

Elements



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THE NEWSLETTER OF THE CANADIAN GEOPHYSICAL UNION

IN THIS ISSUE

President's Column	1	CGU-CSSS Joint Scientific Meeting Banff, May 4-7, 2014	29
Prepare for Montreal Assembly May 2015	2	Hydrology Section News	30
Call for Nominations for Awards	2	Geodesy Section News	32
2014 Awards	3	Biogeosciences Section News	34
J. Tuzo Wilson Medal	3	Solid Earth Section News	35
CGU Young Scientist Award	6	Earth Surface Processes Section News	38
Stan Paterson Scholarship	7	Officers of the CGU Executive	39
CGU 2014 Student Award Winners	8		

LE BULLETIN DE L'UNION GÉOPHYSIQUE CANADIENNE

President's Column

Dear Colleagues,

It is with pleasure that I reflect on our very successful joint assembly in Banff with the Canadian Society for Soil Science and the CIGS - Mantle Convection and Lithosphere Dynamics Workshop. Despite being a bit earlier than usual (and as a consequence a bit snowier) our usual high standards for both science and camaraderie were easily met. I am pleased to announce our new Earth Surface Processes Section that was approved by the membership at the annual general meeting, and welcome the inaugural executive. The CGU continues to grow, and is strengthening as the voice of the geophysical sciences in Canada.

As a function of the change in scheduling for the meeting this year, our annual awards banquet did not include the student awards that are generally handed out at that time. These awards were made after the meeting, and are

reported on here in this issue of Elements. Please take the time to review the excellent science being conducted by our student members, and perhaps extend your congratulations if you know them.

With 2014 meeting still in our recent memory we must turn to our 2015 joint assembly with the American Geophysical Union and GAC/MAC in Montréal, Quebec. Planning for such a large meeting begins early, and you will have already received advanced notification to begin thinking about session proposals. Formal announcements and calls will emerge soon and with increasing frequency. Please speak with your colleagues early, and be prepared to bring ideas forward so that the CGU is front and centre in the scientific program in Montréal next year.

Best wishes for the summer and your field season.

Brian Branfireun

Prepare for the next annual meeting!

CGU Annual Meeting joint with AGU* and GAC-MAC, in Montreal, Quebec, May 3-7, 2015**

It is now time to start preparations for our next big assembly. Please use the following link to find out more on preparations for the Assembly: <http://ja.agu.org/2015/>

The following officers within CGU will be taking responsibility for designing and implementing the CGU scientific program; they will be providing linkages to their counterparts in AGU, GAC and MAC. CGU representation on the Program Committee:

Claire Samson, Vice President CGU (Carleton University) claire.samson@carleton.ca
(to be co-chair of the Program Committee and oversee CGU scientific inputs);

- Carl Mitchell, Vice President Biogeosciences Section (University of Toronto) carl.mitchell@utoronto.ca
- Jeong Woo Kim, Vice President Geodesy Section (University of Calgary) jw.kim@ucalgary.ca
- Daniel Peters, Vice President Hydrology Section (Environment Canada) daniel.peters@ec.gc.ca
- Julian Lowman, Vice President Solid Earth Section (University of Toronto, Scarborough) lowman@utsc.utoronto.ca
- Chris Hugenholtz, Vice President Earth Surface Processes Section (University of Calgary) chhughenh@ucalgary.ca

It is important that individual members of CGU provide their ideas on sessions and, of course their own papers to the CGU program committee. All ideas should be sent to the appropriate section convener with copy to Claire Samson. The session proposal submission website will open on Wednesday 13 August 2014 and close on Wednesday 15 October 2014. More information will follow on the proposal submission process.

* American Geophysical Union

** Geological Association of Canada and Mineralogical Association of Canada

Call for nominations for Awards

Now is the time to start thinking about nominating one or more of your colleagues / students for an award. These awards are very prestigious and bring recognition not only to the individual recipient, but also to the individual's institution.

