Water and Environmental Research Center
Annual Technical Report
FY 2006

Introduction

The Water and Environmental Research Center (WERC), in the Institute of Northern Engineering (INE) at the University of Alaska Fairbanks has three major objectives: graduate and undergraduate research education, quality research, and science and engineering outreach to K through 12. WERC continues to grow in terms of research dollars generated and our research activities are at an all time high. Recently 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 but now represents over 25% of our annual budget. We presently have about 50 research projects ongoing (several are rather large multi-year projects). The mean of the ongoing projects is $215,433.

With the onset of the International Polar Year (IPY), the President of the University of Alaska offered to fund 10 post-doctorates over all of the colleges and institutes in the campus system. In a highly competitive process, WERC was the recipient of four post-doctorates; three are now participating in various WERC reseach efforts (one opted out to take a tenure track position at another University).

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 annually. 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. The Director of WERC is also the General Chairman for the 2008 Ninth International Conference on Permafrost (NICOP) to be held in Fairbanks in June/July, another IPY activity.

Permafrost is pervasive in Alaska. In one of our outreach programs, Dr. Kenji Yoshikawa (in partnership with the University's EPSCOR program) has instrumented several vertical boreholes and installed thermistors in each to monitor the health of the permafrost. Temperature data from these boreholes is stored on data loggers, but also transferred to the local elementary school's internet service. Dr. Yoshikawa uses each field site visit as an opportunity to meet with elementary school classes, explain his research, and raise interest in engineering and science areas. There are currently over 20 instrumented boreholes adjacent to schools around Alaska that Dr. Yoshikawa has drilled and instrumented To learn more about this project, please visit:

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 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. It wasn't that we did not want to do this type of research in the past, but more a poor match of faculty and research dollars.

Much of our research is being driven by climate change, which is clearly obvious in many forms in Alaska. Glaciers are clearly retreating significantly in many areas, permafrost temperatures are on the rise, thermokarst are forming in unprecedented numbers in the permafrost environments, shallow lakes over permafrost are disappearing; these are only a few of the observable phenomena. What we lack in Alaska are high quality, long-term data sets to detect change in such areas as precipitation rates (both rain and snow), and WERC is working with several agencies to address this need. Although the federal agencies were originally quite slow in developing hydrometeorological stations in Alaska, efforts are increasing. Moreover, the environment itself as often proved to be an obstacle to good quality data collection.

In summary, WERC is growing and encompassing more professional disciplines. It is a center of excellence regarding water that is clearly recognized throughout the state. Our one major recent challenge has been attracting good, high quality students. All of our students receive graduate research stipends, and we have more unclaimed stipends available. Improving our numbers of graduate students involved in research will be an important area in the coming years.

Research Program

This past year, we funded four research projects on USGS 104b funding. We generally encourage younger faculty to apply for these grants, or faculty who are opening new lines of research, with a majority of the funding going to graduate student support. One of the principle investigators was unable to attract a graduate student last year and therefore not all of the objectives have been reached yet; this project has been extended one year. Another faculty member has left the Water and Environmental Research Center; his project was terminated on February 28, 2007. Remaining funds from this project will be returned to the USGS.

Glacier Volume Change in Arctic Alaska and its Impact on Alaska’s Hydrologic Cycle

Basic Information

Title:	Glacier Volume Change in Arctic Alaska and its Impact on Alaska’s Hydrologic Cycle
Project Number:	2006AK46B
Start Date:	3/1/2006
End Date:	2/28/2007
Funding Source:	104B
Congressional District:	AK
Research Category:	Climate and Hydrologic Processes
Focus Category:	Hydrology, Climatological Processes, Surface Water
Descriptors:	
Principal Investigators:	Matthew A Nolan

Publication

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

Matt Nolan

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.

Effect of Raw Water Characteristics on Membrane Fouling for Filtration of Surface Water with High Organic Matter Content

Basic Information

Title:	Effect of Raw Water Characteristics on Membrane Fouling for Filtration of Surface Water with High Organic Matter Content
Project Number:	2006AK49B
Start Date:	3/1/2006
End Date:	2/28/2008
Funding Source:	104B
Congressional District:	AK
Research Category:	Water Quality
Focus Category:	Treatment, Surface Water, None
Descriptors:	membrane filtration, DOM, fouling
Principal Investigators:	Silke Schiewer

Publication

Effect of raw water characteristics on membrane fouling for filtration of surface water with high organic matter content

Silke Schiewer

Problem and research objectives

Problem:

Due to the limited availability of groundwater for drinking water production in many areas of Alaska, such as those where permafrost is present, surface waters, which are sometimes of a lower quality, have to be used for drinking water production. Some types of surface water such as rivers or tundra ponds contain large amounts of dissolved or particulate organic matter. When such waters are chlorinated during the process of drinking water production, chlorine reacts with organic matter to form harmful disinfection byproducts.

