Effects of Urbanization on the Chena River in Interior Alaska

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ABSTRACT

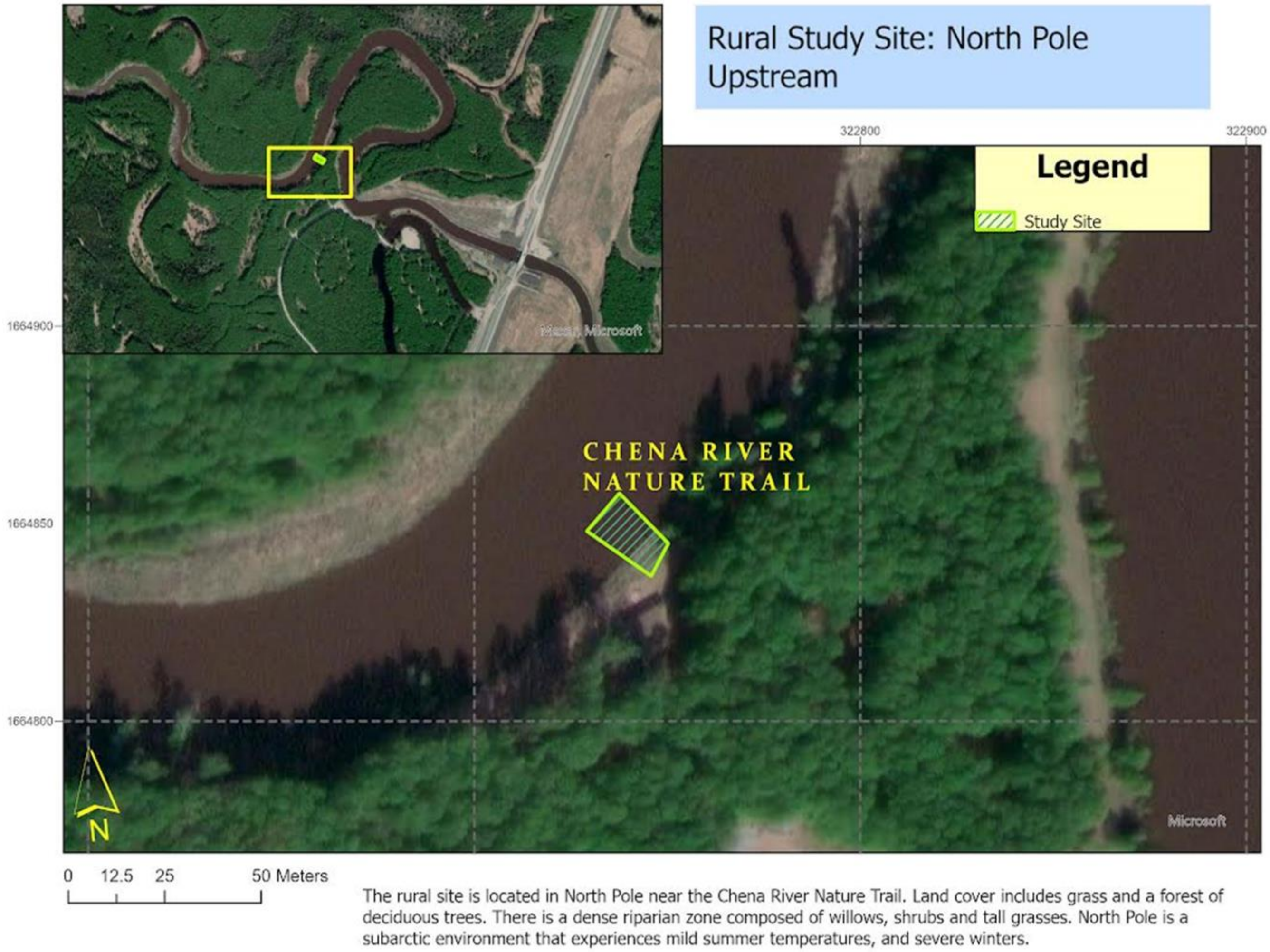
This study aimed to investigate whether there was a significant difference in water temperatures between a rural and urban location on the Chena River in Interior Alaska during the first two weeks of October 2023. Our research question was "How does Urbanization Affect Water Temperature in the Chena River in Interior Alaska?". Data was collected on water, air, surface temperatures and snowpack depth. Data was collected according to the GLOBE atmosphere and hydrosphere protocols. We analyzed each variable using a T-test with a significance level of $\alpha = 0.05$. It was found that there was no statistically significant difference in water temperatures between the urban location in downtown Fairbanks and the rural location near the Chena Lakes State Recreation Area east of North Pole. Differences in air temperature, surface temperature and snowpack were observed. The results suggest that further sampling during multiple seasons is needed to understand how urbanization affects water temperatures. Furthering this research can provide insight into how impervious surfaces in urbanized areas can create a "heat island effect" and thereby increase the temperature of water bodies.

