American Geophysical Union Fall Meeting, Washington, DC, Dec 10-14, 2018

Monthly temperature reconstruction for a ~3,000 year-old Arctic site using fossil wood

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There is no place on Earth where the seasonal influence of temperature is more important than in Arctic regions. Information on warming, however, is limited to only the most recent decades, and therefore incompletely captures the full context of seasonal climate change in this region. Here we present a reconstruction of seasonal temperature during the Holocene using high-resolution oxygen isotope ($\delta^{18}O$) measurements of cellulose extracted from fossil wood. The wood, radiocarbon dated to 2,840 to 2,890 ^{14}C BP, was collected from an outcrop at Duvanny Yar located along the Kolyma River in far northeastern Siberia. This outcrop represents one of the most studied exposures of late Pleistocene through Holocene sediments in northeastern Siberia, and is an ideal stratigraphic deposit for interpreting pre-industrial Arctic climate.

Annual growth rings identified in the wood specimens were subdivided by hand at sub-millimeter resolution and cellulose was extracted from each sub-sample for determination of $\delta^{18}O$ value. Samples showed a quasi-periodic change in $\delta^{18}O$ value through each growth year similar to patterns observed in modern conifers from other high-latitude and Arctic sites. From these data we quantified cold month and warm month mean temperatures (CMMT and WMMT) using a previously published model (Schubert and Jahren, 2015, *QSR*, 125: 1-14). By assuming a normal distribution for monthly temperatures across the year (as seen in the modern Arctic) and our estimates of CMMT and WMMT, we quantify that growing season length (i.e., days with mean temperatures > 0 ^{o}C) was ~40% shorter during the Holocene (~3 ka) compared with today (1980-2012). The lengthening growing season has important implications for the carbon balance in Arctic regions, though changes in primary production, surface albedo, and ecosystem respiration, and suggests potential for the terrestrial Arctic to transition from a carbon sink into a carbon source, contributing to additional warming.