These byproducts are of growing concern and regulations about maximum byproduct concentrations have become increasingly stringent. One approach to decreasing the formation of these byproducts is to eliminate organic matter from the water before chlorination. This can be achieved with membrane filtration. Membrane filtration also has the benefit of generating a high water quality. However a drawback of using membranes to treat surface waters with a high organic matter content is that the presence of organic matter increases membrane fouling. Fouling reduces flux across the membrane and/or requires a higher pressure for filtration, which adds to operating costs. Therefore research is required to investigate under which conditions severe fouling can occur to address this problem and design the process accordingly. The effect of several important water quality parameters on fouling will be investigated in this study.

Hypotheses

Electrostatic attraction and repulsion between organic matter and the membrane can explain why fouling is more severe under certain conditions. At low pH, high ionic strength, or when a high concentration of cations such as Ca^{2+} or Fe^{2+} exists, the negative charge of organic matter is neutralized, which allows aggregation of DOM into larger agglomerates and subsequent removal by deposition on the membrane, which leads to fouling. If the organic matter charge and membrane charge have opposite signs, fouling is reduced by repulsion.

Research Approach

The goal of this research is to determine suitable conditions where membrane filtration can be applied for drinking water production without excessive fouling.

The pH of the solution will be varied in the pH range 4 – 8 to obtain variations in the DOM charge properties. Carboxyl groups, which have a pKa around 5, are abundant in DOM and therefore undergo changes of charge in the investigated range, being neutral below pH 5 and negatively charged at higher pH.

Calcium nitrate will be added to stepwise increase the calcium concentration till the organic matter charge is neutralized.

The ionic strength will be varied by stepwise addition of sodium nitrate. While sodium can balance the negative charge of the organic matter, it typically does not form any complexes with organic matter but is only bound by weaker electrostatic interactions.

The DOM of a chosen surface water source will be characterized in terms of size classes and charge. The organic matter will be fractionated into anionic and cationic constituents with the help of ion exchange resins. In later experiments, rather than studying surface water DOM with naturally varying properties, model solutions with typical organic substances of known chemical characteristics (e.g. same size, different charge) may be employed to create a better defined basis of comparison. Waters containing different types of DOM will be subjected to membrane filtration.

Different types of membrane material, characterized by positive, negative or neutral membrane charge, will be used. To allow a fair comparison, all membranes will feature the same pore size. Flat circular membrane sheets will be employed in a dead end filtration cell to allow easy sampling of the cake layer after the experiment. The permeate flux rate will be determined by continuously monitoring the permeate quantity.

After the filtration tests, the quantity and type of DOM in the permeate will be characterized to evaluate the filtration efficiency and determine which classes of DOM were able to penetrate the membrane without causing fouling. Complementary to that, the cake layer accumulated on the membrane will be characterized in terms of quantity and properties (such as charge).

Progress to Date

This project will support an MS student, but due to difficulties in recruiting a suitable graduate research assistant, the project was delayed in starting. We have requested an extension from Dr. Kane, Director of the Water & Environmental Research Center. While work is underway currently, we have no results to report yet. Results will be reported in the FY2007 Annual Report.

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.

**Watershed response to forest fires in cold regions:
channel development and suspended load variation in streams in Interior Alaska**

Horacio Toniolo

Summary of activities

Instruments including pressure transducers, dataloggers, and autamplers were installed in the streams after spring breakup. Water samples were collected every day. Suspended load concentrations were determined at UAF's laboratories. Topographical surveys were conducted in an area where a small channel is developing. These tasks were carried out by graduate student Paul Duvoy. Results from his work were presented at 2006 AGU Fall Meeting. Main results and findings are described below.

Figure 1 shows a rest area created by the firefighters in the Caribou Poker Creeks Research Watershed (CPCRW) in the summer of 2004. Soil erosion and subsequent channel formation as a consequence of summer rainfalls are ongoing processes in the area. Figure 2 shows the temporal evolution of a channel development on August 2005 after rainfall events and June 2006. An initial topographic survey was conducted in early summer 2006 (Figure 3). A second survey was conducted at the end of summer.

