NEWSLETTER

Improved Processes and Parameterisation for Prediction in Cold Regions

FEBRUARY 2010

Workshop Report

Cold Regions Hydrology Model (CRHM) Workshop and Water Management Workshop in Red Deer

A CRHM workshop was held in Red Deer, Alberta on January 12th, followed by a workshop on CRHM Water Management Implications and Drought Hydrology on January 13th. Close to forty people attended, from provincial and federal government agencies, universities (researchers and students), regional watershed alliances, the forest industry and local community organizations. This event offered the opportunity for a comprehensive two-way dialogue on application and improvement of CRHM and water management in Alberta and beyond. Thanks go to the Prairie Habitat Joint Venture and the North American Waterfowl Management Plan for their financial and logistical support of the course and workshop, with special thanks to Mike Barr and Bob MacFarlane. The CRHM presentation is available online at http://www.usask.ca/ip3/download/CRHM_course_presentation.pdf, the presentation on Water Management Implications of CRHM is available at http://www.usask.ca/ip3/download/CRHM_water_mgmt_implications.pdf, and the presentation on Drought hydrology is available at http://www.usask.ca/ip3/download/Shook_Pomeroy_DRI_Hydrology.pdf.

Outreach

Updated IP3 Website

The IP3 website was recently updated over the New Year with great photos and access to lots of information relevant to both IP3 collaborators and users. Workshop and meeting notices are posted as is access to presentations through pdf files or video files. An Outreach tab allows users to access current and archived newsletters as well as information on other publications and information on Outreach Activities. An IP3 users link allows access to our latest Outreach tool – a User's Forum accessed at http://arts-hydrology-ip3.usask.ca/forum/. Three forum threads are currently set up—one for CRHM, one for MESH and an IP3 general forum. Please check it out and let us know what you think!

IP3 Annual Workshop

IP3 will hold a business meeting on the afternoon of May 31, 2010, followed by a joint reception with the DRI (Drought Research Initiative) and WC²N (Western Canadian Cryospheric Network) networks. Further information will be forthcoming in the spring. Scientific Sessions in "Improved Cold Regions Hydrology Processes, Parameterisation, and Prediction" , chaired by John Pomeroy will take place during the CMOS-CGU Joint Congress in Ottawa, June 1-4, 2010.

Cold regions hydrogeomatics research: C-CLEAR / IP3 partnership activities 2006-2008

AGRG Applied Geomatics Research Group
Centre of Geographic Sciences
Middleton | Nova Scotia | Canada

During the late 1990's airborne lidar (light detection and ranging) became commercially available as a method of high-resolution digital terrain data collection. Hydrological applications of the technology were immediately obvious in the area of flood simulation and coastal and riverine flood impact assessments from municipal to national scales became one of the main uses of lidar. Academic research into other hydrological and water resources applications of this emerging technology have been slower to develop, largely as a consequence of the high cost of hardware and data collection logistics, but also due to the comparatively few lidar mapping sensors in existence. In partial recognition of the accessibility challenge faced by Canadian earth sciences academics in the 'early days' of lidar mapping, Optech Inc. (Toronto, Ontario), supported the occasional "demonstration" survey for university and government researchers. It was after managing two such surveys during the summer of 2000 that the C-CLEAR (Canadian Consortium for lidar Environmental Applications Research) concept was initiated by Chris Hopkinson. The Peace Athabasca Delta (Pietroniro) and the Wapta Icefields (Demuth and Hopkinson) surveys of 2000 provided both the inspiration and model for future C-CLEAR activities. In 2003, Hopkinson partnered with Robert Maher of the Applied Geomatics Research Group (AGRG) in Nova Scotia on a Canada Foundation of Innovation (CFI) grant proposal to obtain a state-of-the-art airborne laser terrain mapper, so that the C-CLEAR model could be formalized and expanded to support nationwide collaborative research. The CFI proposal was successful and C-CLEAR was officially taken on as a research support and outreach activity by AGRG in 2004. Since then, over 100 C-CLEAR missions have been carried out in almost all Provinces and Territories of Canada (see http://agrg.cogs.nscc.ca/projects/lidar_Metadata), with data and research support being provided to professors and graduate students at over 40 universities around the world.

