# Deriving paleo-perspectives on polar systems: Using a PSV constrained chronology to compare lake records from Ellesmere Island with the Holocene history of Petermann Fjord

Joseph Stoner & Brendan Reilly

Oregon State University
College of Earth, Ocean, and Atmospheric Science

Scripps Institution of Oceanography
UC San Diego

NSF

**Petemann15 Team**

Alan Mix
Martin Jakobsson
Maureen Walczak
Anne Jennings
Kelly Hogan
Larry Mayer
Maziet Cheseby

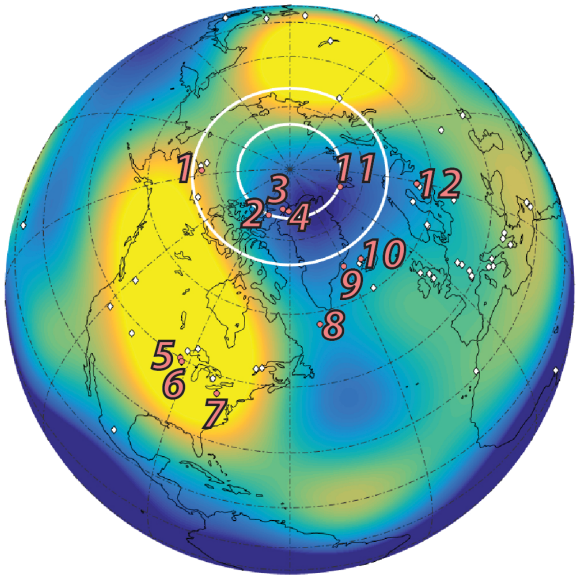
**Ellesmere Island Lake Team**

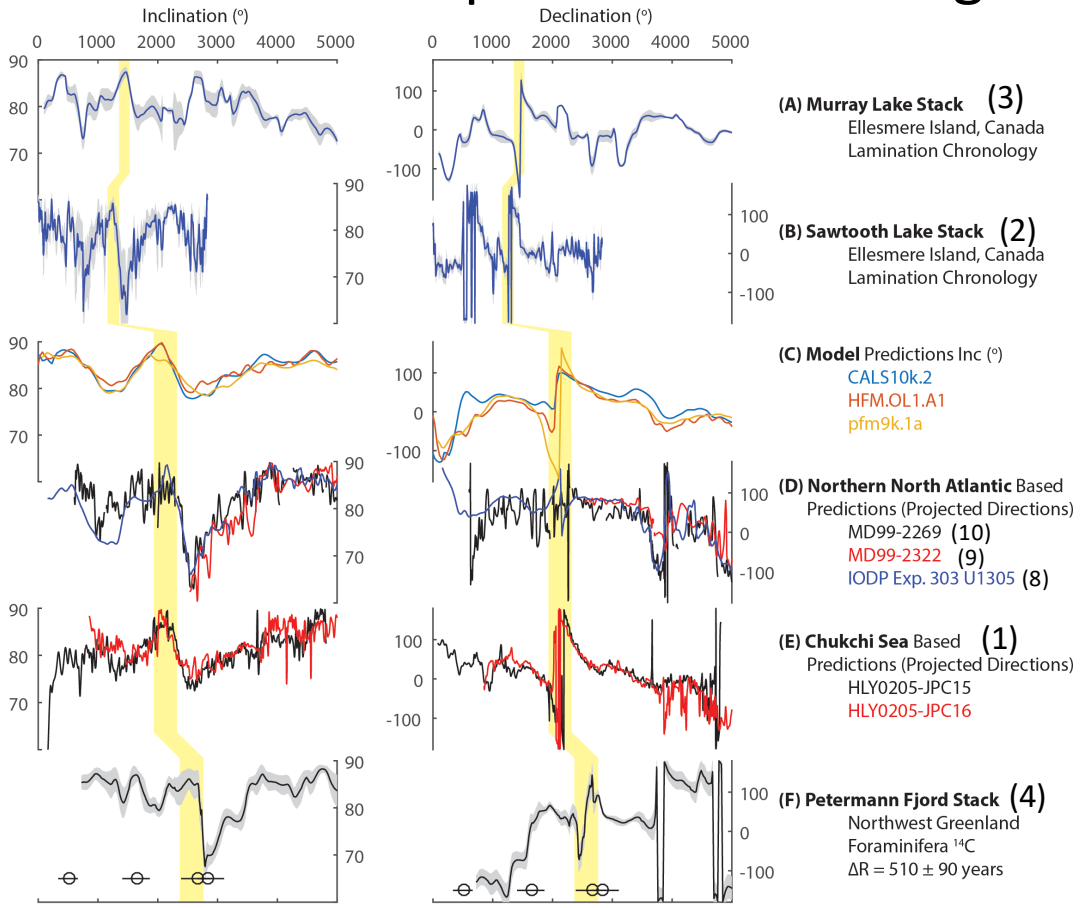
Mark Abbott
Pierre Francus
Francois Lapointe
Tim Cook
Raymond Bradley
Nick Balascio
Whit Patridge

