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Managing Water Resources Development in a Changing Climate
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Tuesday, May 5
8:30 AM – 10:00 AM
Session 11: Managing Arctic Watersheds I

1. Streamflow Estimation in Arctic Watersheds with Sparse Data Sets - Douglas Kane, University of Alaska Fairbanks, Fairbanks, AK (co-authors: Youcha, E.K., Trochim, E.D., Lilly, M.R., Toniolo, H.A.)

Resource development in the Arctic is generating the need to derive estimates of the stream flow hydrology for designing transportation systems. Presently, there are few streams gauged in the Arctic, the period of record is quite short for those stations that exist and the quality of the data collected is often compromised by the environment. In addition, there is often very limited complementary hydrologic and meteorological data in these gauged basins. We are using the few gauged streams that exist to determine the parameterization of a linear reservoir model for the warm season flow regime. This assumes that once we have the parameterization completed that it is transferable to other ungauged watersheds and that there is minimal data (air temperature and precipitation) to input into the model. Even at the calibration phase it is often difficult to capture extreme events (drought and floods). This is partly due to the amount and quality of the input data. There is also the possibility that in parallel to the changing climate that the hydrologic input into these watersheds and the subsequent hydrologic response will change. Precipitation increases, more frequent convective storms and wildfire are likely possibilities in a warming climate.

2. Hydrologic Responses of Catchments with Warm Permafrost - Larry Hinzman, International Arctic Research Center, University of Alaska Fairbanks, Fairbanks, AK

Hydrological processes in the boreal forest of Alaska are dominated by the presence or absence of permafrost. Permafrost is not present everywhere in Interior Alaska, but is predominantly found on north-facing slopes and in valley bottoms. The average annual air temperature is within a few degrees of 0ºC; consequently minor variations in the surface energy balance are enough to allow permafrost to form or to degrade. In this area, north-facing slopes do not receive intense sunlight, even on the summer solstice. Strong temperature inversions develop during cold winter periods, often resulting in valley bottom temperatures up to 25ºC less than neighboring peaks. The large spatial variance in average annual temperatures result in highly variable, but in general, predictable patterns of permafrost distribution.

Ice-rich permafrost has very low infiltration capacity preventing percolation of soil moisture to sub-permafrost groundwater; consequently soils above permafrost typically have much higher moisture content as compared to neighboring soils in permafrost free areas. Soils above permafrost also tend to have thicker organic layers as decomposition is decreased with lower temperatures and anaerobic conditions. Soils above permafrost also respond differently to precipitation events due to limited storage capacity. The highly porous near-surface mosses saturate and drain quickly while the deeper mineral soils remain saturated throughout the year.

Hydrologic processes in the subarctic regions exert a strong influence upon local ecological characteristics. One of the most important factors impacting the local hydrology is the presence or absence of permafrost. The permafrost distribution exerts a controlling influence upon soil moisture levels, which subsequently impacts vegetation distribution, soil genesis, soil microbial processes and surface energy balance. The complex interdependence of thermal and hydrological processes is manifest throughout the subarctic boreal forest because the average annual temperature is very near 0ºC, therefore small changes in climate can yield significant impacts to this ecosystem.

3. Trends in Streamflow in the Yukon River Basin from 1944 to 2005 and the Influence of the Pacific Decadal Oscillation - Tim Brabets, U.S. Geological Survey, Anchorage, AK

Streamflow characteristics in the Yukon River Basin of Alaska and Canada have changed from 1944 to 2005, and some of the change can be attributed to the two most recent modes of the Pacific Decadal

Oscillation (PDO). In general, winter temperatures are colder during the cold-PDO (1944 to 1975), and warmer during the warm-PDO (1976 to 2005), but seasonal and annual precipitation is not significantly different. Between 1944 and 2005, average winter flow and average April flow increased at 15 of 21 sites. Observed winter flow increases during the cold-PDO phase were generally limited to sites in the Upper Yukon River Basin. Winter flow increased during the warm-PDO phase at stations in the Middle and Lower Yukon River drainage basins. Increases in winter streamflow most likely result from ground water input enhanced by permafrost thawing that promotes infiltration and deeper subsurface flow paths. Increased April flow may be attributed to a combination of greater baseflow (from ground water increases), earlier spring snowmelt and runoff, and increased winter precipitation, depending on location. Long-term mean monthly discharges observed at stations along the Yukon River mainstem were below average during winter months of the cold PDO and above average during winter months of the warm PDO. The reverse is also true during the summer months: above-average flow during the cold PDO and below-average flow during the warm PDO. Changes in the summer flows are likely an indirect consequence of the PDO, resulting from earlier spring snowmelt runoff and perhaps increased summer infiltration and storage in a deeper active layer. Annual discharge has remained generally unchanged in the Yukon River Basin, but a few glacier-fed rivers showed increasing trends, which can be attributed to enhanced glacier melting during the warm phase of the PDO. The Porcupine River, a predominantly permafrost basin with no glaciers, showed a decreasing trend. This basin is located in the northeast part of the Yukon River Basin, where precipitation decreased during the warm phase of the PDO, producing less annual flow.

4. Kuparuk River Snow Distributions for Hydrologic Analysis on Alaska's Arctic Slope - Sveta Berezovskaya, University of Alaska Fairbanks , Fairbanks, AK (co-authors: Robert Busey, Douglas Kane)

Snow is central to exploration activities in polar latitudes of Alaska over a very significant part of each year. Presented seasonal snowpack study is part of a state and federally funded hydrological research program on Alaska's Arctic Slope (AAS) in the watersheds of the Kuparuk and Sagavanirktok Rivers. This project was initiated in 2006 to collect and analyze hydrologic and meteorological information for transportation related issues, such as design of stream crossing structures or identifying appropriate routes for gravel roads construction and associated ice roads and pads. Snowmelt is the largest hydrological event for the AAS watersheds. The constraint to snowmelt discharge modeling is the availability of spatially distributed snow water equivalent (SWE) that realistically represents differential snowmelt pattern. Our seasonal snowpack studies include end-of-winter snow survey distributed across watershed and snow ablation observations at selected locations. Field observations are assimilated into SnowModel to define i) end-of-winter spatial SWE distribution, and ii) SWE spatial pattern during ablation. SnowModel (Liston and Elder, 2006) calculates spatial SWE distributions during entire snow-covered season accounting for vertical and horizontal water and energy fluxes. We describe the simulated winter water balance of the Kuparuk River watershed in 2007 and 2008, simulated SWE spatial pattern during ablation and discuss some of the challenges in performing the modeling.