Water and Environmental Research Center
Annual Technical Report
FY 2007

Introduction

In an era of climate uncertainty (climatic warming plus warming and thawing permafrost, declining sea ice extent, shrinking glaciers, changes in vegetation and others), the future role of water in the hydrologic cycle and its interaction with atmospheric, terrestrial, ocean and human systems is unclear. Researchers expect that the impact of climate change (warmer temperatures) will be enhanced in the high latitudes. This can be coupled with a very poor hydrologic database for this area of the world; in this case we are specifically talking about Alaska, where we have all of the water related problems found elsewhere, plus a system that is undergoing change. The recent increase in natural resource value (oil, gas, gold, etc.) has been a catalyst also for development in many remote areas of the state where additional demands are being made on the water resources; some are quite unique, such as building ice roads.

The Water and Environmental Research Center (WERC), in the Institute of Northern Engineering (INE) at the University of Alaska Fairbanks has three major water−related objectives: graduate and undergraduate research education, quality research, and science and engineering outreach to K through 12, to both students and their teachers. WERC continues to grow in terms of research dollars generated and our research activities steadily increase each year. In the past three years, there has been a large influx of State of Alaska money through the Alaska Department of Transportation and Public Facilities and the Alaska Department of Natural Resources. This has historically not been a significant source of funding for WERC, but now represents over 25% of our annual budget. We presently have over 50 research projects ongoing (several are rather large multi−year projects). Annual expenditures for WERC in FY 08 (July 1, 2007 to June 30, 2008) totaled $4,709,000.

With the onset of the International Polar Year (IPY), the President of the University of Alaska funded 10 post−doctorates over all of the colleges and institutes in the state campus system. In a highly competitive process, WERC attracted four post−doctorates (one ultimately opted out when offered a tenure track position at another university). One of these post−doctorates has accepted a faculty position in WERC.

WERC, along with the International Arctic Research Center (IARC) on the Fairbanks campus, hosted another IPY activity, the Ninth International Conference on Permafrost (NICOP). This conference, which convenes every five years, attracted 700 scientist and engineers from over 30 countries. These participants made more than 550 presentations (plenary, poster and oral) over a five day period (June 29 to July 3, 2008). Products generated included a two−volume proceedings (2140 pages, both printed and electronic), extended abstract volume, abstract volume, and a compilation of all nine permafrost conference proceedings on a DVD. There were also pre− and post−extended conference tours, local field trips and several short courses for a wide audience (practicing engineers, graduate students, and K−12 teachers).

WERC's outreach activities continue to expand. Faculty, staff and students make numerous presentations in K through 12 schools and participate by judging in local science fairs. WERC sponsors several workshops and helps with the annual AWRA State Section meeting held in the spring. This meeting is the largest of the water resources related meetings in the state. Dr. Horacio Toniolo, Civil and Environmental Engineering Department and WERC faculty member, is president elect for the Alaska section of AWRA. Faculty, staff and students interact also with the public sector; one example is the South Anchorage area, where there are serious concerns about the quality of the groundwater and the impact that development may have on the groundwater. We have made presentations at community council meetings, with local groups.

Permafrost is pervasive in Alaska. In one of our outreach programs, Dr. Kenji Yoshikawa (in partnership with the University's EPSCOR program, NSF−IPY, NASA− IPY) has instrumented several vertical boreholes and installed thermistors in each to monitor the health of the permafrost. This has been done at about 80 schools in Alaska (a few are in the Yukon, Canada in the Yukon River basin). Temperature data from these boreholes is stored on data loggers, but also transferred to the school's internet service where the students can download the data and monitor what is happening during the seasonal temperature swings. In the past year, 63 of these schools were visited for the purpose of enhancing the school's science education program. For more details, please visit the site at: http://www.uaf.edu/permafrost

The Water and Environmental Research Center collects large amounts of hydrometeorological data in carrying out various research projects. Unlike most states, where there is a very dense hydrometeorological network, Alaska's is very sparse. To provide data for other researchers and general users, we have established a data collection archive on line at our website: http://www.uaf.edu/water/

Much of this data is reported in near real time through various transmission modes. There are also some cameras that take an image every 20 minutes of the weather; one can be visited at:

http://www.uaf.edu/water/projects/NorthSlope/upper_kuparuk/uk−repeater/current.html

We have recently added a new dimension to our research program; we are becoming more involved in the social science aspects of water resources. We have one project on “The Intersection between Climate Change, Water Resources and Humans in the Arctic” and another on “Freshwater Social−Ecological Systems: Analyzing Alaska's Institutional Capacity for Water Security and Hydrological Change.”

Much of our research is being driven by climate change which is clearly obvious in many forms in Alaska; ongoing changes were listed above. What we lack in Alaska is high−quality, long−term data sets to detect change such as in precipitation rates (both rain and snow). The federal agencies were quite slow in developing hydrometeorological stations in Alaska and often the environment proved to be an obstacle to good quality data. Presently with the increase in costs of gas, heating oil, kerosene, etc., there is considerable new exploration ongoing on the North Slope of Alaska. This is both an area of minimal water resources and an environment where much of the water present is in the solid state for much of the year.

In summary, WERC continues to grow and encompass more professional disciplines. It is a center of excellence regarding water that is clearly recognized throughout the state. Our one major challenge is attracting good, high quality students. All of our students receive graduate research stipends, but we continue to have unfilled graduate positions.

Research Program Introduction

This past year, we funded four research projects on the USGS 104b funding:

"Watershed Response to Forest Fires in Cold Regions: Channel Development and Suspended Load Variation in Streams in Interior Alaska"

"The Formation of Preferential Pathways in Permeable Reactive Barriers in Cold Climates due to Ice Formation"

"Increasing Coverage of Alaska within the Global Network of Isotopes in Precipitation"

"Geomorphic Constraints on the Configuration, Magnitude, and Timing of Late−Quaternary Megafloods from Glacier−dammed Lake Atna, Alaska"

We generally encourage younger faculty to apply for these grants with a majority of the funding going to graduate student support. Details on these projects appear in the following pages.

Watershed Response to Forest Fires in Cold Regions: Channel Development and Suspended Load Variation in Streams in Interior Alaska

Basic Information

Title:	Watershed Response to Forest Fires in Cold Regions: Channel Development and Suspended Load Variation in Streams in Interior Alaska
Project Number:	2006AK50B
Start Date:	3/1/2006
End Date:	2/28/2008
Funding Source:	104B
Congressional District:	AK
Research Category:	Ground−water Flow and Transport
Focus Category:	Hydrology, Surface Water, None
Descriptors:	suspended load, soil erosion, channel formation, mapping, discontinuous permafrost
Principal Investigators:	Horacio Toniolo

Publication

1. Toniolo, H., Kodial, K., Hinzman, L. and Yoshikawa, K. Climate change and its effects in Interior Alaska, USA. Proceedings of XXII Latin−American Congress of Hydraulics; Latin−American Region of the IAHR. Guyana city, Venezuela, (2006)
2. Toniolo, H. and Kodial, P. Suspended sediment load variation in a sub−arctic watershed in Interior Alaska. 4th IAHR Symposium on River, Coastal and Estuarine Morphodynamics, Urbana , IL . 2005.
3. Kodial, P., Toniolo, H., Hinzman, L. and Yoshikawa, K. Thermokarst evolution in sub−arctic Alaska : A study case. ASCE Water Resources Congress. Anchorage , AK . 2005.
4. Duvoy, P.X. &H.A. Toniolo. 2006. Watershed Response to Boreal Forest Fires in Interior Alaska. Conference presentation for American Geophysical Union, Fall Meeting 2006.

