South Dome: A new Greenland ice core

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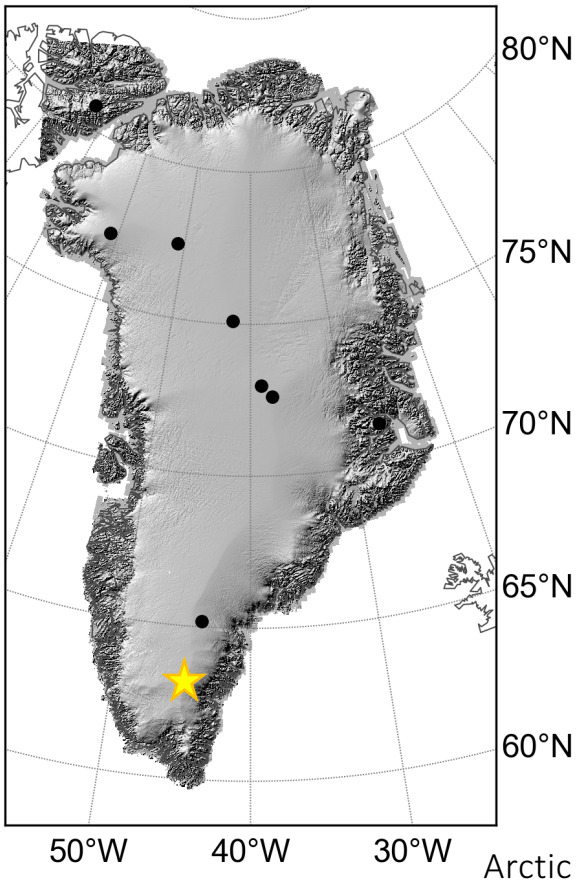
Ice Core Working Group

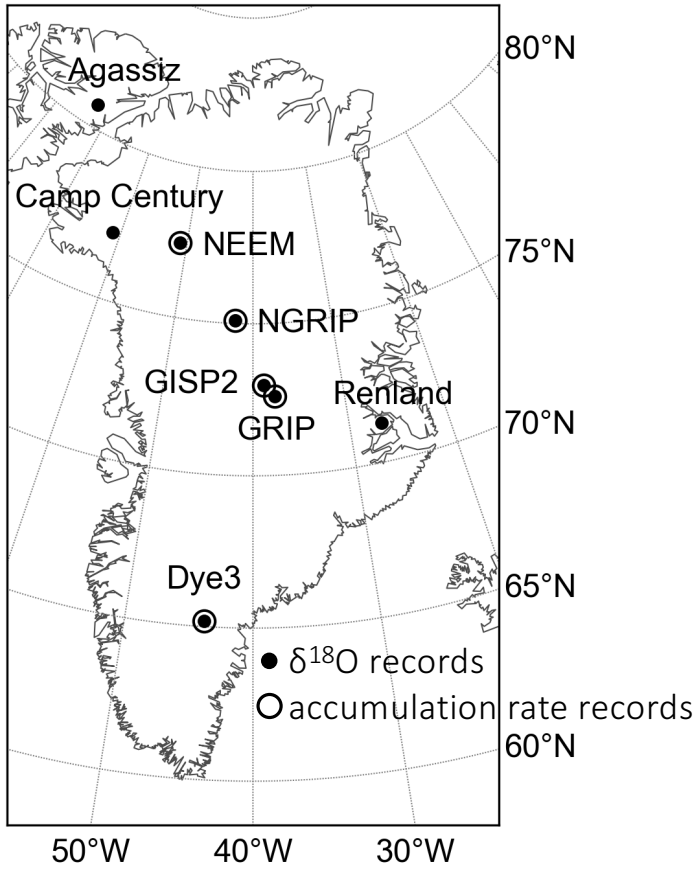
Meeting 2020



Arctic DEM, PGC

Greenland Science Questions

- What was southern Greenland climate from the last glacial to the present?
- Were past, abrupt climate changes larger in southern or northern Greenland?
- Does a southern dome survive even when most of the Greenland Ice Sheet disappears?

