Elements

Volume 30, Number 2 July 2012

THE NEWSLETTER OF THE CANADIAN GEOPHYSICAL UNION

IN THIS ISSUE

LE BULLETIN DE L'UNION GÉOPHYSIQUE CANADIENNE

President's Column

Greetings, fellow CGU Members.

We had a very successful joint meeting in Banff June 5 to 8 with the Canadian Water Resources Association, with more than 550 delegates in attendance. Feedback from delegates on both the program and venue was highly positive, despite an uncharacteristically wet week that featured flooding of the Bow River. CGU sections have been active over the year, providing opportunities for workshops, student conferences, and student poster and presentation prizes at the annual CGU meeting. Thanks to successful meetings and loyal members, CGU is in a sound financial position.

CGU has decided to take the important step of engaging an Executive Director, on a part time basis, as of this fall. The CGU executive director will implement policies set by the Board of Directors, to help take CGU to the next level in terms of membership and scope of activities. The executive director will be an outgoing individual who is passionate about the mission of CGU, and has the needed leadership, management and organizational skills to ensure effective union operations and increase our member and financial base. If you know someone who would excel in this position, please invite them to visit our website where further information will be posted. An ad on this position appears in this issue of *ELEMENTS* as well.

Future meetings include 2013 in Saskatoon with CMOS and CWRA, 2014 in Banff, 2015 with AGU in Montreal, and 2016 with CMOS in Fredericton.

I wish you all an enjoyable summer, and hope to see you next May 30 - June 5 at our 2013 meeting in Paris on the Prairies.

Gail Atkinson

J. Tuzo Wilson Medal – Call for Nominations

The Executive of the CGU solicits nominations for the J. Tuzo Wilson Medal – 2013. The Union makes this award annually to recognize outstanding contributions to Canadian geophysics. Factors taken into account in the selection process include excellence in scientific and/or technological research, instrument development, industrial applications and/or teaching.

If you would like to nominate a candidate, please contact Dr. Cherie J. Westbrook, Chair of the CGU Awards Committee, University of Saskatchewan (Email: cherie.westbrook@usask.ca). At a minimum, the nomination should be supported by letters of recommendation from colleagues, a brief biographical sketch and a Curriculum Vitae. Nominations should be submitted by January 31, 2013. Additional details concerning the nomination process can be obtained from the Chair of the CGU Awards Committee.

L'exécutif de l'UGC vous invite à suggérer des candidats pour la médaille J. Tuzo Wilson – 2013. L'Union décerne la médaille chaque année "en reconnaissance d'une contribution remarquable à la géophysique canadienne". En choisissant parmi les candidats, on considére les accomplissements en recherches scientifique ou technologiques, aux développements d'instruments, aux applications industrielles et/ou à l'enseignement.

Si vous désirez suggérer un candidat pour cette médaille, s.v.p. contacter Dr. Cherie J. Westbrook, Président du Comité des Prix d'Excellence, Université de la Saskatchewan (Email: cherie.westbrook@usask.ca). Les nominations doivent être supportées de lettres de recommandation de collègues, d'un bref sommaire biographique et d'un Curriculum Vitae. Les nominations doivent être soumises avant le 31 janvier, 2013. Des détails additionnels concernant le processus de nomination peuvent être obtenus en communiquant avec le Président du Comité des Prix d'Excellence de l'UGC.

Past Wilson Medallists

1978	J. Tuzo Wilson
1979	Roy O. Lindseth
1980	Larry W. Morley
1981	George D. Garland
1982	Jack A. Jacobs
1983	D. Ian Gough
1984	Ted Irving
1985	Harold O. Seigel
1986	Michael Rochester
1987	David Strangway
1988	Ernie Kanasewich
1989	Leonard S. Collett
1990	Gordon F. West
1991	Thomas Krogh
1992	R. Don Russell
1993	Alan E. Beck
1994	Michael J. Berry
1995	Charlotte Keen
1996	Petr Vaníček
1997	Chris Beaumont
1998	Ron M. Clowes
1999	David Dunlop
2000	Don Gray
2001	Roy Hyndman
2002	Doug Smylie
2003	Garry K.C. Clarke
2004	W.R. (Dick) Peltier
2005	Ted Evans
2006	Alan Jones
2007	Herb Dragert
2008	Ming-ko (Hok) Woo
2009	Garth van der Kamp
2010	Nigel Edwards
2011	Fred Cook
2012	Doug Oldenburg

CGU Young Scientist Award – Call for Nominations

The Executive of the CGU solicits nominations for the CGU Young Scientist Award – 2013. The CGU Young Scientist Awards recognize outstanding research contributions by young scientists who are members of the CGU. Both the quality and impact of research are considered. To be eligible for the award, the recipient must be within 10 years of obtaining their first Ph.D. or equivalent degree. The awards are made by the CGU Executive on the recommendations of a special committee struck for this purpose. The selection committee seeks formal written nominations from the membership, plus letters of support and a current curriculum vitae. Nominations for the CGU Young Scientist Awards may be submitted by CGU members at any time.

If you would like to nominate a candidate, please contact Dr. Cherie J. Westbrook, Chair of the CGU Awards Committee, University of Saskatchewan (Email: cherie.westbrook@usask.ca). The nomination should be supported by three letters of recommendation from colleagues. Nominations should be submitted by January 31, 2013. Additional details concerning the nomination process can be obtained from the Chair of the CGU Awards Committee.

L'exécutif de l'UGC vous invite à suggérer des candidats pour le prix pour Jeune Scientifique de l'UGC – 2013. Les Prix pour Jeunes Scientifiques de l'UGC reconnaissent les contributions exceptionnelles de jeunes scientifiques qui sont membres de l'UGC. La qualité et l'impact de la recherche sont considérés. Pour être éligible pour le prix, le scientifique doit avoir obtenu son premier Ph.D. ou degré équivalent au cours des dix dernières années. Les prix sont accordés par l'Exécutif de l'UGC sur recommendations d'un comité spécial à cette fin. Le comité de sélection sollicite des nominations formelles par écrit des membres de l'UGC, accompagnées de lettres d'appui et d'un curriculum vitae à jour. Des nominations pour les Prix pour Jeunes Scientifiques de l'UGC peuvent être soumis en tout temps par les membres de l'UGC.

Si vous désirez suggérer un candidat pour cette médaille, s.v.p. contacter Dr. Cherie J. Westbrook, Président du Comité des Prix d'Excellence, Université de la Saskatchewan (Email: cherie.westbrook@usask.ca). Les nominations doivent être supportées de trois lettres de recommandation de collègues. Les nominations doivent être soumises avant le 31 janvier, 2013. Des détails additionnels concernant le processus de nomination peuvent être obtenus en communiquant avec le Président du Comité des Prix d'Excellence de l'UGC.

Past Winners

2005	Shawn J. Marshall, J. Michael Waddington
2006	No winner
2007	No winner
2008	Brian Branfireun, Scott Lamoureux
2009	Gwenn Flowers, Stephane Mazzotti
2010	Sean Carey
2011	Michael Riedel
2012	Brian Menounos

CGU Meritorious Service Award – Call for Nominations

The Executive of the CGU solicits nominations for the CGU Meritorious Service Award – 2013. The CGU Meritorious Service Award recognizes extraordinary and unselfish contributions to the operation and management of the Canadian Geophysical Union by a member of the CGU. All members of the CGU are eligible for this award, although the award is not normally given to someone who has received another major award (e.g. the J. Tuzo Wilson Medal). Nominations for the CGU Meritorious Service Award may be submitted by CGU members at any time. The award is made by the CGU Executive based on recommendations from the CGU Awards Committee, and is based on lifetime contributions to CGU activities.

If you would like to nominate a candidate, please contact Dr. Cherie J. Westbrook, Chair of the CGU Awards Committee, University of Saskatchewan (Email: cherie.westbrook@usask.ca). The nomination should be supported by three letters of recommendation from colleagues. Nominations should be submitted by January 31, 2013. Additional details concerning the nomination process can be obtained from the Chair of the CGU Awards Committee.

L'exécutif de l'UGC vous invite à suggérer des candidats pour le Prix pour Service Méritoire de l'UGC – 2013. Le Prix pour Service Méritoire de l'UGC reconnait les contributions extraordinaires et désintéressées à l'opération et à l'administration de l'Union Géophysique Canadienne par un membre de l'UGC. Tous les membres de l'UGC sont éligibles pour ce prix, sauf que normalement, ce prix n'est pas donné à quelqu'un qui a recu un autre prix important tel que la Médaille Tuzo Wilson. Des nominations pour le Prix pour Service Méritoire de l'UGC peuvent être soumises en tout temps par les membres de l'UGC. Le Prix est accordé par l'Exécutif de l'UGC sur recommendations du Comité des Prix de l'UGC, pour l'ensemble des contributions d'un membre aux activités de l'UGC.

Si vous désirez suggérer un candidat pour cette médaille, s.v.p. contacter Dr. Cherie J. Westbrook, Président du Comité des Prix d'Excellence, Université de la Saskatchewan (Email: cherie.westbrook@usask.ca). Les nominations doivent être supportées de trois lettres de recommandation de collègues. Les nominations doivent être soumises avant le 31 janvier, 2013. Des détails additionnels concernant le processus de nomination peuvent être obtenus en communiquant avec le Président du Comité des Prix d'Excellence de l'UGC.

Past Winners

2004	Ron Kurtz
2005	Ted Glenn
2006	J.A. Rod Blais
2007	Ed Krebes
2008	Patrick Wu
2009	Garry Jarvis
2010	Zoli Hajnal
2011	Masaki Hayashi
2012	Kathy Young

The 2012 CGU J. Tuzo Wilson Medallist: Douglas Oldenburg

Citation, by Rebekka Steffen, University of Calgary

I was actually not supposed to stand here and hold the citation for the J. Tuzo Wilson Award, but I didn't hesitate when I was asked to hold it on behalf of his former students and post-docs: Laurens Beran, Stephen Billings, Colin Farquharson, and Yaoguo Li. But I'm not totally wrong here, because half year ago I sent an email to these 4 guys suggesting to nominate our medalist. And many of you can imagine now that it is a great pleasure for me and also an incredible honour to introduce this year's medalist.

During my studies in Europe and Canada, I became well aware of one name – Oldenburg. This name stands for inversion methodologies in geophysics all over the world. The name does not refer to a city in northern Germany; it refers to a person, a man, a professor at UBC in Vancouver. It is Doug Oldenburg, who started his fascinating career in the 60s. Doug did his B.Sc. Honours in Physics at the University of Alberta. In his fourth year, Doug took a geophysics course from Ernie Kanasewich, and was sufficiently intrigued that he worked with Ernie the following summer recording seismic signals in northern Alberta from explosive sources set off in the Great Lakes. Ernie subsequently introduced Doug to Ian Gough, with whom he did his M.Sc. This was the starting point of Doug's enduring interest in electromagnetic geophysical methods. Doug spent a summer with Ian and others taking Geomagnetic Depth Sounding measurements over an array spread throughout the north-western United States and south-western Canada. This is the survey that first revealed the North American Central Plains anomaly, which has since been extensively studied and is thought to be due to a crustal conductor created by one of the continent-arc collisions that formed the continent of North America. At the suggestion of Ian Gough, Doug then moved to the Institute of Geophysics and Planetary Physics at the University of California San Diego to do his Ph.D. Doug was supervised by Bob Parker, and worked on the mathematics of a thermal model for the creation of lithospheric plates at mid-ocean ridges. This was at a time when sea-floor spreading and the theory of plate tectonics was all very new. At Scripps, he also met two more famous Geoscientists: George Backus and Freeman Gilbert. After his Ph.D., Doug returned to the University of Alberta as a Killam Post-Doctoral Fellow for three years. It was during this time that Doug started to apply the ideas of inversion theory that had been formulated at UCSD during his time there to geophysical exploration methods. Doug then moved to the University of British Columbia where he became an Assistant Professor in the Department of Geophysics and Astronomy. Doug has been a professor at UBC since 1987 and now holds the Teck Senior Keevil Chair in Mineral Exploration.

Doug's publication record is substantial. He has published well over a hundred papers, with the majority appearing in the main international journals. Even more impressive, and an indication of the impact that his publications have had, is the number of citations that many of Doug's papers have received. He has an h-factor of 39. Doug has received many awards during his career, the most recent before tonight being the Society of Exploration Geophysicists Distinguished Lecturer for 2011.

Doug, with his graduate students and post-docs, has produced what amounts to the industry standards in inversion software. In particular, at UBC they have developed both the science and the software for 2-D and 3-D inversion of direct-current resistivity and induced polarization data, 3-D inversion of gravity and magnetic data, and 1-D and 3-D inversion of natural-source and controlled-source electromagnetic data. The techniques and the software that Doug's group have produced can definitely be considered to have "improved the general well-being" of the geophysical mineral exploration industry. It is clear that the methodology and especially the software that Doug, his students and his post-docs have produced has enabled many researchers to perform sophisticated and yet practical inversions of their gravity, magnetic, resistivity or electromagnetic data, thus facilitating the construction of quantitative Earth models with which to interpret their data.

Most importantly, we would like to address the personal, human impact of Doug's work. To date, Doug has supervised and mentored 44 graduate students (26 Ph.D. and 18 M.Sc.) and over a dozen Post-Doctoral Fellows. Six of Doug's Ph.D. students are now faculty members at Canadian, American and Australian universities. An appropriate although insufficient term to summarize Doug as a supervisor and mentor is "class act". He is amazingly generous with his time, ever patient to help a student through any difficulties in understanding that they may be having, or to instill in them badly needed enthusiasm and confidence to carry them through their work when their own is flagging.

Finally, we would also like to cite some comments from the numerous reference letters we have received:

"Doug is one of the most intuitive and innovative numerical mathematicians." (Alan Jones)

"Doug is one of the top five geophysicists in Canada and clearly first in his field." (Nigel Edwards)

"Doug is the most innovative researcher worldwide in electromagnetic and other geophysics as applied to the exploration environment. His research is founded on the basic tenet of fast, robust and flexible inversion algorithms with an underlying principle of applicability to real exploration problems and transfer of the new technology for use by industry." (Ron Clowes)

"At the University of British Columbia in Vancouver he formed the UBC Geophysical Inversion Facility, which is widely accepted as THE leading institution for geophysical inversions." (Hansruedi Maurer)

"Doug's work has always been innovative and impressively consequent over decades." (Klaus Spitzer)

"He has made fundamental contributions in geoscience, which in turn provide a strong multiplier effect on the resource industry and economy, and which have fostered a new generation of geoscientists with state of the art capabilities to bring the field forward." (Philip Wannamaker)

"Doug Oldenburg has made an outstanding contribution to Canadian geophysics over the last four plus decades. His work has formed an important contribution to the present state of geophysics in Canada, it has played a vital part in our present understanding of inverse theory, it has been important for electromagnetic geophysics, and it has played an important part in the widespread use of inversion programs and their integration in mineral exploration programs." (Ian Ferguson)

"His sense of humor helps in resolving issues when other things seem to fail." (Eldad Haber)

"Throughout his career, Doug has proudly proclaimed his "Canadian" status, resisting any temptation to be known as a "North American", or to court a direct US relationship for professional advantage. This makes him even more worthy of recognition by the Canadian Geophysical Union!" (Richard Lane)

I would like to add only two more sentences: I am impressed by Doug and his research he has been done in the past decades and is still doing. To say it in the words of the young generation: what you did is really awesome.