Please go to the CGU website for more information including deadlines for nominations: <http://cgu-ugc.ca/awards/> Further details are given via:

[J. Tuzo Wilson Medal](#) [Young Scientist Award](#) [Meritorious Service Award](#)

CGU Student Awards for Annual Scientific Meeting

[Student Travel Support](#) [Best Student Paper Awards](#) [Stan Paterson Scholarship in Canadian Glaciology](#)

The 2014 CGU J. Tuzo Wilson Medal: Philip Marsh

Citation by John Pomeroy, University of Saskatchewan and William Quinton, Wilfrid Laurier University

Dr. Marsh is one of Canada's top Arctic scientists, one of Canada's most outstanding and innovative hydrologists and is recognised internationally as an icon of Northern Canadian Hydrology. He is well known for his expertise in snow physics, chemistry and hydrology, the hydrology of tundra headwater catchments, and the hydrology of the Mackenzie Delta and environs. He has made major advances to our knowledge about how water and chemicals move through snowpacks, and how snow is distributed, melts and forms runoff. He has developed an advanced understanding of the unique flooding properties of the Mackenzie Delta from high discharges, river ice breakup, and perched lakes to storm surges. He has advanced our understanding of tundra snow-vegetation interactions, tundra hydrometeorological modelling, and the role of the Mackenzie River valley in continental water and energy cycling. Dr. Marsh was instrumental in the early fusion of hydrology, atmospheric science and ecology in northern research. He has the remarkable ability to integrate his field and modeling findings with those of ecologists, atmospheric modellers, geologists, and oceanographers. This has advanced the understanding of Arctic land surface functions and interactions, particularly involving snow, permafrost, vegetation, deltas and lakes and their sensitivity to climate change.

Dr. Marsh is an extremely productive scientist having published over 150 papers, 5 book chapters, and 24 reports, many in top journals such as *Water Resources Research*, *Hydrological Processes*, *Limnology and Oceanography*, and *Journal of Hydrometeorology*. He has edited conference proceedings, numerous international journals, and has been the invited keynote speaker at many prominent conferences. He has served as President of the Canadian Geophysical Union and of the Hydrology section, Chief Canadian Delegate to IHP Northern Research Basins Working Group and as the chair, executive member or member of many international scientific committees. He had a central role in ensuring that the Mackenzie River Basin was chosen by the Global Energy and Water Cycling Experiment as a continental scale hydroclimatology study, called MAGS, and served in senior leadership capacities in MAGS and subsequent International Polar Year studies of the Delta and polar snow hydrology in the region. These also informed northern energy development so that it could be conducted in a responsible manner given the local environment. He has been awarded more than \$6.5 million for scientific research in the North and has shared this with his collaborators. This ability to sustain funding for Northern research over the years attests to his exceptional research talents, and that of his team, who undoubtedly have excelled under his leadership and mentorship.



Dr. Marsh is also an exceptional teacher, role model and mentor. Despite his heavy administration and management role as Project Leader for Hydrological Processes and Modelling for Environment Canada, he has been successful in attracting top-quality post-doctoral fellows and graduate students and has served on many graduate committees as an Adjunct Professor at the University of Saskatchewan. Over the years he

has trained 5 Post-Docs, is now training 2 more; has supervised 2 PhD students, and contributes to 7 PhD committees. He has supervised 3 MSc students and contributed to the committees of 2 more. Many of his former students and trainees continue to publish and conduct research with him, and this attests to the high esteem that they have for him.

Through all of this Dr. Marsh has remained not only a careful, thoughtful and productive scientist, but a gentleman in the most positive sense of the word. His unflappable politeness, superb leadership instincts and calm and composed demeanor even under stressful situations has not only served him well in Arctic field work but in government-based science. In this respect he is the “Shackleton” of Arctic Hydrology in Canada – one who has kept his research team loyal and happily working in the most difficult situations. This leadership is in the spirit of Tuzo Wilson.

