Predicting landscape heterogeneity in thaw depth in arctic Alaska

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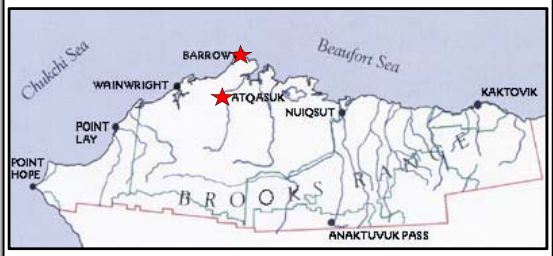
ABSTRACT

With warming, thaw depth is expected to deepen in the Arctic. Deeper thaw could result in the metabolism of archaic carbon and significantly feedback to climate change. However, thaw depth is very complex and is controlled by more variables than temperature alone. Therefore, this project will determine the susceptibility of thaw depth across the landscape. In 2010, long-term plots were established near Barrow and Atqasuk, Alaska to monitor change. These plots are 1 m^2, spaced 100 m apart, creating a 1km^2 grid. In the summer of 2013, soil moisture, organic matter percentage, vegetation cover, canopy height, and thaw depth were collected from each plot. ArcGIS will be used to examine spatial relationships between these variables and make predictions using ordinary least-squares regression. By randomly eliminating plots and predicting a known thaw depth, we can test how strong of an influence these variables have on thaw depth. It is assumed that areas containing low organic matter and less vegetation cover will be more susceptible to warming and thaw deeper than areas containing high organic matter and dense vegetation cover.

STUDY AREA

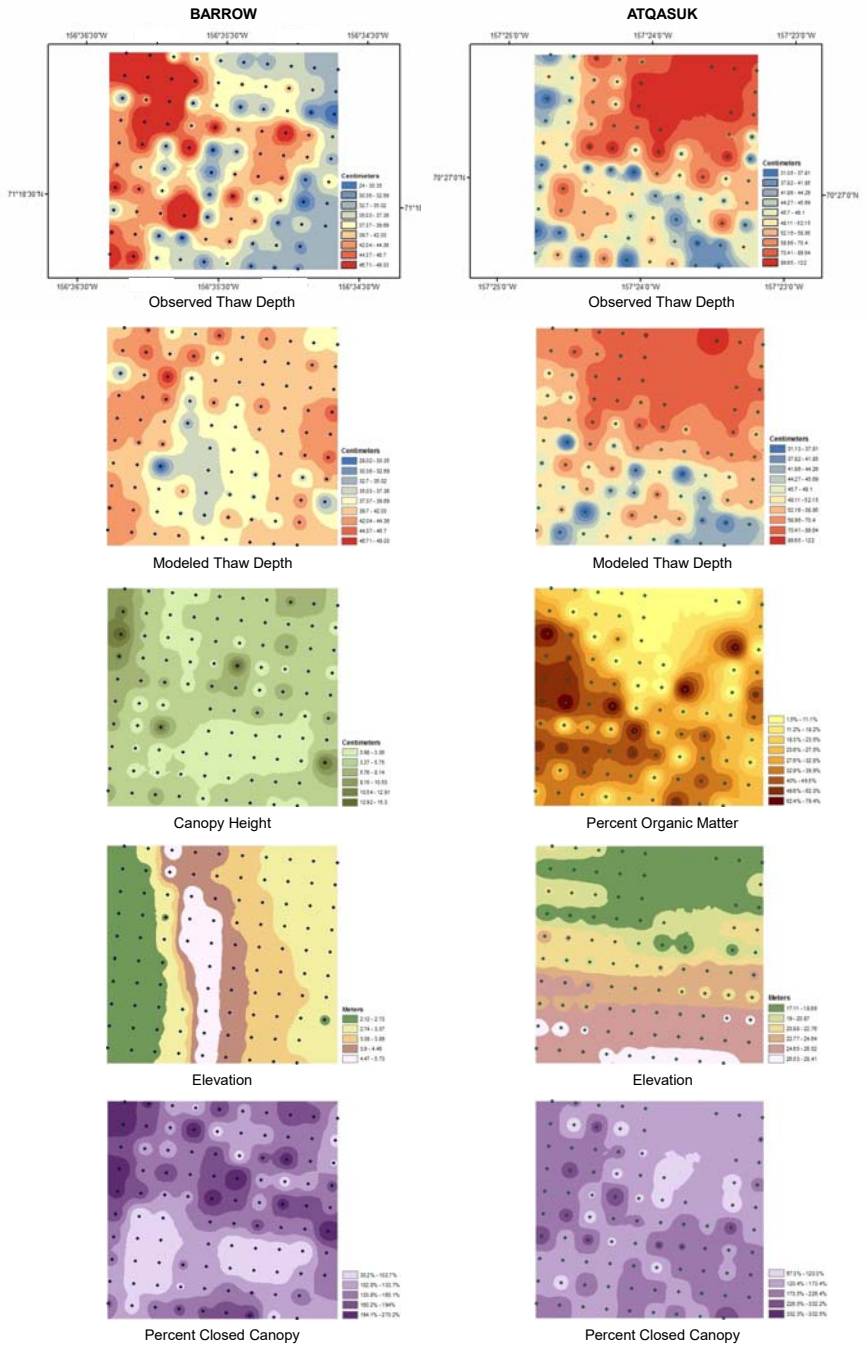
Data for this project was collected from plots within the ARCSS Grids that have been established in Barrow and Atqasuk, Alaska since 2010.
Barrow is located at 71°18'N, 156° 44'W. It is the northern most city in the United States and is 360 miles north of the arctic circle. The average summer temperature is around 40ºF, but is typically very cold and windy.
Atqasuk is located at 70°29'N, 157°25'W. This is approximately 60 miles south of Barrow and is not as populated. Although Atqasuk is still in the arctic, the temperature here is significantly warmer than in Barrow and can even reach 70°F in the summer.



