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Magnitude and seasonality of climate change in South Greenland over the past 12,500 years

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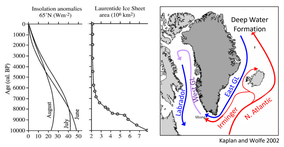
Introduction and Background

- Quantitative climate records elucidate the spatial variability of high-latitude climate change, but temporally-detailed paleotemperature reconstructions from terrestrial land-surface areas of Greenland are sparse.
- South Greenland records may provide insight into longstanding questions regarding controls on 1) timing of the Holocene Thermal Maximum (HTM) and 2) magnitude of abrupt climate change - Younger Dryas (YD) and 8.2 ka cooling.

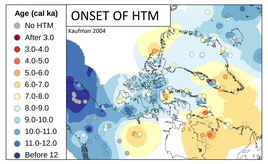
Study Questions

- **What was the magnitude/timing of the HTM in South Greenland?**
- **What was the magnitude of YD and 8.2 summer cooling in South Greenland?**

Holocene Thermal Max.

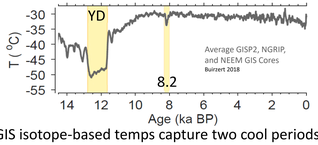


Key controls on Holocene climate:
1) orbital variation ⟶ summer insolation
2) waning ice sheet ⟶ ocean circulation

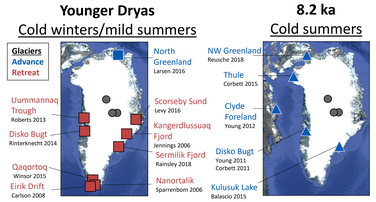


Quantitative records suggest spatial heterogeneity in HTM timing, but South Greenland climate is poorly constrained

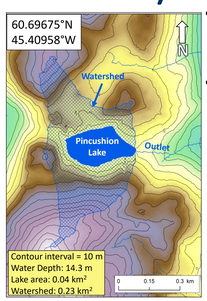
Abrupt Climate Change



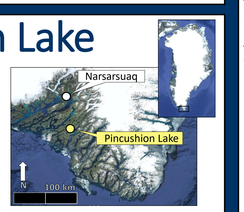
- GIS isotope-based temps capture two cool periods related to influx of freshwater into the N. Atlantic
- YD (8-15 °C cooling) and ~8.2 ka (2-6 °C cooling)
- However, ice sheet/glacier response = opposite trends, with YD retreat and 8.2 ka advance

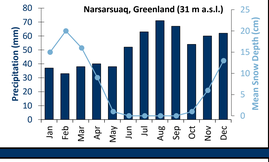


Study Site: Pincushion Lake

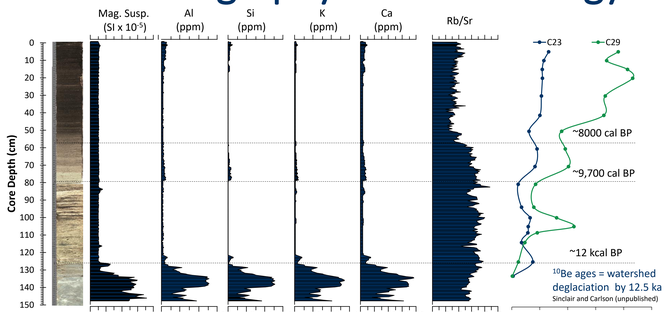


- Ammassivak Highlands = maritime climate, abundant rain and snow
- High elevation (480 m a.s.l.), hydrologically open-basin lake with active outlet
- Modern climate Narsarsuaq = 9.2 °C summer temp, 615 mm mean annual precip
- Core obtained summer 2016 using a universal percussion corer



