The Yukon River Basin Active Layer Network: A Cooperative Project between the Yukon River Inter-Tribal Watershed Council and the U.S. Geological Survey

Introduction

The Active Layer Network (ALN) was launched in 2009 as a cooperative project between the Yukon River Inter-Tribal Watershed Council (YRITWC) and the U.S. Geological Survey (USGS) (*https://sites.google.com/a/yritwc.org/active-layer-network/?pli=1*).[*] The active layer is the layer of soil above the permanently frozen ground that thaws during the summer months and freezes again in the autumn. By measuring the depth of the active layer in late summer at the time of maximum thaw, we are able to better understand the effects of a warming climate on permafrost. The goal of the first two years (2009–2010) was to install the first active layer monitoring network for the entire Yukon River Basin (YRB) and to determine the feasibility of sustaining and evolving the network within the YRB. In August and September 2009, the project was initiated and 12 ALN grid sites were installed. In 2010, 8 more sites were installed, completing a basin-wide network of 20 sites across the YRB (fig. 1).

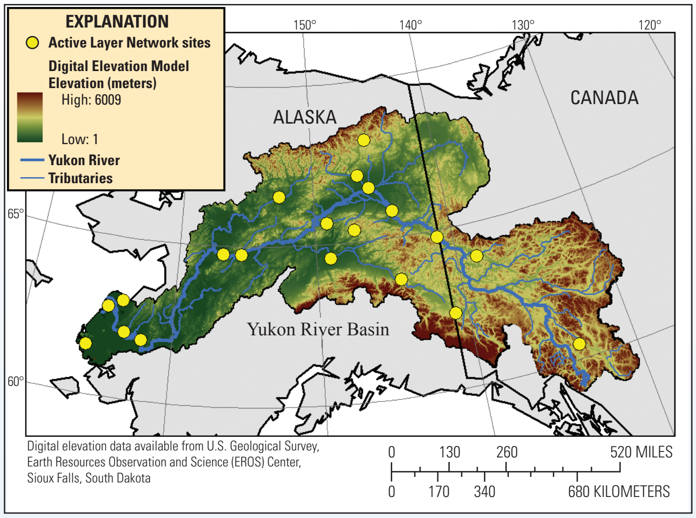


Figure 1. Locations of Active Layer Network sites within the Yukon River Basin in Canada and Alaska.

Problem and Need

Numerous studies indicate that permafrost is thawing and the active layer is deepening (Jorgenson and others, 2006; Romanovsky and others, 2008; Frey and McClelland, 2009). Permafrost thaw will likely lead to changes in groundwater flows (Walvoord and Striegl, 2007) and the quantity and quality of the rivers, streams, and lakes (Striegl and others, 2005, 2007). Moreover, systematic changes in the thickness of the active layer may have profound effects on the flux of greenhouse gases, human infrastructure, and landscape processes in cold regions. It is critical, therefore, that observational and analytical procedures continue over decadal periods to assess trends and detect cumulative, long-term changes.

The USGS/YRITWC ALN cooperative project was established with the goal of building an infrastructure conducive to long-term observations. Research is currently underway using the latest remote sensing technologies to improve the resolution of permafrost maps; existing maps were constructed decades ago with few data. Remote sensing is a tool for efficiently mapping large areas and requires ground-truthed data to verify and refine results. The information provided by the ALN will provide the necessary ground-truthing and facilitate efforts to develop a more accurate permafrost map of the YRB.