A recurring theme in cold regions hydrometeorological research and water resources assessment is a need to quantify both: a) volumes of water in its solid state (e.g. snowpack, glacial ice or permafrost); and b) rates of accumulation and ablation. Individual field measurements of in-situ snow depth or ice melt volume using snow-coursing, depth-probing, and ablation stake approaches are relatively straight forward at the point or plot scale but capturing such measurements at the drainage basin scale has traditionally been problematic; requiring research into field sampling and interpolation methodologies. With the potential afforded by lidar to map terrain at previously unprecedented speeds, resolutions, and accuracy, we are now able to directly observe the morphological expression and spatial variability of these hydrologically important features. However, in the field of cold regions hydrology, lidar has only recently started to gain widespread recognition and there are still many largely unexplored areas of potential application. For example, the ability to simultaneously capture above ground vegetation structural data is opening up new research into areas like canopy snow interception simulation, temporal flux footprint mapping, radiative transfer, and below canopy snow melt modeling. Furthermore, the intensity of returned laser pulses contain a wealth of under-exploited information. In recognition of the emerging cold regions hydrological research potential of lidar, IP3 and C-CLEAR embarked on a number of collaborative lidar research missions in western and northern Canada from 2006 to 2008.

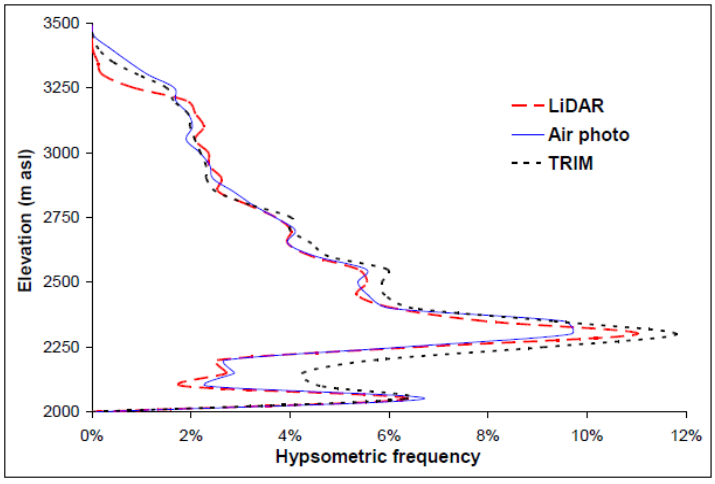


Figure 1. Lake O'Hara watershed hypsometry as automatically derived from 25m grid resolution lidar, air photo and TRIM DEM's (Hopkinson et al., 2009).

In 2006, the first C-CLEAR/GSC/IP3 partnership occurred with lidar surveys and associated field support over the Lake O'Hara Watershed and Peyto Glacier in the Rockies, and several glacierized catchments in the Coast Mountains of B.C. One objective of the Lake O'Hara study was to evaluate the accuracy of watershed attributes when derived from more traditional DEM sources (Figure 1).

Following the success of these missions a larger, more ambitious, summertime campaign was planned to conduct lidar and coincident field surveys over several other IP3 watersheds (Marmot, Peyto, Wolf, Scotty and Baker). In March 2008, a collaboration between the Government of Alberta, the City of Calgary and AGRG enabled a winter snowpack lidar survey of the Marmot Creek watershed coincident with an intensive lidar and field snowpack monitoring experiment over the nearby Elbow Creek watershed. Later in the same year, and as part of IPY research activities over the Mackenzie Delta, another IP3 watershed, Trail Valley Creek, was surveyed and part of Scotty Creek was resurveyed with combined lidar and near infra-red digital photography. The lidar data collected over the IP3 watersheds were post-processed, filtered into ground and non-ground dataset, and gridded for use in image and GIS analysis packages by AGRG researchers, and then shared with the rest of the IP3 research team for further analysis. Of the ten IP3 watersheds, seven were surveyed at least once during these C-CLEAR missions. While many research projects have been enabled through this initiative, AGRG has focused its attention on carrying out or supporting hydrogeomatics projects primarily at Peyto Glacier but also at Lake O'Hara, Marmot Creek and Scotty Creek. Surface and volumetric assessments of glacier wastage have been ongoing at Peyto for many years. Recently, a synthesis of the many glacier surface datasets from 1949 to 2007 was carried out and this work is currently being integrated with mass balance and local climatic records to better understand the long term patterns of surface change and motion. While up to 200m of vertical downwasting is locally apparent on the glacier surface between 1949 and 2007 (Figure 2), the recent seven years of the lidar record illustrated up to 50m of glacier surface loss, up to 20m of moraine downwasting, and up to 50m lateral motion of moraine ridges (Figure 3). Surface downwasting data are being used to validate melt simulations performed at the University of Toronto by Scott Munro. To further study the geomorphic and thermally driven internal melt processes causing moraine subsidence, AGRG and GSC initiated coincident lidar and oblique thermal imaging of an active moraine area. Preliminary results are encouraging (Figure 4) and further work will continue during the summer of 2010.