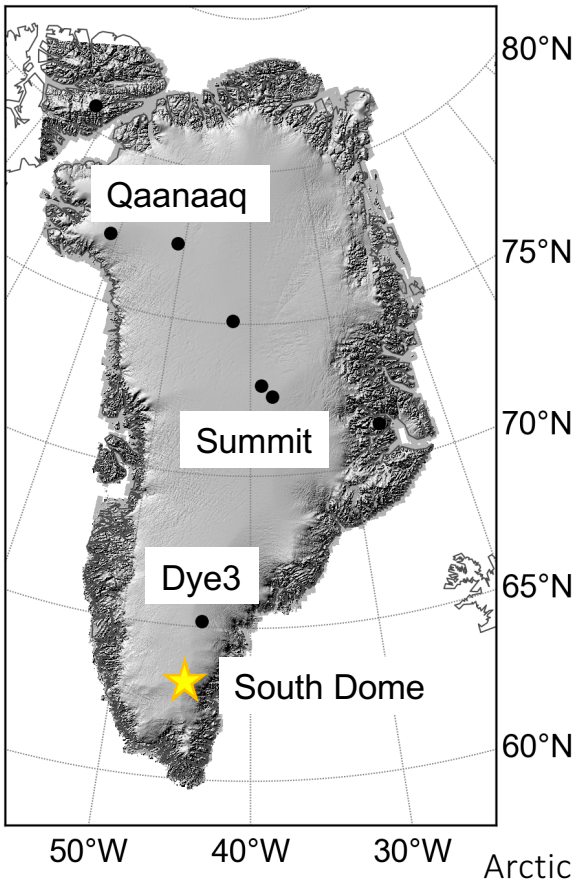


Takeaway Points

1. A southern Greenland ice core is required to learn about southern Greenland climate

2. Dye3 is an old core with low-resolution records

3. South Dome would likely yield high-quality climate records for the last ~60,000 years

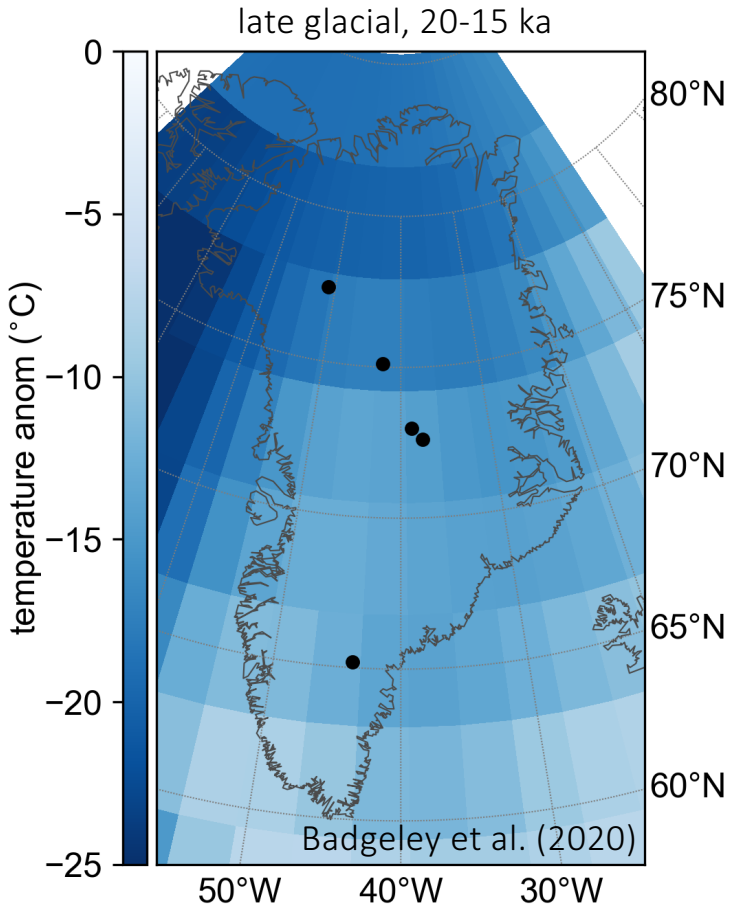


Arctic DEM, PGC

Reconstructing climate using data assimilation

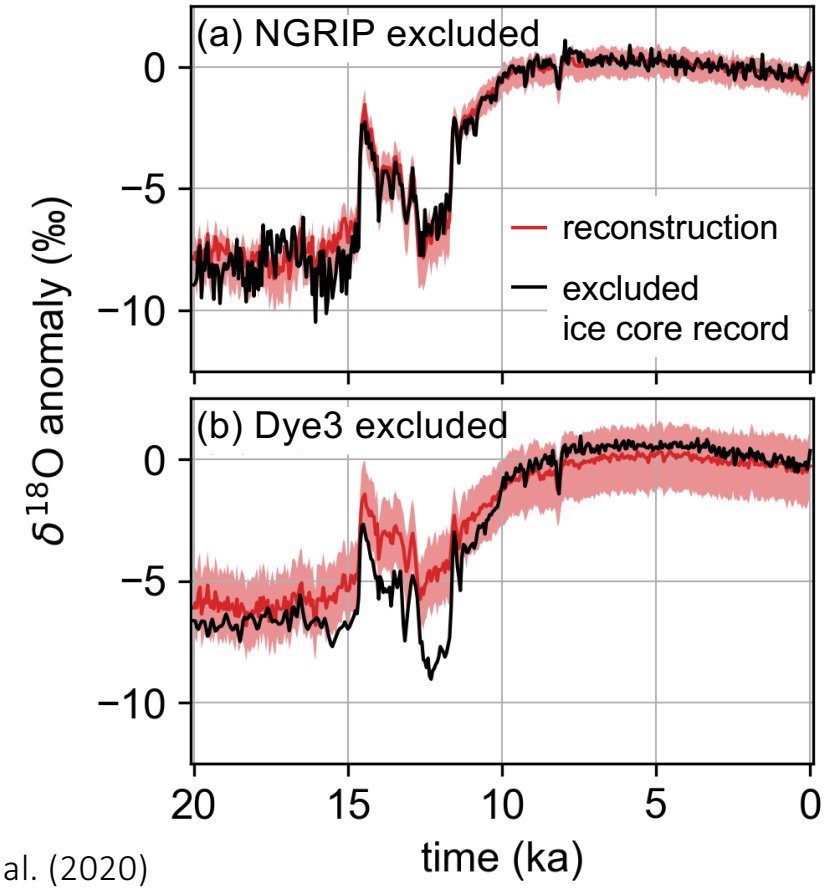
- spatial & temporal reconstructions
- temperature & precipitation
- uncertainty bounds
- evaluate well against independent records

E.g., spatial pattern of the mean-annual temperature anomaly in the late glacial →



S. Greenland results strongly dependent on Dye3

- The reconstructions in (a) and (b) assimilated records from all cores except NGRIP and Dye3, respectively.
- Other ice cores can be used to reconstruct climate at NGRIP, but not Dye3.