INTRODUCTION

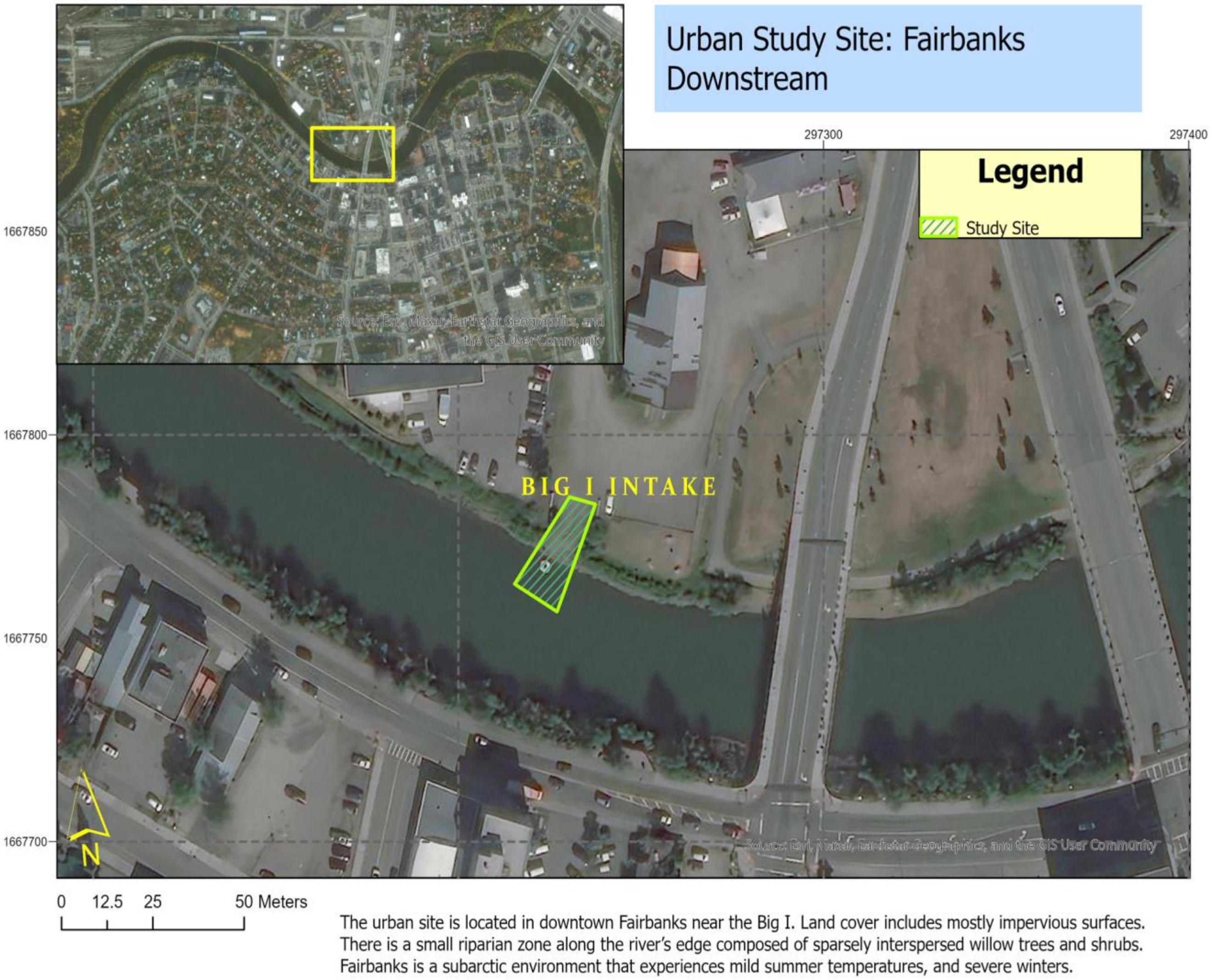
Arctic grayling can be found in freshwater streams and rivers in Alaska, including the Chena River. Often considered a universal variable, temperature has a huge role in the success and overall health of Arctic grayling. These fish are experiencing unprecedented stress from rapid environmental changes across their range (Murdoch et al., 2020). Water temperature directly affects the amount of dissolved oxygen available for grayling, and other aquatic life to use. Dissolved oxygen concentrations that are lethal for 50% of test fish from one study are 0.75 mg/L for adults and 1.50–1.96 mg/L for juveniles at temperatures of 1–3°C (Davis et al., 2019). Many juvenile grayling seem to use impending freeze up as a cue to migrate to their overwinter location (Wipfli et al., 2015). Heat that is absorbed by impervious surfaces can cause an urban heat island effect that may impact water temperature, and thus timing of freeze up. Custom planning for restoring urban riparian zones, and anticipating rapid change in temperature is essential to preserving these northern adapted species (Murdoch et al., 2020). We examined the water, air, and surface temperature at two different sites along the Chena River. This gave us a snapshot of current conditions at a rural and urban site. We then examined potential sources of impact in temperature variation at both sites.

