Implications of ice thickness in urban and rural locations

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Abstract

Arctic and subarctic ecosystems rely on ice for many reasons. There are many organisms that rely on ice formation and ice thickness. Observing changes in this process will help understand the future condition of the water system. How does ice thickness vary in an urban slough location versus a rural slough location? If they are different, what characteristics are associated with ice thickness? Ice thickness measurements from urban and rural slough locations were collected and observed at the end of October and again in the beginning of November in Interior, Alaska. This was to allow time for ice to begin forming. Three measurements of the following factors were taken: ice thickness, snow depth on ice, water depth, air temperature, water temperature and distance from shoreline. The results indicate that the rural location developed thicker ice than the ice formation in the urban location. GLOBE observer landcover and Fresh Eyes on Ice application was used to capture vegetation, terrain, water coverage, structures, and impervious surfaces. It can be inferred that ice thickness in the rural slough location was thicker than in the urban slough location.

Keywords: Ice thickness, landcover changes, ice factor measurements, urban and rural location, impervious surfaces

Question/Hypothesis

The research question for this study asks, how does ice thickness vary in an urban slough location versus a rural slough location? If they are different, what characteristics are associated with ice thickness?

I hypothesize that the ice will be thicker in the rural slough location than in an urban slough location because the urban slough location consists of more impervious surfaces which absorbs heat, therefore, warming the environment around it and contributes to an increase in runoff.

GLOBE data supports a way to better understand the location and the terrain associated with it. Based on the data and photos, assumptions can be drawn based on the different characteristics at the rural and urban locations. Ice thickness is critical for both local and global communities because Arctic communities rely on ice formation during the winter season as a way of life. Climate change has played a major role in ice formation and thickness and is consequently altering ecosystems and lifeways.

This topic was of interest because ice formation and thickness are an important indicator of climate change and can also help determine how ice in rivers and sloughs may be affected by factors such as infrastructure, impervious surfaces, pollution and therefore affect water temperature, air temperature, ice thickness, snow depths.

Introduction

Ice formation is an important an ecological process in northern regions. Observing the nature of ice formation in different locations is significant because it helps gain a better understanding of the temporal and spatial analysis of the changes in and condition of freshwater ecosystems (Fresh Eyes on Ice, 2019). Ice formation in urban locations consist of impervious surfaces and runoff which may include negative factors and contribute to lower ice formation. These factors may include decreasing albedo, contributing to an increasing polluted runoff, and decrease vegetation which hold water in soils trap snow and regulates temperatures. While in rural locations, vegetation is often prevalent, there are minimal impervious surfaces, and potentially less polluted runoff. GLOBE protocols were used with the eventual goal of determining if ice thickness is affected by different land cover types. Parameters associated with ice formation and thickness affect aquatic organisms' survival and their habitat (Prowse et. al). Timing of ice formation and thickness causes variances across hydrologic systems. Ice observations may help outline additional regional hydrologic conditions by defining how differences in landscape and location vary in ice thickness measurements (Arp et. al). Many communities in arctic locations rely on frozen lakes, rivers, and sloughs as resources such as travel, subsistence, and overall quality of hydrologic ecosystems for drinking water. This topic addresses issues with infrastructure, landscape changes, pollution, and impervious surfaces and their potential effect on ice thickness development in nearby sloughs.

GLOBE Badges

Make an Impact

While collecting data for this research, there was an oil slick on the shoreline of the Urban location (Chena Slough). This oil slick was reported to the Department of Conservation (Fairbanks, Alaska). Data collection was recorded into the GLOBE observer app and the Fresh Eyes on Ice webpage to contribute to ice thickness measurements to be studied and followed throughout our community.

STEM Storyteller

Live video of both data collection locations was recorded and posted on Flipgrid. Information pertaining to each location urban (Chena Slough) and rural (Piledriver slough) included location description, nearby disturbances (or lack thereof), and vegetation.

Research Methods

Two contrasting locations consisted of sloughs of similar size (approximate width and depth). In the urban location (Chena slough), landscape consisted of impervious surfaces, infrastructure, sloped land, low density of tree and shrub populations, and polluted runoff (reported to Department of Conservation). In the rural location (Piledriver slough), landscape consisted of vegetation, minimal impervious surfaces and little to no infrastructure in minimally sloped land, natural tree and shrub uniformity and denseness, and otherwise undisturbed and natural ecosystem.