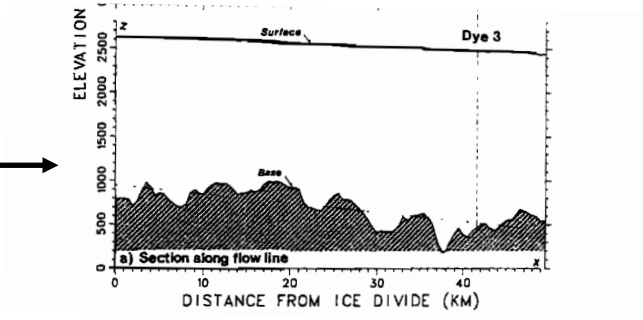


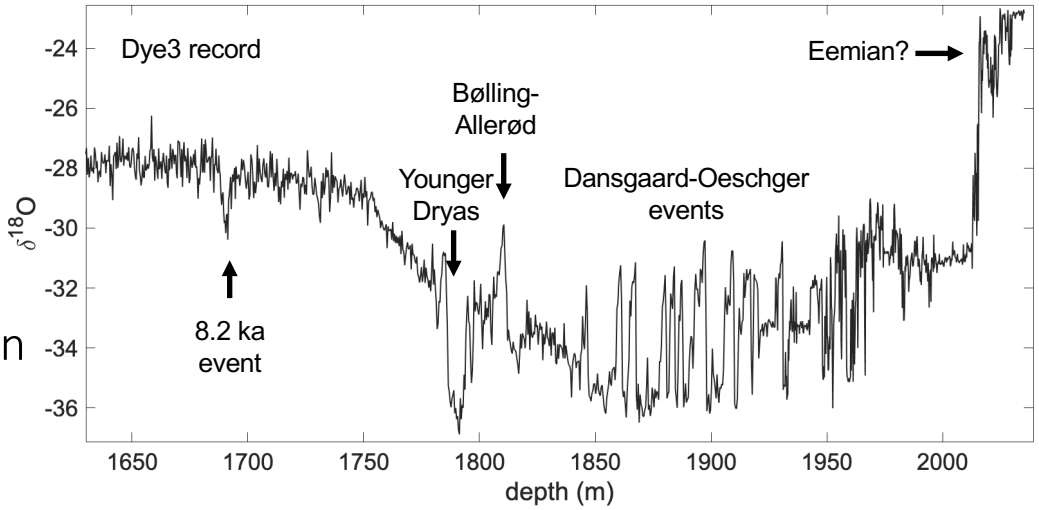
Badgeley et al. (2020)

Dye3 is an old core from a region of complex flow

- Not at a divide
- Complex bed topography upstream
- Poorly-constrained flow history
- Low resolution records
- Gaps in new measurements
- Gas loss concerns for some new measurements

Long, high-quality records from Southern Greenland are possible



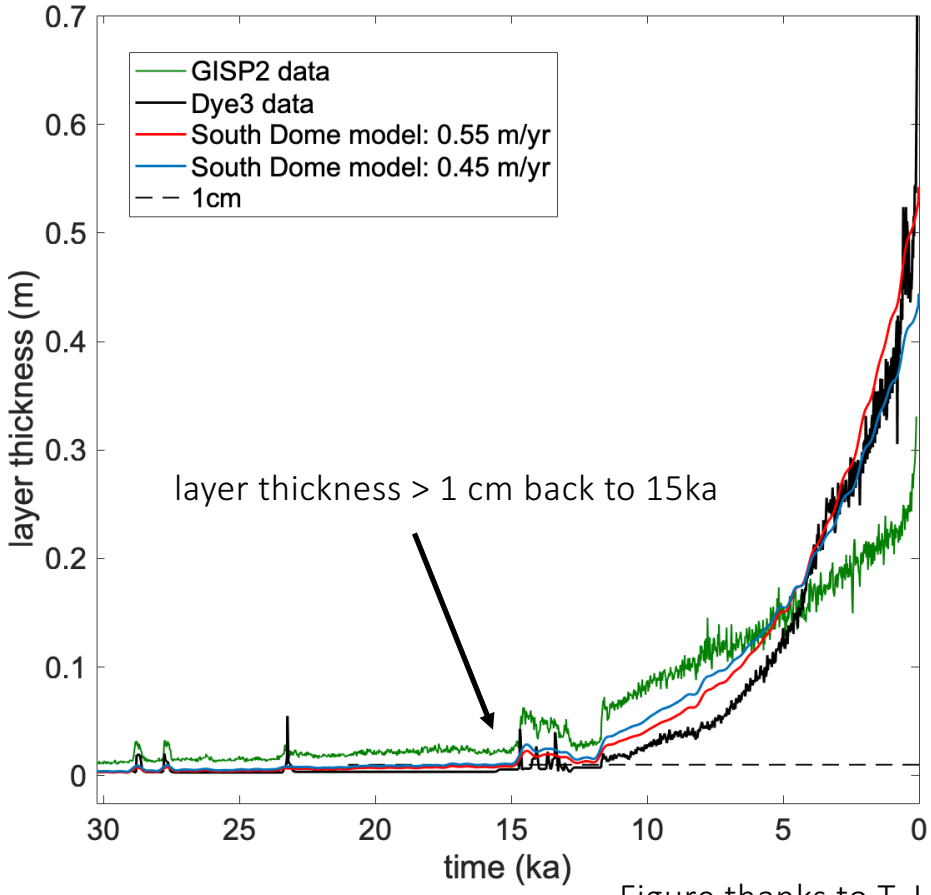


Reeh et al. (1985)