METHODS

We collected data on water, surface, and air temperature at an urban and rural site along the Chena River. Data collection occurred four times between the dates of October 6th to October 17th, 2023. There were two study sites along the Chena River used for this project. One site was rural, and the other was urban. The urban site is located in downtown Fairbanks near the Big I. At this site land cover includes mostly impervious surfaces, with a small riparian zone along the river’s edge. The riparian zone is composed of sparsely interspersed willow trees and shrubs. The rural site is located in North Pole near the Chena River Nature Trail. At this site land cover includes grass and a forest of deciduous trees. The riparian zone is densely composed of willows, shrubs, and tall grasses. Due to their proximity, climatic characteristics between North Pole and Fairbanks are similar. They are both subarctic environments that experience mild summer temperatures, and severe winters.



Map 1. Map of the Rural Sampling Site Located in North Pole, Alaska.



Map 2. Map of the Urban Sampling Site Located in Fairbanks, Alaska.

Data was collected according to the GLOBE atmosphere and hydrosphere protocols. The GLOBE atmosphere protocols were used for air and surface temperature measurements and the GLOBE hydrosphere protocols were used for water temperature measurements. The same measurement methods were used at the urban and rural sites.

To measure air temperature thermometers were used. They were hung from trees and left to measure the air temperature undisturbed for five minutes. Thermometers were not hung in direct sunlight or near humans.

To measure surface temperature, the tools used were a ruler and a hand-held infrared thermometer. The infrared thermometer was exposed to outdoor conditions for at least thirty minutes before temperature was measured to properly acclimate the device. During each sampling visit, nine surface temperature measurements were taken. Measurements were taken at least five meters apart from each other. A ruler was used to measure the snow depth at each spot where a surface temperature measurement was taken.

To collect water temperature measurements, we used the bucket method. For this method we used a bucket attached to a rope and a thermometer. To collect water samples, we threw the bucket into the river, collected water, and pulled the bucket back to shore. A thermometer was placed into the water and left undisturbed for at least 3 minutes. The temperature measurement was read when the thermometer was submerged in the water. The process for collecting water temperature measurements was repeated three times during each sampling trip.

We collected a total of 24 data points for water temperature, 72 data points for surface temperature and 8 data points for air temperature. We analyzed the data using T-tests with a significance level of $\alpha = 0.05$. Our methods helped us to answer the research question because we were able to collect data on a variety of variables. Collecting water temperature data allowed us to see if there was a difference in water temperature. It was our assumption that potential differences in surface and air temperatures between the urban and rural sites could help to provide a justification for why water temperatures may vary between the sites. Using T-tests allowed us to see if there were statistically significant differences in the data collected between sampling locations.