Congratulations, Doug, for receiving the 2012 CGU J. Tuzo Wilson Medal.

Rebekka Steffen, Laurens Beran, Stephen Billings, Colin Farquharson, and Yaoguo Li

Acceptance, by Doug Oldenburg, University of British Columbia

Thank you for those kind words. The CGU is a premier group for geophysical research in Canada and it is an honor to be selected as a recipient of the Tuzo Wilson Medal. The previous recipients of this award include the intellectual giants in Canadian geophysics and people who have pioneered the trajectory for geophysical research and application. To be included with that esteemed group is truly an honor.

No award comes without the work of many people. I would like to thank those who were responsible for nominating me and also my academic and industrial colleagues who have written letters on my behalf, and the CGU awards committee for selecting me. Please accept my gratitude.

Although I started my geophysical career investigating aspects of plate tectonics, the majority of my research has been devoted to working in applied geophysics. This has been motivated by the fact that, as we develop as a society, we are faced with an increased suite of challenges that must be overcome so that we can live sustainably on this planet. The challenges fall into a number of areas. Firstly, there is the need for resources. This includes hydrocarbons and alternative energy sources to power our existing society, minerals for our technology, and ample supplies of clean water to sustain life. We are faced with natural hazards such earthquakes, volcanoes, landslides, and tsunamis. We have geotechnical needs to build highways and tunnels through different geologic terraines. We have environmental challenges. As a society we have been guilty of putting contaminants into our environment and these now need to be located and cleaned up. Lastly we have storage challenges such as removing CO_2 from the atmosphere and storing it underground, storing water in times of plenty and recovering it when needed, or dealing with materials such as mine tailings, industrial contaminants, and radioactive materials which need to be prevented from interacting with our habitable environment. These problems are important and difficult to address. Their solution involves multidisciplinary teams bringing many pieces of information together but for each problem there is a common theme. We need to have information about the subsurface without directly sampling. Thus, almost by definition, geophysics must play an important, if not essential, role.

Over the last few decades great strides have been made in three areas: instrumentation to collect higher quality geophysical data, advances in the mathematics and computational aspects of inverse theory and optimization, and advances in computing hardware. This has allowed us to solve problems that were not possible even a decade ago. The progress that has been made by my group at UBC, and others worldwide, reflects the continual development in these three areas. At the early stages of my career the most challenging problems that could be tackled required an assumption that the earth structure was one-dimensional and values for a few tens of parameters were sought. Although these solutions sometimes added valuable geologic insight, in many cases the interpretations failed or were grossly misleading. Inversions in 2D greatly increased the range of problems for which geophysics could be useful but it wasn't until we were able to work fully in 3D that geologic structure was responsibly imaged. My career, and those of the excellent cadre of young scientists with whom I have had the good fortune to work, have followed a trajectory where we chose the most difficult, but doable, 3D problem that we could solve with the available computing power. Thus we started by inverting potential field data from gravity and magnetic surveys, proceeded to DC resistivity and IP data, and then to frequency and time domain electromagnetic data. The techniques and software that we developed were applicable to a range of problems but the principal reason for our success resulted from our close association with the mining industry. The mining industry has been extra-ordinarily supportive of our research. They have provided funding, field data sets, essential information needed to carry out inversions and, most importantly, the research problems, which, if solved, would be useful in practice. A core suite of companies has sponsored us continually from 1990 through to the present. That support, and the twenty years of stability that it has provided for my research program, is unparalleled. I am exceedingly grateful to the mining industry and to their geophysicists who have been instrumental in guiding the research program and in using our software to validate the effectiveness of formal inversion of geophysical data.

I regard the Tuzo Wilson Medal as a “life-time achievement” award. No successful journey can exist without the assistance from many individuals, and for me, two were very important. The first was Ian Gough, a premier Canadian geophysicist, who inspired me to begin graduate research in geophysics and who introduced me to the field of geomagnetic depth sounding and electromagnetic induction using natural sources. Ian also arranged for me to attend Scripps Institution of Oceanography where I met the second influential person, Bob Parker. It was through Bob that I was introduced to the new field of geophysical inverse theory. It was marvelous because it provided a direct path by which questions about the earth could quantitatively answered. Moreover, the methodology was generic and could be applied in all fields of science and used to answer different questions. I owe an enormous debt of gratitude to both of these people.

Most importantly however I want to thank all of my former and present students, researchers and colleagues. I have been blessed to have worked with an exceptional group of scientists and it is their combined efforts that have led to any successes attributed to me.

In closing I would like to make some comments about the future. I believe this is an exciting time for geophysics. We have crossed a critical threshold in which we can solve 3D inversion problems with considerable geologic complexity. The inversion methodologies and software we are developing are applicable to many problems with different physical scales and different objectives. Thus the geophysicist, with computational skills in forward modelling and inversion, and an ability to formulate the question into one that can be answered through quantitative analysis, has the potential to be a key component in any team effort that is tasked with solving an applied problem. I hope that the work of myself and my group can further contribute to this effort. Thank you.

Doug Oldenburg (left), 2012 CGU J. Tuzo Wilson Medallist, and Gail Atkinson, CGU President.

The 2012 CGU Young Scientist Award Winner: Brian Menounos

Citation, by John Clague, Simon Fraser University

Dr. Menounos is a creative and accomplished young scientist who has already made major contributions to Canadian earth science. His research exemplifies the emergence of physical geography as a geophysical science, where great questions are broken down using sharp quantitative tools. He is widely recognized nationally by his peers and is rapidly establishing a stellar international reputation.

Dr. Menounos obtained his BA (Honours) and MSc degrees from the University of Colorado, Boulder. In 2002, he received his PhD from the University of British Columbia (UBC). His early (BA and MSc) research, under the supervision of Nel Caine at the University of Colorado, was on the character and chronology of debris flows in the Colorado Front Range. Brian completed his PhD degree under the tutelage of Dr. Olav Slaymaker on the relations between climate and sediment delivery to alpine lakes in the southern Coast Mountains of British Columbia. Brian has published the results of his MSc and PhD research in papers in high-quality, peer-reviewed, international journals including *Quaternary Research* (two papers), *The Holocene*, *International Association of Hydrologic Sciences*, *Geomorphology* (two papers), *Canadian Journal of Earth Sciences* (two papers), and *Quaternary Science Reviews*.

Since completing his PhD, Dr. Menounos has made important contributions in two principal areas: (1) the chronology and extent of Holocene glaciation in western North America; and (2) the current state and likely future of the cryosphere in British Columbia. Brian has been a key member of a team of researchers who have greatly improved our understanding of glacier fluctuations in western Canada and Washington State over the past 13,000 years. The research team includes Dr. Gerald Osborn (University of Calgary), Dr. Johannes Koch (Brandon University), Dr. Douglas Clark (Western Washington University), Dr. Jon Riedel (U.S. National Park Service), Dr. Thom Davis (Bentley College), Dr. Peter Clark (Oregon State University, Dr. Kevin Scott (U.S. Geological Survey), and Dr. John Clague (Simon Fraser University). Their findings have been reported in ten journal papers in the past eight years. Brian is the lead author of the most important of these papers, a review on Holocene glaciation in western North America, published in *Quaternary Science Reviews* in 2009.

Dr. Menounos was the lead scientist in the successful project, “Western Canada Cryospheric Network” (W2CN), funded by the Canadian Foundation for Climate and Atmospheric Science. Dr. Menounos received over $2.4 million in Canadian government funds to operate the network, the largest research grant awarded to the University of Northern British Columbia. The network included an illustrious group of researchers at several western Canadian and U.S. universities, including, in addition to Dr. Menounos, Drs. Andrew Bush, Garry Clarke, Stephen Dery, Peter Jackson, Shawn Marshall, Dan Moore, Eric Steig, and Roger Wheate. The award was an astounding achievement for an untenured faculty member, only three years into his first academic appointment, as international reviewers of the project have noted. Through this project, Dr. Menounos galvanized the community of glaciologists working in western Canada and pushed the science forward in ways that otherwise would not have happened. Under his leadership, Canadian glaciology made significant progress. Although the project ended in 2010, the network continues to function informally on the synergies created over the four-year span of funding – journal papers continue to be published the research team. Dr. Menounos alone is co-author on at least ten of these papers, with several others in review or in preparation. W2CN also was a vehicle for training graduate and undergraduate students. Dr. Menounos provided high-quality scientific training for nine undergraduate students, ten graduate students, and three postdoctoral fellows during the period the network functioned. In addition, he has co-supervised four graduate students at other Canadian universities.

Over the course of the WC2N project, Dr. Menounos developed considerable expertise in geomatics technologies, including the digital processing of aerial photography and satellite imagery, Digital Terrain Modelling including LiDAR, and GIS software and processes. He is using these tools to both train students and address fundamental questions in geomorphology.

A further measure of Dr. Menounos’ impact is the increasing number of invited presentations that he gives – some 24 presentations since 2000, including nine in the past two years. The invitations have come from the University of Zurich and Columbia University, to name but two. Brian and his colleagues and students are also regular presenters at national and international geoscience meetings, including the American Geophysical Union, Geological Society of America, Canadian Geophysical Union, and Canadian Association of Geographers. Brian is increasingly being sought for interviews from the print and electronic media on topics of public interest. Most recently, in January 2012, he was interviewed by CBC Television on glacier change in western Canada.

Dr. Menounos is recipient of several awards that demonstrate the esteem with which he is held by his peers and employer. They include the J. Ross Mackay Award from the Canadian Geomorphology Research Group (2008) for a significant contribution to geomorphology by a younger Canadian earth scientist and the UNBC Research Excellence Award (2009).

Acceptance, by Brian Menounos, University of Northern British Columbia

I am deeply honored and touched to receive this award. I would like to extend my warm thanks to the CGU awards committee and all of CGU for receiving this distinction. I'd like to also thank those individuals that nominated me for this award.

There is an obvious parallel between achievements of a scientist and progression of science: Both can't progress in isolation. So, although I was chosen to receive this award, it integrates the collective talent of many scientists. Two of those scientists include my academic advisors Nel Caine and Olav Slaymaker, both of whom are outstanding, dynamic geomorphologists that allowed me the academic freedom to study processes that I found interesting. I have and continue to benefit from excellent mentors including John Clague at SFU, Garry Clarke at UBC, and Gerald Osborn from U of Calgary. My students and postdoctoral fellows are my more recent instructors who continue to teach me new things. I also acknowledge the friendships and talent of many collaborators, too many to name. Finally, I am grateful to my partner Kim and my two young sons Nathan and Orrin who continue to teach me that there is more to life than wet, icy environments.

I have been tremendously fortunate to receive funding from the Natural Science and Engineering Research Council of Canada, the Canada Foundation for Innovation, and the Canadian Foundation for Climate and Atmospheric Sciences. I also acknowledge support from the University of Northern British Columbia.

I feel spoiled, not just because of the reward I received but because of the opportunities that I had as a young scientist in Canada. When I started my career as a university professor almost a decade ago, times were still good to work on curiosity-driven science. Productive earth-science professors training students received funds irrespective of whether their science was pure or applied. Much of my research has investigated the response of glaciers to climate change. While some of this research can be rationalized in terms of benefiting society, much of this science has been driven by my own curiosity about the complex behavior of glaciers and sediment transport in mountain environments.

This evening, I worry about young professors in Canada and how they may be able to achieve tenure and promotion given the tremendous reduction of funds available for Canadian geophysicists, earth-scientists, and hydrologists. Canada desperately needs to increase funding for university scientists to pursue the science that they were hired to do. And we as a scientific community should pressure our MPs and our Government to ensure that funds are available to our community regardless of whether our science is pure or applied, good for the economy, or speaks to the mandate of an elected government. Canada and the world will benefit if they let academic and government scientists just do what they are good at.

In conclusion, I thank the CGU and its members for this award, and I hope that young Canadian scientists have the same opportunities that I had. It is up to us as an academic society to ensure that they do.

L to R: Tracy Brennand, Brian Menounos (2012 CGU Young Scientist Awardee), Gail Atkinson (CGU President)

The 2012 CGU Meritorious Service Award Winner: Kathy Young

Citation, by Masaki Hayashi (U. of Calgary) & John Pomeroy (U. of Saskatchewan)

It is our great pleasure to announce that Professor Kathy Lynne Young is the recipient of the 2012 Canadian Geophysical Union Meritorious Service Award. Kathy has been a very active member of the CGU for many years, and has contributed immensely to the organization.

Kathy obtained her undergraduate and Master degrees from the University of Toronto. Her Master research was on the hydrology of late-lying snow banks in Melville Island, supervised by Professor Antoni Lewkowicz. Her doctoral degree was from McMaster University under the supervision of Professor Hok Woo, and her research was on hillslope hydrology carried out on Ellesmere Island. She continues to work in the Arctic Islands since securing a teaching position at York University in 1995 and is heavily committed to advising undergraduates and training graduate students.

Kathy served as the Treasurer of the CGU between June 2007 and June 2010. The CGU had a policy in the early part of this millennium of reducing the size of its (substantial) savings by subsidizing various activities that would promote growth in membership. This was a sound policy for its time that permitted the CGU to expand and broaden its base. However, when Kathy was elected Treasurer in 2007 it was time to change the policy and tighten the accounting as we had substantial annual deficits that would have eventually led to the complete depletion of our savings and restriction of our function as a scientific society. Kathy quickly diagnosed our financial problems and took strong measures to reduce and finally eliminate deficit budgets. This meant not only finding efficiencies and improving the measurement of our finances, but changes to expenditures, fees and organisation of meetings that we had taken for granted. She proposed these changes in the most humane and civilised way possible, so as to preserve our core functions and our relationship with other scientific societies. The current status of the CGU as a healthy, vigorous and fiscally sound scientific society owes much to Kathy's work as a clever, efficient, open and hard-nosed Treasurer.