Figure 1. *Panoramic view of a "rest area" created by firefighters inside the watershed. Distance from left to right is approximately 200 m.*

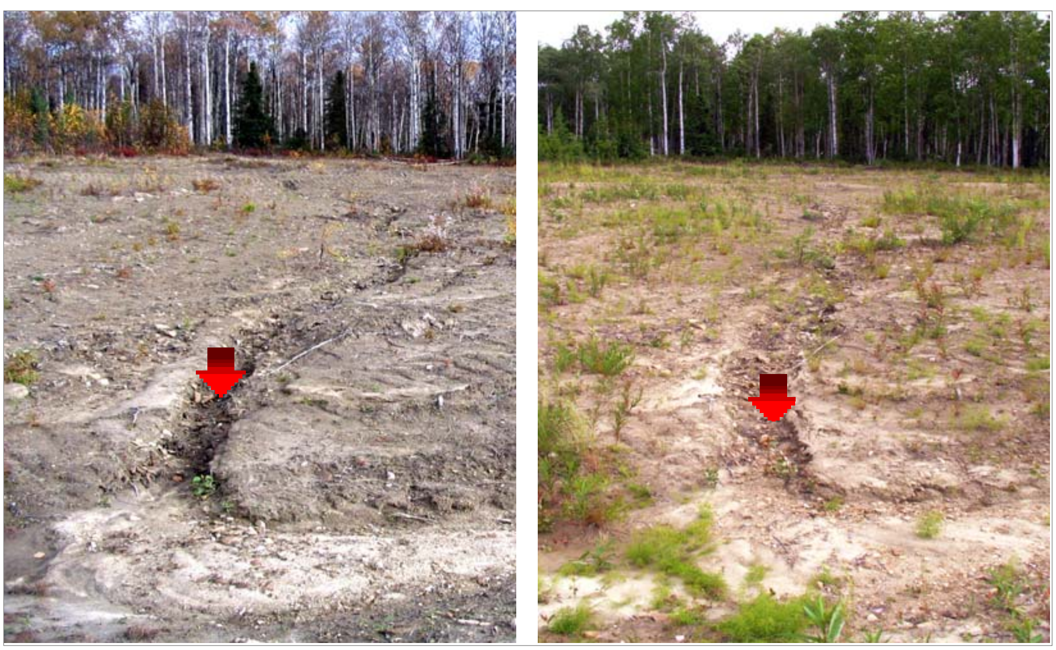

Figure 2. *Landscape evolution in the area indicated in Fig. 1; channel developed in August 2005 after rainfall events (left), Channel in June 2006 (right). Channel widening is evident.*

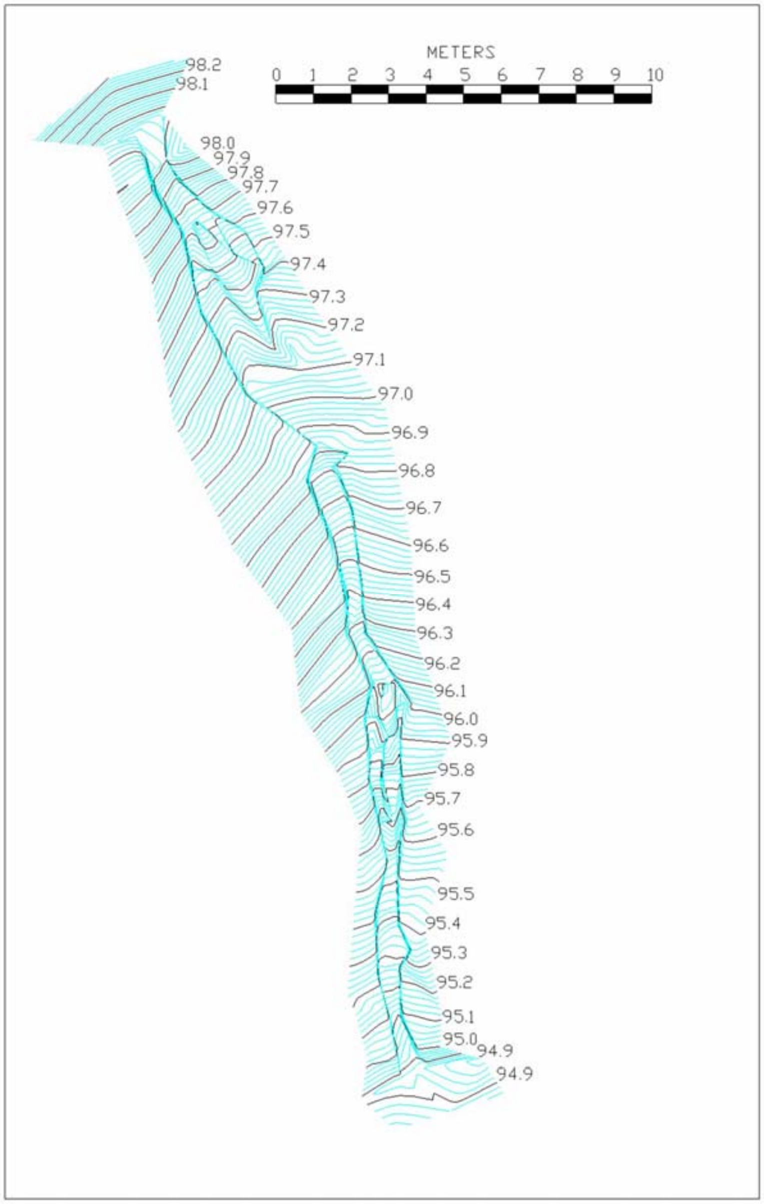

Figure 3. *Channel topography. Survey conducted in July 2006. Datum elevation is 100 m (arbitrary).*

