

EGU2020-20249

<https://doi.org/10.5194/egusphere-egu2020-20249>

EGU General Assembly 2020

© Author(s) 2022. This work is distributed under the Creative Commons Attribution 4.0 License.



Understanding interacting dynamics of hydrology, carbon cycle, and greenhouse gas fluxes in Arctic watersheds

Kaisa-Riikka Mustonen¹, Hannu Marttila², Kaisa Lehosmaa¹, Iina Koivunen¹, Jeffrey Welker^{1,3}, Annalea Lohila^{4,5}, and Jussi Jyväsjärvi¹

¹Ecology and Genetics Research Unit, University of Oulu, Oulu, Finland

²Water Resources and Environmental Engineering Research Unit, University of Oulu, Oulu, Finland

³Department of Biological Sciences, University of Alaska Anchorage, Anchorage, USA

⁴INAR Institute for Atmospheric and Earth System Research, University of Helsinki, Helsinki, Finland

⁵Finnish Meteorological Institute, Climate System Research, Helsinki, Finland

Carbon-water interactions are critical components of Arctic freshwater ecosystems. Dissolved organic matter (DOM) is the basis for in stream biological processes and is the foundation of biogeochemical linkages between terrestrial and aquatic landscapes, and also between the river bodies and the atmosphere via outgassing. Quantity and quality of DOM is further affecting the biochemical processes of aquatic ecosystems, as it is strongly related to the abundance, activity and composition of microbial communities. Microbes are an important part of the freshwaters biochemical cycle as they convert DOM into nutrients. They also play a vital role in carbon mineralization into carbon dioxide (CO₂) and methane (CH₄), which can further be released to the atmosphere resulting substantial greenhouse gas (GHG) emissions. Thus, streams play an important role in global carbon processing, storage and release. However, small Arctic streams and ecologically important interfaces between aquatic and terrestrial ecosystems, in particular, are under-represented in global atmospheric GHG emission estimates owing to a lack of spatial and temporal flux measurements in Arctic conditions.

The objective of our study was to improve understanding of the connections between hydrology, carbon cycle and GHG flux dynamics in Arctic watersheds. We used combination of multiscale measurements to quantify carbon availability (DOC/DIC concentrations) and quality (water absorbance, SUVA₂₅₄ index), water sources (stable H₂O isotope proxies), microbial community structure (rRNA sequencing), and CO₂ and CH₄ fluxes and stream water concentrations. Our study site is typical groundwater influenced peatland dominated second order watershed located at Pallas-Yllästunturi National Park in northern Finland. Sampling was conducted three times during summer 2019 at 20 locations along the stream gradient.

Preliminary results indicate this stream to be a significant contributor of CO₂ and CH₄. GHG fluxes increased from headwaters towards the stream outlet. However, the groundwater hotspots decreased, while runoff from peatland sections increased the fluxes. One particular groundwater hotspot was an exception, as its emission rates of CH₄ were exceptionally high in June, probably

due to increased anaerobic microbial activity within the groundwater system. Microbial contribution to carbon dynamics was evident during our study period as increased DOC loads due to late spring snowmelt dominated runoff from surrounding peatland was mineralized and DIC amount increased towards midsummer. This will be further supported by results from microbial community analysis. Same was evident also in spatial scale, as higher DOC values of headwater sites was reduced downstream and DIC values were increasing respectively. $SUVA_{254}$ index, which correlates positively with higher DOC aromaticity and molecular weight, was lower at groundwater hotspots. This indicates that groundwater hotspots were producing better quality C for microbes, as microbes tend to prefer compounds with lower aromaticity and molecular weight.

Our study addresses the urgent need for catchment level studies on carbon and GHG cycling that focuses on terrestrial-aquatic linkages, and on the mechanistic processes involved, such as microbe-mediated mineralization. Catchment wide studies conducted in Arctic and Boreal regions including interactions between ecosystems are especially needed today as northern areas are experiencing unprecedented extreme warming, precipitation changes and shifting snow depths.