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Sonde profiling reveals mixing and transport influences on water quality monitoring along the Yukon River, Canada

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Northern rivers integrate and transport chemical constituents from watersheds experiencing rapid changes in surface processes, including glacier loss, permafrost degradation, and intensifying wildfires. Northern fieldwork logistics limit water quality monitoring to sparsely situated fixed-stations, with practitioners often collecting single-bank grab-samples. However, physicochemical transformations and mixing during riverine transport can profoundly influence grab-sample representativity and estimates of physical and chemical weathering fluxes from landscape to ocean. Sonde profiling can offer substantial insight into mixing processes in particular, but has rarely been utilized in remote northern settings. We used watercraft-mounted sondes to track turbidity and conductivity across and along a 530 km reach of the Yukon River at high (August 2022) and intermediate discharge (September 2023) while grab-sampling for total suspended sediment (TSS), total dissolved solids (TDS), and total organic carbon (TOC). Opposite-bank concentrations differed by up to 160% for TSS, 49% for TOC, and 64% for TDS below large confluences. Mixing occurred gradually over 49–275 km due to the Yukon River's wide, shallow, and braided channel morphology, low momentum-flux contrasts, and density stratification between tributaries draining geochemically distinct watersheds. Longitudinally, TDS was transported conservatively (<15% variance). In contrast, mainstem fluxes varied up to 116% for TSS and 28% for TOC due to erosion, deposition, and density-stratification. Sonde profiling helped illuminate mixing and transport processes and can reduce uncertainty in land-to-ocean flux estimates in large, data-scarce rivers facing accelerating environmental change.