Report as of FY2006 for 2006AK46B: "Glacier Volume Change in Arctic Alaska and its Impact on Alaska’s Hydrologic Cycle"

Publications

Project 2006AK46B has resulted in no reported publications as of FY2006.

Report Follows

Glacier volume change in Arctic Alaska and its impact on Alaska's hydrological cycle

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Introduction. This project was intended to address the role of glacier volume change in the freshwater hydrological cycle in Alaska. In particular, we addressed the question of the importance of the numerous small glaciers (less than 1 km^2) relative to the fewer large glaciers, particularly on the Arctic Ocean drainage where they seem quite important (Dyugerov and Carter, 2004; Dyugerov and Meier, 2005). We had also intended to explore the impact of changing melt season length on river systems that may be used for various human activities, such as recreation, transportation, and industry. Year One in this project was only intended for data collection and preliminary reduction, so this report just describes our goals and what was accomplished in that year.

Background. Recent studies have shown that most Alaskan glaciers are retreating significantly and adding substantial amounts of freshwater into the local hydrological systems, as well as contributing more to sea level rise than the Greenland or Antarctic ice sheets. Sea level rise is of major concern to all Alaskans as it leads to increased coastal erosion and a freshening of ocean salt water can lead to significant changes in ocean currents and global weather. The changing amount of ice cover and albedo also feeds back into local weather systems, which again affects regional weather. This project is exploring the extent of glacier volume change throughout Alaska with particular emphasis on small glaciers, which have previously been overlooked. Though their reservoirs are smaller individually, small glaciers are much more numerous than the bigger ones and are likely losing mass just as fast as the larger ones, so their impact on time-scales of the next 20 years may be just as strong if not stronger than large glaciers, especially for those draining into the Arctic Ocean.

This project will give us a better understanding not only of the freshwater flux from glaciers to the larger-scale hydrological cycle, but will also give us a much better understanding of regional patterns of climate change throughout the state. The study focuses on the Brooks Range and Alaska Range, where freshwater leads ultimately to the Arctic Ocean or Bering Straight. Little glacier research has been done in these regions, at least when compared to the number of glaciers found here. Our study will also complement a number of USGS and UAF studies (Arendt et al, 2002; Nolan et al., 2005; Cox and March, 2004), including volume change studies but more importantly the use of 'benchmark' glaciers as long-term study sites. In particular, McCall Glacier in the Brooks Range and Gulkana Glacier in the Alaska Range are used as the only two such benchmark glaciers, but little work has been done to assess how well these glaciers represent these huge mountain ranges. Glacier studies are also one of our few means in this State to understand annual trends in mountain snow fall, and it is largely this mountain snow accumulation that keeps our rivers open during the summer. This project also addresses the poor level of mapping of glaciological resources through the creation of new topographic maps, as the existing maps are largely 50 years out of date and were of marginal accuracy in glacier-covered regions due to the problems associated with photogrammetry over low-contrast snow fields.

Year One Studies. In Year One we combined field work, GIS analysis, and remote sensing to measure volume change of over 150 glaciers in the Brooks Range. Most of these glaciers are located in the central Brooks Range, near Atigun and Anatuvuk Passes. As part of other funded research, I was able to obtain new digital elevation models (using the Star3i airborne SAR system) of these regions which were then used to compare against older USGS topographic maps. It quickly became clear that the USGS NED DEMs available online are not suitable for this work, due to various artifacts. To achieve the best results, we purchased copies of the original USGS map sheets of the contour layers, geolocated them, and created DEMs based on these older maps of all of the glaciers within the Star3i DEM's extents. The various options for creating DEMs from contour lines was explored by investigating all methods available and noting their affect on the results of the comparison. During Year One, we did not actually complete the volume change calculations, but rather focused on these issues of accuracy and technique. Subsequent results show substantial ice volume loss has occurred here.

Field work conducted in the eastern Brooks Range showed similar volume changes and helped better elucidate the causes of this change. Our primary field work was on McCall Glacier, where we have a 50 year baseline of research to draw from. Currently we have about a dozen weather stations here, several continuously operating GPS, and a number of volume change transects measured twice per year; these data were intended to be used in Year Two and Three as part of a modeling study to link climate change with glacier change. Analysis of trends here shows that the mass balance of McCall Glacier has been steadily getting more negative, due to a steadily-rising equilibrium line. That is, more snow/ice is melting here than is being accumulated, and in several recent years there has be no snow accumulation at all. These measurements form an important basis for comparison for the central Brooks Range, where as yet we have no field measurements of mass balance or equilibrium lines. Analysis of equilibrium lines (the balance between regions of accumulation and ablation on the glacier) across the Brooks Range is one of the best tools at our disposal for understanding spatial variations in climate change in arctic Alaska. In addition to measurements made at McCall Glacier, volume change was measured via GPS at nearby Hubley, Schwanda, Okpilak, and Kriscott Glaciers along longitudinal transects first measured in 1993-94 and later measured again in 2003-04. Subsequent analysis of these interval measurements showed that the rate of volume loss has increased dramatically over the past decade, continuing a long-term trend of increasing rates.

Future Work. The PI for this project did not submit a continuation proposal for Year 2 this year and has subsequently left the Water & Environmental Research Center. Remaining funds from his project will be returned to the USGS.