SESSION H14: General Hydrology

Conveners: Claire Oswald[1], and Daniel Peters[2]

Co-chairs: Claire Oswald[1], and Daniel Peters[2]

[1]Geography and Environmental Studies Dept., Ryerson University, Toronto, ON, M5B 2K3, Phone: 416-979-5000, Fax: 416-979-5362, E-mail: coswald@ryerson.ca

[2]Environment Canada, Climate Impacts Research Centre, P.O. Box 3060 STN CSC, University of Victoria, Victoria, BC V8W 3R4, Email: Daniel.Peters@ec.gc.ca

Session Description

This session invites contributions from all aspects of hydrology, in particular those not covered by a special session.

Primary Affiliation: CGU / Hydrology

NOTE: THIS DOCUMENT CONTAINS INFORMATION FOR ALL SESSION SUB-SECTIONS. PRESENTER ABSTRACTS ARE FOUND AT THE END OF THE DOCUMENT.

SCHEDULE MAY BE SUBJECT TO CHANGE.

ORAL SESSION H14a

Chairs: C. Oswald & D. Peters **Room: EOSC 135**

Monday, May 29th

TIME	AUTHORS	TITLE
9:00	A. Thiboult & F. Anctil	Accounting for hydrologic model uncertainty in data assimilation
9:15	A. Haghnegahdar*,M. Elshamy, F. Yassin, D. Princz, S. Razavi, H. Wheater & A. Pietroniro	A comprehensive sensitivity assessment approach for analyzing the behavior of a land surface-hydrology model
9:30	G. Seiller, F. Anctil, R. Roy	An empirical multistructure framework for accurate, sharp, and reliable hydrological ensembles
9:45	J. Lin*, R. Ma & Z. Sun	Numerical Simulation of Multi-well Pumping Tests to Estimate Spatial Heterogeneity of a Fractured Formation
10:00	S. Gharari & S. Razavi	Do small-scale hysteretic processes affect the larger-scale behavior of watersheds?
10:15	S. Gurrapu*, D.J. Sauchyn, K.R. Hodder & J.M St. Jacques	Assessment of the standardised precipitation-evapotranspiration index in relation to streamflow prediction in the rivers of western Canada

ORAL SESSION H14b

Chairs: C. Oswald & D. Peters **Room: EOSC 135**

Monday, May 29th

TIME	AUTHORS	TITLE
14:00	E. Ueckermann*, A. Berg, C. Champagne & A. Bonnycastle	Characterizing the SMOS Soil Moisture-Runoff Relationship over Canadian Catchments
14:15	M.A. Hernandez-Henriquez, A.R. Sharma, S.J. Dery	Variability and trends in runoff in the rivers of British Columbia's Coast and Insular mountains
14:30	J. Leach & H. Laudon	Influence of a headwater lake on downstream discharge dynamics
14:45	K.J. Hokanson, K.J. Devito & C.A. Mendoza	Substrate layering and climate control water table configurations in sub-humid Boreal Plain landscapes
15:00	B. Kurylyk, S. Carey, D. Irvine, M. Briggs & M. Bonham	Heat as a hydrogeologic tracer in heterogeneous terrestrial and coastal environments

15:15	R. Wu, J. McKenzie, B. Bussiere, M. Aubertin, V. Martin & S. Broda	Monitoring moisture in waste rock with fiber optic distributed temperature sensing

POSTER SESSION H14

Chairs: C. Oswald & D. Peters **Room: ESB Atrium**

Monday, May 29th

Poster No.	AUTHORS	TITLE
P01-H14	L. Morales-Marin, H. Wheater, K. Lindenschmidt & F. Yassin	A new solute transport model for large scale cold region catchments: A theoretical framework
P02- H14	J.M. Buttle	Mediating stream baseflow response to climate change: the role of basin storage
P03- H14	D.E. Carlyle-Moses & T.G. Pypker	Rainfall Partitioning by the Canopy of a Lone Ponderosa Pine (Pinus ponderosa)
P04-H14	W. Floyd, M. Korver, C. Owen, J. McPhail & R. Brunsting	Stage-discharge rating curve development using an automated salt dilution system on British Columbia's Central Coast
P05-H14	M. Elshamy, A. Pietroniro & H.S. Wheater	Modelling the hydrology and streamflow of the Mackenzie River Basin

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SUBMITTED ABSTRACTS

H14-01: Accounting for hydrologic model uncertainty in data assimilation

Antoine Thiboult[1] and François Anctil[1]

[1] Water Engineering Dept., Université Laval, Québec, QC, G1V 0A6, Phone: 418-656-2131 ext 2032, E-mail: antoine.thiboult.1@ulaval.ca

