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Arctic catchment releases mostly young aquatic carbon despite complete thawing of old organic-rich permafrost soils during growing season.

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Radiocarbon (^{14}C) dating of dissolved organic carbon (DOC) in Arctic freshwaters has been used as a crucial tool for detecting old C mobilised from thawing permafrost, but DO^{14}C in major Arctic rivers is usually quite young. New methods for the collection of both CO_2 and CH_4 from inland waters allow novel observation of dissolved $^{14}CO_2$ and $^{14}CH_4$ alongside DO^{14}C, and provide a more sensitive method than aquatic OC alone – published Arctic freshwater ^{14}C studies to date focus only on DOC, particulate OC, or ebullition CH_4/CO_2. The mobilisation of old C sourced from deepening permafrost soil active-layers into Arctic freshwaters has the potential to form a significant positive climate feedback.

We compare ^{14}C in DOC, dissolved CO_2 and dissolved CH_4 at five time points over a single growing season from streams, ponds and lakes underlain by continuous permafrost in the western Canadian Arctic. Using age distribution analysis based on atmospheric $^{14}CO_2$ records, we estimated the age of aquatic C that would otherwise be labelled as "modern" due to the ^{14}C bomb peak. We then calculated the vertical and lateral C fluxes in the study systems, and estimated the proportion derived from old permafrost C. The upper organic-rich soils are the dominant hydrologic pathway, which were completely thawed by late season, and we hypothesised that mobilisation of older, deeper organic soil C would be visible in the aquatic ^{14}C by late in the growing season.

Early in the season, median aquatic DO^{14}C and CO_2 ages were 65-131 years old (all ^{14}C ages reported here are years before sampling date). By the end of the season, DO^{14}C was 156-271 years old, while CO_2 was 113-161 years old, demonstrating that aquatic C ages reflect the mobilisation of thawing older permafrost C. CH_4 concentrations were generally low throughout and only two dates were obtained: 202 and 1,970 years old.

Overall there was limited evidence of very old permafrost organic C, which comprised 0-10% of vertical and lateral aquatic fluxes. Our results demonstrate that permafrost thaw will result in the mobilisation of old C into the aquatic phase as DOC, CO_2 and CH_4, but also indicate potential resilience within these systems in response to climate change.