Summer 2013 Keck Proposal

Holocene and Modern Climate Change in the High Arctic, Svalbard, Norway

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Project Summary
Since 2003, our group has been running a summer NSF-sponsored REU site on Svalbard for motivated geoscience undergraduate students. The Svalbard REU directly involves students in important climate change research and exposes them to the challenges and rewards of conducting high latitude research. We have recently submitted a renewal proposal to the NSF, but even if funded, the REU program will not begin until the summer of 2014. As a result the Linné field site is available during the 2013 summer for a Keck-sponsored research program, as it was in 2009. We are once again excited to lead a Keck program to Svalbard, we have all the equipment (boats, motors, CTD, water samplers etc.), established logistics, and a network of monitoring instrumentation available to Keck students.

The main focus of the Svalbard REU program is monitoring modern processes in order to document the context and impact of recent warming and to establish reliable transfer functions between sedimentation and meteorological/glaciological variables that will allow the lake sediment record to be better interpreted as a high-resolution record of late Holocene climate change. Keck students can take advantage of our 10 years of data and pursue a wide variety of research projects concerning lacustrine sedimentation, periglacial features, raised marine shorelines, and late Holocene moraines that exist in the valley. We propose a four week Keck research program that will include one week of training and lectures in Longyearbyen, 2 weeks of field work at the field site, followed by one week of lab work at Mount Holyoke College. As with the Svalbard REU program, students will be integrally involved in defining their own research questions and designing specific testable hypotheses. Students will complete their research projects at their home institutions during the following academic year with on-going support from the faculty mentors.

Intellectual Merit
The Arctic is an area of active research because it is highly sensitive to climate change and because climatically induced environmental changes in this region can instigate further changes of global consequence. Recently published data indicate that the Arctic is warming far faster than lower latitudes and even greater rates of change and ecosystem disruption are predicted with the continuing decay of the Arctic Ocean pack ice. The Svalbard archipelago is strongly influenced by the northern end of the warm Gulf Stream current, and therefore its climate is sensitive to changes in global scale oceanic circulation. Svalbard has warmed considerably during the last 90 years and climate proxies indicate even greater Holocene climate variability. Despite this, little is known of sub-century climate change and virtually nothing is known of decadal scale variability in this Arctic region. We have initiated a long term monitoring of the rapidly changing Arctic cryo/hydrosphere that will inform interpretation of high-resolution proxy records from the Svalbard region.

Project Overview
Svalbard, because of its high latitude location (76-80° N lat.) in the North Atlantic, its modern towns and facilities, its abundant glacial and marine environments, and its rich Quaternary history, provides an unparalleled opportunity for meaningful Arctic research by undergraduate
Arctic science is not routinely part of undergraduate curricula and few polar research opportunities exist for undergraduate students due to the expense, logistics, and safety considerations associated with bringing students into the field. In light of the concerns with recent and projected climate change and the importance of the Polar Regions in the global climate system, there is a need to introduce more students to polar research. Svalbard is a unique environment in which to run a safe and effective polar undergraduate research program because it contains a rich assortment of glaciers and fjords, a variety of periglacial features, and a well-documented Quaternary history of glaciation and post-glacial marine emergence (Forman et al., 1987; Forman, 1990; Mangerud and Svendsen, 1990; Ingolfsson et. al., 1995). In addition, the modern town of Longyearbyen (Fig 1) has excellent facilities for supporting research (including airports and modern medical facilities). Previous and ongoing work indicates that significant Holocene environmental change occurred on Svalbard, and recent observations demonstrate that this region is experiencing rapid changes in climate (Serreze et al., 2000; Humlum, 2002; Moritz et al., 2002; ACIA, 2005; Overpeck et al., 2005; Holmgren et al., 2010; D’Andrea et al., 2012).

Research Questions and Student Projects

In the Svalbard REU program, undergraduate students are researching the Linné Valley glaciolacustrine system in order to establish linkages between climate, glacier mass balance, sediment transport, and sedimentation in the lake. Our network of monitoring instruments deployed at the field site for the last 10 years combined with our summer fieldwork provide a valuable and growing database critical to understanding the inherent variability of these natural systems. Specifically, students are: 1) monitoring the environmental response to recent climate change, 2) quantifying the response of the glacial, fluvial, lacustrine, and fjord systems to measured weather fluctuations; and 2) using these relationships to calibrate and interpret sediment records from lakes and fjords in order to reconstruct late Holocene climatic changes.

