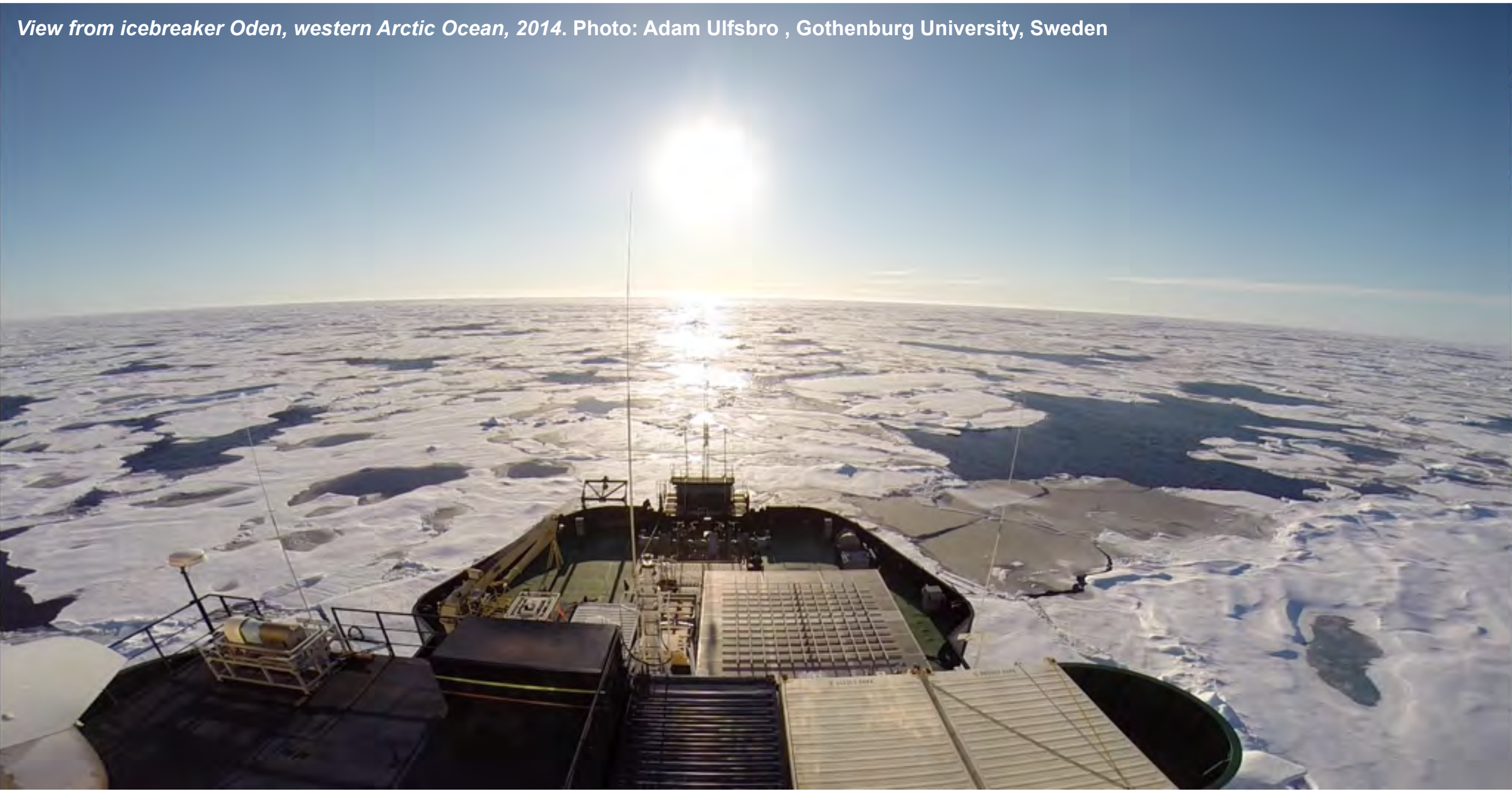
A Polar Perspective on Future MSP Drilling



View from icebreaker Oden, western Arctic Ocean, 2014. Photo: Adam Ulfsbro , Gothenburg University, Sweden

Matt O'Regan (matt.oregan@geo.su.se)

Department of Geological Sciences, Stockholm University, Stockholm, Sweden

Bolin Centre for Climate Research | Stockholm University

Scientific Drilling in Polar Regions

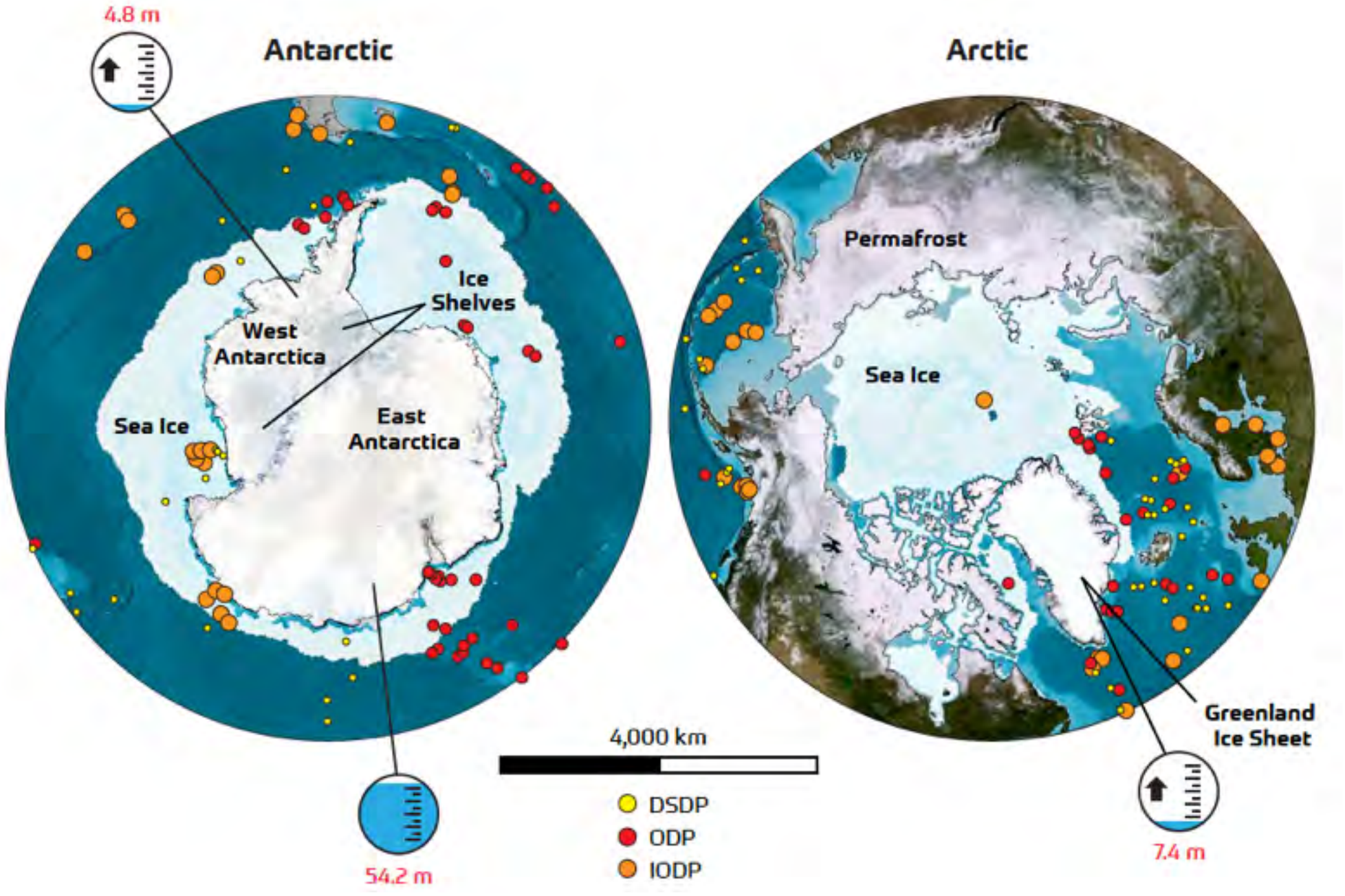
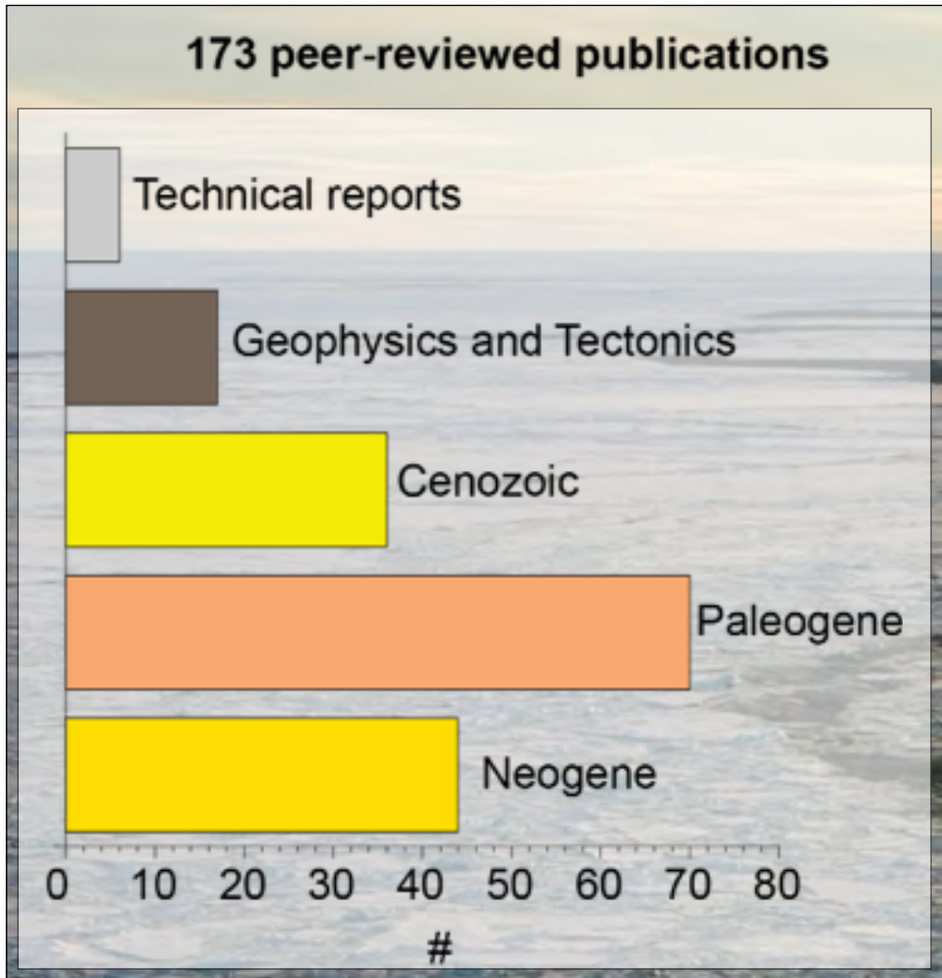


