How does thermal insulation impact ground temperature covers on permafrost soils?

R. Basaliso and D. Baffrey

NRM 370: Introduction to Watershed Management, University of Alaska Fairbanks

University of Alaska Fairbanks
Department of Natural Resources and Environment

Abstract

More frequent and widespread thermokarst formations– driven by rising global temperatures associated with climate change– represent a physical risk to communities in Alaska that depend on permafrost for stable foundations. Thermokarst features are expected to expand in scope and duration due to favorable climate conditions and surface temperatures. Our study area lies within the Chena River watershed, a tributary to the larger Tanana River watershed, where continued temperature increases heightens the likelihood of permafrost degradation. This project investigates the effects of thermal insulation on permafrost soils on the University of Alaska Fairbanks communities. By examining the precipitation data collected by the Alaska Climate Research Center dating back to 1932, we examine changes in snow depth in relation to thermokarst events.

Introduction

Permafrost is any type of ground that has been frozen continuously for a minimum of two years, including soil, sediment, rock, and water (Denchak, 2018). Permafrost forms when water freezes and accumulates soil, sediment, and rocks within or around it. This mass lies underneath Earth's "active" layer of soil (EPA, 2025).

Essential components of the contributors to permafrost thaw is the temperature of the ground at shallow depths, as well as seasonal timing and snow cover. The main cause of permafrost thaw is the increase of the surface temperatures of the Earth. Climate change effects and impacts can be observed worldwide, but vary on regional or local scales.

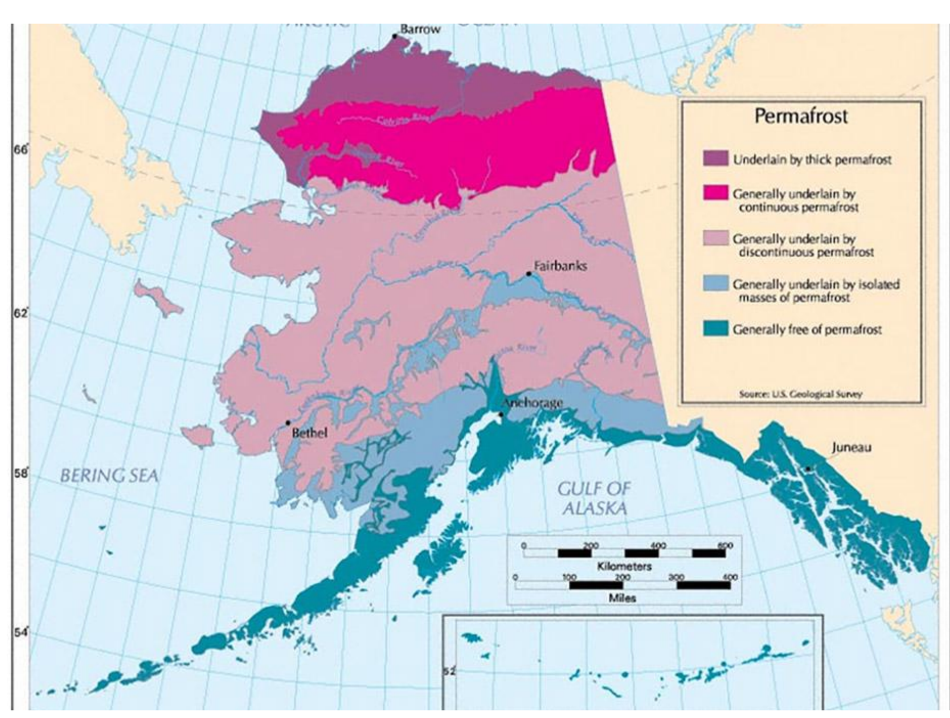


Figure 1: Expected permafrost distribution of Alaska.

Data source: U.S. Geological Survey

Methodology

Soils and air temperature data collected on the University of Alaska Fairbanks campus at the frost tube site behind Irving. By using standardized GLOBE protocols such as the GLOBE Temperature protocol and GLOBE Atmosphere protocol to record the soil temperatures, air temperatures, and precipitation conditions. At this site, organic matter such as fallen leaves or snow was moved out of the way and soil temperatures were collected at both 5cm and 10cm with a calibrated thermometer. The thermometer remained in the ground for 1-3 minutes or until the temperature stabilized. Air temperature was collected using the same thermometer, held away from the person and exposed to the air without extra shade or body heat becoming factors.

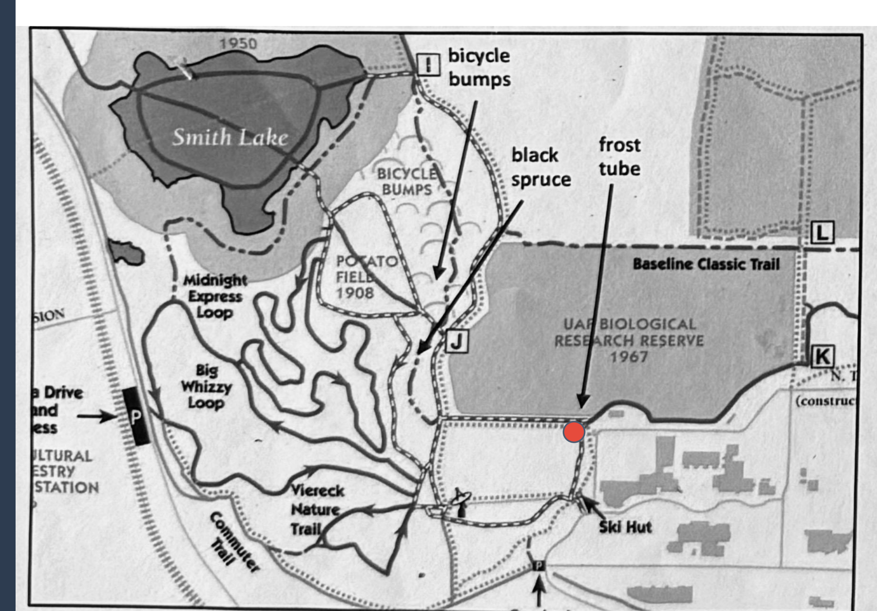


Figure 2: UAF frost tube

We recorded the temperature data approximately the same time of day which fell in the evenings after our tuesday lecture and friday nights to keep the timing consistent at 6-8pm to minimize variation. This means that we kept our testing between 3-4 days apart while testing twice a week for three weeks. This timeframe gave us a look at freeze-up, snow coverage, and a shift to freezing temperatures.