[*]For additional information concerning the Web site, contact Carol Thomas, YRITWC: 907-258-3337; *cthomas@yrtitwc.com*

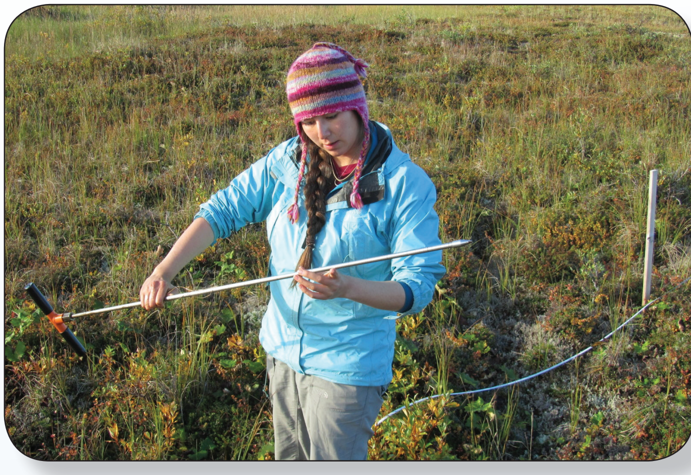
Previous Work

Faculty at the University of Alaska–Fairbanks (UAF) pioneered permafrost and active layer network studies in Alaska through the collaborative development of the global Circumpolar Active Layer Monitoring program (CALM). The primary goal of CALM is to observe the response of the active layer and near-surface permafrost to climate change over long (multi-decadal) time scales. The CALM observational network, established in 1991, by 2007 boasted more than 125 participating sites representing multiple countries in both hemispheres. Active layer thickness is measured at approximately 60 sites on grids ranging from 1 hectare (ha) to 1 square kilometer (km^2). Additionally, soil temperatures, including permafrost temperature from boreholes, are observed at 100 sites following standard CALM protocols (*http://www.udel.edu/Geography/calm/*).

Methods

Site Locations

The location of grid sites was based on several factors. First, locations were chosen based on the presence of generally continuous permafrost at a depth that can be measured manually with a calibrated rod. Second, distribution of sites within the YRB must represent the wide range of physiographic regions and land cover such as upland, lowland, un-forested, and forested areas. Third, the site must be available for community involvement and maintenance. The specific location of each



Carol Thomas, YRITWC, measuring the depth of the active layer in Kotlik, Alaska.

site within the chosen regions was selected through community participation using community member's local knowledge of permafrost distribution and depth, followed by onsite field measurements. Once a site was chosen, latitude and longitude coordinates were taken at the four corners of the grid using a global positioning system (GPS). Site elevation obtained from GPS was also recorded at the center point.

Design

The general project design for the ALN follows protocols from CALM, and further guidance was sought from UAF professors who have led their own permafrost studies in Alaska in order to supplement data from CALM (Romanovsky, V.E., UAF, and Yoshikawa, K., UAF, personal commun., 2009).

With the exception of one site, where a 100-m line configuration was used due to logistical constraints, all sites used a 50-m^2 square grid in which the depth of the active layer was measured at 5-meter (m) intervals for a total of 100 measurements per site. Protocol obtained from CALM suggests a grid size of 100 m^2; however, a 50-m^2 grid was deemed acceptable because of difficult terrain and length of time for installation (Romanovsky, V.E, UAF, personal commun., 2009). The grids were constructed by placing 1-m wooden stakes at 5-m intervals along parallel lines, providing consistent spatial measurements to run a meter tape to measure along. These stakes also serve as place markers to help find the site in the future. Depth of the active layer was measured using a calibrated 1.1-m steel metal rod with a blunt tip and a T-handle grip. The rod was pushed into the active layer until it made contact with the permafrost. Contact of the rod tip with the permafrost has a distinct feel to the experienced technician. Using this experience, differences among other materials, such as rocks and roots, can also be distinguished. The depth was measured and recorded on a modified CALM field sheet. To minimize the questionable influence of tussocks on the active layer measurement, the measurements were made at the lowest surface level within about 30 centimeters (cm) of the designated point.

Each of the 20 ALN sites was equipped with two HOBO® S-TMB-M002† soil temperature sensors and two HOBO S-SMx-M005† soil moisture sensors. One of each sensor was placed at a shallow depth, several centimeters into the surface organic soil, and also at a deeper depth, several centimeters above the permafrost. Sites were also equipped with a HOBO Pro v2† air temperature sensor placed about 1 m above the ground surface. In locations with forest cover, the air temperature sensor was placed on a nearby tree. In cases where there were no trees, such as sites in the tundra, the temperature sensor was mounted on a wooden stake.