RESULTS

It was found that there is no statistically significant difference in water temperatures between the urban and rural sampling sites on the Chena River. We chose to use a T-test with a significance level of $\alpha = 0.05$. The results of our T-test suggest that there is no significant difference between water temperatures (T stat =

0.226, df=22, p=0.823). We calculated the average water temperature across all samples taken at each site. At the North Pole site, the average water temperature was 1.29 °C, while the average water temperature at the Fairbanks site was 1.25°C. Through Figure 1 it can be seen that there is overlap between the error bars for each sampling location, further confirming that there is no difference between the water temperatures of our samples.

We did find a statistically significant difference between the surface temperatures taken from the rural and urban site. We chose to use a T-test with a significance level of $\alpha = 0.05$. The results of our T-tests suggest that there is a significant difference between surface temperatures (T stat = 3.24, df=41, p=0.002). The average surface temperature for North Pole over the sampling period was -2.23°C, while the average surface temperature for Fairbanks was -3.73°C.

We did not find a statistically significant difference between air temperatures from the rural and urban areas during our sampling period. We chose to use a T-test with a significance level of $\alpha = 0.05$. The results of our T-test suggest that there is not a significant difference between air temperatures during our sampling period (T stat = -0.06, df=6, p=0.952).

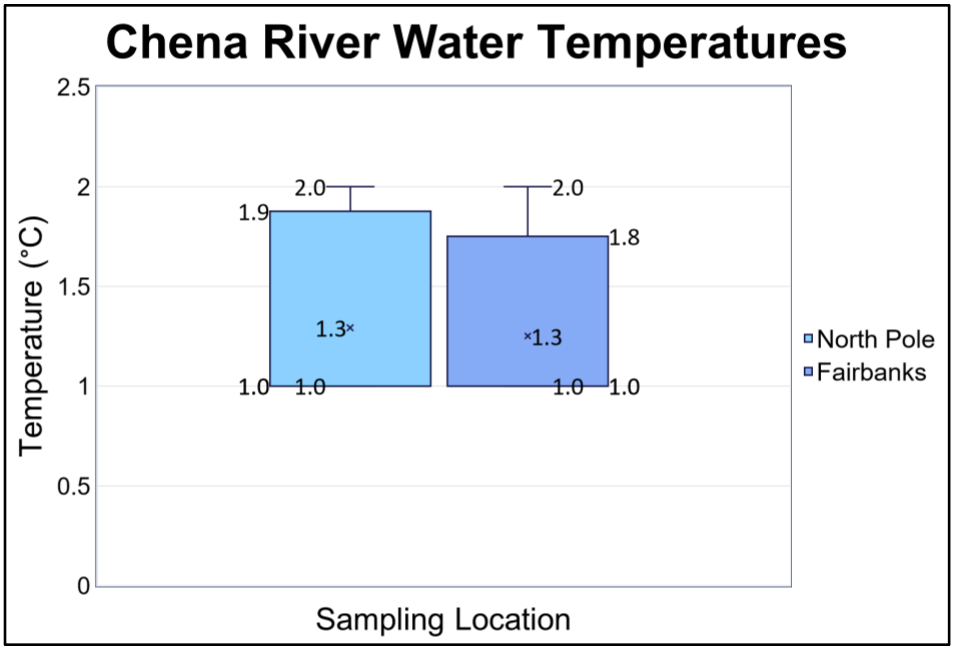


Figure 1. Comparison of Average Chena River Water Temperatures in North Pole and Fairbanks. n=24 (four dates x three samples per each location).

