Report on the IP3 3rd Annual Workshop

12-15 November 2008
Westmark Hotel and Conference Centre
Whitehorse, Yukon

Session 1 – Welcome and Introductions

John Pomeroy chaired the opening of the 3rd annual IP3 workshop. The workshop was opened with a welcome from **Elaine Taylor,** Minister of the Environment for the Yukon Territory. **Erica Wilson** brought a welcome from the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS). **John Pomeroy** then went on to give an overview on the current status of the IP3 Network and plans for the network through to its ending in 2010.

Session 2 – Scientific Reports

Chaired by **Bill Quinton**

An overview of the Theme 2 Parameterisation workshop held in June 2008 reviewed participant's discussions on parameterisation schemes. Four aspects were identified for parameterisation: hillslope, vegetation type, climate, and soil and geology. The suggestion was made that some basins could be used as benchmark sites for certain parameterisation schemes, with the need for model structure to accommodate better parameterisation.

Sean Carey

Hydrological Processes and Parameterisation: Infiltration and Runoff

Questions to be answered by research in the Wolf Creek basin include "How do different ecosystems contribute to runoff?" and "How are different models performing with regards to infiltration?" In conjunction with answering these questions, work is ongoing in hydrochemistry to aid in runoff identification and refining hydrological response unit (HRU) classifications for better model parameterisations. Different models were tested and soil moisture simulations were run for both Scotty Creek and Wolf Creek. Work done since the last IP3 workshop included study on flow transit time distribution on hillslopes using spatially distributed hydraulic conductivity, and residence time distribution, which has been performed before but not with snow. Ongoing research includes channel ice and aufeis work which has a strong influence on ground water and infiltration in organic permafrost soils. Future work involves using multi-function heat pulse probes to be tested spring 2009 in Wolf Creek.

Chris Spence

Parameterisation of Subarctic Canadian Shield Hydrological Processes

Work at Baker Creek has a process focus through identification of contributing area dynamics leading to expected streamflow sites. At the element scale, the frost table is being modeled, while the basin scale covers over 360 lakes. Storage distribution has been modeled and found to be not random. LiDAR data for this site have proven invaluable. Flow chart design suggests the need for a new tile

connector – to be tested with CHRM and MESH. Work for 2009 will attempt to develop scaling relationships to link storage thresholds and contributing area dynamics to Baker Creek runoff response.

Rick Janowicz
Scaling implications of Variable Frozen Soil Infiltration on Runoff Generation
Research objectives looked at quantifying the spatial variability of parameters governing infiltration into frozen soil and runoff in cold regions. Four sites in Wolf Creek covering various landscape types including alpine, forest, sub-alpine, and Granger basin were used for collecting data for soil moisture content, snow water equivalent (SWE), and porosity. Findings suggest that there is substantial difference in infiltration and runoff with differing landscape types. SWE is determined by wind flow change, melt rate is determined by slope and aspect, soil moisture is determined by drainage, and organic layer thickness is determined by slope and aspect.

Scott Munro
The Peyto Glacier Boundary-Layer Experiment
Automated weather stations at four different elevations on the glacier were used in a point process investigation. A twin profile experiment collected data on energy balance terms and boundary layer acceleration and cooling. Glacier "boundary layer hot flash" theory was described as a very brief warm spell that coincides with a lull in the glacier winds, demonstrating boundary layer flow instability. This is important for parameterisation as there is no consideration in models for "hot flashes". More work is to be done comparing eddy correlation and bulk transfer eddy fluxes.

Session 3 – Scientific Reports
Chaired by **Al Pietroniro**

Bill Quinton
IP3 Progress at Scotty Creek
Process and initial parameterisation studies at Scotty Creek; a landscape with lakes, isolated bogs, connected bogs, fens and peat plateaus, was presented. Hydraulic conductivity was found to be highly depth dependent with hydraulic conductivity decreasing by three orders of magnitude from the activated to saturated soil zones. Topography was found to have a strong control on frost table position which affects hydrological connectivity through fill and spill mechanisms at small spatial scales. A new bog development model was presented - as canopy coverage decreases; the increased incoming short wave radiation to the ground surface causes a depression in the frost table which eventually disappears, creating a bog. Basin runoff in the context of changing ground cover was examined: as the basin area covered by bogs increase, runoff decreases; as the basin area covered by fens increase, runoff increases; and as drainage density increases, runoff increases. Future activities include: examining canopy influence on frost table depth distribution, chamber studies on internal energy exchanges and water cycling, and developing a peat plateau CHRM model and MESH runs.