## If we are to understand the climate and environmental evolution of polar systems, we need robust ways to compare paleo-records from marine and terrestrial archives.

- **Experiment**: Compare **the Holocene evolution of the Petermann fjord and ice tongue** on NW Greenland (Reilly et al., 2019; Jakobsson et al., 2018) with paleo records derived from proximal Ellesmere Island lakes.
  - **Lower Murray Lake** NW of Archer Fjord ~ 150 km from Petermann fjord (e.g., Besonen et al., 2008; Cook et al., 2009).
  - **Sawtooth Lake** on the Florsheim Peninsula ~450 km (Francus et al., 2002; Lapointe et al., 2019).
- **Objective:** Explore the regions climate and environmental evolution to assess whether there are large scale patterns.
- **Problem:** Independent chronologies imply regionally complex geomagnetic (and climatic) signals. Although there are potential geomagnetic mechanisms to explain this complexity (St-Onge and Stoner, 2011), it counters a growing understanding that geomagnetic changes on centennial to millennial timescales (paleomagnetic secular variation, or PSV) reflect large spatial scale dynamics (e.g, Nilsson et al., 2010; Stoner et al., 2013; Walczak et al., 2017). Although this concept has not been explicitly tested for Ellesmere Island/NW Greenland, the applicability of using well dated PSV records from lower latitudes (60s°) to date High Arctic sediments was recently tested using high quality radiocarbon chronologies for Svalbard (Olafsdottir et al., 2019; Gjerde et al., 2018; van der Bilt et al., 2018). **If more generally true for the High Arctic, PSV could provide a way to date these often difficult to study archives.**
- **Our Approach**: A tuning target was developed, originally for Petermann Fjord, called the Western Hemisphere Arctic PSV Stack (WHAP18, Reilly et al., 2019) that brackets Ellesmere/NW Greenland on two sides using well dated, high resolution, and quality records from the northern North Atlantic (Stoner et al., 2013) and the Chukchi Sea (Lund et al., 2016).
- **Primary Assumptions:** That lower latitude paleomagnetic records can predict High Arctic PSV (e.g., (Olafsdottir et al., 2019), with predictions based upon high quality, high resolution, regional records (northern North Atlantic, Chukchi Sea) being more appropriate than than those based upon global models (Nilsson et al., 2014; Constable et al., 2016) , and that all three sites will compare to the tuning target equally well.

# PSV Comparison on their own independent chronologies




(2,3) St-Onge & Stoner, 2011, Oceanography
(8,9,10) Stoner et al., 2007 Paleo, 2013, G3.
(1) Lund et al., 2016, PEPI
(C) Nilsson et al., 2014, GJI
(C) Constable et al., 2016, EPSL
(4) Reilly et al., 2019; in prep.
(11) Olafsdottir et al., 2019

Yellow bar denotes the 'f to e transition' a well known mid-latitude PSV feature (e.g., Thompson and Turner, 1979) observable from Europe to North America, our contention is the time transgressive appearance in Arctic PSV results from chronologic difficulties rather than true geomagnetic variability. By correcting for this we can improve the chronologies and synchronize the records.