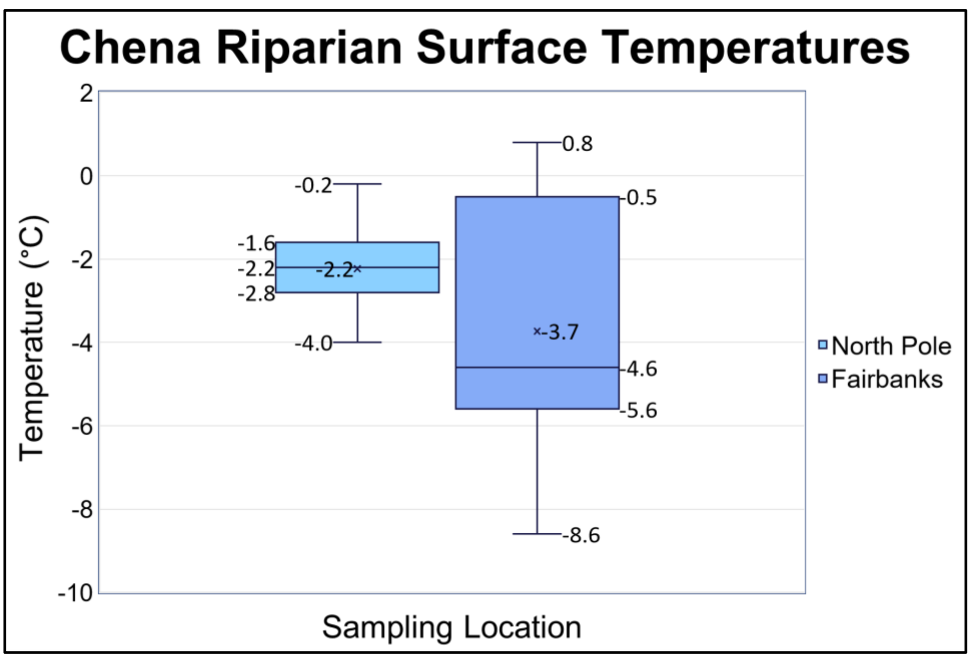


Figure 2. Comparison of Average Riparian Surface Temperatures for the Chena River Sampling Sites in North Pole and Fairbanks. n=72 (four dates x nine samples per each location)

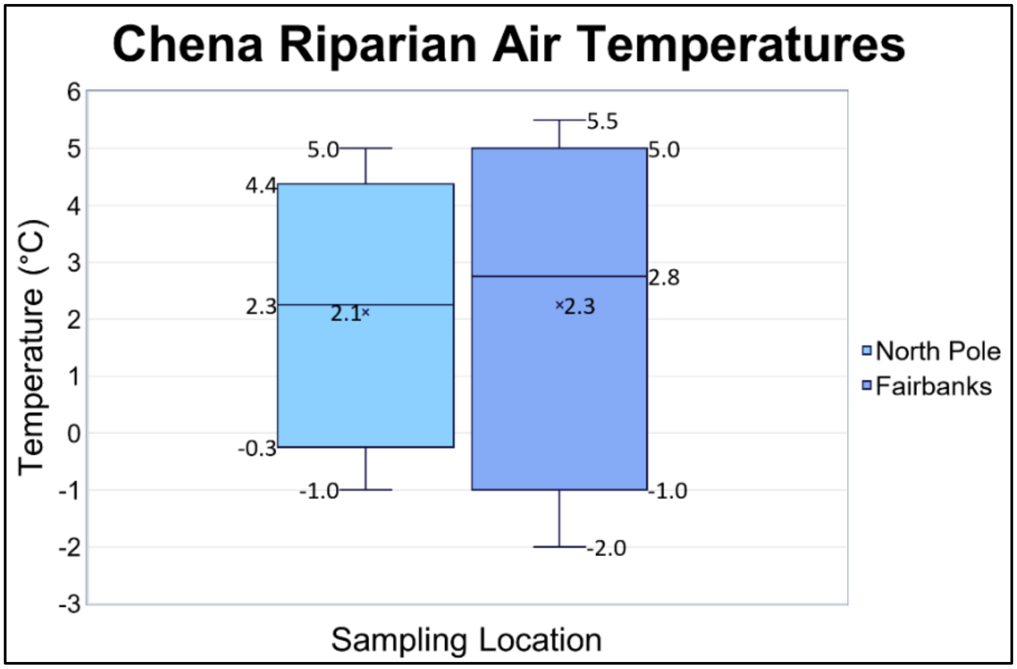


Figure 3. Comparison of Average Riparian Air Temperatures for the Chena River Sampling Sites in North Pole and Fairbanks. n=8 (four dates x 1 sample per each location).

