How does a permafrost lake influence downstream carbon cycling?

Iva Thomason; Project Mentors: Sarah Ellen Johnston and Paige Kehoe

Background

The Arctic is warming at nearly twice the rate of the mid-latitudes. Due to this warming, there are drastic changes in the environment, including in waterways. Permafrost releases ancient organic carbon (OC) into the modern environment as it thaws in warming Arctic temperatures. This permafrost has been found to be highly available for microbes to decompose into CO_2 and CH_4 representing a positive climate feedback. By measuring the rate of biodegradable dissolved organic carbon (BDOC) consumption by microbes in lakes and streams around the Fairbanks area, we can assess the impact of seasonal changes and permafrost thaw on BDOC. One of the biggest expected impacts is the freshet, the flooding of the river due to the melting of the snow that happens in early to mid May. Studies of permafrost in Siberia have also shown high rates of microbial consumption of dissolved OC (DOC) owing to the very energy rich composition of organic matter in frozen soils. These studies and previous work at Big Trail Lake, a recently formed permafrost lake showing very high methane emissions, are the inspiration of this research. Here I build on these findings to investigate the influence of permafrost thaw on lake carbon cycling. Big Trail Lake is a natural laboratory that would provide answers to pressing questions related to permafrost thaw and biogeochemistry.

Methods

I collected samples biweekly at Big Trail Lake, located approximately ten minutes from the UAF campus. I collected surface water samples from four sites including Big Trail Lake (BTL), Big Eldorado Creek (BEC), Goldstream Creek before and after the confluence with Big Eldorado Creek (GCUp and GCDown, respectively). I also measured multiple parameters at each sample location, including the percent dissolved oxygen using a portable YSI ProSolo. These sites were selected to assess the downstream transport of dissolved organic matter (DOM) and biolability through the aquatic network. Water samples were filtered to 0.2 microns and inoculated using 1.2-micron filters. They were filtered and acidified at days 0, 2, 14, 21, and 28 and run on a total organic carbon analyzer (TOC) for DOC and total nitrogen (TN) concentrations. The loss of BDOC that is expected from the measurement is connected to the DOC released by microbes when they consume DOM. I measured DOM composition using absorbance and fluorescence spectroscopy using a Horiba Duetta spectometer, giving a bulk fingerprint of the DOM composition.

