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Hydrologic and biogeochemical significance of perennial thaw zones in degrading permafrost

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Studies spanning arctic and boreal regions provide observations and physically-based models describing the deepening of the active layer in response to climate warming. A growing number of data and model-based studies document the development of perennial thaw zones, or supra-permafrost taliks, below the depths of seasonal ice as the next stage in top-down permafrost thaw evolution. Discerning the presence and movement of water (or lack thereof) in these actively thawing zones and their hydraulic connectivity are of high interest as these hydrologic characteristics affect biogeochemical cycling and the lateral transport of dissolved constituents, including organic carbon, released from permafrost. The strength of the permafrost-carbon feedback, for example, is critically dependent on coupled hydrologic and biogeochemical processes in shallow thawed zones. Our recent examination of soils in interior Alaska, USA, reveals a larger potential yield of dissolved organic carbon (DOC) and total dissolved nitrogen (TDN) from near-surface Holocene permafrost soils upon thaw than previously recognized. In parallel, cryohydrogeologic modeling and geophysical observations in these settings suggest that perennial thaw zones may be more prevalent than previously thought. All lines of evidence suggest that more attention toward lateral hydrologic transport of permafrost DOC and TDN is warranted in expanding the typical one-dimensional view of the permafrost-carbon feedback. While side-by-side comparison of hydrology and biogeochemistry studies in permafrost systems help construct critical conceptual building blocks, advances in more fully integrated approaches are needed toward quantitatively constraining current and projected lateral hydrologic export of aqueous constituents, including DOC and TDN, influenced by thawing permafrost. Material presented here from site-based research in Alaska describes necessary steps toward such advances.