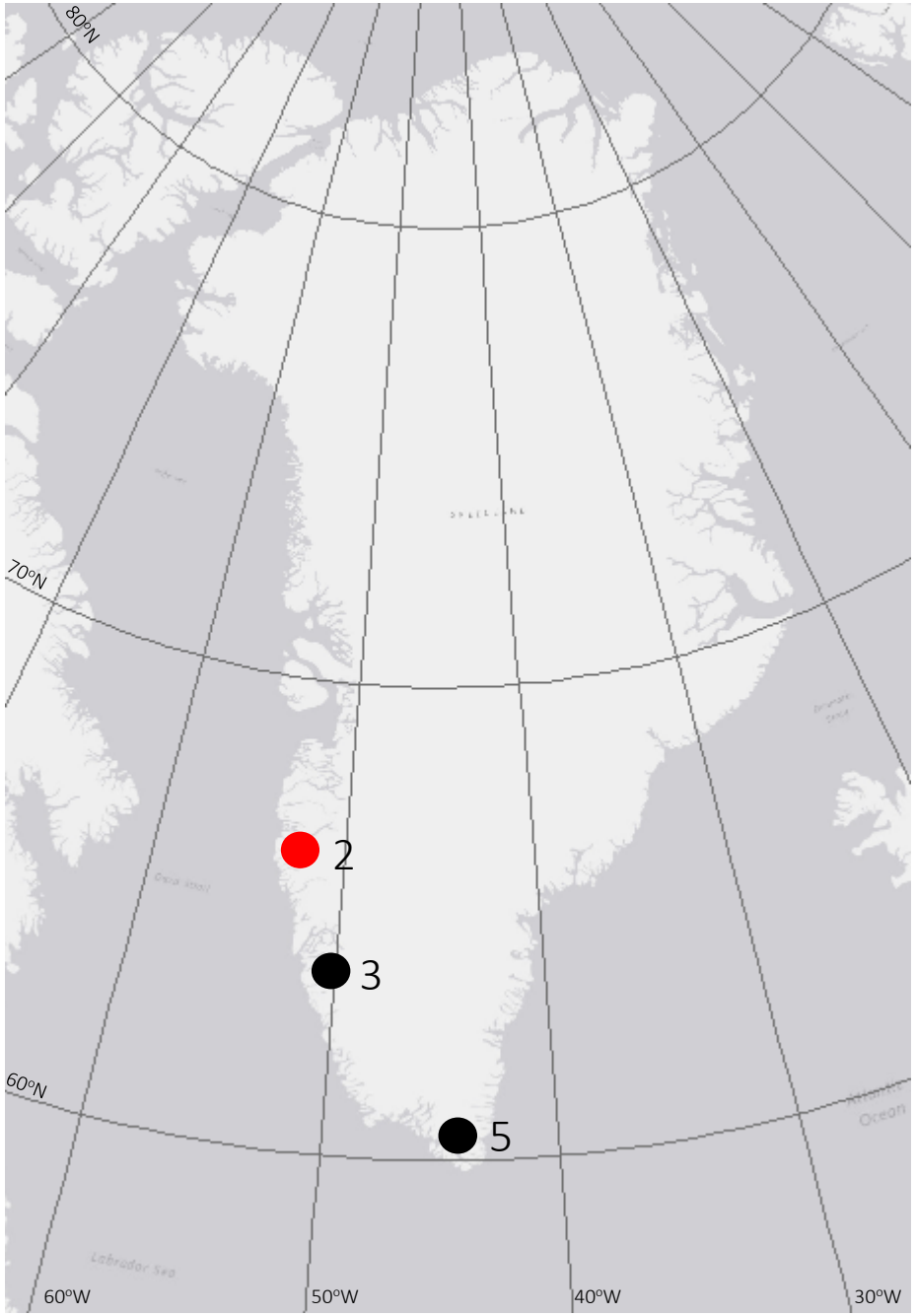
Records capture sub-millennial scale variability