Phil Marsh
Snow and Small Lake Processes at the Arctic Forest/Tundra Transition in the Western Canadian Arctic
Process observations and modeling studies were presented for Trail Valley Creek, Havikpak Creek and two lake sites – Denis Lagoon and TUP Lake. The recent field campaign at Trail Valley was described: snow surveys were coordinated with aircraft microwave surveys, and snow cover was obtained from SPOT imagery and aerial photography. Improved vegetation height and distribution information was

obtained from new LiDAR data. Large variability in sensible heat fluxes was observed over snow-free areas due to differing soil moisture, temperature, slope, and aspect. Year-to-year variations in snow accumulation and melt were examined using a suite of fine-scale models with successful modelling of end of winter snow distribution and snow-covered areas. Data collected at Denis Lagoon and TUP Lake were used to examine the roles of lake size, depth and shape on evaporation. The product of horizontal wind speed and the difference between water surface and atmospheric vapour pressure were shown to have a strong control on lake evaporation. Planned activities include: MESH/CLASS model runs, examining the links between snow, active layer depth and runoff, examining impacts of small lakes on sub-grid scale fluxes, and testing of Raoul Granger's lake evaporation parameterisation.

Richard Essery

Snow Processes and Parameterisation in Complex Landscapes

A parameterisation was presented for energy balance snowmelt modeling associated with varying shrub exposure. New LiDAR datasets provided much greater quality data (topography and vegetation height) for high resolution modelling and was a major improvement over existing 30 m digital elevation model (DEM) and Landsat classification. High-resolution blowing snow modelling was performed using SBSM (simplified blowing snow model), driven by both Mason & Sykes and Liston wind flow parameterisations with good agreement found for modeled and observed snow depth, while adding the LiDAR-derived vegetation height severely reduced simulated snow depth variability. Snow survey trends from Granger Basin were presented with snow depth following vegetation height on slopes and the deepest snow found in gaps of vegetation at the valley bottom. Future work involves incorporating the full Prairie Blowing Snow Model (PBSM) into a distributed blowing snow model, coupling a blowing snow model with a canopy energy balance model, basin-scale implementation of a distributed snow model and Global Environmental Multiscale Model (GEM) atmospheric fields, and comparing distributed and aggregated parameterisations.

Ken Snelgrove

Exploring Hydrologic Similarity in the Marmot Creek Basin

TOPMODEL was used to simulate discharge at Marmot Creek. Hydrologic tiles were grouped by the topographic index and two flow routing algorithms were tested. No significant difference in the frequency distribution of the topographic index for the 90 meter resolution occurred; however, major discrepancies appeared at the 1meter resolution. Potential evapotranspiration was also modeled at Marmot Creek, with the Canadian Land Surface Scheme (CLASS) used to simulate changes in stomatal resistance, and aerodynamics resistance modeled using the Penman-Monteith evaporation equation. Future work will involve planning of further potential evapotranspiration estimates, examining the scaling behaviour of topographic index calculations, implementing TOPMODEL soil-water redistribution within CLASS, and modeling for finer scale topography.

John Pomeroy

Snow Dynamics and Model Parameterisation in Alpine, Arctic, and Forested Basins

Innovative snow observation techniques are being developed and presented, with an acoustic device using sound waves to determine snowpack depth and density. The device is less expensive and time consuming compared to standard snow surveying techniques and is being further developed to determine snowpack tortuosity. A blowing snow parameterisation for large-scale models and land surface schemes is being developed, whereby snow will be transported between landscape units and between grid squares. Blowing snow modeling results over Granger Basin (Wolf Creek) show that explicit representation of both vegetation and topography must be included in model inputs. Progress in snowmelt modeling was also presented with the SNTHERM model used to examine energy balance.