Wires from the sensors were covered with tin foil or plastic casing in an attempt to protect the wires from rodents (marmots, ground squirrels, mice, and so forth). The soil moisture and

Leah Mackey, YRITWC, measures the active layer near Hess Creek where it crosses the Dalton Highway, Alaska.

Brett Uhle (front), USGS, and Victor Tonuchuk Jr. (back), Environmental Coordinator for the Kotlik Traditional Council, download air temperature data at the ALN site near Kotlik, Alaska.

†The use of brand, trade ™, or firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

temperature sensors were linked by wires to a HOBO Micro Station† data logger and set to record data every 30 minutes to be downloaded in one calendar year.

Community Participation

Local participants were engaged in the execution of this project, allowing researchers to obtain valuable site-specific information known only by community members. Community participation at each grid location will increase the chances of moving toward long-term data collection, which is critical to the objectives of the ALN project. Utilizing and expanding the local skill base through community participation is a key component to the success of the USGS/YRITWC ALN project and will become the focus of the project in 2012 and beyond.

Engaging with the communities about the purpose and importance of the ALN project is essential to the success of this study. During site installations in 2009, students from Fort Yukon and Beaver, Alaska, participated in staking out the grid, taking active layer measurements, and reading GPS coordinates, giving the students an opportunity to learn about the cooperative USGS/YRITWC ALN project across the YRB. During follow-up site visits and new site installation in 2010, USGS and YRITWC staff lectured at local schools about the project and involved students and teachers in the actual grid installation and measurement when possible. When site visits were not possible, classes were taken on field trips to participate in experiential learning and install a mock grid at a site near the school (see photo, below).

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Challenges and Future Work

Building robust infrastructure is key, and that goal was achieved in 2009 and 2010. The focus of the project is now on monitoring and maintaining the sites. The most challenging part of any long-term research project is ensuring its continuation. Changes in or the discontinuation of funding sources, staff, and research priorities are all obstacles to successful long-term research. An advantage of the ALN project is its simplicity—site visits occur only once a year in the late summer when the active layer is at its maximum depth. During the site visit the grid is measured and sensor data are downloaded to a computer. The sensors are reset, batteries are changed, and if needed, damaged sensors are replaced as part of maintenance. Year three of the ALN project will focus on training community members as volunteer technicians to assist in the basic maintenance and annual measurements as required by CALM protocol.

Karonhiakta'tie Bryan Maracle (center), YRITWC, explains how to set up the ALN grid to students in Carcross, Yukon Territory, Canada.

Acknowledgments

The USGS and YRITWC thank the Indigenous Observation Network (ION) field technicians that facilitated the engagement of local participation in the ALN study and completed successful installations at selected grid sites across the basin. Without their assistance the ALN would have been considerably more difficult. Special thanks to Dr. Vladimir Romanovsky and Dr. Kenji Yoshikawa of the University of Alaska–Fairbanks for the time they took to share their experiences and advice throughout the initiation of the project

For additional information contact:

Paul F. Schuster

U.S. Geological Survey
3215 Marine Street, Suite E-127
Boulder, CO 80303
Phone: 303-541-3052
Fax: 303-541-3084
Email: *pschuste@usgs.gov*

Carol Thomas

Yukon River Inter-Tribal Watershed Council
725 Christensen Drive, Suite 3
Anchorage, AK 99501
Phone: 907-258-3337
Fax: 907-258-3339
Email: *cthomas@yritwc.org*

Karonhiakta'tie Bryan Maracle

Council of Athabascan Tribal Governments
Post Office Box 33
Fort Yukon, AK 99740
Email: *bmaracle@catg.org*

**At the ALN site near Chevak, Alaska.
Left to right: Brett Uhle, USGS; Carol Thomas, YRITWC; Deborah Friday-Aguchuk, Chevak Native Village Environmental Program; Cynthia Paniyak, Chevak Native Village Environmental Program.**