Image: Exploring Earth by Scientific Ocean Drilling, 2050 Science Framework

IODP 302, *The Arctic Coring Expedition* (ACEX), 2004



Total core recovery: 339 m

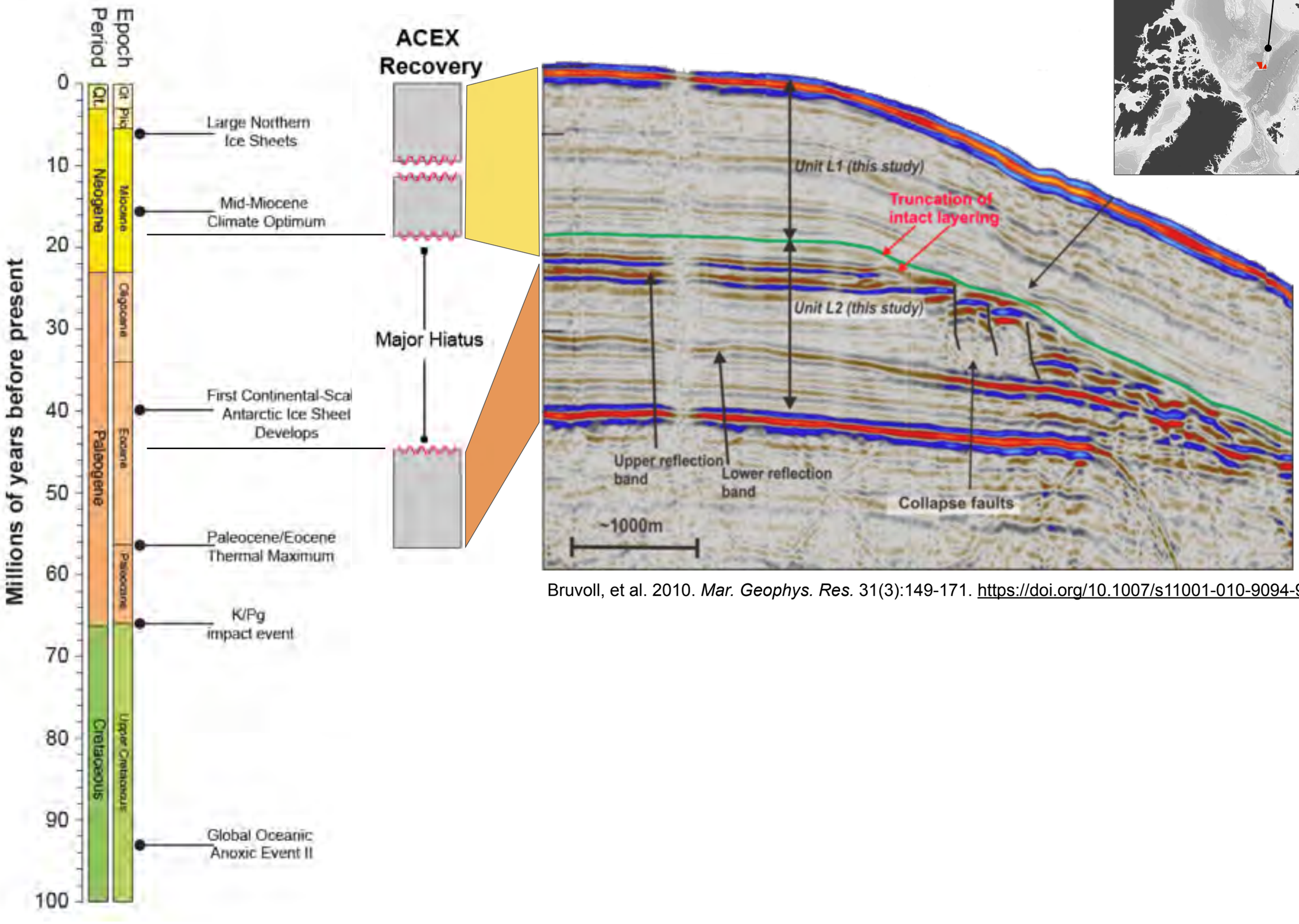
"The history of Arctic climate and circulation is so poorly known that we can look at the recovery of any material as a true exploration that will, by definition, increase our knowledge and understanding of this critical region."

Larry Mayer (UNH), 1999, *ACEX* drilling proposal (#533)

Photo: Martin Jakobsson , Stockholm University, Sweden

ACEX Mugshot, 2004

IODP 302, *The Arctic Coring Expedition* (ACEX), 2004



Bruvoll, et al. 2010. *Mar. Geophys. Res.* 31(3):149-171. https://doi.org/10.1007/s11001-010-9094-9

Post-ACEX expedition planning

1. **Arctic Ocean History: From Speculation to Reality**

Consortium for Ocean Leadership (US), the ESF, AOSB, and the Nansen Arctic Drilling Program

AWI Bremerhaven, Germany, November, 2008

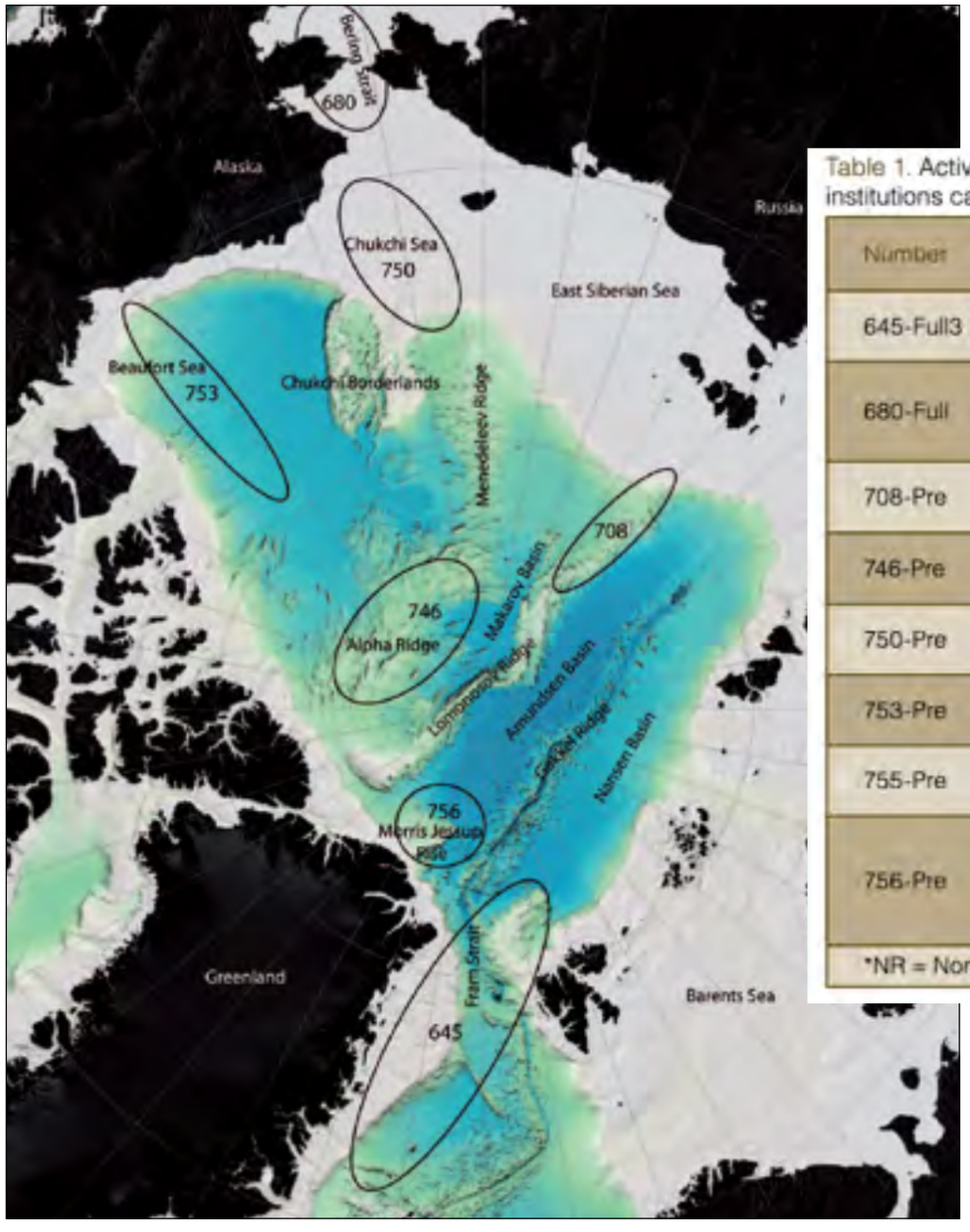


Table 1. Active Arctic-related IODP proposals (as of October, 2009). More details on these proposals including the list of co-proponents and involved institutions can be obtained from the IODP website (http://www.iodp.org/active-proposals).

Number	Short Title	Contract Proponents	University/ Institute	Country	Platform*	E-mail
645-Full3	North Atlantic Gateway	W. Jokat	AWI Bremerhaven	ECORD/ Germany	MSP+NR	Wilfried.Jokat@awi.de
680-Full	Bering Strait Climate Change	S. J. Fowell	University of Alaska Fairbanks	USA	MSP	ffsjf@uaf.edu
708-Pre	Central Arctic Paleoceanography	R. Stein	AWI Bremerhaven	ECORD/ Germany	MSP	Ruediger.Stein@awi.de
746-Pre	Arctic Mesozoic Climate	W. Jokat	AWI Bremerhaven	ECORD/ Germany	MSP	Wilfried.Jokat@awi.de
750-Pre	Beringia Sea Level History	L. Polyak	Ohio State University	USA	MSP+NR	Polyak.1@osu.edu
753-Pre	Beaufort Sea Paleoceanography	M. O'Regan	Stockholm University	ECORD/ Sweden	NR	Matt.oregan@geo.su.se
755-Pre	Arctic Slope Stability	D. Winkelmann	GEOMAR	ECORD/ Germany		dwinkelmann@ifm-geomar.de
756-Pre	Morris Jesup Rise: Drilling the Arctic Ocean Exit Gateway	M. Jakobsson	Stockholm University	ECORD/ Sweden		Martin.jakobsson@geo.su.se