State: AK

Project Title: Watershed response to forest fires in cold regions: channel development and suspended load variation in streams in Interior Alaska – Final Report.

Project Type: Research

Focus Category: Hydrology, Surface Water

Keywords: Suspended load, soil erosion, channel formation, mapping, discontinuous permafrost.

Start Date; 03/01/06

End Date: 02/28/08

PI: Horacio Toniolo
E-mail: ffhat@uaf.edu

Summary of activities and results

Instruments including pressure transducers, dataloggers, and autamplers were installed in two streams in the Caribou-Poker Creeks Research Watershed (CPCRW) and Boston Creek. Instruments were deployed in the field after spring breakup and removed at the end of summer of 2006 and 2007. Water samples were collected every day. Boston Creek was gaged every two weeks during the field seasons. Suspended load concentrations were determined at UAF's laboratories. Topographical surveys were conducted in an area where a small channel developed as a consequence of firefighter activities. These tasks were carried out by students Paul Duvoy (2006) and Jonathan Hucthinson (2007). Results from this work were presented at 2006 and 2007 AGU Fall Meetings. Main results and findings are described below.

Figure 1 shows the temporal evolution of the small channel and the recovery of vegetation in an area affected by fire suppression activities, near the access to C4 in the

Figure 1. *Landscaped evolution in the area affected by fire suppression activities; channel developed in August 2005 after rainfall events (left), channel in June 2006 (center), reestablished vegetation in August 2007 (left).*

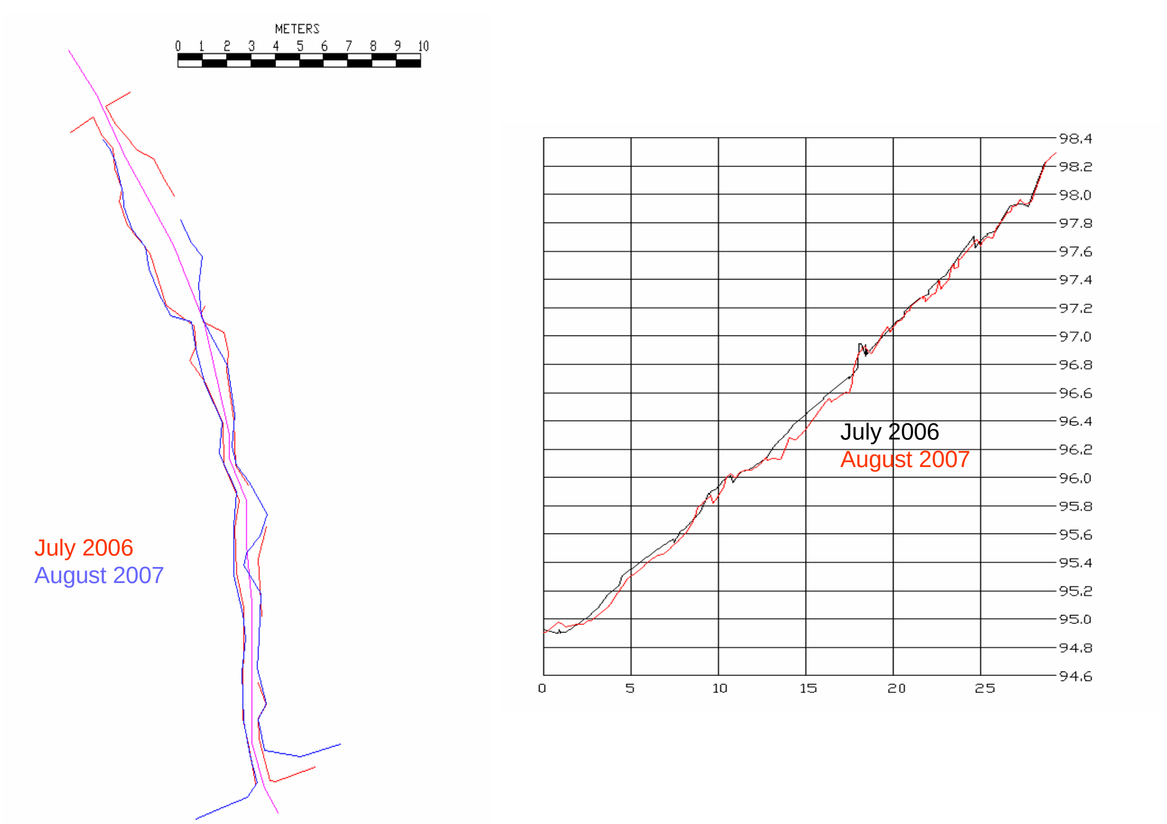

Figure 2. *Channel topography. Plan view (left), longitudinal profile (right). Channel widening and deepening is evident. Datum elevation is 100 m (arbitrary).*

CPCRW. Available data suggests that vegetation is reestablished in the area. Figure 2 shows the channel plan view and thalweg longitudinal profile.

The channel is continuing its development. The channel depth is increasing along the entire reach; channel widening is evident near the mouth. While erosion continues to be an active process, natural recovery is also evident, and the development of the channel seems to be slowing down.

Initial work on suspended load in streams in the CPCRW (C4, fire-free; P6, partially burned) and Boston Creek (fully burned) was initiated by Kodial and Toniolo during the summer of 2005. These streams were systematically sampled during 2006 and 2007. Also, the response of suspended load in streams to rainfall events was investigated last year. Precipitation data corresponding to 2005, 2006 and 2007 come from a weather station located near the Boston Creek.

Figure 3 shows the precipitation records and suspended loads for C4, P6, and Boston Creek from top to bottom respectively. Data covers a period of three years after the initial fire, which occurred in 2004. Graphs indicate that, in some watersheds, the concentrations decreased from 2005 to 2007, particularly in the fully burned watershed. The unburned zone has remained relatively constant. Data for the partially burned stream indicates enormous changes in the concentration during the summer of 2007. These changes are attributed to local-channel instability conditions in the sampling area. Last year (2007) experienced a higher amount of rainfall than the previous two years. In general, peaks in sediment concentrations are in phase with precipitation events.