Abstract

Data assimilation (DA) has the capability to improve hydrological forecast by combining numerical simulations and observations. It is a key component of the most sophisticated operational forecasting systems by providing more suitable model initial conditions. The particle filter (PF) is one of the algorithms frequently used to perform data assimilation. It is convenient since it handles non-linear systems and do not make assumptions about the form of the probabilistic densities. Typically, the PF is applied on a single hydrological model to reinitialize model hidden states when new observations become available. To reach optimal performance, some ad hoc tuning needs to be performed, essentially to account for model uncertainty. This tuning may be complex because model uncertainty quantification is not straightforward. Nonetheless, it can be estimated by the use of multiple cooperating models (a multimodel ensemble), which rely on dissimilar structures and conceptualizations. The outputs of the models are used to create a probability density function with a spread that reflects model uncertainty. We suggest a new methodology based on the PF to update efficiently and simultaneously the states of the different models within the multimodel ensemble. The underlying idea is to compare the densities issued from the multimodel with the observation density. While in the traditional PF, appropriate initial conditions are estimated by computing the likelihood of the deterministic model trajectories (the particles), the new methodology gives a probabilistic information to the particles. The models are jointly updated in a way that ensures to create predictive densities that explicitly include structural and forcing uncertainties to mimic the observation and its uncertainty. The methodology is assessed on several catchments in the Province of Québec. Preliminary results indicate that this technique is efficient and provides gain over individual model updating.

Presentation type: Oral Presentation

H14-02: A comprehensive sensitivity assessment approach for analyzing the behavior of a land surface-hydrology model

Amin Haghnegahdar[1*], Mohamed Elshamy[1], Fuad Yassin[1], Daniel Princz[1], Saman Razavi[1], Howard Wheater[1], Al Pietroniro[2]

[1] Global Institute for Water Security, University of Saskatchewan, Saskatoon, SK, S7N 3H5, Phone: +1(306) 966-2021, E-mail: amin.haghnegahdar@usask.ca
[2] Environment and Climate Change Canada, National Hydrology Research Centre, Saskatoon, SK, S7N 3H5

Abstract

Model sensitivity analysis plays a crucial role in understanding the behavior of complex physically-based environmental models and improving their performance. Local sensitivity analysis, as commonly used by modellers by manually changing the model parameters one-at-a-time, is insufficient due to the existing nonlinearity and interactions within these complex models. Therefore, Global Sensitivity Analysis (GSA) techniques should be adopted to provide a comprehensive understanding of the model behavior and identify its dominant controls across the entire feasible parameter space. In this study, we adopt a multi-criteria GSA approach to systematically assess the behavior of the Modélisation Environmentale–Surface et Hydrologie (MESH) across various hydroclimatic conditions in Canada including sub-basins in the Great Lakes Basin, Mackenzie River Basin, and South Saskatchewan River Basin. We use a novel and efficient method, called Variogram Analysis of Response Surfaces (VARS), to perform this sensitivity analysis. VARS is a variogram-based GSA technique that can efficiently provide a spectrum of sensitivity information across a range of scales within the parameter space. We use multiple metrics to identify dominant controls of model response (e.g. streamflow) in each case under various conditions such as high flows, low flows, and flow volume. We also investigate the influence of initial conditions on model behavior as part of this study. Our preliminary results suggest that while vegetation and drainage properties are the most dominant factors in controlling streamflow, initial conditions (mainly related to soil temperature) can still be very influential even after one year into the simulation. Accordingly, this type of GSA can significantly help with estimating model parameters and initial conditions, decreasing calibration computational burden, and reducing prediction uncertainty. [267 words]

Presentation type: Oral Presentation

H14-03: An empirical multistructure framework for accurate, sharp, and reliable hydrological ensembles

Grégory Seiller[1], François Anctil[1], and René Roy[2]

[1] Civil and Water Engineering, Université Laval, Québec , +1 418 656 3653, francois.anctil@gci.ulaval.ca
[2] Hydro-Quebec Research Institute, Varennes, and Ouranos Inc., Montreal