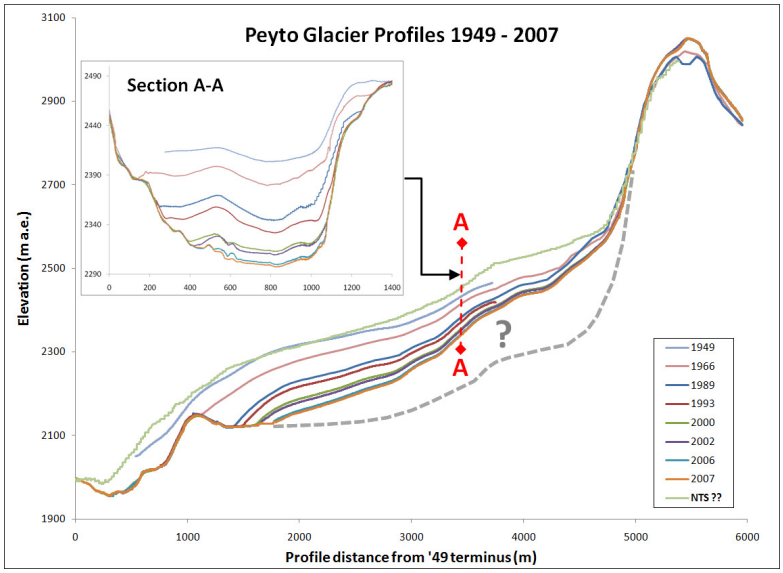


Figure 2. Long and cross sections of the Peyto Glacier surface from 1949 to 2007. Surfaces derived from digital softcopy photogrammetry (1949, 1966, 1993), digitization of archive maps (1966), lidar (2000, 2002, 2006, 2007) and digital topographic products obtained from Geobase (NTS).

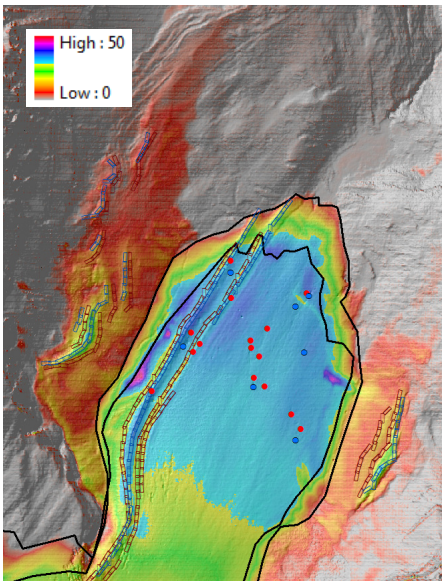


Figure 3. Surface downwasting (in metres) over Peyto Glacier snout and lateral moraines from 2000 to 2007. Positional changes in moulins (dots) Moraines (hatched lines) and ice extent (black lines).

