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Peatland Carbon Dynamics on the North Slope of Alaska During the Holocene: The Role of Climate, Sea Ice, and Buried Peat

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Our recent and ongoing data syntheses indicate that peatlands accumulated more carbon (C) during past warm climate intervals in the circum-Arctic region, including Alaska. In particular, peak C accumulations have been observed during the Holocene Thermal Maximum (HTM) in the early Holocene when summer insolation was higher. However, we do not know the regional patterns and impacts of sea-ice change on Holocene peat C accumulation, especially around the Arctic Ocean where increased vegetation productivity has already been linked to sea ice declines in recent decades. Here we review Holocene peatland and tundra C accumulation records on the North Slope, along with our preliminary results, to investigate spatiotemporal pattern of C accumulation and the possible role of sea-ice change. As in many other northern high-latitude regions, most peatlands on the North Slope initiated in the early Holocene. Several discontinuous and low-resolution peat accumulation records from the region appear to show high accumulation rates or high C content in the early Holocene. In addition, we note that many peatlands that existed during the earlier Holocene on the North Slope have disappeared and are presently covered by mineral soils under tundra or eolian sandy deposits, indicating that current peatland extent is only a fraction of early Holocene extent. In contrast to highest C accumulation rates in the early Holocene, our preliminary results from a 70-cm-long peat core (lat. 70.71 N; long. 153.87 W) from northwest Teshekpuk Lake, near the Teshekpuk Lake Observatory on the Arctic Coastal Plain, about 10 km from the Arctic Ocean, shows a very different pattern. The highest C accumulation of 12.7 gC/m2/yr is observed after 2.9 ka, much higher than the rate of 3.8 gC/m2/yr at 8.1-2.9 ka. Furthermore, the period with high C rates after 2.9 ka at this site was dominated by well-preserved peat mosses (Sphagnum) and with abundant leaf fragments, likely from dwarf birch (Betula nana). This thick peat sequence was formed in an ice wedge polygonal trough at ∼8 ka, suggesting localized but potentially widespread prolonged peat accumulation in these landscape elements that were vulnerable to degradation, thaw subsidence, and wetting since the HTM, and then peat growth was accelerated in the late Holocene. We hypothesize that the multitude ecological changes in the late Holocene were in response to regional climate warming caused by the reduction in sea-ice cover in the Chukchi Sea (de Vernal et al. 2013, QSR 79: 111-121), just off the coast of northern Alaska. If our observations from northern Alaska are also applicable to other high-latitude regions, our findings have important implications for understanding the role of peatlands in the global C cycle in the past (buried peat) and future (feedback from sea-ice reduction).