Abstract
This presentation outlines the design and experimentation of an Empirical Multistructure Framework (EMF) for lumped conceptual hydrological modelling. This concept is inspired from modular frameworks, empirical model development, and multimodel applications, and encompasses the overproduce and select paradigm. The EMF concept aims to reduce subjectivity in conceptual hydrological modelling practice and includes model selection in the optimization steps, reducing initial assumptions on the prior perception of the dominant rainfall-runoff transformation processes. EMF generates thousands of new modelling options from, for now, twelve parent models that share their functional components and parameters. Optimization resorts to ensemble calibration, ranking and selection of individual child time series based on optimal bias and reliability trade-offs, as well as accuracy and sharpness improvement of the ensemble. Results on 37 snow-dominated Canadian catchments and 20 climatically-diversified American catchments reveal the excellent potential of the EMF in generating new individual model alternatives, with high respective performance values, that may be pooled efficiently into ensembles of seven to sixty constitutive members, with low bias and high accuracy, sharpness, and reliability. A group of 1446 new models is highlighted to offer good potential on other catchments or applications, based on their individual and collective interests. An analysis of the preferred functional components reveals the importance of the production and total flow elements. Overall, results from this research confirm the added value of ensemble and flexible approaches for hydrological applications, especially in uncertain contexts, and open up new modelling possibilities. [240 words]

Presentation type: Oral Presentation

H14-04: Numerical Simulation of Multi-well Pumping Tests to Estimate Spatial Heterogeneity of a Fractured Formation

Jingjing Lin[1*], Rui Ma[1], and Ziyong Sun[1]

[1] School of Environmental Studies, China University of Geosciences, Wuhan, Hubei 430074, China, Phone: 18511997767, E-mail: jjlin90@163.com

Abstract

The characterization of aquifer heterogeneity is crucial for the assessment of groundwater resources and groundwater and surface water interactions, as well as the sustainable exploitation of aquifers. Pumping test is a standard and widely used approach to determine the spatial distributions of hydraulic parameters of aquifer systems. In this study, we employed numerical modeling to inversely estimate the heterogeneity of a fractured medium located in Qitaihe city, Heilongjiang province of China. Three multi-well pumping tests with pumping rates ranging from 614.16m^3/d to 2025.36m^3/d were conducted in the fractured formation where lies in the upper reaches of Taoshan reservoir. The characteristics of hydrographs at the observation wells during three pumping tests were analyzed. Subsequently, a three-dimensional finite-difference numerical model was established with MODFLOW code, and the equivalent porous medium method was applied to describe the fracture network. Hydraulic conductivity and storage coefficient were continuously calibrated to obtain the good matches between the simulation and observation values of hydraulic heads during the pumping tests. Our results illustrate that hydraulic parameters of the aquifer system at the study site are highly spatial heterogeneity, and the vertical hydraulic conductivity is much greater than horizontal hydraulic conductivity, reflecting the typical characteristics of the fractured medium. The model results also show that the fractures are mainly distributed along the valley plain, which is controlled by the geological structure of the study area. High vertical permeability formation, with the vertical hydraulic conductivity of 10~100 m^3/d, exists below the reservoir, leading to an intense interaction between the reservoir and the groundwater. These results will provide insight into the flexible management of groundwater resources in the fractured aquifer.

Presentation type: Oral Presentation

H14-05: Do small-scale hysteretic processes affect the larger-scale behavior of watersheds?

Shervan Gharari[1], Saman Razavi[1]

1-Global Institute for Water Security (GIWS), University of Saskatchewan, Saskatoon, SK, S7N 3H5, Phone: 306-966-6661 E-mail: shervan.gharari@usask.ca

Abstract

Hysteresis is a widely observed phenomenon in hydrology and beyond, at a range of spatio-temporal scales. Despite significant research efforts, hysteretic behaviors and their implications for hydrologic modelling and prediction have remained poorly defined and understood. The current state of the art is that almost all practical models in use do not include any hysteretic components or relationships that directly represent such behaviors. Using existing strategies for hysteresis modeling from other disciples, we evaluate to what extent the addition of hysteretic components to a hydrological model (such as soil moisture and soil suction head – soil hydraulic conductivity) would change the model performance and associated uncertainties. Our analyses also show that a properly designed model structures can largely compensate for the lack of hysteretic components in models and allow mimicking the observed hysteretic behaviors. [133 words]

Presentation type: Oral Presentation

H14-06: Assessment of the standardised precipitation-evapotranspiration index in relation to streamflow prediction in the rivers of western Canada

Sunil Gurrapu[1 2 *], David J. Sauchyn[1], Kyle R. Hodder[2], Jeannine-Marie St. Jacques[3]

[1] Prairie Adaptation Research Collaborative (PARC), University of Regina, Regina, S4S 0A2, Phone : 639-999-2426, E-mail: gurrapus@gmail.com
[2] Department of Geography and Environmental Studies, University of Regina, Regina, S4S 0A2
[3] Department of Geography, Planning & Environment, Concordia University, Montreal, H3G 1M8