GLOBE landcover observations were collected to determine landscape differences between the two contrasting locations. Fresh Eyes on Ice applications for ice thickness observations were efficient for this research and recorded to contribute to freeze-up observations. In both locations, three ice measurements were taken and observed in the early portion of the ice formation season (24 October 21). Two weeks later (7 November 21), three more measurements were taken to determine changes in ice thickness throughout time. Additionally, on the two separate days at the urban and rural locations, measurements of different parameters associated with ice thickness were observed and recorded. These measurements included ice thickness (cm), water depth (cm), snow depth on ice (cm), air temperature (°C), water temperature (°C) and distance from the shoreline (m).

The urban location (Chena Slough), which is in North Pole, Alaska behind the Badger Gas convenience store on the corner of Badger, Persinger and Peede road. This location was chosen because of the impervious surfaces, infrastructure and the modified landscape surrounding it. The rural location (Piledriver Slough), which is in Moose Creek, Alaska off Eielson Farm Road. This location was chosen because of its landscape, natural vegetation and lack of impervious surfaces and infrastructure surrounding it. To obtain measurements of ice thickness, three random locations on each slough was selected and measured. Due to it being early in the ice forming season, limitations on safely taking ice measurements were considered. . Measurements were taken and observed each day at each location during midday under normal conditions.

Figure 1

Google Earth image of the Urban location – Chena Slough (Badger Gas in North Pole)

Figure 2

Google Earth image of the Rural location – Piledriver Slough (Eielson Farm Road in Moose Creek

Figure 3

Urban location – Chena Slough (Badger gas in North Pole)

**Contains lower density of vegetation, more impervious surfaces.

Figure 4

Rural location – Piledriver Slough (Eielson Farm Road in Moose Creek

Contains higher density of vegetation, less impervious surfaces.

Results

The results of this research indicate that ice is thicker in rural locations than in urban locations for the data collected. As shown in Figure #5, a comparison between ice thickness at each of the two sites in correlation with the two days when data was collected.

Analysis at which determines whether ice is thicker in rural or in urban locations and additional characteristics associated with these results is displayed in Figure #6. This figure depicts parameters of water temperature, air temperature and snow depth in association with each of the two locations of ice thickness measurements. The results from Figure #5 suggest that site #4 and site #5 in the rural location of the Piledriver slough displays the thickest ice for both data collection days. Additionally, as shown in Figure #6, the rural location displays slightly lower water temperature, but slightly higher air temperatures and slightly lower snow depths as compared to the urban location measurements taken. These results show that ice thickness is determined by water temperature, while air temperature and snow depths may be associated with higher density in vegetation such as trees surrounding and insulating the outer layer of the ice on the slough. An overview of the analysis conducted addresses the research question because ice thickness measurements from data in Figures #5 and #6 suggest that rural locations acquire ice development more rapidly than in urban locations. A summary of the results from this study presents information suggesting that urban locations consist of more impervious surfaces which lead to conclusions of lowering ice formation due to having a lower albedo and ultimately warmer water temperatures than in rural locations. The rural location has lower water temperatures, lower snow depths and higher air temperatures, which suggests that an increase in ice thickness is due to lower water temperature. Yet, in this location, low snow depths and high air temperatures could raise speculation that due to the density of vegetation and spatial vegetation coverage thus acts as an insulator for the understory and for the ecosystem.

	24-Oct-21			7-Nov-21			Mean	St. Deviation	P-Value
Urban - Ice thickness (cm)	5.715	6.985	9.843	8.255	4.763	9.843	7.56733333	2.11965749	0.95892445
Rural - Ice thickness (cm)	9.843	10.16	8.573	13.018	10.478	9.843	10.3191667	1.34392651	0.21702292

Summary Table 1

Indicates ice thickness in each location on each date and displays the mean, standard deviation and P-value of ice thickness at each location.