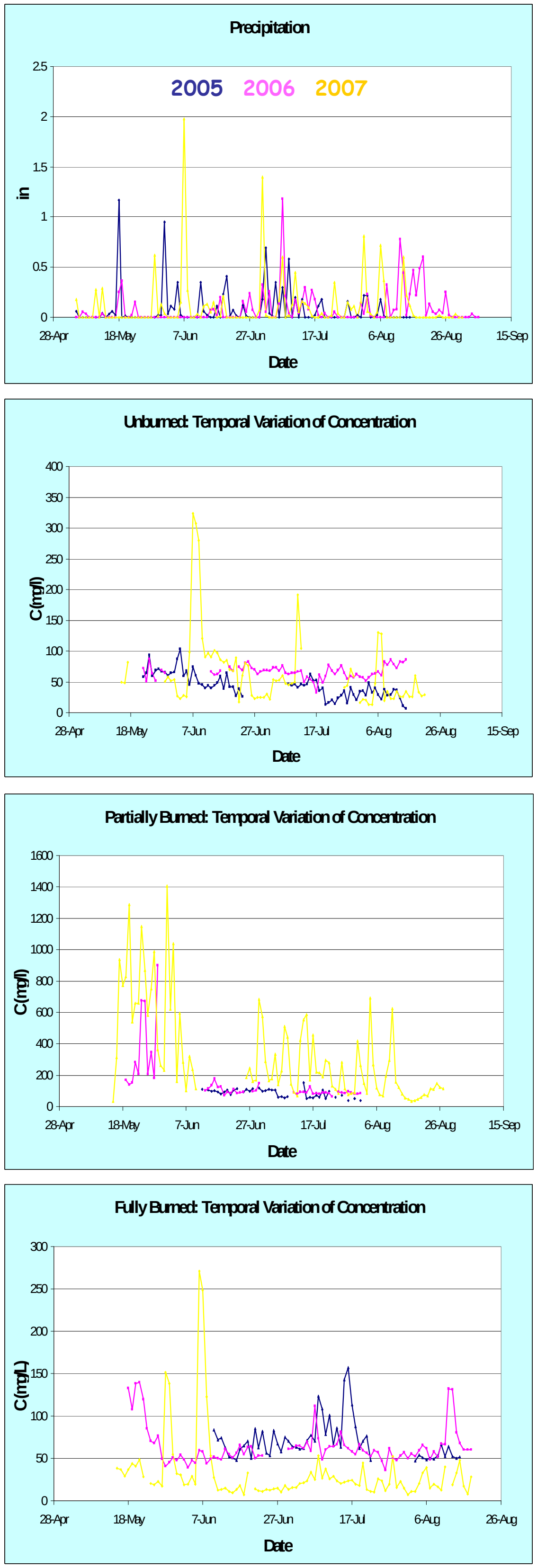

Figure 3. *Temporal variation of precipitation and suspended loads in studied streams.*

The formation of preferential pathways in permeable reactive barriers in cold climates due to ice formation

Basic Information

Title:	The formation of preferential pathways in permeable reactive barriers in cold climates due to ice formation
Project Number:	2007AK63B
Start Date:	3/1/2007
End Date:	2/28/2008
Funding Source:	104B
Congressional District:	AK
Research Category:	Ground−water Flow and Transport
Focus Category:	Groundwater, Hydrology, Treatment
Descriptors:	
Principal Investigators:	David L. Barnes

Publication

1. W.J. Fourie and D.L. Barnes, (2007), The Simulation of Pore Scale Fluid Flow with Real World Geometries Obtained from X−Ray Computed Tomography, Proceedings: Comsol Conference, Boston
2. P.G. Young, B. Notarberardin, B. Walker, W. Fourie, R. Said, (2008), Computational Simulation of Mechanical and Multi−physics Behavior of Porous Media, Biot Conference, New York, Accepted

The formation of preferential pathways in permeable reactive barriers in cold climates due to ice formation

Walter Fourie and David L Barnes

1) Water Related Problem

Results from this research will help provide a better understanding of how contaminated surface and ground water can be treated with permeable reactive barriers in cold climate regions such as the North Slope of Alaska and Antarctica.

2) Question to be addressed

The use of permeable reactive barriers in the arctic are subject to the formation of preferential pathways by the formation of ice and entrapment of non-aqueous phase liquids.

3) Research Approach

The flow path of water or a non-aqueous liquid through a porous medium can best be imaged with X-Ray Computed Tomography. The method is non-destructive and allows successive infiltration instances to be captured in three dimensions. The purpose of these initial studies where to (a) verify that successive infiltrations of melt water into a frozen permeable reactive media (zeolite) can be imaged through X-Ray Computed Tomography, and (b) to verify that four distinct phases, (1) zeolite, (2) air, (3) water (or ice), and (4) NAPL, can be imaged simultaneously and then separated through image analysis. These methodologies can then be used to investigate the formation of preferential pathways in permeable reactive barriers in cold climates.

For part (a) the zeolite was saturated with deionized water and allowed to drain to residual, after which it was frozen and scanned. The sample was then infiltrated with four successive infiltrations of 0.05ml deionized melt water. The sample was kept below freezing the entire time and scanned after each infiltration.

For part (b) the zeolite was saturated with water containing 2% NaI and then allowed to drain to residual. The I^- ions are strong X-Ray absorbers and ensures that a distinction can be made between the aqueous and non-aqueous phases. Subsequently gasoline was infiltrated into the sample and allowed to drain freely. The sample was then imaged in the CT Scanner.

4) Summary of Results to Date

Figures 1 and 2 show the results after the four successive infiltrations. In Figure 1 the apparent thin film of ice around all the particles may just be an image artefact. Scanning a completely dry sample has thus far proven difficult as a small amount of ice is needed in the sample to cement the particles together. Without the ice, small vibrations and the rotation of the sample in the scanner cause the particles to move, which causes errors in the reconstruction. The small flecks of ice in the pore space are also image artefacts. As expected, ice is first formed in the small pore spaces, where the infiltration water is initially held by capillary force, before it turns into ice. Between infiltration (c) and (d), ponding occurred on the top of the sample and the water turned into ice before it could infiltrate. Hence the apparent lack in the increase of ice from infiltration (c) to (d).

In Figure 2 is a three dimensional reconstruction of the air phase after each infiltration. These reconstructions allow quantitative measurement of the volumes available for infiltration as well as the reduction in permeability due to the presence of ice (Fourie & Barnes, 2007).