Abstract
Knowledge of the spatial and temporal distribution of water resources is important information for decision makers to address adaptation options, adaptive management practices and policies for planned adaptation to changing climate. Hydrological models based on various physical processes of the hydrological cycle are generally used to simulate streamflow in rivers. Although physically based and conceptual hydrological models are used to project or forecast streamflows, their use is limited depending on the available datasets. However, statistical hydrological models are more convenient and less time consuming because they are based on empirical relationships between historical climate and streamflow. Several statistical models were developed to project streamflows of 21st century in the watersheds of western Canada using several low-frequency atmosphere-ocean circulations such as Pacific Decadal Oscillation, El Nino-Southern Oscillation as predictor variables. However the reliability of the projected streamflows produced by driving the statistical models using the large-scale climate indices is founded on the reliability of the chosen global climate model in projecting the large-scale climate. In this study, we propose to use the regional indices of climate such as standardised precipitation evapotranspiration index (SPEI) to regress and project summer and annual streamflow in several watersheds of western Canada. We adopted principal component regression to assess SPEI as a predictor variable in simulating streamflow in selected watersheds of western Canada. Based on our analysis, we suggest that SPEI developed from regional climate is efficient in predicting or projecting summer and annual streamflows in the watersheds of western Canada.

Presentation type: Oral Presentation

H14-07: Characterizing the SMOS Soil Moisture-Runoff Relationship over Canadian Catchments

Elené Ueckermann[1*], Aaron Berg[1], Catherine Champagne[2], Adam Bonnycastle[1]

[1] Geography Dept., University of Guelph, Guelph, ON, N1G 2W1, Phone: (519) 824-4120 Ex 52564, E-mail: eueckerm@uoguelph.ca
[2] Agriculture and Agri-Food Canada, Ottawa, ON, K1A 0C6

Abstract
Soil moisture plays a key role in runoff generation through its control on rainfall partitioning over a catchment. While many studies have shown the value of assimilating soil moisture into hydrological forecasting models on small scales, a large-scale analysis of the strength and controls on the catchment soil moisture-runoff relationship has not been conducted in a Canadian context. The objective of this research was to evaluate the strength of this relationship over a series of variable Canadian watersheds using macroscale estimates of soil moisture obtained with the Soil Moisture and Ocean Salinity Mission (SMOS) satellite. Data from the satellite, which is able to estimate volumetric soil moisture data within the top <5cm of soil using an L-band radar, was used to derive average daily and weekly absolute and anomaly soil moisture data over a subset of 80 watersheds across Canada. Warm season data from 2011 to 2014 was compared to the calculated to runoff ratio from local discharge and climate data through a regression analysis at various thresholds and lag times. To determine the relative importance of the antecedent soil moisture for runoff generation, the basins were further characterized according to a series of climate and topographical parameters used for a predictive model development. Preliminary results show a significant ($P>0.05$) positive correlation between soil moisture and runoff ratio over 25% of the catchments studied, as well distinct spatial trends in these correlations. The presence of soil moisture and precipitation thresholds offer some explanatory power for these results, while climate variables such as average annual precipitation and number of precipitation events are more important than topographic variables in determining the strength of the soil moisture-runoff link. This method shows promise as a large-scale tool to offer new insight on large-scale controls on runoff over remote landscapes in Canada.

Presentation type: Oral Presentation

H14-08: Variability and trends in runoff in the rivers of British Columbia's Coast and Insular Mountains

Marco A. Hernández-Henríquez [1], Aseem R. Sharma[2], and Stephen J. Déry [1,2*]

[1] Environmental Science and Engineering Program, University of Northern British Columbia, Prince George, BC, V2N 4Z9, Phone: 250-960-5193, Fax: 250-960-5845, E-mail: Stephen.Dery@unbc.ca
[2] Natural Resources and Environmental Studies Program, University of Northern British Columbia, Prince George, BC, V2N 4Z9, Phone: 250-960-5427, E-mail: asarma@unbc.ca

Abstract
The complex topography and sharp climatic gradients of the Coast and Insular Mountains of British Columbia (BC) lead to a variety of distinctly different hydrological regimes. As the regional climate continues to change and winter precipitation falling as rain rather than snow increases, rivers may transition from nival to hybrid or pluvial regimes. In this context, this study investigates runoff variability and trends for 136 rivers and creeks draining BC's Coast and Insular Mountains over 1914-2015. Our findings indicate that rivers flowing eastward to the Nechako and Chilcotin plateaus contribute the lowest annual runoff values compared to westward flowing rivers where runoff is high. Low interannual runoff variability is evident in westward rivers and their alpine watersheds, whereas eastward rivers exhibit high interannual runoff variability. On Vancouver Island, some of the rivers with the highest annual runoff exhibit high interannual variability and runoff extremes that occur in succeeding months in the fall. There is a shift towards more positive detectable trends in annual and seasonal runoff from the middle (1966-2015) to the late (1986-2015) period. In addition, the leeward side of the Coast Mountains exhibit more positive trends compared to the windward side during 1986-2015. This study provides crucial information on the hydrology and shifting streamflow regimes of mountain watersheds across BC's coast in response to elevational amplification of regional climate change. The presentation will conclude with a discussion on the implications that variability and trend changes in runoff may have in the rivers of the Coast Mountains of BC and future research endeavours.

