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Summertime sources of mercury in the Yukon River, Canada

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The Yukon River is the world's fifth largest circumpolar drainage, spanning regions of isolated through continuous permafrost, glaciated headwaters, and current and historic gold, silver, copper, lead, and zinc mining. Yukon River's annual and summertime mercury concentrations and yields (mass exported per watershed area) exceed other major circumpolar drainages by more than 50%. Yet the source of elevated mercury remains elusive. Potential sources include organic-bound mercury released from thawing permafrost, mercury-rich atmospheric emissions from East-Asia deposited on the land surface of Yukon and Alaska, melting glacial ice containing legacy mercury accumulated over millennia, or mercury-rich sediments disturbed by placer mining. To determine the predominant summertime source region and mode of transport of mercury through the Yukon River, we sampled water in eleven key tributaries and the mainstem of Yukon River in July of 2021. Total mercury concentrations ranged from 0.4 to 56.5 ng/L and yields ranged from 0.3 to 477.1 mg/km^2/day. The highest values were observed in the largest glacierized tributary (the White River). In contrast, rivers downstream of large reservoirs, lakes, wetlands, placer mining, or situated in pristine discontinuous permafrost were characterized by much lower concentrations and yields (< 5 ng/L; < 5 mg/km^2/day). High mercury concentrations persisted 300 km downstream of glacierized tributaries in the Yukon River mainstem (12.8 ng/L; 20.0 mg/km^2/day), reflecting the sustained downstream transport of mercury associated with fine suspended sediments eroded in the glacierized tributaries. Our results reveal that glacierized watersheds are the main summertime source of mercury to the Yukon River. The results offer important implications regarding future Yukon River mercury exports to the Bering Sea in a warming climate, and highlight the importance of considering physiographic factors (presence of glaciers, glacial sediments, permafrost, lakes, wetlands, and land disturbance) in understanding the sources, sinks, and transport of mercury at continental scale drainages.