Microbial CO_2 production at the Greenland Ice Sheet margin

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Melting of the Greenland Ice Sheet could have important implications for local and global carbon (C) cycle feedbacks [1-3]. Quantifying these feedbacks is essential for predicting future climate change, as well as understanding linkages between ice sheet decay and climate change in the geologic past. Here, we sampled supraglacial streams and subglacial discharge from the Russell Glacier in western Greenland during the 2014 and 2015 melt seasons. We synthesize geochemical (e.g., $\delta^{18}O$, $\delta^{13}C$, and $\Delta^{14}C$) and microbiological (cell counts and DNA sequencing) observations to develop a more comprehensive understanding of C cycling at ice sheet margin.

We find that concentrations of dissolved organic carbon in supraglacial streams are highly heterogenous, while concentrations of dissolved inorganic carbon (DIC) are largely uniform and derive from a spatially and temporally constant mixture of microbially-sourced C (~25%) and atmospheric C (~75%). Supraglacial inputs account for approximately 40 – 50% of subglacial DIC. The remaining DIC derives from subglacial microbial CO_2 production and carbonate weathering. Surveys of the microbial community in the subglacial environment primarily find anaerobic heterotrophs and C1-oxidizers (methanol and CH_4) Methanogenic archaea are present but not abundant. This data, combined with isotopic observations, suggest that CH_4 oxidation is likely a neglible input to the subglacial DIC pool. Ultimately, we find that early season snowmelt and periodic rain events deliver young, organic C to the subglacial environment. These pulses of organic C drive heterotrophic microbial respiration, with the cumulative effect being a seasonal shift in the source of basal DIC, from microbial- to carbonate- dominated. We suggest that the magnitude of microbial CO_2 produced by this mechanism could increase in a warming world. Upon discharge to the proglacial area, some CO_2 may evade to the atmosphere and act as a positive feedback to climate warming, while the remainder will impact coastal waters.

[1] Hood et al. (2015) Nat. Geosci. **8**, 91-96. [2] Lawson et al. (2014) Biogeosciences **11**, 4015-4028. [3] Ryu and Jacobson (2012) Chem. Geol **320**, 80-95.