Presentation type: Oral Presentation

Preferred Session: General Hydrology

H14-09: Influence of a headwater lake on downstream discharge dynamics

Jason Leach[1] and Hjalmar Laudon[2]

[1] Dept. of Geography, Simon Fraser University, Burnaby, BC, V5A 1S6, Phone: 778-782-4937
E-mail: jleach@sfu.ca
[2] Dept. of Forest Ecology and Management, Swedish University of Agricultural Sciences (SLU), Umeå, Sweden

Abstract
Headwater lakes and their outlet streams are common hydrologic features in glaciated landscapes. These lakes can influence discharge, water quality and ecological characteristics of downstream lotic environments; however, the timing and magnitude of these influences, as well as their prevalence downstream, remain unclear. We examined the role of a headwater lake on downstream discharge dynamics for a lake-stream network located in the boreal forest region of northern Sweden. We used an eight year data set of stream discharge and stable water isotopes measured at 0.1, 1.4, 3.4, and 4.2 km downstream of a headwater lake. In addition, we analyzed discharge from a nearby stream that lacked a headwater lake to provide a comparison to the lake system. We observed that the stream draining the lake maintained higher baseflow levels compared to the stream without a headwater lake except during dry years. The lake also had a moderating influence on rain-event peakflow magnitudes; however, the lake did not appear to impact the timing of peakflow except immediately downstream of the lake. In addition, stream water sourced from the lake contributed as little as 1% to as much as 75% to total downstream discharge, with the remaining water sourced from hillslope inputs. This variability in water source was related to the hydroclimatic state of the catchment. Our results highlight that headwater lakes can have a pronounced influence on downstream discharge dynamics and that understanding these influences is crucial for interpreting and predicting stream water quality and ecological patterns and processes at the landscape scale. [252 words]

Presentation type: Oral Presentation

H14-10: Substrate layering and climate control water table configurations in sub-humid Boreal Plain landscapes

KJ Hokanson[1], KJ Devito[1], CA Mendoza[2]

[1] Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada. T6G 2R3, Phone: 780.492.9936, E-mail: hokanson@ualberta.ca
[2] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB, Canada T6G 2E3

Abstract
The Boreal Plain (BP) region of Canada, a landscape characterized by low-relief, a sub-humid climate and heterogeneous glacial landforms, is experiencing unprecedented anthropogenic and natural disturbance, including open-pit oil sands mining. Understanding the controls on water table position and predicting changes in water table positions under varying physical and climatic scenarios will become even more important as constructed and reclaimed landscapes become more prevalent following open-pit mining. The BP is composed of a mosaic of forestland, wetland, and aquatic land covers (Hydrologic Units) that contrast in dominant vegetation cover, ET, and soil storage that, in turn, influence water table configurations. Additionally, these Hydrologic Units overlie heterogeneous glacial landforms with large contrasts in storage and hydraulic properties which, when coupled with wet-dry climate cycles, result in complex water table distributions in time and space. Several forestland-wetland-pond complexes were selected at the Utikuma Research Study Area (URSA) over three distinct geologic terrains to explore the roles of local relief and substrate layers on the distribution of Hydrologic Units and water table configurations. In the absence of larger ground water flow systems, local relief and shallow low conductivity substrates allow for the formation of near surface water tables and wetlands, regardless of topography. Furthermore, wet and dry climate conditions can result in appreciably different water table configurations over time, ranging from mounds to hydraulic depressions, depending on the arrangement of Hydrologic Units, dominant geology, and substrate layering.

[234 words]

Presentation type: Oral Presentation

H14-11: Heat as a hydrogeologic tracer in heterogeneous terrestrial and coastal environments

Barret Kurylyk[1], Sean Carey[1], Dylan Irvine[2], Martin Briggs[3], Mariah Bonham[2]

[1]School of Geography and Earth Sciences, McMaster University, Hamilton, Canada, Phone: (905) 525-9140 ext. 26311; Email: kurylykb@mcmaster.ca,
[2]School of the Environment and National Centre for Groundwater Research and Training, Flinders University, Adelaide, Australia
[3]U.S. Geological Survey, Office of Groundwater, Branch of Geophysics, Storrs, USA

