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THE NEWSLETTER OF THE CANADIAN GEOPHYSICAL UNION

IN THIS ISSUE

LE BULLETIN DE L'UNION GÉOPHYSIQUE CANADIENNE

President's Column

Colleagues and friends,

It was a pleasure to meet with many of you at our Annual meeting last month, and great to be back in CGU's "home town" venue of Banff. We enjoyed welcoming colleagues from the Canadian Society of Agricultural and Forest Meteorology to our stimulating and successful meeting. This year's Banff meeting was attended by 200 registrants, providing about 60 talks and posters daily over our 3-day meeting, in addition to the President's Plenary Session and a special lecture by our Tuzo Wilson medalist. We had a rich program of special sessions in all of our CGU section areas, including Hydrology, Geodesy, Solid Earth, and Biogeosciences. It is particularly satisfying to see the growth of interest in our new CGU sections (Solid Earth and Biogeosciences), as the development of new sections enriches our meetings and membership base and will help ensure the long-term health of CGU. We also enjoyed a number of social functions at the meeting, including the Icebreaker reception, a traditional Western Canadian Barbecue (complete with line dancing!), and the CGU Awards Banquet. Special thanks to Rod Blais, Holger Steffen and Ed Krebes for their hard work in organizing a successful scientific program and an enjoyable meeting.

I know you will join me in congratulating our CGU award winners on the well-deserved recognition they have been given for their accomplishments. We congratulate our Tuzo Wilson Medalist, Fred Cook, our Young Scientist awardee, Michael Riedel, and the CGU Meritorious Service awardee, Masaki Hayashi. We also congratulate the winners of the student paper awards, who inspire us with their promise of many stimulating scientific developments to come in the future. We thank Hugh Geiger, Cherie Westbrook, and their hard-working volunteer committees who judged the posters and presentations. We welcome Brian Branfireun as the new Vice-President of CGU, along with our new Treasurer Richard Petrone. We thank outgoing Treasurer Kathy Young for all her hard work on our behalf, and also past-President John Pomeroy, who concluded his "tour of duty" on the Executive Committee. And we offer our special thanks to Spiros Pagiatakis, our outgoing CGU President, for his guidance and dedication to CGU over the last two years. He will be a tough act to follow!

We continue to work on building the connections between CGU and our sister societies. One way we do this is through building the Canadian Societies for the Geophysical Sciences, inviting in new member societies to help provide a strong voice for our science; we also partner with sister societies to work on specific initiatives. Another way we build bridges is through joint meetings. We are pleased to be working with the Canadian Water Resources Association on a joint annual meeting in Banff for 2012, and in 2013 we will be meeting with the

Canadian Meteorological and Ocean Sciences group in Saskatoon. Stay tuned for further details! And in the meantime, please be an active member in CGU, and encourage others to join our vibrant society.

With best wishes for the summer!
Gail Atkinson

J. Tuzo Wilson Medal – Call for Nominations

The Executive of the CGU solicits nominations for the J. Tuzo Wilson Medal – 2012. 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, 2012. 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 – 2012. 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, 2012. 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

CGU Young Scientist Award – Call for Nominations

The Executive of the CGU solicits nominations for the CGU Young Scientist Award – 2012. 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, 2012. 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 – 2012. 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, 2012. 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

CGU Meritorious Service Award – Call for Nominations

The Executive of the CGU solicits nominations for the CGU Meritorious Service Award – 2012. 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, 2012. 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 – 2012. 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, 2012. 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	2009	Garry Jarvis
2007	Ed Krebes	2010	Zoli Hajnal
2008	Patrick Wu	2011	Masaki Hayashi

CGU-CSAFM Joint Annual Meeting, Banff, May 15 – 18, 2011

Rod Blais

The 37th Annual Meeting of the Canadian Geophysical Union (CGU) was held jointly with the Annual Meeting of the Canadian Society of Agricultural and Forest Meteorology (CSAFM) at the Banff Park Lodge in Banff, AB, on May 15-18, 2011. Some 211 participants (including 96 plus eight single-day students) took part in the four day meeting, out of which eight plus two students indicated CSAFM membership. The scientific theme for the meeting was "**Geophysical Sciences for the Future**".

The joint CGU-CSAFM Meeting started with a Plenary Presidential Session on Sunday evening with the following Invited Speakers:

- E.R. Ivins: High Precision Space Geodetic Observations for Cryosphere, Hydrology and Solid Earth Sciences
- H.S. Wheater: Water Security in Western Canada – A Research Agenda
- N. Roulet: Fluxes of Energy, Water and Carbon in Terrestrial Ecosystems – Peatlands as an Example

and the Woo Lecture in Hydrology on Tuesday afternoon was given by:

- B. Wilcox: Ecohydrology in the Anthropocene: It Is Going to Be Interesting

The Technical Program included:

the GEODESY sessions:

- Advances in Space-Based Positioning
- Geoid-Based North American Vertical Datum
- Geodynamics of North America: Earthquakes, GIA and Deep Mantle Processes
- On Advanced Geocomputations and Web Collaboration

the HYDROLOGY sessions:

- General Hydrology I, II & III
- Wetland Ecohydrology I, II & III
- Post-Disturbance Forest Hydrology I & II
- Making Quantitative Connections between Groundwater and Surface Water
- Improved Cold Region Hydrology Processes, Parametrization and Prediction I, II, III & IV

the SOLID EARTH sessions:

- Imaging in Earth Sciences and Engineering
- Observing and Modeling Earth's Deep Interior
- The Laboratory Prospect to the Earth's Interior
- Insights into Weak and Strong Ground Motions
- New Developments in Seismic Hazard Estimation
- New Insights into the Crust and Mantle Structure on the North American Continent
- Physical and Mineralogical Properties of Meteorites and Planetary Materials as a Record of Solar System Processes

the BIOGEOSCIENCE sessions:

- General Biogeosciences
- Effects of Invasive Earthworms on Biogeoscience Processes

and the CSAFM sessions:

- Carbon and Water Cycling in Canadian Forests and Peatlands, and Micrometeorology of Canadian Ecosystems
- Application of Remote Sensing and Geographic Information Systems in Solving Environmental Issues

Also, as in previous years, a Geoid Workshop was organized by M. Veronneau on Monday afternoon. Poster sessions were held on Monday, Tuesday and Wednesday afternoons.

A Field Trip to the Columbia Icefield, organized by Scott Munro, on Sunday May 15 had some 11 participants, apparently all from CGU. Two Exhibitors, Campbell Scientific (Canada) Corp. and Hoskin Scientific Limited, had the latest in terms of environmental sensors and related data acquisition systems for the benefits of the participants.

This Joint Meeting was quite successful in its technical and social programs. The SPC and LAC members (listed in the Program Book and the website) have all contributed much to the organization of the meeting and deserve our sincere thanks. Special recognition should be included for Holger Steffen, our conference webmaster, and Margaret-Anne Stroh for all the arrangements. Any further comments and/or suggestions are always welcome.

The 2011 CGU J. Tuzo Wilson Medallist: Frederick A. Cook

Citation, by David Eaton

Fred Cook is one of the top geoscientists in Canada and is recognized as one of the world's leading crustal geophysicists. Over an illustrious 29-year academic career at the University of Calgary, Fred Cook amassed a truly world-class publication record concentrating on the application of geophysical techniques to address geological problems. It is especially fitting for the J. Tuzo Wilson medal that the main focus of his work has been the geological evolution of continents and orogenic belts (mountain systems) utilising a variety of geophysical and geological techniques, especially deep seismic reflection profiling. Recently, he has developed new high-resolution geophysical imaging methods to aid in the search for gemstones and other mineral deposits.

Fred Cook established his international reputation early in his career and is widely known for his work on the 'thin-skinned' thrusting in the southern Appalachians. Through a comprehensive and systematic set of ground-breaking publications, his interpretations of regional seismic profiles established a new tectonic paradigm for fold and thrust belts - including those that are now obscured by subsidence and burial. His work, which demonstrated unequivocally that the southern Appalachian fold-thrust belt was deformed by thin-skinned tectonics – i.e., by transport of thin (km-scale) thrust sheets along subhorizontal detachment surfaces over large distances (up to 100's km) - not only changed the prevailing view of the Appalachians, but also created a template for understanding the architecture of many similar orogenic belts around the world. This early work in Fred's career was a huge success for the U.S. COCORP program and laid the groundwork for a generation of deep-crustal seismic programs around the world, including Canada's LITHOPROBE program. Many of Fred Cook's first-authored publications quickly become highly-cited classics.

Canada is fortunate to have attracted Fred Cook to come to Calgary in 1982, long before the days of Canada Research Chairs and other initiatives designed to attract the best and brightest. After coming here, he was instrumental in establishing and sustaining the internationally-acclaimed LITHOPROBE program. One of the keys to LITHOPROBE's success was the unusually close interaction it engendered between different geosciences disciplines, especially between geologists and geophysicists. As a co-transect leader for two of the largest and most successful LITHOPROBE transects (Southern Cordillera and SNORCLE), Fred Cook was extremely effective in bringing together these two solitudes and influencing the research directions and careers of dozens of researchers in government and academia.

Although a geophysicist by training, Fred's work always commanded the utmost attention and respect from the top scientists in all fields of geoscientific research. Particularly noteworthy achievements from Fred's extensive list of LITHOPROBE publications include insightful work on the southern Canadian Cordillera and the startling discovery of 'frozen' (ancient) subduction beneath the northwestern Canadian Shield. A now-famous image of seismic reflectors dipping beneath the Great Bear Arc has become the 'poster child' of ancient subduction, showcased at international deep-crustal seismic meetings more times than I can recall.

Of course, it is no accident that Fred Cook's accomplishments have achieved such status. The superb seismic profiles, upon which his interpretations were based, reflected meticulous, state-of-the-art data processing performed under his direction at the Lithoprobe Seismic Processing Facility (LSPF). This national facility, which operated under Fred Cook's capable leadership for several decades, was arguably the best centre for crustal seismic processing in the world. Not only did LSPF serve as a Mecca for crustal seismic research and training, attracting seismologists from around the world, it also left an enduring legacy in the form of LITHOPROBE's online seismic atlas. In an age when many scientists focus only on peer-reviewed publications and other activities that bring them clear recognition, Fred Cook's unselfish devotion to important but behind-the-scenes roles such as this is of high note. As one of those rare and tireless individuals who oversee all activities to completion, he deserves full credit for the highly successful operation of LSPF and the LITHOPROBE transects that he led.

Fred Cook served as an inspirational role model and mentor for some of the most highly gifted graduate students that I have met. I count myself to be lucky to have had the opportunity to work with Fred Cook while doing my Masters degree. Observing his dedication, remarkable focus and contemplative approach to science, I learned lessons that helped me immeasurably in my own academic career.

As a researcher, Fred Cook has made seminal discoveries of fundamental importance that have changed our view of how mountain belts are created. As an unselfish scientific leader, he helped to propel the LITHOPROBE project to international prominence, and has exerted a highly positive influence on a generation of Canadian geoscientists. As a mentor, he has inspired his students and research associates to seek creative solutions and achieve more than they ever thought possible. In short, Fred Cook is eminently deserving of the 2011 J. Tuzo Wilson Medal.

Acceptance, by Fred Cook

Thank you, Dave, for those kind words; I am honoured and humbled to receive this award from the CGU. I thank all of you for being here, and I particularly want to express appreciation to my wife, Christy, for rearranging her schedule to attend.

I am especially honoured because Tuzo Wilson had a huge influence on my career, and was instrumental in me being here today. I did not know Tuzo well; I only met and spoke with him perhaps 3 or 4 times. However, the first, and most important, of these was in the mid 1970's. I had completed my Masters' degree at the University of Wyoming in 1975 under Scott Smithson. For this work I had acquired and analyzed gravity data and heat flow data from the Rio Grande Rift in southern New Mexico. Christy and I then moved to Oklahoma City where I went to work for CONOCO.

Tuzo gave a talk at the Oklahoma City Geological Society while we were there on the tectonics of western North America. Near the end of his talk, he suggested an interpretation for the origin of the Rio Grande rift that related it to subduction of the ridge between the Farallon and Pacific plates. It was a 'eureka' moment for me, not because I thought the idea was necessarily correct, although it may well turn out to be, but because it gave me a new way to look at what I had done – a perspective that required a much larger view than I had previously even considered. I spoke with Tuzo after his talk and decided then to pursue applying geophysical methods to understanding tectonics.