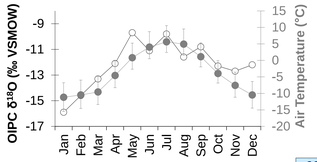


Core Stratigraphy and Chronology

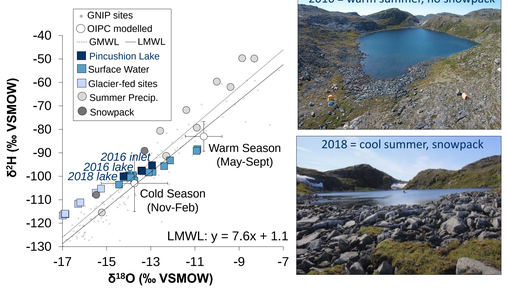


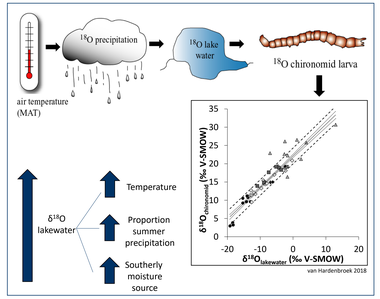
Isotopes suggest early, variable HTM warmth

Modern Water Isotopes and Framework for Interpreting Chironomid $\delta^{18}O$

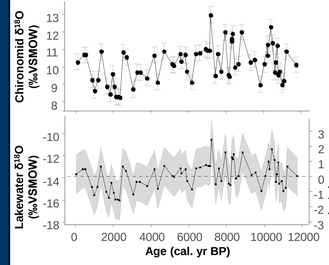


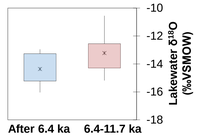
- Modelled monthly isotopes of precipitation at Pincushion Lake correspond to monthly temperatures
- Isotopes of precipitation and snowpack samples plot as expected on GMWL (winter more depleted, summer enriched in ^{18}O)
- Regional surface water samples suggest no evaporative enrichment
- Pincushion samples from 2016, 2018 reflect temperature differences





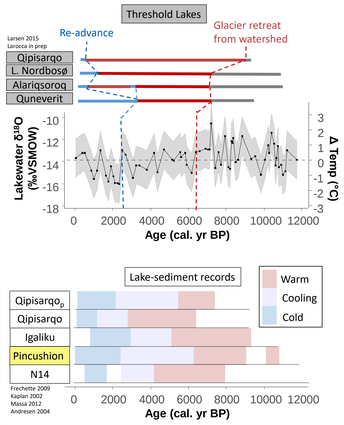
Chironomid $\delta^{18}O$





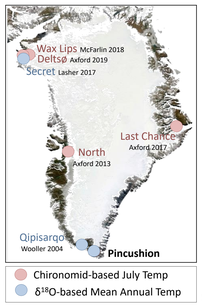
Isotope values suggest warmer early vs. late Holocene, but high centennial-scale variability

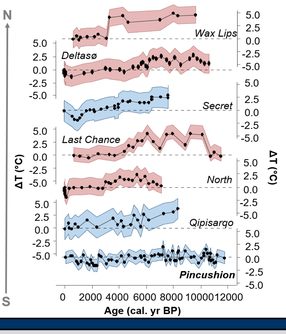
Comparison to Nearby Lake-Sediment Records



- Warmer early- to mid-Holocene and cold late-Holocene temperatures agree with timing of local glacier retreat and advance from threshold lakes in the region
- Other lake-sediment records suggest similar overall millennial trends, but local heterogeneity in timing of transitions

HTM warming subdued in S. Greenland





- We compare our new Pincushion Lake reconstruction to quantitative chironomid isotope and assemblage reconstructions from Greenland.
- Suggests that Holocene temperature change, and the HTM in particular, was subdued in South Greenland compared to other land-surface areas.