Abstract:
A number of analytical approaches have been proposed for using heat as a hydrogeologic tracer in terrestrial, coastal, and marine environments. These analytical techniques have typically invoked the assumption of homogeneous thermal properties; however, heterogeneous thermal properties are ubiquitous in subsurface environments, both at the scale of geologic strata as well as at finer (cm) scales in streambeds. Herein, we demonstrate how an analytical solution, previously developed for determining vadose zone fluxes, can also be applied to estimate water fluxes in layered, saturated subsurface environments. The solution allows for *n*-layers with each layer characterized by a distinct thermal conductivity. One primary limitation of the solution is that it assumes temperature profiles are at steady-state. This condition may be violated in streambeds due to diurnal surface temperature change or in deeper (borehole) temperature profiles due to multi-decadal climate change and inter-borehole flow. However, upward groundwater flow strongly reduces the downward propagation of complicating surface signals, as does ice cover, and the effects of climatic shifts on near-surface borehole temperatures can be readily identified. The application of the solution for studying groundwater-surface water interactions is demonstrated using temperature data collected from a streambed in a coastal river with an abrupt change in thermal properties at the interface between layers of sand and organic soil. Also, a deeper subsurface temperature profile recorded in a layered environment along the coast in southern Australia is analyzed to estimate deeper vertical water fluxes. A simple spreadsheet tool is presented to allow users to enter data from shallow or deep temperature-depth profiles and run the solution to infer vertical flows. Potential applications of this spreadsheet tool in marine environments will be discussed.

Presentation type: Oral Presentation

H14-12: Monitoring Moisture in Waste Rock with Fiber Optic Distributed Temperature Sensing

Robert Wu[1*], Jeffrey McKenzie[1], Bruno Bussière[2], Michel Aubertin[3], Vincent Martin[3], and Stefan Broda[4]

[1] Department of Earth and Planetary Sciences, McGill University, Montreal, QC, H3A 0E8, Phone: 514-398-6767, E-mail: qiong.r.wu@mail.mcgill.ca
[2] Research Institute on Mines and the Environment, Université du Québec en Abitibi-Témiscamingue, Rouyn-Noranda, QC, J9X 5E4
[3] Research Institute on Mines and the Environment, Ecole Polytechnique Montreal, Montreal, QC, H3C 3A7
[4] Bundesanstalt für Geowissenschaften und Rohstoffe, Berlin, Germany

Abstract
A major challenge in mine-site reclamation is the long-term environmental management of waste rock piles. Waste rock piles consist of heterogeneous and coarse-grained material, and their design influences the internal movement of water and vapour, which may promote the production of contaminated drainage. New designs for waste rock piles have been developed to incorporate inclined fine-grained layers. Numerical simulations show that this improved design creates a capillary barrier effect which directs water away from the pile interior. We will present results using fiber optic distributed temperature sensing (FO-DTS) that is, for the first time, used to observe the internal hydrology water through waste rock. Recent FO-DTS advances have shown that soil moisture conditions can be monitored using heating pulses from fiber optic cables. Results will be presented from two experimental systems: 1) The experimental waste rock pile, which is 60 m long, 32 m wide, and covered with 25 cm of non-reactive crushed waste rock and 75 cm of sand. Within the pile, 500 m of fiber optic cable is laid in a grid pattern in three levels within the pile. 2) A laboratory waste rock column 80 cm in diameter and made of 45 cm of non-reactive crushed waste rock overlain by 30 cm of sand. Fiber optic cable is wrapped in a helical pattern within the column. The FO-DTS system has a spatial resolution of 0.5 m, a temporal resolution of 20 seconds, and resolves soil moisture once every hour in a day. Preliminary results from the study show that a layered cover with capillary barrier effects can limit water infiltration, and that the FO-DTS provides unique data as to the geospatial distribution of moisture. This study will ultimately help design guidelines for compacted covers, leading to an improved environmental response in waste rock piles. [297 words]

Presentation type: Oral Presentation

P01-H14: A new solute transport model for large scale cold region catchments: A theoretical :framework

Luis Morales-Marín[1], Howard Wheater, Karl Lindenschmidt, Fuad Yassin

Global Institute for Water Security (GIWS), University of Saskatchewan, National Hydrology Research Centre, Saskatoon, SK S7N 3H5.