Kathy is an enthusiastic supporter of the CGU. She encourages her students to participate in the CGU annual scientific meetings and the regional meetings of the Hydrology Section. Being a prominent Arctic hydrology researcher, she plays a very active role in the international research community and promotes the Canadian geophysical sciences internationally. For example, she served as the Canadian Chief Delegate to the Northern Research Basin Symposia/Workshops in 2006-10 and organized a memorable Workshop in 2009 on board a vessel in Eastern Arctic, for delegates of 8 circumpolar nations. Recognized for her contribution to Arctic science, she is made a Fellow of the Arctic Institute of North America.

We are very delighted to present the 2012 Meritorious Service Award to Professor Kathy Young. She is richly deserving of this honour.

Acceptance, by Kathy Young, York University

I am extremely honoured and thrilled to be the recipient of the 2012 Canadian Geophysical Union Meritorious Service Award. I am especially grateful to my nominators Drs. Masaki Hayashi and John Pomeroy for taking the time to write a thoughtful and kind letter on my behalf. I am proud to be a member of the Canadian Geophysical Association and rightly acknowledge that being the Treasurer of this wonderful association was the best service position that I have held in my academic career so far. Everyone in the CGU executive was supportive of my ideas, gave me the room to maneuver and they were always there when I needed advice or clarification to move financial matters along. I am especially grateful to the CGU Association for being patient with some slightly painful financial changes, such as increases in membership and conference fees. These additional funds have allowed the CGU to move back into the “black,” which has ensured it the flexibility to encourage the development of new geophysical sections in the CGU, the continued promotion of student conferences, and has provided the CGU with a strong financial footing on which to plan and execute joint scientific meetings (CMOS, CWRA).

In closing, I am delighted and humbled to be the recipient of the 2012 Canadian Geophysical Union Meritorious Service Award.

2011 Gerhard Herzberg Canada Gold Medal Awarded to W.R. Peltier

CGU member Dick Peltier of the University of Toronto has been awarded the 2011 Gerhard Herzberg Canada Gold Medal for Science and Engineering by the Natural Sciences and Engineering Research Council of Canada (NSERC) for his pioneering research work in Earth Systems Science. The medal is the highest honour awarded by NSERC. The medal comes with a $1 million prize to be used for discovery research over the next five years. Regular participants in the CGU annual meetings around the turn of the century will remember that Dick chaired a number of interesting technical sessions on climate system history and dynamics, a multidisciplinary research project he headed, at these meetings.

HYDROLOGY SECTION NEWS

CGU HYDROLOGY SECTION COMMITTEE REPORTS 2012

Prepared by Daniel Peters

Northern Research Basins Committee

Chair and Canadian Chief Delegate: Christopher Spence, Environment Canada, Saskatoon, SK.

The main activities of the CGU-HS Northern Basins Committee during the last year focused on preparing for the 18th Northern Research Basins Symposium and Workshop in Western Norway, August 15 – 20, 2011. This meeting began in Bergen and involved travel via ship and bus to Loen, Kjenndal, Fjœrland, Sognefiord and Voss. The conference theme was **Methods For Measuring, Collecting and Assimilating Hydrological Information in Cold Climates.** Full details of the meeting and the proceedings can be found at www.18thnrb.com.

As outlined in the NRB Mandate and the Canadian NRB Terms of Reference, Canada can send up to 10 delegates invited by the Canadian Chief Delegate (and approved by the CGU-HS Executive). From an original list of 10 invited delegates, only five were able to attend due to schedule conflicts and conference request denials. These include:

Chris Derksen, Environment Canada: Snow
Richard Janowicz, Yukon Territorial Gov't: Water Management
Dr. Terry Prowse, Environment Canada University of Victoria: Ice
Kathy Young, York University: Permafrost Hydrology
Ming-ko Woo, McMaster University: Permafrost Hydrology

That notwithstanding, the delegates that were able to attend represented the country well. For example, Dr. Terry Prowse of Environment Canada gave a plenary talk on hydrological aspects of Canadian oil sands development.

Finding delegates able to attend the NRB symposia and workshops is becoming increasingly difficult for several reasons. The structure and location of the meetings, with an emphasis on field excursions in northern landscapes, can result in very expensive registration costs. The NRB competes with other workshops and conferences for the attendee dollar, and so must be competitive in terms of cost and scientific rigor. The current invitation process can limit young scientists from attending, which would inject new participants into the working group. The cost limits many people. After some discussion with previous delegates to the NRB, the Committee will recommend to chief delegates from other member countries the following to perhaps make the NRB more appealing and competitive with other workshops.

1) Emphasize the workshop aspect of the NRB; with scientifically relevant and innovative themes.

2) Propose that the host country invite one keynote speaker from each member country; this speaker being a well established senior scientist or a upcoming rising promising scientist.
3) Perhaps integrate a short course component to assist with technology transfer among member countries.

Canada continues to be responsible for the main NRB websites and NRB listserv; maintained through a contract with Laura Brown of the University of Waterloo. These web sites: www.canadiannrb.com and www.northernresearchbasins.com contain information about the working group, the Canada continues to be responsible for the main NRB websites and NRB listserv; maintained through a contract with Laura Brown of the University of Waterloo. These web sites: www.canadiannrb.com and www.northernresearchbasins.com contain information about the working group, the Canadian committee, past meetings, links to relevant websites, numerous photos, and the 18th NRB. These two sites need to be updated to include the results of the 18th NRB. Contact Chris Spence at chris.spence@ec.gc.ca for more information.

Canadian National Committee for the IAHS Prediction in Ungauged Basins Initiative (CNC-PUB)

Chair: Christopher Spence, Environment Canada, Saskatoon, SK S7N 3H5, chris.spence @ec.gc.ca

Vice Chair: Paul Whitfield, Environment Canada, Vancouver, BC V6C 3S5, paul.whitfield@ec.gc.ca

CWRA Members at Large:

Taha Ouarda, Institut national de la recherche scientifique, Québec, QC G1K 9A9 taha_ouarda@ete.inrs.ca

Al Pietroniro, Environment Canada, Saskatoon, SK S7N 3H5 al.pietroniro@ec.gc.ca

CGU-HS Members at Large:

John Pomeroy, Centre for Hydrology, University of Saskatchewan, Saskatoon, SK S7N 5C8 pomeroy@usask.ca (CGU-HS)

Robert Metcalfe, Renewable Energy Section, Ontario Ministry of Natural Resources, Peterborough, ON K9J 7B8 robert.metcalfe@ontario.ca

Objective and Roles:

The objective of CNC-PUB http://www.iahs-pub.org/WG15.php is to coordinate and communicate IAHS's PUB http://www.iahs-pub.org/index.php program in Canada.

The roles of the CNC-PUB are defined as follows:

- Liaising with water resource managers and government agencies in the development of programs supportive of the PUB initiative,
- Supporting PUB working group implementation and funding in Canada,
- Supporting outreach of working group scientific progress,
- Encouraging technology transfer from working groups,
- Reporting to CGU-HS and CSHS on Canadian PUB activities, and,
- Reporting to IAHS on Canadian PUB activities through CNC-IAHS and the PUB SSG.

Progress on Issues and Objectives:

The **Putting PUB into Practice** workshop was held May 10 – 14, 2011. The principal aim of the meeting was to make progress towards a crystallisation of 'state of the art' PUB research, in order to facilitate its encapsulation in tools which contribute directly to the solution of real-world challenges in water resources management. The meeting brought together a broad cross-section of researchers, practitioners and toolset developers with interests in this field. By examining a gradient from data-rich to data-poor contexts, and considering the needs of a range of hydroclimatic regions, the workshop participants shared and consolidated knowledge between and across PUB Themes and Working Groups, and the variety of regional efforts and perspectives represented in the movement. As the PUB decade winds down, it is crucial for the Canadian and international PUB movement to focus on information and technology transfer at meetings such as these. Accordingly, the proceedings will be published as a CWRA monograph in late 2012.

Other technology and information transfer projects include publishing of a special issue of the Canadian Water Resources Journal on the thematic workshop **Zeroflow: A PUB Workshop on Intermittent Streams** held February 23 - 25, 2011 at the Dinosaur Trail Golf and Country Club, Drumheller, Alberta. The organizing committee included Sarah Boon, University of Lethbridge; Emily Huxter, Environment Canada; Daniel Peters, Environment Canada ; Christopher Spence, Environment Canada ; Ilja Tromp-van Meerveld, Simon Fraser University; Paul Whitfield, Environment Canada.

A final special session on PUB was convened at the 2012 joint conference of the Canadian Geophysical Union and Canadian Water Resources Association. Six papers were submitted on a variety of topics that addressed the PUB themes of catchment classification,

The PUB decade ends in 2012 with the Delft Symposium October 23 – 24 in Delft, The Netherlands. The symposium will report on the scientific achievements that were made during the decade and the insights that were gained. Contributions from all Canadian scientists that have worked on PUB efforts are encouraged to attend to share their conclusions and views on the advances made during the decade and regarding the remaining research questions. The symposium has a general part with invited talks providing a summary of the PUB decade, presentations on the Synthesis report and the PUB manual, as well as a visionary session on the future challenges. More information can be found at http://pub.iahs.info/meeting2012/

With the end of the PUB initiative, this joint committee of the Canadian Geophysical Union and the Canadian Water Resources Association should be dissolved. The committee thanks all those involved over the years for their commitment and efforts. The table below summarizes the activities and publications of Canadian PUB.

Summary of Canadian PUB Activities and Publications:

Year	Event	Publication
2004	Prediction in Ungauged Basins: Approaches for Canada's Cold Regions (Yellowknife workshop)	CWRA Monograph
2005	PUB in Mountainous Regions Workshop (Manning Park workshop)	Commentary in CWRJ 31(2)
2007	CGU annual conference session	
2007	CWRA annual conference session	
2007	Low-Flow Prediction in Ungauged Basins (PUB) in Canada (Québec City workshop)	*Canadian Water Resources Journal* 33(2)
2008	Healthy peatlands for healthy watersheds: processes and tools for analysis (2008 CWRA annual conference session)	*Canadian Water Resources Journal* 34(4)
2011	Zeroflow: A PUB Workshop on Intermittent Streams (Drumheller workshop)	*Canadian Water Resources Journal* 37(2)
2011	Putting PUB into Practice (Canmore workshop)	CWRA Monograph (pending)
2012	CWRA/CGU joint annual conference session	

Committee on Isotopic Tracers

Committee Members:

Jean Birks (Chair), Alberta Innovates- Technology Futures, University of Waterloo
Tom Edwards, University of Waterloo
John Gibson, Alberta Innovates- Technology Futures, University of Victoria (Past President IAHS International Commission on Tracers)
Claude Hillaire-Marcel, GEOTOP-UQAM
Bernhard Mayer, University of Calgary
Fred Michel, Carleton University
Tricia Stadnyk, University of Manitoba
Brent Wolfe, Wilfrid Laurier University

Background:

The CGU - HS Committee on Isotopic Tracers was established in 1997 to support and facilitate information exchange between isotope specialists and hydrologists both within Canada and internationally, and to address issues of importance to isotopic investigations including integration within broadly-based hydroscience research programs. Recognizing and supporting promising applications of isotopic tracers, promoting cooperative research, providing information resources, and articulating research and educational needs to government agencies, universities, and the general hydrology community are the fundamental aims of the Committee.

Objectives and Activities:

The long-term objectives of the committee are to:

- promote and advance the understanding and application of isotopic tracer techniques in hydrology and related sciences
- initiate and participate in research and education programs, maintain contact with relevant organizations, report on national and international research activities, information sources, isotope monitoring networks, and databases
- establish working groups and/or subcommittees to assess specific, high-priority topics for research, monitoring and/or development, and
- disseminate current research and important findings to the scientific community via discussion, meetings and conferences, and publications

Progress on Issues and Objectives:

Tracer committee members continue to be active in the promotion and advancement of the understanding and application of isotopic tracer techniques in hydrology and related sciences. Of particular interest are the application of isotope tracers in the water survey, in understanding of precipitation processes and for regional, national and global networks that serve to build scientific capacity for tracer-based research. Some highlights from 2011-12 include:

The Water Survey of Canada, in cooperation with the University of Manitoba, University of Victoria, and Alberta Innovates Technology Futures, is supporting development of a national pilot network to demonstrate the value in systematic collection of river discharge and analysis for oxygen-18 and deuterium across Canada. Water sampling of several hundred key gauging stations is expected to commence in 2012-13. Further information can be obtained from John Gibson (jjgibson@uvic.ca).

An important precipitation isotope summary was published this year that explores the ability to model the spatial distribution of oxygen-18 isotopes in precipitation across Canada (Delavau et al. 2011). The paper utilizes the Canadian Network for Isotopes in Precipitation (CNIP) database. For more information contact Carly Delavau (umdelav0@cc.umanitoba.ca). Research on the isotopic labeling of precipitation in the arctic is being conducted by Fred Michel in collaboration with Dr. Feng at Dartmouth college in New Hampshire.

Jean Birks is leading the Canadian contribution to an International Atomic Energy Agency sponsored research program on “Use of Environmental Isotopes in Assessing Water Resources in Snow, Glacier, and Permafrost Dominated Areas under Changing Climatic Conditions”. In addition to describing the value of synoptic river surveys for large northern rivers (e.g. Yi et al. 2009), Canada is participating in a pilot study for testing the representativeness of snow lysimeters, snow cores, and Frisbee samplers. For more information contact Jean Birks (jean.birks@albertainnovates.ca).

Isotopic tracers methodology for estimating water yield to ungauged lakes has been incorporated within Environment Canada’s Oil Sands monitoring plan (see Environment Canada 2011). This strategy has previously been used by the Regional Aquatic Monitoring Program (RAMP) and by Environment Canada’s Acid Rain program to better understand site-specific hydrologic conditions across Canada (Gibson et al. 2010a,b). For more information contact John Gibson (jjgibson@uvic.ca) or Jean Birks (jean.birks@albertainnovates.ca).

Isotope tracers will be widely featured at the upcoming Goldschmidt Conference: Earth in Evolution to be held in Montreal during June 24-29 2012. Two sessions that will be convened by members of the isotope tracer committee including: 22c. Applications of emerging geochemical and isotopic analytical techniques for integrated water resource management and environmental monitoring, and 14e. New developments in understanding natural and anthropogenic water contaminants in the Athabasca oil sands region. Both sessions will highlight advances made in use of isotopic tracers. For more information contact Yi Yi (yiyi@uvic.ca).

Alberta Innovates Technology Futures and the Canadian Water Network are sponsoring an Oil Sands Water Research Colloquium on Surface and Groundwater Management in the Oil Sands Industry to be held June 6, 2012. The session will include discussion of isotopic and geochemical methods for fingerprinting water sources. For more information contact Jean Birks (jean.birks@albertainnovates.ca).