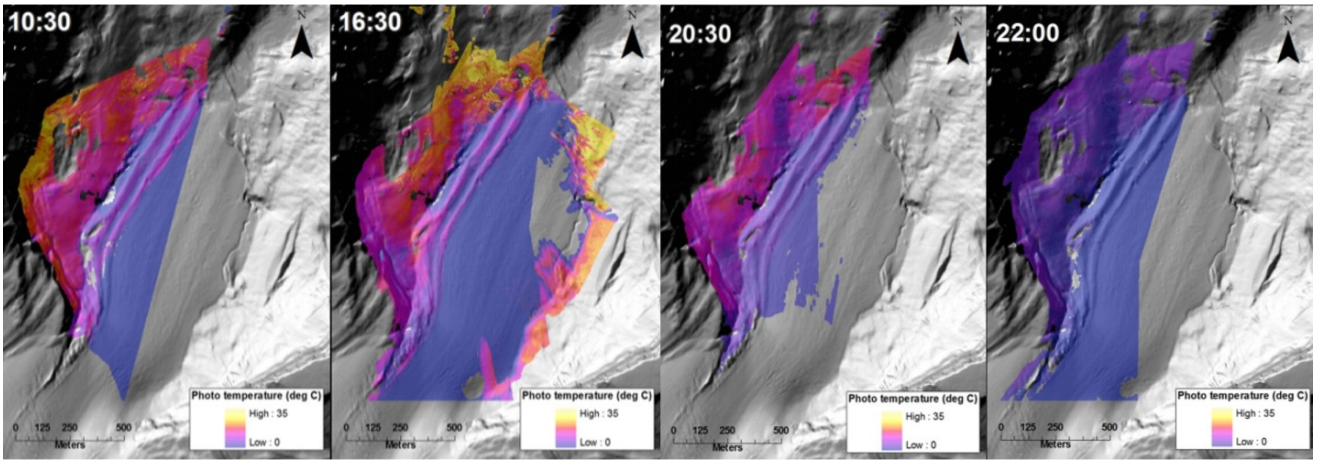


Figure 4. Orthorectified and mosaiced diurnal thermal infrared imagery draped over coincident lidar DEM collected in August 2007 (Hopkinson et al., in press)

The summer and winter data collections over Marmot and Elbow Creeks yielded valuable results on snowpack distributions in alpine and montane forest environments. Some of the lidar-derived terrain and canopy controls are illustrated in Figure 5. This information has been used in a Government of Alberta "proof of concept" study to investigate the efficacy of lidar sampling methods as a supplement to traditional in situ winter snowpack monitoring practices. While most snow depth controls were generally as to be expected from existing literature, one observation that stood out was a small but consistent increase in snow depth at tree line. While terrain, snow, and ice surface maps are the lidar data product most often employed in cold regions hydrological research, the above ground point cloud representing vegetation and forest canopy conditions, is currently under utilized. Ongoing studies at Scotty Creek are attempting to quantify the insulating effects of vegetation overlying permafrost terrain by using both lidar canopy height and fractional cover models to parameterize models of shortwave radiation (Figure 6). Investigation of the long term changes in permafrost and peat plateau extent at Scotty Creek has been facilitated by using the combined lidar and orthoimagery collected in 2008 to control, rectify and compare with archived imagery dating back to 1947 (Chasmer et al., in review).