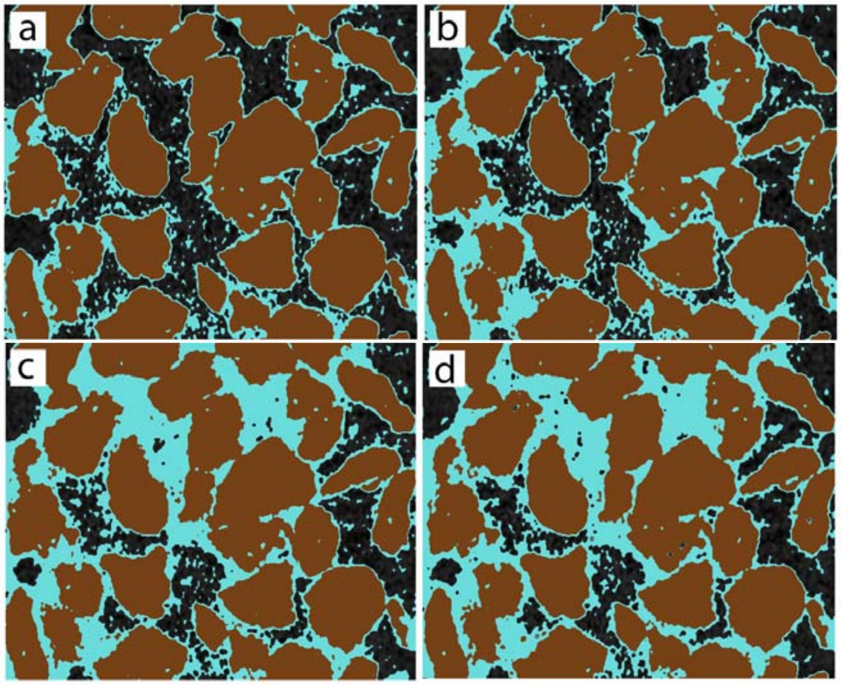

Figure 1: Four vertical cross-sections representing the infiltration of water into the zeolite. The brown is the zeolite and the blue is the ice.

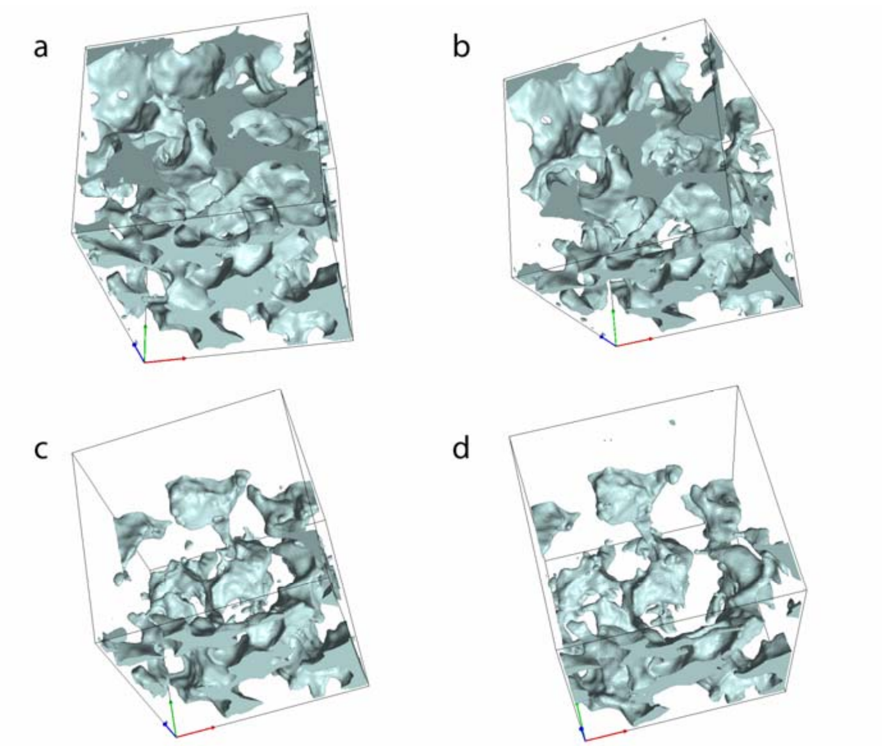

Figure 2: Four reconstructions of the available air space after the successive infiltrations. The samples are seen from below, the green arrow indicating the positive z-direction.

Figure 3 shows the reconstruction with all four phases present, solid (zeolite), NAPL, water and air. From these reconstructions we can glean the relative positions of the water and NAPL as well as whether snap-off occurs or not. The morphology of the NAPL can also be calculated and will be cross referenced through chemical means (Cho & Annable, 2005). These values are indicative of the mobilization potential of the NAPL entrapped within the permeable reactive barrier.

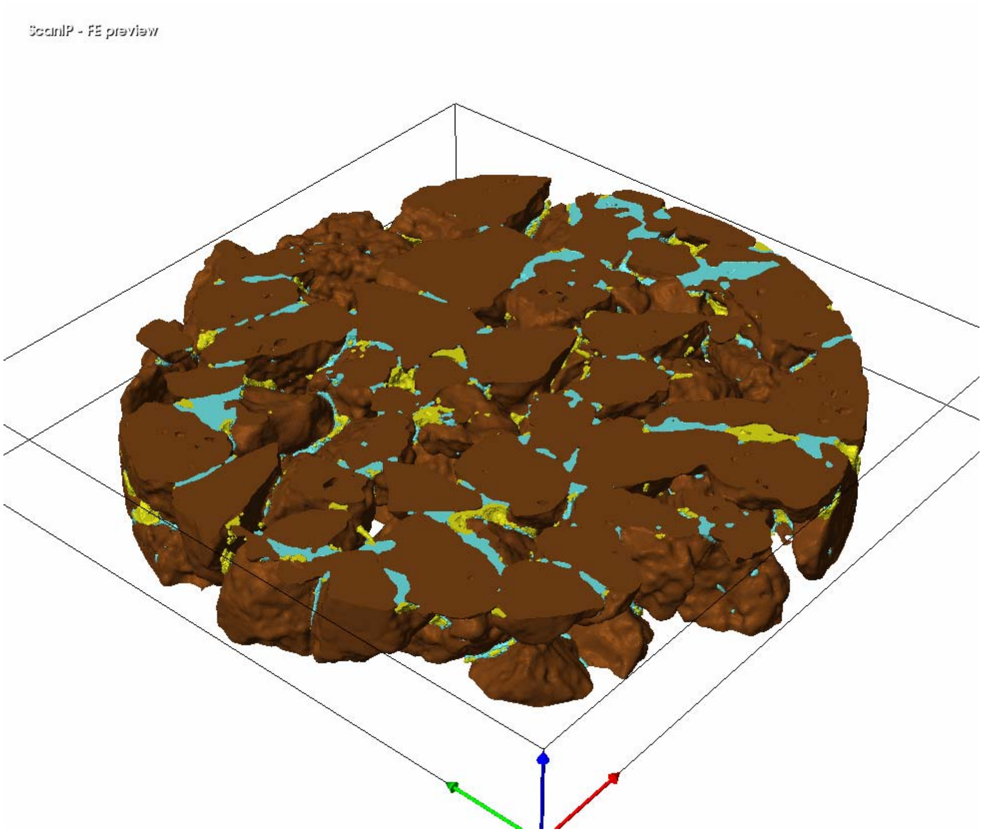

Figure 3: Three dimensional reconstruction of zeolite infiltrated with a NaI solution and gasoline. The NaI solution is blue in color and the gasoline is gold.