*NR = Non-Riser MSP = Mission Specific Platform

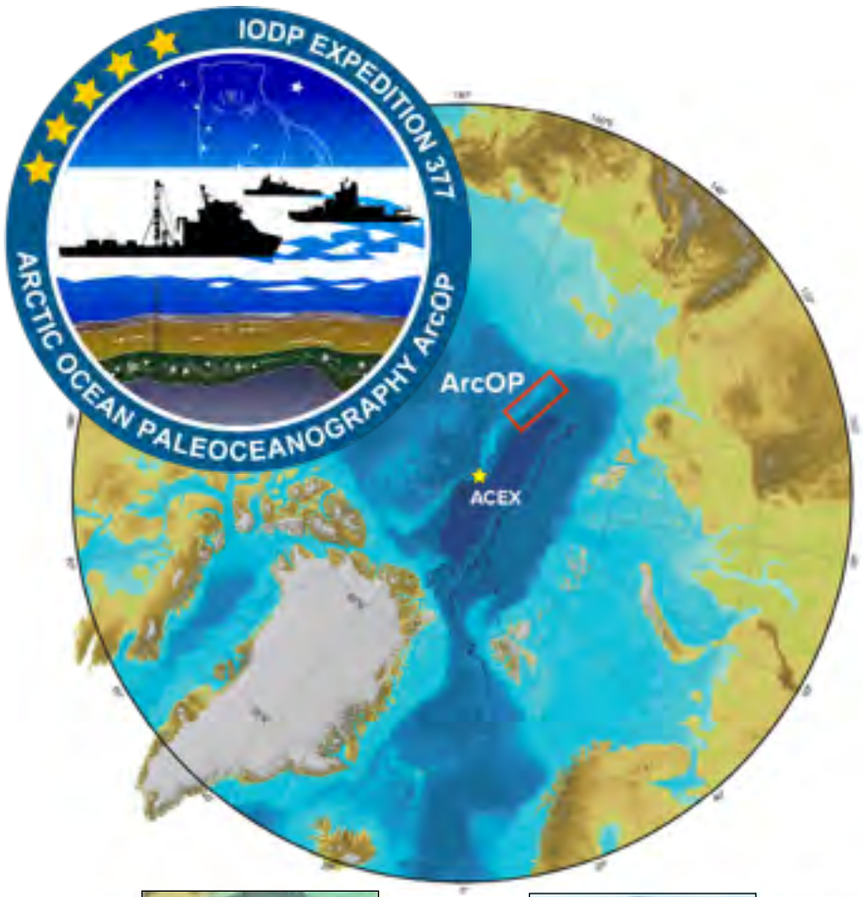
SOURCES: (map) Dove and Leigh, Scientific Drilling in the Arctic Ocean: A summary document to encourage Academic and Industry collaboration, January 2011. (table) Coakley and Stein, Arctic Ocean Scientific Drilling: The Next Frontier, workshop report. doi:10.2204/iodp.sd.9.09.2010

2. **Overcoming Barriers to Arctic Ocean Scientific Drilling: The site survey challenge**

Magellan Workshop Series

Copenhagen, Denmark, November, 2011

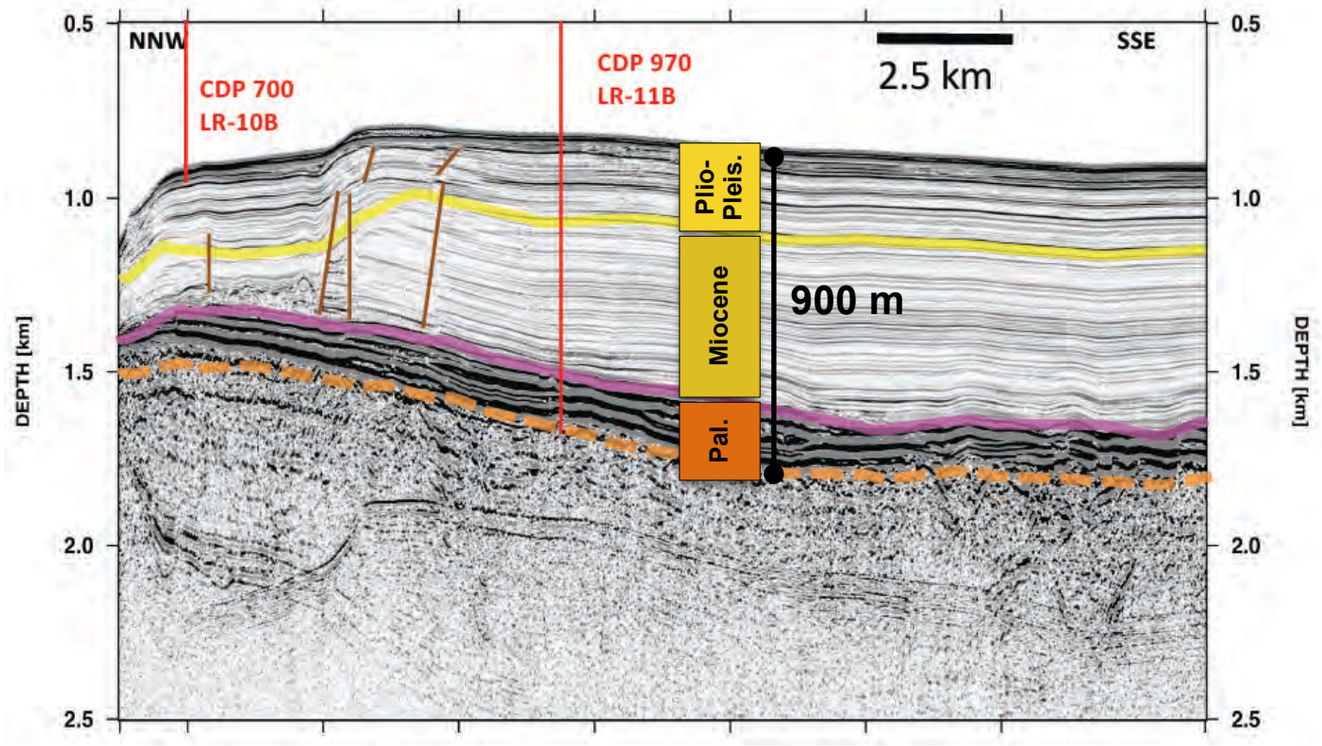
Expedition 377 - Arctic Ocean Paleoceanography (ArcOP)



Ruediger Stein **Kristen St. John**

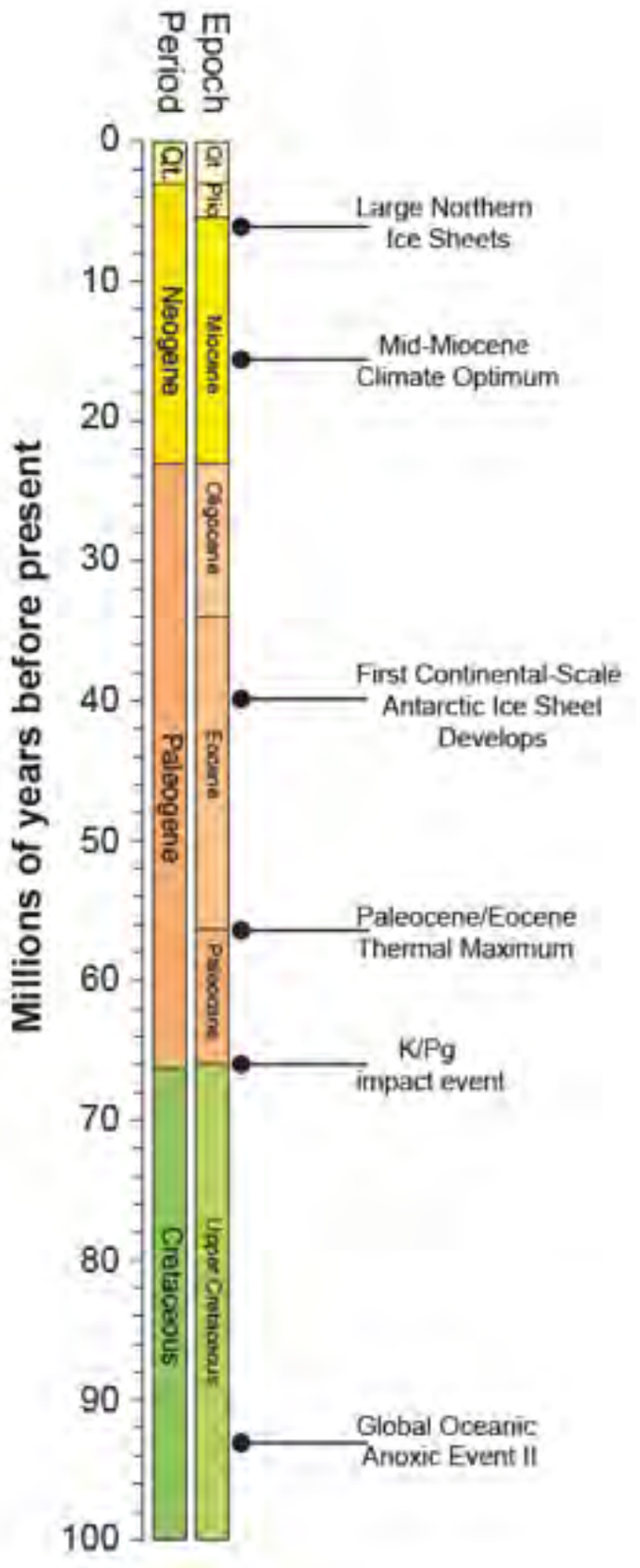
Co-chief Scientists

"Recovery of a complete (composite) stratigraphic sedimentary record on the southern Lomonosov Ridge to meet our highest-priority pale oceanographic objective, the continuous long-term Cenozoic climate history of the central Arctic"



Pre-proposal first submitted in 2006, originally scheduled in 2018, and postponed indefinitely in 2022. A 16 year timeline and still counting.

Chasing the ‘Holy Grail’



- MSP’s provide an incredible amount of flexibility in designing proposals and reaching drilling targets. What we ask for in the proposal determines the type and cost of drilling.

- Deep holes require staying on site for a long time. This is logistically challenging and very expensive in continuously moving sea ice.

- Ultimately, there is no single site that will deliver the complete history of the Arctic cryosphere (sea ice, ice sheets, glaciers and permafrost).

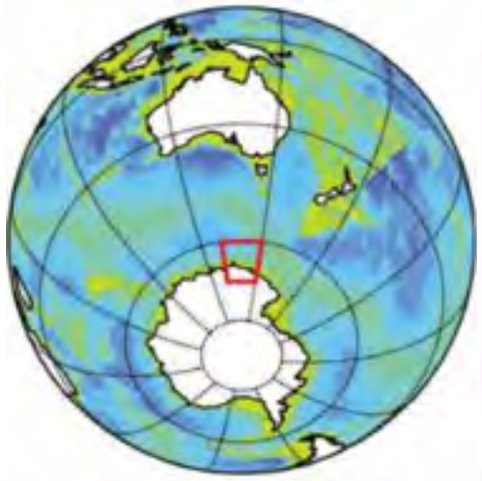
- To address many of the goals in the 2050 Science Framework, we need to increase scientific drilling activity in the Arctic. This can be achieved with numerous ‘smaller’ focused campaigns.

Alternate Approaches

Expedition 373 (813-Full) - George V Land, Antarctica: Cenozoic Paleoclimate: *T. Williams et al.*

"Here we propose to use the MeBo sea bed drill for improved core recovery and easier access to the shelf. We propose to drill two stratigraphic transects of shallow (~80m) holes to investigate Antarctica's role in icehouse and greenhouse climates, and the transitions between the two."