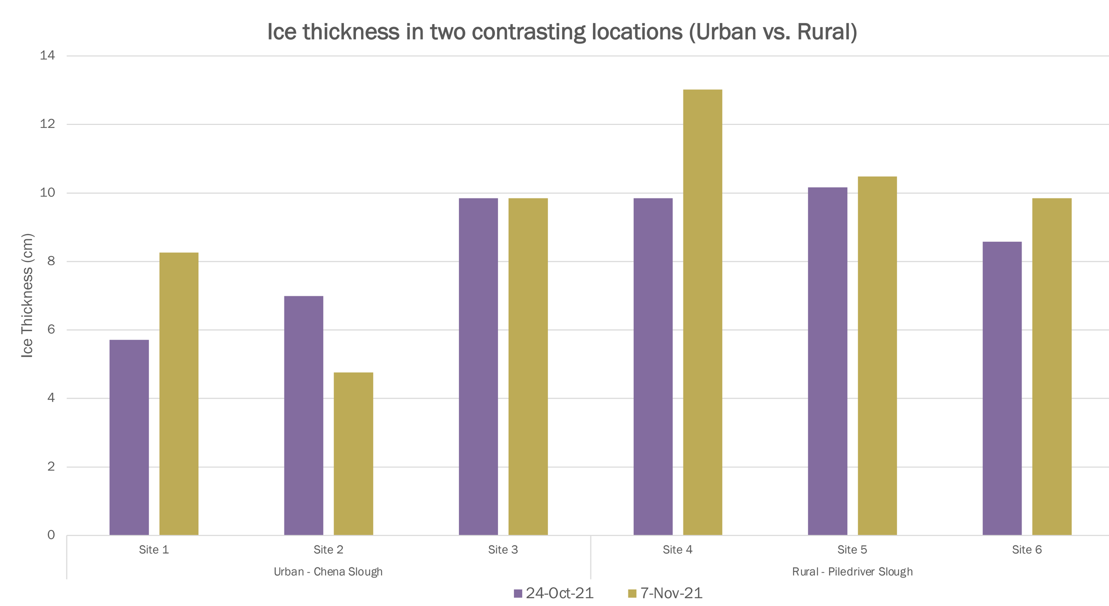

Figure 5

Displays ice thickness (cm) in urban and rural slough locations. The violet bars represent data collected on 24 October 21. The gold bars represent data collected on 7 November 21. Using single-factor ANOVA statistical testing indicated a P-value in the urban location:0.95892445 and standard deviation: 2.11965749.

Single-factor ANOVA P-value in the rural location:0.21702292 and standard deviation: 1.34392651.