Acceptance by Philip Marsh, Wilfrid Laurier University

Mr. President, Ladies and Gentlemen

Thank you Bill and John for those very kind words and for leading my Wilson Medal nomination, and of course to my anonymous friends for generously viewing my work and providing letters in support of my nomination. It was of course never expected, but is greatly appreciated.

This honour means a great deal to me as the CGU has been an important part of my scientific career since 1993 when the CGU-Hydrology Section was formed. I always look forward with great pleasure to come to the annual meeting.

It is extremely humbling to join the list of previous Wilson Medalists, including those who I have known well: Don Gray, Hok Woo and Garth van der Kamp. Although I have greatly enjoyed working with Don and Garth, the most influential has been Hok Woo. When I applied to graduate school, one acceptance was from Hok Woo, then a young faculty member at McMaster University. As Hok’s first graduate student, he offered me the opportunity to carry out fieldwork in the Canadian Arctic Islands and I jumped at the opportunity. This turned out to be one of a few pivotal decisions in my professional life, and Hok has remained a life long friend and colleague. I did not know at that time that Hok was a truly unique and very talented researcher. Over the coming years I learned many things from Hok, and together we had the opportunity to observe the arctic and discover many unknown aspects of the hydrology of Arctic Canada. While at McMaster I was fortunate to also learn from a number of other talented scientists. Those I spent the most time in the field with were Brian McCann and Wayne Rouse.

After graduating from McMaster, I faced the difficult decision of either moving to an academic position or to Environment Canada’s National Hydrology Research Institute (NHRI) that was soon to move from Ottawa to Saskatoon into the newly built National Hydrology Research Centre (NHRC). I made what turned out to be another pivotal decision in my life, and Shirl and I moved to Saskatoon, where we ended up spending the next 27 years. I will forever be indebted to Don Mackay who hired me at NHRI, and who was the guiding force behind their northern research program. Don had the foresight to allow the scientists in the group to pursue basic science, while ensuring that this research had application to key societal interests in the northern Territories. This approach to science management continued until recently as Don’s research management approach was also used by his direct successors, Wally Nicolaichuk and Fred Wrona.

In the mid-1980’s Don encouraged me to join a small group studying the hydrology of the Mackenzie Delta as there was considerable concern about the impacts of hydroelectric development on the Liard River to the south. At that time Bob Hecky at the Freshwater Institute in Winnipeg introduced me to Lance Lesack who was just finishing his PhD on lakes of the Amazon flood plain. Lance and I

continue to work together on issues related to the links between the hydrology, biogeochemistry and ecology of the delta.

Another important point in my career occurred when I became involved in Mackenzie GEXEX Study, otherwise known as MAGS, in the 1990's. This project brought together an interdisciplinary team of hydrologists, atmospheric scientists, modellers, and remote sensors. MAGS's legacy includes a number of northern research observatories and research projects such as Improved Processes, Parameterization, and Prediction (IP3), International Polar Year (IPY), Drought Research Initiative (DRI), and the currently funded Changing Cold Regions Network (CCRN).

The science that is being acknowledged by the Wilson Medal tonight has only been possible through the generous funding of Environment Canada, and numerous other organizations including NSERC, CFCAS, PERD, and other Government of Canada programs. As important are my collaborators, students, post-doctoral fellows, and technicians.

I would like to start by acknowledging the contributions of Cuyler Onclin and Mark Russell at NHRC. Their abilities in carrying out complex field programs and data analysis are first rate, and without their dedication, often under extreme northern weather conditions, many of our papers would not have been published. I have also been extremely fortunate to work and publish with many people of the caliber of Lance Lesack who I mentioned earlier, including: John Pomeroy, Bill Quinton, Natasha Neumann, Stefan Pohl, Stefano Endrizzi, Al Pietroniro, Chris Spence, Daqing Yang, Barrie Bonsal, Terry Prowse, Fred Wrona, Joseph Culp, and many others. My work has also been influenced by many other national and international friends and colleagues, including Larry Hinzman, Doug Kane, Kathy Young, and many others too numerous to mention in what I have tried to keep as a short acceptance speech.