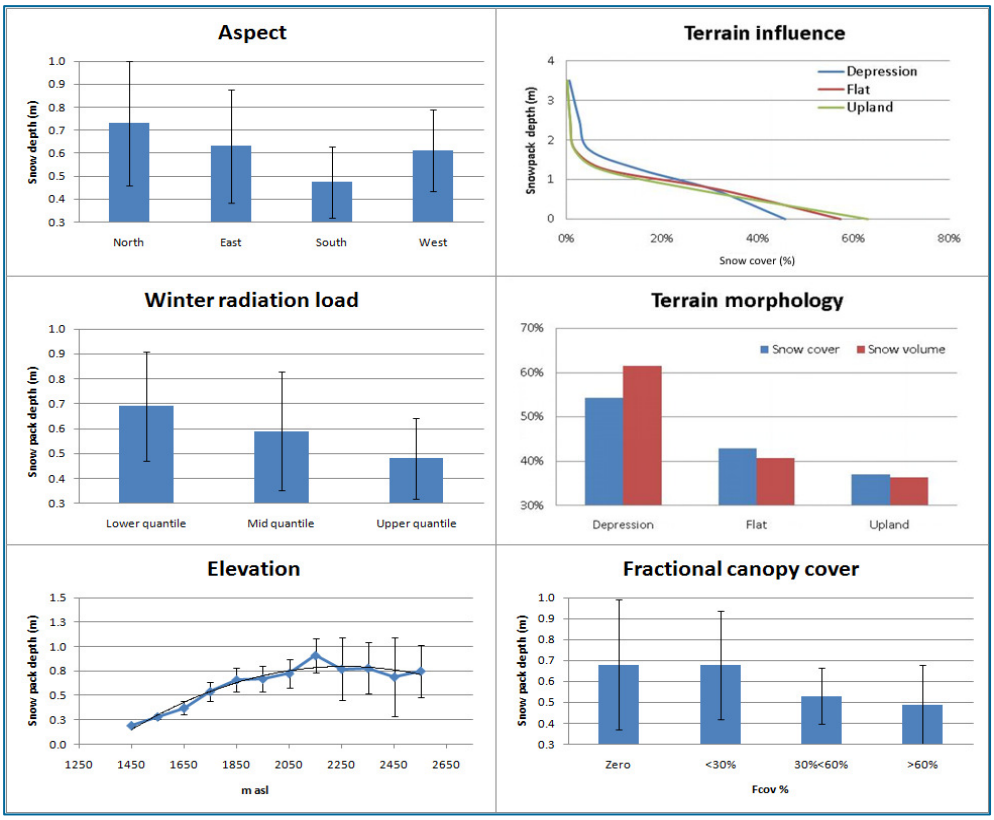
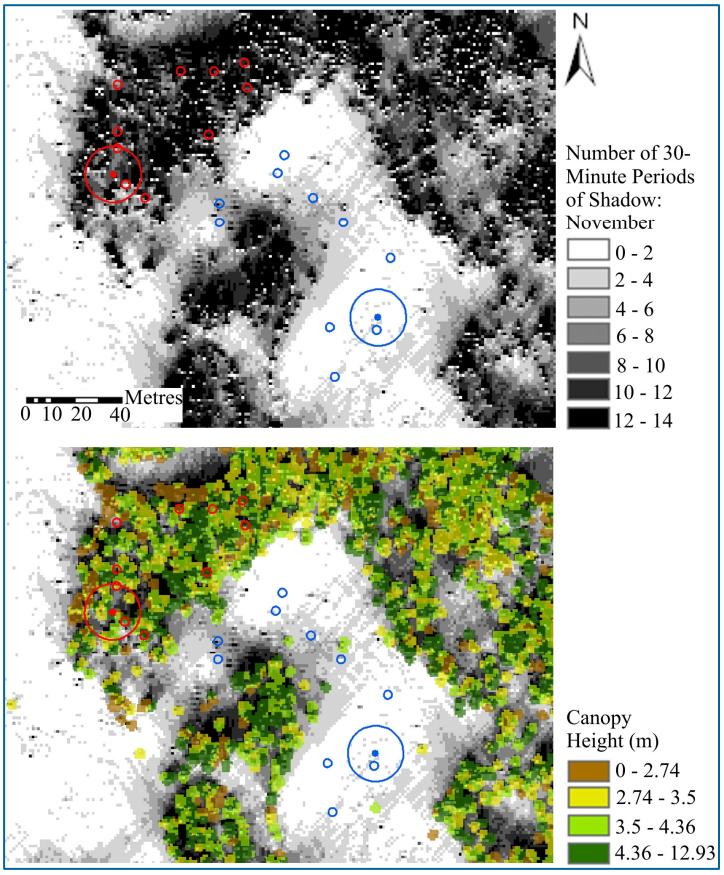


Figure 5. Lidar-derived terrain, canopy, SW radiation controls on lidar-derived snow depth over Elbow and Marmot Creek Watersheds (2007 summer surface subtracted from 2008 winter surface) (Hopkinson et al., in review).



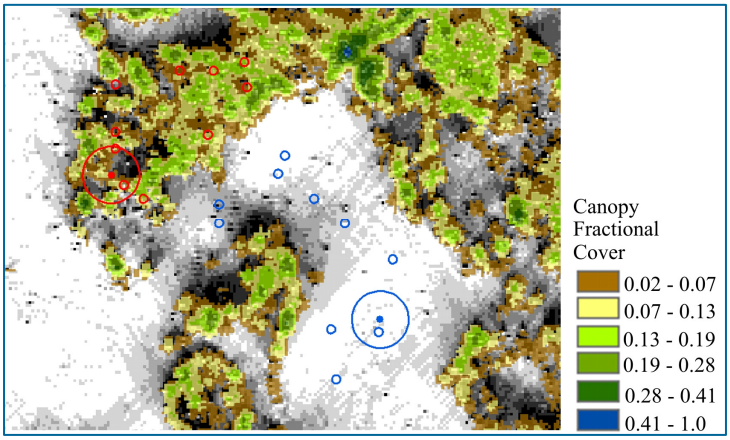


Figure 6. Lidar modelled canopy height (left), fractional cover (above) and direct beam shadowing (top left) over peat plateau permafrost landscape at Scotty Creek (Wright et al., in review; and Chasmer et al., in review).