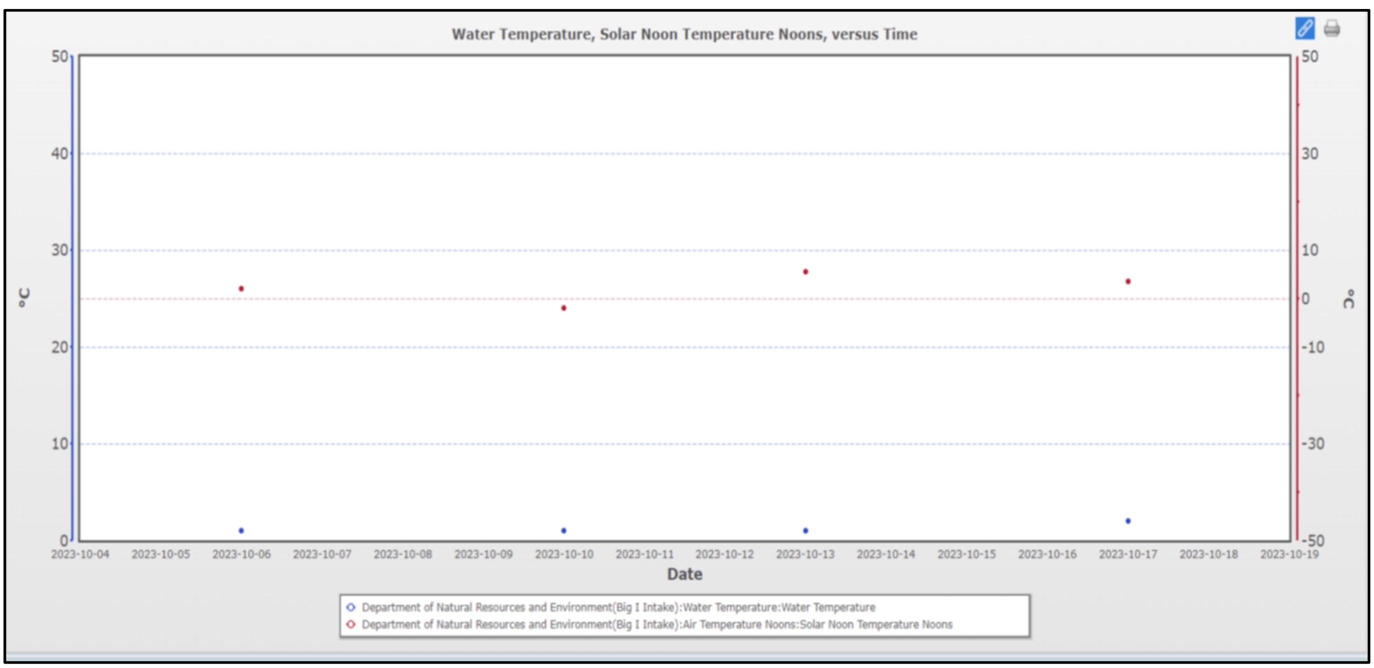


Figure 4. Globe Visualization of Water Temperature Data from Both Sampling Sites.