5) Publications

W.J. Fourie and D.L. Barnes, (2007), The Simulation of Pore Scale Fluid Flow with Real World Geometries Obtained from X-Ray Computed Tomography, Proceedings: Comsol Conference, Boston

P.G. Young, B. Notarberardin, B. Walker, W. Fourie, R. Said, (2008), Computational Simulation of Mechanical and Multi-physics Behavior of Porous Media, Biot Conference, New York, *Accepted*

6) Student Involvement in Project

The PhD student, Walter Fourie, performed all the experimental procedures and the computer analyses.

7) References

Cho, J. and Annable, M.D., (2005), Characterization of pore scale NAPL morphology in homogeneous sands as a function of grain size and NAPL dissolution, *Chemosphere*, 61, 899-908

W.J. Fourie and D.L. Barnes, (2007), The Simulation of Pore Scale Fluid Flow with Real World Geometries Obtained from X-Ray Computed Tomography, Proceedings: Comsol Conference, Boston

Increasing coverage of Alaska within the global network of isotopes in precipitation

Basic Information

Title:	Increasing coverage of Alaska within the global network of isotopes in precipitation
Project Number:	2007AK64B
Start Date:	3/1/2007
End Date:	2/28/2008
Funding Source:	104B
Congressional District:	AK
Research Category:	Climate and Hydrologic Processes
Focus Category:	Hydrogeochemistry, Hydrology, Climatological Processes
Descriptors:	
Principal Investigators:	Matthew John Wooller

Publication

Report: Increasing coverage of Alaska within the global network of isotopes in precipitation.

Wang Y. and Wooller M.J.

Aug 2008

1) Water-related Problem

The natural spatial distribution of oxygen ($\delta^{18}O$) and hydrogen (δD) isotopic compositions of precipitation over continental areas are primarily a function of the fraction of water remaining in an air mass as it moves inland over topographic features. The $\delta^{18}O$ and δD are also influenced by temperature, altitude, distance inland along different storm tracks, environmental conditions at the sources of the vapor, latitude and humidity. Therefore, the pattern of isotopic composition in precipitation in modern hydrological systems is a product of global and local meteorology processes. As a result, these isotopes serve as ideal hydrological tracers and have been applied to study past climate, paleohydrology, wildlife migration, archeology and forensics. As part of the polar regions and the Arctic, Alaska has experienced significant climate changes over the past 20 years. Current global warming has significantly affected the life style of native Alaskan and wildlife in the far north due to the decrease sea ice and snow cover and increased permafrost thawing. However, the information the isotopic patterns in the modern hydrological cycle in Alaska are extremely limited compared to other regions in the globe.

Studies of high latitude climate change will increase our scientific understanding of global change and link scientific findings to policy decisions. However, the short time span of direct observations limits our ability to evaluate the roles of natural climate variability and greenhouse gas forcing in explaining modern observations. Climate sensitivity of regions at high latitude can be evaluated by reconstructing changes during the past and providing records that extend beyond instrumental observations. Stable isotopes of past precipitation (e.g., from ice cores and lake sediments) have been analyzed and used to reconstruct past meteorology and hydrology. Past variations in the isotopic composition of precipitation are best understood and interpreted in relation to the isotopic variation displayed by modern precipitation. The Global Network of Isotopes in Precipitation (GNIP) can provide an understanding of isotopic variation in modern precipitation. However, information about temporal and spatial isotopic patterns of modern precipitation in Alaska is very limited within GNIP,

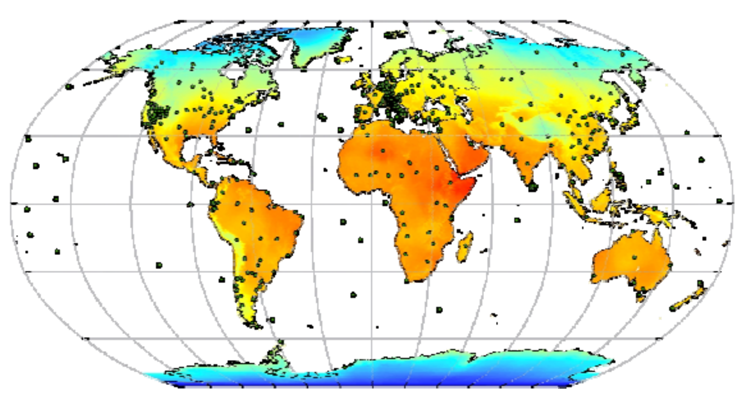

Figure 1: Locations of the stations currently being used to monitor the stable isotope (O and H) composition of precipitation (figure taken from http://wateriso.eas.purdue.edu/waterisotopes)

with only three locations that have provided data (Figure 1). The uneven distribution of isotopic data measurements currently impedes a comprehensive understanding of past climate and hydrological cycles in Alaska. Thus, it is necessary to begin increasing Alaska's spatial and temporal resolution within GNIP. Realizing the potential for application of water stable isotopes in a number of scientific disciplines, the World Metrological Organization (WMO) and International Atomic Energy Agency (IAEA) established the Global Network for Isotopes in Precipitation (GNIP) in the early 1960s. This worldwide network of precipitation-monitoring stations persists and continues to evolve today. However, the GNIP data measurements are distributed very unevenly in space. Currently Alaska, with only three data points (Anchorage, Barrow, and Nome), is one of the most sparsely represented states in the USA. It is necessary to increase Alaska's spatial resolution within GNIP. Optimal geographic areas to include and to examine short-term climate changes are localities representing boundaries between climate zones, where ecosystems are very sensitive to changes in air mass transportation, precipitation and evaporation.

2) Question to be Addressed

Southwest Alaska, extending from central Alaska to coasts of Bristol Bay, is an ideal region to investigate past and current environmental change. The main objective of this project was to conduct stable hydrogen and oxygen isotope analyses of an entire annual suite of precipitation samples from King Salmon Weather Station in southwest Alaska (Figure 2). Questions to be addressed included: 1) What is the seasonal magnitude of isotopic variation for precipitation at the King Salmon weather station? 2) Is the seasonal variation related to climatic variation and/or sources of precipitation? 3) How does the isotopic variation in precipitation from King Salmon compare with the isotopic composition of lake water from a lake (Idavain Lake - being used to study past precipitation) local to King Salmon?