The thermal radiation associated with pine trees was examined as forest thermal radiation enhances snowmelt, largely due to increased longwave radiation. Alpine snowmelt and snow-covered area depletion modeling was presented using SNOBAL to model snowmelt. Future work includes basin seasonal SWE and snow properties using the acoustic sensor, snow canopy unloading algorithm, alpine snow blowing parameterisation for MESH/CLASS, snowmelt parameterisation for forested slopes, snow covered area depletion model for alpine terrain, and parameterisation of the non-turbulent contribution to snowmelt sensible heat estimation.

Session 4 – Scientific Reports

Chaired by **Sean Carey**

Al Pietroniro

Land-Surface-Hydrological Models for Environmental Prediction – case study – Wolf Creek

The environmental prediction framework, methodology and MESH/CLASS modeling case study for the Wolf Creek Basin was presented, outlining the IP3 prediction strategy which combines inductive (for basin segmentation), and deductive (process descriptions) approaches. The objectives were to define an optimum representation of spatial heterogeneity to allow scaling from point scale to catchment scale, examine the effects of spatially distributing solar forcings and snow conditions, and identify landscape-based stable model parameterisations. It was shown that the best simulated results occurred when distributed solar forcing and initial snow conditions were included as opposed to averaged forcings and conditions. The Wolf Creek landscape-based parameters were then applied to Trail Valley Creek and the snow-covered area depletion was simulated well. MESH development includes the tile connector to redistribute mass energy between tiles with a grid cell (e.g., snow drift).

Ric Soulis

Micro-scale to Meso-scale: an Update on the IP3 Sub-grid Soil-Water Budget

A revised parameterisation of the MESH (from the Mackenzie GEWEX project, MAGS) soil-water budget was presented. Modelling imperatives were presented including minimizing the number of HRU's, using distribution-based algorithms whereby fluxes are summed by area or parameter values established using Prabaility-density functions (PDF's), and embedding as much physics as possible in the algorithms. A sloped MAGS tile includes surface runoff, interflow and drainage layers. The revised IP3 tile will include initial state, transition state and steady-state layers. An improved parameterisation of recession curves that incorporates an empirical blend of gravity and suction driven curves was incorporated in WATDrain V3. An instrumented hillslope data set is needed to test these new parameterisations.

Diana Verseghy

The Canadian Land-Surface Scheme (CLASS) for Cold-Climate Regional Modelling

CLASS updates were presented from version 3.4 including new snow process parameterisations, parameterisations for organic soils, and allowances for multiple soil layers. International Polar Year (IPY) related modelling results centred over Quebec were presented. Future work involves using CANGRID precipitation, adding subgrid lake fraction using satellite-derived lake temperatures, and extending a deeper soil column.

Edgar Herrera

Modelling Wind Flow in IP3 Basins using GEM

The GEM-LAM/MEC (GEM-Limited Area Model/Modelisation Environmentale Communautaire)system was used in modelling wind flow over Marmot Creek basin. The objective was to evaluate the relationship between topography and windflow (preferred regions of convergence, divergence, acceleration, deceleration, and flow separation) and evaluate the GEM-LAM model wind field sensitivity to initial conditions. A nested cascade approach was employed with GEM first applied at the global scale (~33km) down to a finer scale (~200m). Simulated snow depth, wind direction, humidity and precipitation were represented, with spin-up period critical in producing reliable output. Future work includes: validating simulated snow depth using LiDAR data, investigating the use of the nested cascade techniques to produce fine-scale wind fields and incorporating a blowing snow parameterisation.

Tom Brown

Update on the Cold Regions Hydrological Model

New developments within the Cold Regions Hydrological Model (CHRM) were demonstrated. Model results can be exported and brought back into CHRM to visualize the effects of changing parameter values. Groups of modules can be created using the macro feature, allowing the user to run multiple projects in parallel; for example, multiple basins can now be run within the same model. The AKA feature allows the user to easily change between forcing data; for example, measured versus modeled wind speed. CHRM can now be run using MS Excel, allowing the user to perform batch runs with different observation and parameter files.