1. Target outcropping sediments



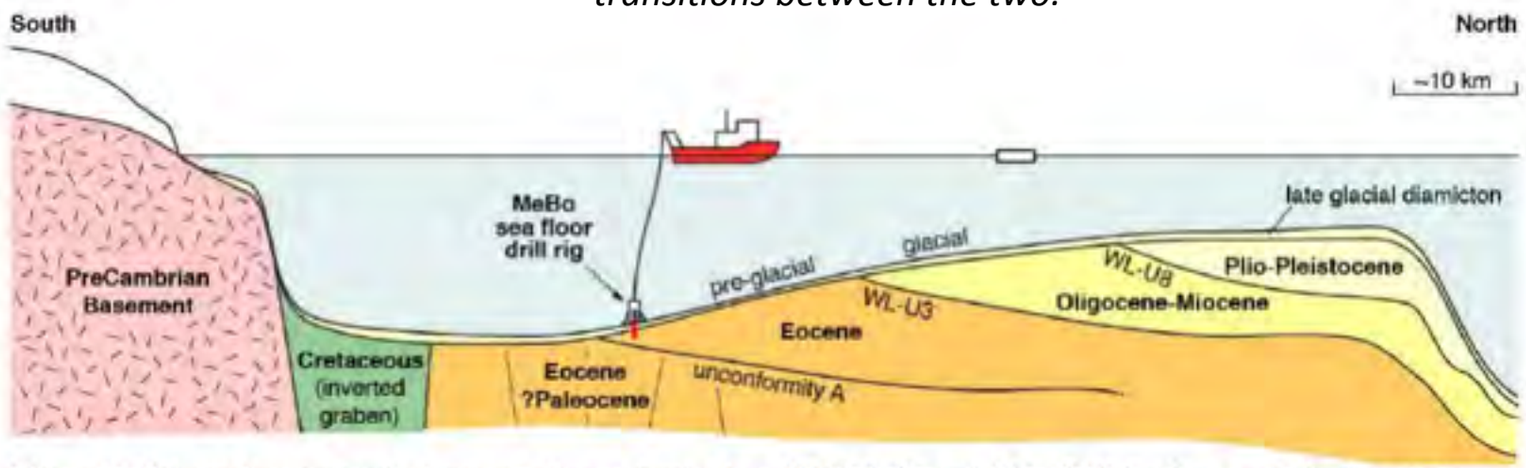
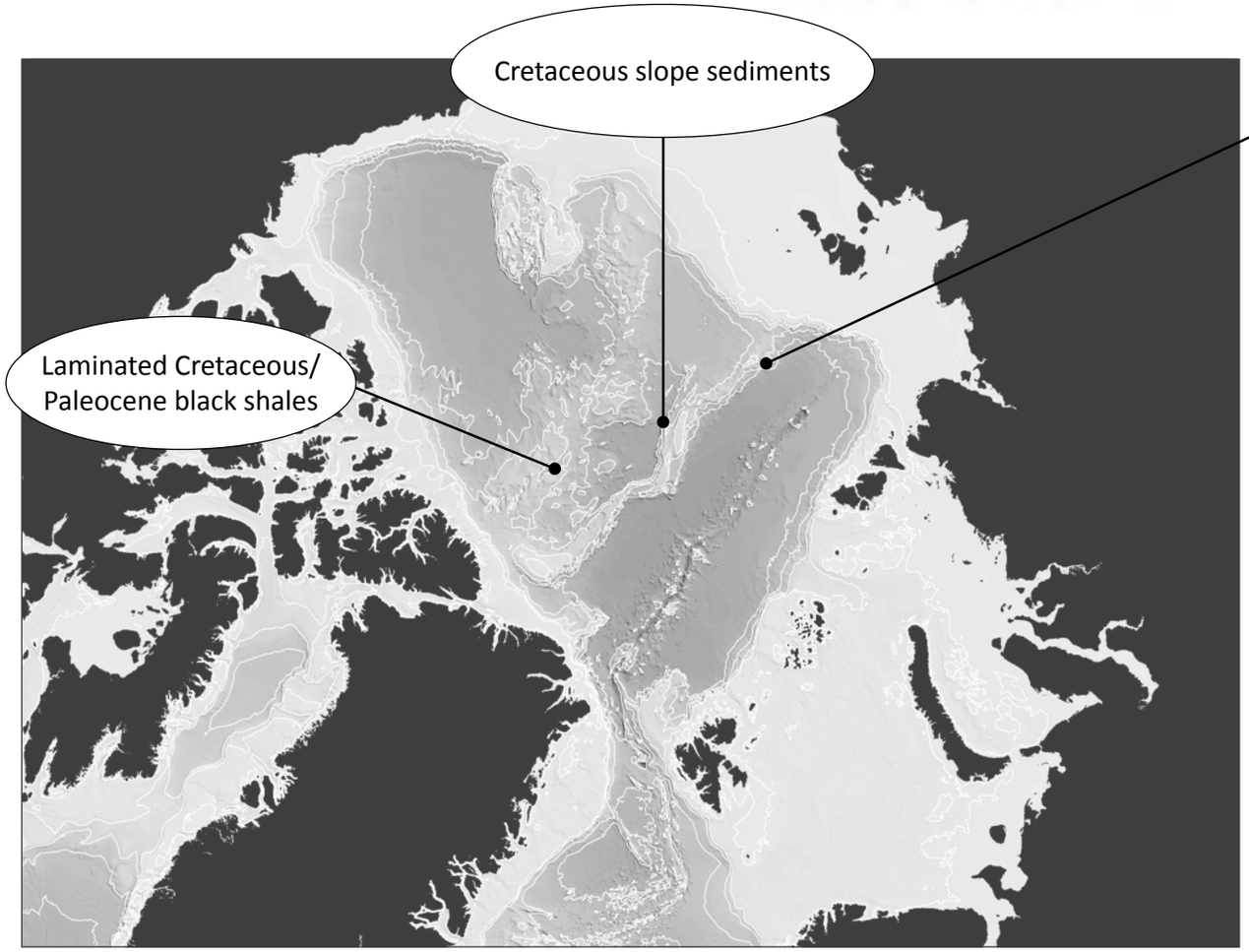
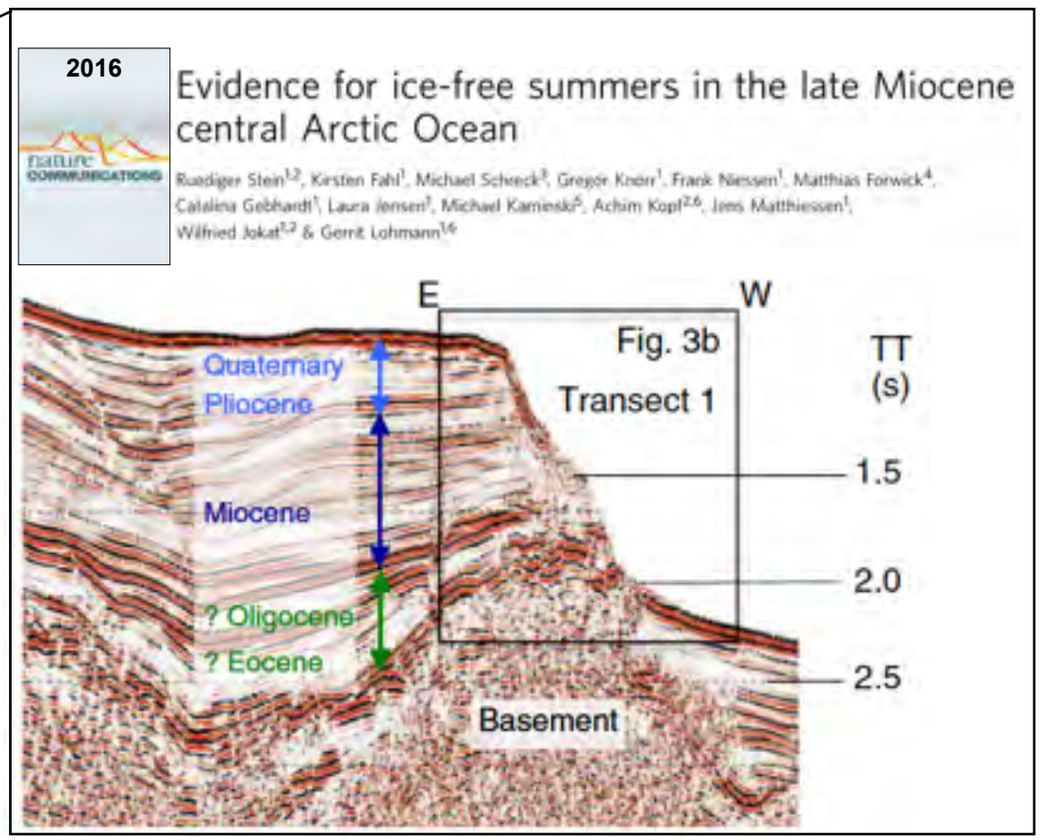


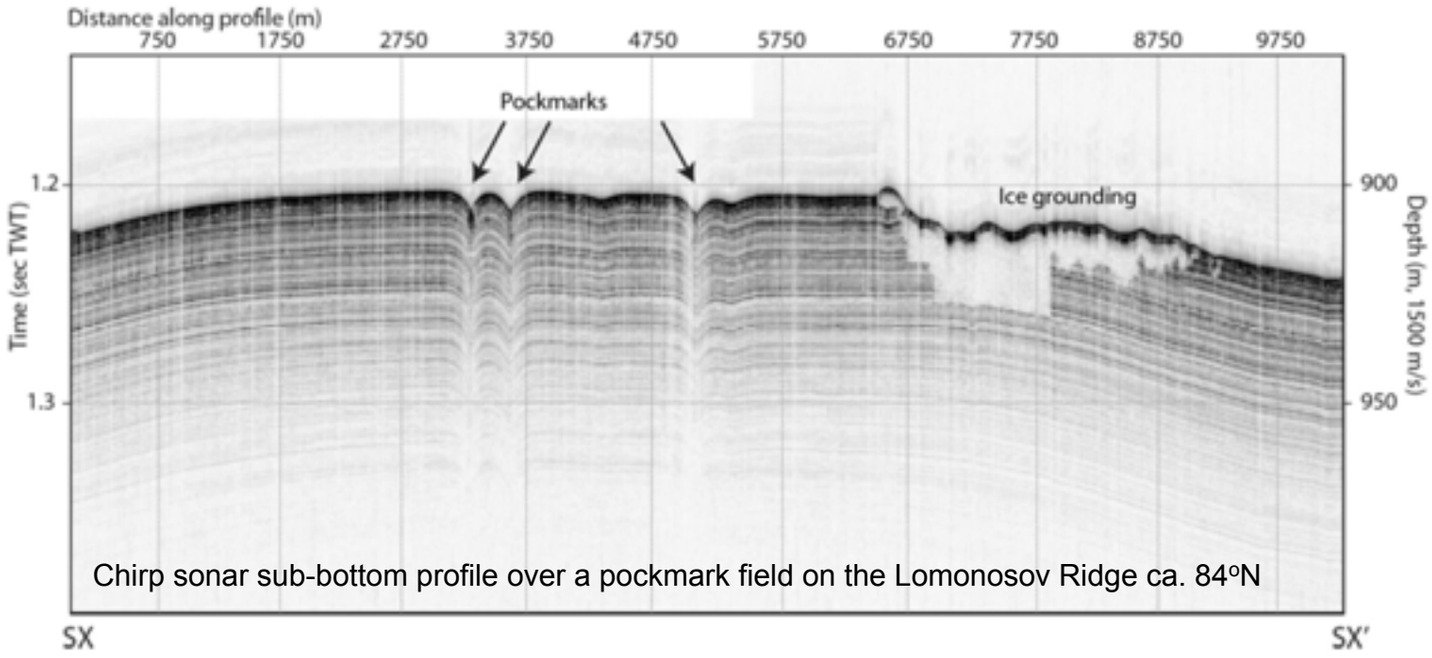
Figure 2. Schematic composite transect along seismic lines WEGA-02 and IFP-103/107. Seaward-dipping strata mean younger sediments are found on the outer shelf, and older sediments are found in the inner shelf. Vessel and MeBo rig not to scale.