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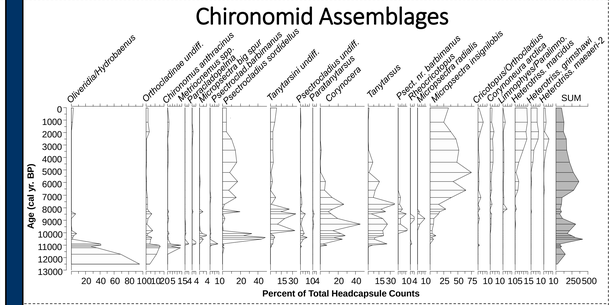
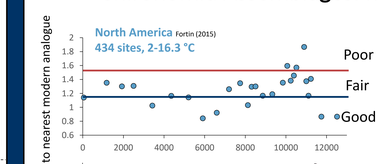
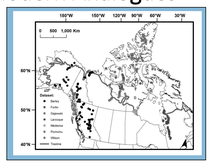
Chironomids Reveal YD and 8.2 ka Summer Cooling

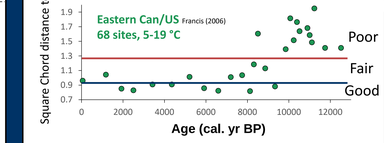
Chironomid Assemblages

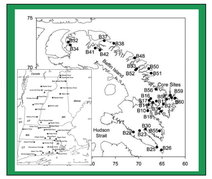


Chironomid Assemblages: Modern Analogues



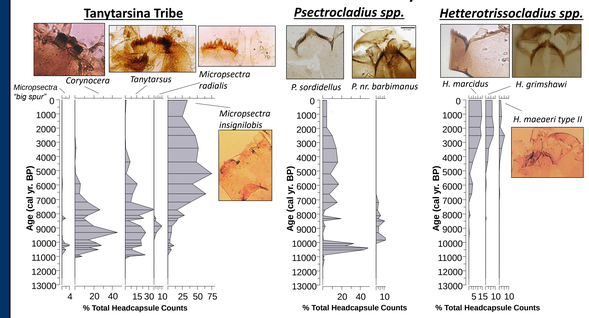






- North America training set has overall good/fair modern analogues
- Eastern Can/US = only good/fair analogues mid to late Holocene

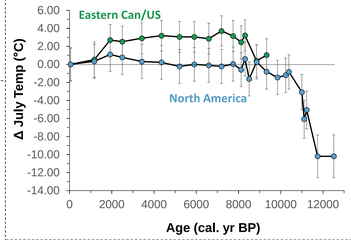
Taxonomic resolution and key taxa



Lumped taxa may have biogeographic and optima/tolerance differences
- Tantarsina taxa dominate assemblages and show stratigraphic variability
- *P. nr. barbimanus* is unique to Greenland, and is abundant 10.5-6.5 ka
- *H. grimshawi* often in cooler lakes, highest abundance after 2.5 ka

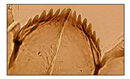
Summer Temp Reconstruction

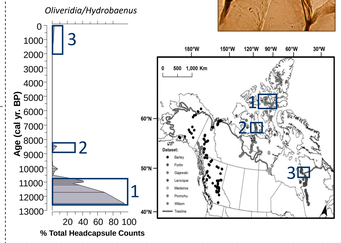
- Where analogues exist, temperature trends differ between training sets
- North America training set captures Younger Dryas and 8.2 ka cooling
- Eastern Can/US = higher overall TJuly (captures a warmer temperature range), and is consistent with the isotope record



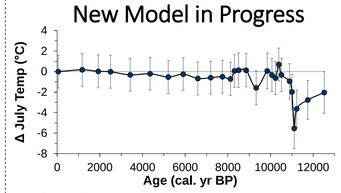
Cold indicator *Oliveridia*

- *Oliveridia* is a cold stenotherm, and is abundant during the YD, returning 8.2 ka and late Holocene
- Suggests cool summers





New Model in Progress



- Combined training set suggests early Holocene modern analogues in Canada, late Holocene in SW Greenland
- See A. Medeiros poster (this session)

Conclusions and Future Work

- Chironomid isotopes suggest high climate variability on centennial timescales, with overall warmer versus cooler conditions in the early versus late Holocene, respectively
- Chironomid assemblage changes suggest cold summers during the Younger Dryas and 8.2 ka cold periods, but magnitude of temperature changes require improved taxonomic resolution of training set (in prep)