In recognition of this growing area of hydrogeomatics and in celebration of ten years of C-CLEAR projects, a special session entitled "*The application of lidar to problems in cold-regions hydrometeorology and water resources*" will be hosted at the **Remote Sensing and Hydrology Symposium**, September 27 – 30th, 2010, in Jackson Hole, Wyoming (http://www.remotesensinghydrology.org). Symposium papers will be published in a dedicated IAHS "Redbook". IP3 students and investigators wishing to showcase new and novel hydrological research applications using the lidar data collected during the 2006-2008 C-CLEAR campaigns are encouraged to attend and/or present. For further information on the special session or future C-CLEAR campaigns, contact Chris Hopkinson: chris.hopkinson@nscc.ca.

References

Chasmer, L., Hopkinson, C., Quinton, W., Quantifying errors in historical permafrost plateau change in the Canadian sub Arctic from aerial photography and airborne lidar from 1947 to 2008. *Canadian Journal of Remote Sensing* (accepted pending revision).

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New Initiatives

Canadian Rockies Snow and Ice Initiative 2010 Speaker Series

A group of individuals studying snow and ice are working to create a presence in Canmore, Alberta, under a program called the Canadian Rockies Snow and Ice Initiative (CRSI). A Speaker Series is the first offering of the Initiative. The first presentation was held on January 26th, 2010, with Dr. John Pomeroy presenting "The Canadian Rockies Snow and Ice Initiative—What is it, and what might it do?" Following Dr. Pomeroy's presentation, the audience asked questions of a panel of CRSI members including John Pomeroy, Bob Sandford, Shawn Marshall, Julie Friddell, Laura Lynes, and Kevin Shook. The CRSI speaker series is sponsored by IP3, the Western Canadian Cryospheric Network, the Centre for Hydrology at the University of Saskatchewan, the Biogeoscience Institute of the University of Calgary, The Western Watersheds Climate Research Collaborative, and the United Nations Water for Life Decade. Special thanks go to Lafarge, Canadian Rockies Public Schools and the Canadian Foundation for Climate and Atmospheric Sciences for financial support of the series. Each presentation is being video-taped and audiotaped and will be available on the IP3 and Friends of Banff Park Radio websites. Thanks go to Banff Park Radio for their support—everyone is encouraged to check out their many audio offerings online. Six additional presentations in the Speaker Series will take place in Canmore in February through May, with speakers from Canada, Europe and the United States speaking on topics as varied as "*Research on snow and glaciers in the European Alps*" and "*What glaciers tell us about global climate change*". Video files of the presentations, and further information can be found on the Outreach page of the IP3 website, and a detailed presentation schedule may be accessed from; http://www.usask.ca/ip3/download/CRSI_Speaker_Series_2010.pdf.

Network News

IP3 in Action

* Welcome to Muluneh Mekonnen, a new Post-Doctoral Fellow working for the IP3 Network on MESH modelling. Muluneh will be responsible for using the MESH land-surface hydrology modeling system on a variety of northern Canadian basins with a priority for evaluating, testing and coding the MESH modeling system on IP3 and IPY research domains.

* A thank you to Edgar Herrera who has been the GEM modeller for IP3 for the past several years. Edgar will be starting a new position with CanaTec in Calgary linking an ocean model with a sea ice model. Edgar pushed the GEM model to its limits in northern and complex topography and will be publishing on his work in the near future.

* The short course "Physical Principles of Hydrology" to be held at the University of Calgary's Biogeoscience Institute's Barrier Lake Station in the Kananaskis Valley from March 2-11, 2010 has proven to be very popular with all 40 seats filled and a wait list available for cancellations.

* The IP3 network has officially been extended through to March 2011. This is a no-cost extension that will allow the Secretariat functions to remain in place for data management and outreach in wrapping up the network.

* IP3 is pleased to have been awarded a new grant in partnership with WC^{2}N and DRI. This grant funding from CFCAS will allow for the production of a popular science book to be written by Robert Sandford and published by March 2011. The working title of the project is "Western Water Security:Threats from Climate Change and Extreme Weather" and is proposed as a synthesis of research outcomes from the three networks.