South Dome: A cold, divide site

Modern site characteristics:

- Mean annual accumulation rate: 0.55 m/yr
- Bed likely around -12 °C
- Mean annual temperature around -20 °C
- Mean annual $\delta^{18}O$: -28 ‰



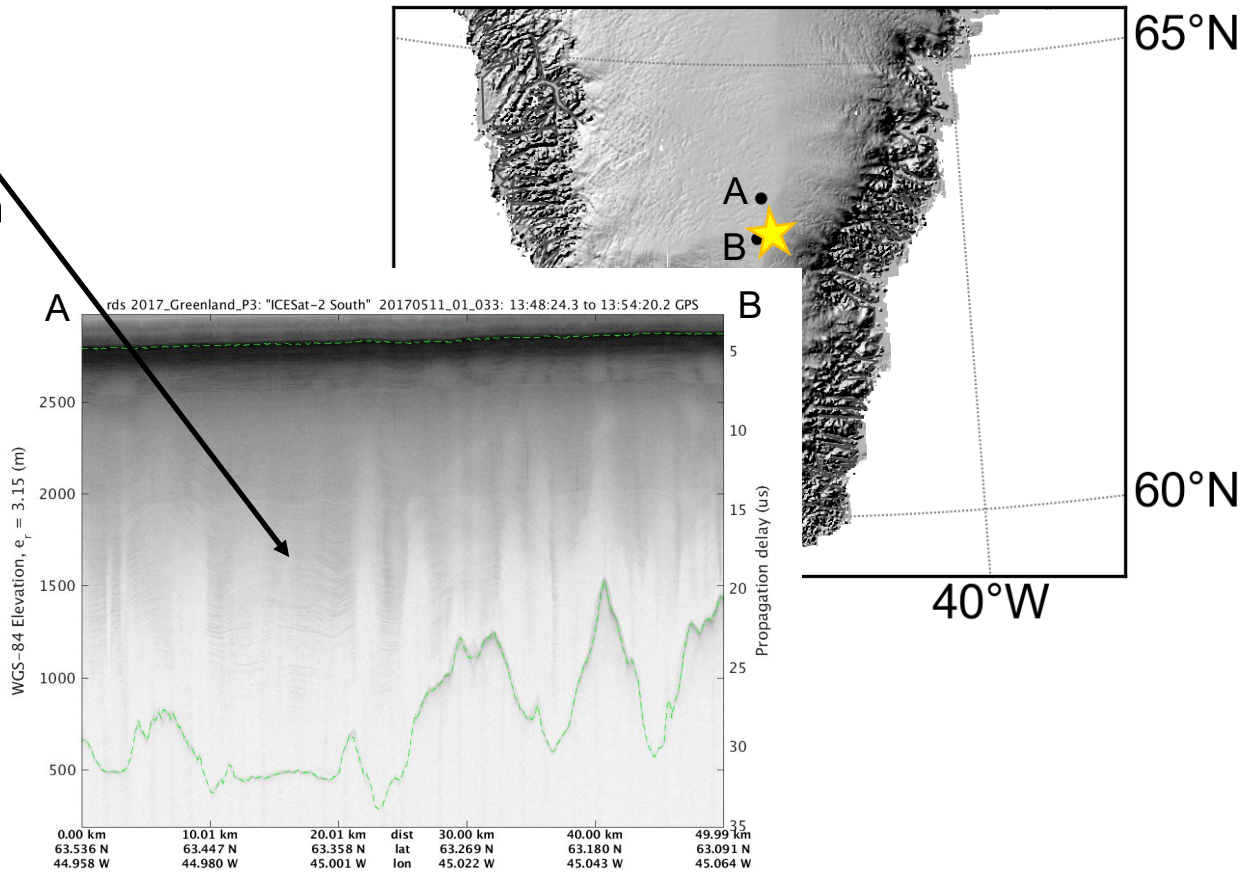
Lawson et al. (1982), Reeh et al. (1985); Steffen and Box (2001)

Figure thanks to T. J. Fudge

South Dome: Thick package of horizontal layers

- Likely horizontal layering*
- Ice thickness: 1800-2400 m
- Surface elevation: 2900 m