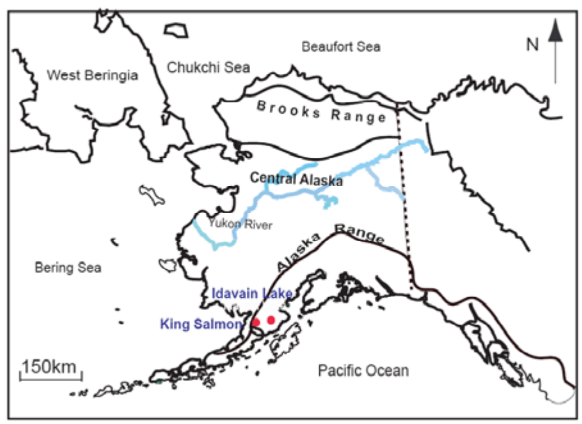

Figure 2: Location of Lake Idavain and King Salmon weather station.

3) Research Approach

Precipitation samples were collected for an entire year by staff at the King Salmon National Weather Service Station, under the guidance of and in collaboration with Yiming Wang and the PI (Wooller).

When multiple precipitation events occurred within a day, the King Salmon Staff also took multiple samples for analysis. A minimum sample size of 5 ml of precipitation was collected by the King Salmon Staff each time the amount of precipitation was measured at the weather station. The samples were capped tightly to prevent evaporation and were archived in a refrigerator until 100 samples had been collected. The staff then mailed the batch of samples to Yiming Wang at the Water and Environmental Research Center, who prepared the samples for stable isotope analysis at the Alaska Stable Isotope Facility (ASIF). ASIF is a state-of-the-science, professional stable isotope laboratory that specializes in measuring the stable isotope composition of many different types of samples, including water (see www. uaf.edu/water/ASIF/ASIF.html). ASIF is directed by the PI and operated as a recharge center within the University of Alaska Fairbanks where analyses were conducted.

The stable hydrogen and oxygen isotope composition ($\delta^{18}O$ and δD) of water samples were conducted at ASIF using instruments and techniques standard for the discipline of stable isotope biogeochemistry. The $\delta^{18}O$ and δD of water samples were measured by injecting 0.2 µl of sample (using a CTC Analytics A200SE liquid autosampler) into an on-line pyrolysis thermochemical reactor (Finnigan ThermoQuest TC-EA) coupled to a continuous flow isotope ratio mass spectrometer (Finnigan MAT Delta + XL). A typical quality control scheme involved analyzing laboratory working standards after every seventh sample. Laboratory working standards included DMW (internally calibrated Duckering Building Millipore Water), NIST standard (REF 8535 V-SMOW), GISP (8536) and SLAP (8537). Multiple $\delta^{18}O$ and δD analyses of DMW (n = 15) conducted during a sample sequence typically yield 2σ = 0.4‰ and 1.7‰ respectively. Each sample and standard were analyzed in triplicate. Triplicate $\delta^{18}O$ and δD analyses of separate DMW water samples (n = 15) typically yielded 2σ of between = 0.3‰ and 1.6‰ respectively. The stable hydrogen and oxygen isotope composition of the precipitation over the sampled year were compared with climate data that was collected and is freely available from the King Salmon Weather Station.

4) Summary of Results to Date

There was a large variation in δD and $\delta^{18}O$ values of precipitation (n=295) from King Salmon weather station, ranging from -240.0 to -26.0 ‰ and -33.0 to -1.5 ‰ respectively (Figure 3). Individual rain events within a month, such as August for example, varied from -155.0 to -21.5 ‰ for δD and from -20.2 to -1.5 ‰ for $\delta^{18}O$. A similar magnitude of variation between individual rain events was also evident in the other months. The slope (~6) of the King Salmon's Local Meteoric Water Line (LMWL) is slightly less than the slope (8) of the Global Meteoric Water Line (GMWL) (Figure 3). The volume weighted δD and $\delta^{18}O$ data from the precipitation collected from King Salmon weather station from August 2006 to July 2007 also show of great monthly and seasonal variability in the region (Figure 3). The lowest isotopic values occurred in December 2006, yielding a mean δD of -171.3 ‰ and $\delta^{18}O$ of -23.8 ‰. The highest isotopic values of precipitation occurred in July 2007 and October 2006 and both months had a mean δD of -87.3 ‰ and $\delta^{18}O$ of -10.7 ‰ (Figure 3), which are also consistent with the previously measured lake water values from Idavain lake.

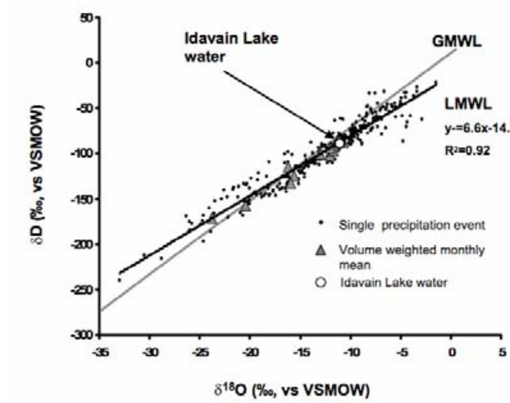

Figure 3: The $\delta^{18}O$ and δD of precipitation from King Salmon. A local Meteoric Water Line (LMWL) was plotted against the Global Meteoric Water Line. The lake water from Idavain Lake near King Salmon also plotted on the LMWL indicating that the lake was primarily driven by a precipitation signal.

Storm trajectory models can help us to distinguish specific moisture sources at a certain locality. By matching isotope values to those storm trajectories, we are able to examine the isotopic compositions of the storm sources. Storm trajectories extracted from an online storm track archives at NOAA's Air Resources Laboratory (ARL) (http://www.arl.noaa.gov/ready.html) (Figure 4) demonstrated that King Salmon receives its precipitation sources from a number of different directions, bringing different isotopic composition of precipitation to the station. As examples, storms arrived at 12am August 8th 2006 from mainly westerly and southerly direction and generated precipitation with δD of -44.3 ‰ and $\delta^{18}O$ of -5.5 ‰ respectively (Figure 4a). At 12am on August 16th 2006 storm were mostly northwesterly or westerly, which yielded a δD of -98.6 ‰ and $\delta^{18}O$ of 12.1 ‰ for (Figure 4b). During November 30th 2006, southerly flow brought precipitation with a δD of -70.4 ‰ and a $\delta^{18}O$ of -7.3 ‰. Precipitation of December 19th 2006 was primarily derived from northwesterly and northerly directions and precipitation was more depleted with a δD of -134.6 ‰ and a $\delta^{18}O$ of -18.1 ‰ (Figure 4d).