Session 5 – IP3 Collaborators

Chaired by Chris Spence

Masaki Hayashi

Hydrological Storage and Pathways in Alpine Headwaters: Lake O'Hara Study Update This research looks at the delivery of glacial melt into a glacial lake. The key finding demonstrates that most glacier water travels underground to reach lakes. Research questions raised from these findings include: "Where is groundwater stored?", "How long is it stored?", "How much is stored?", and "How can groundwater processes be represented in models?" Inputs were identified as snowmelt, glacial melt, and rain. Results to date have shown that there is more water output than input in August and September. A sustained base flow indicates that the groundwater is storing the melt and slowly releasing it. Debris-covered glaciers and moraines require the use of ground penetrating radar and electrical resistivity imaging to record their volume contribution to groundwater.

Ron Schincariol

The Supporting Role of Laboratory Mesocosms in Scotty Creek Field Studies

The objective of this research is to study moisture dynamics in the active layer to develop a numerical model for better estimation of the water table during ground thaw. A $1,000,000 plant growth chamber that can simulate precipitation, temperatures below freezing, sunrise and sunset, temperatures of -40^{o}C with two refrigeration units, and the ability to simulate snow is being used with a Scotty Creek plant and peat soil sample. A high-resolution scale allows it to work like a lysimeter and measure evapotranspiration and sublimation. A water tracer will be used to determine how water moves through peat at Scotty Creek.

Tim Link

Hydrologic Research at Reynolds Creek: the Southernmost Node of the IP3 Network

This site is located in southwest Idaho in the upper mountainous regions of Reynolds Creek. Data collected reveals increasing temperatures; though the system is still snow dominated, the systems that were previously mixed snow and rain are now mostly rain, while lower elevations see no snow at all where they previously had small amounts. Changes in monthly flows demonstrate more flow coming earlier in the year with the system becoming more extreme. Continuing work is looking at the hot tree effect and radiation regimes in forest gaps, along with snow vegetation interactions using infrared sensors.

James Craig
Parameterisation – Upscaling Threshold Behaviour in Distributed Surface Water Models It has been determined that numerous non-linearitie in numerical surface water models induced instability. A study was suggested to "smooth" thresholds to handle rate discontinuities – more stability occurred but with no physical basis. The method chosen was to upscale from a point process with threshold discontinuities. Similar upscaling can be applied to rates controlled by any forcing function as state variable. This has been tested on degree-day snowmelt models with future work to implement in energy balance models.

Bryan Tolson
MESH 1.2 Modelling Results for IP3 basins: Scotty, Wolf and Reynolds
The key for model calibration is fine-tuning the parameters to allow the model to predict more accurately. Three larger basins (~200km^2) were tested for hydrologic predictions at a regional scale. Calibration experiments were run on the three basins using 1-grid, 1-GRU (grouped response unit) models with a computational budget of 4000 model simulations calibrated to basin outlet streamflows only. Calibration results were discussed with the need to compare model performance under alternative special discretisation strategies. The need to "cleanup" the terminology of spatial discretisation (tile, grid, cell, etc) was also recommended. Future work will be to further develop spatially distributed MESH models using spatial data collected from a different group of basins.

Session 6 – Collaborations and Partnerships in Related National and International Programs

Chaired by **Diana Verseghy**

Shawn Marshall
The Western Canadian Cryospheric Network
WC^{2}N asks the question "What are the glaciers doing in western Canada?" Seven glacial climatic regions were chosen for study with the goal of modeling larger scale dynamics. Documentation of historical glacier extent, glacier mass balance studies, and glacier response to climate change are the key research objectives. Glaciers are a critical resource supplying freshwater, hydro power, and acting as flow regulators and thermostats for fish-bearing streams and rivers. Many glacial streams have been warming and glacier volumes are decreasing significantly.

Ron Stewart
The Drought Research Initiative as a Stepping Stone
DRI is interested in studying extremes in the climate system. Major climate changes have been occurring and we have no predictive ability for drought. The initiative is looking at the Prairie Provinces in particular as they are most at risk for drought, with the need to understand how everything

works together: surface water, groundwater, and interactions with the atmosphere. Research is looking at large-scale flow patterns for years of drought as well as events that alleviate drought in other years.

Terry Prowse
Terrestrial Hydrology in Cold Regions: ICARPII to WCRP-CliC
An overview of the Second International Conference on Arctic Research Planning (ICARP II) introduced Working Group #7 – Terrestrial Cryosphere & Hydrology. One of the scientific questions raised by the working group includes looking at flow into the Arctic Ocean. Changes in precipitation regimes and increases in terrestrial flow have changed freshwater inputs to the Arctic Ocean. There is a large research community assessing these issues and IP3 could feed into this.

