Integrating Contemporary Arctic Research into Secondary Education Curriculum: Experience, Outreach, and Curriculum Building through a Field Season in Svalbard

Daniel S. Frost[1], Michael J. Retelle[2], Steven Roof[3]

[1] Carrabassett Valley Academy, Carrabassett Valley, ME, [2] Bates College, Lewiston, ME, [3] Hampshire College, Amherst, MA

A view of Longyearbyen from the peak adjacent the Linnebreen and Larsbreen Glaciers

Abstract

Students in grades 9-12 are rarely exposed to contemporary scientific research in the arctic regions and often only hear of polar issues through anecdotal media contributions. Moreover, science and mathematics education at the secondary level consistently navigates a course where topics are relegated to the world of academia, answers can be checked with a key, experiments should always 'work,' and the real world relevance of it all can be kept at an arm's length. Through programs such as PolarTREC and the collaboration of high school teachers with active researchers in the arctic regions, students can connect with current scientific missions and greatly enhance their global perspective while enriching their studies of enumerable topics at their home institutions. Such objectives are met by:

-Teachers, researchers, and professors establishing working relationships that share ideas, data, and insights into current arctic and local field research. Such collaboration is not only useful in spurring intellectually productive scientific dialogue but also can often serve as a valuable link/contact for students into the world of higher education and beyond. Possibilities for student involvement in meetings, camps, and field courses emerge when secondary educators have an ear to the happenings of research groups such as ARCUS or collaborative universities.

-Teachers participating in actual arctic research acts as a means to lend credibility to the information they pass on, a link for students to relate to the science, and to stay professionally active in the fields they teach. If students can hear first-hand accounts of science in the field and laboratory it becomes real to them, not just writing in a text book.

-The creation of curriculum that integrates actual data along with the background story of how it was ascertained. While the scientific education applications of arctic field work and data collection are direct there a number of ways for the science to serve as the basis for education in mathematics. Examples include geometrical analysis of frost polygons and patterned ground, the use of advance rates of surging glaciers and retreat rates of receding glaciers in algebraic modeling, calculating algebraic best-fit lines using temperature profile data with depth in the active layer above permafrost, and countless other ways.

-The involvement of students in completing original research in both the field and lab to explore interconnections with local and arctic science. In a time of rapid global climate change, students can readily examine how climate change is manifesting itself in their own environment and compare that to those in the arctic, where change is occurring at an unprecedented rate. Students living in landscapes formerly glaciated in the Pleistocene can examine current glacial processes to see how their own landscape was formed. In areas where lakes are in close proximity, teachers and students can undertake lake monitoring and even recover paleoclimate/paleoenvironmental records and note the changes in the sediment character of their waterbodies as opposed to those of the arctic (organic matter content, laminated sediments, glacial versus non glacial lakes, etc.). Examples of all of the above are readily available as web content but more importantly packaged with the pure intent of education and outreach in journals such as those of educators participating in the PolarTREC program.

Additionally, in the same vein that educators encourage students to attend and present at academic meetings and workshops, research scientists and teachers must themselves actively conduct outreach beyond their classroom to the community and in return to the working relationships they've fostered. This poster explores ideas on how to integrate arctic scientific research into science and mathematics education and the benefits of teacher involvement in such projects as the Svalbard Research Experience for Undergraduates and the greater PolarTREC program as a whole.

Global & Map View of Svalbard

Roof, 2013

Looking Over Karst Topography to Kapp Linne, Svalbard

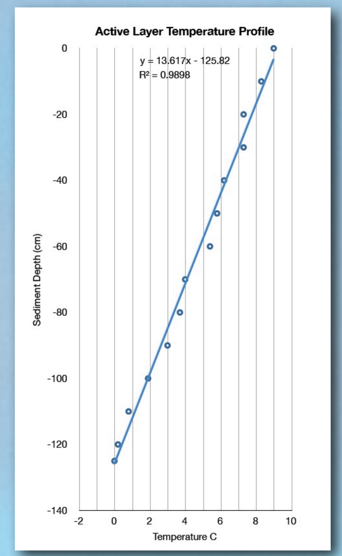
View of Linnebreen Across Linnevatnet

Arctic Research and the Use of Real Data in the Classroom

The utilization of actual scientific data, when used properly, can provide a much more intimate connection for students in the classroom to topics that they've previously never considered. Students in mathematics courses are constantly looking for a connection to the real world and working with fresh, relevant data can bolster any response to the age old "when will I ever use this?" 'Can' the textbook factoids and use examples and activities that explore questions in students' own back yard, regional scientific topics, and big and small science in the polar regions for an academic connection at many different levels.