A special session will be held at the next Geological Society of America 2012 ANNUAL MEETING to be held in Charlotte, North Carolina, November 4-7 2012, co-sponsored by CGU committee on isotopic tracers, entitled “Biotracers, Mineralogical and Geochemical Properties of Circum-Arctic Sediment Sources and Runoff towards the Arctic Ocean (TS 123)”. A large community is presently planning a drilling program in the Arctic Ocean in order to set up a robust geological history of the basin. One critical issue is to link detrital sediments to circum-Arctic sources using mineralogical, elemental and isotopic tracers as well as biotracers. Geoscientists with experience in surficial deposits, bedrock, major rivers and estuarine systems in surrounding lands, on ocean margin- and deep sediments are invited to contribute with reviews and new information about the mineralogy, geochemistry and biological/organic content of such potential sediment sources and their variability through time. Applications to issues such as changes in continental erosional rates and mechanisms are also welcome. For information contact Dennis Darby (ddarby@odu.edu) or Claude Hillaire-Marcel (chm@uqam.ca).

One important new research program underway is NSERC Discovery Frontiers Program: ADAPT: Arctic Development and Adaptation to Permafrost in Transition (PI Vincent; 2011-2016). This multidisciplinary and multi-faceted research program broadly addresses the fundamental research question: "What are the implications of rapid environmental change in Canada and the circumpolar North caused by thawing permafrost conditions?" Co-PI Brent Wolfe's (WLU) research will identify linkages among hydrological processes, limnological conditions and greenhouse gas exchange in thermokarst lakes. This is important because climate-driven alterations to lake-water balances (e.g., greater evaporation due to longer ice-free seasons, changes in precipitation regimes, accelerated permafrost thaw and more frequent lake drainage events) may influence limnological properties and hence greenhouse gas evasion rates. Research will utilize water isotope tracers and other approaches in present and past hydroecological studies of thermokarst lakes located in the subarctic discontinuous permafrost region in Nunavik and the continuous-discontinuous permafrost region in the western Hudson Bay Lowlands. For further information contact Brent Wolfe (bwolfe@wlu.ca)

References cited:

Delavau, C. Stadnyk, T., Birks, S.J., 2011. Model based spatial distribution of oxygen-18 isotopes in precipitation across Canada. submitted to the Canadian Water Resources Journal. Aug. 16, 2011.

Environment Canada, 2010. Integrated Monitoring Plan for the Oil Sands: Expanded Geographic Extent for Water Quality and Quantity, Aquatic Biodiversity and Effects, and Acid Sensitive Lakes Component, F. Wrona, P. diCenzo, K. Schaefer (eds.), Ottawa, Canada, p. 70.

Gibson, J.J., Birks, S.J., McEachern, P., Hazewinkel, R., Kumar, S., 2010a. Interannual variations in water yield to lakes in northeastern Alberta: Implications for estimating critical loads of acidity. Journal of Limnology 69 (Suppl. 1) 126-134, 2010 - DOI: 10.3274/JL10-69-S1-13.

Gibson, J.J., Birks, S.J., Jeffries, D.S., Kumar, S., Scott, K.A., Aherne, J., Shaw, P., 2010b. Site-specific estimates of water yield applied in regional acid sensitivity surveys in western Canada. Journal of Limnology 69 (Suppl. 1) 67-76, 2010 - DOI: 10.3274/JL10-69-S1-08.

Yi, Y., Gibson, J.J., Helie, J.-F., Dick, T.A., 2009. Synoptic and time-series stable isotope surveys of the Mackenzie River from Great Slave Lake to the Arctic Ocean, 2003 to 2006. Journal of Hydrology Volume 383, pp.223-232, doi:10.1016/j.jhydrol.2009.12.038.

Recent publications in the field:

A number of recent contributions have been published that describe application of isotopic tracers in hydrologic studies. These include:

Azcurra, C.S., Hughes, C.E., Parkes, S. , Hollins, S.E., Gibson, J.J., McCabe, M.F., Evans, J.P, 2011. A comparison between direct and pan-derived measurements of the isotopic composition of atmospheric waters. 19th International Congress on Modelling and Simulation, Perth, Australia, 12-16 December 2011, http:/mssanz.org.au/modsim2011.

Buhay WM, BB Wolfe and A Schwalb. 2012. Lakewater paleothermometry from Deep Lake, Minnesota during the deglacial-Holocene transition from combined □^{18}O analyses of authigenic carbonate and aquatic cellulose. Quaternary International 260: 76-82.

Hughes, C.E., Stone, D.J.M., Gibson, J.J., Meredith, K.T., Sadek, M.A., Cendon, D.I., Hankin,
S.I., Hollins, S.E., Morrison, T.N., 2012. Stable water isotope investigation of the Barwon-Darling River system, Australia. IAEA Tecdoc 1673, pp. 95-110, International Atomic Energy Agency, Vienna, Austria, ISBB 978-92-0-126810-5.

MacDonald LA, AM Balasubramaniam, RI Hall, BB Wolfe and JN Sweetman, 2012. Developing biomonitoring protocols for shallow Arctic lakes using diatoms and artificial substrate samplers. Hydrobiologia 683: 231-248.

MacDonald LA, KW Turner, AM Balasubramaniam, BB Wolfe, RI Hall and JN Sweetman. 2012. Tracking hydrological responses of a thermokarst lake in the Old Crow Flats (Yukon Territory, Canada) to recent climate variability using aerial photos and paleolimnological methods. Hydrological Processes 26: 117-129.

Mayer, B. & Wassenaar, L., I. (2012): Isotopic characterization of nitrate sources and transformations in Lake Winnipeg and its contributing rivers, Manitoba, Canada. – Journal of Great Lakes Research, published on-line on March 10, 2012.
Nightingale, M. & Mayer, B. (2012): Identifying sources and processes controlling the sulphur cycle in the Canyon Creek watershed, Alberta, Canada. – Isotopes in Environmental & Health Studies, 48(1): 89-104.

McGowan S, PR Leavitt, RI Hall, BB Wolfe, TWD Edwards, T Karst-Riddoch and SR Vardy. 2011. Interdecadal declines in flood frequency increase primary production in lakes of a northern river delta. Global Change Biology 17: 1212-1224.

Wiklund JA, RI Hall and BB Wolfe. 2012. Timescales of hydrolimnological change in floodplain lakes of the Peace-Athabasca Delta, northern Alberta, Canada. Ecohydrology 4: (in press).

Wolfe BB, EM Light, ML Macrae, RI Hall, K Eichel, S Jasechko, J White, L Fishback and TWD
Edwards. 2011. Divergent hydrological responses to 20th century climate change in shallow tundra ponds, western Hudson Bay Lowlands. Geophysical Research Letters 38, L23402, doi:10.1029/2011GL049766.

Wolfe BB, TWD Edwards, RI Hall and JW Johnston. 2011. A 5200-year record of freshwater availability for regions in western North America fed by high-elevation runoff. Geophysical Research Letters 38, L11404, doi:10.1029/2011GL047599.

Yi, Y., Gibson, J.J., Cooper, L.W., McClelland, J.M, Holmes, R.M, Peterson, B., Isotopic signals (^{18}O, ^{2}H, ^{3}H) of six major rivers draining the Pan-Arctic watershed,

Global Biogeochemical Cycles,26, GB1027, doi: 10.1029/2011GB004159.

Recent graduate thesis focused on isotopic tracers:

Chao, J. Major ion and stable isotope geochemistry of the Bow River, Alberta, Canada. MSc (Geoscience, University of Calgary.
Jasechko, S., 2011. Stable isotope mass balance of the North American Laurentian Great Lakes, M.Sc. Thesis (Earth Sciences Univ. Waterloo).

Light (Dobson) E. 2011. Characterizing the present and past hydrology of shallow ponds in the Churchill area using isotopic methods. MSc (Geography and Environmental Studies WLU). Recipient of Wilfrid Laurier University Gold Medal for Academic Excellence.

Proemse, B. C. Tracing Industrial Emissions in the Athabasca Oil Sands Region Using Stable Isotope Techniques. PhD (Geoscience, University of Calgary).

Tattrie, K., Groundwater surface water interactions in a wetland rich low relief Boreal environment. M.Sc. Thesis (Geography Univ. Victoria).

White J. 2011. Characterizing current and past hydroecological conditions in shallow tundra ponds of the Hudson Bay Lowlands. MSc (Biology Univ. Waterloo).

Wiklund J. 2012. Lakes of the Peace-Athabasca Delta: Controls on nutrients, chemistry, phytoplankton, epiphyton and deposition of polycyclic aromatic compounds (PACs). PhD (Biology Univ. Waterloo).

Erosion and Sedimentation Committee

Chair: Peter Ashmore, Department of Geography, University of Western Ontario, London, ON, N6A 5C2, Email: pashmore@uwo.ca

Members:

Dr. Dirk DeBoer, University of Saskatchewan
M. Conly, Environment Canada (CWS), Sasakatoon
Dr. M. Church, University of British Columbia
Dr. A. Roy, Université de Montréal
Dirk DeBoer IAHS-International Commission on Continental Erosion Canadian Delegate

Objectives:

The scientific advancement and practical application of knowledge of erosion, transport and deposition of sediment in fresh water systems - topic coverage similar to that of the IAHS Commissions on Continental Erosion some aspects of Water Quality.

i) communication of current research via discussion, meetings, conferences and publications;
ii) identification and promotion of high priority research topics in the Canadian context;
iii) promotion and encouragement of the transfer of knowledge and technology in the field of interest.

Meetings & Activities:

- Continued representation of E&S topics at CGU-HS sessions, including 2011 & 2012 meetings.
- Reciprocal membership arrangement and affiliation between CGU and Canadian Geomorphology Research Group has resulted in several sessions at other national conferences.
- 2012 meeting includes sessions HRW 9 and 10,"Biogeomorphology- interactions between riparian ecosystems, aquatic ecosystems and stream channels" and "Fluvial responses to environmental change".
- Co-sponsor with CGRG of sessions R1 and R2: "Hypothesis-driven science: linking field observations to earth-surface processes" and "Advances in fluvial and glacial geomorphology".
- Reciprocal membership arrangement and affiliation between CGU and Canadian Geomorphology Research Group has resulted in sessions at other national conferences.
- Phil Owens (UNBC) is member of ICCE scientific committee for meeting in Chengdu "Erosion and sediment yields in the changing environment", October 2012.
- Mike Stone (Waterloo) is incoming ICCE President.
- Committee meeting at CGU 2012 conference will consider new leadership and members, and future directions for the Committee.

GEODESY SECTION NEWS

Prepared by Joe Henton, President, CGU Geodesy Section

2012 CGU Joint Meeting with CWRA

The CGU-Geodesy Section had a productive series of formal (and informal) meetings during the recent 2012 CGU Joint Meeting with CWRA (Banff, June 5-8, 2012). In addition to geodesy-themed scientific sessions: "*Regional and global geoid-based vertical datums*" (G1A, G1B, G1C), "*Geodetic sciences and their applications to geodynamics*" (G23), and "*Geophysical and geodetic applications in hydrological sciences*" (H1), the CGU/CWRA meeting also hosted the *14th Canadian Geoid Workshop*. The theme of this year's well-attended workshop was "*Geoid-based Vertical Datums - North American and International Initiatives*". We wish to express our thanks to the conveners and chairs of these sessions and workshop.

Best Student Paper in Geodesy

The winner of the "Best Student Paper in Geodesy" for 2012 is Rebekka Steffen (*University of Calgary*). The title of her presentation was "Effects of changes in frictional strength on the fault behaviour in northeastern Canada". We would also like to thank Rebekka for giving the Citation to the 2012 CGU J. Tuzo Wilson Medallist: Doug Oldenburg. The overall caliber of student presentations at this meeting was very high and we greatly appreciated their contributions throughout the meeting.

New Geodesy Section Executive

The Geodesy Section Executive for the 2012/2013 term was elected during the Annual General Meeting, and it is composed of: Joseph Henton (President, *Natural Resources Canada*), Marc Véronneau (Vice-president, *Natural Resources Canada*), Jeong Woo Kim (Secretary, *University of Calgary*), Mohamed Elhabiby (Treasurer, *University of Calgary*), Dan Roman (Member-at-large, *National Geodetic Survey, NOAA*), Robert Kingdom (Member-at-large, *Fugro Airborne Surveys - Ottawa*). The past president is Patrick Wu (*University of Calgary*).

Geodesy Sessions, Workshops and Ideas for the 2013 Meeting

We are all looking forward to the 2013 Joint Scientific Congress of the CMOS, CGU and CWRA to be held in Saskatoon. If you have any suggestions for Geodesy Section activities during the next year's meeting, please forward your ideas to Marc Véronneau who will represent the Geodesy Section on the Scientific Program Committee. Please note that the CGU-GS may be able to provide financial support for new initiatives that provide recognition and/or benefit to our members (*e.g.*, ideas suggested during the Annual General Meeting included establishing an award for distinguished scientists in the field of geodesy and support for student-focused activities and workshops).

The 13th Canadian Geoid Workshop

Geodetic Survey Division, NRCan
Ottawa, Ontario, Canada

The National Geodetic Survey (USA), Instituto Nacional de Estadística y Geografia (Mexico) and Geodetic Survey Division (Canada) are working towards the definition and realization of new vertical reference System for North America (NAVRS). NAVRS will be an equipotential surface, which will be realized by geoid modeling. It would allow access to the vertical datum through GNSS technologies and allow consistent orthometric heights at any locations across the continent. This new realization of the vertical datum would replace the traditional approach of leveling, which is costly and time-consuming when establishing and maintaining a national datum and limits the access to the datum only where benchmarks are available.

The 13th workshop will focus on three items: 1) Definition of the NAVRS, 2) Theory and data exchange and 3) Monitoring geoid changes. The first item will looks at standards and conventions in establishing the NAVRS. The second item will consist at evaluating theory and data exchange status between national agencies. Finally, the last item consists in establishing cooperation between national agencies and academic institutions for the purpose of realizing an infrastructure for monitoring the geoid variation.

Le 13ième atelier canadien sur le géoïde

Division des levés géodésiques, RNCan
Ottawa, Ontario, Canada

Le National Geodetic Survey (E.U.d'A), Instituto Nacional de Estadística y Geografia (Mexique) et la Division des levés géodésiques (Canada) travaillent ensemble vers la définition et la réalisation d'un nouveau système de référence altimétrique pour l'Amérique du Nord (SRANA). SRANA sera une surface équipotentielle qui se sera réalisé par une modélisation du géoïde. Ceci permettra accès au datum vertical par l'entremisse de la technologie GNSS et permettra des altitudes orthométriques consistantes en tout lieu à travers le continent. Cette nouvelle réalisation du datum vertical remplacera l'approche de nivellement traditionnelle qui est laboureuse et coûteuse pour l'établissement et l'entretien d'un réseau national et qui limite l'accès qu'aux repères altimétriques.