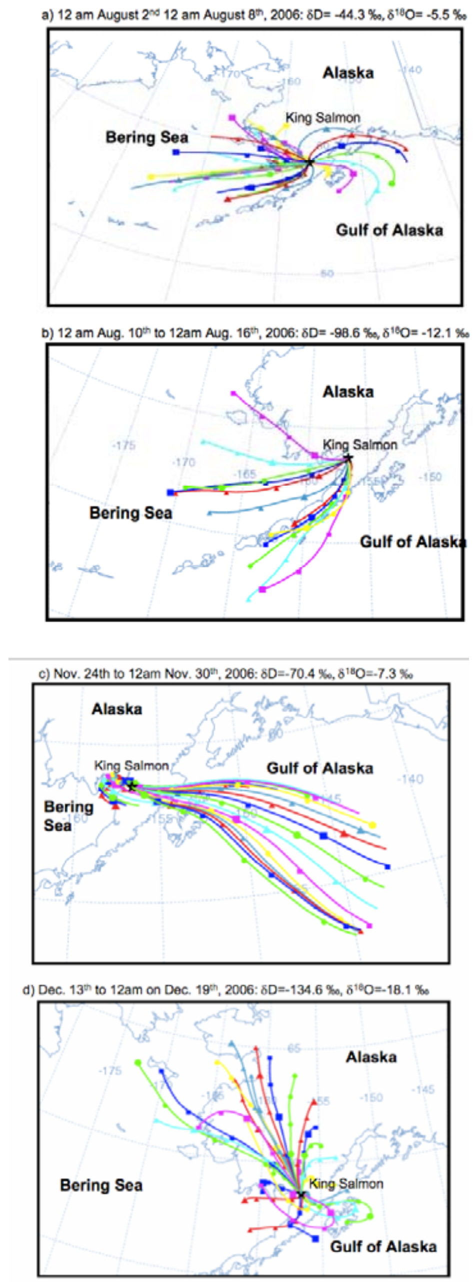

Figure 4: The examples of storm trajectories traveled to King Salmon weather station over different period and their isotopic compositions of precipitation. All the storm trajectories are tracked back a week prior to the ending time. Different color present different storm directions and symbols along each trajectory indicates the position of the air parcel over the calculation period, the interval of which is defined by 24 hours here (storm trajectories sources derived from Air Resources Laboratory (ARL).

5) Publications

Wang Y. The development and application of stable oxygen and hydrogen isotope analyses of chironomidea (Dipetra) as indicators of past environmental changes. A thesis, In preparation (submitted in August 2008)

Wang, Y., D. O'Brien, D. Francis and M.J. Wooller. A laboratory based growth experiment examining the influence of diet and water on the stable oxygen and hydrogen isotope composition of chironomids (Chironomidae: Diptera). In preparation.

Wang, Y., Finney, B., Krumhardt, A., Cohn, B., Wooller, M. J., Isotope evidence for shifts in atmospheric circulation patterns during the late Quaternary in Southwest Alaska. In preparation.

6) Student Involvement in Project

The data derived from this project has been an important component of Yiming Wang's PhD thesis research program. Yiming has now successfully completed her PhD. Her first priority was to initiate a year-long collection of samples by an appropriate weather station (King Salmon). The training potential associated with this project has been the direct support of a student's research program. Training was supplied by the PI in analyzing the data that has been produced by this project and preparing the data for presentation at a national meetings and for publication in a peer-reviewed, international journals. Yiming has also received training from staff at the ASIF in preparing water samples for stable isotope analysis. This project also relates to an education and outreach component organized by Yiming as part of the International Polar Year youth program at UAF. Yiming has involved native Alaskan schools in a survey of isotopes in precipitation at their schools.

Geomorphic constraints on the configuration, magnitude, and timing of late−Quaternary megafloods from glacier−dammed Lake Atna, Alaska

Basic Information

Title:	Geomorphic constraints on the configuration, magnitude, and timing of late−Quaternary megafloods from glacier−dammed Lake Atna, Alaska
Project Number:	2007AK65B
Start Date:	3/1/2007
End Date:	2/28/2008
Funding Source:	104B
Congressional District:	AK
Research Category:	Climate and Hydrologic Processes
Focus Category:	Geomorphological Processes, Floods, Climatological Processes
Descriptors:	
Principal Investigators:	Michael Gregg Loso

Publication

2007 NIWR Funded Research Project

Annual Report

Title: Geomorphic constraints on the configuration, magnitude, and timing of late-Quaternary megafloods from glacier-dammed Lake Atna, Alaska

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1) Water-related Problem

Over 700 contemporary Alaskan lakes are impounded by glaciers, and all are subject to sudden, catastrophic drainage. The frequencies, seasonal timing, and magnitudes of such glacier outburst floods are difficult to predict because they bear no statistically-discernible relationship to flood frequency plots based upon precipitation and melt-driven flood events. Because these floods threaten transportation infrastructure, human settlements, ecological habitats, and increasingly, recreational users, we seek a better understanding of the factors controlling glacier-dammed lake formation and drainage.

Contemporary global climate changes are projected to include accelerated warming in arctic regions, and subsequently accelerated glacier retreat is likely to have a significant impact on glacier-dammed lakes. No systematic effort has been made to estimate the number of glacier-dammed lakes present in Alaska during the last, late-
Pleistocene ice age, however, and an ongoing study of modern glacier-dammed lakes clearly demonstrates that while some lakes are disappearing in response to ongoing glacier retreat, new lakes are also forming.

Whether a given climatic change results in the creation, alteration, or destruction of a glacier-dammed lake in some particular location is determined largely by the geomorphic setting. Glacier shrinkage typically exposes newly deglaciated terrain, and in some settings (particularly in tributary valleys), that new terrain provides suitable “habitat” for creation of new lakes or expansion of existing lakes. The relationship between climatic changes and glacier-dammed lake behavior is more complicated, therefore, than it first appears. Studies of former glacier-dammed lakes provides an opportunity to better understand the interrelated geomorphic and climatic factors that govern the hydrologic behavior of contemporary lakes.

In Alaska, the study of such features has a more direct and tangible benefit: the identification and characterization of geomorphic features that impact modern hydrology. In the substantial portions of southcentral Alaska once covered by glacier-dammed lakes, remnant features provide both constraints (e.g. low permeability fine-grained lake bottom sediments) and opportunities (e.g. coarse-grained deltas) for communities and persons interested in appropriately siting wells, septic fields, and drainage systems. These features are also potentially important for determining the suitability of sites for construction of residential/commercial structures, pipelines, roads, and other infrastructure at risk for seismic shaking, permafrost degradation, and other hazards. Surficial exposures of such features are for the most part well-mapped, but Quaternary deposits in southcentral Alaska are commonly stratigraphically complex, with hydrologically significant units hidden beneath younger deposits. More detailed mapping and field investigations will provide better information for hydrologists, planners, engineers, and developers.