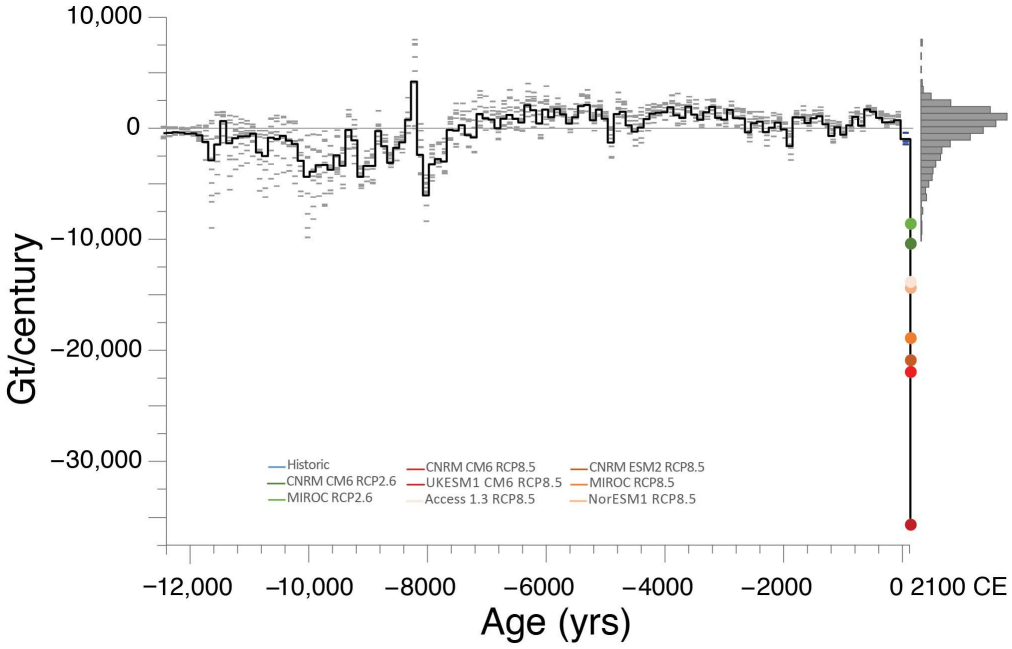
*More data required



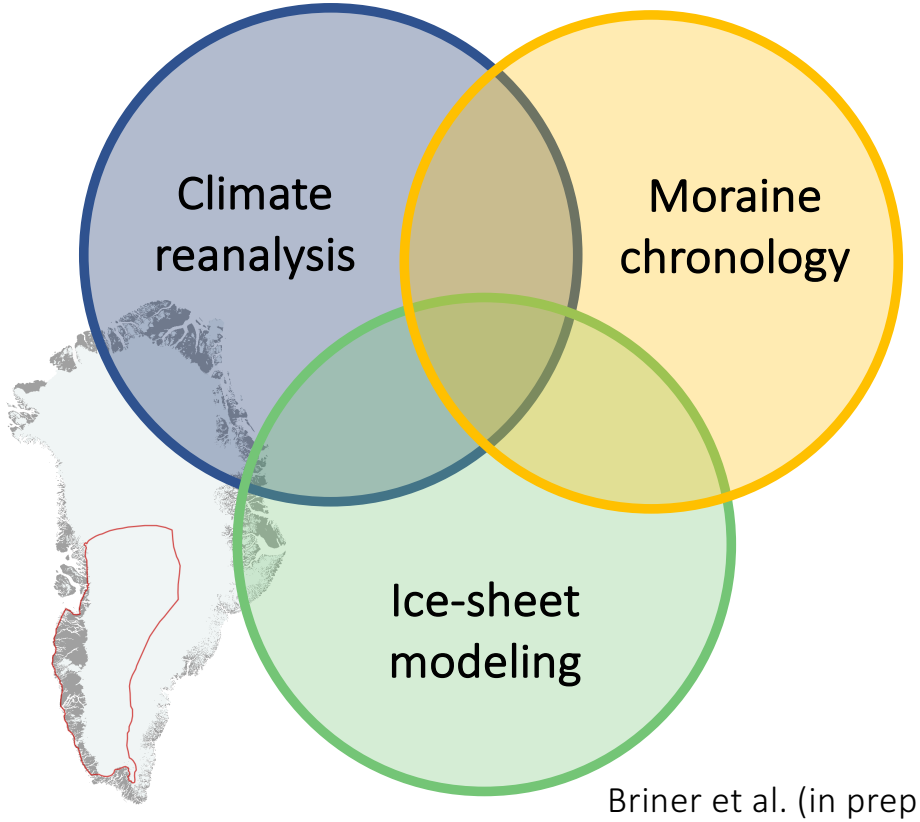
CRESIS OpenPolarServer; Arctic DEM, PGC; Morlighem et al. (2017)