While thinking about what to say this evening, I began to consider the many hydrologic advances made since 1975 when I first went to the Arctic with Hok. At that time we knew very little about the water cycle in northern Canada, and in reality few people cared, as there were few public policy reasons to better understand the arctic environment. At that time for example we did not know the magnitude of the major components of the water balance, but did realize that since measured discharge was larger than measured precipitation, that there must be significant errors! Our understanding of many key cold regions processes were poorly known, we had limited remote sensing data sets, no high resolution elevation data, and as a result, minimal predictive ability. If we look at the current state of our hydrological sciences, it is obvious that we have made great strides, and because of the unfortunate fact of climate change, the arctic is now of great importance to understanding the future of our climate system. Although, we still have much to do to address the uncertainties, I'm extremely excited about the advances I think are possible in the coming years. The combination of unique new field instrumentation, geophysical techniques, exciting new remote sensing methods, high performance computing, and new modeling techniques will allow us to make great advances in the coming years.

Last year I had an opportunity to move from NHRC to Wilfrid Laurier University in Waterloo. Although there were many reasons to move, one of the most important was the opportunity provided by a 10 year partnership agreement between the GNWT and Laurier that Bill Quinton was pivotal in negotiating. My hope is to use this partnership to continue Don MacKay's legacy of using basic science research to help the Government of the NWT meet its requirements to address its environmental concerns.

And finally, I need to thank my parents for their complete support and for encouraging me to follow my interests at University, with no pressure to be concerned about where it would lead. And of course I would like to thank my wife Shirley, for her companionship and support over the years. Among other things Shirley has helped me to keep a healthy science-life balance. I would also like to thank my children Jessica and Christopher for their understanding when I was in the field for long times. Hopefully the great times we had exploring the western mountains by ski, and northern Saskatchewan

by canoe, made up for the times I was away in the field. It has also been a pleasure to watch and learn from them as they pursue their intellectual interests. It was of course wonderful that both Chris and myself won separate CGU Awards here tonight.

Thank you again to the CGU. It is a great honor.

The 2014 CGU Young Scientist Award Winner: Geneviève Ali

Citation by Jeffrey J. McDonnell, Professor of Hydrology and Associate Director, Global Institute for Water Security

I have known Geneviève for five years, including two years as co-advisor of her Post Doctoral research at the University of Aberdeen. Geneviève is the best young Canadian scholar in the hydrological sciences that I am aware of. Despite her current Assistant Professor rank, Geneviève is already a leader in the field—promoting a new science of connectivity and leading many initiatives in Manitoba and internationally. These superlatives are backed up by impressive metrics: several invited talks at AGU thusfar and 14 papers in ISI journals since 2009! I am unaware of any other young Canadian hydrologists with such a record. Her hire as Junior Chair in Watershed Systems Research program at the University of Manitoba is a testament of this.

Her PhD advisor, Andre Roy notes in his support letter that “one of her papers was selected as a featured article by the editors of *Water Resources Research* and highlighted in *EOS* (the weekly newsletter of the American Geophysical Union). This is a major impact for a doctoral thesis.” I would rate her PhD as the top in Canada in the past decade. As a Post doc, Geneviève led the creation of several new indices of hydrological connectivity in terrestrial and aquatic systems. Geneviève is impressively interdisciplinary in her research approaches for someone at her career level. In her post doc work, she seamlessly integrated stream ecology work with runoff generation process studies and water quality analyses. Geneviève has very impressive quantitative skills and this has enabled her to tackle many problems and develop many new statistical relations among hydrological measures.