In 1977, Christy and I moved to Ithaca, New York so that I could begin graduate work on the COCORP project at Cornell University with Jack Oliver, Larry Brown and Sid Kaufman. In COCORP, we applied the Vibroseis seismic reflection profiling technique to mapping the deep structure of the continent. Jack and Sid felt it was time to record long transects to focus on the tectonic evolution of continents. By that time (late 1970's) we had quite a good understanding of how ocean basins form (and Tuzo was instrumental in that), but our knowledge of continents was substantially less. The subject of my dissertation work was to apply the technique across the southern Appalachian Mountains, one of the classical and best studied mountain belts in the world.

We recorded about 300-350 km of seismic data across strike; at the time it was the longest transect of its kind in the world. The results were successful, not because the data quality was particularly great, but because we learned a lot about how the mountains formed. This was an important lesson for me that Jack Oliver and I discussed many times: the value of the results is often more about what we learn from a project than about signal to noise or other measures of what we commonly refer to as data 'quality'.

Indeed, Jack always seemed to have good instincts and great advice, two traits he was admired for. In my experiences with him, however, he got one thing wrong. In 1981, I was offered a position at the University of Calgary and he told me that he predicted that I "would be back from Canada within two years." Well, I am still here. I often saw Jack at meetings for years after and he almost always commented something like "Fred, did you ever make the right decision!' How true.

When we moved to Calgary in 1982, both Christy and I were uncertain what to expect; we felt a little bit like 'strangers in a strange land'. But my colleagues at the University were all very welcoming. Phil Simony, Ed Ghent, Don Lawton, the late Al Levinson, and many others have always been strongly supportive.

In 1983, I received a call from Mike Berry at the GSC asking me if I would like to attend a meeting of the COCRUST (Consortium for Continental Reconnaissance Using Seismic Techniques) group. I felt very much like a neophyte graduate student again, because the meeting was small and included the major players in Canadian crustal seismology at the time – Ernie Kanasewich, Ron Clowes, Mike Berry, Alan Green, Zoli Hajnal, Bob Mereu, among others – all of whom I knew by their international reputations, but only a couple of whom I had even met. Just as with my colleagues at the University of Calgary, however, the COCRUST group welcomed me and over the following years became phenomenal colleagues to work with.

About a year earlier, Charlotte Keen and the CANDEL (Canadian Committee on the Dynamics and Evolution of the Lithosphere) committee had published an article in Geoscience Canada promoting a case for a major, national multidisciplinary project to study the lithosphere called LITHOPROBE. One of the objectives of the COCRUST meeting was to determine ways to meld the seismic component from COCRUST into such a national project. This was truly the ground floor of Lithoprobe, and I was fortunate enough to have been a part of it.

Over the next few years, Lithoprobe got underway with initial studies on Vancouver Island, in Kapuskasing, Ontario, and then in southeastern British Columbia. We began the now infamous Lithoprobe transect meetings – yearly meetings of all scientists, sometimes hundreds, that were interested in each transect. These fostered many opportunities for meeting and collaborating with an even wider group of geophysicists and geologists. Over the years, in addition to my seismological colleagues, I was fortunate to work with, and learn from, scientists such as John Percival, Ray Price, Jim Monger, Alan Green, Alan Jones, Philippe Erdmer and many, many more.

In 1987 the second, and much more extensive, phase of Lithoprobe was funded. The Secretariat was established at the University of British Columbia and a major physical installation was the Lithoprobe Seismic Processing Facility (LSPF) at the University of Calgary. For the next 20 years or so, Lithoprobe operated with Ron

Clowes at UBC as a wonderful Director and someone who has been an absolute joy to work with. To complete the organizational structure of the LSPF, I made what is one of the best decisions of my research career – I offered the position of Manager of the LSPF to Dr. Kris Vasudevan.

When I described the position to Kris, I carefully noted that his primary work responsibility was to help keep the computing facility operational, but I soon found out that that was far too limiting for Kris. He led short courses in using the system, data processing and even conducted his own research into such topics as simulated annealing, fractal patterns in seismic records, skeletonization, point pattern analysis and coherency filtering. Much of this work was done at a time when our computing power was less than what many of you have on your iPhones or other handheld devices today.

From 1988 until 2003, Lithoprobe recorded various kinds of geophysical data in ten transect regions. One of my favorites will always be the SNORCLE (Slave-NORthern Cordillera Lithospheric Evolution) transect in which we were successful in getting seismic reflections almost to the base of the lithospheric plate – true lithospheric profiling.

But, as great as all of these projects and colleagues have been, one does not go very far in academia without fantastic graduate students, assistants and post-doctoral fellows. I have been very fortunate to have students who have challenged me; I am certain that I learned as much or more from them as they did from me. In the end, of course, the most rewarding thing for me is that they have all been able to strike out on their own and achieve what they set out to do.

I want to close with a few words about my most ardent supporter, best friend, and love - my partner of 40 years (next month) and wife of 36 years, Christy. Christy has endured my absences due to many, many Lithoprobe meetings, numerous scientific meetings, NSERC meetings and years of extended fieldwork. She has been a teacher, started her own school, performed for years as a musician, volunteered hundreds of hours at the Alberta Children's hospital and is now a key volunteer for hospice in our community. One of her favourite expressions for our daughter, Adrionna, who only recently finished her teens, is to 'stay grounded'. Christy's example has always done exactly that for me and I will forever be grateful.

Thank you all, again, and I sincerely hope that you are as fortunate in your endeavours as I have been in mine.

The 2011 CGU Young Scientist Award Winner: Michael Riedel

Citation, by Roy Hyndman

I am very pleased to nominate Dr. Michael Riedel for the Canadian Geophysical Union Outstanding Young Scientist Award. Dr. Riedel is one of Canada's most impressive young geophysicists with great potential for future scientific achievements. For a still young researcher (PhD 2001), Michael has made exceptional scientific contributions, both in their scientific significance and in their importance to the needs of Canada and Canadians. His primary work has been in seismic structure studies of natural gas hydrate both beneath the seafloor and beneath arctic permafrost, but he also has made contributions in analyses of downhole geophysical logging, mapping of earthquake active faults on the seafloor, and deep sea slope failures that may result in local damaging tsunamis.

The scientific advances that Michael made in his PhD work at the University of Victoria led to his acceptance as a postdoctoral fellow (PDF) at the Pacific Geoscience Centre, Geological Survey of Canada. Michael was subsequently appointed to a faculty position at McGill University. Michael's appointment a McGill Endowed Research Chair was a considerable honour that recognized both his past achievements and his great potential as a researcher and teacher in the future. Two years ago we were very fortunate that Michael returned to the Pacific Geoscience Centre as a Research Scientist and to the University of Victoria School of Earth and Ocean Sciences as Adjunct Associate Professor. He also maintains an Adjunct position at McGill University.

Michael's PhD study was focused on a comprehensive seismic structure and other geophysics investigation of natural gas hydrate off Vancouver Island. Michael made substantial contributions in detecting, mapping, and characterizing the most important marine hydrate occurrences, both for potential future clean energy resource and for controls on human-time scale climate change. He participated on numerous deep sea research cruises, including chief scientist several times on the primary Canadian west coast deep sea research ship CCGS TULLY, each time leading a multi-institution international scientific team of ~20.

During his PDF Michael was responsible for two extensive studies and research reports to the Korea Institute of Geology, Mining and Materials (KIGAM) (Korea Geol. Survey) on processing, analysis and interpretation of seismic and other geological data in the East Sea (Sea of Japan) (KIGAM research funding). His work indicated that there likely were large concentrations of hydrate resulted in a substantial revision of their hydrate targets in the East Sea. His work and conclusions were key to the Korean hydrate drilling program in the fall of 2007 that encountered very significant hydrate concentrations. As would be expected, he is very well regarded in Korea. He is one of the foreign members of the Korea Hydrate Program Advisory Committee.

Michael's first involvement on the Ocean Drilling Program (ODP/IODP) was as a Canadian representative scientist on Leg 204 off Oregon. Following this program, Michael revived our previously unsuccessful proposal for a drilling transect across the margin of Vancouver Island to study the processes of progressive landward hydrate formation and final dissociation in the accretionary sedimentary prism. Much to the surprise and delight of all of us involved, his proposal was accepted by IODP and scheduled as 2-month long Expedition 311. His successes with scientific results from the Oregon drilling program led to his choice as co-chief scientist on IODP hydrate drilling Expedition 311 off Vancouver Island. To be chosen as a co-chief scientist for one of the IODP ($25M) drilling programs was exceptional for such a young scientist. This successful work also led Michael to be appointed co-director of IODP Canada.

Following the IODP 311 drilling, Michael's reputation for scientific and organizational capability led to his being co-chief scientist on a major (~$50M) drilling program by Oil and Natural Gas Corp. off India and more recently as chief-scientist on hydrate drilling by KIGAM in the East Sea off Korea. Michael has now been designated as chief scientist for the planned KIGAM second ~$50M program of scientific drilling, geophysical data, and core analysis for gas hydrate off Korea, an extraordinary recognition.

Among Michael's other achievements, he was chief scientist on a CCGS TULLY survey to map and characterize potentially earthquake active faults in Georgia Strait, potentially tsunami generating slope failures off Vancouver Island, worked on Saguenay sedimentary processes, and on hydrate studies off eastern Canada.

Michael started his strong informal support and mentoring of graduate students during his time as a postdoctoral fellow, and continued with formal supervision of a number of MSc and PhD students at McGill and currently at University of Victoria (2 postdoctoral fellows and 5 graduate students). Michael has great energy and enthusiasm that carries others along with him. He is exceptional in his support and encouragement of his students and PDFs and of other young scientists, not just at PGC and the University of Victoria, but elsewhere internationally.

The most readily quantifiable measure of Riedel's exceptional scientific productivity is his 46 publications mainly in the most respected peer reviewed international journals. The impact of these publications is demonstrated by the more than 325 citations by others (Google Scholar). This is an impressive number indeed for a scientist only 9 years from PhD. Many senior scientists do not reach this level of citation during their entire career.

Michael's scientific stature has led to his membership on the Council of Academies (Royal Society etc.) Review Committee on the Future of Gas Hydrate Studies in Canada, the U.S. Geological Survey Advisory Board on Natural Gas Hydrate, the Korea International Advisory Committee for Gas Hydrate, and as co-director of IODP Canada.

Michael is an exceptional young scientist, a very appropriate candidate for the Canadian Geophysical Union Outstanding Young Scientist Award.

Acceptance, by Michael Riedel

I am thrilled to receive the CGU Young Scientist Award in recognition of 10 years of productive post-PhD research. I would like to thank the CGU Award Committee for their consideration of my nomination, and especially Dr Roy Hyndman, who provided the citation for this award. Roy was my PhD supervisor (1998 - 2001) and has since then been a long-time supporter of my research both at the Geological Survey of Canada and at McGill University. I doubt I would be in this position today were it not for the tremendous support of many other researchers and co-workers in the field, whom I have come to know as colleagues over the years. First of all I would like to thank Scott Dallimore and Fred Wright, who entrusted me with my first postdoctoral research project at the Mallik Arctic Gas Hydrate Drilling Program in 2002, doing work on physical property characterization of the recovered core and assisting other scientists conducting seismic surveys in the vicinity of the drill site in challenging terrain conditions and -40°C temperatures. The practical experiences gained, together with the opportunity to collaborate with so many international scientists (especially Erik Spangenberg and Johannes Kulenkampff from Geo-Forschungs-Zentrum Potsdam) while participating in the first-ever production-test for gas hydrates, were fundamental to my decision to continue the pursuit of research in the field of gas hydrates. Soon after returning from Mallik I jumped onto another remarkable drilling experience - this time in the marine realm, on Leg 204 of the Ocean Drilling Program (ODP). During this expedition I worked closely for the first time with Dr Tim Collett of the United States Geological Survey. Over the past decade we have sailed together on many more ocean drilling cruises, and today we both share a great friendship. Since those early days of Mallik and ODP I have been involved in many other marine gas hydrate drilling expeditions around the globe. I believe any successes I have had in the course of this work have only been possible because of the support and hard work of many other people: the extremely hard-working drilling crews who never complain and pull core and deploy the drill-string in all kinds of weather and sea conditions (in down-pouring ice-cold rain during October in the Pacific, to above-30ºC and high humidity conditions of the Indian Ocean in the middle of summer, or weathering through a Typhoon off Korea); the core-technicians and lab-specialists, and of course of the vessel-support crews (from the captain to the machinists and cooks and stewards) that make life onboard safe and also pleasurable. Last but not least, my thanks go to all fellow research-scientists with whom I have had the pleasure to sail and to learn from, helping me to expand my own horizons. Being on those drilling-vessels for many weeks on end sometimes feels like being imprisoned, but on the other hand it is an enormous opportunity to work in close company with the brightest scientists on the globe. Working side-by-side with experts in fields such as micro-fossil analyses, or organic geochemistry, micro-biology, well-log engineering or borehole instrumentation, has given me a much better appreciation of the complexities of the geological and biological processes controlling gas hydrate formation and accumulation, and how I as a geophysicist can better predict their abundance and in situ characteristics. My acceptance of this award is a recognition of all the people who contribute materially to the success of these innovative and exciting research endeavours, making it possible for someone such as I to receive the CGU Young Scientist Award. Finally, I would like to also include all my graduate students, both at McGill University and University of Victoria, with whom I have had the pleasure to work. Their exuberance and refreshing ideas help keep me up-to-date and on my toes and thus, in spirit at least, a "young scientist".