Initial work on suspended load in streams in the CPCRW (C4, fire-free; P6, partially burned) and Boston Creek (severely burned) was conducted by Kodial and Toniolo during the summer of 2005. Figure 4 shows the temporal variation in concentration in different streams during 2005 and 2006. Available data suggest that suspended load concentrations in the unburned and partially-burned streams were somewhat higher in 2006. Concentrations in the totally-burned stream were similar during the last two summers.

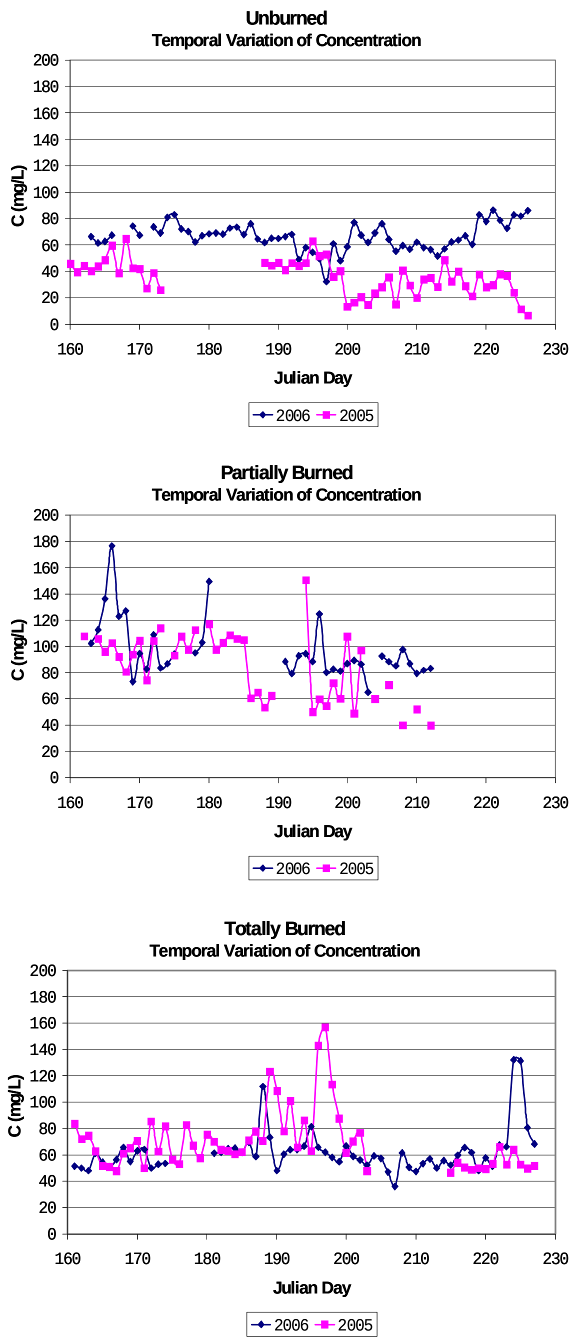

Figure 4. *Concentration variation during 2005 and 2006.*

Future work

Field and lab work will continue in 2007. Instruments will be deployed in the streams; a topographical survey will be conducted at the end of summer. Concentrations will be obtained at UAF's labs. Comparison between existing data and future data will be carried out.

Investigation of Streamflow Response to Seasonal Snowcover Change in the Yukon River

Basic Information

Title:	Investigation of Streamflow Response to Seasonal Snowcover Change in the Yukon River
Project Number:	2006AK51B
Start Date:	3/1/2006
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	AK
Research Category:	Climate and Hydrologic Processes
Focus Category:	Geomorphological Processes, Hydrology, None
Descriptors:	discharge, climate, snowcover, and permafrost
Principal Investigators:	Daqing Yang

Publication

1. Yang, D., Yukon River Streamflow Response to Seasonal Snowcover Changes, American Water Resource Association Alaska Annual Meeting, Fairbanks, April 3-5, 2007.
2. Yang, D., Challenges in understanding arctic hydrology system changes,Asia CliC Workshop, Yokohama, Japan, May 17-19, 2007.
3. Yang. D., Streamflow response to seasonal snowcover change over the large northern rivers, American Geophysical Union Fall Meeting, San Francisco, December, 2006.