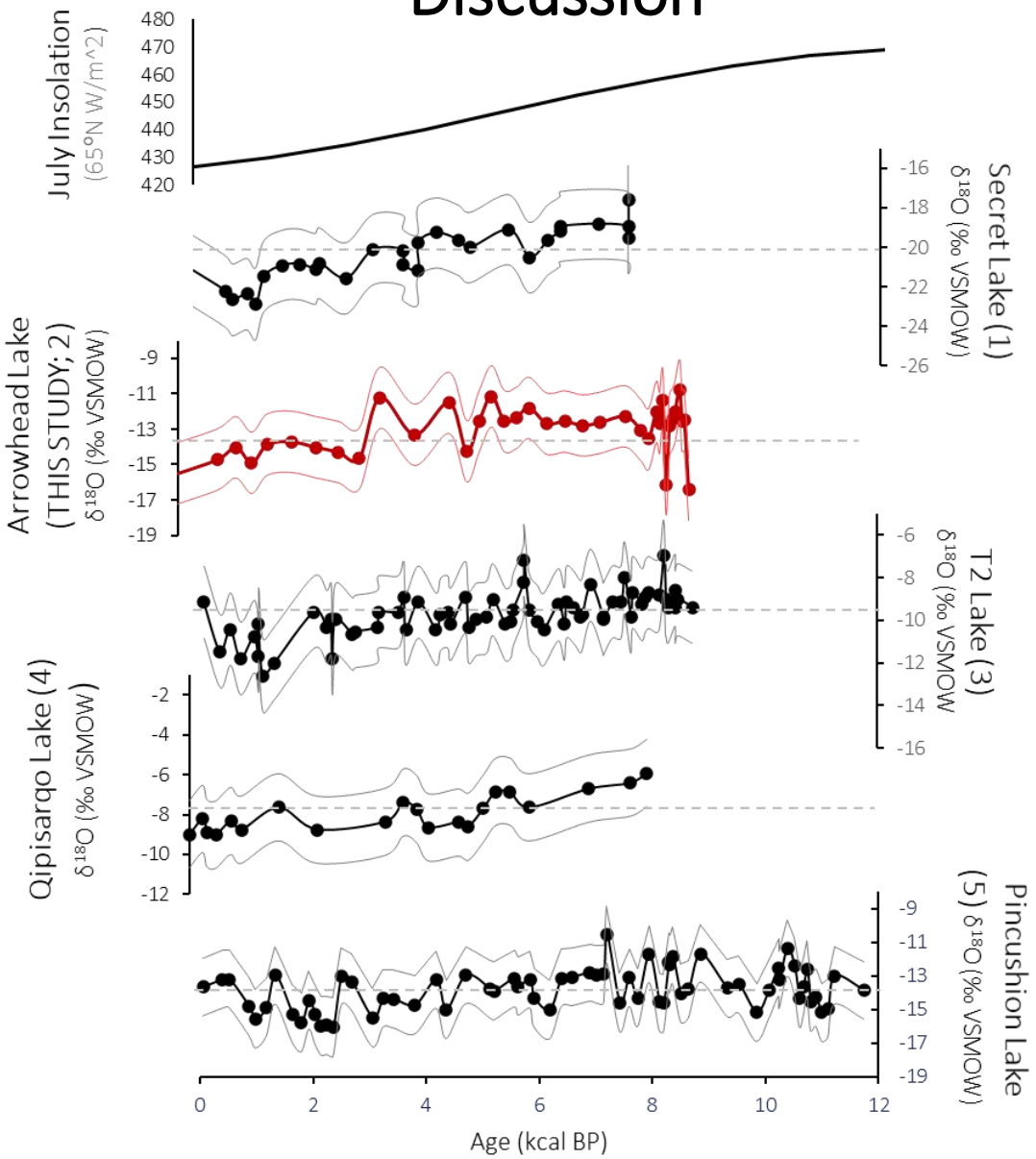


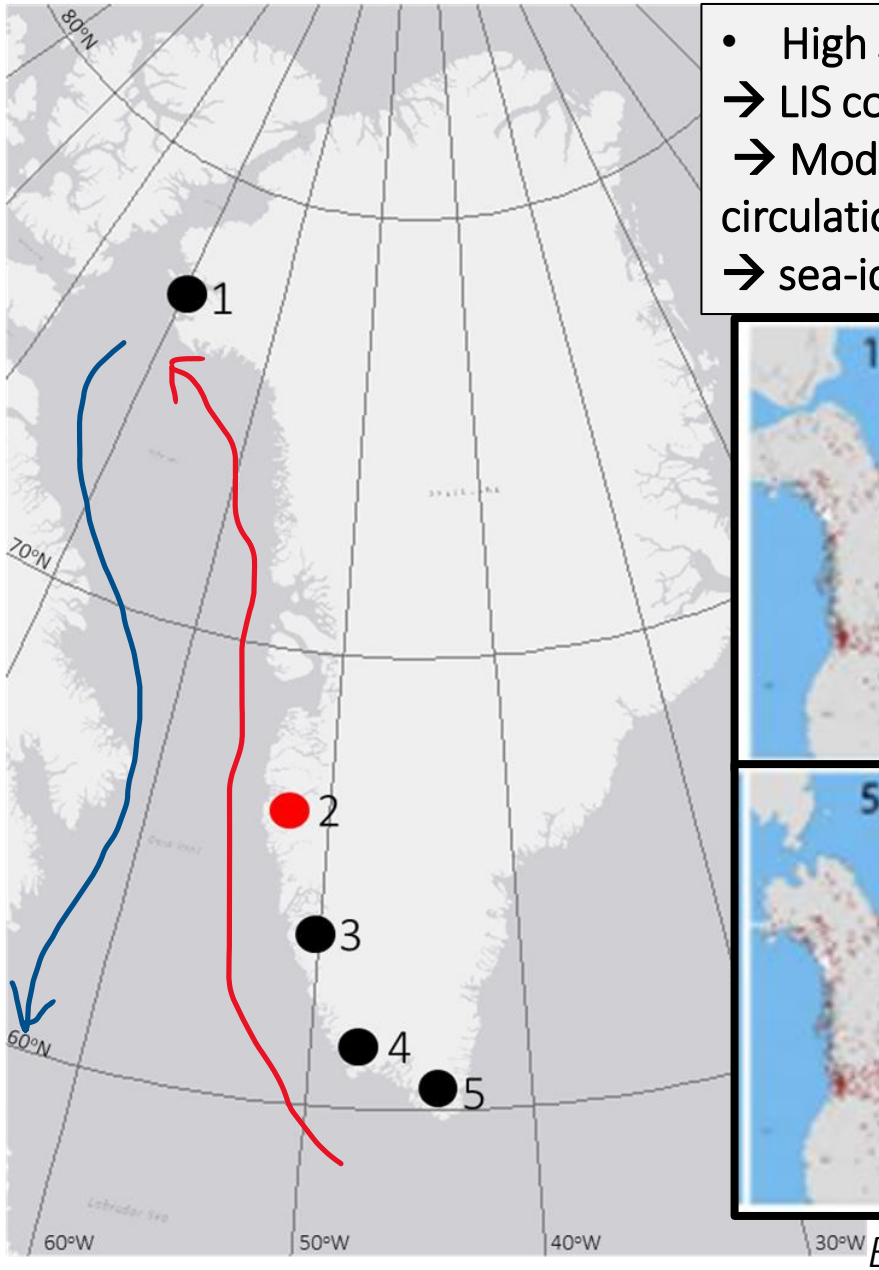
Records capture sub-millennial scale variability