The 2011 CGU Meritorious Service Award Winner: Masaki Hayashi

Citation, by Kathy Young, Ed Krebes, & Phil McCausland

We are delighted to announce that the recipient of the CGU 2011 Meritorious Service Award is Professor Masaki Hayahsi. Masaki's exceptional and continuing service to the Canadian Geophysical Union is an inspiration to all; we strongly believe that he is much deserving of this prestigious award and should be duly recognized by the broader CGU membership for his dedication to our Union.

Dr. Hayashi was Secretary of the CGU Executive from 2003 to 2010 and now continues as its Web Master. As Secretary, Masaki was responsible for maintaining registration lists, sending out reminders for annual fees, and maintaining the CGU Listserv where he sent out information to CGU members about annual CGU conferences, workshops, nominations for awards and other critical items of interest to all CGU members. He was also required to keep the CGU executive up to date on meetings, teleconferences and minutes of all correspondence. Masaki has been an effective administrator: his emails, minutes and other communications are always timely, clear and succinct and the executive has come to rely on his wise counsel. An email sent to Masaki is always replied to - the message back is clear, complete and always friendly.

Masaki played a critical role in bringing the CGU into the 21st Century. A few years ago he initiated a re-vamping of the CGU website and set up a new online membership registration, modernizing our membership tracking. He also envisioned the need for posting job opportunities for highly qualified personnel (graduate students, post-docs, and technicians). Now, the CGU website is actively browsed, and is generating funds for other CGU activities. In addition, the CGU Sections have followed his lead and are now posting scholarly opportunities on their own web sites.

What is very appealing about Masaki is his modesty. Despite being an incredibly active Canada Research Chair and scholar, he continues to be outgoing and interested in the research of others, especially young scholars. He willingly participates as a judge for student papers and posters at our annual general meetings and is generous in giving of his time, expertise, equipment and lab facilities, often times, to students of other colleagues. He asks for nothing in return, finding his reward in others' success.

We are extremely delighted to present the 2011 Canadian Geophysical Union Meritorious Service Award to Professor Masaki Hayashi. He is richly deserving of this honour, and the CGU has been improved by his dedicated service.

Acceptance, by Masaki Hayashi

I am honoured to receive the Meritorious Service Award. I thank Kathy Young, Philip McCausland, and Ed Krebes for nominating me for the award; and the current and previous members of the CGU Executive Committee whose collegiality, generosity with time, and wisdom inspired me while I was serving as the CGU Secretary. I would also like to thank Kate Bentley for assisting me with membership services and so many other things, and Mei Jun for skillfully updating the CGU web site.

I joined the CGU in 1994, when I was still a graduate student. Since then, I have befitted tremendously from the CGU in numerous ways, for example, presenting my research results at the annual meeting and receiving friendly suggestions and comments, finding out what my Canadian colleagues are doing, and making new contacts and developing research collaborations. So, when the former CGU Secretary, Kelin Wang asked me in 2003 if I was interested in taking over his position, I was very glad to accept the invitation. In this regard, I am thankful to Kelin for giving me the opportunity and guiding me through the transition period. For an assistant professor in an early career stage, serving on the CGU Executive Committee gave me a chance to understand the inner working of the Canadian geophysical community and our roles in context of the international community. This experience opened my eyes to broad issues (e.g. divided views on climate variability among earth scientists) from the national perspective, and helped me grow as a more experienced and mature scientist. I did put some time and effort into the day-to-day business of the CGU, but that was the time well spent considering what I have gained from my association with the CGU over the past 17 years. I am so grateful to the CGU for recognizing my efforts through this award, and I hope that this will encourage younger generations of scientists, students in particular, to become more involved with the CGU.

Leonard S. Collett, 1922-2011

Leonard Stanier Collett, the 1989 CGU J. Tuzo Wilson Medalist, passed away on March 9, 2011, in Ottawa. The citation and acceptance for the 1989 Wilson Medal can be found in the 1989 December issue of the CGU Newsletter (vol. 7, no. 3). A detailed memorial article can also be found in the June 2011 issue of The Leading Edge (published by the Society of Exploration Geophysicists).

Len received a Bachelor's degree in Chemistry from McMaster University in 1945 and a Master's degree in geophysics from the University of Toronto in 1948. After graduation, he worked for a few years for the Newmont Mining Corporation in Arizona where he tested physical rock properties in connection with the Induced Polarization (IP) phenomenon. This was followed by a distinguished 37-year career (1953-1990) with the Geological Survey of Canada, where he held senior research and development positions in electrical and electromagnetic methods in geophysics, environmental geophysics, and technology transfer. In 1969, Len became one of the few principal investigators selected to measure the electrical properties of the lunar rocks returned by the NASA Apollo mission. Len had a close association with, and made significant contributions to, the Canadian geophysics industry.

Len considered the support and encouragement of future generations of geophysicists as fundamentally important, and generously supported the KEGS Foundation which awards scholarships to Canadian geophysics students.

Shiu Luk

Professor Shiu Luk passed away on February 16, 2011. Shiu was a Professor in the Department of Geography at the University of Toronto Mississauga (formerly Erindale College). Shiu received his BA (Hons) (1968) and M.Phil (1972) from the Department of Geography at the University of Hong Kong. After receiving his PhD from the University of Alberta in 1975, Shiu held positions at Brock University and the University of Guelph before joining the Department of Geography at Erindale College in 1978. Shiu was about to become Director of the Institute of Land Information Management when he became ill in 1994 and was forced to retire. Shiu was a soil scientist who was a pioneer in international research at our campus. His research was well funded by both IDRC and CIDA. Before he became ill, Shiu was leading numerous projects in China including work on the Three Gorges project and soil management in Inner Mongolia. A very active and engaged academic, Shiu had over 30 peer-reviewed publications in top soil science and hydrology journals and was the editor of *Chinese Geography and the Environment*. He was a very active member of the department and a strong advocate for environmental education. His presence and contributions have long been missed.

- Information provided by Kathi Wilson, University of Toronto Mississauga

HYDROLOGY SECTION NEWS

CGU HYDROLOGY SECTION COMMITTEE REPORTS 2011

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 was preparing for the 18th Northern Research Basins Symposium and Workshop in Western Norway, August 15 – 20, 2011. This meeting will begin in Bergen and involve travel via ship and bus to Loen, Kjenndal, Fjœrland, Sognefiord and Voss. The conference theme is **Methods For Measuring, Collecting and Assimilating Hydrological Information in Cold Climates.** Two Canadians have been invited to deliver keynote addresses; Dr. Daqing Yang on snow, and Dr. Terry Prowse on research basins. Full details of the meeting can be found at www.18thnrb.com.

As outlined in the NRB Mandate and the Canadian NRB Terms of Reference, Canadian participation in the NRB meeting is limited to 10 delegates invited by the Canadian Chief Delegate (and approved by the CGU-HS Executive). The expertise of the delegates is meant to best encompass the breadth of the northern Canadian hydrology field and of the particular conference theme. The Canadian Chief Delegate to the 18th NRB meeting will be Christopher Spence of Environment Canada, while Scott Lamoureux, of Queen's University will serve as the Deputy Chief Delegate. The remaining slate of official Canadian delegates was submitted to the CGU-HS for approval in Jan.'11. These include:

Chris Derksen, Environment Canada: Snow
Richard Janowicz, Yukon Territorial Gov't: Water Management
Sarah Boon, University of Lethbridge: forest hydrology
Craig Smith, Environment Canada; Precipitation
Dr. Terry Prowse, Environment Canada University of Victoria: Ice
Daging Yang, Environment Canada: Regional Hydrology
Ming-ko Woo, McMaster University: Permafrost Hydrology

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. 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)

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 Improved Processes, Parameterization and Prediction in Cold Regions (IP3) initiative will complete its final year of funding in 2011 by the Canadian Foundation for Climate and Atmospheric Sciences. IP3 is registered as a cold regions working group with the international PUB initiative (http://www.iahs-pub.org/WG16.php). More information on IP3 specifically can be found at www.usask.ca/ip3.

This report will be tabled after the **Putting PUB into Practice** workshop has been held from May 10 – 14, 2011. It is being arranged by a Local Organising Committee chaired by Paul Whitfield recently of Environment Canada, in conjunction with a Scientific Programming Committee led by Dr. John Pomeroy (PUB 4th Biennium Chair) and formed from leading members of the PUB movement from around the world. The principal aim of the meeting will be 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 is bringing 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 will seek to share and consolidate 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.

CNC-PUB continued the delivery of thematic workshops with **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. In more arid regions of Canada, streams contain water only during restricted periods of the year. Improving the measurement, prediction and management of water flux and availability in intermittent systems is important to economic and environmental sustainability in certain areas of Canada. This workshop brought together scientists and managers who are engaged in understanding and managing these systems. We hosted seven invited speakers, four poster presentations, and an additional thirty attendees from various sectors of academia, government and industry. Participants came from across the country, highlighting the importance of intermittent streams to many regions of Canada. The workshop was structured around a series of presentations and discussions that centred on three key themes; measurement, analysis, and applications. The invited speakers have provided their presentations in PDF format, which are posted on the workshop's website, http://www.sfu.ca/~zeroflow/. We are also working on a special issue of the Canadian Water Resources Journal, which will contain papers from this workshop. As a follow-up to the workshop, we invited participant input on two key points that arose from our discussions:

1: Data Visualization: What do you see as useful tools for visualizing data from or about temporary streams? What tools do you currently use and why?

2: Temporary Stream Classification: We agreed that temporary stream systems require some type of classification technique or unique 'barcode'. What parameters might we include in this classification system, and how might we ensure that it remains dynamic?

We welcome additional input from the PUB community on these topics, and hope to host a second workshop to build on the progress from this one.

Future Meetings and Activities

The PUB decade ends in 2012, and as noted above information and technology transfer activities will be the focus of CNC-PUB. The jointly held annual conferences of the Canadian Geophysical Union and the Canadian Water Resources Association in 2012 and 2013 provide excellent opportunities for special PUB sessions to highlight the progress made in improving prediction in ungauged basins in Canada. Canada is proposing a Kovacs Colloquium on PUB to be held in Paris in 2012 as a PUB wrap-up activity.

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 for the evaluation of hydrological and hydroclimatic models and the organization of regional, national and global networks that serve to build scientific capacity for tracer-based research. Recent advances in water isotope lasers have made analyses of δ^{18}O and δ^{2}H of water and water vapour more accessible to the hydrological community giving new importance to our objective of promoting and advancing isotope tracer techniques. The proliferation of new water isotope datasets offers new opportunities to use the labeling of the stable isotopes of water to improve understanding of hydrological processes including coupled land-atmosphere processes.

Some highlights from 2010 include:

Meetings and Workshops:

- International Symposium on isotopes in Hydrology, Marine Ecosystems, and Climate Change Studies 27 March- 1 April 2011, Monaco, Organized by the International Atomic Energy Agency.
- The Roles of Stable Isotopes in Water Cycle Research: Keystone, Colorado 28 March – 30 March 2011. Sponsored and organized by the Biogeosphere-Atmosphere Stable Isotope Network (BASIN). The goal of the workshop was to review recent advances in the use of stable isotopes as a means to inform and deepen our understanding of ecological, hydrological and atmospheric processes impacting the water cycle.
- Tracer committee members are currently participating in a Co-ordinated Research Project organized by the International Atomic Energy Agency titled "Use of Environmental Isotopes in Assessing Water Resources in Snow, Glacier, and Permafrost Dominated Areas Under Changing Climatic Conditions". The goal of this project is to assemble isotopic evidence for water derived from snowpack, glaciers, and permafrost in adjacent groundwater and surface waters under present climatic conditions in a variety of snow-and-ice dominated catchments and to evaluate the potential alterations to these relationships under changing climatic conditions. The first meeting was held on 30 Aug.- 4 Sept. 2010 and included cold region hydrologists working in Canada, Georgia, Germany, Japan, Pakistan, Russia, Slovakia, Slovenia and the United States.

Other and ongoing committee activities:

- Maintenance of the Tracer Committee web-site http://www.science.uwaterloo.ca/~jjgibson/gibson_files/isotope.html
- Support of IAEA/WMO Global Network of Isotopes in Precipitation and Large Rivers Program.
- Liaison and support for expanding national isotope monitoring/science networks (Canada: Canadian Network for Isotopes in Precipitation, United States: USNetwork for Isotopes in Precipitation).