Investigation of Streamflow Response to Seasonal Snowcover Change in Yukon River

PI: Daqing Yang

1. Background

The Yukon River is one of the largest rivers in the northern regions. It contributes 203 km^3 per year freshwater to the Bering Sea. Hydrologic conditions and its changes of the Yukon River significantly affect regional biologic and ecologic systems. Unlike other large northern rivers, the Yukon has received less research attention. The USGS produced a report in 2000 to document the major hydrologic patterns with the basin. Studies found that large parts of southern Canada and the Yukon Territories have experienced reduced runoff. Snowcover is one of the critical land memory processes that significantly affect atmosphere, hydrology and ecosystems in the high latitude regions. Snowcover melt and associated floods are the most important hydrologic event of the year in the northern river basins. Studies show that snowmelt has started early over the recent decades in the northern regions of Canada, Alaska and Siberia associated with warming in winter and spring seasons. This change in the melt pattern may indicate a hydrologic regime shift over the high latitudes. Due to insufficient investigation and lack of long-term records, our current understanding of Yukon River hydrology and climate changes, particularly large-scale snowmelt processes and their interaction with climatic change and variation, is incomplete. This limits our capability of documenting past change and predict future change over this largest watershed in Alaska.

We recently applied the weekly snowcover data in large Siberian watersheds (Lena, Yenisei and Ob rivers) and identified a close association of the runoff to snowcover extent changes during the spring melt period. Our initial analyses of snowcover and streamflow data in Alaska also show a strong correlation of monthly runoff with snowcover extent during early summer season. These encouraging results clearly indicate the potential of using the weekly snowcover information to improve snowmelt runoff modeling and prediction in the high latitude regions. This research project continues our effort in the Yukon River with a focus on analyzing basin and sub-basin snowmelt processes.

2. Study Objective

This research will use the weekly NOAA snowcover extent data to study the streamflow hydrology in the Yukon River. The focus of this research is to examine the streamflow response to snowcover extent change during the spring melt season. The overall objective of this research is to determine the potential of using remotely sensed snowcover information to improve our capability of snowmelt runoff modeling and forecasting over large northern river basins. The major work of this research project includes:

A. *Generation and analysis of weekly snowcover extent and runoff time-series*
B. *Examination of streamflow response to snowcover extent change*
C. *Cross-validation of results*

3. Summary of Activities

During 2006, we have developed snow cover, climate and streamflow datasets over the Yukon River. We have complied temperature, precipitation, snowcover, and streamflow data for the sub-basins within the watershed. On the basis of these data, we have generated weekly basin snowcover, temperature, precipitation and streamflow time-series. We also defined basin temperature and precipitation regimes (Figs. 1-2), and calculated the basin-mean snowcover extent and SWE (Figs. 3-4) over the river for the entire AVHRR and SSMI records.

These weekly data clearly show the seasonal changes of snowcover, such as the weekly snowcover climatology, dates of snowcover formation/disappearance and duration of snowcover/snow-free days, and rates of snowcover change during the accumulation and melt seasons. They also show the interannual variations (i.e. the range of maximum and minimum values. The weekly snow cover, temperature and precipitation data allow us to explore the compatibility between winter snowfall and snowcover data. The maximum SWE over a basin is usually less than winter snowfall due to snow sublimation. Comparisons of basin winter snowfall and SWE accumulation show that maximum SWE is generally less than winter snowfall accumulation in most winter during 1988-2001, except for a few years when SWE was greater than total snowfall.

We found a negative relationship between basin temperature and snow cover extent. When basin mean temperature stays around –20^{o}C, basin snow cover percent varies between 80% and 100%. When temperature is about –10^{o}C, snow percent ranges from 30% to 100%. When temperature close to 0^{o}C, snow cover percent varies from very low (close to snow free) to very high (100% snow cover). We also found a negative relationship between temperature and SWE. The maximum SWE in Yukon basin is around 120mm, and this can occur for temperatures from –35^{o}C to –7^{o}C. The SWE at 0^{o}C varies from 0mm to 100mm. Basin snow free (SWE = 0mm) when basin temperatures are around 7^{o}C.

Our ongoing efforts focus on examination of streamflow response to snowcover extent and SWE changes, and cross-validation of results. We are using bias-corrected precipitation data to compare with SSM/I and *in-situ* snowcover data over the Yukon basin and sub-basins. We also examine snowcover extent changes and variations over time, including trend analysis, in order to identify extreme snowcover cases and investigate their association with climate conditions. We are generating weekly discharge time-series from the daily streamflow data collected at different locations within the watersheds, and analyzing them to define the seasonal runoff changes. These include weekly runoff regime, rates of streamflow in the snowmelt season and peak flow. We will also examine the spatial and temporal changes in streamflow, including extremes and trends.