Le 13ième atelier portera attention à trois éléments : 1) la définition du SRANA, 2) la théorie et l'échange de données et 3) la surveillance des changements du géoïde. Le premier item regardera aux standards et convention pour la réalisation du SRANA. Le second élément consiste à évaluer la théorie et l'efficacité des échanges de données entre les agences nationales. Finalement, le dernier élément consiste à établir de la coopération entre les agences nationales et les institutions académiques afin de réaliser une infrastructure pour surveiller les variations du géoïde.

BIOGEOSCIENCES SECTION NEWS

Submitted by Merrin Macrae

The Biogeosciences (BS) has had another exciting year! We had three sessions at the 2012 Annual Meeting of the Canadian Geophysical Union, held in Banff, Alberta. We also had a strong representation at the Eastern Student conference (held jointly with the Hydrology section). We are looking forward to another great year next year!

Altaf Arain (President) and Ed Johnson (Vice-President) have completed their terms in their Executive Positions. We thank them for their service over the past two years! Brett Eaton was elected as President; Merrin Macrae as Vice-President, and Mark Johnson and Tim Duval as Members at Large. Past members, Carl Mitchell (Secretary) and Altaf Arain (Treasurer) will continue to serve on the board.

Membership:

Our goal over the next three years is to significantly increase both membership and attendance at CGU meetings. We plan to accomplish this by targeting key groups/topics each year, which will be tied to the focus of the annual meetings. In 2013 (Saskatoon, SK), the CGU meeting will be held jointly with CMOS and CWRA. As usual, the BS session accepts all submissions related to the subject area of "Biogeosciences". However, we will host several special sessions related to the topic of "Biometeorology" in 2013. We invite members of the CGU community to provide suggestions for potential speakers to invite to this meeting, and please consider hosting a special session related to this general subject area. At future meetings, we plan to focus on topics such as "Biogeomorphology" and "Ecohydrology". We invite the CGU community to suggest potential topics of interest for future meetings. We are also seeking potential sessions to be held with other CGU sections such as HS in 2013 and at future meetings.

Student Involvement:

The BS section also provides student awards at CGU annual meetings for oral and poster presentations. Please encourage your students to apply for these awards!

The BS group will also initiate a "Mentorship Dinner" program. Modelled after activities at the Ecological Society of America (ESA) conferences, students can sign up to go out to dinner with member/mentor. This provides our students with valuable contact time with possible mentors, and facilitates overall mentorship, collaboration opportunities and networking. We hope that our members will consider volunteering to have dinner with a student (or small group of students) at future CGU meetings. This initiative is still in the early stages of development and we are happy to have any suggestions that our membership may have to help move this forward. Please contact us if you are willing to be a part of this initiative. We will likely be contacting many of you!

CGU 2012 Best Student Paper Award Winners

A number of awards were presented in recognition of outstanding performance in scientific research and presentation by students. Each of the awards comes with a monetary prize. The awards were announced and presented at the Awards Banquet at the recent 2012 CGU-CWRA Joint Meeting in Banff. To be considered for an award, the student must be the first author and presenter of the paper (visit http://www.cgu-ugc.ca for details).

Some of the award winners are listed below, and some of their expanded abstracts follow. Other abstracts may appear in the January 2013 issue of *ELEMENTS*, space permitting.

The CGU component of the organizing committee of the Congress and the CGU Executive Committee would like to sincerely thank all the judges of the student papers for their careful evaluations of the student presentations.

CGU Best Student Paper (all fields of geophysics – oral presentations):

Winner: Colin McCarter (University of Waterloo). The Hydrology of the Bois-des-Bel Peatland 10 Years Post-Restoration: a Tale of Two Scales. Co-author: J. Price.

Shell Canada Outstanding Student Poster Paper:

Winner: T. Hamilton (University of Lethbridge). To what extent does topography control landcover diversity? : A case study. Co-author: C.H. Hugenholtz.

Chevron Canada Outstanding Student Paper in Seismology (oral or poster):

Winner: Hadi Ghofrani (University of Western Ontario). New Insights on Ground Motions for Large Subduction Earthquakes: Critical Parameters for Scenario Ground Motions for HAZUS Applications in South-Western B.C. Co-author: Gail M. Atkinson.

D. M. Gray Award for Best Student Paper in Hydrology (oral presentation):

Winner: N.J. Kinar (University of Saskatchewan). Acoustic Measurement of Snow. Co-author: J.W. Pomeroy.

Campbell Scientific Award for Best Student Poster in Hydrology:

Winner: R.C. Zanatta (Brock University). Hyporheic zone influence on reach-scale water budgets within a boreal shield catchment of Quebec, Canada. Co-authors: S.K. Carey, M.C. Richardson.

Geodesy Section Award for Best Student Paper in Geodetic Research & Education (oral presentation):

Winner: Rebekka Steffen (University of Calgary). Effects of changes in frictional strength on the fault behaviour in northeastern Canada. Co-authors: P.Wu, H. Steffen, D.W. Eaton.

New Insights on Ground Motions for Large Subduction Earthquakes: Critical Parameters for Scenario Ground Motions for HAZUS Applications in South-Western B.C.

Hadi Ghofrani & Gail M. Atkinson
Department of Earth Sciences, Western University Canada, Canada, N6A 5B7
hghofran@uwo.ca; gatkins6@uwo.ca

Summary

A key input for seismic risk assessment using HAZUS or similar methodologies is a scenario ShakeMap providing the expected strength of motions across a region for a given earthquake scenario. A critical component in creating ShakeMaps is estimating amplification of the motions for site-specific soil information. The **M**9.0 2011 Tohoku earthquake has provided important new quantitative information on site response that will be invaluable in refining seismic hazard analysis and mitigation efforts, particularly in southwestern B.C., where similar events are expected in the future. We performed a detailed characterization of site response effects from the Tohoku event. We find that site amplification effects were very strong at most sites, often exceeding a factor of five. Thus the importance of site response studies for vulnerable regions is highlighted; to protect infrastructure it is critical that the site response be realistically estimated. We take advantage of the well-determined site responses from Tohoku, made possible by networks of instruments recording both on the surface and at bedrock depth below (within boreholes) to develop an empirical model of site amplification. The model predicts amplification based on the horizontal-to-vertical spectral ratios for surface motions and simple physical characteristics of sites. The model allows site amplification to be estimated based on site parameters that are typically known or easily obtained. Thus experience from the Tohoku event can be "transported" via the model to other regions such as Cascadia. Expected motions for a similar event in the Cascadia subduction zone will be simulated next, by modifying the Tohoku model to reflect the expected attenuation and site response in the Cascadia region. This work will aid in seismic hazard assessment and mitigation efforts in the active Cascadia region of southwestern B.C.

Introduction

Site amplification, or the increase in amplitudes of seismic waves as they traverse soft soil layers near the Earth's surface, is a major factor influencing the extent of earthquake damage to structures (e.g. Field and Jacob, 1995). Understanding of site-specific amplification effects and their role in determining ground motions is important for the design of engineered structures.

We perform a thorough analysis of site amplification during the Tohoku event by taking advantage of surface and borehole motions from the KiK-net (KIBAN kyoshin network: http://www.kik.bosai.go.jp/) to estimate the site transfer functions for all sites. Furthermore, detailed assessment of both linear and nonlinear site effects is conducted by investigating changes of site responses in amplitudes as well as fundamental frequency. The applicability of the horizontal-to-vertical (H/V) spectral ratio technique as an alternative tool to estimate site response is evaluated by modeling the relationship between H/V ratios and surface-to-borehole spectral ratio (S/B) ratios, as a function of physical site properties. We develop a suite of simple, useful, and reliable models for prediction of site amplification effects based on available site parameters. Finally, we develop an empirical model of ground motions for the Tohoku earthquake and compare it to the predictions of several existing ground motion prediction equations (GMPEs).

Strong ground motion data and record processing

The strong-motion data used in this study were collected from the KiK-net network. KiK-net consists of 687 strong-motion observation stations installed both on the ground surface and at the bottom of boreholes. We supplement the Tohoku-event data by adding all other events of $\mathbf{M} \geq 5.5$ that were recorded on the KiK-net stations from 1998 to 2009. For all KiK-net stations, we have processed and analyzed 30453 records from 258 earthquakes. The number of events for each station varies from 4 to 150. The processing procedure includes windowing, correction for baseline trends and band-pass filtering. We have applied non-causal, band-pass Butterworth filters with an order of 4. The selected frequency range of analysis is 0.1 to 15 Hz.

Calculation of site response using surface-to-borehole spectral ratio (S/B)

In this study, we use an alternative to the standard spectral ratio (SSR) method (Borcherdt, 1970), called the surface-to-borehole spectral ratio (S/B) approach, where the reference site is at the bottom of a borehole directly below the soil site, rather than at a bedrock surface away from the site. S/B spectral ratios are used to provide a direct measure of site response. However, destructive interference between the up-going incident wave field and down-going reflected waves from the surface at specific frequencies can produce a notch in the FAS of the borehole recording (Steidl et al., 1996). The surface-to-borehole ratios corrected for the depth effect, S/B', can be obtained by multiplying S/B by the coherence (C^2) between surface and borehole recordings (Steidl et al. 1996):

$$S/B' = C^2(S/B) \qquad (1)$$

where

$$C^2 = \frac{|S_{12}(f)|^2}{S_{11}(f)S_{22}(f)} \qquad (2)$$

$S_{11}(f)$ and $S_{22}(f)$ are the power spectral densities of the seismograms recorded at the surface and downhole, respectively, and $S_{12}(f)$ is the cross-power-spectral density function.

Relationship between amplification and site parameters

We examine the relationship between site amplification (S/B') and site variables describing the depth and stiffness of the deposit. As a commonly-used index parameter for the shear-wave velocity profile, we use the average shear-wave velocity in the uppermost 30 m.

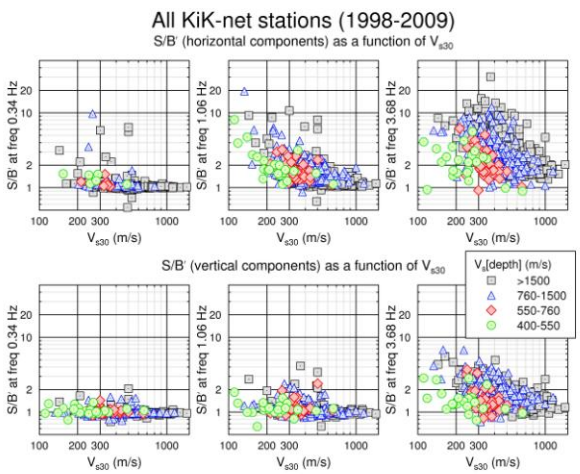

Figure 1: Amplification (S/B') for the KiK-net stations relative to V_{S30}. Sites are categorized into four groups based on their V_S[depth] which is shear wave velocity at the depth of installation.

Figure 1 explores the relationship between site amplification and V_{S30}, considering all KiK-net data. We see some evidence for greater amplification, for the same V_{S30}, if $V_S[\text{depth}] \geq 760$ m/s, due to impedance effects. But the amplification for the data in the range 760-1500 m/s appears to be about the same as that for > V_S[depth]1500 m/s. Therefore, the S/B' ratio data for $V_S[\text{depth}] \geq 760$ m/s are used to characterizing the overall site amplification. We perform a simple least-squares regression to determine the amplification for each frequency:

$$\log(S/B') = m.\log(V_{S30}/V_{ref}) + b \qquad (3)$$

where V_{ref} = 760 m/s. The regression coefficients are tabulated in Table 1 for several representative frequencies.

Table 1: Coefficients for site correction factors, horizontal component

Frequency (Hz)	Tohoku		All KiK-net	
	m	*b*	*m*	*b*
0.52	-0.248	0.027	-0.211	0.023
0.99	-0.518	0.063	-0.491	0.055
1.90	-0.748	0.157	-0.768	0.148
4.55	-0.622	0.338	-0.724	0.357
8.75	-0.076	0.447	-0.205	0.495
10.88	0.057	0.438	-0.014	0.490

Another important site parameter, in addition to site stiffness, is the fundamental resonance frequency (f_0). The fundamental frequency depends on both layer depth and stiffness, and may carry information on deeper part of the soil column, in comparison to V_{S30} which considers only the top 30 m. The fundamental frequency is obtained for the KiK-net data using the peak of the horizontal-to-vertical (H/V) spectral ratios of the recorded strong motions at the sites (Lermo and Chávez-García, 1993).

The fundamental frequency f_0 is related to the depth-to-bedrock (i.e. $f_0 = V_S/4HB$). Depth-to-bedrock (HB), defined by the depth of a layer with V_S760 m/s, or to a significant impedance contrast between surface soil deposits and material with V_S760 m/s, is obtained for each site from the velocity profile. Figure 2 plots the f_0 as a function of V_{S30}, respectively. Results indicate that V_{S30} is a good proxy to estimate the natural frequency of a site. Furthermore, the fundamental frequency inferred from the H/V ratios matches well with that derived from the theoretical relation ($f_0 = V_S/4HB$).

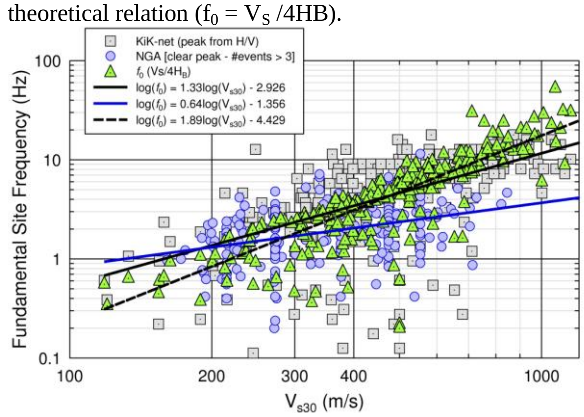

Figure 2: Fundamental site frequency (f_0) as a function of V_{S30}. Lines are the best linear fit to f_0 as a function of V_{S30} for each dataset.

To check if the V_{S30}-f_0 correlation is region-specific, or if the relation is valid in other tectonic regions, we use the 2005 Pacific Earthquake Engineering Research Center (PEER) global ground motion database, which was used for the development of the 2008 NGA West models (shallow events in active tectonic regions). We calculate the H/V ratios for all sites in the database and pick the fundamental frequencies, considering just those stations that show a clear single peak and recorded at least 3 events. The slope of the V_{S30}-f_0 relation is less significant (0.64 ± 0.10) than that for Japan (1.33 ± 0.12). The lower values of f_0 for the NGA data indicate deeper bedrock, for the same V_{S30}, in most regions that comprise the NGA database (e.g. Atkinson and Casey, 2003).

