**Fill out the registration form and send or e-mail to:**

McGill University
Earth and Planetary Sciences
Attn: Jeffrey McKenzie
3450 University St, Rm 238
Montreal, Quebec H3A 2A7
jeffrey.mckenzie@mcgill.ca

Registration for

# Cold Regions Groundwater Modelling Workshop

Surname _____

First Name _____

Institution _____

Address _____

City and Postal code _____

Country _____

E-mail _____

Telephone _____

Reason for Attending: _____

_____

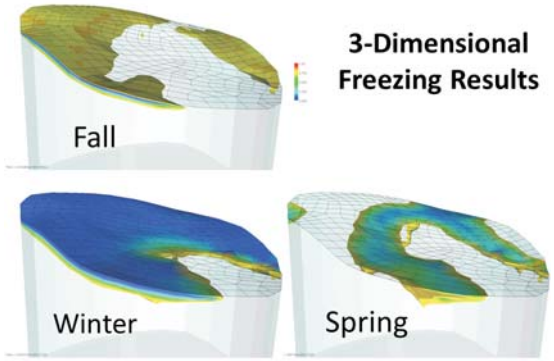
## Course fee and registration

- Registration received by 16 September 2011 – CDN$ 500
- Registration received after 16 September 2011 – CDN$ 600

The fee covers instruction and course notes. Accommodation and meals are not covered. Participants will receive a CD with step-by-step class examples, as well as a notebook containing all lectures and examples. ArgusONE, the preprocessor engine, is a commercial product that must be purchased (http://www.argusint.com/Prices.html, GIS+QUAD package) for participant use in model setup after the workshop.

Payment in full must be received with the registration form. The fee may be paid by check made out to *Earth and Planetary Science, McGill University*. Other payment methods are available. In case of participant cancellation, the fee is not refunded. Enrollment is limited so register early. In the unlikely case the course is cancelled, the fee will be fully refunded.

Invoice provided upon requiest.



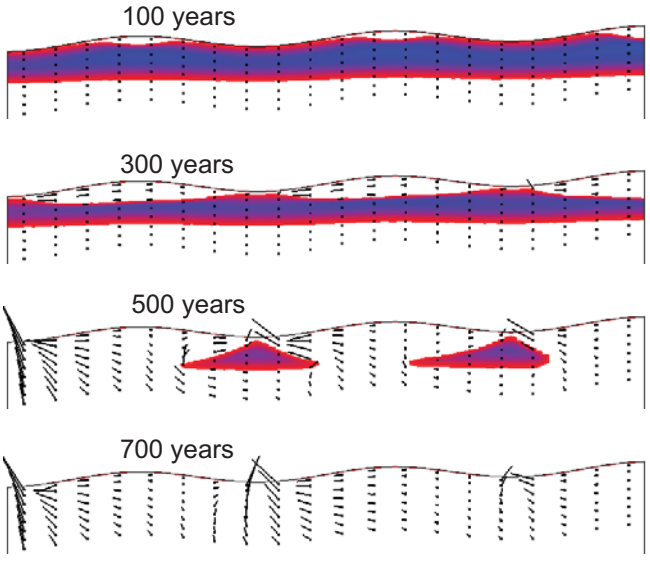

# Groundwater Modelling Workshop

## Simulation of groundwater flow with freeze and thaw

## November 7 - 11, 2011

McGill University
Earth and Planetary Sciences

**DEADLINE FOR REGISTRATION IS OCTOBER 17, 2011**



# Cold Regions Groundwater Modelling Workshop

## Simulation of groundwater flow with freeze and thaw
## 7 - 11 November 2011

Cold-regions hydrologic systems are undergoing rapid changes, as observed by increased carbon export, increases in arctic river discharge, and disappearance of arctic lakes. The state of arctic hydrologic systems is strongly influenced by both seasonal ground ice and perennially frozen ground (permafrost), both of which act as impermeable subsurface layers. However, the distribution of ground ice is being altered by global warming and this, in turn, is impacting cold-regions hydrology. Until recently, predictive models of permafrost thaw and distribution considered only heat conduction, and did not incorporate transport of heat advection (movement of heat due to groundwater flow). The few existing groundwater models of systems containing subsurface ice assumed static ground-ice patterns that did not change as a result of groundwater flow. In fact, where groundwater flows through a permeable subsurface, heat advection often dominates heat conduction. Thus, groundwater flow and its dynamic interaction with ground ice must be considered when predicting future timing and type of changes in surficial hydrology, chemistry, morphology, and ecology of earth's cold regions. This workshop focuses on simulation of cold-regions groundwater systems using a computer simulation code that incorporates not only heat conduction, but also heat advection, with dynamic freezing of groundwater and thawing of ground ice.