Alternate Approaches

2. Continuous Recovery of Shallow - (but critical) - Targets



Chirp sonar sub-bottom profile over a pockmark field on the Lomonosov Ridge ca. 84°N

Estimated Depths of Epoch Boundaries

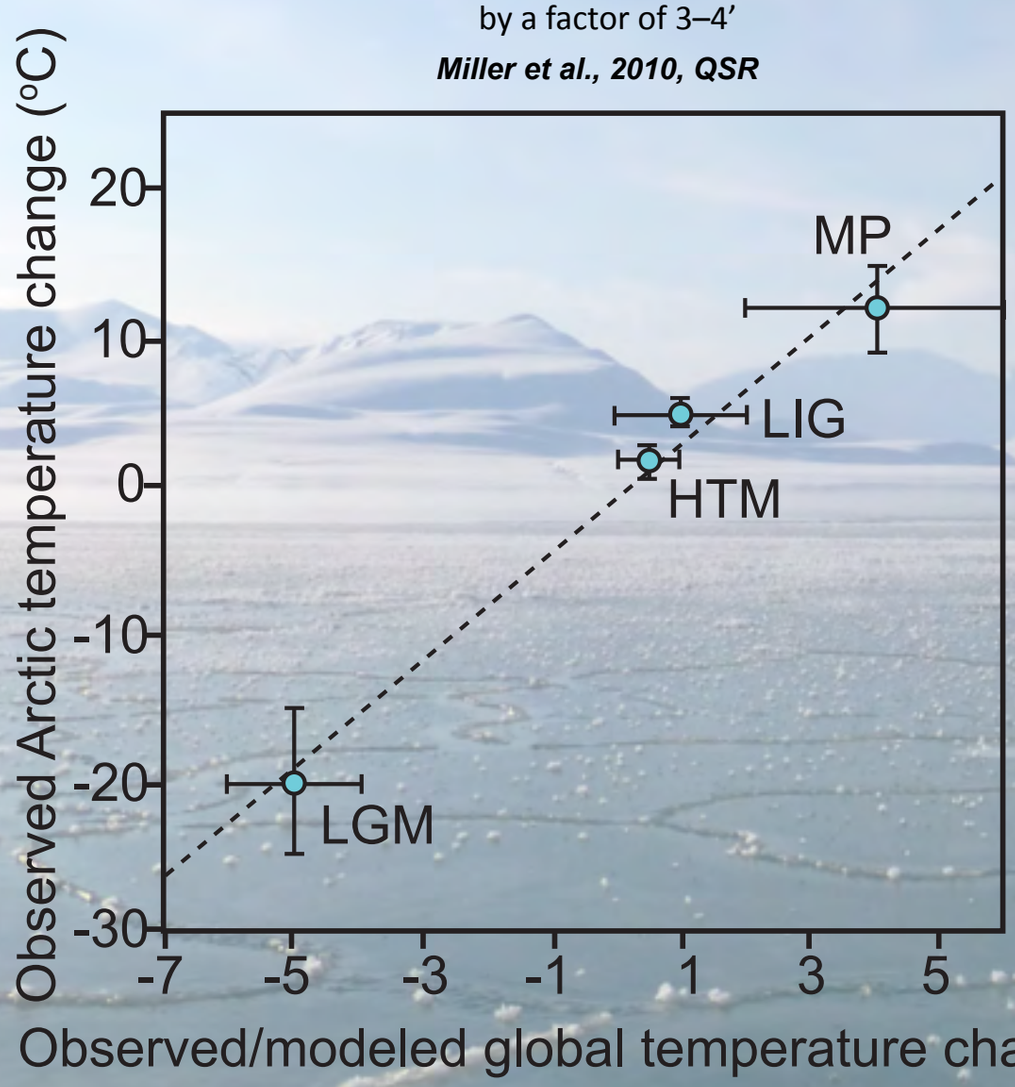
Epoch	Depth (m) at 1 cm/ka	Depth (m) at 2 cm/ka
Quaternary	25.8	51.6
Pliocene	53.5	106.6

!!!Shallow sediments were not well recovered on ACEX, with complete (overlapping) recovery in the the upper 19 m**!!**

Polar Amplification and Sea Ice

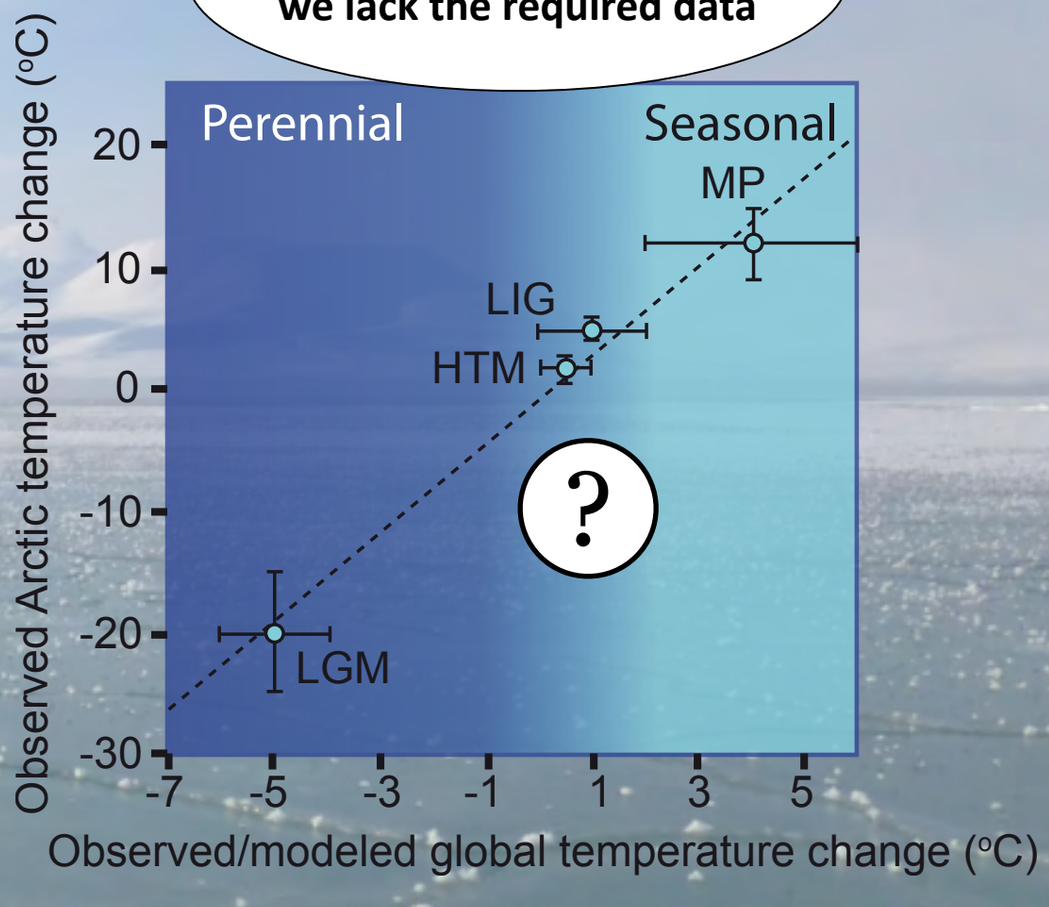
'Arctic temperature change
consistently exceeds the Northern Hemisphere average
by a factor of 3–4'

Miller et al., 2010, QSR



?

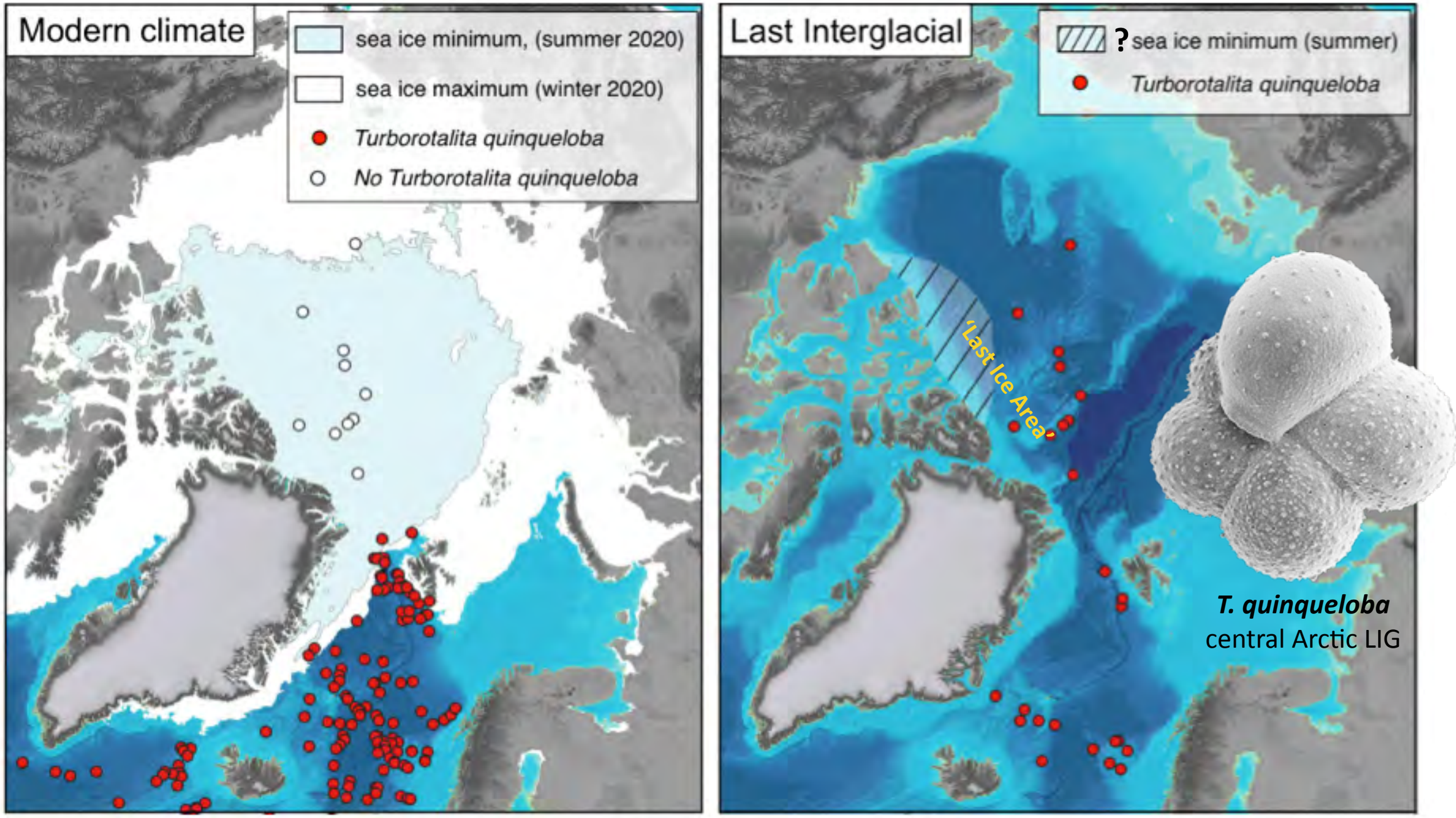
This is conceptual because we lack the required data



Arctic amplification: can the past constrain the future?