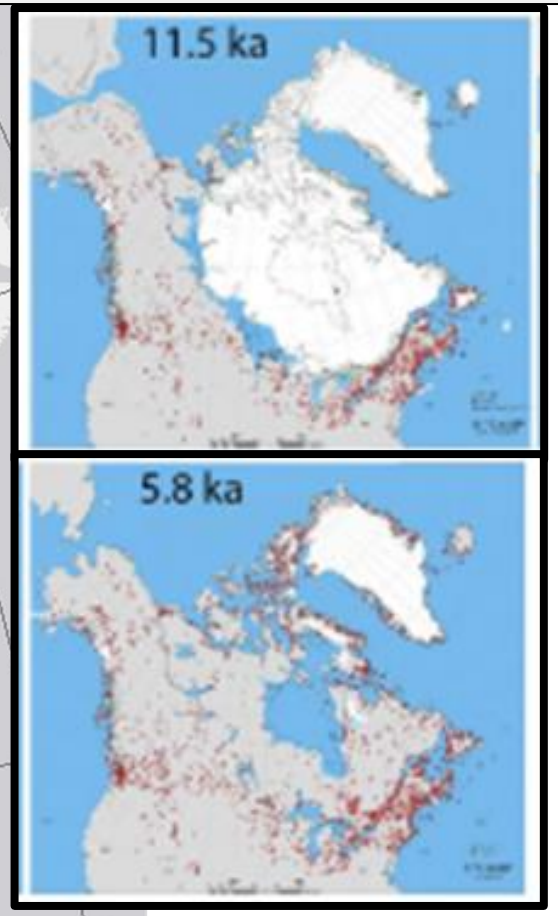


Discussion



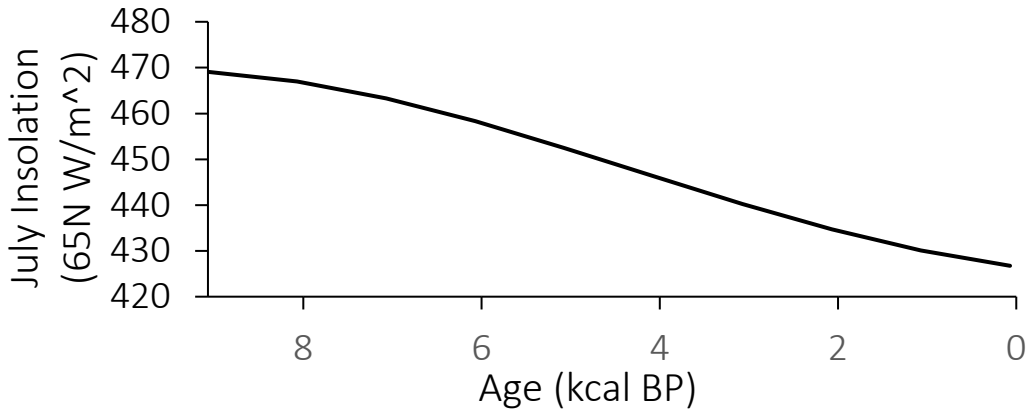


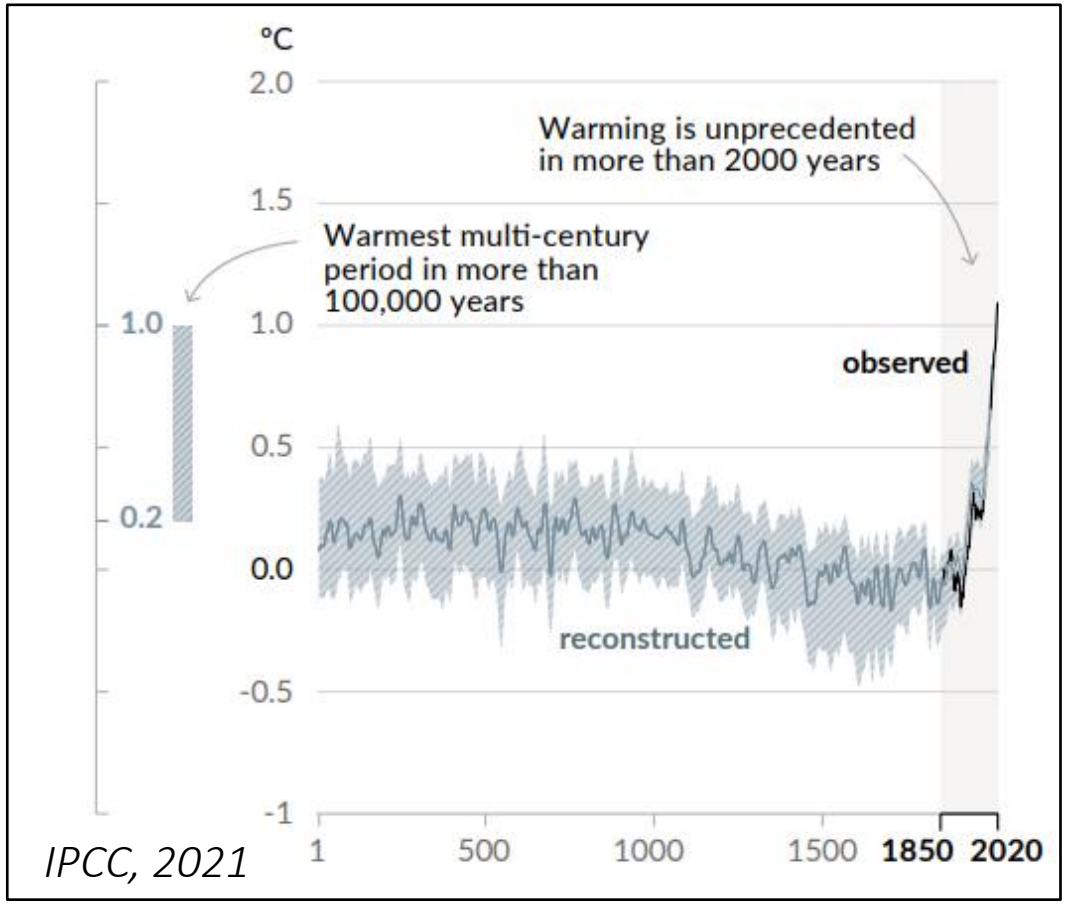
- High summer insolation
→ LIS collapse
→ Modified ocean circulation
→ sea-ice variability



