COLLABORATIVE RESEARCH: Spatial and Temporal Influences of Thermokarst Failures on Surface Processes in Arctic Landscapes

Intellectual Merit: Recent summaries of international research clearly document the past and future extent of climate warming in the Arctic. These summaries suggest that in the future, rising temperatures will be accompanied by increased precipitation, mostly as rain: 20% more over the Arctic as a whole and up to 30% more in coastal areas during the winter and autumn. These climate changes will have important impacts on Arctic Systems. Of direct interest to the research we propose here is the likelihood that warming will promote permafrost degradation and thaw. Formerly frozen soils may be further destabilized by increased precipitation, leading to hillslope thermokarst failures. We have recently documented that thermokarst failures are abundant and appear to have become more numerous around Toolik Lake on the eastern North Slope and in the western Noatak River basin in Alaska. We hypothesize that a widespread and long-term increase in the incidence of thermokarst failures will have important impacts on the structure and function of arctic headwater landscapes. **We propose to use a systems approach to address hypotheses about how thermokarst failures influence the structure and function of the arctic landscape.** Specifically we will focus on the composition of vegetation, the distribution and processing of soil nutrients, and exports of sediments and nutrients to stream and lake ecosystems. **We further propose to link results obtained at this hillslope scale to patterns observed at the landscape scale to test hypotheses about the spatial distribution of thermokarst failures in the arctic foothills**. We contend that it is important to understand these interactions because perhaps the greatest potential impacts of changing land surface processes and formation of thermokarst failures are feedbacks to the climate system through energy, albedo, water, and trace gas exchange.

This proposal addresses the core mission of the ARCSS program to take an integrated, synthetic, and interdisciplinary approach to understanding the Arctic System. The proposed research is designed to quantify linkages among climatology, hillslope hydrology, geomorphology, geocryology, community ecology of vegetation, soil nutrient dynamics, microbial ecology, trace gas dynamics, and aquatic ecology. We will use a combination of field experimentation, remote sensing, and simulation modeling as a means to quantify these relationships. We propose to work with native communities to determine the linkages between relatively recent observations based on technical data and local knowledge based on community experience, and to correlate the rate of thermokarst occurrence with long-term climate oscillations and indices. Finally, we will integrate this research with other ARCSS and international programs, and will disseminate the results from this research widely through collaborations with the International Arctic Research Commission and other groups.

Broader Impacts: Evidence of climate change is becoming widespread, but nowhere is this evidence stronger than in the Arctic. While many universities and colleges offer courses in science, engineering, and policy that are relevant to problems associated with changing climate in the Arctic, there are few examples of education and career training opportunities that are explicitly focused on this subject. There are even fewer opportunities for people in remote rural or economically depressed areas – such as the Native communities in the Arctic that are most directly affected by climate change – who often do not have direct access to universities, but do have access to communication tools on the internet. Other potentially interested communities include primary and secondary school educators who want to learn about climate change to enhance their teaching and who may need credits for continuing education or science specialty certification, as well as environmental and public interest organizations that could use this information in furthering their missions. We plan to reach geographically isolated and underserved students and adults in Alaska Native communities and will develop an online course and knowledge base that will be freely available to the public. We will integrate the findings from this research on thermokarsts within the broader context of climate change in the Arctic and include Native observations. Multimedia information will be integrated through web delivery to address different audiences: advanced high-school students, early university students and K-12 teachers; the lay public, and remote arctic communities that are directly affected by climate change impacts. The project will provide direct training and career development opportunities for 10 graduate students and post-doctoral fellows as well as numerous undergraduate students. We will collaborate with the Association of Early Polar Career Scientists (APECS) and the Young Researchers Network at the University of Alaska-Fairbanks on this. We will work with the University of the Arctic, Tribal Natural Resources Education Program, and GLOBE to enhance climate change education for different student audiences.