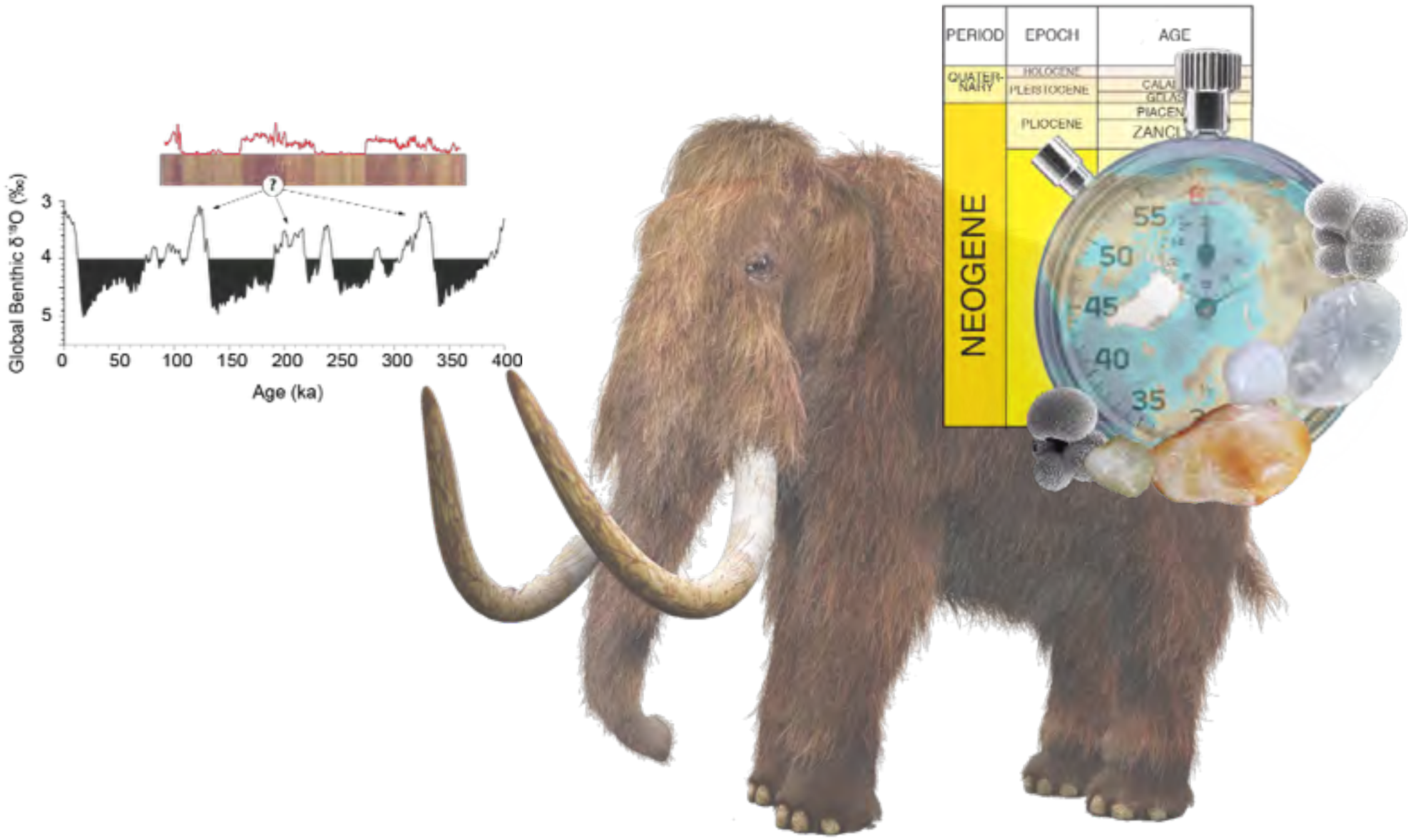
Gifford H. Miller[a,*], Richard B. Alley[b], Julie Brigham-Grette[c], Joan J. Fitzpatrick[d], Leonid Polyak[e], Mark C. Serreze[f], James W.C. White[a]

Thresholds in the Past . . .



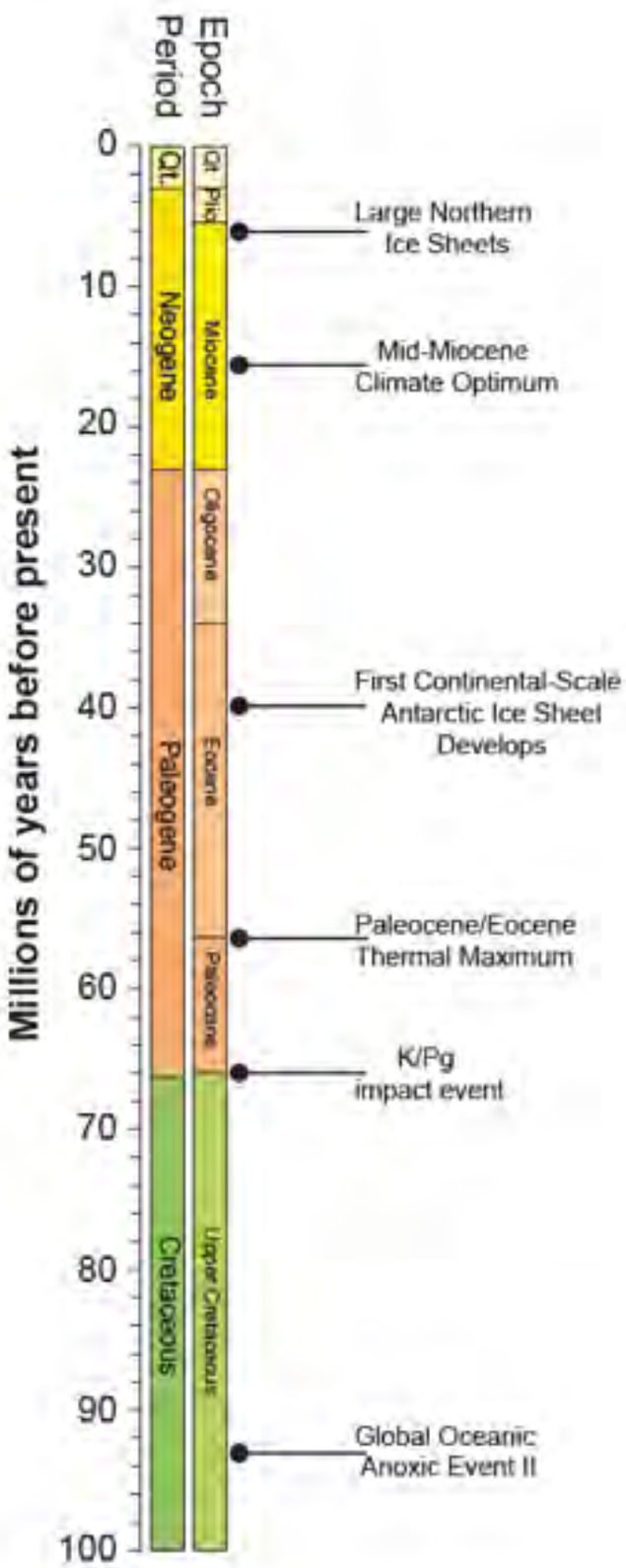
Flor Vermassen, Stockholm University, in review

The Elephant in the Room . . .



. . . Maybe 50+ years of ‘age uncertainty’ is not an impediment to drilling - but the foremost scientific question.

Connections in the '*Climate Factory*' Transcend Timescales



2014 nature geo

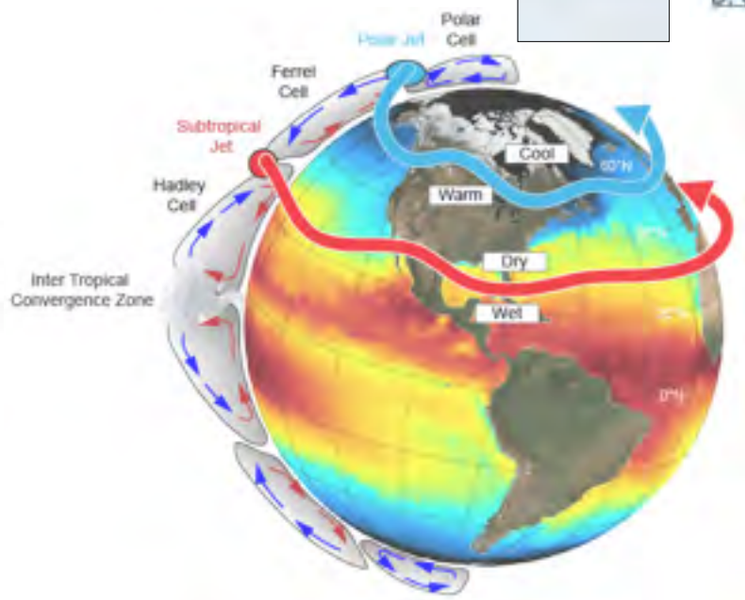
Recent Arctic amplification and extreme mid-latitude weather

Judah Cohen, James A. Screen, Jason C. Furtado, Mathew Barlow, David Whittleston, Dim Coumou, Jennifer Francis, Klaus Dethloff, Dara Entekhabi, James Overland & Justin Jones

2018 nature communications

The influence of Arctic amplification on mid-latitude summer circulation

D. Coumou, G. Di Capua, S. Vavrus, L. Wang & S. Wang



2019 nature climate change

CLIMATE DYNAMICS

Midlatitudes unaffected by sea ice loss

John C. Fyfe

2022 comms earth

Asian monsoon intensity coupled to Antarctic climate during Dansgaard–Oeschger 8 and Heinrich 4 glacial intervals

Yi-Jia Liang, Shi-Tao Chen, Yong-Jin Wang, Kan Zhao, Shao-Hua Yang, Zhen-Jun Wang, Yu-Zheng Huang, Hai Cheng & R. Lawrence Edwards

2018 nature communications

Late Miocene climate cooling and intensification of southeast Asian winter monsoon

Ann E. Holbourn, Wolfgang Kuhnt, Steven C. Clemens, Karlos G. D. Kochhann, Janika Jöhnck, Julia Lübbers & Nils Andersen

2021 nature geo

Hydrological impact of Middle Miocene Antarctic ice-free areas coupled to deep ocean temperatures