Abstract

Many distributed watershed water quality models (e.g. SWAT, HSPF, AnnGNPS, INCA) have been developed to simulate the overland and in-stream erosion and transport of solutes. These models have in common that they require large amounts of input data information and, because of their large number of parameters, calibration is time consuming requiring considerable computational resources limiting their application to small basin and experimental plots. Moreover, the models' complex structure and the non-linearity of the included biochemistry processes increase the level of model uncertainty. In cold regions, current community models have seldom been implemented at large scales because these models do not reproduce correctly most of the processes associated with snow and frozen soil. For example, snowmelt runoff and its effects on sediment erosion and transport is poorly represented in most of these community models. Also, the reproduction of freeze-thaw cycles in the soil and its implication on solute mobilization is not considered. A modelling framework of solute transport in large-scale cold region catchment is presented here. The model is couple to the semi-distributed hydrological land surface scheme model MESH developed by Environment Canada that integrates the Canadian Land Surface Scheme (CLASS) model with the hydrological routing model, WATFLOOD, to estimate sediment transport. MESH has been successfully applied to several large-scale catchments to simulate hydrological processes in cold regions. The model is computationally efficient because, it is parallelized and able to run in computer clusters. The theoretical framework presents the methodology to estimated soil detachment, overland transport and transformation and in-stream solute routing associated to cold region hydrological processes. As future work, the model will be implemented in the South Saskatchewan River and will provide information for future water quality management practices and policies.

Contact information:

[1] Email:luis.marin@usask.ca, Phone: 306 966 7243, Fax: 306 966 1193

Presentation type: Poster

P02-H14: Mediating stream baseflow response to climate change: the role of basin storage

J M Buttle[1]

[1] School of the Environment, Trent University, Peterborough, ON, K9L 0G2, Phone: 705 748-1011 x7475, Fax: 705 748-1205, E-mail: jbuttle@trentu.ca

Abstract
Inter-basin differences in streamflow response to observed changes in regional hydroclimatology may reflect variations in basin characteristics that control the retention and release of water inputs. These aspects of storage may mediate a basin's sensitivity to climate change. The hypothesis that temporal trends in stream baseflow exhibit a more muted reaction to changes in precipitation and evapotranspiration for basins with greater storage was tested on the Oak Ridges Moraine in southern Ontario, Canada. Long-term (>20 year) baseflow trends for 19 basins were partly related to corresponding trends in precipitation amount and type and in potential evapotranspiration. Inter-basin differences in storage properties were characterized using physiographic, hydrogeologic and streamflow metrics. The latter included the slope of the basin's flow duration curve and its estimated dynamic storage (Kirchner J, 2009, *Water Resources Research* 45: coi:10.1029/2008WR006912). Baseflow trend magnitude was positively related to a basin's dynamic storage, but was uncorrelated to basin physiographic, hydrogeologic or flow duration curve characteristics. Previous work suggested that smaller dynamic storage was linked to greater damping of temporal variations in water inputs and reduced inter-annual variability in streamflow regime. Dynamic storage was associated with such basin properties as water and wetland coverage as well as variability in aquifer and unsaturated zone thickness in the present study. Storage and release of water inputs to a basin may assist in mediating baseflow response to temporal changes in regional hydroclimatology, and may partly account for inter-basin differences in that response. Such storage characteristics should be considered when forecasting the impacts of climate change on regional streamflow.

Presentation type: Poster

P03-H14: Rainfall Partitioning by the Canopy of a Lone Ponderosa Pine (*Pinus ponderosa*)

Darryl E. Carlyle-Moses[1] and Thomas G. Pypker[2]

[1]Department of Geography and Environmental Studies, Thompson Rivers University, Kamloops, BC, V2C 0C8, Phone: 250-828-5235, E-mail: dcarlyle@tru.ca

[2]Department of Natural Resource Science, Thompson Rivers University, Kamloops, BC, V2C 0C8

Abstract

Rainfall, throughfall and stemflow data associated with 33 events in a semi-arid ecosystem were collected for an individual ponderosa pine (*Pinus ponderosa*) from mid- May through mid-November 2015 in Kamloops, British Columbia (50.67^{o} N, 120.37^{0} W, 549 m a.m.s.l.). The tree height was 3.91 m, while the diameter at breast height and crown projected area were 15.8 cm and 6.13 m^{2}, respectively. Cumulative rainfall depth was 201.5 mm, with events ranging from 0.2 to 52.3 mm. Throughfall was measured with 104 gauges; 13 gauges along each of 8 radial spikes from the tree bole for each cardinal and intermediate directions. Nine gauges were placed beneath the canopy (one adjacent to the bole and one each at relative spacings of 0.125 times the canopy radii) and 4 gauges were placed outside the canopy (at spacings of 0.25 times the distance from the canopy edge to a horizontal distance equal to the tree height). Cumulative throughfall depth beneath the canopy typically increased with increasing distance from the tree bole in a non-linear fashion ranging from a mean of 39.9% of cumulative rainfall at 0.125 times the crown radii to a mean of 92.3% at the canopy edge. Cumulative throughfall outside of the crown also increased with increasing distance from the tree. Stemflow amounted to 2.0 mm or 1.0% of cumulative rainfall on a canopy area basis. The study period funelling ratio was 3.1 with an event maximum of 5.2. The role of event rain depth and meteorological conditions, including rain intensity, wind speed and direction, and associated rain inclination angles, on the spatiotemporal patterns of throughfall within and outside the canopy, as well as their influence on event stemflow and interception loss will be discussed, as will the potential implications of the observed patterns for future hydrological and biogeochemical studies in these ecosystems.

