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Super Interglacials and persistent warmth paced Arctic Climate Evolution over the Past 3.6 Myr: Lake El'gygytgyn, Western Beringia, a new polar lens focused on high latitude environmental change

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The Pliocene-Pleistocene climate evolution of the Arctic must have modulated the glacial history of Greenland and the onset of Northern Hemisphere glaciation. Yet what is known from the terrestrial stratigraphy of Arctic climate change comes from sites that are spatially and temporally fragmented. In 2009, International Continental Deep drilling at Lake El'gygytgyn (67o30' N, 172 o 05' E) recovered lacustrine sediments dating back to 3.58 Ma that now provide the first time-continuous Pliocene-Pleistocene Arctic paleoclimate record of alternating glacial-interglacial change. The warmest/wettest Pliocene interval of the lake record occurs from ∼3.58-3.34 Ma and is dominated by exceptional tree pollen implying July temperatures nearly 7-8o C warmer than today with nearly ∼3 times the annual precipitation. Atmospheric CO_2 levels are estimated to have been 360 to 400 ppm implying exceptionally high climate sensitivity and polar amplification. In fact, pollen spectra and modern analog analysis show an unbroken persistence of summers much warmer and wetter than the last interglacial, MIS 5e until nearly 2.2 Ma. Extreme warmth in the Mid Pliocene Arctic occurs at the same time ANDRILL results suggest the West Antarctic Ice Sheet was non-existent. Modeling sensitivity experiments using 300 and 400 ppm CO_2 are consistent with sustained forests at Lake El'gygytgyn during this interval and restricted glacial ice over Greenland in both cold and warm boreal summer orbits especially for the PRISM interval. This has implications for reinterpreting the M2 isotopic shift in the North Atlantic suggesting that most of the ice advance at that time was in Antarctica.

Using physical, chemical, and biological proxies we find pronounced glacial episodes commenced ∼2.6 Ma ago, but the full range of typical Pleistocene glacial/interglacial change wasn't established until ∼1.8 Ma ago. Greenland must have also responded to numerous "super interglacials" during the Quaternary record, with maximum summer temperatures and annual precipitation, especially during MIS 9,11 and 31, at Lake El'gygytgyn exceeding that documented for MIS 5e. The correspondence of many of these super-interglacials with retreat of the West Antarctic Ice Sheet (Naish et al. 2009) could coincide with intervals when the Greenland Ice was reduced in size. The climate record from Lake El'gygytgyn, especially the history of past interglacials, provides a fresh means of testing the evolving magnitude of polar amplification over time, and the sensitivity of the Greenland Ice Sheet to extreme warmth in the rest of the Arctic.