* John Pomeroy was invited to present on the CRHM model at a workshop in Kelowna in January. "The Effects of Climate and Forest Cover Change on Snowmelt-Dominated Water Supplies in the Okanagan" is a project under the auspices of the Future Forest Ecosystems Science Council of British Columbia and use of the CRHM model is an integral part of the project.

Ongoing Research

The Interaction of Vegetation and Runoff in Boreal, Subarctic, and Alpine Watersheds in Relation to Climate Change

The effects of a warming climate, such as permafrost reduction and vegetation community change, are expected to be pronounced in cold regions. The only effective quantitative tools for predicting climate change affects upon and feedback responses to ecosystems and hydrologic processes at the planetary surface are models, particularly atmospheric general circulation models (GCM's). The use of historical data sources (e.g. the North American Regional Reanalysis Archive) combined with strategic aerial photograph and satellite imagery is proposed for the present investigation of hydrological and ecosystem change for the past 60-70 years over extensive cold regions, where ground-based studies are sparse.

Wilfrid Laurier University geography graduate student Clay Morgan is concerned primarily with defining relationships between watershed runoff and important vegetation community indicators, such as ecosystem primary productivity and the treeline, in boreal, subarctic, and alpine regions of northwest Canada. In particular, his research entails including the dynamic nature of succession with environmental and climatic changes of vegetation communities in climate-hydrology monitoring.

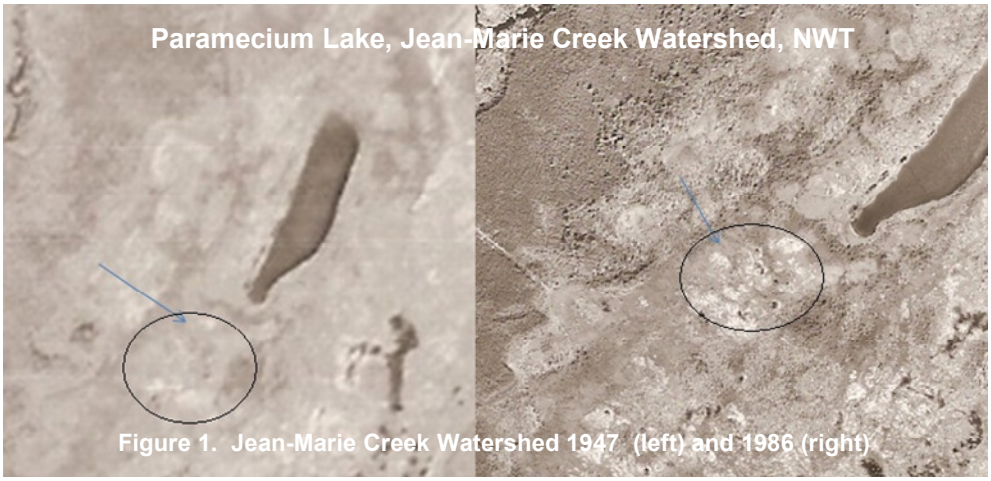

Figure 1. Jean-Marie Creek Watershed 1947 (left) and 1986 (right)

The focus study areas are the Jean-Marie Creek and Trail Valley Creek watersheds in the Northwest Territories and the Wolf Creek watershed in the Yukon. Aerial photo comparisons between 1947 and 1986 reveal a reduction in wooded areas of the Jean-Marie Creek landscape (Figure 1). Similar changes in vegetation makeup in other peatland sites near Fort Simpson, NWT have been correlated with permafrost reduction. For a representative catchment in the Wolf Creek watershed, image analysis suggests that from 1946 to 1995, the tree line advanced up the mountainside at an average rate of 1.24 metres per year with a concomitant 59% tree/shrub density increase (Figure 2). Similar vegetation change rates in Yukon mountain sites have been attributed to climate change (e.g. Kluane Lake).

This study is currently concerned with identifying and relating important vegetation, hydrologic, and climatic parameters in terms of developing algorithms for the effective prediction of vegetation and runoff changes within the Mackenzie and Yukon River basins for inclusion in GCM's, which historically have neglected the element of vegetation succession with climate change.

