

for Prediction in Cold Regions

Water Research

SUMMER 2009

SPECIAL POINTS OF INTEREST:

- **Monitoring and** predicting mountain weather and snowpacks, glaciers and streamflow in a changing climate
- **Determining the** impact of declining forest cover on runoff production
- Modelling small and large basin water systems in anticipation of increased downstream demand

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IP3 Research Network

IP3 is a research network funded by the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS) for 2006-2010 and supported by partners in all levels of government as well as the private sector. The IP3 network is comprised of several dozen investigators, collaborators, and students from across Canada, the US, and Europe and is headquartered at the University of Saskatchewan's Centre for Hydrology. IP3 is devoted to an improved understanding of the study of water and weather systems in cold regions, particularly



Weather station

Canada's Rocky Mountains and western Arctic. Data is being collected from several different research areas, where scientists are studying snowpacks, glaciers, lakes, wetlands, permafrost, streamflow, and runoff. Using these data to test water and climate models will lead to improved understanding and predictability of snow accumulation and melt, glacier motion and growth, soil moisture and evaporation, thawing permafrost, and changes in lake levels and streamflow in cold environments. This information is of key importance to applied water management and policy development for agriculture, communities, recreation, sustainable industrial development and infrastructure as well as environmental conservation in western and northern Canada.

Western Relevance

Some of the most significant water resource and supply challenges in Canada are in western Canada. The Rocky Mountains are the water towers of the Canadian Prairies and continual monitoring of upstream water production is necessary to ensure that changes in streamflow can be planned for in downstream allocations. Enhanced monitoring and research in the mountains is essential in identifying climate change impacts on glaciers, snowpack and streamflow.



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Peyto Glacier automated weather station

A parameterisation is a means of describing a complex phenomenon in relatively simple mathematical form so that it may be used in a computer simulation

Processes

Field observations are being carried out at ten different research locations, each 10 to 200 km² in area, ranging from high altitude mountain sites in the south (Rocky Mountains) and north (Yukon) as well as low elevation sites in the north (Northwest Territories). These different sites were selected to provide varying types of vegetation, natural land features, climate, and precipitation patterns. Field observations from these sites include hourly measurements of air temperature, humidity, wind speed, rainfall, snowfall, and snow depth, with glacier surface measurements and streamflow measurements recorded during monthly or annual field campaigns. The goal of collecting data is to move towards a better understanding of the key climate processes as they relate to water systems in cold regions.

Parameterisation

Parameterisation involves the scaling of specific processes such as snowmelt, blowing snow redistribution, runoff and streamflow, evaporation, and frozen soil infiltration. These land and water processes are described in a mathematical form enabling them to be entered into a computer model. Models with parameterisations are run against models using measured data to allow for comparison and validation of both the parameterisations and the model. One of the modeling tools being developed is the Cold Regions Hydrological Model (CRHM) which is used as a first step in developing mathematical descriptions of the natural world. The model is a proving ground where parameterisations (approximations) can be tested against actual observations to determine how well the model describes various landscape and environmental possibilities.

Prediction

Marmot Creek snow depth survey



Models can be used for prediction of snowpack levels, lake levels and streamflow in small watersheds. IP3 is working with various models which link separate water and climate models allowing surface water systems to influence and react to the atmosphere just as weather and water co-exist in the natural world. IP3 science is contributing to a direct improvement in water resource modeling capability of cold region processes such as permafrost, frozen soil, snow sublimation and snow redistribution by wind and vegetation. Validating and improving models for weather, water, and climate systems leads to better prediction of climate change impacts on water resources and surface climates in cold regions.

WATER RESEARCH

Marmot Creek

Marmot Creek feeds the Kananaskis River and the Bow River System from the Rocky Mountains in Alberta. Marmot Creek is a small watershed primarily covered with sub-alpine forest with alpine tundra ridgetops. This research site has 9 permanent meteorological stations collecting data such as precipitation, snow



Spring snowcover

depth, air temperature, humidity and wind speed. Specific research at this site is focused on snow accumulation in forested versus non-forested areas through modeling of varying forest radiation effects on snowmelt. The importance of wind redistri-

bution of snow in alpine areas as it relates to snowmelt is being els. Innovative snow observation techniques are being explored



Summer snowmelt

studied using data collected for validation of developed modat this site through testing of an acoustic measuring device.

Peyto Creek

Peyto Creek drains a glacierized alpine basin in Banff National Park that forms part of the headwaters of the North Saskatchewan River. This watershed is 60% covered by the Peyto Glacier which has been the subject of intense observation for over 40 years. The Peyto research basin has three automated weather stations adjacent to the glacier and is part of the National Glaciology Programme of Natural Resources Canada. Data have been collected allowing examination of changes in glacier mass during the summer melt period. This research has led to the development of a framework for modeling the glacier daily melt rate. Current work is looking at ice/snow albedo designations sufficient for modeling purposes. Further work is proceeding on determining modeling parameterisations for evaporation and air temperature effects on glacier melt modeling.



Glacier weather stations

Less snowfall and more rainfall lead to smaller summer streamflows

Lake O'Hara

Lake O'Hara, BC, is a wet alpine watershed that ultimately feeds into the Columbia River Basin. Three small glaciers occupy 5% of the basin which is monitored by two meteorological stations and five stream gauging stations. Current work is focused on investigation into groundwater pathways. Research at this site is focused on determining the data needed for snowmelt runoff models to accurately describe melt and thaw depths in groundwater movement. Models are currently being run to determine answers to questions about runoff sources and flow paths as well as the time it takes for water to be moved through each part of the water system.



Snow survey team

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To learn more about IP3 visit our website at http://www.usask.ca/ip3/

Improved Processes & Parameterisation for Prediction in Cold Regions

IP3 contributes to better weather and climate prediction, to estimation of streamflow from ungauged basins, to predicting changes in Rocky Mountain snow and water supplies, to calculating freshwater inputs to the Arctic Ocean, and to sustainable management of mountain and northern water resources. Study of snowmelt modeling, water storage, and streamflow are essential for a better understanding of how climate change affects our freshwater resources. IP3 is working to involve the water resource management community in the sharing of knowledge gained through this research.



Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)

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Reynolds Creek



Snow surveys in Reynolds Creek basin

Reynolds Creek is the southern-most node of the IP3 network and is a mountainous research site in southwestern Idaho. The site is part of the Northwest Watershed Research Centre and is heavily monitored with 36 weather stations and numerous gauges reading streamflow, snowfall, and snow depth. Research results demonstrate that while higher elevation runoff is still snow-dominated, lower elevation runoff is now rain-dominated, leading to an earlier melt and reduced streamflow. Current research includes the study of radiation regimes in forest openings, and relationships between snowmelt characteristics and vegetation coverage.

Photos, diagrams and research provided by IP3 members