Field Component: Keck students will be integrally involved in defining the research questions and designing testable hypotheses. Student projects can build on previous REU projects and take advantage of our growing weather and observational records, or students can pursue a variety of projects relating to the glacial history of the area, permafrost features, hill slopes etc. The only project that we “need” to pursue is the recovery and analysis of 18 sediment traps we have deployed in the lake, beyond that, students are free to develop their own specific research questions and appropriate field techniques. In all cases, the faculty mentors will help coordinate and
focus student research projects. Below is a list of data that we are collecting and will be available for student projects—most data series have a sample interval of 30 min:

- Automated weather station
- Air temperature stations at 6 locations in the valley
- Ablation stake network on Linnébreen (glacier)
- Temperature and solar radiation sensors (glacier)
- Meltwater stream temperature (two locations)
- Three Snow trees (measure snow depth and snow melt timing and rates)
- Lake temperature (5 moorings and 3-5 different depths—each mooring)
- Lake level (measured with a level-logger)
- Annual sediment traps (5 moorings and 3-5 different depths—each mooring)
- Automated sediment trap (proximal mooring)
- Lake water turbidity (proximal mooring)
- Four automated cameras (twice daily images of valley and glacier)

In addition to the monitoring data, we have the ability to recover sediment cores from the local lakes and we have automated water samplers that can be programmed to sample the lake and river water at regular intervals. These water samples can then be filtered to determine the amount, texture and composition of the recovered samples.

Over the years of running our REU program, we have developed a wonderful working relationship with UNIS, the Norwegian University on Svalbard (see www.unis.no). UNIS faculty and students participate in our fieldwork each year and we often share field lodging with other arctic researchers. UNIS has developed safe and effective safety guidelines and training procedures to ensure safe work in the Arctic environment. All Keck participants will undergo the required safety training provided by UNIS. The UNIS logistics department also assists with transportation to/from the field site, provides safety equipment, and coordinates any necessary emergency response. During our 8 years of fieldwork (ca. 36 students), we have had only one injury requiring medical treatment.

**Lab Component:** Subsequent to the field work we plan to return to Mt. Holyoke College for a week to conduct preliminary sample and data analysis. We do not expect students will complete all of their lab work during this period, rather, it will be a time to split sediment cores and sediment trap samples, process water samples, share and start evaluating all the sensor data we collected and further refine the direction and scope of each student project. Al Werner’s Quaternary lab will host this work and students will stay in the MHC dorms. Students will have access to computers, an environmental SEM, wet lab facilities, library resources and analytical facilities in the 5-Colleges including a Coulter particle size analyzer, Scanning XRF, Geotek Multi-Sensor Core Logger (UMass) and an ICP-MS for sediment and water analysis. We plan to break-up the lab work by taking students on local field trips in the Connecticut Valley to see the varves and deltas of Glacial Lake Hitchcock.

**Educational Philosophies and Student Activities**

Students learn best by having ownership of their research project. In most cases, students have a good notion of how to proceed and will “rise to the challenge” to accomplish a goal—faculty are often most effective as safety nets and sounding boards (McNeal and D’Avanzo, 1997). Research that is perceived as “important” (rather than “busy work”) commands greater attention because the answers are not known and the students correctly feel as though they are making significant contributions to the project. We believe that it is important for students to struggle with real research questions and the details associated with research methods, instrument operation, data interpretation, etc (cf. Lonergan and Andersen, 1988; Huntoon et al., 2001;
We observe that students mature quickly as scientists when they have ownership of their tasks and experience success. As such, we give our students enough guidance to keep them on track, but we let them solve their own problems as much as feasible. Students work together in small groups (2-4) to make decisions and they frequently present data and hypotheses to and get feedback from their peers in other research teams. We carefully monitor individual students’ needs and provide personalized guidance throughout the research process. Students will be expected to continue their research during the following academic year and we will work closely with them and their advisers to insure progress in this direction. Although not all student projects result in a publication, it is worth noting that the research results derived from Svalbard Keck participant Vaillencourt (2009) were recently published in Geology (D’Andrea et al., 2012).

Although the main goal of our program is to advance student research skills, we also use the research activities to model and teach a variety of complementary tools and techniques when needed. Because the senior personnel in our project have constant contact with the students throughout the summer, our training and development activities are hands-on and personalized. For example, students receive GIS training in the evenings using the GPS data they collected during the day. Students learn how to build or modify field equipment as necessary for their specific projects. Senior personnel share their knowledge and ideas, and we model the maturity, patience, and flexibility required to conduct research in remote environments. Students learn important ancillary skills such as firearm safety, small boat handling, and the importance of teamwork. During ‘spare’ time (i.e., while hiking to/from field sites or during dinner), senior personnel discuss with students everything from graduate school and career options to the variety of responsibilities required of college/university professor-researchers. In the evenings after dinner, faculty and students utilize a computer, projector in a common work room to review and discuss data and strategize future field activities.