A. The Use of Thermal Gradients in the Active Layer for Algebraic Modeling: Best-Fit Lines

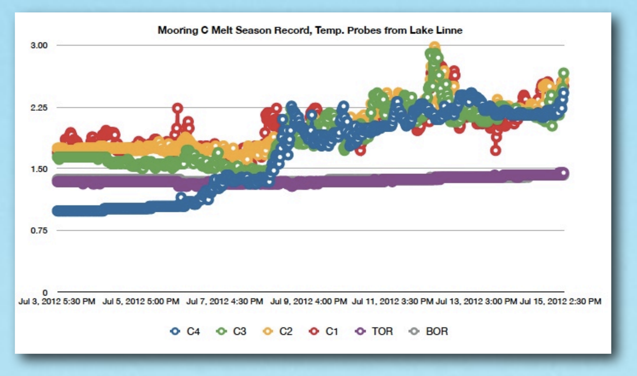
In these Algebra 2 activities, students use actual permafrost data from Svalbard to construct best fit lines and model the data. This provides students with an introduction to geothermal gradients and a direct application of their mathematic skills. They are then asked to compare data amongst different sites, examine the meaning of x and y-intercepts of the graphs, analyze data sets that show more than one simple gradient (two lines due to sedimentary unit changes), and then finally allowed to check their work where they can with graphing utilities.



Hanna and Elin Probing the Active Layer

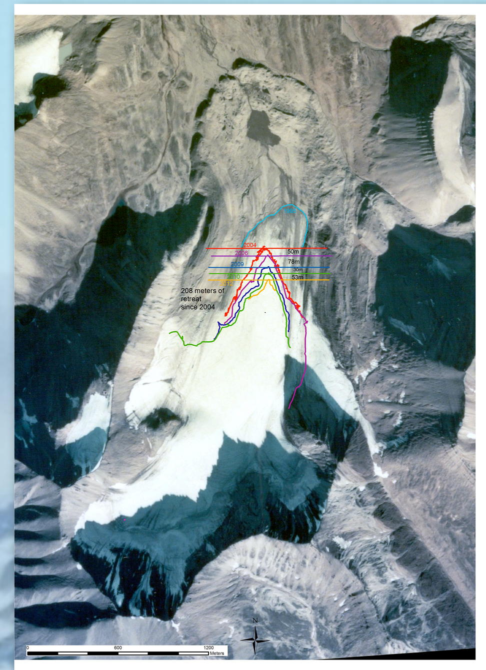
B. Introducing Students to Time-Lapse Photographic Data, Mooring Temperature Data, and Reconstructing Melt Seasons at Linnevatnet, Kapp Linne, Svalbard

By combining visual and instrumental data, students are allowed to reconstruct the melt season and see the link between what happens on a simple graph and spreadsheet and what is happening physically within a watershed. The extent both temporally and the number of data types can be tailored to the story you are looking for students to unearth. When did the melt get registered at depth x in water column? Interflow or Underflow? Can you see the turbid plume entering the lake? Was it registered by the intervalometer? and many more...

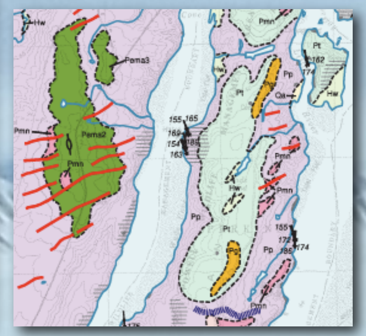


C. Contemporary Polar Glacier Retreats & the Laurentide: Putting Post LIA and Wisconsin Deglaciation Into Perspective

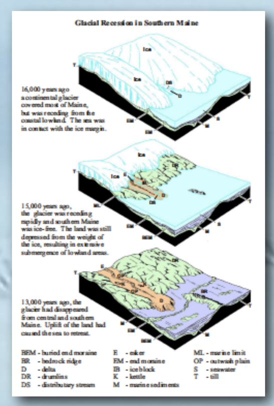
Students living in areas formerly glaciated in the Pleistocene can appreciate the link between current retreat rates of glaciers and the rates that took place thousands of years ago in their own back yard. How does an 80 year old moraine differ from one weathered by the Holocene? Are retreat rates unprecedented now compared to then?