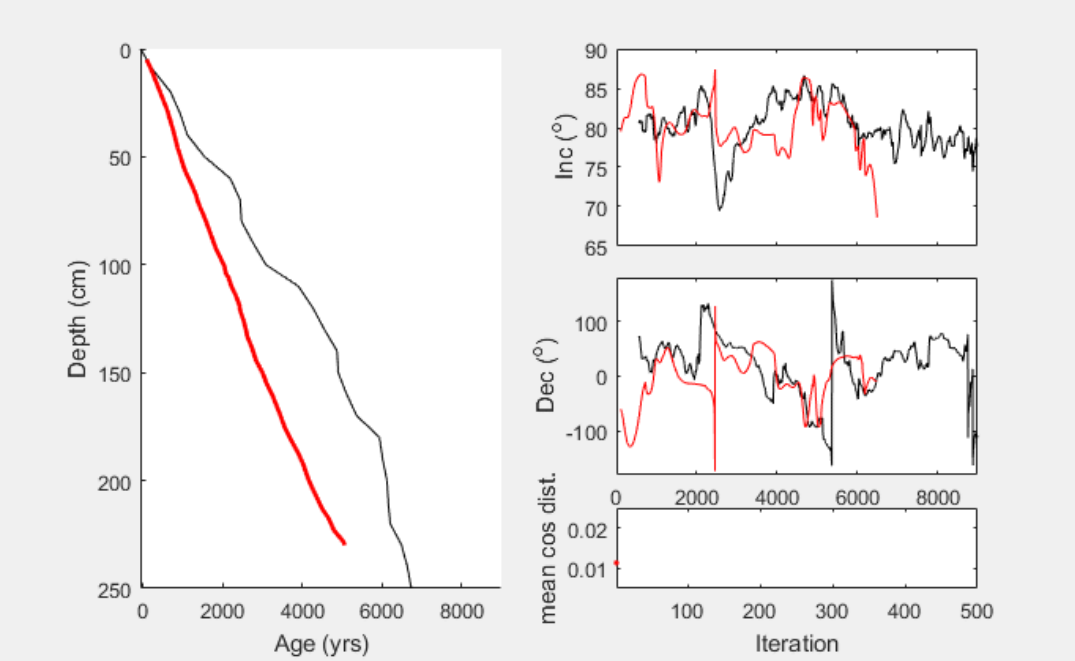
**Approach: Age Model at all three locations (Petermann, Murray, Sawtooth) obtained using an objective correlation approach (example from Lower Murray Lake).**

Assumptions used:

- PSV Target: Stack of N. N. Atlantic and Chukchi Sea Representative of Regional PSV
- **Minimum age: 4** ka (approx. 1 ka less than laminations counted)
- **Maximum age:** 9 ka (approx. maximum age for the opening of Nares Strait)

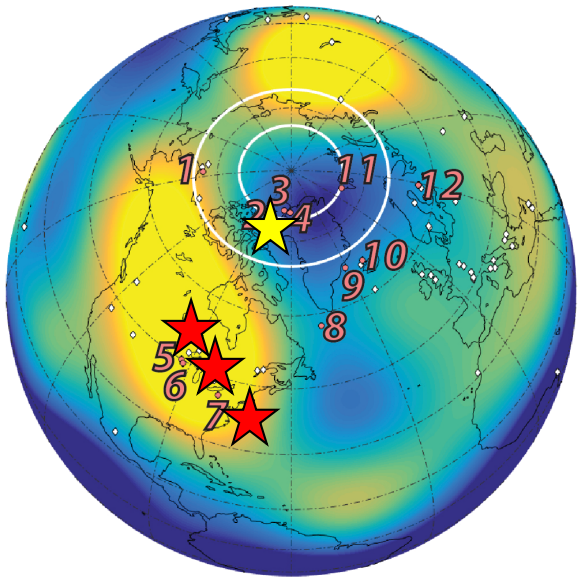
Example – Murray Lake (3) compared to Target Curve

**Lower Murray Lake vs. PSV Target (WHAP18)**




In this case: Evaluates 1 Million Possible Age-Depth Relationships Red line is the Murray Lake Varve Chronology (Cook et al., 2009), black line is the optimal PSV correlation between Murray Lake resulting in a much older stratigraphic record.