Below is an outline of the student research training components that we have successfully refined in past years and will employ in a Keck sponsored program:

- **We actively involve students from the start, rather than allowing them to be passive in the learning process.**
- **The international experience is exciting, but daunting to some students, so we make sure everyone is mentally and physically prepared, and we travel as a group.**
- **We teach safe field practices and expose students to the range of recent research on Svalbard so that they can begin to identify and refine their research topics.**
- **We want students to establish ownership of their project and define and justify their proposed research objectives. We also think it is important that students are exposed to and understand the significance of other research projects and thus, students will assist each other in the various projects.**
- **Essential learning takes place throughout the day and evening. Daily plotting, correlating, and interpreting of data influences subsequent research design and serves as an important vehicle for learning.**
- **We culminate the summer experience with a mini-symposium: a time for the group to learn from each other and to place their work in a larger perspective.**
✓ Academic follow-through is a critical component of our program. We also believe that formal presentations in front of public audiences are a critical but often neglected part of student research training. These public symposia also serve to advertise our program to new students each year.

Faculty Mentors
Faculty participants have more than 60 years combined of high-latitude field experience and established track records of involving undergraduate students in their research and publishing research results with current and former students. Although we are formally asking for support to fund only two Keck faculty, Steve Roof plans to request funds from Hampshire College to support his involvement.

**Steven Roof:** Steven Roof has been teaching at Hampshire College since 1995. He has been doing field research in the Arctic since 1992 and climate change research since 1986. His dissertation research focused on reconstructing middle Pleistocene glaciations in northwestern Alaska and establishing links between sea level, sea ice, moisture availability, and the initiation of glaciation at high latitudes. His polar research has taken him to Alaska, Russia, Antarctica, and Svalbard. Since arriving at Hampshire College in 1995, he has also been mentoring undergraduate students and directing student-centered research on late Pleistocene climate change in Death Valley, California. Of the 12 students directly involved with Roof’s Death Valley research thus far, six are currently in graduate school, one is teaching public high school earth science, and one is teaching elementary school environmental science. A majority of the students who have participated in his field trips to Death Valley have been women. This past year, he took three first-year students (two were women) to Death Valley region to do field research. His teaching at Hampshire College focuses on student-oriented, inquiry-based learning. Steven guides first year students through introductory science courses such as *Geological Controversies*, where they learn how scientists develop, test, and refine scientific theories by studying the evolution of scientific concepts from revolutionary ideas to foundational theories (e.g., evolution of plate tectonics theory). All of his senior students have participated in and presented their results at regional and national professional meetings. He was the co-PI of the original Svalbard REU program during its first funding cycle and the lead PI for the second cycle.

**Al Werner:** Al Werner has been teaching at Mount Holyoke College for 20 years. He is a Quaternary Geologist with primary interests in Holocene climate change. He believes that students learn best when they see field relationships firsthand and when they are actively involved in field projects. His undergraduate courses include: *Environmental Geology, Surface Processes, Ground Water Geology, Global Climate Change and Oceanography*. He has been teaching on an annual basis at UNIS as a guest lecturer. He has over 30 years of experience in high latitude regions including Alaska, Svalbard, and the Canadian Arctic. He conducted three field seasons of dissertation research on Svalbard in the mid 1980’s and has served as Director and Lead PI of the Svalbard REU during its inception. He has extensive experience with glacial geomorphology/mapping and lake coring to extract records of Holocene glacier activity and environmental change. Recent research has focused on evidence of late Holocene climate change in the Ahklun Mountains (SW Alaska; Levy et al., 2004) and using lake records to reconstruct volcanic ashfall history on the Kenai Peninsula and in the Anchorage metropolitan area (Hancock et al., 2001, 2002; Schiff et al, 2008). He routinely involves students in his summer research projects and nearly all of his thesis students have gone on to graduate school.

**Mike Retelle:** Mike Retelle is a Quaternary Geologist who has been at Bates College since 1987. His primary teaching and research interests are in the fields of glacial and Quaternary Geology with specific interests in modern surficial processes and paleoenvironmental records.
from glacial, lacustrine, and marine sediments in Maine and the Arctic. Mike has worked in the Arctic since 1981, beginning with his Ph.D. research on northern Ellesmere Island. He teaches courses in introductory geology, a Climate Change seminar for first-year students, upper level courses in Sedimentology and Quaternary Geology, and a Limnology and Paleolimnology Field course. He has advised over 75 senior thesis students in the required year-long senior thesis program at Bates, the majority working on projects related to environmental change in Maine and in the Arctic. His thesis students regularly attend and present thesis research at professional meetings including the Geological Society of Maine, Geological Society of America and the annual Arctic Workshop. Mike has worked in Svalbard since 2003 and has been a visiting lecturer in several courses at the Norwegian University Centre is Svalbard UNIS, including Arctic Hydrology and the Physical Geography of Svalbard.

Budget Justification
Support is requested to fund a four week research program that focuses on climate change in the Norwegian High Arctic. Funds are requested to support a three week field program in the Norwegian Arctic followed by a week of lab work at Mount Holyoke College for six students and two faculty mentors. Dr. Roof (Hampshire College) plans to join the research group using other funding. Domestic travel is requested for only three of the students – we anticipate the other three students will not require domestic airfare.

References


Hagglom, A., 1982. Driftwood in Svalbard as an indicator of sea ice conditions, Geografiska Annaler, 64a, p. 81-94.