Recent Retreat of Linnebreen, Kapp Linne, Svalbard



De Geer Moraine Complexes, Richmond, ME 7.5'



Laurentide Glacial Retreat Diagram for Maine

Marvinney, 2003

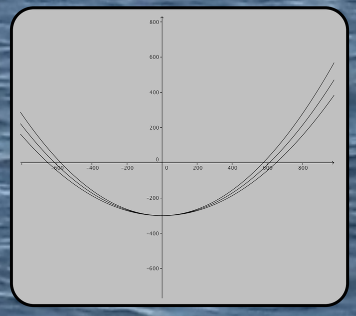
D. Other Ideas?

The Geometry of Frost Polygons & Patterned Ground

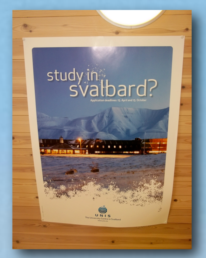
Sea Ice Extents & Statistics

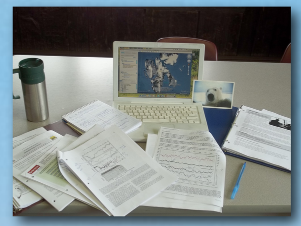
Source: W. N. Meier et al., 2013, New Estimates of Arctic and Antarctic Sea Ice Extent during September 1964 from Recovered Nimbus 1 satellite Imagery, The Cryosphere Discussions, 35-53

Modeling U-Shaped Valleys With Higher Order Polynomials



The PolarTREC Program

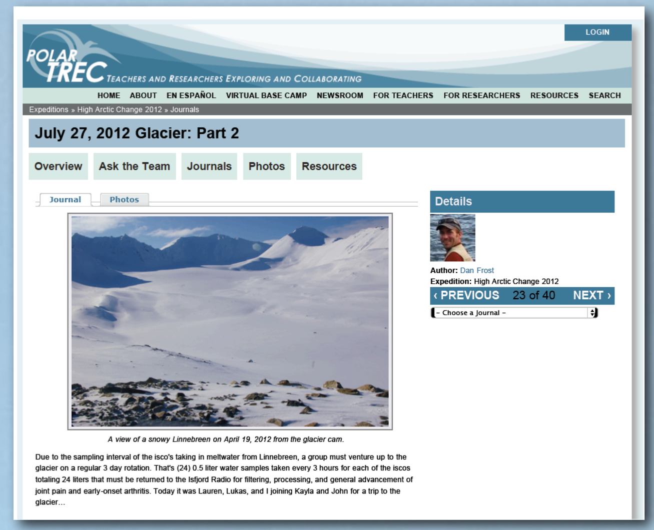




Overview

The PolarTREC program connects teachers and researchers in the arctic/antarctic regions to :

1. Improve teachers knowledge of polar science through first hand research experience
2. Bring contemporary polar science back to classrooms of 'lesser latitudes'
3. Strengthen outreach components of major scientific research projects to K-12 education and greater communities



An Example Beginning of a Journal Entry

A. Journals: While in the field, PolarTREC teachers post daily web journals that include recounts of life in the field, details on project progress and scientific breakthroughs, educational posts guiding readers through the underlying scientific concepts, and as much picture and video content that polar bandwidths can handle.

B. Ask the Team: In the field, PolarTREC teachers participate in this interactive area where they are asked miscellaneous questions regarding the science they are participating in or the content of their posts. This provides a unique arena for outsiders to get real-time, first hand information on polar science.

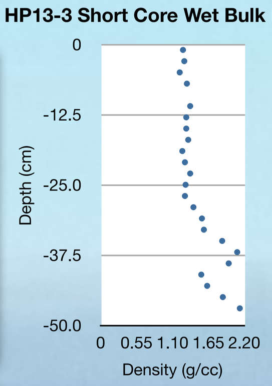
Author with group and stoked Thesis Student

Ask the Team Page, PolarTREC

Svalbard 2012 REU & UNIS AG212

Many Thanks To: Mike Retelle, Steve Roof, Al Werner, Hanne Christiansen, the 2012 Svalbard REU, UNIS AG212, Sarah Crowley, Janet Warburton, ARCUS, NSF, Bates College and Carrabassett Valley Academy

Field-Based Research and Projects with High School Students & Their Polar Connections: Field Work = Good



Looks a tad less organic?