Figure 3 plots the fundamental site frequency as a function of depth-to-bedrock, which is interrelated to V_{S30}. We also show in Fig. 3 the corresponding relationship for the PEER-NGA strong motion dataset; for the PEER-NGA data, the "depth to bedrock" is assumed to be the depth to V_S = 1.0 km/s (Z1.0), as it is the closest proxy to our selected V_S760 m/s. The Japan and PEER-NGA data show similar trends, but there is a higher intercept for the PEER-NGA data, probably because they are referenced to stiffer, deeper bedrock. We also show the estimated Z1.0 from the velocity profiles of KiK-net stations in Fig. 3.

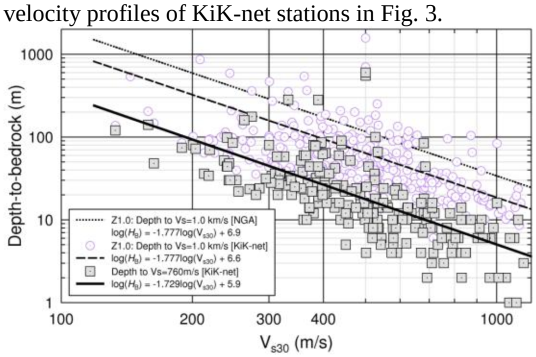

Figure 3: Depth-to-bedrock as a function of V_{S30}. The dotted line is the best fit to the Z1.0 from NGA database. The dashed line is the estimated model for predicting Z1.0 in Japan.

Using H/V as an extra parameter to estimate site amplification function

The H/V spectral ratio has been widely used to provide a preliminary estimate of site amplification (Nakamura, 1989). We explore the use of H/V as an amplification function for the KiK-net data. This will be useful for other applications where H/V is known but borehole data are not available to constrain site amplification. We performed a linear regression using:

$$\log(Y) = a_1.\log(V_{S30}) + a_2.\log(f_0) + a_3 \qquad (4)$$

where Y is the ratio of the site amplification to the average of H/V. By using H/V and V_{S30} with Equation (4), we obtain a good match to the observed site transfer functions for the whole range of frequencies (Fig. 4). The advantage of this method could be significant for assessing the site effects by using a single station or in an area where a rock reference site cannot be found.

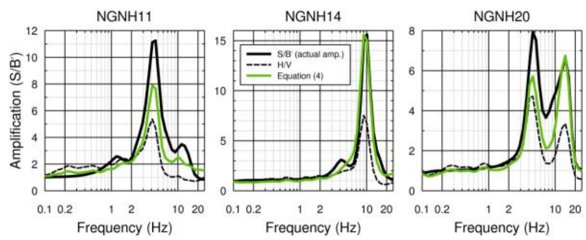

Figure 4: Comparison of S/B' ratios using cross-spectral ratios (solid black line) for NGNH11, NGNH14, and NGNH20 with mean H/V ratios (dashed black line). Transfer functions are overlaid by prediction model using V_{S30} and f_0 as predictor parameters and adding H/V as an extra parameter (green line).

Non-linear site amplification

Under strong shaking, soil shows nonlinear and hysteretic behavior, with the effective modulus G decreasing at high strain (Beresnev and Wen, 1996). As a consequence, nonlinearity will result in a shift of the resonance frequency to lower values, and the reduction in amplification, as the amplitude of motions increases (e.g. Silva, 1986).

Figure 5 shows the nonlinear behavior of a site subjected to strong seismic shaking (PGA ~ 530 cm/s^2). The spectral ratio for MYGH04 is compared for the strongest part of the signal and the coda-window, noting that the shaking during the coda is a representative of weak-motion (Chin and Aki, 1991).

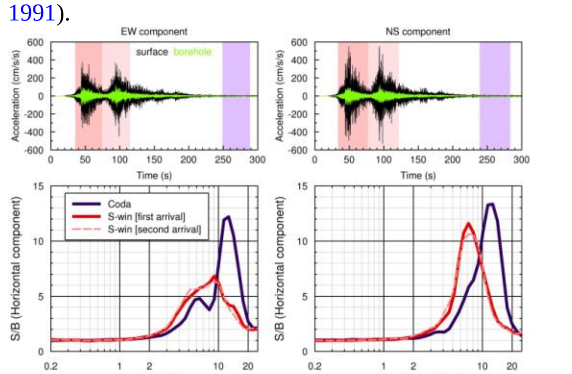

Figure 5: Amplification of EW and NS components at MYGH04 for the S-window of the first arrival (tick solid red), S-window of the second arrivals (dashed light red), and coda-window (blue).

From Fig. 5, a clear shift of the peak amplitude frequency to lower frequencies during the strong shaking portion of the record can be seen. Also, the amplitudes are reduced for the S-window spectral ratios in comparison with the coda-window spectral ratios.

The short-time Fourier transform (STFT) analysis (Wu et al. 2010) is carried out to detect the PGA threshold of nonlinearity using both surface and borehole time series for each station. A decrease of fundamental frequency and amplitude due to the nonlinear behavior of a site can be detected within strong part of the signal, relative to the coda window and background noise (Fig. 6).

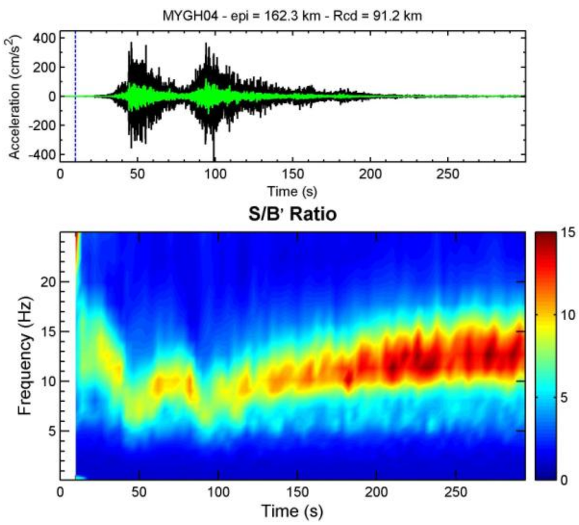

Figure 6: Temporal evolution of S/B for the MYGH04 station.

We calculate the average of spectral ratios at each station over all events (A_{ref}) and the frequency of that peak (f_{ref}). The same procedure is repeated for calculating spectral ratios at the same sites for Tohoku earthquake. In this case, the maximum amplitude (for the mainshock) is called A_{MS} and the fundamental frequency is called f_{MS}. We consider just stations that show a clear, single peak in the H/V at the surface. In total, 225 out of 475 stations passed these criteria and among them only 42 stations showed nonlinear behavior (shifting of the fundamental frequency to lower frequencies, and a decrease in amplitude). To quantify the nonlinear behavior, in Fig. 8 we plot the ratio A_{MS}/A_{ref} and f_{MS}/f_{ref} as a function of PGA_{ref}, which is the predicted median PGA for V_{S30} = 760 m/s. The plots show that there is a weak but steady trend indicating nonlinear behavior, even from low amplitude, for all soil types. The slope and standard error (SE) of the best fitted line for A_{MS}/A_{ref} is -0.0018 ± 0.0014. For the f_{MS}/f_{ref} ratio, the slope is -0.0028 ± 0.0009.

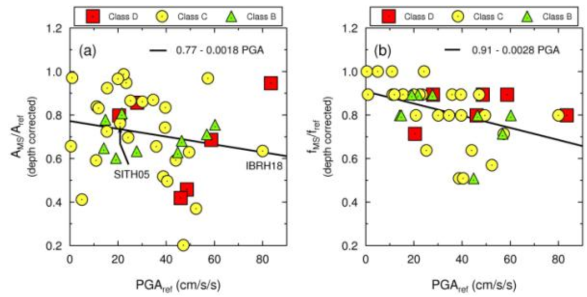

Figure 8: Looking for nonlinearity symptoms such as a decrease in the predominant frequency and/or amplification amplitude as a function of PGAref (predicted for V_{S30} = 760 [m/s]).

We conclude that nonlinearity, though present in some cases, was not a pervasive phenomenon during the Tohoku event for the KiK-net sites; only a small fraction of sites show amplitude and frequency content that is shifted significantly. However, it should be mentioned that there are many cases for liquefaction-related damage during the Tohoku earthquake.

Overall characteristics of Tohoku ground motions

Having evaluated site amplification for the Tohoku motions, we can now characterize the Tohoku ground motions with site effects removed. We fit the site-corrected Tohoku motions using:

$$\log(Y) + \log(R_{eff}) - site_{factor} = c_0 + c_1.F.R + c_2.B.R \qquad (5)$$

where for stations in the forearc region, F = 1 and B = 0, otherwise (for backarc stations) F = 0 and B = 1 (Ghofrani and Atkinson, 2011). The $site_{factor}$ is calculated using coefficients in Table 1. The regression coefficients are given for pseudo-spectral acceleration (PSA) in Table 2.

Table 2: Regression coefficients for PSA (geometric mean of horizontal components)

Frequency	PSA (cm/s²)		
(Hz)	c_0	c_1	c_2
0.52	3.96	-0.0005	-0.0013
0.99	4.19	-0.0009	-0.0019
1.90	4.30	-0.0011	-0.0024
4.55	4.33	-0.0013	-0.0028
8.75	4.28	-0.0010	-0.0028
10.88	4.23	-0.0009	-0.0027

New Insights on Ground Motions for Large Subduction Earthquakes

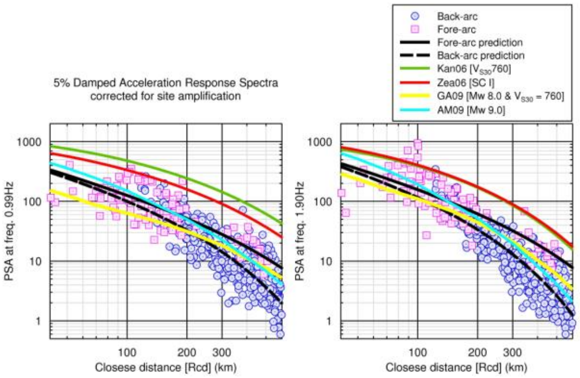

Figure 9: Comparing event-specific prediction equation for the site corrected Tohoku ground-motions (B/C) with other GMPEs (Kan06 = Kanno et al. 2006; Zea06 = Zhao et al. 2006; AM09 = Atkinson and Macias, 2009; and GA09 = Goda and Atkinson, 2009) at four frequencies.

A comparison between the event-specific Tohoku prediction equation and the motions predicted by regional ground motion prediction equations (GMPEs) for Japan is shown in Fig. 9. The observed PSA values are corrected for site amplification using coefficients from Table 1, before comparison with GMPEs for a reference condition of B/C. The Zae06 and Kan06 GMPEs are over-predicting Tohoku ground motions at 1.0 Hz, while AM09 is similar to the new equation for the back-arc stations. It is clear from Fig. 9 that the attenuation (slope and curvature) of single Q-factor GMPEs – especially at subduction zones – is controlled mostly by the backarc stations.

Conclusions

The **M**9.0 2011 Tohoku earthquake has provided important new quantitative information on site response that is invaluable in refining seismic hazard analysis and mitigation efforts:

1. The site amplifications are much greater than those indicated by standard building code factors based on NEHRP site class (factors of 4 to 8 at f > 2 Hz).
2. Empirical relationships have been derived to predict site amplification using H/V, V_{S30}, and f_0.
3. Nonlinear site response was not pervasive during the 2011 M9 Tohoku earthquake.
4. Generic GMPEs developed for subduction regions appear to under-estimate the Tohoku motions if soil amplification effects are not removed. However, once site effects are taken into account the agreement is reasonable.

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Acoustic Measurement of Snow

N.J. Kinar (n.kinar@usask.ca) and J.W. Pomeroy (john.pomeroy@usask.ca)
Centre for Hydrology, University of Saskatchewan,
117 Science Place, Saskatoon, Saskatchewan, S7N 5C8 Canada

Abstract: An acoustic gauge has been developed to non-invasively measure SWE, snow density, depth, temperature, and heat flux. The gauge has been tested at a stationary location at Marmot Creek Research Basin in the Canadian Rockies. This is the first test of an acoustic gauge used to collect time-series acoustic data. The acoustics observations were linked to snow hydrology parameters by the development of an inverse model constrained by a forward model. The inverse constrained model performed well when compared to measurements of snow depth, density, water equivalent, temperature and heat flux.

1. Introduction

Observations of snowpack physical properties have often been made using invasive measurements. The digging of snowpits and the use of snow measurement tubes modifies the snowpack structure and does not allow for multiple samples to be taken at the same location. Acoustic waves can be sent into snow and the resulting reflections used to measure snowpack physical properties. To facilitate these measurements, a new acoustic sensor has been developed and tested.

2. Theory and Instrumentation

The sensor is comprised of a loudspeaker and microphone assembly situated at nadir above the surface of the snowpack. Both the loudspeaker and the microphones are fastened to the side of an electronics enclosure case facing the snow. The separation distance between the loudspeaker and the microphones is 8 cm. Six microphones are arranged in a linear array with an inter-element separation distance of 1 cm (Figure 1).

To take an acoustic sample, a custom electronic circuit was used to generate a Maximum Length Sequence (Rife and Vanderkooy, 1989). The MLS was emitted from the loudspeaker and the produced sound wave had a duration of ~1.6 s. During this time, the sound wave was reflected from the snow surface and the bottom of the snowpack. The pressure wave reflections from the snowpack were detected in the air medium by the microphone assembly. The MLS produced by the loudspeaker was pseudo-random noise with a flat frequency spectrum and a bandwidth less than 10 KHz to ensure that the sound wave could penetrate the snowpack (Kinar and Pomeroy, 2009).

The signal output from each microphone was digitized using a 16-bit Analog-to-Digital Converter (ADC) with a sampling rate of 400 kHz. Signals from each microphone were cross-correlated with a reference signal to determine the impulse response of the snowpack and to remove cross-talk caused by the air-coupled wave between the loudspeaker and microphone assembly.

Using differences in the time of arrival between microphones at offset distances from the loudspeaker, the speed and attenuation of the sound pressure wave propagating through the snowpack was determined at the output of a bandpass filter bank. The speeds and attenuations were used as inputs to a model comprised of partial differential equations governing the Biot theory of sound propagation through porous media (Stoll, 1989) coupled with: a mixture theory model of water in snow (Bengtsson, 1982); a theory of thermal conductivity in porous media (Jackson and Black, 1983); and Fourier's Law of heat transport. To further stabilize the solutions of the inverse model, a finite-difference forward model using a Saul'yev splitting scheme (Saul'yev, 1996) was used to find solutions to an unsaturated wave equation on a rectangular grid. This is referred to as the "inverse constrained" model.