Other News

The isotope hydrology community was saddened to hear of the death of our valued colleague, Gian Maria Zuppi, who passed away on 12 May 2011. Gian Maria was a well-respected hydrologist, who developed isotope techniques for tracing and dating water in the hydrological cycle. He was the present President of the IAHS International Commission on Tracers. A tribute to Prof. Zuppi can be found at http://iahs.info.

Applications of Isotopic Tracer Techniques:

The trend in Canadian isotope tracer research has recently been towards sustained long-term monitoring of precipitation and river discharge to enable better characterization of spatial and temporal variability in isotope signatures and their underlying causes.

A number of large-scale research programs using water isotope tracers to better characterize past and present hydrological processes are currently underway in Canada including:

- the **Mackenzie River Basin** as part of the Global Energy and Water Cycle Experiment and the IAEAs Coordinated Research Project (CRP) on Large River Basins,
- the **St. Lawrence River** also as part of the IAEA CRP Large River Basin project,
- the **Peace Athabasca Delta, Slave River Delta, Old Crow Flats, and Wapusk National Park** are all large-scale field programs in which researchers are using water isotope tracers to characterize the water balance of modern lakes as well as using isotopic archives to evaluate changes in hydrology over the last millennium,
- the **Grand River Basin** is the location of an intensive campaign sampling groundwater, river water and precipitation providing the first basin-wide isotopic sampling within the Great Lakes catchment,
- **Nelson River Basin** will be the location of a new 4-year isotope sampling program in which the isotopic composition of rivers, lakes, wetlands, snow, baseflow, precipitation and evaporation will be used to improve the hydrological modelling of the basin using isoWATFLOOD.
- A 5-year study to determine critical loads for nitrogen in Boreal ecosystems is currently being initiated at two field sites near **Fort McMurray.** Isotopic tracing of water and nitrogen will be used to assess the connectivity of bogs, fens and uplands in the region.
- Isotopic tracers are being used in studies focused on the **Athabasca River** near Fort McMurray to try to identify inputs from groundwater seeps and tailings ponds. A pilot study conducted during 2009 and 2010 to assess potential for inorganic and organic labelling of process-affected water from oil sands operations to the Athabasca River can be downloaded at: https://era.library.ualberta.ca/public/view/item/uuid:b263c6c6-5de3-43c2-bca3-f5e979fecf2d

Dissemination

Tracer Committee members have been actively promoting the use of isotope tracer techniques in hydrology through refereed publications, meetings and conferences, as well as supporting the training of highly qualified persons. The Tracer Committee website has been updated to include links to some recent publications. Other dissemination highlights include:

- There is open access to the Journal of Limnology where some of the above-mentioned papers describing the use of isotope-based site-specific estimates of water yield for regional acid sensitivity assessments. http://www.jlimnol.it/JL_69_supl1/JL_69_supl1.htm

Upcoming Meetings:

- International Association of Hydrological Sciences, 28 June- 7 July 2011: Earth on the Edge: Science for a Sustainable Planet, “Tracer hydrology as a tool for estimating flow parameters, groundwater dynamics, pollution transport and bioremediation processes in heterogeneous systems: , Melbourne, Australia.
- Canadian Water Resources Association, 27-30 June, 2011, “Our Water – Our Life – The Most Valuable Resource”, St. John’s Newfoundland.
- Association of Isotope Geochemists 19-23 September 2011. Tarragona, Spain.

CNIP Subcommittee:

Operation of CNIP continued during the past year, with sampling conducted by the Meteorological Service of Canada and analyses supplied by the Environmental Isotope Laboratory, University of Waterloo. The network consists of 19 stations distributed across Canada (spanning almost 40° of latitude and 70° of longitude) collecting weighted monthly precipitation samples for $\delta^{18}O$ and $\delta^{2}H$. The majority of CNIP sampling sites are meteorological stations operated by the Meteorological Service of Canada and the Canadian Air and Precipitation Monitoring Network (CAPMoN) with analyses conducted by the Environmental Isotope Laboratory, University of Waterloo. The CAPMoN networks primary use is for monitoring non-urban air quality to establish spatial and temporal trends in atmospheric pollution (e.g. ozone, particulate, smog, acid rain). In addition, CNIP also includes 3 stations where daily precipitation samples are collected for $\delta^{18}O$ and $\delta^{2}H$ analyses. This valuable dataset marks the first time that both the southern and northern regions of the country have been simultaneously sampled, and currently consists of a nine-year dataset for the entire country. This partnering between CNIP and CAPMoN has benefited both parties by creating a comprehensive dataset that includes geochemical as well as isotopic characterization of precipitation chemistry providing additional tracers to constrain source areas and transport history. Between January 1998 and January 2010 over 6000 precipitation samples were received at the Environmental Isotope Laboratory at the University of Waterloo, approximately 5000 of which have already been analyzed.

Meetings and Activities

- Birks, S.J. Edwards, T.W.D. Neelmoy, N.C. Gibson, J.J., Drimmie, R.J., Michel, F. and McTavish, D., Isotope climatology of Canada: Insights from the first decade of CNIP operation (1997-2007), Joint Assembly, The Meeting of the Americas, 24-27 May 2009, Toronto, Canada.

- Maintenance of the CNIP subcommittee web-site, http://www.science.uwaterloo.ca/~jjgibson/gibson_files/cnip.html
- Maintenance of the CNIP web-site, http://www.science.uwaterloo.ca/~twdedwar/cnip/cniphome.html
- Liaison and support for expanding national isotope monitoring/science networks (Canada: Canadian Network for Isotopes in Precipitation, Canadian Geophysical Union Committee on Isotope Tracers and CNIP Subcommittee, Manitoba Network for Isotopes in Precipitation, United States: USNetwork for Isotopes in Precipitation, Australia: GNIP, OzFlux, Bureau of Meteorology, CSIRO, ANSTO)

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 meeting.
- Reciprocal membership arrangement and affiliation between CGU and Canadian Geomorphology Research Group has resulted in several sessions at other national conferences.
- Currently developing initial suggestions for sessions at CGU 2012 with CWRA and with CGRG (who are planning their annual meeting at CGU in 2012) on topics in the general area of hydro-geomorphology, and watershed and channel restoration.
- 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.
- Canada hosted the 7th International Workshop on Gravel Bed Rivers in Tadoussac, Quebec, September 2010. A. Roy was conference Chair and the organization and scientific activities were done entirely by a group of Canadian geomorphologists and hydrologists, and sponsored by several Canadian universities, public agencies and private companies. A conference book (lead editor M. Church) and special issue of Earth Surface Processes and Landforms (co-editors P. Ashmore and C. Rennie) are forthcoming.

SOLID EARTH SECTION NEWS

This is the second complete year of operation for the new CGU Solid Earth Section. Our membership is growing and Solid Earth sponsored seven sessions at the 2011 annual meeting in Banff, including sessions on seismic hazards, geophysical imaging, mineral physics, mantle and core modeling, and North America's crust and upper mantle structure.

The Banff meeting also featured the 2nd running of the Solid Earth Section's Student Best Paper Award, based on submissions of an extended abstract of no more than 3 pages including figures and references by students who were first author and presenter of their paper at the meeting. The Award consists of a $500 prize and a commemorative plaque. The winner for 2011 is Agnieszka Pawlak of the University of Calgary. Her extended abstract and presentation at the Banff meeting was entitled, "Azimuthal anisotropy of Hudson Bay using ambient noise." Congratulations, Agnieszka!

A new Solid Earth Section Executive was elected in May as well, for the 2011-2013 term. We welcome the incoming Section President, Sam Butler (University of Saskatchewan), Vice President Claire Samson (Carleton University) and Member-at-Large Andrew Frederiksen (University of Manitoba), and thank outgoing (now Past) President Kristy Tiampo and Member-at-Large Mahmoud Abd El-Gelil. The new Section Executive, contact information and other details are available on the CGU Solid Earth website, at:

http://www.cgu-ugc.ca/SESection/index.htm

- Phil McCausland
Secretary, CGU Solid Earth Section

GEODESY SECTION NEWS

Prepared by Patrick Wu, President, CGU-Geodesy Section

In the CGU-CSAFM Joint Meeting this year (2011), we had 4 scientific sessions: 1) ***Geoid-based North American Vertical Datum***, 2) ***Geodynamics of North America: Earthquakes, GIA and deep mantle processes***, 3) ***Advances in Space-based Positioning***, 4) ***On Advanced Geocomputations and Web Collaboration.*** In total, there were 22 oral and 2 poster presentations. In addition there was a ***Geoid workshop***.

Best Student Paper in Geodesy: The winner in 2011 is Panagiotis Vergados (York University). The paper, co-authored with Spiros D. Pagiatakis, is titled **"**Assessing the effect of gravity anomalies on GPS/RO-derived temperatures: First results from the GRACE mission**"**.

Special Issue Publication in GEOMATICA: CGU-GS members are encouraged to submit papers to the Special Issue. The deadline for submission is Sep 30, 2011. Please submit to <Marc.Veronneau@NRCan-RNCan.gc.ca>

New Scientific Network: Calvin Klatt announced the existence of the "Canadian Geodesy-Related Science Network".

IAG-CNC-IUGG : The Canadian National Council to the IUGG represents Canada with the IUGG and with all international associations that compose the IUGG. One of them is the International Association of Geodesy (IAG). Currently, the Senior national delegate is Marcelo Santos and the Junior National Delegate is Joe Henton - all serving for 4 years coinciding with the IUGG. As the term ends, the Senior delegate retires and the Junior takes over as Senior. A new Junior delegate is to be nominated before July 6th, 2011.

Geodesy Section Executive:
The following are members of the Geodesy Section Executive for the 2010/2012 term: Patrick Wu (president , Calgary), Marc Véronneau (vice-president, NRCan), Joe Henton (secretary, NRCan), Mohamed Elhabiby (treasurer, Calgary), JeongWoo Kim (member-at-large, Calgary), Mohammed El-Diasty (member-at-large, York). The past president is Marcelo Santos (UNB).

BIOGEOSCIENCES SECTION NEWS

Prepared by M. Altaf Arain, President, CGU-Biogeosciences Section

The Biogeosciences Section had a very successful annual meeting during the CGU-CSAFM joint assembly held in Banff from May 15-18, 2011. The Section hosted three sessions (one joint with the CSAFM) at the 2011 annual meeting with 45 abstracts (21 oral presentations and 24 posters) and was the third largest section when compared to 111 abstracts in HS and 46 abstracts in SES. Biogeosciences session details are given below.

B1 - Effects of Invasive Earthworms on Biogeoscience Processess (9)
BC3 - Carbon & Water Cycling in Canadian Forests and Peatlands (26)
B4 - General Biogeosciences (10)

The Section offered two awards for the Best Student Oral Presentation and Best Student Poster Presentation in Biogeosciences during the 2011 CGU annual meeting. Apart from a plaque each award also carried $500 cash prize. The winner of the best oral presentation award was Lijun Xia for her presentation entitled "Soil respiration responses to temperature are affected by substrate supply and earthworm activities" (by Lijun Xia and Katalin Szlavecz), while the best poster award winner was Claire Oswald for her presentation entitled "Controls on the spatial distribution of ambient mercury and applied mercury isotope in a Boreal Shield soil landscape" (by C.J. Oswald, B.A. Branfireun, A. Heyes).

Biogeosciences Section members also had an annual general meeting on May 17 in Banff. Apart from past section activities, participants in the annual meeting discussed potential special sessions for the 2012 CGU-CWRA joint annual meeting and various options for collaborating with other societies to promote Biogeosciences-related activities. The Section plans to host a joint student conference with the CGU Hydrology Section Eastern Student Conference at McMaster University in Winter 2012.

See the section's web page for more details: http://www.cgu-ugc.ca/BGS_Section/.