Figure 3: Dawson in the wild

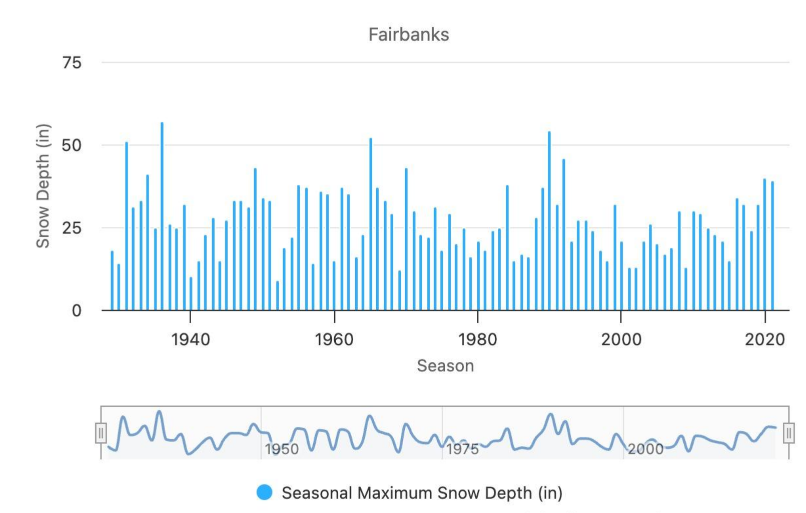
Data source: Rina Basaliso

Results

Figure 4: Soil temperature in relation to data collection following soil temperature protocol.

The soil temperature data is collected over the span of three weeks does not provide adequate evidence to fully support our hypothesis.

Figure 5: Time series data of the annual total snow depth rates of Fairbanks, Alaska (1930-2020) Data source: Alaska Climate Research Center



Time series data from the past 10 years indicate a consistent rise in precipitation rate which could correspond with the increasing occurrence of thermokarst events within the UAF campus, as noted by Cameron Wohlford, PE Director for the UAF Division of Design and Construction. Wohlford indicated a rise in thermokarst events industrialized areas, specifically the parking lot behind the Akasofu building. With limited to no vegetation, this creates a permanent insulative layer year-round (Sustainability Directory, 2025).

While higher precipitation on vegetated areas leads to greater snow accumulation, and this snow acts as an insulating blanket over the soil's active layer, trapping heat within the soil. This insulation accelerates permafrost thaw and increases soil moisture content. As additional water infiltrates frozen ground, thermokarst features develop, creating gaps in the geologic record.

Discussion

The data that we collected from testing the soil temperature shows that there is a gradual decrease in the soil temperature along with the air temperature lowering. The soil temperature had a slower drop then the air temperature. This leads us to believe that snow acts as a insulating layer which keeps the soil a little warmer than the air above it.

Figure 6: Permafrost thaw causing ground subsidence near Fairbanks.

Photo by: UAF Geophysical Institute

While I believe that we got a good amount of data to look into permafrost soils, I think that a longer window would be better to have a full season of data. Understanding how snow insulation affects soil is important to predict permafrost stability. Also, permafrost monitoring is key when trying to expand and changing the ground temperature of an area with construction and infrastructure.

Acknowledgements

We acknowledge the Alaska Native nations whose ancestral land we are seated on. The Troth Yeddha' campus resides on the land of the Dena people of the lower Tanana River.

Citations

Alaska Department of Transportation & Public Facilities. (n.d.). *Building in permafrost country.* Retrieved from https://dot.alaska.gov/traveltopics/building-in-permafrost.shtml

Boyce, R. (2025, January 24). *Thawing permafrost causes ground to sink in cold regions; scientists urge action.* Geophysical Institute, University of Alaska Fairbanks. Retrieved from https://www.gi.alaska.edu/news/thawing-permafrost-causes-ground-sink-cold-regions-scientists-urge-action

George Washington University. (2025, January 14). *Research finds frozen ground in the Arctic is sinking at an increased rate.* Media Relations. Retrieved from https://mediarelations.gwu.edu/research-finds-frozen-ground-arctic-sinking-increased-rate

Manos, E., Witharana, C., & Liljedahl, A. K. (2025). Permafrost thaw-related infrastructure damage costs in Alaska are projected to double under medium and high emission scenarios. *Communications Earth & Environment, 6*, Article 221. https://doi.org/10.1038/s43247-025-02191-7

Sustainability Directory. (2025, February 4). *What role does vegetation play in permafrost? Climate.* Retrieved November 21, 2025, from https://climate.sustainability-directory.com/question/what-role-does-vegetation-play-in-permafrost/

Streletskiy, D. A., Farquharson, L., Zwieback, S., Iwahana, G., & others. (2024). Thawing permafrost is subsiding in the Northern Hemisphere—Review and perspectives. *Environmental Research Letters.* https://doi.org/10.1088/1748-9326/ada2ff