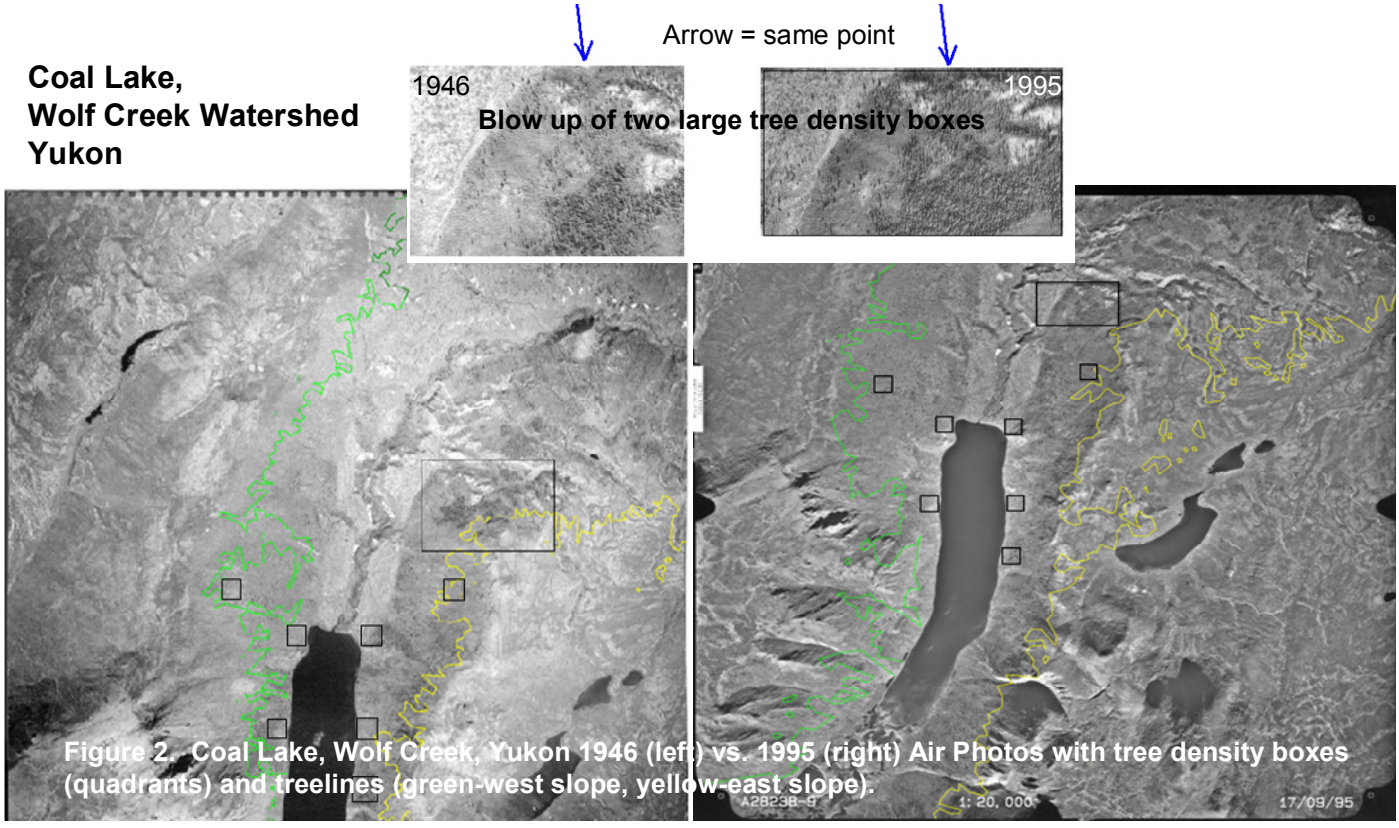

Figure 2. Coal Lake, Wolf Creek, Yukon 1946 (left) vs. 1995 (right) Air Photos with tree density boxes (quadrants) and treelines (green-west slope, yellow-east slope).

IP3 Outreach is available for setting up cold regions model training sessions or meetings between scientists and users for sharing of information. Informational brochures are available for public distribution, including brochures on IP3 research focused in the north, IP3 research in the mountain watersheds, and an overview of the Cold Regions Hydrological Model (CRHM) and its structure and specifications.

IP3
Improved Processes & Parameterisation for Prediction in Cold Regions

Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)
Fondation canadienne pour les sciences du climat et de l'atmosphère (FCSCA)

Information in this issue submitted by John Pomeroy, Julie Friddell, Chris Hopkinson, Clay Morgan and Nadine Kapphahn

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