# Comparing Normalized Intensity on similar longitudes as a potential check?




King et al., 1983, PPP
Lund & Banerjee, 1985, JGR
Brachfeld & Banerjee, 2000, JGR
Nilsson et al., 2014, GJI
Constable et al., 2016, EPSL

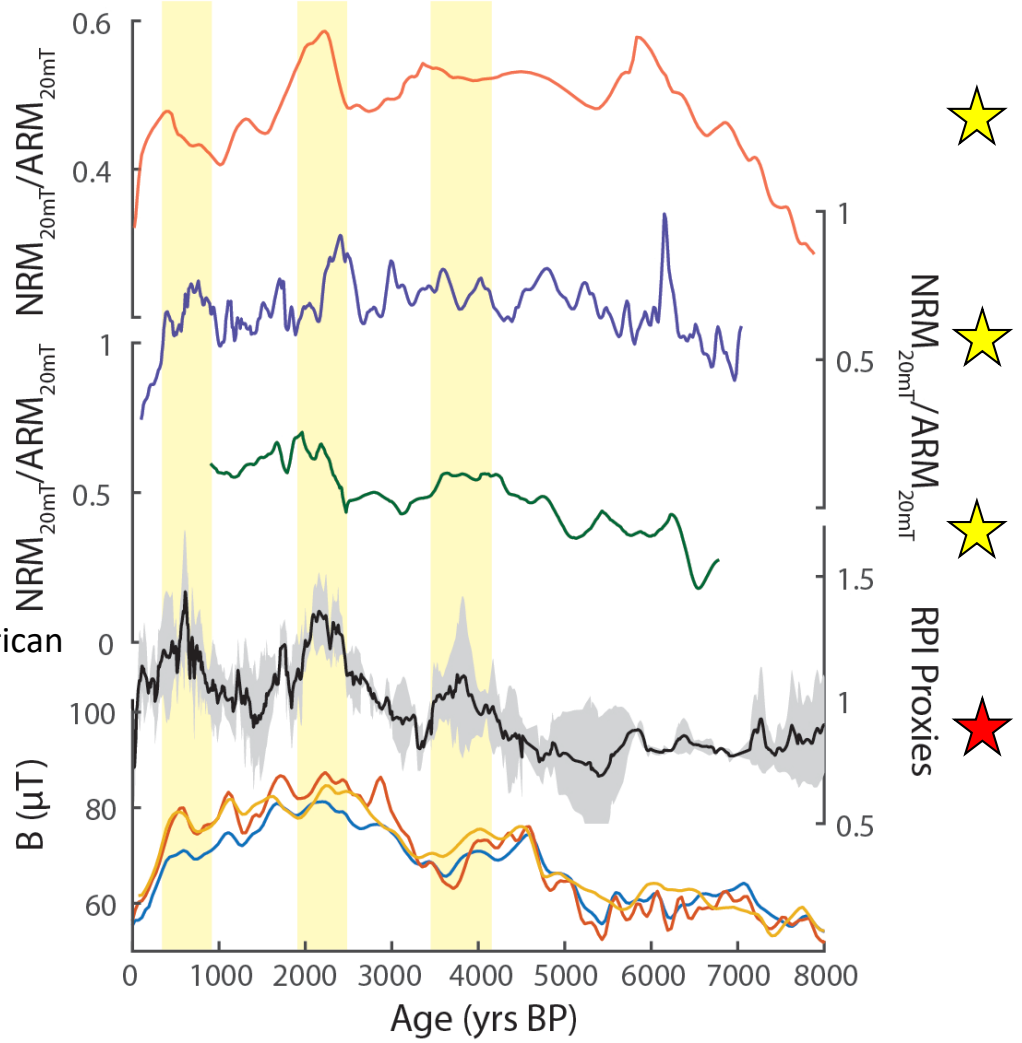
(3) Murray Lake

(2) Sawtooth Lake

(4) Petermann Fjord

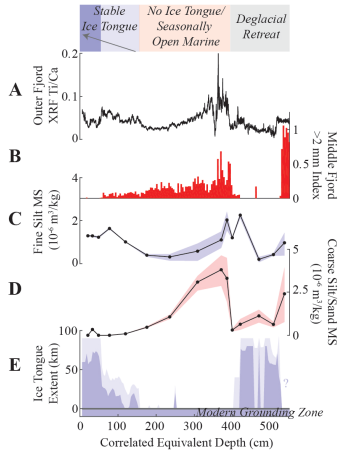
(5,6, 7) North American Lake Stack

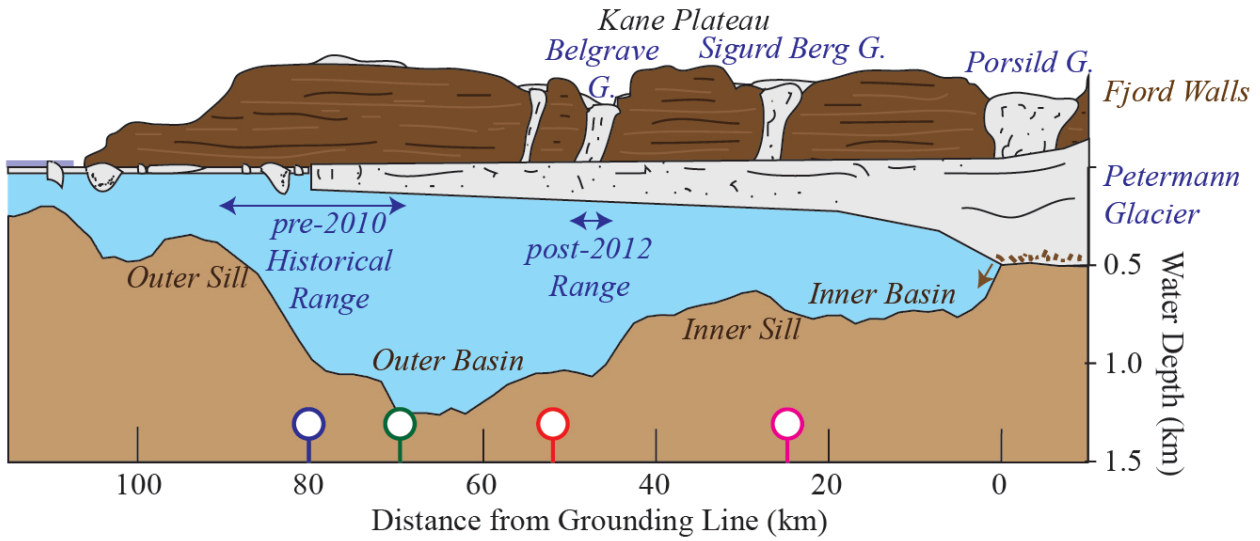
CALS10k.2
