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Quantifying the magnitude, spatiotemporal variation and age of aquatic CO_2 fluxes in western Greenland

Hazel Long (1), Susan Waldron (1), Trevor Hoey (1), Mark Garnett (2), and Jason Newton (3)

(1) School of Geographical and Earth Sciences, University of Glasgow, Glasgow, G12 8QQ, (2) NERC Radiocarbon Facility, Scottish Enterprise Technology Park, East Kilbride, G75 0QF, (3) Scottish Universities Environmental Research Centre, Scottish Enterprise Technology Park, East Kilbride, G75 0QF

High latitude regions are experiencing accelerated atmospheric warming, and understanding the terrestrial response to this is of crucial importance as: a) permafrost soils hold vast amounts (1672 Pg; Tarnocai et al., 2009) of carbon (C) which may be released and feedback to climate change; and, b) ice sheet melt in this region is accelerating, and whilst this will cause albedo and heat flux changes, the role of this in atmospheric gas release is poorly known. To understand how sensitive arctic environments may respond to future warming, we need measurements that document current C flux rates and help to understand C cycling pathways.

Although it has been widely hypothesised that Arctic regions may become increasingly significant C sources, the contribution of aquatic C fluxes which integrate catchment-wide sources has been little studied. Using a floating chamber method we directly measured CO_2 fluxes from spatially distributed freshwaters (ice sheet melt, permafrost melt, and lakes/ponds) in the Kangerlussuaq region of western Greenland during the early part of the summer 2014 melt season. Fluxes from freshwaters with permafrost sources were in the range -3.15 to +1.28 μmol CO_2 m^{-2} s^{-1}. Fluxes from a river draining the ice sheet and the Russell Glacier were between -2.19 and +4.31 μmol CO_2 m^{-2} s^{-1}. These ranges show the systems can be both sources (efflux) and sinks (influx) of CO_2. Much freshwater data worldwide shows CO_2 efflux, and recording river/stream systems being a CO_2 sink is unusual.

Analysis of dissolved inorganic carbon (DIC) concentrations of the water sources revealed higher concentrations of DIC in the meltwater of permafrost systems (0.66-1.92 mmol) than the ice melt system (0.07 to 0.17 mmol), as well as differences in the carbon stable isotope ratio ranges (δ^{13}C permafrost-melt, -9.5 to -1.2 permil; δ^{13}C ice-melt, -11.7 to 7.3 permil).

Where we recorded CO_2 efflux we collected effluxed CO_2 for radiocarbon analysis, and here we will present the first estimates of gas-age from ice and permafrost melt. The measured age of the released gas, along with stable isotope ratios of the DIC, can be used to identify the source and dominant transport processes of the CO_2 in these systems. We use these data to test the hypothesis that the age of the CO_2 efflux from the ice-meltwater will be older than that from the permafrost-meltwater because the source of CO_2 in the ice-meltwater is considered to be sintered air or trapped organic matter.

By directly measuring aquatic CO_2 efflux and age from this climatically sensitive arctic location and quantifying drawdown in high-pH ice melt streams, we have a unique dataset that aids understanding of key feedbacks affecting the impact of projected future climate change.