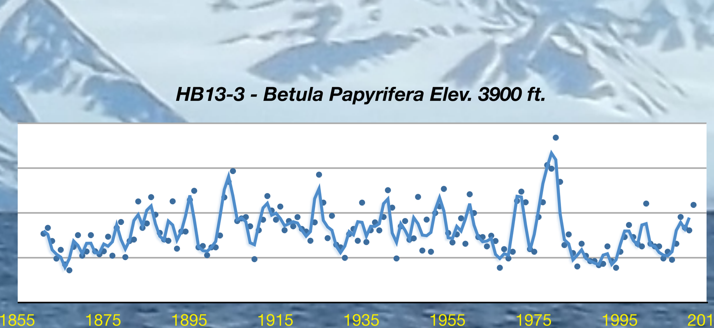
Lacustrine Sediment Paleoclimatology: The Search for Laminated Sediments in Temperate and Arctic Latitudes (and the meaning!)

-Limnological field work is an excellent experience for introducing high school students to working outside in any season. There, students learn first hand such techniques as bathymetric mapping, how to survey water quality and clarity, underwater photography and videography, and how to take sediment cores, preserving the fragile nature of possible structures in the gyttja. From there a myriad of lab analysis can be completed to suit curriculum and the sediment compared to that of other locations.

-Additionally, students get to be part of the excitement that is hunting meromictic lakes and learn about in-lake processes and the possibility of finding varved mud (best done after an introduction to tree rings for ease of explanation).

Assessing Paper Birch Growth Rates in Alpine Environments

-With an abundance of trees at temperate latitudes and an inexpensive increment borer, students can readily undertake dendrochronological work. Additionally, locations for taking cores can be varied to examine stresses on growth within species. If a mountain is nearby (and a chairlift) students can study the effects of vertical zonation on trees at the extent of their habitable range in the Alpine zone. Local climate records may also be referenced to explore the limiting factors on biological growth and potentially make inferences on climate change prior to the instrumental record for the area if their records extend far enough back.



Graph of Tree Ring Thickness vs. Age of High E. Birch

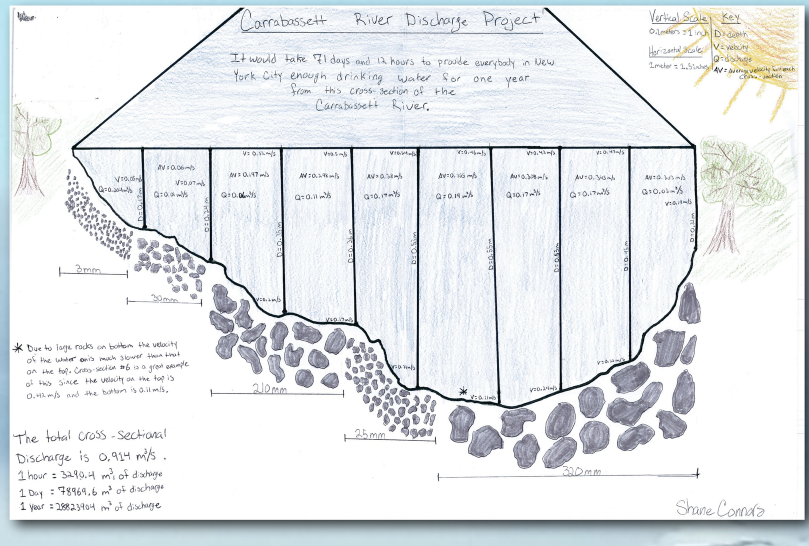
North American Range: Betula Papyrifera

Safford, John C. Bjorkbom, and John C. Zasada, http://www.na.fs.fed.us/pubs/silvics_manual/volume_2/betula/papyrifera.htm

Digital Image of High Elevation Birch Increment Bores

Students extracting the dendrochronology

CVA Students: Spring Time Q Measurements



Example of Student Work Analyzing Stream Discharge, Carrabassett River, Carrabassett Valley, ME

Steve Roof & Svalbard REU Students Measuring Q in Linneelva

Stream Dynamics and Calculating Melt Season Discharge Rates

Much like the arctic, the nival melt in Maine can be furious and a very interesting time to be watching local rivers and streams. The measurement of water velocities and calculation of discharge rates is an excellent project for students to be able to connect with stream dynamics and understand the quantification of the water passing by. Follow-up projects can include facies mapping when the water recedes, erosion and deposition by fluvial systems, and the reconstructing of paleo-flow channels in comparison to earlier velocity measurements. In areas where the fluvial systems enter water bodies, links to the sedimentary record can also be made and the minerogenic contributions could be compared to the almost strictly clastic composition of arctic lake/stream systems.