HFM.OL1.A1
pfm9k.1a

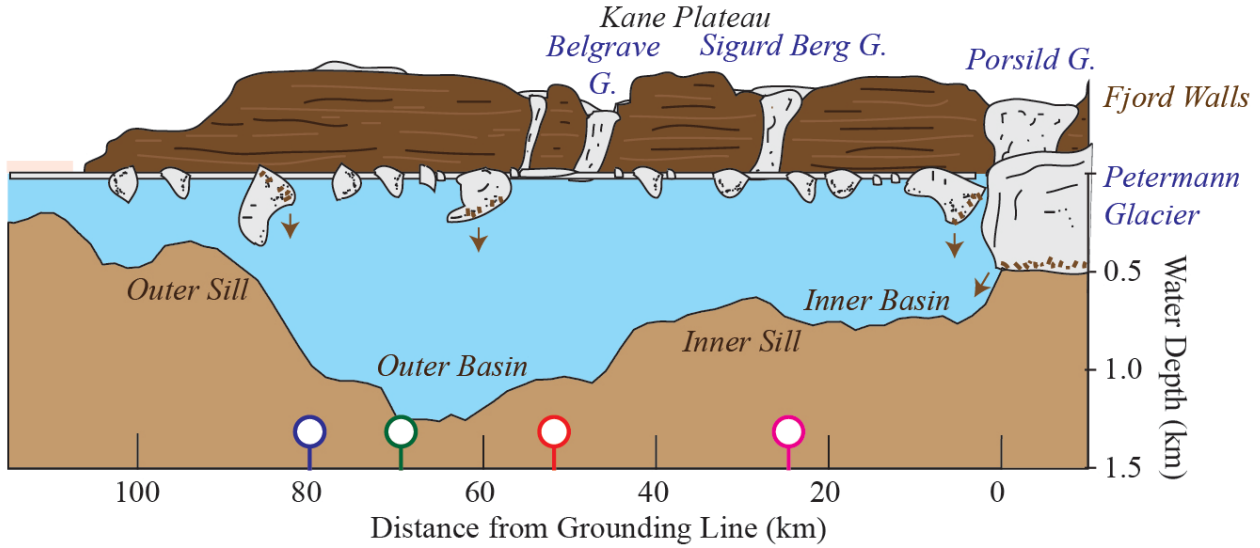


# What we learned from Petermann Fjord Coring

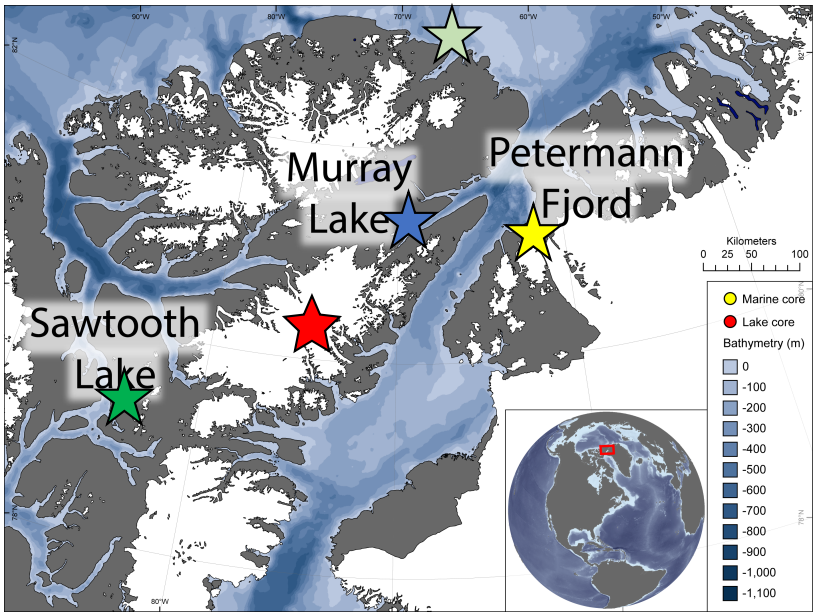
**The Petermann Ice Tongue was absent for almost 5 of the last 7 thousand years! (Reilly et al., 2019)**



**PSV constrained chronologies at all sites imply a consistent regional climate signal suggesting that High Arctic climate deteriorated substantially over the last 2000 yrs after a much warmer Mid-Holocene**




Grønnow & Jensen, 2003, Mono. on Greenland
England et al., 2008, GRL
Cook et al., 2009, Paleolim.
Patridge, 2002, M.S. Thesis
Lecavalier et al., 2017, PNAS
Reusche et al., 2018, GRL
Reilly et al., 2019; in prep

Sea ice packed in

Murray Lake lithology changed

Atmosphere cooled

Lithology at Sawtooth was more variable

The Petermann Ice Tongue returned after a ~ 5 thousand year absence

**Reilly et al., in prep**