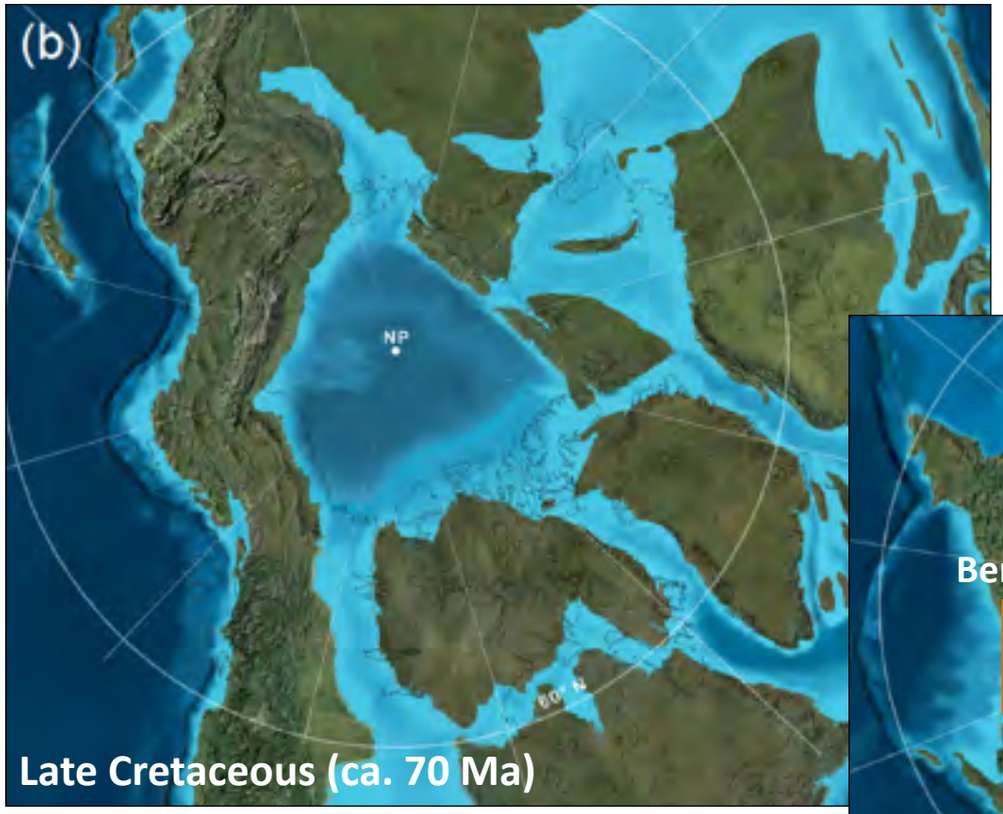
Catherine D. Bradshaw, Petra M. Langebroek, Caroline H. Lear, Daniel J. Lunt, Helen K. Coxall, Sindia M. Sosdian & Agatha M. de Boer

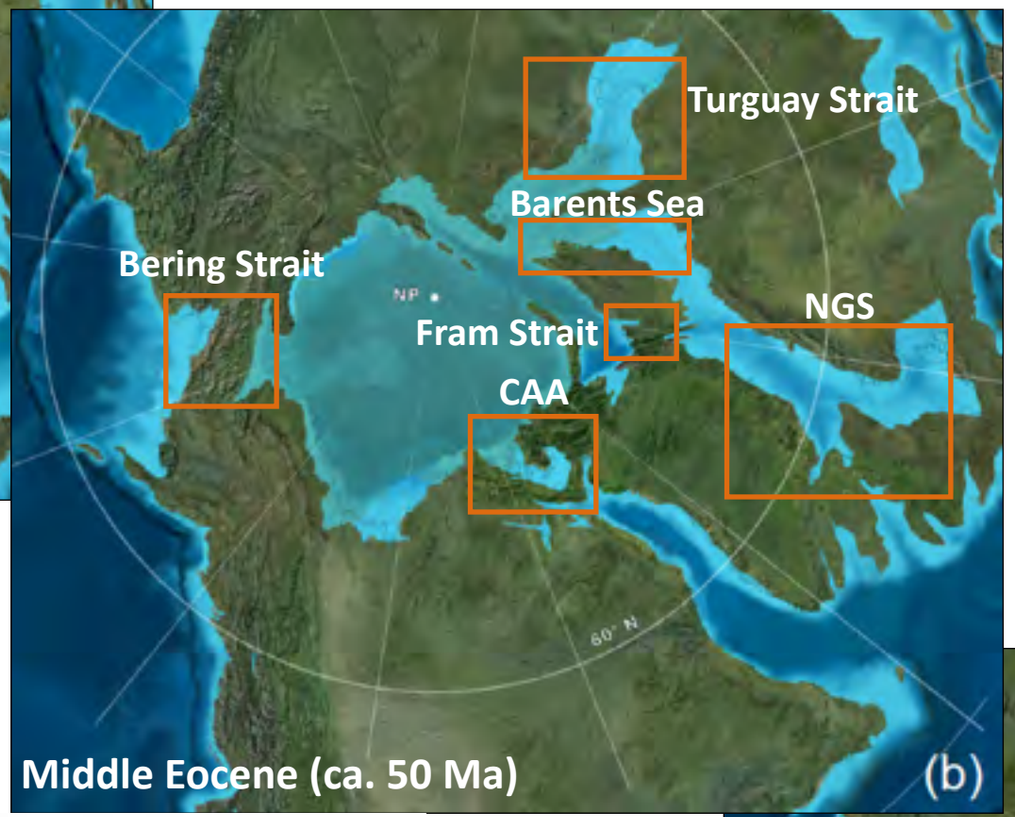
2020 nature communications

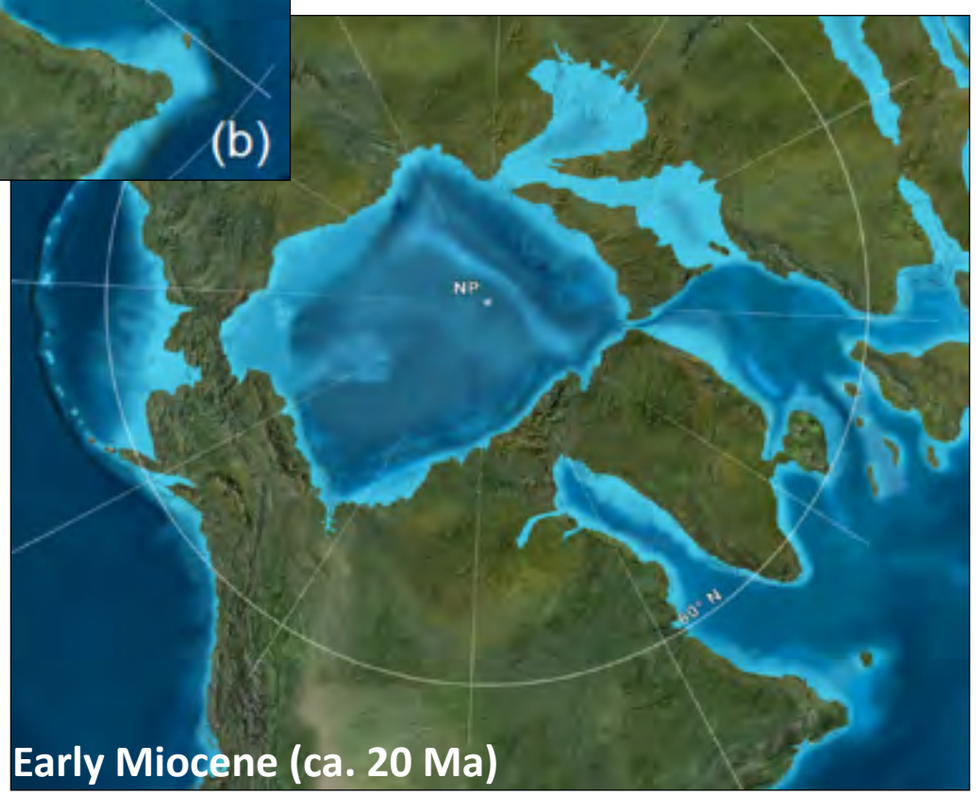
High-latitude biomes and rock weathering mediate climate–carbon cycle feedbacks on eccentricity timescales

David De Vleeschouwer, Anna Joy Drury, Maximilian Vahlenkamp, Fiona Rochholz, Diederik Liebrand & Heiko Pälike

Tectonics, Paleogeography and Ocean Circulation







2019

https://doi.org/10.1038/s41467-019-13828-x OPEN

Arctic closure as a trigger for Atlantic overturning at the Eocene-Oligocene Transition

David K. Hutchinson[1], Helen K. Coxall[1], Matt O'Regan[1], Johan Nilsson[2], Rodrigo Caballero[2] & Agatha M. de Boer[1]