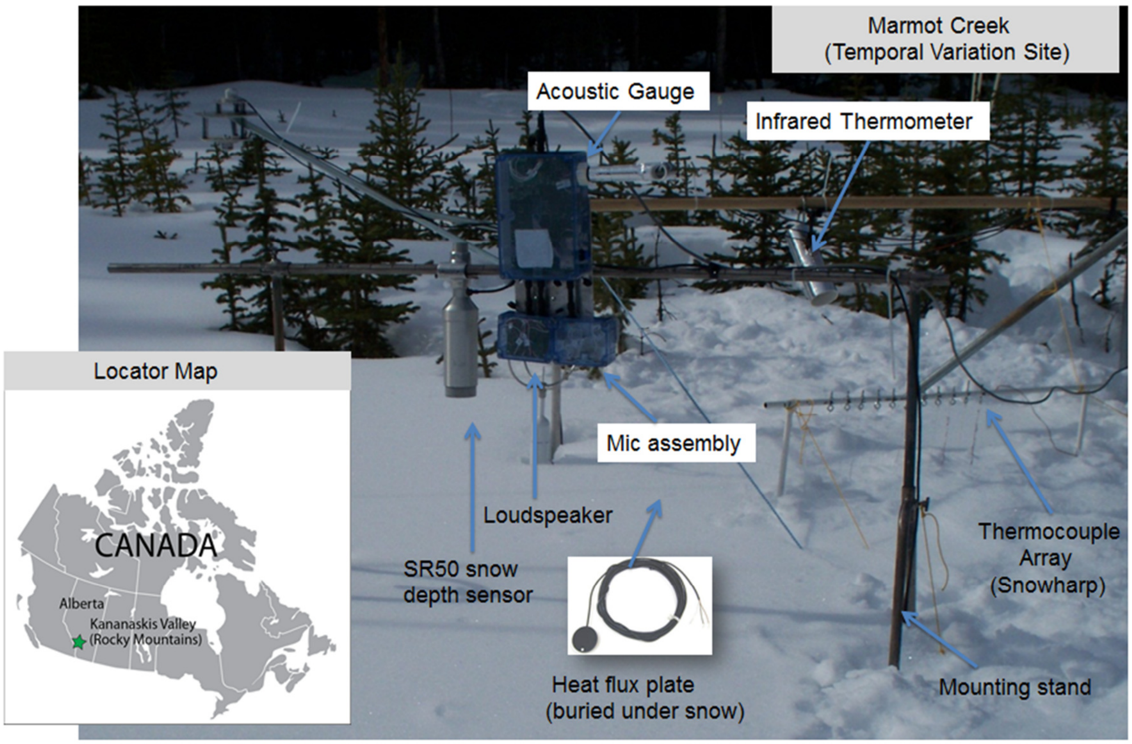

Figure 1. Experimental setup showing acoustic gauge and associated measurement instrumentation

The acoustic device was deployed one metre above the snow at the Upper Clearing site in Marmot Creek Research Basin (50.95654 N, 115.1754 W, at 1844.6 MASL) in the Canadian Rockies. For the stationary setup, an SR50 ultrasonic snow depth sensor was fastened on the stand next to the acoustic gauge to measure snow depth. A narrow-beam thermal infrared radiometer measured snow surface temperature, and a heat flux plate was buried under the snowpack. Approximately 50 thermocouples were suspended vertically throughout the snowpack, and the resulting temperature-sensor array was referred to as a "snowharp." Snowpit measurements of snow layer depth and density were taken using standard gravimetric sampling with a RIP snow sampler and scale. Due to power consumption constraints, the stationary acoustic gauge was set up to take a sample once every hour.

3. Results

Figure 2a shows comparisons of SWE measured using gravimetric and acoustic methods. The Root-Mean Squared Error (RMSE) between methods is less than 20 mm, indicating the accuracy of the acoustic method. The Mean Bias Deviation (MBD) is negative and shows that the acoustic model underpredicts SWE by approximately 20%. This is comparable, but slightly higher than the errors in SWE measurement between two different gravimetric techniques (Goodison, 1981). In a likewise fashion, the RMSE between depth-integrated gravimetric and acoustic density is less than 20 kg m^{-3}. The acoustic model underpredicts depth-integrated snow density with a MBD less than 3%. The 11 cm RMSE between the SR50 measurements and the acoustic model indicates a difference in depth measurements between the ultrasonic SR50 and the audible sound wave produced by the acoustic gauge. Whereas the SR50 determines snow depth by measuring the time taken for an ultrasonic pulse to reach the snow surface, the acoustic model determines the distance from the top of the snowpack to the bottom. Unlike the SR50 measurements, the height of the acoustic gauge above the ground does not have to be known for this method to work. However, buried vegetation beneath the surface of the snowpack can cause scattering of the acoustic wave, thereby causing snow depth to be underpredicted by the acoustic model.

Figure 2 demonstrates that an increase in snow density occurs with a decrease in snow depth. The depth-integrated snow density decreases with an increase in snow depth after snowfall events deposit fresh snow. Physical processes such as compaction, wind redistribution of snow, the frequency of snowfall events, snowpack metamorphism and ablation are responsible for changes in snowpack density. The results shown in Figure 2 are for a stationary location, and may not be valid for transect measurements of snow depth, density and SWE, where differences in landform type, vegetation and elevation contribute to spatial heterogeneity of these parameters (Pomeroy and Gray, 1995).

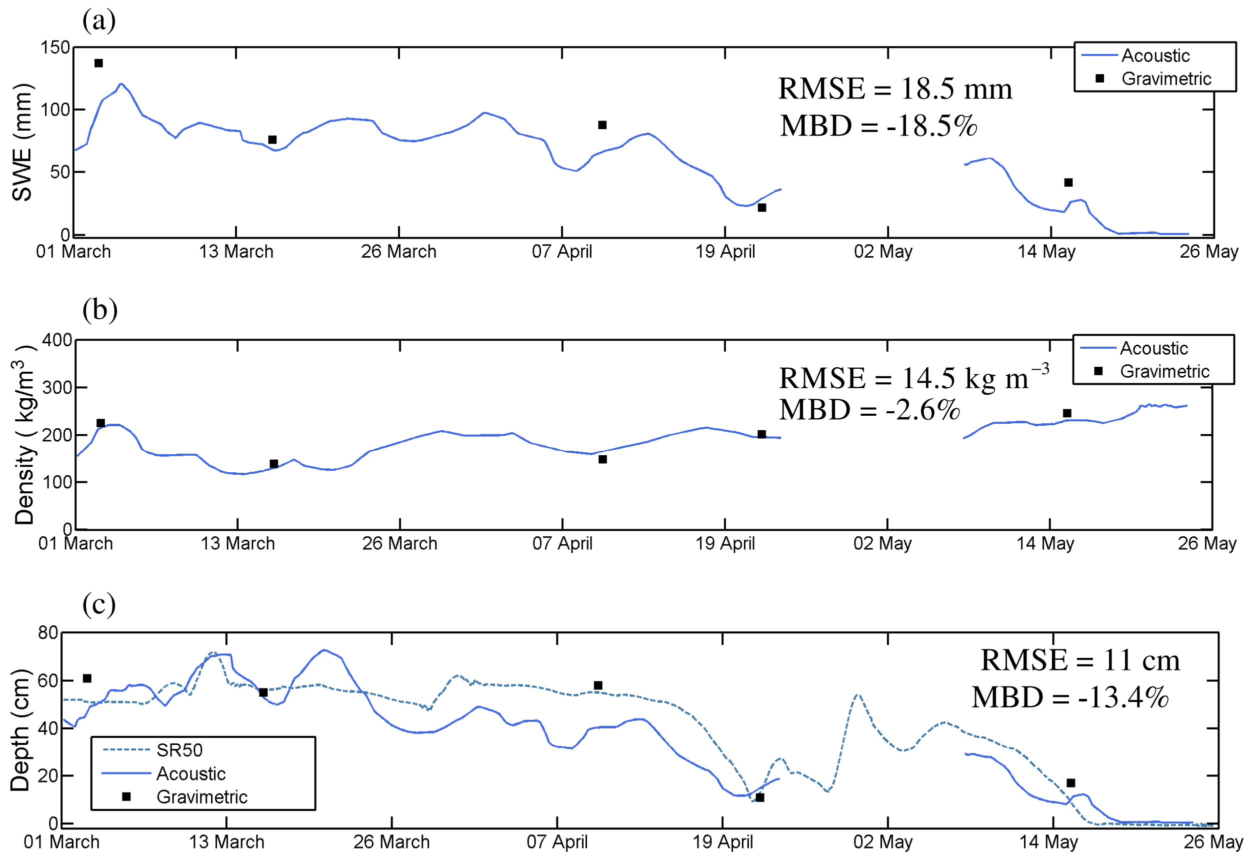

Figure 2. SWE, density and depth measured by the acoustic gauge

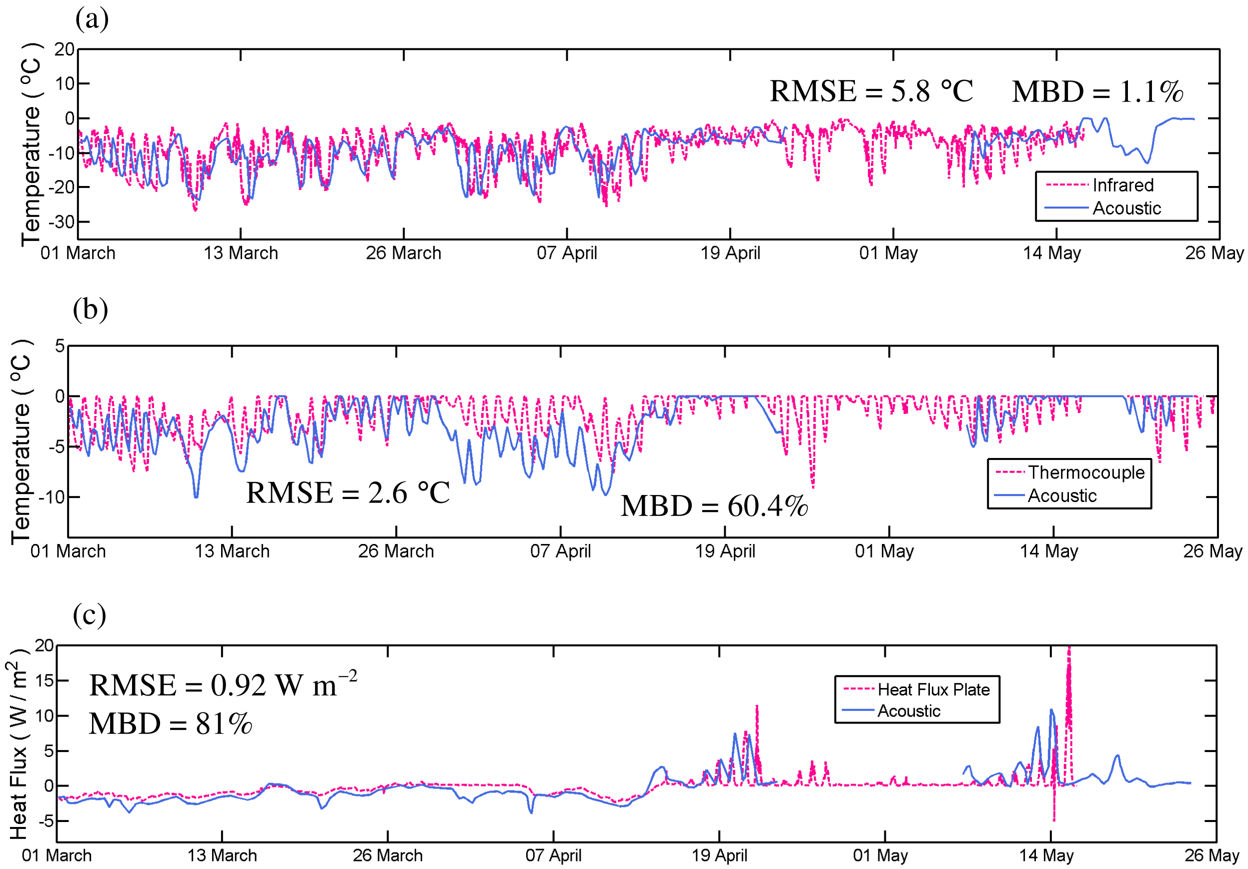

Figure 3. Infrared snow surface temperature, thermocouple array ("snow harp") and heat flux measured by the acoustic gauge

Figure 3a compares the snow surface temperature measured using an infrared thermometer with the acoustic model output of the first sound wave reflection from the top of the snowpack. The inverse constrained model overpredicts snow surface temperature and exhibits some temporal hysteresis due to reflections from buried vegetation.

Large differences are exhibited between depth-integrated snow temperatures measured by the thermocouple array ("snow harp") and the acoustic device (Figure 3b). Because the snowharp consisted of wires buried in the snowpack, heating of the wires by the sun introduced an additional source of error into the thermocouple measurements. This demonstrates the difficulties with invasive measurement devices used to determine snowpack properties. The acoustic device temperature measurements are significantly lower than the melting point of snow for most of the testing period, whereas the snow thermocouple measurements rise to temperatures above zero degrees Celsius. In an attempt to compare measurement techniques, snowharp thermocouple temperature data was constrained to zero degrees Celsius.

Comparisons between measured and modelled heat flux at the bottom of the snowpack are shown by Figure 3c. To make these comparisons with the buried heat flux plate, the acoustic model output of the final sound wave reflection from the bottom of the snowpack was used. This sound wave reflection may contain false multiple reflections from the ground surface. Before mid-April, the heat flux as measured by the heat flux plate and the acoustic model is negative, indicating movement of heat from the ground into the snowpack. During the time of ablation (mid-April onward), the heat flux becomes positive, indicating warming of the snowpack and the transference of heat from the snow into the ground. The acoustic measurements show this change up to the beginning of a melt event. The inverse constrained model does not capture the peak of the melt event near 14 May. However, a rise in heat flux during the preceding days is apparent. More research is required to quantify the effects of snowmelt on the propagation of a sound wave through snow.

4. Conclusions

Snow measurement using gravimetric instruments is a tedious and time-consuming process. The development of an acoustic gauge allows hydrologists to non-invasively measure snowpack properties by a sound wave. Each snow measurement can be completed in less than two seconds. Due to the non-invasive nature of the measurement, more than one measurement can be made at the same geographic location. Because research in cold environments is expensive and often conducted under conditions hazardous to human beings, the time and effort saved by use of an acoustic device could simplify the logistics of hydrology research.

Automated acoustic devices could be deployed at remote locations inaccessible during the snow accumulation and ablation season. This could provide real-time monitoring of snow at high-latitude and high-elevation field sites. Acoustic devices deployed on sea ice could monitor changes in accumulated snow cover to help predict summer ice melt.