Like her former advisor, I cannot think of a junior faculty member in Canada who is more deserving of recognition her outstanding scientific contributions. I see Geneviève developing further as a leader in Canada in the coming years. We need more role models like her, particularly for young women entering our science. Recognizing her for a CGU Young Scientist Award would be something that would benefit the development of Canadian hydrological sciences and be most deserving recognition of her stunning early career accomplishments.

Acceptance by Geneviève Ali, University of Manitoba

I warmly thank the CGU for this award. I am happy, humbled and “astonished” to be the recipient of such an honour. Choosing a career in Hydrology and Academia was simply the best way to allow me to wear rubber boots and play with water during work hours and I certainly did not expect this choice to lead to any kind of recognition. It makes this unexpected award even more enjoyable.

Although my career is still very young, I can already say that the number of people who have influenced my path is incredibly large; most of them probably don't even realize it. While I cannot go through the whole list, there are four people I need to acknowledge. I owe a debt of gratitude to André Roy, who took me on as a pure Hydrology student at the University of Montreal at a time when most of his research program was rather focused on fluvial geomorphology. I am also extremely grateful to Doerthe Tetzlaff, Chris Soulsby and Jeff McDonnell who entrusted me with their postdoctoral research projects and expanded my horizons quite significantly. I have been blessed enough to work with those wonderful scientists whom I am trying to emulate, though some days much less successfully than others! I would not be in the position I am in today were it not for their tremendous support.

I must also thank Jeff McDonnell, who was kind enough to instigate the nomination process: it is extremely appreciated. I hope I can feed into my own students just half of the passion and enthusiasm that Jeff and my other mentors have communicated to me. I also wish to acknowledge my very dynamic group of students at the University of Manitoba: they keep me on a steep learning curve and for that I am very thankful. As for my friends and colleagues from the CGU community, I thank you all for your companionship and I hope to continue rubbing elbows and even making scientific history with you, just one little step at a time.

The 2014 Stan Paterson Scholarship in Canadian Glaciology winner: Chris Marsh

Acceptance: It is a great honour to receive this award; thank-you. Dr. Stan Patterson is well known for his seminal research that has, in part, allowed for the tremendous progress of the cryosphere sciences. With this award, Dr. Paterson has left a legacy to encourage and support young researchers. Through this legacy, Dr. Paterson is continuing to help shape the course of scientific insight into these remarkable systems that are so important to society as sources of fresh water and as areas of immense ecological value. I would like to thank my longtime friend and supervisor Dr. John Pomeroy who has constantly encouraged my interest into the cryosphere sciences from pre-undergrad to graduate studies, and who has, at every step, challenged me to further refine my scientific approach. Further, I would like to thank my parents, for without them I would not have found my love of science and would be unable to follow in the footsteps of great scientists like Dr. Stan Paterson.



CGU 2014 Best Student Paper Award Winners

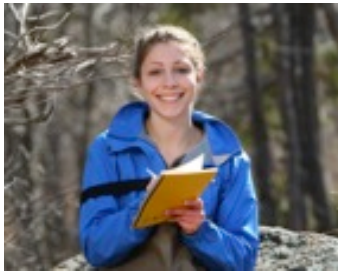
A number of awards are presented in recognition of outstanding performance in scientific research and presentation by students. Each of the awards comes with a monetary prize. To be considered for an award, the student must be the first author and presenter of the paper (visit <http://www.cgu-ugc.ca> for details).



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

Winner: **Ms E. Sinem Ince**, York University
Improvement of GOCE Level 1b Gradiometer Data Processing Over Magnetic Poles
E. Sinem Ince, Spiros D. Pagiatakis
Department of Earth and Space Science and Engineering, Lassonde School of Engineering, York University, Toronto
seince@yorku.ca, spiros@yorku.ca