DATA COLLECTION METHODS –

Data was collected using point framing, thaw depth probes, soil moisture and temperature instruments, soil sampling, and soil lab analysis.

GEOGRAPHIC REPRESENTATION OF RESULTS



RESULTS

Barrow

Variables used in the regression model	P-Value
Average Canopy Height: Calculated using the point frame data. The height of the first hit from each intersection for individual plots were summed and then averaged by the total number of first hits to obtain the average canopy height for each plot.	**0.026**
Soil Moisture: Collected at each plot on the grid by using a Spectrum TDR 300 field scout soil moisture probe. Measurements were taken in the lower left corner of each plot for consistency.	0.416
Percent Organic Matter: Soil samples were collected within 1 meter to the East of each plot to insure similar soil type. Excess water weight was removed by using a drying oven. Later, subsamples were precisely weighed, placed into a muffle furnace to burn off the organic matter, and reweighed after cooling. Calculations on the differing weights we done to obtain the percent organic matter.	0.517
Elevation: The elevation at each plot was retrieved from the data collected by the Circumpolar Active Layer Monitoring group of George Washington University.	**0.023**
Open Canopy: It was decided that bare ground (such as poop, algae, fungi), lichens, bryophytes, litter, and equipment (such as tags, or other man made materials), would represent an open canopy and provide an environment more susceptible to direct solar radiation. Using the point frame data, each hit in these categories were totaled and divided by the total number of hits to obtain the cover percentage.	0.967
Closed Canopy: It was decided that plants considered to be Forbs, Graminoids, Deciduous shrubs, and Evergreen shrubs would represent a closed canopy and produce an environment that was not as susceptible to direct solar radiation. Using the point frame data, each hit in these categories were totaled and divided by the total number of hits to obtain the cover percentage.	**0.048**
Temperature: The soil temperature was collected at each plot using a Taylor thermometer. It was consistently placed in the lower left corner of the plot until the temperature stabilized and then was recorded.	0.178
Overall R^2 Value	0.099

Atqasuk

Variables used in the regression model	P-Value
Average Canopy Height: Calculated using the point frame data. The height of the first hit from each intersection for individual plots were summed and then averaged by the total number of first hits to obtain the average canopy height for each plot.	0.119
Soil Moisture: Collected at each plot on the grid by using a Spectrum TDR 300 field scout soil moisture probe. Measurements were taken in the lower left corner of each plot for consistency.	0.945
Percent Organic Matter: Soil samples were collected within 1 meter to the East of each plot to insure similar soil type. Excess water weight was removed by using a drying oven. Later, subsamples were precisely weighed, placed into a muffle furnace to burn off the organic matter, and reweighed after cooling. Calculations on the differing weights we done to obtain the percent organic matter.	**0.006**
Elevation: The elevation at each plot was retrieved from the data collected by the Circumpolar Active Layer Monitoring group of George Washington University.	**0.013**
Open Canopy: It was decided that bare ground (such as poop, algae, fungi), lichens, bryophytes, litter, and equipment (such as tags, or other man made materials), would represent an open canopy and provide an environment more susceptible to direct solar radiation. Using the point frame data, each hit in these categories were totaled and divided by the total number of hits to obtain the cover percentage.	0.573
Closed Canopy: It was decided that plants considered to be Forbs, Graminoids, Deciduous shrubs, and Evergreen shrubs would represent a closed canopy and produce an environment that was not as susceptible to direct solar radiation. Using the point frame data, each hit in these categories were totaled and divided by the total number of hits to obtain the cover percentage.	**0.039**
Temperature: The soil temperature was collected at each plot using a Taylor thermometer. It was consistently placed in the lower left corner of the plot until the temperature stabilized and then was recorded.	0.273
Overall R^2 Value	0.402

MAIN POINTS

- Given that arctic tundra has a largely varied micro-topography, is thaw depth accurately predictable at a large scale or will small interval measurements always be needed?
- The Atqasuk study site has more variability in each variable than the Barrow study site, but the model was able to generate a stronger prediction for Atkasuk.
- Canopy height was the most significant variable in Barrow, lower canopy height corresponded with lesser thaw depth.
- Being able to predict how large areas of the tundra may respond to warming based on plot level measurements is one goal of the ARCSS Grid. Recent speculation about the composition of the tundra hypothesize that it is shifting to one that is more dominated by grasses and sedges rather than mosses and lichens. If this change was to occur, this would create more of a closed canopy and our model would suggest more areas that had greater thaw.

Acknowledgements

Thank you to Dr. Robert Hollister for providing guidance and suggestions.

Thank you to Kelsey Nyland and GWU for providing us with thaw depth data.

George Washington University. (2013). *Circumpolar Active Layer Monitoring* (*CALM*) [U1_alt_1995_2013, U3_alt_1995_2013]. Retrieved from http://www.gwu.edu/~calm/data/CALM_Data/North.html

Thank you to Keith Kofoed and University of Texas El Paso for providing dGPS points of the study plots.

Thank you to Tim Botting and Jessica Gregory for training us on the use of Microsoft Access to gather our data.