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Subsurface Organic Carbon in Arctic Floodplains: Stocks and Dynamics

YUTIAN KE[1], A. JOSHUA WEST[2], M. ISABEL SMITH[2], EMILY C GEYMAN[1], HANNAH DION-KIRSCHNER[1], JOHN S. MAGYAR[1], JOSHUA SOMTOCHUKWU ANADU[1], MICHAEL P. LAMB[1] AND WOODWARD W. FISCHER[1]

[1]California Institute of Technology
[2]University of Southern California
Presenting Author: yutianke@caltech.edu

Permafrost deposits host the single largest soil organic carbon (OC) pool on Earth, representing more than two times the present carbon stock of either the atmosphere or terrestrial vegetation. Floodplains are key places where lateral carbon fluxes are particularly dynamic—OC can accumulate, erode, and/or degrade quickly due to river migration. Yet the magnitude and cadence of subsurface OC cycling in Arctic floodplains remains poorly constrained, contributing to significant uncertainty in forecasting future atmospheric CO_2. Here we present a large suite of new measurements that constrain OC stocks, fluxes, and reactivities in discontinuous permafrost floodplains in sites across the Yukon River Basin in Alaska. We collected and analyzed 500 soil and sediment samples from exposed banks and bars of the Koyukuk River near Huslia and the Yukon River near Beaver. Our study employed a combination of elemental carbon content and geophysical analyses to investigate carbon stocks and how they change over time using a space-for-time approach examining floodplain terrains with a continuum of ages over the Holocene. We used ramped pyrolysis/oxidation, stable and radiogenic isotopic carbon analysis to constrain OC degradation rates. Our results show that while OC degrades predictably as t^{-1} within point bar deposits (e.g. OC tends to decay faster in newly-formed point bars compared to older terrains), overall subsurface OC stocks accumulate continuously over time due to the accumulation of overbank mud and dead plant biomass, with the result that the OC stocks in mature floodplain deposits are approximately two times larger than those in fresh point bars. There is some indication that river migration rates may accelerate in the future as permafrost becomes less common in these landscapes. Our results suggest that higher river migration rates could lead to a net export of carbon from subsurface deposits in Arctic river floodplains.