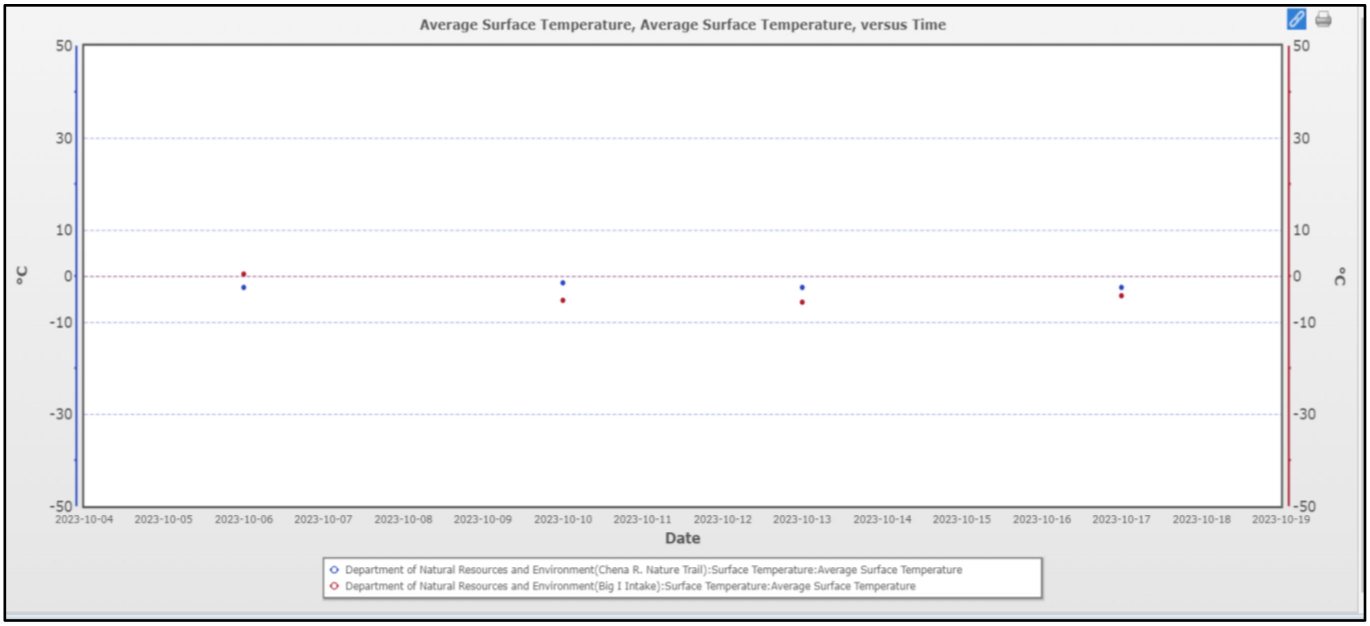


Figure 5. Globe Visualization of Surface Temperature Data from Both Sampling Sites.

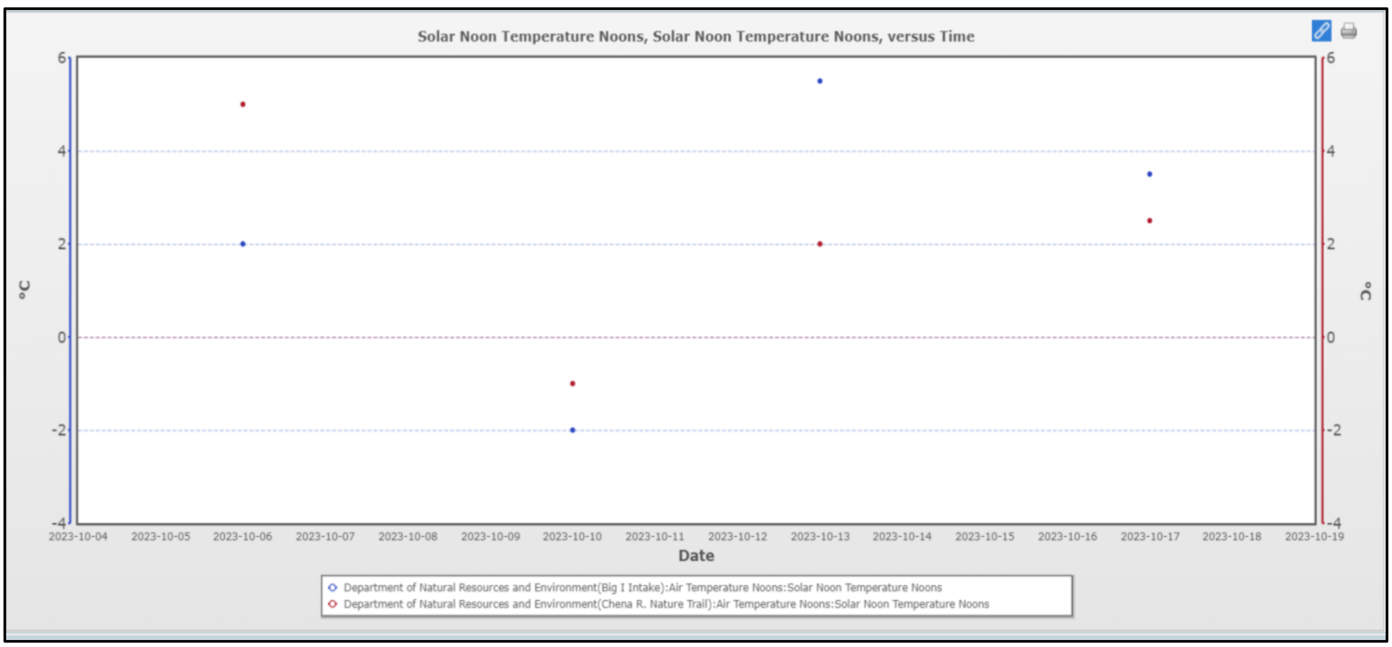


Figure 6. Globe Visualization of Air Temperature Data from Both Sampling Sites.