Ice-sheet sensitivity to climate forcing

Jason Briner, Josh Cuzzone, Jessica Badgeley, Nicolás Young, Eric Steig, Mathieu Morlighem, Nicole-Jeanne Schlegel, Greg Hakim, Joerg Schaefer, Jesse Johnson, Alia Lesnek, Elizabeth Thomas, Estelle Allan, Ole Bennike, Allison Cluett, Beata Csatho, Anne de Vernal, Jacob Downs, Eric Larour, Sophie Nowicki



Snow on Ice Project



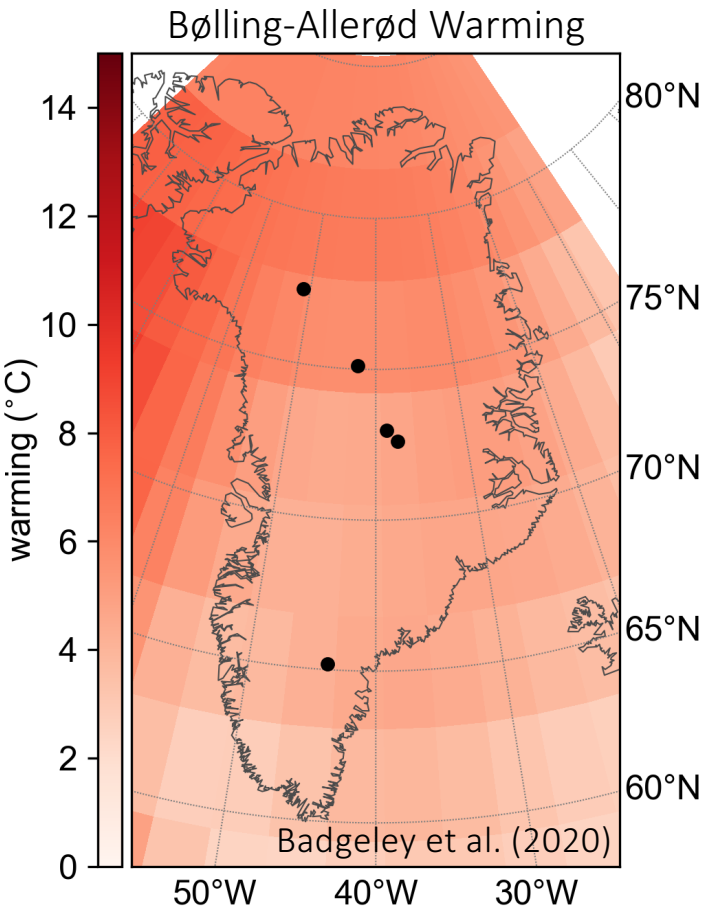
Briner et al. (in prep)

Climate variability: Higher in North or South?

- Constraining southern Greenland climate is important for questions such as:

What mechanisms drive abrupt climate events?

- Our results show robust pattern of greater variability in the North.