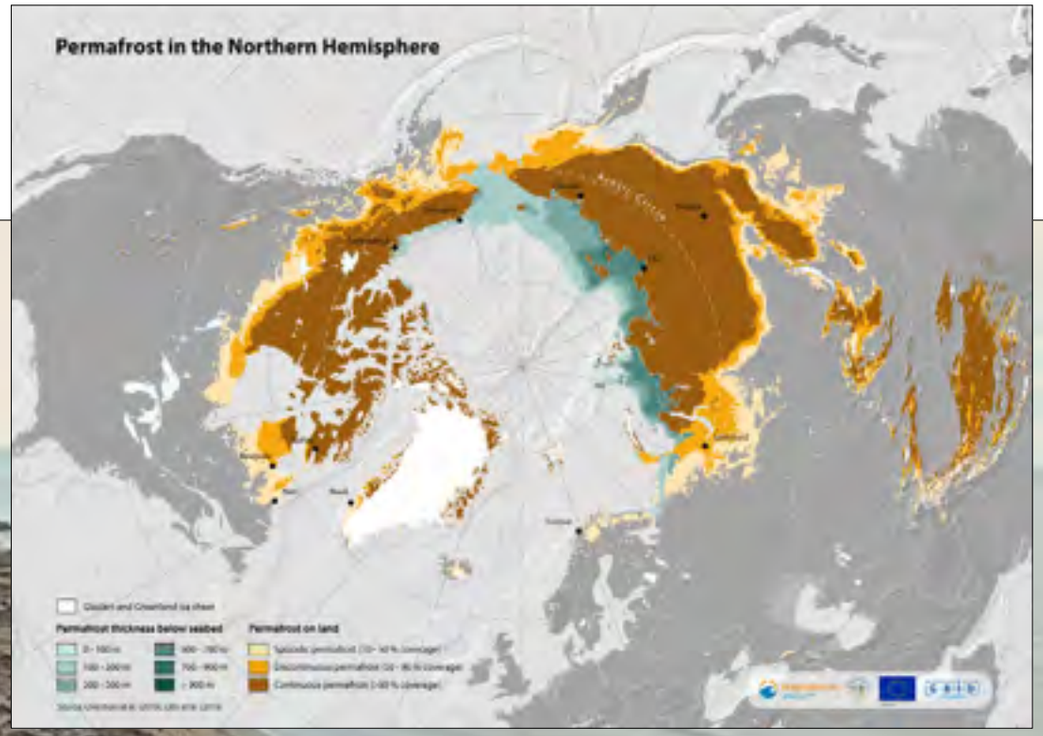
2018

Closure of the Bering Strait caused Mid-Pleistocene Transition cooling

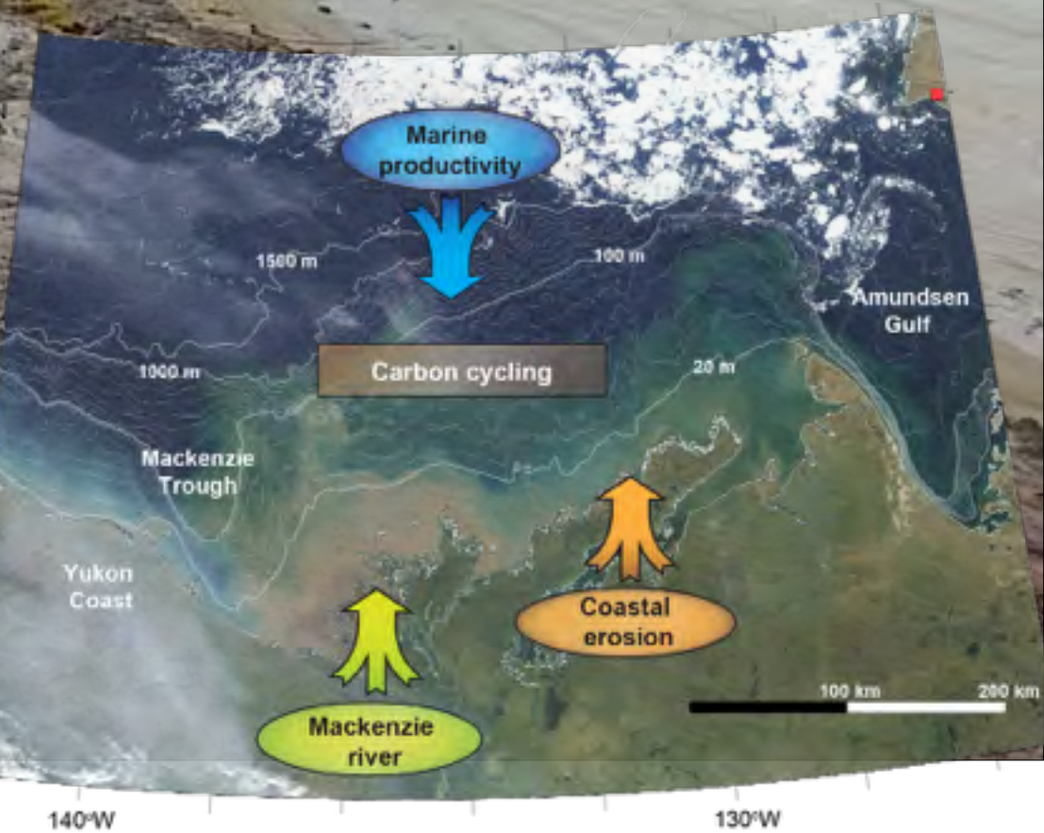
Sev Kender, Ana Christina Ravelo, Savannah Worne, George E. A. Swann, Melanie J. Leng, Hirofumi Asahi, Julia Becker, Henrieka Detlef, Ivano W. Aiello, Dyke Andreasen & Ian R. Hall

Blakey, Paleotectonic and paleogeographic history of the Arctic region. *Atlantic Geology*, 5**7**, 7–39 (2021)

Terrestrial-Marine Carbon Dynamics



Source: www.grida.no/resources/13519



Drone footage from the Beaufort Sea Coast. **Image: Dustin Whalen, GSC-Atlantic/NRCan**

2022

Deglacial release of petrogenic and permafrost carbon from the Canadian Arctic impacting the carbon cycle

Junjie Wu, Gesine Mollenhauer, Ruediger Stein, Peter Köhler, Jens Hefter, Kirsten Fahl, Hendrik Grotheer, Binghing Wei & Seung-Il Nam

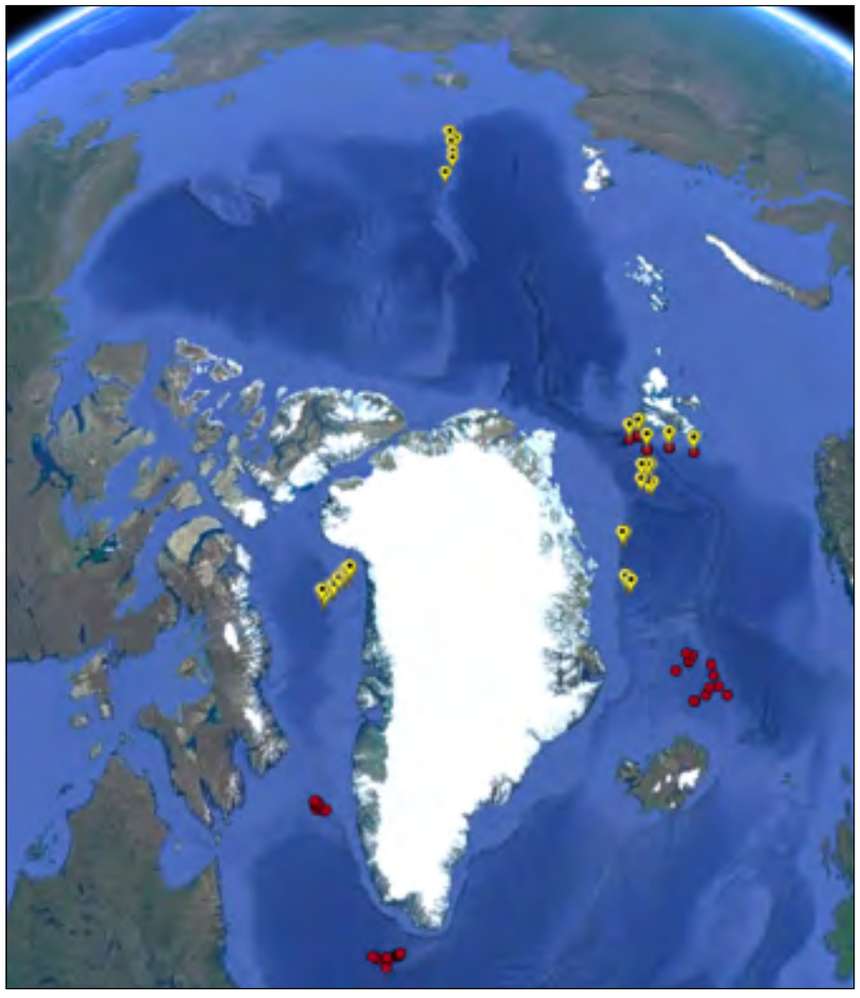
2020

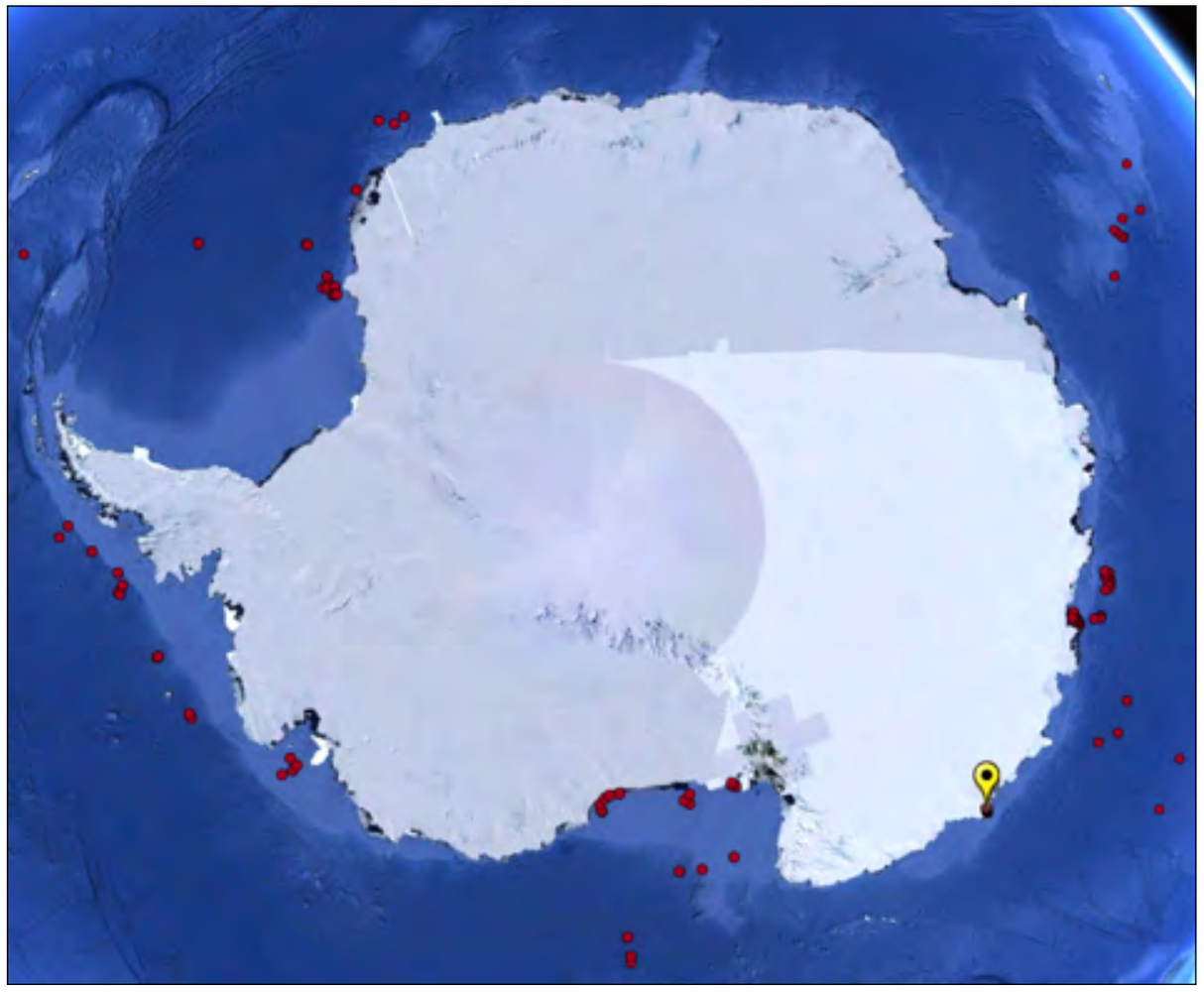
Remobilization of dormant carbon from Siberian-Arctic permafrost during three past warming events

Jannik Martens[1,2]*, Birgit Wild[1,2], Francesco Muschitiello[3,4], Matt O'Regan[2,5], Martin Jakobsson[2,5], Igor Semiletov[6,7,8], Oleg V. Dudarev[6], Örjan Gustafsson[1,2]*

Final Remarks . . .

- There are a lot of exciting planned (yellow) and proposed (red) drilling sites in the polar regions that address central themes in high latitude ice sheet evolution and ocean circulation.





- However achieving many of the high level goals set by the 2050 Science Framework requires increased scientific drilling activity in the Arctic. This begins with a renewed effort to develop feasible drilling proposals that acknowledge the cost and logistical challenges of working in sea ice.

End

View from CCGS Amundsen, Northern Banks Island, Canadian Beaufort Sea, September 2021.