[300 words]

Presentation type: Poster

P04-H14: Stage-discharge rating curve development using an automated salt dilution system on British Columbia's Central Coast

William Floyd [1,2], Maartje Korver[3], Colby Owen[4], James McPhail[4], Ray Brunsting[3]

1 Ministry of Forests, Lands and Natural Resource Operations, Canada
2 Department of Geography, Vancouver Island University, Canada
3 Hakai Institute, Canada
4 Hakai Energy Solutions, Canada
Contact: Bill.Floyd@viu.ca 250-616-3262

Abstract

Stream discharge is a fundamental observation in hydrology, yet it is inherently difficult to measure continuously, especially in remote, steep, mountain streams. In most natural environments, continuous stream discharge is measured indirectly through the use of stage-discharge rating curves, whereby manual stream discharge measurements are taken along the range of stage readings. In watersheds with a freshet centered around snowmelt, the timing of such events are comparably easier to forecast and prepare to be on location to take manual measurements. In watersheds where peak flows are associated with high intensity rain and rain-on-snow events, when streams can peak in hours, being on location to measure discharge can be both unsafe and difficult to time. If access is via boat or aircraft, the probability of being on site to capture the peak flows are likely much lower than the return interval of the targeted event. All of this leads to a high degree of uncertainty in the upper end of rating curves. As a response to these challenges, an automated salt dilution system was designed and installed near the mouth of seven watersheds (2.9 to 12.8 km^2) as part of a study on BC's Central Coast examining the flux of terrestrial materials and nutrients to the ocean. Since the fall of 2014, over 300 stream measurements have been a taken, with complete or near complete rating curves constructed for each watershed. Incomplete mixing of salt during dilution measurements and rapidly changing stage values during high discharge measurements were the greatest sources of uncertainty in the rating curves. These data formed the foundation of a recently submitted paper showing that dissolved organic carbon fluxes from these watersheds are among the highest in the world.

P05-H14: Modelling the hydrology and streamflow of the Mackenzie River Basin

Mohamed Elshamy[1], Alain Pietroniro[2] and Howard S. Wheater[1]

[1] Global Institute for Water Security, University of Saskatchewan, Saskatoon, SK, Canada, Phone: 306 966 7243, Fax: 306 966 1193, Email: mohamed.elshamy@usask.ca
[2] National Hydrology Research Center, Environment and Climate Change Canada, Saskatoon, SK, Canada

Abstract

Accurate simulation of river streamflow is essential for water resources management and climate change impact studies. The Mackenzie River Basin (MRB) is the largest in Canada. It drains an area of about 1.8 Mkm^2 and discharges more than 300 km^3 to the Beaufort Sea in the Arctic each year. This influences the regional as well as global circulation under current climate which can have implications for climate change. Given the large size and hydrological diversity of the basin, ensuring proper simulation of flow at the large scale is extremely challenging. As an example, the Western tributaries of the Mackenzie are relatively steep as they originate from the Canadian Rockies while the Eastern tributaries lie in the prairies with several interconnected shield-lakes and wetlands, all underlain by discontinuous and continuous permafrost. A baseline model for the MRB has been developed using MESH (Modélisation Environmentale Communautaire - Surface and Hydrology) at 0.125° spatial resolution. Using the main-stem of the Mackenzie River itself as a divide, calibration of one large western sub-basin (Liard) and another large eastern sub-basin (Great Bear Lake River) were generalized to cover the whole basin. The Liard was calibrated using streamflow data from 3 gauges on the main river representing the upper catchment, the middle catchment, and the whole catchment. Performance criteria covered low flows, high flows, and volume bias in a pseudo multi-criteria optimization framework. The Great Bear Lake region was calibrated in two stages, first minimizing the volume bias at the basin outlet and then optimizing the lake outflow parameters for 3 interconnected lakes. Large lakes proved to play an important role shaping streamflow hydrographs and require special attention during calibration. Overall, the MRB model reproduces streamflows at many points on the main river and its tributaries reasonably well and thus can be used to investigate scenarios of change as well as to assess the vulnerability to climate change and the sensitivity to forcing datasets. This work highlights the need for rational and meaningful examination of the hydrological diversity in any calibration strategy.

Presentation type: Poster