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Isotopic constraints on water balance of tundra lakes and watersheds affected by permafrost degradation, Mackenzie Delta region, Northwest Territories, Canada

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Widespread permafrost thaw in Canada's western Arctic has led to formation of shoreline retrogressive thaw slumps (SRTS), a process influential in modifying water and biogeochemical balances of tundra lakes. To investigate hydrological effects of SRTS, water sampling campaigns were conducted in 2004, 2005 and 2008 for paired lakes (pristine vs catchments disturbed by SRTS) in the upland region adjacent to the Mackenzie Delta, Northwest Territories, Canada. An isotope balance model to estimate evaporation/inflow, precipitation/inflow, water yield and runoff ratio was developed incorporating seasonal evaporative drawdown effects and a vapour mixing model to simulate gradients in Beaufort Sea marine air versus continental moisture sources. Site-specific water balance results reveal systematically higher evaporation/inflow and precipitation/inflow for lakes with active SRTS compared to undisturbed lakes, and typically higher ratios for lakes with stabilized versus active SRTS. For lake catchments, water yield is found to be higher for active SRTS sites compared to undisturbed and stabilized SRTS sites, suggesting that slumping is an initial but not a sustained source of water delivery to lakes. Catchments with history of wildfire are found to have lower water yields, attributed to reduced permafrost influence. Conceptually, we define a thaw trajectory whereby undisturbed sites, active SRTS, stabilized SRTS, and ancient- SRTS define progressive stages of permafrost thaw. We postulate that release of additional runoff is mainly due to permafrost thaw in active SRTS which also promotes lake expansion, talik formation, and subsurface connectivity. Eventual stabilization of slumps and reduced runoff is expected once permafrost thaw sources are exhausted, at which time lakes may become more reliant on replenishment by direct precipitation. The effect of snow catch in slumps appears to be subordinate to thawing based on eventual decline in runoff once thaw slumps stabilize. Improved, site-specific hydrologic understanding will assist ongoing research into carbon cycling and biogeochemical feedbacks.