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A sediment budget approach to quantify sediment fluxes and organic carbon mobilisation in an Arctic catchment

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High Arctic erosion processes coupled with physical and chemical mobilisation of abundant soil organic carbon (SOC) stocks may play a critical role in driving Arctic biogeochemical cycles. The role of internal catchment dynamics such as detachment, transport, and colluvial/alluvial storage in controlling the generation, recycling, and export of sediment and SOC is poorly understood. We formulate a sediment and carbon budget for the 8140 km² Alaskan Kuparuk Catchment using a 1985-2017 Landsat NDVI imagery record to delineate bank erosion and Google Earth™ to map landslide events. We calculate: 1) average inputs of sediment by alluvial bank erosion and landslides (including active layer detachments and thaw slumps), 2) transport fluxes from landslide deposits by spatially modelling fluvial transport capacity, and 3) total outputs from a record of suspended sediment collected at the catchment outlet. We calculate carbon export by estimating carbon erosion using the concentration of SOC as calculated by the Northern Circumpolar Soil Carbon Database. Alluvial bank erosion ($0.6 \pm 0.12 \text{ Tg yr}^{-1}$) exceeded catchment sediment yield by an order of magnitude (0.06 Tg yr^{-1}), demonstrating that recycling of sediment between floodplains, bars, and channels dominates the sediment budget of this catchment. Landslides are the dominant input of new sediment to the system, contributing 11 Tg of sediment (17 Tg including channel-disconnected). When considering the average export rate from transport-limited landslide deposits, this flux (between 0.008 and 0.4 Tg yr^{-1}) is in near equilibrium with the average annual flux from the catchment (0.06 Tg yr^{-1}). SOC inputs from bank erosion (932 t yr^{-1}) explained the majority of estimated $1505 \pm 114 \text{ t yr}^{-1}$ POC outputs. Our work demonstrates that the annual erosion and redeposition of sediment in Arctic permafrost catchments greatly exceeds net export. Current measurements of sediment fluxes in a warming Arctic considerably underestimate total sediment and SOC mobilisation from carbon rich active layers.