Chris Spence
Linkages Between IP3 and the IAHS PUB Initiative
The PUB (Predictions in Ungauged Basins) initiative is currently working on an assessment report with four years left in the initiative. Utilities, water management, and other disciplines are struggling to understand how models can perform to interpret their needs. The PUB initiative is still going strong with BC Hydro working towards an NSERC grant to help fund new research projects.

Session 7 – International Polar Year
Chaired by **Masaki Hayashi**

Terry Prowse
River and Lake Ice: Quantification, Extremes and Historical Trends
Issues, objectives, results, and future research for five key areas of interest advanced under IPY cryosphere/hydrology and ArcticNet were presented. Freshwater ice quantification of the spatial extent, distribution, and volume of river ice across the Northern Hemisphere has been required as no comprehensive records had previously been collected. Hydrologic extremes for the Mackenzie River Basin were studied through extraction and calculation of spring breakup variables, looking for patterns and climate controls that drive extreme events. Results demonstrated that the severity of breakup is most influenced by upstream discharge related controls, while timing is most influenced by downstream ice. Atmospheric linkages are being studied to obtain a better understanding of atmospheric circulation patterns associated with freshwater ice variability. Simulation of lake ice phenology and climate change models indicate thinner lake ice and earlier break-up, with the greatest changes occurring at high latitudes. Future work in all areas involves expanding simulation results with confirming field verification studies.

Peter di Cenzo
Arctic Freshwater Systems: Hydrology and Ecology Highlights and Preliminary Results
This research project was designed to improve process-level understanding of freshwater and nutrient flow into the Arctic Ocean and develop predictive models for measuring freshwater and nutrient flux. Assessments of freshwater biodiversity with the development of a legacy database included monitoring hydro-ecological sensitivities of ecosystems to climate variability and landscape perturbations. Specific research includes hydrometric monitoring of the Mackenzie Delta including identification of river ice cover and break-up patterns, as well as aquatic biodiversity assessments of observed species. Future research projects include CABIN (Canadian Aquatic Biomonitoring Network) – northern community capacity building for local monitoring and research programs on Baffin and Ellesmere Island.

Kathy Young

Hydrology of Polar Bear Pass, Nunavut: IPY Summer 2008

The long term goal of research in the Polar Bear Pass research basin is to improve understanding of hydrology of low-gradient High Arctic regional wetlands. The research site is located in an important national wildlife area, where the biology of the area is well known but the hydrology is not. The short term research goal is to investigate hillslope wetland linkages, pond sustainability, and soil moisture and evaporation. Hillslope-wetland linkages were studied at two sites during the 2008 field season. Windy River is a second order stream with continuous discharge from lots of rain, while Landing Strip Creek is a smaller first order stream that had dried out by July 1st. Hillslope creeks are important for recharging wetlands – the water balance of snow is not as important as rain. During snowmelt, linkages are created while after snowmelt, flow will cease without rainwater input, with a sizeable amount of rain needed to keep streams from drying out. Plans for 2009 include assessing the freshwater supply through expansion of snow surveys, continuing with the hillslope-wetland linkages by expanding creek networks, and further study of pond connectivity, soil moisture, ground ice, and evaporation.

Stephen Dery

Recent Trends and Variability of River Discharge in Northern Canada

Background information was presented with statistics on the main freshwater inputs to the Arctic Ocean. The Mackenzie River was recognized as the largest Canadian contributor to the freshwater budget of the Arctic Ocean. Trends and statistics were presented for 45 different rivers over the following periods: 1970-1990, 1976-1996, 1982-2002 and 1970-2002. Increases in discharge in the north are related to changes in streamflow and increased air temperature, with a pattern of increase starting in 1990 in association with the Arctic oscillation (AO). Future work will look at establishing the causes and seasonality of river discharge changes and investigating atmospheric teleconnections.

Session 8 – Theme Discussion

John Pomeroy chaired a presentation and open discussion on themes with the questions "What are we doing well?" and "What are we missing?" Discussion from the floor centered on concerns about data management issues with consensus that the topic will need to be discussed further.