Results

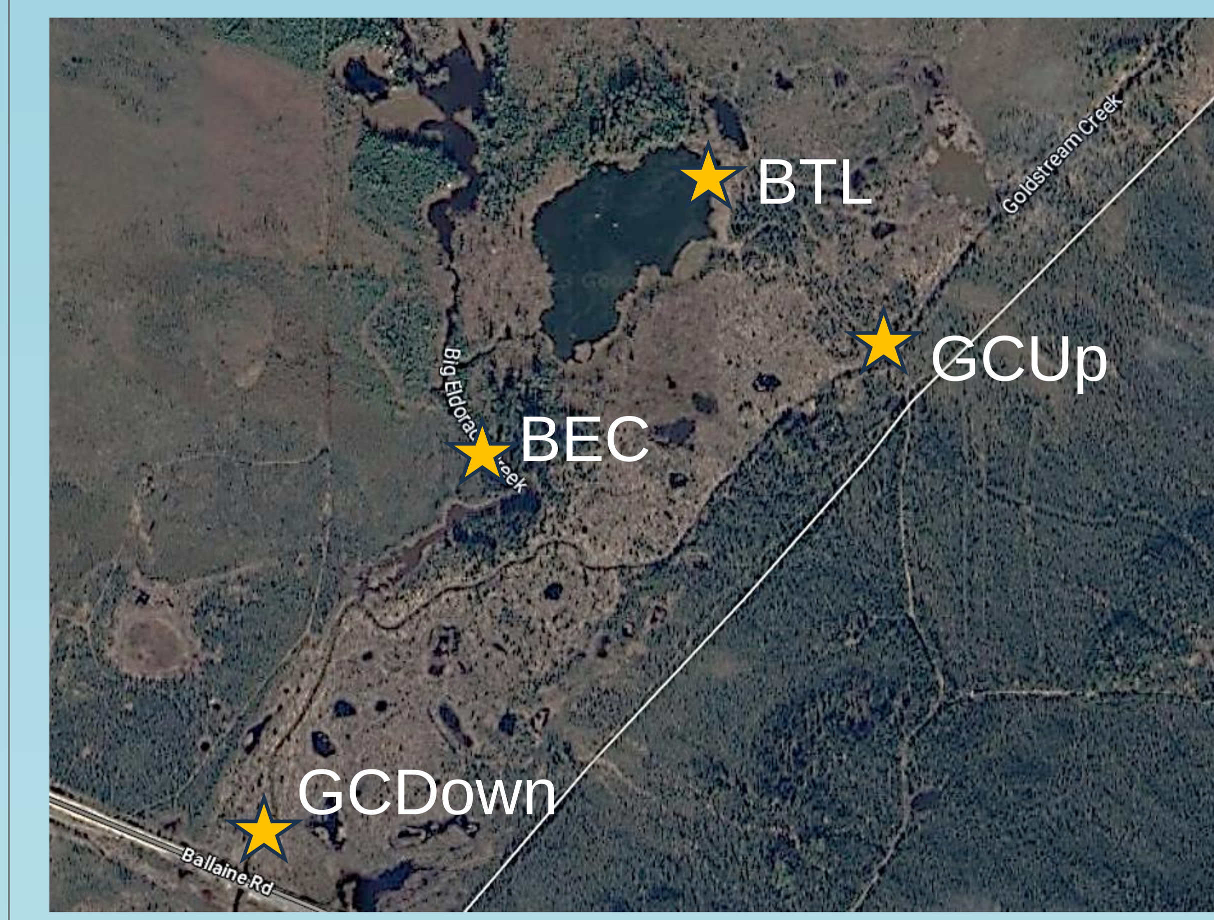
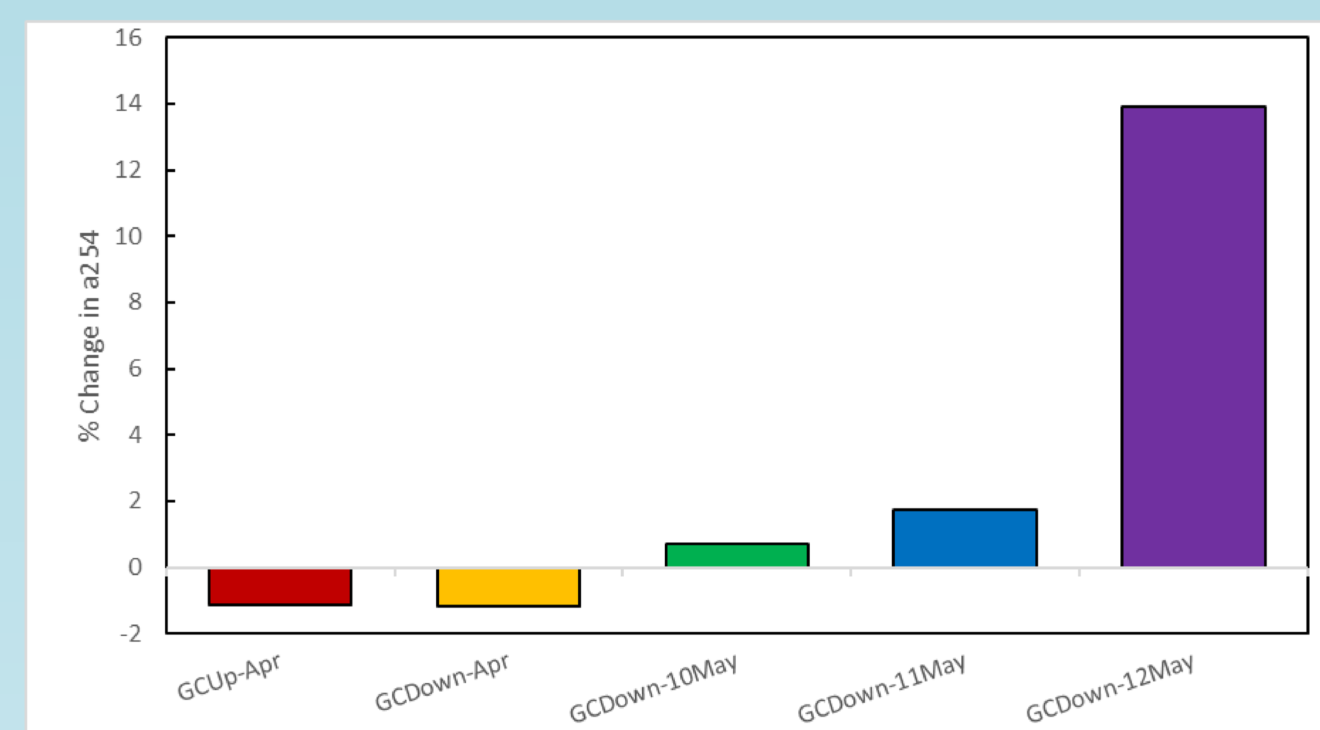


Figure 1: Map of Big Trail Lake, Big Eldorado Creek, and Goldstream Creek; gold stars indicate samples sites

Figure 2: Over all change in absorbance at 254 nm (a_{254}) values for BDOC incubations at selected sites (between days 0 and 28).