McMaster Centre for Climate Change - to *promote and facilitate research, education and public outreach activities in Earth's Climate System*

Report by M. Altaf Arain
Director, McMaster Centre for Climate Change

Numerous measurements and climate-modeling studies show an increase in both global and regional temperatures resulting from an increase in atmospheric greenhouse gas (GHG) concentrations. Geological records of paleoclimate suggest that current GHG concentrations are greater than levels existing over the past 100 million years. This recent warming has been more pronounced in high latitudes and is rapidly transforming the environment and ecosystems of these regions. Canada, being a northern country, is expected to be among the most climate-change-affected countries in the world, both positively and negatively, depending on the aspect under consideration. Many scientific studies point towards an increase in the frequency and severity of extreme weather events such as heat waves, ice storms, hurricanes/tornados, floods and droughts, due to global and regional climate changes. These events are already having a direct impact on the environment and ecosystems in various regions across the world, including lengthened growing seasons and increased occurrence of severe droughts, forest fires and insect infestations in the Canadian boreal and temperate regions, flash floods in the eastern USA, persistent droughts in the American southwest and heat waves in Europe. Apart from vegetated ecosystems, future changes in precipitation patterns are expected to affect infrastructure such as roads, culverts, water supplies and drainage networks. Changes to freshwater availability and water levels in lakes and rivers will negatively impact the sustainability of regional water resources, water quality and hydro-electric power generation in many regions across the world, including the Great Lakes. Poor air quality will have impacts on human health. Increased heat stress may result in elevated mortality rates in the elderly population, as witnessed in 2003 in Europe. Melting of permafrost in northern latitudes would provide access to untapped resources and development opportunities. Nevertheless, the exact nature and magnitude of climate change-related impacts in these regions is highly uncertain. Future climate change impacts pose a serious long-term threat to the viability of natural resources and ecosystems, as well as to the health of Canadians. There is an urgent need to better understand the processes that affect the Earth's climate system and their impact on the growth and survival of ecosystems and the well-being of human societies. There is also a need to update and inform the public, in particular the younger generation about the significance of climate change and its impacts, both positive and negative on environment, ecosystems and humans.

In order to advance climate-related research, education and outreach activities, McMaster University, has recently established a multi-disciplinary research centre, the "McMaster Centre for Climate Change", in Hamilton, Ontario, Canada.

The mission of the McMaster Centre for Climate Change is to promote and facilitate education, research activities and collaborations to study the processes of Earth's climate system and the impacts of climate change on the environment, ecosystems, water resources and human health.

There are seven theme areas (working groups) comprised of scientists to manage and advance the research activities of the Centre:

- Physical Climate and Modelling
- Ecosystem Impacts and Adaptations
- Water Resources and Hydroclimate
- Paleoclimate and Isotope Geochemistry
- Infrastructure Impacts
- Human Health and Societal Impacts
- Sustainability, Resilience and Public Policy

The Centre's research efforts focus on understanding and modelling both short- and long-term climate processes to advance the predictive capabilities of Earth System models. Apart from studying climate change impacts on the environment, ecosystems, water resources and infrastructure, the Centre also focuses on exploring human perceptions of, and responses to, climate change and its likely impact on human health, social activity and Canadian society. It makes efforts to promote graduate and undergraduate teaching and scholarship, enhance public outreach and provide scientific input to academic and public debates on environmental and climate change issues. The Centre also promotes and encourages the application of scientific knowledge for the sustainability of ecosystems and natural resources that may help to improve the environment, human health and the management of natural resources. Centre will make efforts to bring together university, government and industry/business partners to work on policy issues related to climate change mitigation and adaptation for the benefit of society.

For further details and information on Centre activities, see the web site at http://climate.mcmaster.ca/

CGU 2011 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 2011 CGU-CSAFM 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).

The award winners are listed below, and three of their expanded abstracts follow. The other abstracts will appear in the January 2012 issue of ELEMENTS.

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: Asim Biswas (Dept. of Soil Science, University of Saskatchewan). Depth Persistence of the Spatial Pattern of Soil Water Storage in a Hummocky Landscape (co-author: B. C. Si).

Shell Canada Outstanding Student Poster Paper:

Winner: Camille D. Brillon (University of Victoria). Crustal Structure offshore Vancouver Island from Bayesian Receiver Function Inversion of NEPTUNE Seismic Data (co-authors: J. F. Cassidy, S. E. Dosso, W. Wilcock, E. Hooft, D. Toomey, and P. McGill).

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

Winner: Agnieszka Pawlak (Dept. of Geoscience, University of Calgary). Azimuthal anisotropy of Hudson Bay using ambient seismic noise (oral, co-authors: D. Eaton, S. Lebedev, F. Darbyshire, I. Bastow).

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

Winner: Chris Marsh (Dept. of Geography & Planning, University of Saskatchewan). Implication of mountain shading and topographic scaling on energy for snowmelt (co-authors: J. Pomeroy, R. J. Spiteri).

Campbell Scientific Award for Best Student Poster in Hydrology:

Winner: Jason A. Leach (Dept. of Geography, University of British Columbia). Effects of clearcut logging on headwater stream temperature and simulated bioenergetic consequences for cutthroat trout (co-authors: R. D. Moore, S. G. Hinch, T. Gomi).

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

Winner: Panagiotis Vergados (Dept. of Physics & Astronomy, York University). Assessing the effect of gravity anomalies on GPS/RO-derived temperatures: Results from the GRACE mission (co-author: S. D. Pagiatakis)

Solid Earth Section Award for Best Student Paper:

Winner: Agnieszka Pawlak (Dept. of Geoscience, University of Calgary). Azimuthal anisotropy of Hudson Bay using ambient seismic noise (oral, co-authors: D. Eaton, S. Lebedev, F. Darbyshire, I. Bastow).

Biogeosciences Section Award for Best Student Paper (oral):

Winner: Lijun Xia (Dept. of Earth and Planetary Science, Johns Hopkins University). Soil respiration responses to temperature are affected by substrate supply and earthworm activities (co-author: Katalin Szlavecz).

Biogeosciences Section Award for Best Student Paper (poster):

Winner: Claire J. Oswald (Dept. of Geography, University of Toronto). Controls on the spatial distribution of ambient mercury and applied mercury isotope in a Boreal Shield soil landscape (co-authors: B.A. Branfireun, A. Heyes).

Depth Persistence of the Spatial Pattern of Soil Water Storage in a Hummocky Landscape

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I. ABSTRACT

Understanding the relationships between soil water at the surface and subsurface layers can help understand hydrological processes at depth. The objective of this study was to examine the similarities in the overall and scale specific spatial patterns of soil water storage at different depths. Soil water storage was measured along a transect at St. Denis National Wildlife Area, Saskatchewan, Canada using time domain reflectometry (0 to 20 cm) and neutron probe (20 to 140 cm at 20 cm depth interval). High soil water storage was observed in depressions and low water storage on knolls creating an inverse spatial pattern relative to elevation. High Spearman rank correlation coefficients between the surface and subsurface soil layers indicated strong similarity in the overall spatial pattern of soil water at different depths. Wavelet coherency analysis indicated strong similarity in the large-scale (> 72 m) spatial patterns of soil water at the surface layer and deeper layers during the recharge period, which weakened slightly during the discharge period. However, the small- and medium-scale spatial patterns changed with depths at any time. The scale specific similarity in the spatial pattern of soil water can be used to guide estimating subsurface soil water at different depths from the surface soil water.

II. INTRODUCTION

Soil water is a key determinant factor for infiltration, runoff, percolation, and evapotranspiration. It exhibits high spatio-temporal variability at different scales (Brocca *et al.*, 2010), which makes the monitoring in large areas challenging. Information on soil water at different scales is required to improve hydrological and climatic modeling and prediction (Western *et al.*, 2002).

Soil water is generally easier to measure in the surface soil than in the subsurface. With the launch of several satellite instruments, remote sensing techniques showed promise in assisting hydrologists to describe and measure surface soil-water for large areas (Heathman *et al.*, 2003; Brocca *et al.*, 2010). However, plant roots, one of the most important factors regulating soil water storage, are not restricted to only surface layer. In addition, knowledge of surface soil water is often inadequate to understand overall hydrological processes. Therefore, information on soil water dynamics at different depths is necessary.

Soil water varies largely in space, depth, and time. However, if a field is surveyed repeatedly for soil water, some points may always be wetter and some would be drier than the field average. As these points within a field maintain their rank over time, the spatial pattern of one measurement series will be similar to the spatial patterns of another. This phenomenon has been termed as time stability (Vachaud *et al.*, 1985) of the spatial pattern of soil water. Time stability has been examined over a range of areas, sampling schemes, and sampling periods at different parts of the world. Similarity between the spatial patterns of soil water storage over time at different depths was also examined (Pachepsky *et al.*, 2005). However, information about the similarity or the persistence of the spatial pattern at different depths measured at a time is scarce. We define this similarity as depth persistence of the spatial pattern.

The depth persistence can provide an opportunity to correlate the easy-to-measure surface soil water to the soil water at depth, and therefore provide the necessary information in adopting the data assimilation techniques in integrating the remote sensing and soil water modeling (Heathman *et al.*, 2003; Brocca *et al.*, 2010). However, different factors and processes operating at different scales make the spatial pattern of soil water highly scale-dependent (Kachanoski and de Jong, 1988). Identifying the scales and the similarity of these scales of soil water at different depths can help build the scale-specific relationship between soil water contents of the surface and subsurface layers. Therefore, the objective of this study was to examine overall and scale-specific similarities of soil water spatial patterns at different depths.

III. MATERIALS AND METHODS

The study site was located at St. Denis National Wildlife Area in central Saskatchewan, Canada (52°12′ N latitude, 106°50′ W longitude). The landscape of this area is hummocky with slopes ranging from 10% to 15%. The soils of the area are mainly Dark Brown Chernozem developed from moderately fine to fine-textured, moderately-calcareous, glacio-lacustrine deposits and modified glacial till. The dominant climate of this area is semi-arid and the vegetation is mixed grass.

Soil water was measured along a transect of 128 points (576 m with regular interval of 4.5 m) using time domain reflectometry (TDR; at 0 to 20 cm) and neutron probe (20 to 140 cm at every 20 cm depth interval). A standard calibration equation was used for TDR. The neutron probe was calibrated along the transect for several times over three years at different topographic locations and different moisture conditions. Soil water content was measured for 20 times over a four-year period (2007 – 2010) and the water storage was calculated by multiplying with depth. The measurements were completed at different environmental events such as snowmelt, rainfall, or prolonged dry period.

One of the important processes controlling the hydrology of the study area is snowmelt that takes place within a short period. The rate of water loss through evaporation and deep drainage (very small amount) during this period is generally lower than that of water addition from snowmelt and spring rainfall (Hayashi *et al.*, 1998). Therefore, there is a net increase in soil water storage and the period is considered as the ‘recharge’ period. However, with time, high evapotranspiration demand from growing vegetation and the scanty precipitation during later summer and fall in the study area deplete stored soil water. This period is generally considered as the ‘discharge’ period. Though, all the necessary analysis was performed for all measurements in all years, due to space restriction, we have presented the details of only two measurements, one from each period during 2008 (2 May 2008 and 23 August 2008 representing the recharge and discharge period, respectively).

Similarity of the overall spatial pattern of soil water storage was examined using Spearman’s rank correlation analysis following Vachaud *et al.* (1985). Wavelet coherency analysis was completed using the MATLAB (The MathWorks Inc.) code written by Grinsted *et al.* (2004) and is available at URL: http://www.pol.ac.uk/home/research/waveletcoherence/. Theory of the wavelet coherency analysis is available elsewhere (Torrence and Compo, 1998; Grinsted *et al.*, 2004) and is beyond the scope of this paper.

IV. RESULTS AND DISCUSSION

There were two strong peaks in the spatial distribution of soil water storage (100 to 140 m and 225 to 250 m along the transect) at the surface 0 to 20 cm layer on a day (2 May 2008) during the recharge period (Figure 1). These locations were situated within depressions. In the study area, approximately 30% of the annual precipitation occurs as snow during winter, which is redistributed unevenly in the landscape by the strong wind in the prairie region (Pomeroy and Gray, 1995). Fast snowmelt during early spring contributes a large amount of water within a short period. However, the frozen ground at that time does not allow much water to enter the soil and snowmelt water runs off to depressions (Gray *et al.*, 1985; Hayashi *et al.*, 1998). Therefore, there was much higher soil water storage in depressions than on knolls, creating a wide range of soil water storage in the landscape for all depths during the recharge period (Figure 1).

The average soil water storage for the surface 0 to 20 cm soil later was 6.3 cm, which gradually decreased to 5.7 cm at the 120 to 140 cm layer. The coefficient of variation (CV) was the highest (28 %) in the surface layer (0 to 20 cm), and gradually decreased to 16 % at the deepest layer (120 to 140 cm). The standard deviation (SD) of soil water was the highest (1.7 cm) in the surface 0 to 20 cm layer and declined at deeper layers. Usually, the soil water storage capacity decreases with the increase in bulk density and the decrease in soil organic matter from the surface to deep layers. In our study, the stronger variably in the surface soil water may be due to the highly variable organic matter content at the surface (CV = 41%). In addition, topography controlled differential exposure of solar radiation, wind, and local rainfall enhances the variability of surface soil water (Hu *et al.*, 2010). Therefore, there was higher CV and SD in the surface soil than that at deeper soil during the recharge period. Moreover, deeper soil layers are less influenced by the meteorological conditions, creating 'inertia' in soil water dynamics (Martínez-Fernández and Ceballos, 2003; Hu *et al.*, 2010).