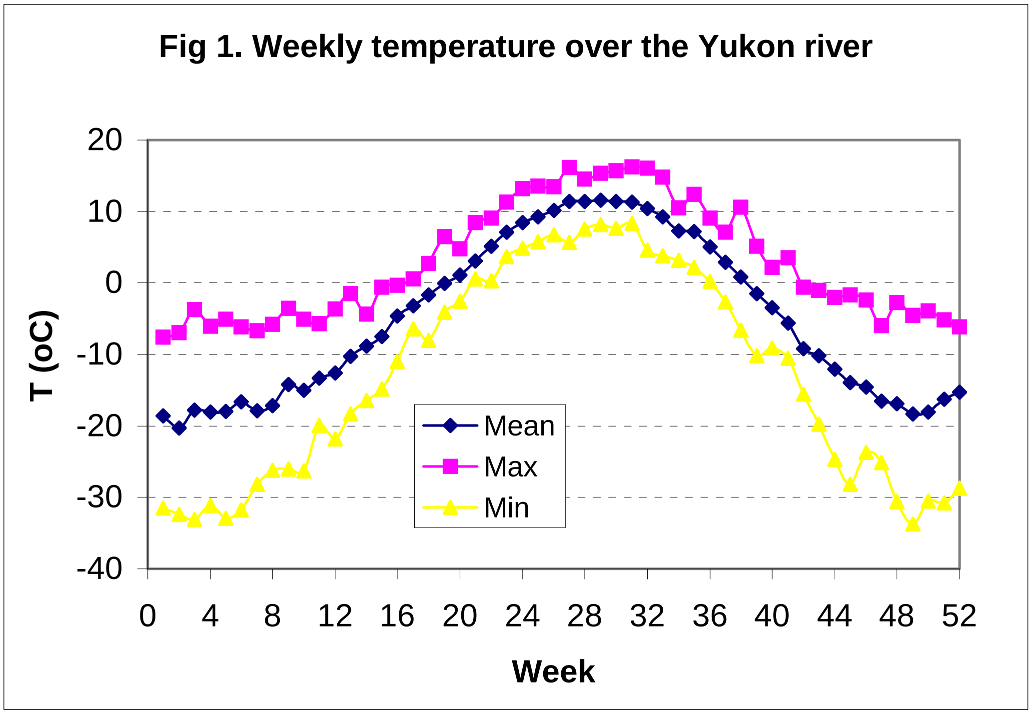
Fig 1. Weekly temperature over the Yukon river
T (oC)
20
10
0
-10
-20
-30
-40
0 4 8 12 16 20 24 28 32 36 40 44 48 52
Week
Mean
Max
Min

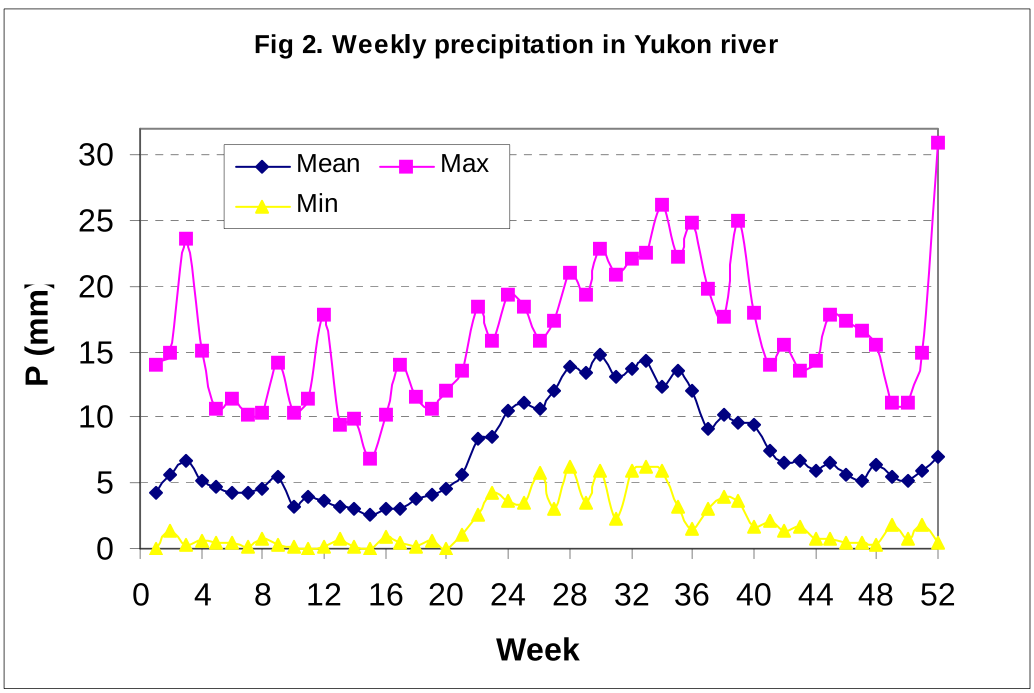
Fig 2. Weekly precipitation in Yukon river
P (mm)
30
25
20
15
10
5
0
0 4 8 12 16 20 24 28 32 36 40 44 48 52
Week
Mean
Max
Min