2) Question to be Addressed

A geomorphic study of former glacier-dammed Lake Atna provides us with an opportunity to provide a greater understanding of the following problems:

1. Hundreds of modern glacier-dammed lakes routinely give rise to floods that threaten property, life, and infrastructure;
2. Ongoing climate change makes it difficult to predict where and when glacier dammed lakes will form, change, or disappear, with obvious consequences for the distribution of potentially damaging floods; and

3. Geomorphic features associated with former glacier-dammed lakes exert an important (and in many cases, the primary) control on the suitability of southcentral Alaskan lands for hydrologic and development purposes, but in many cases the geometry and characteristics of these features are unknown or poorly understood.

3) Research Approach

The research proposal outlined eight specific tasks which have provided new data and analyses that greatly enhances the overall body of knowledge surrounding Alaska's Quaternary history in the basin, including:

1. A detailed, georeferenced, digital base map of the Copper River basin showing topography based upon the highest resolution, most accurate data available.
2. Digitized ArcGIS shapefiles that represent all known and previously mapped geomorphic features relevant to Lake Atna and associated megafloods. Digitized ArcGIS shapefiles that represent new and/or previously unpublished geomorphic features located using contemporary satellite imagery.
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4. Accurate elevations for all mapped features, with ground-truthed accuracy of +- 1 m (vertical) at key sites.
5. Comparison of elevations of all known Lake Atna shoreline features (strandlines, deltas, etc.), with analysis of spillway relationships, megaflood pathways, and observed isostatic and/or tectonic warping.
6. Stratigraphic columns, sediment samples and description, and geomorphic interpretations of previously undescribed Lake Atna landforms (primarily deltas) along the Gulkana and Tonsina Rivers, and perhaps other sites.
7. Volume estimates for various Lake Atna occupations, and estimates of associated flood spillways, pathways, and magnitudes.
8. High precision calibrated AMS radiocarbon dates for up to 20 samples extracted from key stratigraphic locations, with intention of augmenting existing dating controls to provide a better chronology of shoreline occupations and floods.

4) Summary of Results to Date

A brief description of activities to date are provided below. These activities correspond numerically to the eight tasks outlined in section 3) Research Approach:

1. Graduate student, Lucus Gamble, created a base map of the of the Copper River basin by using ArcGIS 9.2 to mosaic 15-minute, 45 m by 45 m digital elevation model (DEM) with a 1:63,360 scale USGS topographic quadrangle maps for the entire basin. This base map proved to be a valuable tool for interpretation of meso-scale landforms (strandlines and deltas) and locating previously unpublished Lake Atna features and basin anomalies.
2. Lucus is continuing to heads-up digitize, using ArcGIS 9.2, a scanned and georeferenced copy of Williams and Galloway (1986) depicting lake sediments, shorelines, glacial moraines, and location of stratigraphic sections and radiocarbon sample dates within the basin.
3. Lucus is currently created, and continues to update, a geodatabase of all new geomorphic features observed during the summer 2007 (and summer 2008) field season. Specific attributes for these features include feature type, sediment texture, lithofacies code (after Evans and Benn, 2004), elevation and when possible radiocarbon date.
4. Lucus visited numerous sites during the 2007 field season. Most notably, three sites within the Gulkana Wild and Scenic River Corridor (glaciolacustrine and glaciofluvial deposits), Gakona 1 and Gakona 2 (glaciolacustrine bluff exposures), Hogan Hill (anomalous strandline feature at approximately 745 m), Meier's Lake gravel pit (paleo-river delta), Alphabet Hills terrace (strandline), Canyon Lake deposit (dune or strandline), Meier's Lake terrace (paleo-river terrace), Suslo Mountain kame terraces (possible 745 m strandline), Nabesna Road, Wrangell – St. Elias National Park deposit (745 m strandline). Elevation data was collected at these keystone features and others using a Trimble® Pathfinder® ProXH™ global position system (GPS), an external Zypher™ antenna, and H-Star™ postprocessing technology.
5. Comparison of known shorelines at 600 m, 700 m, 745 m and 800 m have been made using the "contour" function in a spatial analyst extension of ArcGIS 9.2.
6. Collaborative efforts between APU and the BLM Glennallen Field Office resulted in a five day float down the Gulkana River. We observed numerous Lake Atna features

including, glaciolacustrine and glaciofluvial sedimentation, strandlines, paleo-river deltas, and other anomalous features (possible dune) within the river corridor. The sedimentary exposures were recorded and identified by their lithofacies code as described (after Evans and Benn, 2004). Other defining characteristics recorded included, grain size, depositional structures, deformational structures, inclusions, fossils and trace fossils, bed thickness, bed geometry, and contacts between lithofacies. When possible, organic inclusions were collected from the sediment units for Accelerator Mass Spectrometry (AMS) Radiocarbon dating.

7. Estimates of associated flood spillways and pathways has been made using GIS and field trips to Mentasta Pass (likely spillway) and road accessible sites along the Richardson Highway south of Glennallen.
8. AMS radiocarbon dates were submitted from 10 new Lake Atna features to ^{14}CHRONO Centre for Climates, the Environment and Chronology, Queen’s University Belfast for analysis. Many of the samples results were “modern” although samples were collected *in situ* beneath features such as dropstones.

5) Publications

To date, none of the collaborators of this project have published the data collected. The NIWR has graciously funded a second year of research pertaining to this project. We will include these results with data collected during the 2008 field season for publication after the conclusion of the student’s (Gamble’s) thesis.

6) Student Involvement in Project

The majority of federal funding requested for this project was for salary and logistical support for graduate student, Lucus Gamble, Masters candidate in the Environmental Science program at Alaska Pacific University. Principal Investigator Michael Loso is the chair of Lucus’s research committee and oversaw training, academic instruction and project status during this study period. Lucus also received mentorship from several other research collaborators, including:

- Peter Haeussler, Research Geologist, USGS, Alaska Science Center
- John Jangala, Archeologist, BLM, Glennallen Field Office

- Dick Reger, Geologist, Reger Consulting
- Paula Reimer, Director, ^{14}CHRONO Centre for Climate, the Environment and Chronology, Queen's University Belfast

When possible, training opportunities, both in the field and lab, were made to both undergraduate and graduate students at APU during this project. Results of this project were used in the classroom and lab activities by Michael Loso in geoscience related courses offered at APU.

Information Transfer Program Introduction

See the Introduction for Information on our web sites where activities and data can be obtained. More information is available at http://www.uaf.edu/water/.

USGS Summer Intern Program

None.

Notable Awards and Achievements

The Water &Environmental Research Center (WERC), along with the International Arctic Research Center (IARC), both at the University of Alaska Fairbanks, hosted the Ninth International Conference on Permafrost (June 29 to July 3, 2008) on the campus. Over 800 scientists from around the world participated. To learn more, or to order the proceedings, visit http://www.nicop.org/.

Douglas L. Kane, WERC Director, received a Fellow Member Award from the American Water Resources Association.

WERC graduate student Erin Trochim received an award for the Outstanding Student Presentation at the Fall 2007 American Geophysical Union Meeting in San Francisco.

Publications from Prior Years