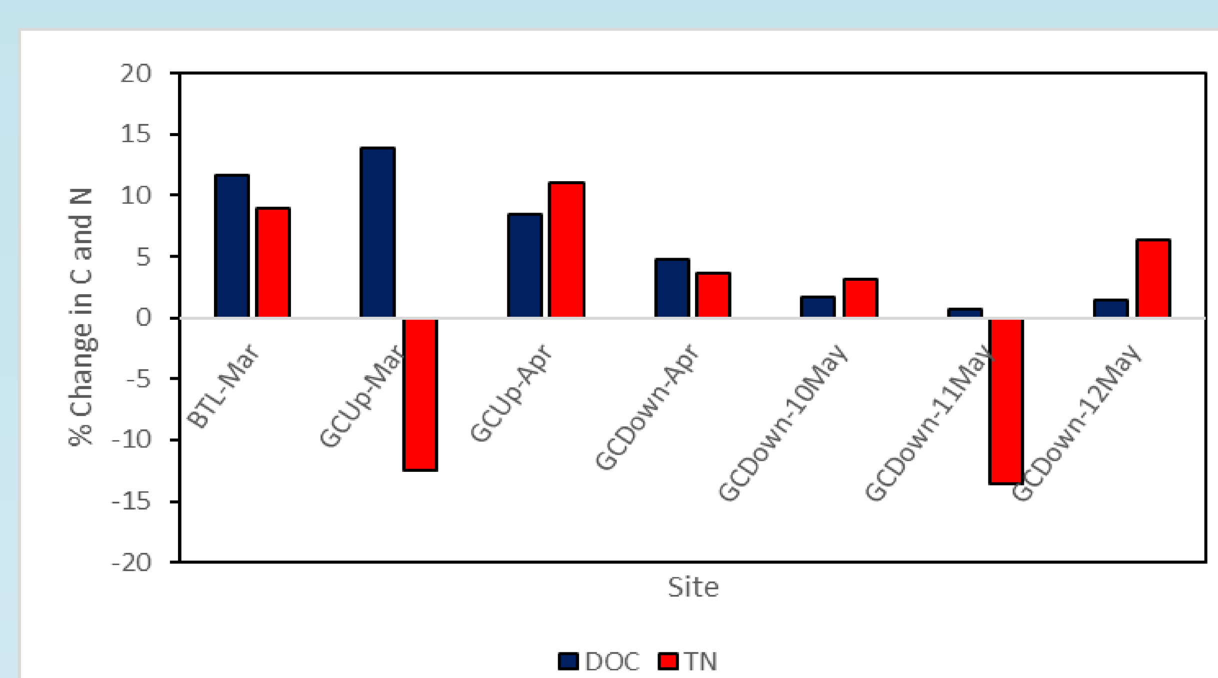


Figure 3: A look at the percent change in DOC and TN between day 0 and day 28 from the TOC data.

Acknowledgements:
Thank you to URSA for providing the funding for this project. Thank you to Sarah Ellen Johnston and Paige Kehoe for being my project mentors, as well as Ryan Owens and Emily Peterson for working alongside me on their own projects.

Conclusions

While there are differences in a_{254} and DOC values between the different samples, there is very little percent change across them. For GCUp-Apr and GCDown-Apr, this is expected due to the river still having ice on, making the sample mostly melt and having little microbial activity. There is also the potential for the microbes in the stream to be consuming non-carbon. The biggest change in the data was a 14% loss in the a_{254} values between days 0 and 28 of GCDown-12May, indicating a greater loss of DOM in the sample. GCDown-12May was the sample collected shortly after the freshet. There was a greater decrease in carbon during mid-March compared to the summer. As the summer progressed, the percent BDOC also declined. These findings could indicate that microbes thrive better in the colder temperatures compared to the warm summer waters, possibly due to the higher amounts of DOC found in the winter samples. Shortly before the freshet (GCDown-11May), the data shows almost a 15% increase in nitrogen in the sample. This could be an indication of the microbes being nitrogen-fixing. Percent values of DOC, TN, and a_{254} have a clear change in between the spring and summer samples. Overall, these findings suggest that that this system is highly responsive to seasonal variation.

***Project Continuation**: This project is currently in progress. I will continue to collect and analyze samples throughout the fall semester. I also plan to continue this into next spring to evaluate seasonal changes in BDOC in this permafrost influenced system.*