Workshop participants will learn to set up, run, and interpret a highly-configurable variable-density groundwater flow and solute/energy transport simulator (U.S. Geological Survey's SUTRA code http://water.usgs.gov/nrp/gwsoftware/sutra.html) in a new not-yet-publicly-released version that incorporates the dynamic freeze-thaw process. Simulations will be set up using a powerful graphical interface (SutraGUI based on ArgusONE™ http://www.argusint.com/) and post-processing will be done with SutraSuite post-processing software. In daily lectures and computer exercises, participants will learn to model groundwater flow and solute/heat transport problems, for constant and variable density systems, with freezing and thawing in saturated and unsaturated zones. Laboratories involve graphical generation of the model structure and graphical post-processing of simulation results in 2D and 3D.

### Who should attend
Anyone with an interest in using groundwater models to solve practical or theoretical hydrology problems involving freeze/thaw. Participants may be consultants, hydrologists, hydrogeologists, engineers, faculty and students; staff from governments, consultancies, and universities are welcome. This is not an introductory-level groundwater modeling course, so some experience in the application of numerical models to study groundwater problems is recommended.

### Course leaders
**Dr. Clifford Voss** (U.S. Geological Survey - USGS) and **Dr. Jeffrey McKenzie** (McGill University) are the instructors. Cliff has lead a hydrogeologic research project concerning transport phenomena and numerical modeling for 30 years and he is the Editor of Hydrogeology Journal. One current focus is on cold-regions hydrology and impacts of warming climate on permafrost regions. Jeff is a Professor in Earth and Planetary Sciences and one of his interests since 2005 has been in developing numerical models that incorporate freeze-thaw processes within a groundwater modeling framework.

### Course Topics
- Groundwater flow and solute/energy transport concepts and governing equations.
- Variable-density groundwater flow concepts and phenomena.
- Concepts, simplifying assumptions, and governing equations for freezing and thawing of groundwater in the saturated and unsaturated zone.
- Model creation: Conceptual modelling, parsimony, calibration, prediction and sensitivity analyses.
- Setting up energy transport models with freeze/thaw: boundary conditions, freeze functions.
- Approaches to practical and successful modeling studies.
- Use of GIS (Geographic Information Systems) data when building a model.
- Modelling methodology and numerical approximations.
- 2D and 3D cold-regions and variable-density groundwater flow simulation exercises on classroom computers.

### After the workshop
Participants will be able to apply principles of groundwater flow, energy transport and freezing/thawing for modeling evaluation of hydrologic systems containing ground ice. The participant will be able to apply the SUTRA code and SutraSuite pre- and post-processors for practical simulation analysis of freeze/thaw and other types of flow and energy or solute transport problems. The instructors and US Geological Survey (USGS) SUTRA support persons will help participants to use the code after the workshop.

Note: The freeze/thaw version of SUTRA has not yet been publicly released by USGS; release is expected by the end of 2012 and use of the code will be free of charge. Participants who wish to work with the code before that time can become official USGS 'beta testers' who agree to provide feedback to the code developers and to publish results only after USGS publicly releases the code, unless a USGS employee who supported the work is a co-author.

### Course location
The course will be held in the Department of Earth and Planetary Sciences at McGill University in Montreal, Canada (http://eps.mcgill.ca/). Computers with software and needed data pre-loaded will be provided to participants in the classroom. McGill University is in central Montreal. The university can be easily reached by bus and metro.

### For more information
For more information please contact:
Jeffrey McKenzie (jeffrey.mckenzie@mcgill.ca)

### Hotel
Accommodations have to be booked by the participants themselves. McGill University has arrangements with numerous downtown hotels for discounted rates (http://www.mcgill.ca/travelservices/hotelprogram/listing/). Some participants will be staying at the Château Versailles.

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