DISCUSSION

The one statistically significant difference we observed was that of the surface temperature. The average surface temperature was -2.23°C, while the average surface temperature for Fairbanks was -3.73°C. While this may not seem like a large temperature difference, when the T-test was applied with a significance level of α = 0.05, the p value was 0.002, which means there's only a 0.2% chance that this difference that we observed is just by chance. As we discussed earlier, a difference of just a few degrees can have a large impact on grayling (Davis et al., 2019). We expected to see a similar difference in water temperature but did not. This is a good thing. Recent efforts to revitalize the riparian zones of the Chena River may be working to stabilize and regulate the temperature of the water in the channel. This is allowing the water in the channel to stay relatively stable in temperature even when the ground surface is changing dramatically in temperature along the stream corridor.

In our statistical analysis, by using a significance of 0.05, we accept the five percent chance that any significance we observe (or do not observe) is by chance. There is also the possibility of systematic error; though by following GLOBE protocols, we minimize the chances of that occurring.

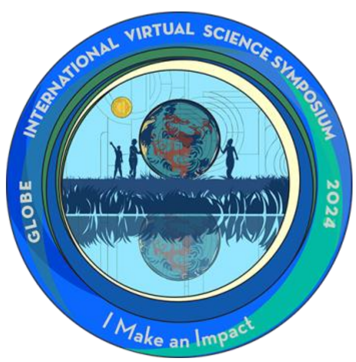
We expected to find a significant difference in water temperature between our rural and urban sites. We expected the water temperature would reflect the heat island effect more than we observed. Our results do not support our hypothesis, but with more observation, that may change. Since we did see a significant difference in surface temperature, we believe the heat island effect may still affect the temperature of the river. We simply did not have enough data to see it. The amount, and quality, of riparian zones along the channel likely also play a large role in temperature moderation of the Chena River.

CONCLUSIONS

We believe that there is further seasonal sampling with longer duration and more urban and rural sample sites needed to draw conclusions on how urbanization affects water temperature on the Chena River. We did find a difference in surface temperature between sampling locations, and we could design an investigation to assess the quality of riparian habitat between the rural and urban areas and the extent that riparian vegetation reduces the urban heat island effect. To link the potential impacts of air and surface temperature increases due to urbanization and their corresponding water temperature, more sampling and data analysis and mapping of urban catchments would be needed.

We appreciated doing this research for GLOBE and NASA because it allowed us to have a better understanding of the environment within our community.

BADGE DESCRIPTIONS

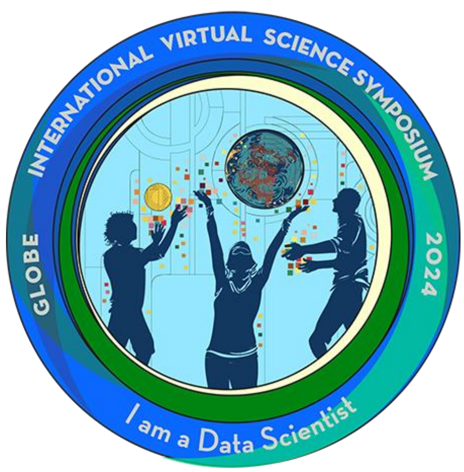


“I make an impact”

The research we conducted has important local and global implications. Our study involves the habitat of fish that are relied on by many communities for food. The issue of Chinook Salmon returning in reduced numbers is of high concern in our community. Other fish species that are relied on are also affected, such as Arctic Grayling.

"I am a collaborator"

This report and its associated data collection and analysis was collected and analyzed by Jesi Lobato and Catherine Smith along with help from our GLOBE mentor Christi Buffington. Catherine Smith performed all statistical analysis and collected the data for one of the sites. Jesi Lobato made maps and figures and collected all data for the other site. This project could not have been a success without everyone involved as our sites were far away from each other. No one person could have collected all the data on the same days and in the same time frame.



"I am a data scientist"

We performed statistical analysis on all data collected. While the collected data is limited in scope and scale, we were still able to observe a statistically significant difference in surface temperature.

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