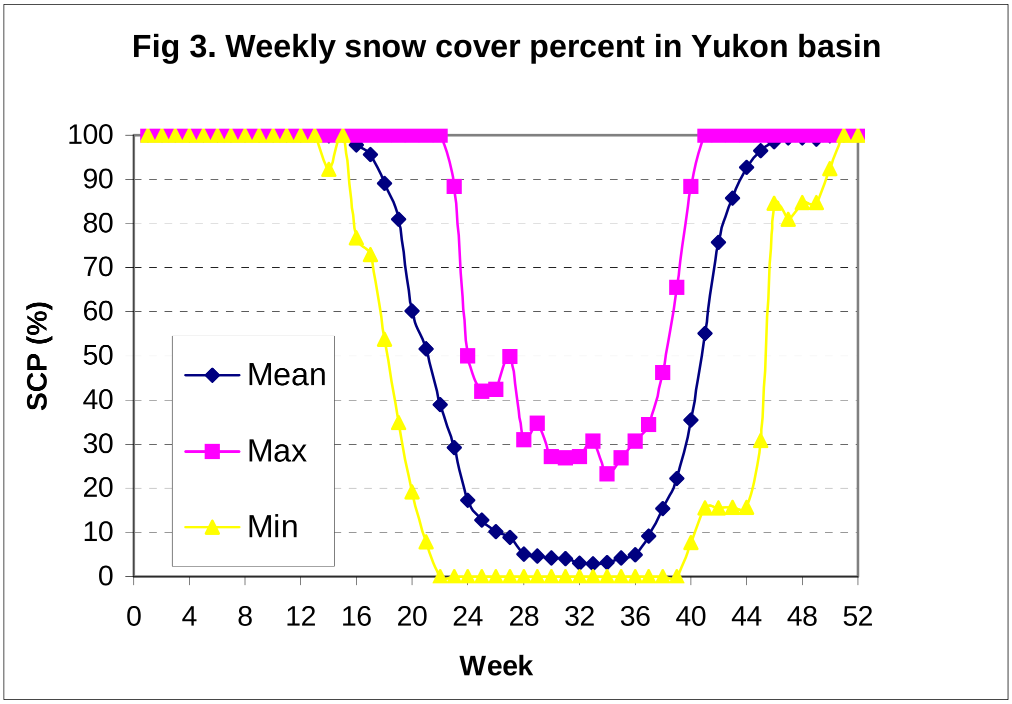
Fig 3. Weekly snow cover percent in Yukon basin
100
90
80
70
60
50
40
30
20
10
0
SCP (%)
Mean
Max
Min
0 4 8 12 16 20 24 28 32 36 40 44 48 52
Week

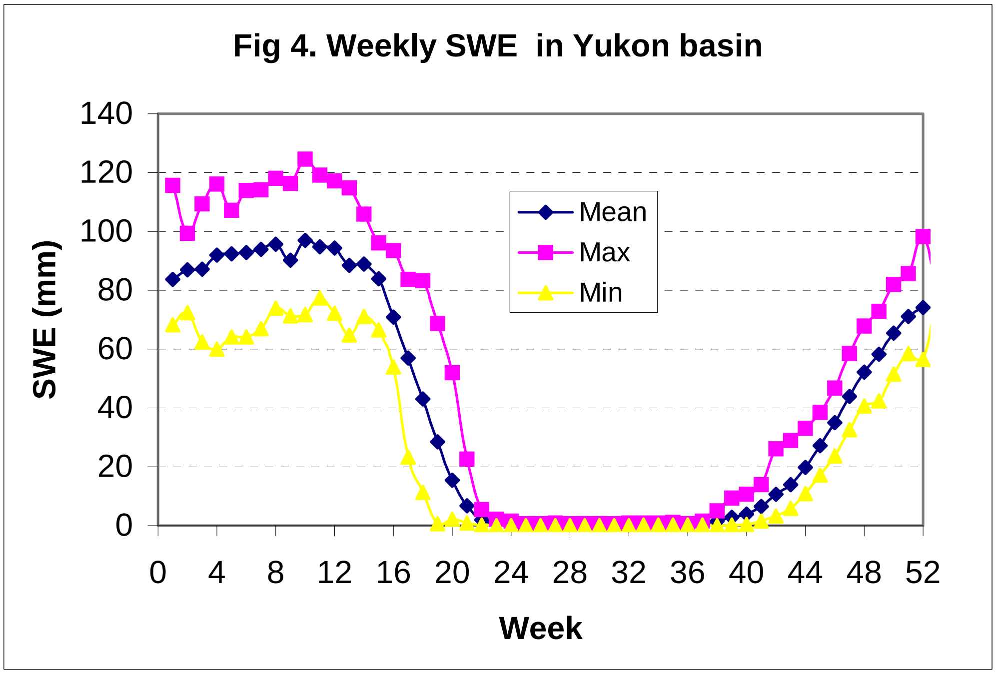
Fig 4. Weekly SWE in Yukon basin
140
120
100
80
60
40
20
0
SWE (mm)
Mean
Max
Min
0 4 8 12 16 20 24 28 32 36 40 44 48 52
Week