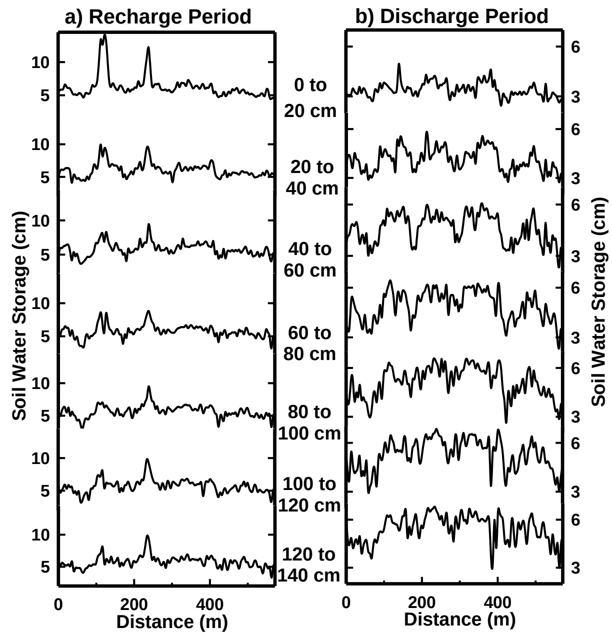

Figure 1: *Spatial distribution of soil water storage at different depths during a) recharge (2 May 2008) and b) discharge (23 August 2008) period are shown.*

The average soil water storage was 3.4 cm in the surface layer (0 to 20 cm) and gradually increased to the deepest layer (5.4 cm at 120 to 140 cm) on a day (23 August 2008) during the discharge period. Depressions were dried up during the discharge period and the spatial distribution did not have any strong peaks (high soil water storage; Figure 1). High amount of water in the depressions allowed plants to grow better than those growing on knolls (leaf area index data- unpublished). Therefore, during the discharge period, the increased evapotranspiration demand from vegetation reduced the difference (small range) in soil water storage along the transect. The CV of soil water storage was 13 % in the surface (0 to 20 cm) layer and gradually increased to 19 % at the 80 to 100 cm layer. The SD of soil water was the lowest in the surface 0 to 20 cm layer (0.43 cm) and gradually increased with depth. This is because the plants generally take up more than 70% of the water they need from the top 50% of the root zone (Feddes, *et al.*, 1978). The intense root activity in the surface layer depleted stored water irrespective of landscape positions and equalized soil water storage over the transect.

Overall similarity of the spatial pattern of soil water storage between any two depths was examined using Spearman rank correlation (all coefficients are significant at $p > 0.999$). The rank correlation coefficient (r) was 0.84 between soil water storage of 0 to 20 cm and 20 to 40 cm layers and was 0.64 between 0 to 20 cm and 120 to 140 cm layers on a day (2 May 2008) during the recharge period. High rank correlation coefficients between any two-depth layers indicated strong depth persistence in the overall spatial patterns during any time. This may be due to less heterogeneity between soil layers, which could not completely de-couple the surface hydrology from the subsurface ones. The largest value of *r* was observed between any two consecutive soil layers at any time, which gradually decreased with the increase in distance between soil layers. This may be because the reduced response towards atmospheric forcing (Hu *et al.*, 2010), runoff, evapotranspiration, root activity or soil structural disturbance (Pachepsky *et al.*, 2005) in the deeper layer that controlled the dynamics of soil water storage. However, the value of *r* between any two layers during the discharge period was smaller than that during the recharge period. For example, the value of *r* was 0.80 and 0.48, respectively between the above-mentioned layers on a day (23 August 2008) during the discharge period. This is because a particular process (such as runoff) operating in the recharge periods may be in different intensity from that in the discharge period. This is different from Grayson *et al.* (1997) who indicated the change in the major controls of soil water storage at different seasons.

The scale-specific correlations between soil water at the surface layer and layers of different depth were examined using wavelet coherency analysis. Significant coherent relationships (red color encircled by black line) between soil water contents at different depths at a scale and location indicated the depth persistence of the spatial pattern of soil water storage at that scale and location. Significant coherency at medium-scales (18 to 72 m) may be attributed to the variations in landform elements and micro-topography within depressions (Kachanoski and de Jong, 1988; Figure 2). However, strong depth persistence at large scales (> 72 m; Figure 2) may be a result of alternating knolls and depressions. The strong correlation between elevation and soil water storage at different layers from both periods clearly showed the large-scale dependence of soil water on elevation (graph not shown). The decrease in the total area of significant coherency and its intensity (color) at different scales from the surface to subsurface layers and from recharge to the discharge period (Figure 2) indicated the reduction in the degree of depth persistence. This is because the strong evapotranspiration demand, which changed the relationship between the surface layer and subsurface layers. However, the scale of dominant variation remained almost the same, regardless of depth and season. At the same time, the total area of significant relationship was much larger with the maximum at the deepest layer, which indicated strong similarity in the processes operating at depth (graph not shown). Greater the depth, more stable the hydrological dynamics is. Therefore, the maximum similarity in the spatial pattern of large scales at the deepest layer indicated the similarity in the hydrological processes operating at the scale > 72 m, which may be controlled by topography (Kachanoski and de Jong, 1988).

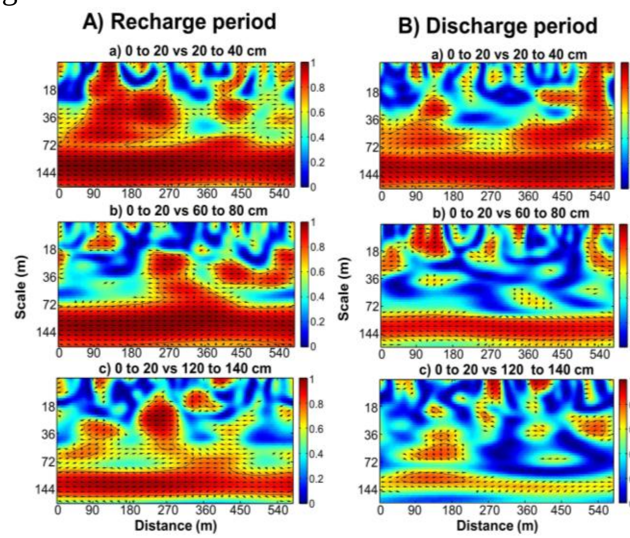

Figure 2: *Wavelet coherency of soil water storage between a) 0 to 20 cm and 20 to 40 cm, b) 0 to 20 cm and 60 to 80 cm, and c) 0 to 20 cm and 120 to 140 cm depth layers from A) the recharge and B) discharge period are shown. The color bar indicates the strength of the wavelet coefficients; the solid black line indicates 5% significance level; and the arrows indicate the type of correlation (right directed- positive; left directed- negative).*

The persistence in the spatial patterns of soil water storage between the surface layers and deeper layers can be used to correlate the easy-to-measure surface soil water to the soil water of subsurface layers. Therefore, it improves the understanding of soil water dynamics of subsurface layers from the surface measurements. The persistence of the spatial pattern at large-scales can be used to improve the prediction of soil water storage at depth, thus is promising in reducing the cost and resources.

V. CONCLUSIONS

In this study, we examined the similarity of the overall and scale specific spatial pattern of soil water storage at different depths. The overall spatial pattern of the surface layer was very similar to the layers closest to the surface and gradually decreased with the increase in distance between the layers. The correlation between the spatial patterns of soil-water at the surface layer and subsurface layers benefited from the persistence of the large-scale patterns, but reduced from inconsistent spatial patterns at small and medium scales. The scale information of soil water variations at different depths helps determine if the easy-to-measure surface soil water can be used to estimate soil water at depth and understand the landscape hydrological dynamics.

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Azimuthal anisotropy of Hudson Bay using ambient noise

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David W. Eaton, University of Calgary, Calgary Alberta
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Summary

The Hudson Bay basin is the least studied of four major Phanerozoic intracratonic basins in North America, which include the hydrocarbon-rich Williston, Illinois and Michigan basins. Using azimuthal anisotropy results in conjunction with isotropic group velocity maps from previous work, we can further focus our study on determining the formation and regional crustal structure beneath Hudson Bay. Twenty-one months of continuous ambient-noise recordings have been acquired from 37 broadband seismograph stations that encircle Hudson Bay. These stations are part of the Hudson Bay Lithospheric Experiment (HuBLE), an international project that is currently operating more than 40 broadband seismograph stations around the periphery of Hudson Bay. The inter-station group-velocity dispersion curves found from noise generated seismic interferometry studies, also know as ambient-noise tomography, are input into a tomographic inversion procedure producing crustal azimuthal anisotropy.

This work marks the first study where solely ambient seismic noise data has been considered in azimuthal anisotropy work. After extensive resolution testing, good path coverage was found to produce robust tomographic maps. Results show a dominant northeast-southwest anisotropic direction. Mid-crustal results correlate well with regional geology, as expected, but lower crust/upper mantle results show a more complicated anisotropic fabric. Stresses from plate motion, rebound stresses and magnetic fabrics are considered in aiding in understanding and interpreting the results.

Introduction

Hudson Bay is a vast inland sea that overlies the Paleozoic Hudson Bay basin, an intracratonic basin with similar stratigraphic record to the hydrocarbon-rich Williston, Illinois and Michigan basins. The processes of formation of the intracratonic basins such as Hudson Bay are poorly understood; this study seeks clues to achieve a better understanding of these processes by investigating regional crustal structure. Although the method of investigation, known as ambient noise tomography (or seismic interferometry) has been widely used in recent years (e.g., Shapiro et al. 2005; Curtis et al., 2006; Yao et al., 2006; Yang et al. 2007; Moschetti et al. 2007; Lin et al. 2007, 2010), this study is one of the first to incorporate seismic anisotropy into the analysis. Existing studies of seismic anisotropy in the Hudson Bay region (e.g., Bastow et al., 2011) have used SKS shear wave splitting to reveal plate-scale fossil anisotropic fabrics that preserve a record of the Precambrian tectonic evolution of the region - specifically the Trans Hudson Orogen (THO). However, these teleseismic phases sample the upper mantle, so whether or not fossil fabrics exist at crustal levels remains unclear.

In this paper we apply ambient-noise tomography to 37 broadband seismograph stations located around the perimeter of Hudson Bay (Figure 1) with continuous recording for 21 months. The present study builds on earlier work (Pawlak et al. 2010) in which we imaged the tectonic structure of the crust and upper mantle beneath Hudson Bay based on isotropic analysis (following Benson et al. 2007). Here, we review the ambient-noise method briefly, followed by the anisotropy inversion method in more detail. Tomographic results are shown, followed by a detailed analysis of parameter selection for the inversion process as well as resolution reconstruction. We interpret the anisotropic data by comparing our results with principal stress field direction, plate motion directions and regional total field magnetic anomaly data in the area.

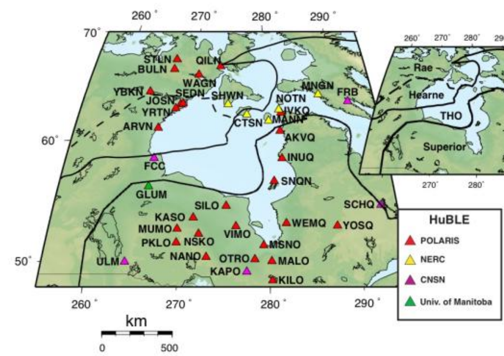

Figure 1: Map of Hudson Bay showing all HuBLE stations used in this study. Black lines represent approximate location of tectonic boundaries (after Eaton and Darbyshire 2010). Inset map describes the major tectonic zones.

Methods

Continuous data from 37 broadband seismic stations installed around Hudson Bay have been analyzed. All stations are part of the HuBLE experiment aimed at understanding the subsurface beneath the Bay. Data were collected for 21 months, starting from September 2006 and ending May 2008. Raw data consists of three-component measurements of ground motion with a sampling rate of 40Hz.

Data processing procedures follow Bensen et al. (2007). First, data are cut into individual one-day records and resampled to 1Hz. Daily trends, means and instrument response are removed. Earthquake signals and instrument irregularities are also removed using a one-bit time normalization followed by spectral whitening and bandpass filtering between 0.005Hz and 0.3Hz. Once the daily time series are processed, cross-correlations of the vertical component are preformed between all possible stations pairs and all available daily records.

Usually, an average of the causal and acausal cross-correlation time lags are used for dispersion analysis. With significant asymmetry in each half, we have adopted an approach in which either the causal or (time-reversed) acausal half is selected based on which has the higher signal-to-noise ratio (SNR) (Pawlak et al. 2010). This SNR-based selection method yields better-defined dispersion ridges. The resulting one-sided correlation is called an empirical Green's function (EGF). Time-frequency analysis is used to estimate group-velocity dispersion curves for each EGF. Detailed processing procedure is described in Pawlak et al. 2010.