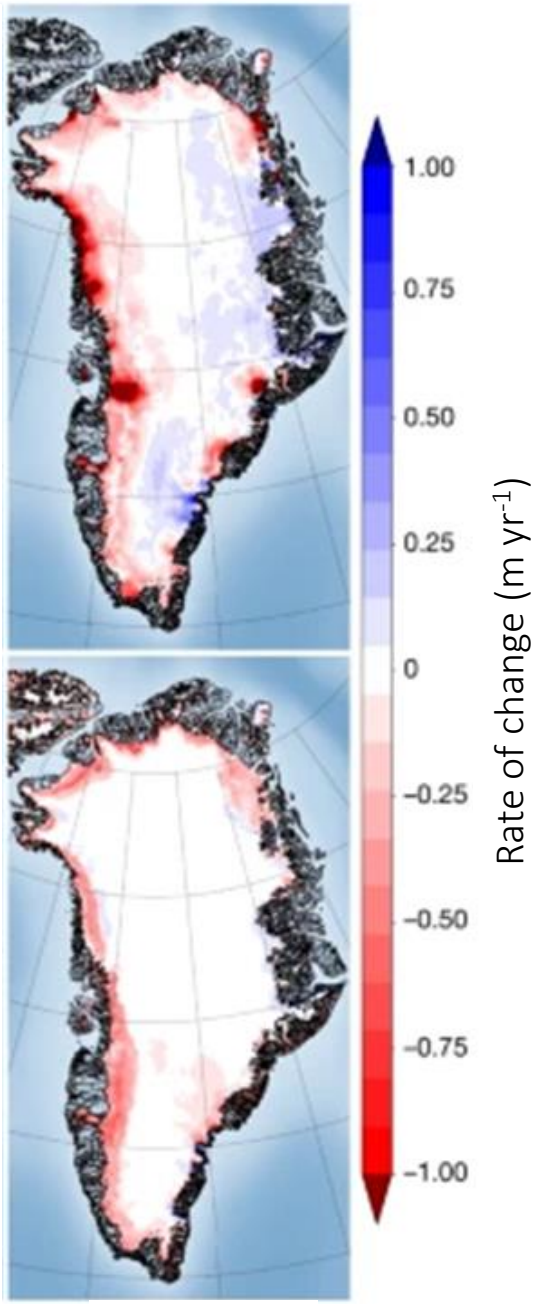
Briner et al. 2016

Discussion





IPCC, 2021



2012-2017

Shepherd et al. 2020

- Millennial scale climate partially driven by summer insolation
- Our record supports N-S gradient in magnitude change
- Records capture sub-millennial scale variability
- High summer insolation
  → LIS collapse
  → Modified ocean circulation
  → sea-ice variability
  → Late Holocene = insolation
- System state change effect on GRIS today

Conclusions

- These chitin-based reconstructions are interpreted to reflect past meteoric water
- Regional records show N-S gradient in magnitude of $\delta^{18}O$ change
- High resolution $\delta^{18}O$ records show variability in the climate system likely related to sea-ice and ocean circulation