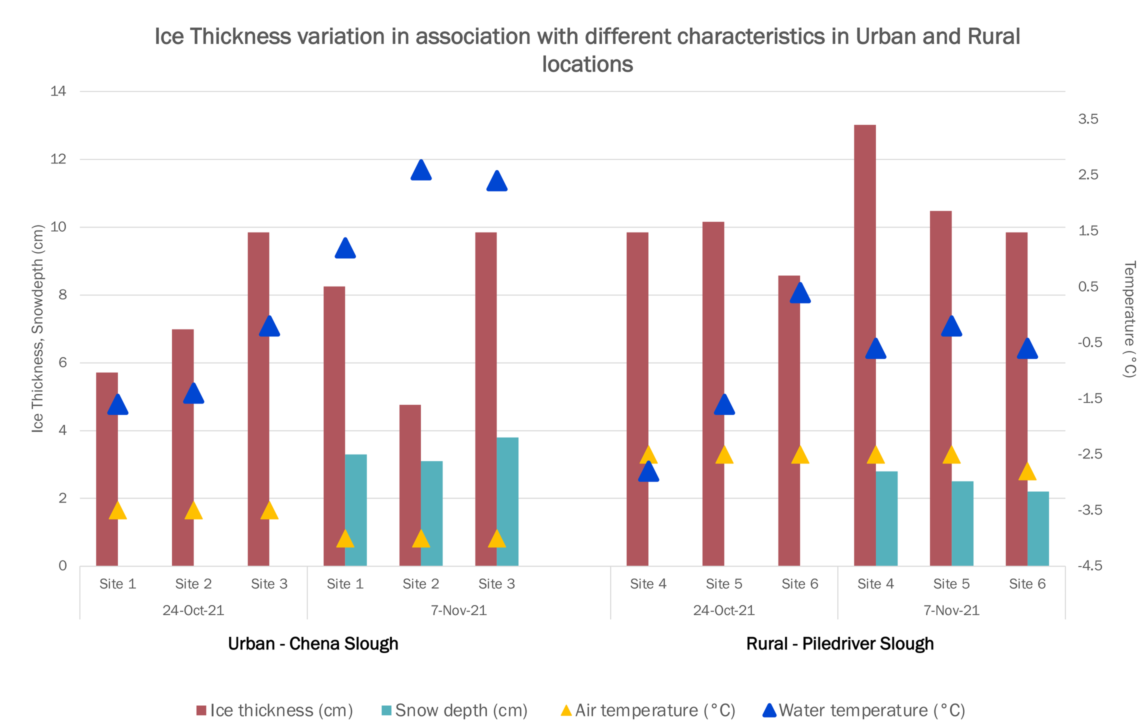

Figure 6

Displays ice thickness variation in association with different characteristics in urban and rural slough locations based on the date of collection at each site.

Red bars represent ice thickness (cm). Teal bars represent snow depth on the ice (cm). Yellow triangles represent air temperature (°C). Blue triangles represent water temperature (°C)

Rural and urban ice thickness Two-way ANOVA statistical testing indicates a P-value : 0.03799715.

Discussion

Results pertaining to this study can be concluded that there is a statistically significant relationship between ice thickness measurements and urban vs. rural ($P<0.05$). Rural locations displayed greater ice thickness measurements in comparison to urban locations. (P-value of 0.038). Additionally, assumptions can be built following the measurement results from additional ice formation and related factors (snow depth, water temperature, air temperature and water depths). An ANOVA (analysis of variance) statistical analysis was used to explore the effect of ice formation variables on ice thickness at both the urban and rural locations. Using the single-factor ANOVA analysis, the urban location indicated a P-value of 0.95892445. The rural location indicated a P-value of 0.21702292. These values indicate that there is not a statistical relationship between the ice thickness means and the dates of measurement collection. These results mean that ice thickness is influenced by location, vegetation, impervious surfaces, disturbances, and infrastructure. This study is important to science and our community because ice development is critical in Arctic hydrologic and terrestrial ecosystems. Communities rely on ice formation, thickness, and timing which supports culture, customs and traditions, family beliefs, and values. Comparing the results of this study to similar studies by other researchers reveals similar results as compared to rural versus urban locations in the Arctic. The results help answer the research question of this investigation because the outcome of different sites at the two contrasting locations determined that one location (rural) presented thicker ice at most sites than that of the opposing (urban) location throughout the timing of observations. The results support the hypothesis because it was suggested that the rural location (Piledriver slough) would represent thicker ice than the urban location (Chena slough). There were minor complications while collecting data for this research due to the timing of this study. This was largely due to ice formation barely beginning in the two locations. Analyzing data was slightly difficult due to decisions in which graphing technique to use to display the best results from this study. Uncertainties and limitations in this research process may indicate weak results due to few observations. Additional measurements of all the parameters included in this research, over a longer time frame would present stronger evidence and results for this study.

Conclusion

Ice thickness appears to be influenced by location and/or landcover that surround the slough. For this research, the rural location indicated larger measurements of ice thickness in comparison to urban locations. Ice formation and thickness is an important function of ecological processes in the Arctic. Additional methods for determining ice thickness in two opposing locations could include more time for data collection to capture additional ice thickness measurements and further implications of testing factors relating to ice formation. Improvements in the methods could include using an actual ice auger to drill slightly larger holes in the ice. Recommendations for follow-up research could include examining additional measurable parameters: vegetation density or impervious surfaces to indicate if the results are the same or similar.

This conclusion is supported by the results because the rural location where there were less impervious surfaces and more vegetation also represented larger ice thickness measurements than in the opposing urban location with more impervious surfaces and less vegetation. Conducting this research for GLOBE and NASA is appreciated because it is a contribution and support towards the community and environment. This study contributed to gaining a better understanding and evaluation of ecological processes that occur in Arctic and winter environments all around the world.

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