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Landscape Controls on the Hydrological Variability of Thermokarst Lakes between Inuvik and Tuktoyaktuk, NWT

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The Arctic is warming at twice the rate of the rest of the world, causing precipitation to shift from snowfall to rainfall, permafrost to thaw, longer snow-free land and ice-free lakes, and increased evaporation. Thermokarst lakes across the Arctic have experienced different changes over the past decades: in some regions, lakes are expanding through thawing adjacent permafrost, while in other regions they are drying up and shrinking, or not changing at all. It is important to understand what governs lake water balance as it affects lake ecosystems that support large populations of migratory birds and fish; are important to local communities for food and recreation; and control the flux of carbon and other nutrients from thawing permafrost into lakes. For example, lake inflow, evaporation and water residence time affect the concentration of nutrients within lakes, ultimately affecting the aquatic ecosystem and greenhouse gas release. Previous research has focused on quantifying the water inputs and outputs of individual lakes, but a better understanding of the drivers and processes controlling lake water balances is required to understand how they will respond to a changing climate.

We measured lake water flux components at multiple spatial and temporal scales across the 5000 km^2 boreal – tundra transition zone between Inuvik and Tuktoyaktuk, Northwest Territories, Canada. Lake water flux components were measured at two adjacent thermokarst lakes with different ratios of lake area to catchment area (LACA), from 2017 – 2019. Also, water isotope samples were collected from March – September 2018 from ~100 lakes across 2000 km^2. From these water isotope compositions we estimated the ratio of evaporation to inflow, residence time, and the mixture of snowmelt and rainfall runoff in each lake. Catchments of all 7500 lakes in the region were delineated using a high-resolution digital elevation model in order to estimate their LACA, and evaluate connectivity between lakes.

Paired lake water balance measurements showed that the lake with a larger LACA had a residence time an order of magnitude shorter than the larger lake, and displayed larger fluctuations in water level. Also, the ratio of evaporation to inflow was significantly larger in lakes with smaller LACA. Water isotope compositions showed that only 10-50% of a lake's water is replaced by snowmelt in spring, as the majority of snowmelt runoff flowed overtop of lake ice and through the lake outlet. Deeper lakes had significantly less snowmelt mixing, as the volume of water for the snowmelt to

mix with was greater than in shallower lakes. These results show that lake water balance can be characterized using lake and catchment properties, allowing future research to more easily characterize lake hydrology and build further understanding about how lake water balance is connected to other aspects of the permafrost environment.