Real-time data from the acoustic gauge could be used directly as internal state variables in land surface scheme and climatology models, reducing the need to treat the snowpack as a conceptual black-box system driven by mass and energy fluxes at interfaces between the snowpack surface and the ground. This may help to improve predictions of drought, flood and climate change made using these models, and may also lead to a new generation of predictive applications.

SWE, snow density, snow depth, snow temperature and heat flux can be measured by the use of acoustics. An inverse model constrained by a forward model provided good estimates of these key snowpack parameters. This is the first test of a device used to take acoustic time-series measurements of snowpack parameters at a stationary location.

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Hyporheic zone influence on reach-scale water budgets within a boreal shield catchment of Quebec, Canada

R.C. Zanatta[1], S.K. Carey, and M.C. Richardson
[1]Department of Geography and Environmental Studies, Carleton University, Ottawa, Ontario, K1S 5B6; Email: rzanatta@connect.carleton.ca

Introduction

At the catchment scale any change in discharge during baseflow conditions is often attributed to groundwater recharge or discharge along the stream length. However at smaller spatial scales along the channel (i.e. reach scale) net discharge is not always a function of groundwater input or output. Reach-based research on streams in alpine catchments has found that variation in net discharge occurs along different sections of a channel, and that this change in discharge reflects the difference in concurrent gross channel water gains and losses not associated with groundwater flow (Payn et al., 2009; Covino and McGlynn, 2007; Harvey and Bencala, 1993). This process by which water exits a channel, enters the subsurface, and returns back to the channel downstream is termed hyporheic exchange. Water and solute loss can be substantial, occurring at multiple scales and the magnitude of such loss has been found to correlate with certain channel types and morphological features such as upslope accumulation area (UAA), channel slope, and valley width (Jencso et al., 2010)

The objective of this research is to: 1) quantify mass loss of conservative solute and gross channel water losses and gains to establish the importance of the hyporheic exchange process on stream longitudinal water budgets during recession periods in a boreal shield headwater catchment, and 2) evaluate if relations exist between exchange and catchment morphometry.

Study Area

Watershed 8 (45º32'04.90''N 75º53'55.10''W) is a 2.94 km^2 catchment in Gatineau Park, Quebec, lying above the Eardley escarpment draining northeast into Meech Lake (Fig. 1). W8 is located within the boreal shield region of Canada with thin humo-ferric podzolic soils and Precambrian bedrock outcrops. Nine reaches were selected for study with reaches 1 to 6 on the main channel which branches to the west upstream from the outlet, while reaches 7 to 9 are located in a separate subwatershed to the south at a much greater elevation (Fig. 1).

Methods

Six series of tracer injections were performed on the 9 reaches from July to November 2011. Slug injections consisted of 200 g pre-dissolved sodium chloride (NaCl) in 2 L of stream water. Solute concentrations were measured at reach upstream and downstream ends using HOBO specific conductance probes logging at 2 second intervals. The loggers were calibrated at the beginning of the study period and a mass (g) concentration (μS/cm) relationship was modeled. Mass recovery was quantified using the downstream concentration pulses for each upstream injection and subsequently used to determine mass loss (g) for each reach. Mass loss was normalized to reach length (m) as reach distance varied from 102 to 225 m. Two methods of discharge measurement were utilized: i) velocity-area using a SonTek Flo Tracker, and ii) dilution gauging with mixing lengths ranging from 15 to 45 meters. Gross hydrological losses and gains were calculated following the methods of Payn et al (2009).

Several watershed topographic parameters including wetness index and drainage slope were determined for each reach using ArcMap 10 and System for Automated Geoscientific Analyses (SAGA). In addition to the multi-reach experiment, four series of tracer injections were conducted on reach 2 using four different injection masses (50, 100, 200, and 400 grams) each field week in order to assess the influence of tracer mass on interpretation of hyporheic exchange.

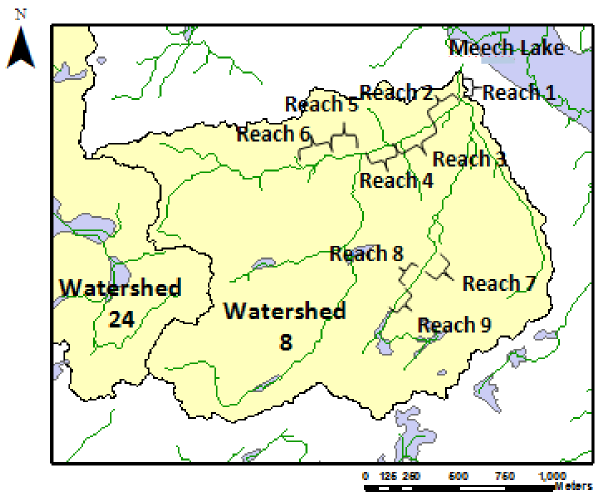

Fig. 1. Map of Watershed 8 and location of reaches

Results

Mass loss was substantial in all reaches and increased throughout the summer baseflow recession to a maximum of 88% at reach 4. High solute exchange exists for all reaches despite most exhibiting slight positive net discharge values. Minimum gross channel water loss during low flow conditions ranged from 34% to 88% of reach upstream discharge with maximum potential gross losses exceeding well over 100% for most reaches. A distinct power law relationship exists between mass loss and discharge for the 6 main channel reaches ($R^2 > 0.9$) with a large increase in the rate of loss associated with flows less than 10L/s. Long contact times of the solute clouds in reaches 7 and 8 combined with time constraints in the field limit the availability of data for those two reaches during lower flows.

Reaches 2, 4, and, 7 had high amounts of mass loss while the others had low to moderate mass loss (Fig. 2). Under low flow conditions, the proportion of solute and gross water loss in reaches 3, 6, and 9 increased markedly. Mass loss increased for each reach as contact time increased (r^2 ranging from 0.63 to 0.96 for reaches 1-6). When normalized to contact time reaches 2, 4, and 7 still maintained high magnitudes of mass loss however reach 1 experienced the greatest magnitude of loss for most weeks (Fig. 2). The variation in loss between weeks for each reach also decreased, removing the large increase in loss associated with low flows. The multi-mass experiments show high variability in mass loss (10 to 20%) between injection amounts for each field week with weeks 1 and 4 having significantly similar mass loss values ($p > 0.05$) despite an 18L/s difference in downstream discharge. The 50 g injection from week 1 resulted in mass loss percentages greater than the 100, 200, and 400 g injections during the lower flow period week 4 (Table 1).

Table 1: Mass loss values for the multi-mass experiments. Downstream discharge is listed beside the week.

	Mass Loss (%)			
Injection Mass (g)	Week 1 – 36.9L/s	Week 2 – 10.7L/s	Week 3 – 3.3L/s	Week 4 – 18.7L/s
50	28.2	46.2	52.2	29.8
100	7.3	36.0	59.4	11.3
200	10.9	36.4	66.7	16.4
400	13.7	42.9	68.8	25.9

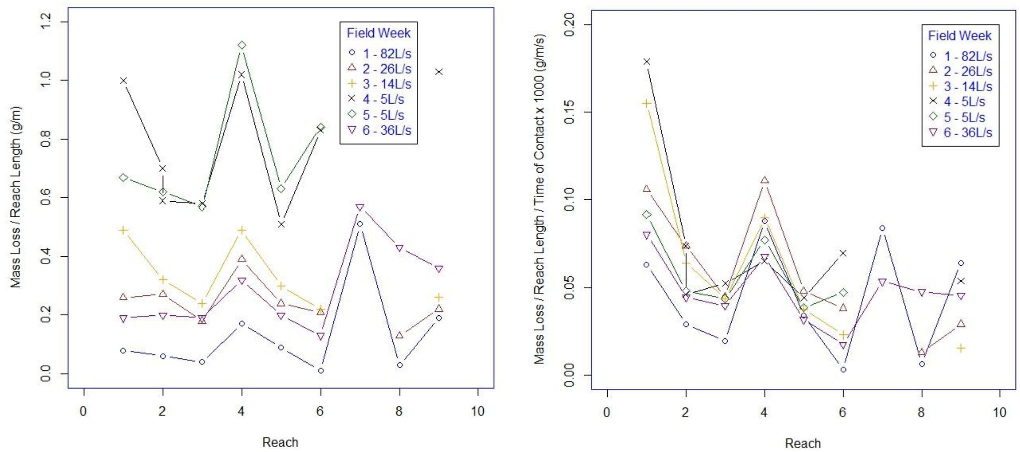

Fig. 2 Left graph - Mass loss normalized to reach length for each reach over all 6 field weeks. Discharge at the downstream end of reach 1 is given beside each field week in the legend. Right graph – Mass loss normalized to reach length and time of contact of the solute cloud in the channel.

Discussion and Conclusions

Results suggest discharge is a principal factor in the amount of mass loss. The large increase in mass loss for all reaches during the low flow weeks (5 L/s at the downstream end of reach 1) may represent a response to a secondary factor associated with baseflows below a specific discharge value. The reduced variation in loss between weeks from normalizing for time demonstrates the dependence of loss on contact time. Inter-reach variability in mass loss apparently implies watershed control on exchange potential. However, most watershed properties analyzed in this study showed no significant relationship with mass loss result, unlike results reported elsewhere (Payn et al., 2009). High losing reaches 1, 2, 4, and 7 did have the greatest channel slopes, which produce greater pressure gradients and larger downstream hyporheic flowpaths. Longer flowpaths exiting reaches 4 and 5 could be returning to reach 3 resulting in larger gross gains and less mass loss within this reach. Low losing reaches 3 and 6 also exhibit smaller average valley widths, which tend to constrict the size of the hyporheic zone and hence reduce magnitude of exchange. Furthermore these two reaches have large UAA more conducive to prolonged hillslope groundwater connectivity in effect limiting the scale of hyporheic flow (Jencso et al., 2010). The increase in mass loss to reaches 3, 6, and 9 during low flow conditions may be from water table disconnection and the influence of channel morphology (braiding and meandering). Overlap in mass loss between weeks caused by different injection amounts stresses the need to use a constant injection mass for all reaches when conducting hyporheic tracer studies otherwise comparative analysis may be unduly biased.

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We seek a dynamic, independent and talented individual for the position of Executive Director, Canadian Geophysical Union

Position: Executive Director, CGU

Accountable to: CGU Board of Directors

Primary Objective: To advise and assist the Board of Directors in the formulation of objectives, goals and policies of the Union; to implement policies approved by the Board; to provide leadership in the management of the operations of the Union; to plan and undertake initiatives to grow the membership and resource base of CGU.

Background: The CGU has an ambitious program of stated goals:

- ADVANCE and promote the scientific study of Earth and its environment in space and to serve as a national focus for the geophysical sciences in Canada
- FOSTER cooperation between the Canadian geophysical community and other national and international scientific organizations.
- ENCOURAGE communication through the organization and sponsorship of conferences and the publication of scientific results.
- PROMOTE integration of geophysical knowledge with that of other sciences concerned with the improvement of life on Earth.

These goals require the efficient management of a large number of activities which have a significant administrative and managerial component. Examples include the management and growth of membership initiatives, the effective planning for successful and profitable annual meetings, maintaining an effective web/social media presence, and interacting with other societies and organizations. To enable the CGU to reach its full potential requires a high level of effort, diligence and professionalism in the conduct of all of these functions. The increasingly complex environment of legislation and regulation with which the CGU must be compliant increases the administrative and management burden.

Specific responsibilities:

1. Develop and make recommendations to the Board of Directors and/or the Executive Committee on any policies and other matters requiring their consideration and approval. Provide supporting information necessary to enable the Board to properly evaluate such recommendations.

2. Evaluate, on a continuing basis, the Union's policies, programs, activities, and operations to ensure proper execution of responsibilities.

3. Develop and implement plans to grow the CGU member and resource base, in consultation with the CGU executive.

4. Develop plans and policies as required to ensure CGU compliance with applicable government regulations regarding non-profit societies, and execute such plans after review by the Executive Committee.

5. Manage the Union's operations, including oversight of computer systems, databases and software, and taking prudent steps to provide for the security of the physical assets and records of the Union.

6. Assist the Secretary and Treasurer in ensuring an effective system of financial accounting for receipts and disbursements, and in the exercise of prudent judgment in the disbursement and investment of assets. Assist the Treasurer in arranging for an annual CPA audit of the Union's financial records.

7. Direct the planning, development and preparation of the annual budget proposed to the Board of Directors for consideration and approval, after review by the Secretary and Treasurer.

8. Keep the officers and directors informed on the conditions and operations of the Union on all important matters. Plan and coordinate meetings of the Executive Committee and Board of Directors. Ensure that records are maintained as required.

9. Represent the Union to other professional scientific societies and organizations.

10. Manage the Society's membership activities, including membership development, application & renewal systems, and membership services.

11. Assist in the management of the Union's publications, including acting as Editor of the CGU newsletter *Elements*.

12. Maintain the CGU website.

13. Oversee the planning and execution of the Union's annual meetings by local organizing committees; consult as needed. Liaise with other organizations in the planning of joint meetings. Assist in obtaining sponsorships for the annual meeting.

14. Provide consultation and assistance to CGU officers in the completion of their duties such as appointing committee members, meeting preparation, making reports to the Board, representation at official meetings etc.

15. Assume other responsibilities or perform other duties as may be necessary for the administration of the Union or deemed necessary by the Board of Directors.

16. Attend the annual CGU meeting and assist in its meetings as required.

Skills Required:

We seek an individual who will be effective, professional and passionate about achieving the goals of the CGU. The Executive Director position requires strong leadership and excellent communication skills. The ability to formulate objectives, develop an action plan to achieve them, and work independently to execute an action plan is essential. General knowledge of science and the functioning of scientific societies, along with an entrepreneurial attitude, are required. Experience in strategic and financial planning is highly desirable. A post-secondary degree is essential, with considerable experience in science, education, public relations and management.

Remuneration:

The Executive Director is a part-time position, 2 days/week, with flexible hours and location as determined by the Candidate. It is a one-year renewable contract position, at the rate of $20,000/year. Travel expenses will be provided as required, upon approval of the Executive Committee. The Executive Director shall function as an Independent Consultant, and is not an employee of the CGU. There are no benefits associated with the position.

Application procedure: please send a cover letter and CV in PDF format to the CGU secretariat at CGU@ucalgary.ca, with a copy to the CGU president, gmatkinson@aol.com., with the subject line "CGU Executive Director". Your cover letter should address why you are a good candidate for this position, and how you would approach this role. Your CV should provide your educational background and experience, highlighting roles and responsibilities that relate to the requirements of this position. We will accept applications during the time period of July 15 through Aug. 15, or until the position is filled.

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Submissions should be sent to the Editor:

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