Next, the Rayleigh-wave group-velocity dispersion curves are inverted for isotropic and azimuthally anisotropic velocity maps following the procedure described by Darbyshire and Lebedev (2009) for surface waves. For weakly anisotropic media, the Rayleigh (or Love) velocity can be expressed as the sum of an isotropic component (δU_{iso}) and terms that describe the azimuthal variation (Smith and Dahlen, 1973):

$$\begin{aligned}\delta U(\omega) &= \delta U_{iso}(\omega) + \\ & A_1(\omega)\cos(\Psi) + A_2\sin(2\Psi) + \\ & A_3(\omega)\cos(4\Psi) + A_4(\omega)\sin(4\Psi)\end{aligned} \quad (1)$$

where ω is the angular frequency, $\delta U_i(\omega)$ is the measured inter-station average group-velocity and the 2Ψ and 4Ψ terms account for the π- and $\pi/2$-periodic variations, respectively, of velocity with wave-propagation azimuth Ψ. The 4Ψ signal, although non-negligible, is generally not statistically significant (Smith and Dahlen, 1973). For this study, the 4Ψ result is used solely for testing robustness of the isotropic and 2Ψ results with respect to the amount of 4Ψ signal allowed in the models.

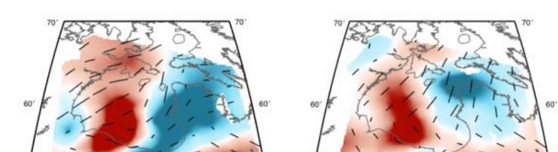

Figure 2: Tomographic maps for periods 20s (left) and 30s (right). Isotropic Rayleigh-wave group velocities are shown in red (lower velocity) and blue (higher velocity). The black lines correspond with 2Ψ anisotropy directions.

Results

Results are shown in Figure 2, for 20s and 30s periods. Red color represents lower isotropic velocities and blue represents higher isotropic velocities. The 20s period is mainly sensitive to mid-crustal depths (~ 10-25 km), while 30s is sensitive to the lower crust (20-35 km). A low velocity region is evident within the centre of Hudson Bay, as compared with the higher velocities that form a horseshoe shaped region that coincides with the Archean Superior craton (Figure 1). These isotropic results are generally consistent with isotropic tomography results found in Pawlak et al. 2010, which are based on a different tomographic reconstruction method.

Black bars in Figure 2 show the 2Ψ anisotropy fast directions. We see a difference in anisotropic direction between the 20s and 30s periods. The 20s period maps exhibit a predominately northeast-southwest direction, while the 30s period map is dominated by almost north-south fabric. The mid-crustal anisotropic fabric (20s period) appears to correspond well with the tectonics of the region, namely, where we see the horseshoe shaped Superior craton and the fast isotropic velocities, we see the anisotropic patterns deviate from the dominant northeast-southwest direction to a more 'horseshoe' shaped pattern. The lower-crust/upper-mantle, although it has a dominant almost north-south pattern, is strongly rotated (approximately 90 degrees) in the central region. This shift does not appear to correlate with regional tectonics, but it does appear to follow the isotropic velocity fabric.

Discussion

Stress-field directions have changed in the last 9000 years due to rebound stress from the last ice age (Wu 1996). However, the principal horizontal stresses 9000 years ago and at the present projected from rebound stress including tectonic and overburden stresses, are very similar in the Hudson Bay region (Wu 1997). Within the bay these directions are northeast - southwest, similar to the dominant direction found in both our mid-crustal (20s period) and lower crustal (30s period) maps.

Magnetic data has been used in recent years in relation to seismic anisotropy (Bokelmann and Wüstefeld 2009, and Wüstefeld et al. 2010). Due to the limiting temperature for ferromagnetic behavior and the depth decay ($1/r^3$), magnetic data is well suited for studies of the uppermost lithospheric fabrics (Bokelmann and Wüstefeld 2009). Previous studies found a relation between seismic anisotropy in the mantle from shear wave splitting results compared with crustal magnetics. This relation suggests vertically coherent deformation, in which the crust and mantle deform coherently (Silver and Chan 1988). Since ambient-noise studies are confined to the crust and uppermost mantle, comparing crustal magnetic features is quite appropriate.

Magnetic data is readily available from the Geological Survey of Canada. A selection of this data is shown in Figure 3. This data is gridded on a 400m grid and is an assemblage of aeromagnetic and marine data. Anisotropy data for 20s period and basic tectonic boundaries are overlain on the magnetic map. There is a very similar pattern in both datasets right in the center of the Bay, showing an effect, potentially, from the tectonic boundaries. The 30s period anisotropy, however, appears to have little correlation to the magnetic data, suggesting there is no (or little) vertically coherent deformation between the crustal and upper mantle or within the crust.

Conclusions

Azimuthal anisotropy work has been done for the first time using only ambient-noise source data. Results yield mid-crustal (20s period) background fabric consistent with regional crustal stresses and local anisotropic features corresponding to regional geology and consistent with magnetic fabrics. Lower crustal (30s period) features appear to have general background fabric also consistent with regional crustal stresses, but have a puzzling 90-degree rotation that is yet to be explained. The lack of coherence between SKS data suggests that perhaps the effects of Precambrian tectonics have now been over-printed at the crustal levels.

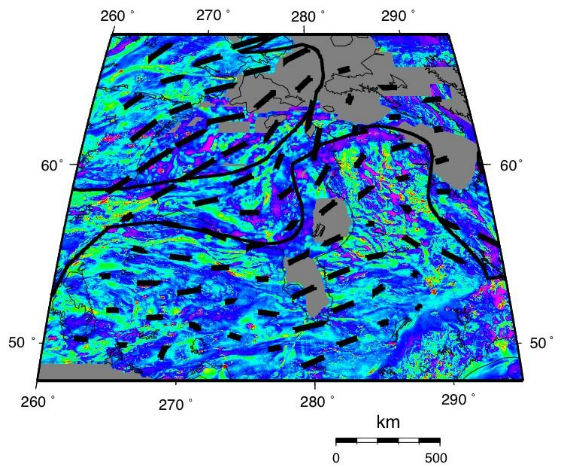

Figure 3: Comparison between magnetic fabric and (20s period) crustal anisotropy. Tectonic boundaries are overlaid for reference.

Acknowledgements

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Implication of mountain shading and topographic scaling on energy for snowmelt

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Abstract

In many parts of the world, snowmelt energetics are dominated by incoming solar radiation. This is the case in the Canadian Rockies, where sunny winters result in high insolation. Solar irradiance at the snow surface is affected by the atmosphere, the slope and aspect of the immediate topography, and shading from surrounding terrain. Errors in estimating solar irradiation are cumulative over a season and can lead to large errors in snowmelt predictions. Current gridded methods used to estimate solar irradiance in complex terrain work best with high-resolution DEMs, such as those produced using LiDAR. The requirement for high-resolution DEMs is a significant problem when modelling large spatial domains due to the lack of LiDAR elevation information over much of Canada. However, it is possible that adaptive triangular meshes, a type of unstructured triangular mesh that can adapt to fine-scale processes during model runtime, are more efficient in their use of DEM data than fixed grids when producing solar irradiance maps. A field and modelling study aimed at determining the effect of changes in DEM resolution on fixed grid and adaptive mesh irradiation calculations is discussed in this paper. As part of this study, the accuracy of these techniques is compared to measurements of mountain shadows and solar irradiance collected in the Marmot Creek Research Basin, Alberta. Time-lapse digital cameras and networks of radiometers provide datasets for diagnosis of model accuracy.

Introduction

In areas of variable topography, a surface's aspect significantly controls how much incident solar radiation a surface is exposed to. In a catchment in the Yukon, Canada, Pomeroy et al. (2003) found that on a clear day at midday, a south-facing surface had 80% more radiation than the north-facing surface. Carey and Woo (1998) found that aspect played a significant role in snowpack melt timing and attributed this as one factor that accentuates the contrast in timing and magnitude of the snowmelt between north and south facing slopes. Chueca and Julián (2004) found that shortwave radiation had implications for glacial ablation, concluding that the morphology and spatial distribution of small cirque glaciers could be primarily attributed to the differences in shortwave incoming radiation.

Structured meshes in GIS are generally referred to as rasters or grids. Raster based models are common because their computer representation can be trivially implemented using two dimensional arrays, a feature intrinsic to any modern programming language. Despite their widespread use, rasters have a number of significant limitations for use in hydrological modelling: drainage directions are often constrained to 45^o intervals, and geometric artifacts and other sub-grid variability can be artificially introduced because of the ridged structure (Tucker, 2001). Representing a non-rectangular hydrological basin requires buffering around the basin in order to capture its irregular shape with regular cells. This can result in having to either mask areas out, compute values for areas not being used in the simulation, or focusing on a 'window' within the basin that can be fully captured via a raster, neglecting the rest of the basin. These problems can be partially mitigated when unstructured meshes are used for topographic representation.

Research basin

The model domain for this project is Marmot Creek, shown in Figure 1, a research basin operated by the Centre for Hydrology, University of Saskatchewan in the Kananaskis Valley, Alberta. The basin ranges in elevation from approximately 1450 to 2886 m.a.s.l and is located at approximately 50^{o} 58'N and 115^{o} W. Vegetation is characterized by a combination of clear cut, meadow, forest, and alpine terrain. Shortwave pyranometers were placed at the indicated sites in Figure 1; Apogee SP-110s at Fisera Ridge North and South, South Meadow, Vista View, and Haymeadow; Kipp & Zonen CRN1s at Fisera Ridge and Haymeadow; and Delta-T SPN1s were installed at Fisera Ridge and Haymeadow. Two time-lapse cameras were installed; one at Fisera Ridge looking towards Mount Allan, and one at Fisera Ridge North facing Mount Collembola.

Importance of shading

As noted above, slope and aspect is important for energy calculations. However, many studies do not considered shading of a surface from the surrounding terrain. As shown in Figure 2, sharp topographic shadows dramatically decrease the irradiance to a slope. The errors from failing to capture this process accumulate throughout the season.

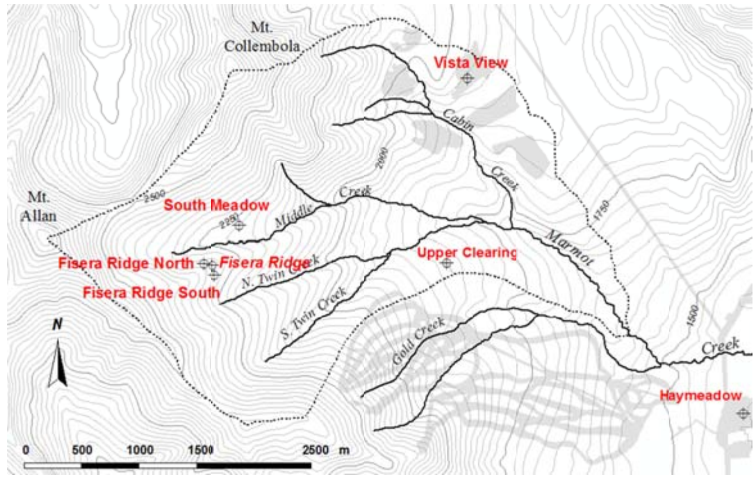

Figure 1: Marmot Creek Research basin, Alberta.

Figure 2: Time lapse photographs from Fisera Ridge north showing topographic shading. The red arrow shows the south meadow clearing site. Photos taken Nov 10, 2010 at 15:00 and 16:00.

Model development

A raster dataset, such as that derived from LiDAR, may be triangulated using Delaunay triangulation. Using this method, the triangulation could be constrained to the model domain, streams, or any other feature as required. Once the triangulation is constructed, shading locations can be mapped using, and expanding upon, the method proposed by Montero, et al. (2009). Other methods such as ray tracing are possible, however when working with arbitrarily orientated triangles it becomes difficult to know how many directions to look in. As the topographic scale changes, the look directions and collision tests must change, further increasing the uncertainty of the tests, and increasing the computational costs.

The method of Montero et al. (2009) determines shaded areas by determining what triangles are in front of other triangles with respect to the sun. To do this, the coordinate system is rotated so that the vertical coordinate (z) is rotated until it points at the sun. In this rotated configuration, some triangles may be located between the sun and other triangles, and therefore result in shading. Details of this rotation follow.