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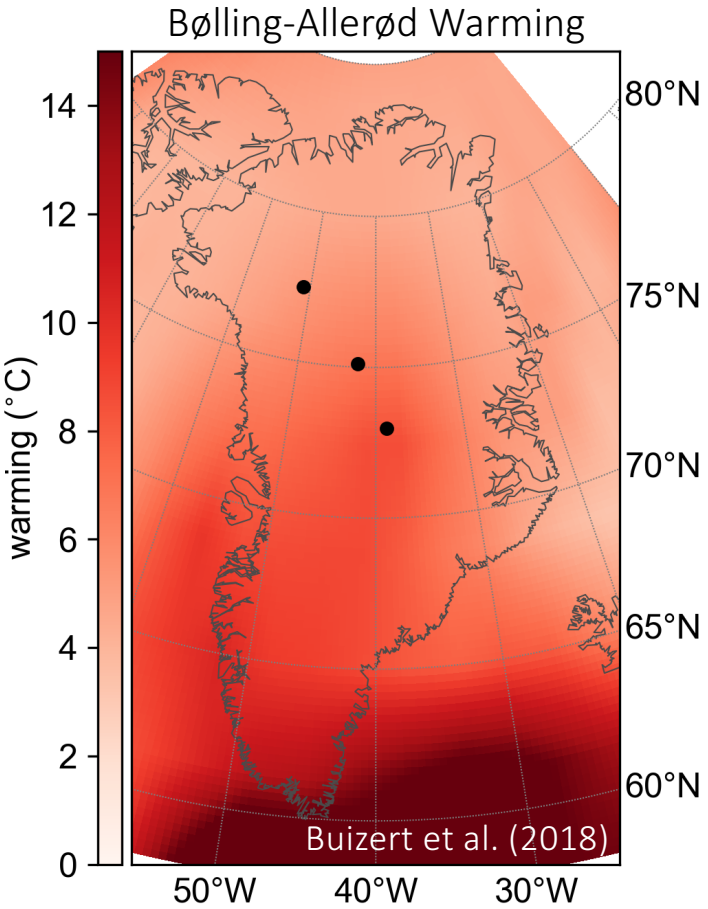
- Contrary to findings from $\delta^{15}N$ of N_2 derived temperature.

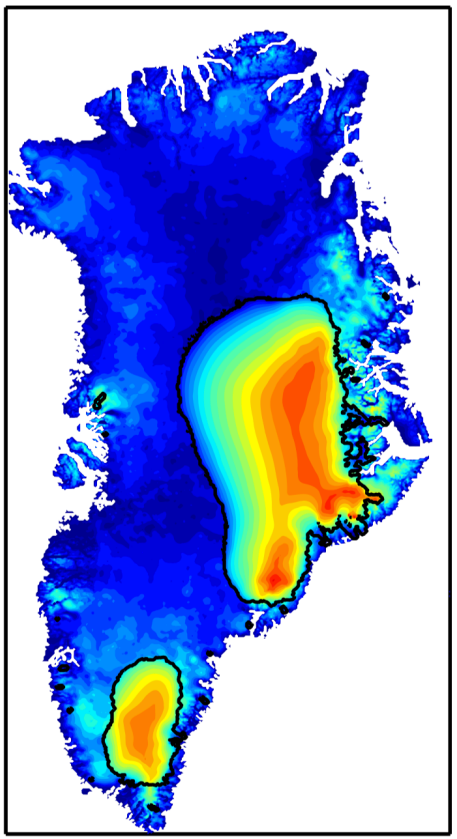


Is South Dome a survivor?

What is the Greenland ice-sheet response to warmer-than-present conditions?

- Ice-sheet models show that a southern dome survives extreme ice-mass loss

- Evidence from basal ice and subglacial bedrock helps constrain:
  - when that location was last ice-free
  - what the climate was like during that time



Fyke et al. (2014), Schaefer et al. (2016), Willerslev et al. (2007), Spector et al. (2018)

Summary

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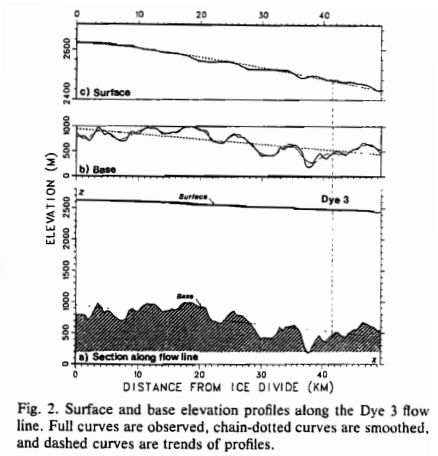

Fig. 2. Surface and base elevation profiles along the Dye 3 flow line. Full curves are observed, chain-dotted curves are smoothed, and dashed curves are trends of profiles.