Information Transfer Program

Student Support

Student Support					
Category	Section 104 Base Grant	Section 104 NCGP Award	NIWR-USGS Internship	Supplemental Awards	Total
Undergraduate	0	0	0	0	0
Masters	3	0	0	0	3
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	3	0	0	0	3

Notable Awards and Achievements

Publications from Prior Projects

1. 2005AK43B ("Investigation of the mechanism of arsenic biosorption by modified crab shells") - Conference Proceedings - Zhang, Hong & Silke Schiewer. 2005. Arsenic (V) Sorption on Crab Shell Based Chitosan, in Proceedings of Proceedings of the 2005 World Water and Environmental Resources Congress, May 15-19, 2005, Anchorage, Alaska; Sponsored by Environmental and Water Resources Institute (EWRI)of the American Society of Civil Engineers) (doi10.1061/40792(173)296)
2. 2005AK45B ("Characterizing sources and growth potential of indicator bacteria in cold region streams") - Conference Proceedings - Graham R. Stahnke, William Schnabel, Khrys Duddleston, and Tammie Wilson. 2005. Antibiotic Resistance Analysis of Enterococci in Chester Creek. Proceedings of the 2005 World Water and Environmental Resources Congress, May 15-19, 2005, Anchorage, Alaska; Sponsored by Environmental and Water Resources Institute (EWRI)of the American Society of Civil Engineers.(doi 10.1061/40792(173)294)
3. 2004AK29B ("Infiltration in Coarse Soil and Formation of Infiltration Ice") - Articles in Refereed Scientific Journals - Fourie, W., D.L. Barnes, and Y. Shur. 2007. The Formation of Ice From the Infiltration of Water in Frozen Coarse Grain Soils. Cold Regions Science and Technology, 28, no 2: 118-128 .
4. 2004AK29B ("Infiltration in Coarse Soil and Formation of Infiltration Ice") - Articles in Refereed Scientific Journals - Barnes, D.L. and S.M. Wolfe. Accepted for Publication. Influence of Ice on the Infiltration of Petroleum into Frozen Coarse Grain Soil. Petroleum Science and Technology. (Invited paper).
5. 2002AK5B ("Investigation of Fouling in Membrane Bioreactors for Wastewater Treatment") - Articles in Refereed Scientific Journals - Psoch, C.; Schiewer, S. 2006. Anti-Fouling application of Air Sparging and Backflushing for MBR. Journal of Membrane Science 283 No. 1-2, (Oct. 2006) 273-280.
6. 2002AK5B ("Investigation of Fouling in Membrane Bioreactors for Wastewater Treatment") - Articles in Refereed Scientific Journals - Psoch, C.; Schiewer, S. 2006. Direct filtration of natural and

simulated river water with air sparging and sponge ball application. Desalination 197 (Oct. 2006) 190-204

7. 2002AK5B ("Investigation of Fouling in Membrane Bioreactors for Wastewater Treatment") - Articles in Refereed Scientific Journals - Psoch, C.; Schiewer, S.2006. Resistance analysis for enhanced wastewater membrane filtration with application of air sparging and back flushing. Journal of Membrane Science 280 (Sept. 2006) 284-297.
8. 2002AKB5 ("Investigation of Fouling in Membrane Bioreactors for Wastewater Treatment") - Articles in Refereed Scientific Journals - Psoch, C.; Schiewer, S.2006. Dimensionless numbers for the analysis of air sparging aimed to reduce fouling in tubular membranes of a membrane bioreactor. Desalination, 197 (Oct. 2006) 9-22.
9. 2004AK21B ("Short- and Long-term As-Aluminium Oxyhydroxide Sorption Interactions in Aquatic and Soil Environments") - Articles in Refereed Scientific Journals - Schiewer, S.; Niemeyer, T.2006. Soil heating and optimized nutrient addition for accelerating bioremediation in cold climates. Polar Record 42 No. 220 (Jan. 2006), 23-31.
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