Surface Water Biogeochemistry Across Thawing Permafrost in Northwestern Alaska

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Thawing of ice-rich permafrost deposits in the Arctic mobilizes carbon, nitrogen, and trace metals into surface waters. As a consequence, the biogeochemical characteristics of ponds, lakes, streams, and coastal waters are changing in ways that can influence aquatic productivity, greenhouse-gas emissions, and water quality. These shifts affect aquatic ecosystems and also have implications for local communities that depend on aquatic resources. As permafrost thaw is accelerating under rapid Arctic warming, understanding spatial differences in surface water chemistry across the landscape, along with their relation to geomorphological setting and their spatio-temporal dynamics, can provide important insights into the hydrological and biogeochemical processes related to permafrost degradation within the contributing catchments.

As part of interdisciplinary fieldwork focused on permafrost-ecosystem interactions in northwestern Alaska from 2022 through 2025, we conducted extensive water sampling campaigns on the Baldwin and Seward peninsulas. Sampling locations included sites visibly impacted by recent, rapid permafrost thaw, such as thermokarst features, thaw slumps, and thermo-erosional gullies as well as sites that appear undisturbed based on their current surface expression or that have no ice-rich permafrost. The multi-year sampling design across environmental, permafrost, and surface geology gradients and disturbance types enables comparisons across varying disturbance intensities and landscape settings. The collected water samples were analysed for pH, electrical conductivity (EC), dissolved organic carbon (DOC), total dissolved nitrogen (TDN), the absorption of coloured dissolved organic matter (CDOM), stable water isotopes ($\delta^{18}O$, δD), and major ions, providing a valuable baseline dataset to characterize hydrochemical variability.

Our analyses aim to identify patterns that distinguish thaw-impacted from undisturbed sites, to explore potential linkages between catchment features and water chemistry, and to evaluate how different types of permafrost disturbance manifest in aquatic systems. The presentation will provide a first overview of spatial variability and spatio-temporal development and offer a preliminary interpretation of the results in the context of ongoing permafrost thaw, with emphasis on its implications for hydrological connectivity, material fluxes, and Arctic freshwater ecosystems and future trajectories.