Let h_o be the solar elevation, and A_o be the solar azimuth (clockwise from north, in radians) for a certain time *t*. Then the vector defining the solar beam ($\vec{s}$) in terms of a unit spherical coordinate system is given by

$$\vec{s} = \begin{bmatrix} \cos h_o \sin A_o \\ \cos h_o \cos A_o \\ \sin h_o \end{bmatrix}.$$

Let *x,y,z* be a reference coordinate system with *x* positive in the east, *y* positive in the north, and *z* positive in the vertical direction that the topographic data is defined in. Let *x',y',z'* be a coordinate system obtained by performing an XZX Euler rotation of *x,y,z*.

Let R_x be the x rotation matrix and R_z be the z rotation matrix given as:

$$R_x = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\phi & -\sin\phi \\ 0 & \sin\phi & \cos\phi \end{bmatrix}$$

and

$$R_z = \begin{bmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

Then the rotation from *x,y,z* to *x',y',z'* is done via the Euler rotation *E* where

$$E = R_x(-q_o)R_z(-z_0)R_x(0)$$

$$E = \begin{bmatrix} \cos z_o & \sin z_o & 0 \\ -\cos q_o \sin z_o & \cos q_o \cos z_0 & \sin q_o \\ \sin q_o \sin z_o & -\sin q_o \cos z_o & \cos q_o \end{bmatrix}.$$

Where, borrowing from Montero, et al. (2009), $q_o = \frac{\pi}{2} - h_o$ and $z_o = \pi - A_o$.

The rotation E is applied to each vertex of every triangle. Then the rotated triangles can be projected onto the x'y' plane by ignoring their z' values; that is, they are shown as 2D triangles. The triangles can then be coloured according to each of the 3 vertex's z' values. An example of this is shown in Figure 3; the colours represent the z' values of each triangle, ranging from blue for low, and red for high. The scene is shown with the observer between the sun and the terrain. No scale is given because the z' values are not physical values and are relative, denoting "closer to" the sun for high values, and "farther from" the sun for low values. This is shown from a different perspective in Figure 4, with the observer located looking approximately towards the sun.

Shadow detection

Montero et al. (2009) suggested constructing the entire triangulation via nested triangles. However, this does not allow for constraining to hydrologically important features such as basin outlines, or streams. Therefore in this paper nested Rivara 4-T triangles (Rivara, 1987) will be used only after the Delaunay triangulation. In this approach, each Delaunay triangle is subdivided into 4 sub triangles following the algorithm proposed by Rivara (1987). Because of the nesting, it allows triangles to be refined and coarsened during model runtime without requiring a domain wide remeshing, nor changing the shape of the Delaunay triangles. Instead of starting with many small triangles, triangles can be refined as needed to capture shadow bounds, and coarsened when either fully in sun or shadow. This adaptive resolution is computationally more efficient and allows for capturing the shadow boundary accurately, even if the original dataset is not of a high resolution.

In order to determine which triangles are shaded, a centre for each sub-triangle is calculated and, if a sub-triangle centre lies within another non sub-triangle, a collision has occurred. This is done instead of triangle-triangle collision detection because it is computationally more efficient.

This recursive, sub-triangle representation allows for capturing the advancing front of the shadow. Montero et al. (2009) only considered one level of subdivision, as is currently done here. However future work will allow for multiple levels of adaptive division. This will allow each of the larger Delaunay triangles to contain an arbitrary number of smaller, nested triangles. An example binary shadow/no shadow map constructed using this method is shown in Figure 5. The locations A and B in Figures 3, 4 and 5 show areas that are expected to be shaded. As shown in Figure 3, B should be shaded and location B in Figure 5 confirms this. Although some numerical problems are visible in Figure 5 where triangles fail to be properly classified, this is attributed to the approximating triangle-triangle detection. This numerical precision will be fixed in future work.

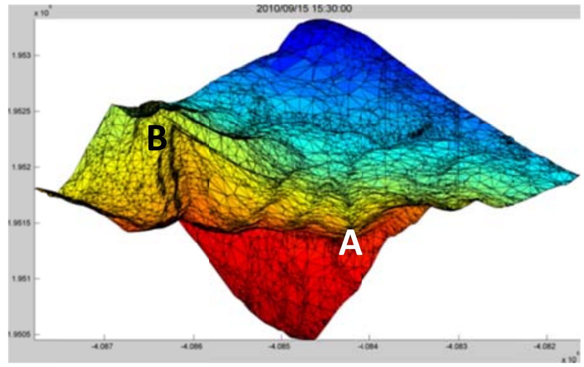

Figure 3: Domain projected onto x'y' coloured by z' values. Shown with the observer located between the sun and the terrain. The red values are "closer to" the sun and the blue values are "farther" from the sun. Model time: 15:30. Labels A and B discussed below.

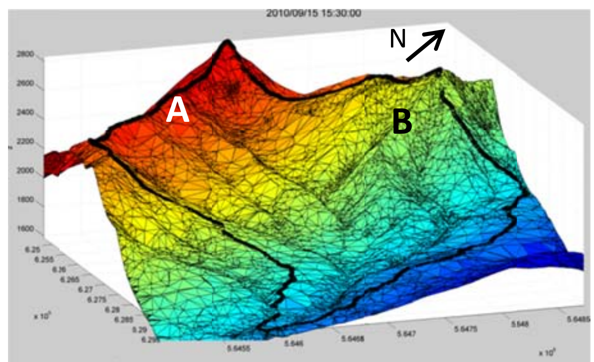

Figure 4: The red values are "closer to" the sun and the blue values are "farther" from the sun. This shows that the left most ridge-line has an opportunity to shade topography shown in shades of yellow or green for example. Model time: 15:30. Marmot Creek basin is outlined in black.

However, these are promising initial results as it shows a TIN without ray tracing creating topographic shadows from remote topographic features.

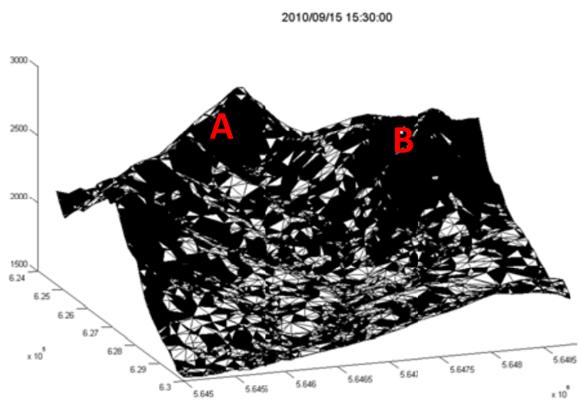

Figure 5: Binary shadow/no shadow map. The ridge line (A) in Figure 3 is clearly shown as shaded. Model time: 15:30

Verification

The model outputs, such as shown in Figure 5, will be compared to orthorectified imagery taken with the time lapse cameras. An example shot (not orthorectified) is shown in Figure 2. Once the imagery is orthorectified, image processing can determine the shadow bounds allowing for direct empirical comparison with model data. In addition, measured irradiance will be compared to model outputs of direct and diffuse beam for shadow and no-shadow areas. As well, a variety of existing shading codes will be run to determine the effects of spatial resolution on their predictions. Finally, as there has not been a systematic comparison of nested TIN codes described in the literature, the effect of resolution change on results will be investigated.

Conclusion

Raster representation of topography for hydrological purposes is not always ideal, and alternative data structures can mitigate most of the shortfalls. For example, utilizing adaptive meshes to capture sub-triangle shading can more efficiently utilize low resolution datasets. Utilizing ideas put forth by Montero, et al. (2009), an unstructured, adaptive mesh is used to capture shading without the need for ray tracing. These model data will be compared to orthorectified imagery to validate the model and help understand scaling effects. Further comparisons with measured irradiance will be done.

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Announcing Official Certification in Meteorology

On June 5, **ECO Canada** officially launched the new **Professional Meteorologist (P. Met)** certification at the 2011 **Canadian Meteorological and Oceanographic Society (CMOS) Congress** in Victoria, British Columbia.

The P. Met Certification will formally recognize the unique skills and knowledge of meteorologists working in various fields such as forecasting, consulting and research, among other areas.

"Professional credibility for meteorologists has become a priority for the industry. The increased impact of severe-weather and natural disasters has drawn public interest around the work of meteorologists. ECO Canada recognizes that it is imperative to have a mechanism that provides professional credibility to meteorologists" says **Grant Trump, CEO of ECO Canada**.

"Ongoing professional development is crucial to success as a meteorologist. P.Met provides a framework for professional development and will ensure that Canadian meteorologists stay abreast of the latest forecasting techniques and advancements in the science" says **Christopher Scott, Forecast Operations Manager at the Weather Network**. "Encouraging meteorologists to be active educators in their community will serve to broaden the public's knowledge of our profession and ultimately improve the understanding of weather forecasts."

The development of **National Occupational Standards** for meteorology, serves as the foundation of the P. Met Certification program and is a result of the collaborative efforts of the entire meteorological community including the private sector, academia and government. National Occupational Standards form the basis for all certification programs offered through ECO and are updated approximately every 5 years to ensure they remain reflective of emerging areas in an ever-changing industry.

Claire Martin, On-Air Broadcaster at CBC says "Like it or not, your local TV weather presenter is often seen as being the 'face of the science.' Achieving and displaying a P.Met designation will bring a level of confidence in the individual presenter, and trust in the on-air product that does not currently exist.

Professional certification is awarded based on academic and experiential criteria as well as the evaluation of an individual's competency level as compared to the National Occupational Standards (NOS) for Meteorology. More information is available online at **www.eco.ca/meteorology.**

This program was funded in part by **Human Resources and Skills Development Canada (HRSDC)**, the Government of Canada's Sector Council Program.

For more information, please visit www.eco.ca/meteorology.

Annonce de la certification officielle en météorologie

Le 5 juin, **ECO Canada** a officiellement lancé la nouvelle certification de **Météorologue professionnel (P. Met.)** au **Congrès 2011 de la Société canadienne de météorologie et d'océanographie (SCMO)** à Victoria en Colombie-Britannique.

La certification de P. Met. reconnaîtra officiellement les compétences et les connaissances uniques des météorologues travaillant dans différents domaines tels que les prévisions météorologiques, le conseil et la recherche, entre autres secteurs.

«La crédibilité professionnelle pour les météorologues est devenue une priorité pour l'industrie. L'augmentation des impacts du temps violent et des désastres naturels a attiré l'intérêt public vers le travail des météorologues. ECO Canada reconnaît qu'il est impératif d'avoir un mécanisme qui donne une crédibilité professionnelle aux météorologues», dit **Grant Trump, PDG d'ECO Canada**.

«Le perfectionnement professionnel continu est essentiel pour le succès en tant que météorologue. La certification P.Met. fournit un cadre pour le perfectionnement professionnel et assurera que les météorologues canadiens restent au courant des plus récentes techniques et avancées en prévisions météorologiques», dit **Christopher Scott, directeur des opérations de prévisions météorologiques au Weather Network**. «Encourager les météorologues à être des éducateurs actifs dans leur communauté servira à augmenter les connaissances du public sur notre profession et en fin de compte améliorer la compréhension des prévisions météorologiques.»

Le développement des **Normes professionnelles nationales** pour la météorologie sert de fondation pour le programme de certification de P. Met., et il est le résultat des efforts de collaboration de toute la communauté météorologique y compris le secteur privé, les universités, et le gouvernement. Les Normes professionnelles nationales forment la base de tous les programmes de certification offerts par ECO et elles sont mises à jour à tous les 5 ans afin d'assurer qu'elles reflètent toujours les secteurs émergents dans une industrie en constante évolution.

Claire Martin, radiodiffuseur à l'antenne de la CBC dit: «Que vous aimiez cela ou non, votre présentateur météo de TV local est souvent considéré comme un «scientifique». Terminer et présenter une désignation P.Met. donnera un niveau de confiance envers le présentateur individuel, et envers le produit qui n'existe pas actuellement».

La certification professionnelle est octroyée selon des critères universitaires et d'expérience, ainsi que selon l'évaluation du niveau de compétence d'un individu en comparaison avec les Normes professionnelles nationales (NPN) pour la météorologie. De plus amples renseignements sont disponibles en ligne au **www.eco.ca/meteorology.**

Ce programme a été financé en partie par **Ressources humaines et Développement des compétences Canada (RHDCC)**, et par le Gouvernement du Canada par l'entremise du Programme des conseils sectoriels.

Pour de plus amples renseignements, veuillez visiter le www.eco.ca/meteorology.

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***Editor's Note*: ELEMENTS, the newsletter for the Canadian Geophysical Union, is published and distributed to all CGU members twice each year; one Summer issue and one Winter issue. We welcome submissions from members regarding meeting announcements or summaries, awards, division news, etc. Advertisements for employment opportunities in geophysics will be included for a nominal charge (contact the Editor). Notices of post-doctoral fellowship positions available will be included free of charge.**

Submissions should be sent to the Editor:

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Electronic submission is encouraged.


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