Sean Carey led the discussion on Theme 1 by highlighting the need to maintain instrumentation to continue collecting data for the last full year of IP3. Themes 1 and 3 need to talk together about what information is needed – eg soil classification for soil moisture modeling and the importance of labeling conditions under which measurements are achieved.

Bill Quinton led the discussion on Theme 2 raising the question: "What processes do we want to include in models?" Answers included streamflow, soil moisture, and energy, as determined by the endpoints required by users. Issues not addressed at this time included large rivers, river ice, groundwater dynamics, and glacier dynamics. The need for tile connectors in translating complexity to models – how to deal with lateral transfer – was recognized as a key model issue to be solved in dealing with fill and spill mechanisms.

Al Pietroniro led the Theme 3 discussion with the suggestion that IP3 needs to start working on modelling basins now as funding and students will finish up next year. Future planning requires grouping basin principal investigators with a specific modeler in charge of each basin. Users suggested that they need just a simple output and endpoint – process details are not necessary for them. Outreach

issues were discussed along with information management issues including archiving final IP3 legacy. Discussion was held about an IP3 special journal issue in 2009 in HESS (Hydrology and Earth System Sciences) for contributions from January to July 2009.

Session 9 – Report from the Board of Directors

Ming-Ko Woo
Summary Report
An overview of the mandate of the Board of Directors was presented: to ensure financial accountability, oversee scientific integrity and quality of research programs, and promote effective communication activities. The board was pleased with progress to date, in particular with inter-network collaborations and a strong presence in national and international arenas.

Session 10 – Future Planning
Chaired by **John Pomeroy**

Bob Sandford
Rocky Mountain Hydrometeorological Observatory
Presentation was made on the upcoming workshop, "Monitoring and Prediction of Western Water and Weather" to be held December 8-10th in Canmore, Alberta. The importance of interpreting research done by IP3 to the public was emphasized, as was the value of promoting IP3 work through both policymakers and public forums. Goals for public awareness include mounting a national television campaign and publishing 4 books on water and water research in Canada. The presentation reflected on the need to optimize results through determining next steps over the next few years including putting new monitoring stations in place and accessing continued funding for water research. The timing for raising public awareness appears to be good as there is currently more interest in collecting water resource information by senior government levels.

John Pomeroy
National and International Programs and Group Discussion on Plans for IP3 Follow-on Activities
There is current national and international interest to follow up investigations that combine high altitude and high elevation studies. Relationships are being established with other networks such as the Climate and Cryosphere Project (CliC), the Global Energy and Water Cycle Experiment (GEWEX), the Group on Earth Observations (GEO), etc. IP3 needs to continue to pursue national linkages through hydrology, cryospheric science, atmospheric sciences, and water resources. It is important to continue to advance our understanding and prediction abilities with the tools we have created, and apply our knowledge in the field. We need to consider the following issues: keeping current research basins running, importance of remote sensing, keeping model development progressing, and the importance of demonstration projects to user groups.

Session 11 – Poster Session
Poster session and reception were held at the Beringia Centre.

Session 12 – Users' Perspectives on IP3

Chaired by **Bob Reid**

Bob Reid
Overview and Current Status of the IP3 Users' Advisory Committee, and Summary Report on UAC Workshop in Canmore, March 2008
The importance of the Users' Advisory Committee to IP3 was presented along with a review of sponsors and members. An overview of the March 2008 Canmore workshop was presented with a summary of needs arising from the workshop. These included: the need for an observing and monitoring network, sharing of data analysis, information, prediction and models and new concepts for research. WC^2N will be involved in the next workshop, possibly spring 2009 in Edmonton.

Ian Church
IPY Collaboration with IP3
Background information on IPY was presented with discussion of IPY legacy issues for polar agendas including research groups and funding for polar research. International results have led to close relationships between IASC (International Arctic Science Committee) and SCAR (Scientific Committee on Antarctic Research) with more than 63 countries involved with IPY. Young polar research groups such as APECS (Association of Polar Early Career Scientists) and PYRN (Permafrost Young Researchers Network) were also supported. SAON (Sustained Arctic Observing Networks) is being drafted as a major legacy item for long term Arctic monitoring and sharing of data.

John Diiwu
Watershed Management in the Alberta Green Area
The need for watershed management to maintain a viable economy was stressed with the recognition that forested watersheds are the main source of drinking water. Influences from wildfire and mountain pine beetle outbreaks were presented as well as the need to manage recreational impacts on water values. Current watershed studies were discussed – Marmot Creek study with IP3, Lost Creek with University of Alberta, and the Foothills Research Institute in Hinton. The importance of long-term monitoring with information needed for decision making was emphasized.

Session 13 – Users' Application of IP3 Science
Chaired by **Ian Church**

Rick Janowicz
Adapting Yukon water management practices to changing Yukon hydrologic regimes
The Yukon hydrologic response was presented defining four different response regimes: (1) glacial – from high precipitation in mountains – runoff peaks in late summer with greatest volume; (2) interior – lowest runoff peaks over discontinuous permafrost with snowmelt dominant source peaking in June; (3) northern – half discontinuous and half continuous permafrost – area has decreased precipitation, however runoff peaks are greater due to permafrost influence; and (4) Arctic/coast - permafrost driven with least precipitation but quickest and highest runoff. Historical temperature and precipitation trends identify increased summer precipitation, decreased winter precipitation, and increased temperatures in both summer and winter. The Yukon government is in the process of finalizing a climate change action plan that includes adaptation strategies, actions for reducing greenhouse emissions, and monitoring of impacts. Specific climate change impacts include: increasing peak flows due to melting glaciers in the Atlin/Kluane region, decreased peak flows due to thawing permafrost in the Porcupine/Firth River area, increased snowpacks and warmer/wetter summers leading to significant flooding, hillslope slump

causing by thawing permafrost triggering debris flows, and increasing winter flows in all zones. Hydrologic response over the last three decades has shown significantly earlier spring break-ups with warming winters contributing to a greater frequency of ice jams and subsequent flooding.

Al von Finster

Applications of IP3 science: fish and fish habitat, present and future

Fish are important to Yukoners! Fish habitat management historically has been "place more than process" with emphasis on water quality, water quantity, riparian areas and steady-state conditions with little or no temporal component. Current fish habitat management has increased its consideration of process and change: understanding watershed and landscape effects, geology and geomorphology, weather and climate, hydrology and geohydrology, thermal regimes, natural disturbance regimes, and temporal considerations. Decreasing flows in some creeks require decisions to no longer invest effort in supporting fish restoration. Involvement with IP3 and future planning involves developing and maintaining information planning, and gathering, storing, and sharing of regional long term data sets to describe trends. This can allow for societal planning for changes including development of management plans to reduce negative effects and increase benefits resulting from changes in hydrologic systems; for example, Tweedsmuir Glacier/Turnback Canyon could become eventual salmon habitat when melted out.

Panya Lipovsky

Permafrost-related landslides in south and central Yukon

Landslides (earth flows, debris slides, and rock falls) can occur through retrogressive thaw slump and active layer detachment failure. Stresses on slopes are ultimately determined by gravity and water with external stresses causes by topography, river migration, recent glacial retreat, or human disturbance and loss of material strength caused by weathered source materials, intense rainfall/snowfall events, and groundwater, permafrost, or forest fires. Intense rainfall or snowmelt is one of the main triggers of landslides. Permafrost restricts drainage with an impermeable layer; if permafrost thaws, it contributes more moisture to soil and reduces its strength. Active layer detachments can occur on very gentle slopes with the permafrost table acting as a failure plane. Detachments are usually triggered by forest fires or high snowfall/rainfall events, with one study showing 150 active layer detachments within one year of a major forest fire. Retrogressive thaw failures are usually triggered by river erosion or vegetation disturbance, whereby the ice is exposed and causes ongoing retreat in melting back. Ice thaw causes embankment failures with material transported several kilometers away in large mobile flows.

Meeting Conclusion

Al Pietroniro

"Themes to parameterisation teams" were presented for the following processes: snow, vegetation, glaciers, frozen ground, hillslopes and lakes/ponds/muskeg. "Themes to basin modelling teams" were assigned with the goals of moving basin understanding and parameterisations to CHRM and MESH (MEC – Surface and Hydrology), for further model development and improved predictions.

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