Full paper below



Shell Outstanding Student Poster Paper

Winner: **Ms Kelly Biagi**, Dalhousie University
Catchment liming to protect Atlantic Salmon in Nova Scotia – approaches needed and knowledge gained.
Biagi, K.¹, Angelidis, C.¹, Armstrong, M.¹, Sterling, S.¹, Clair, T. A.¹ and Breen, A.²
¹Earth Sciences, Dalhousie University, ²Bluenose Coastal Action Foundation



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

Winner: **Mr Kegan Farrick**, Western University
Wetting the sponge: Storage, rainfall and runoff relationships in a Mexican tropical dry forest
Kegan Farrick¹ and Brian Branfireun²
¹Department of Earth Sciences, Western University, London, Ontario, Email: kfarrick@uwo.ca
²Department of Biology and Centre for Environment and Sustainability, Western University, London, Ontario

Full paper below



D.M.Gray Scholarship in Hydrology

Winner: **Mr Colin McCarter**, University of Waterloo



Campbell Scientific Award for Best Student Poster in Hydrology

Winner: **Ms Tara Despault**, Western University

Fluorescence fingerprinting of dissolved organic matter in the Attawapiskat River Watershed – Towards the development of *in situ* proxies for mercury in northern waters

T. Despault¹ & B. Branfireun²

¹Dept. of Earth Science, Western University; Email: tdespaul@uwo.ca

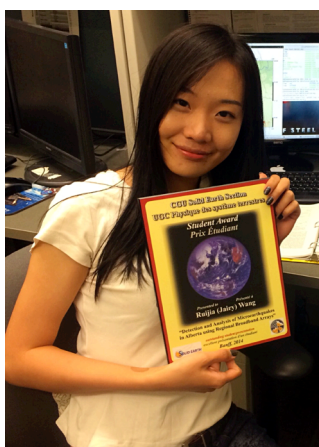
²Dept. of Biology, Western University

Extended abstract below

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

Winner: **Ms E. Sinem Ince**, York University

Same paper as above



Solid Earth Section Best Student Paper Award

Winner: **Ms Ruijia (Jairy) Wang**, University of Alberta

Detection and Analysis of Microearthquakes in Alberta Using Regional Broadband Arrays

R. Wang & Y. J. Gu

Dept. of Physics, University of Alberta, Edmonton, AB

Phone: 780-952-1904, Email: ruijia3@ualberta.ca

Abstract below



Biogeosciences Best Student Paper Award

Winner: **Mr Max Lukenbach**, McMaster University

Does Restoration Reduce Wildfire Vulnerability in Drained and Mined Peatlands?

M.C. Lukenbach¹, G. Granath¹, H. K. MacDougall¹, K. Hokanson¹, P.A. Moore¹, M.

Strack², D.K. Thompson³ & J. M. Waddington¹

¹School of Geography and Earth Sciences, McMaster University,

Email: lukenbmc@mcmaster.ca

²Department of Geography, University of Calgary

³Northern Forestry Centre, Canadian Forest Service

Abstract below

Improvement of GOCE Level 1b Gradiometer Data Processing Over Magnetic Poles

E. Sinem Ince, Spiros D. Pagiatakis

Department of Earth and Space Science and Engineering, Lassonde School of Engineering, York University, Toronto

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Abstract

The latest gravity field mission GOCE has mapped the Earth's static gravity field with an unrivalled precision. Being the first satellite of its kind and having a unique instrument onboard make GOCE special. Nevertheless, this also makes GOCE data and its' processing challenging. In order to solely observe and map the Earth's static gravitational field, the influence of all other temporal gravitational and non-gravitational effects should be eliminated from GOCE gradiometer observations. In this study, the leakage of the non-gravitational forces into the gradiometer data is sought and the reasons behind this kind of deficiency are investigated. It is found that the attitude of GOCE has been affected by unexpected external sources, such as solar wind and magnetic storms around the magnetic poles. Under optimum conditions, such non-gravitational effects should be measured by accelerometers as common-mode accelerations and compensated. However, it is seen that the effects of these phenomena leak into the differential-mode accelerations, which should include only gravitational forces and rotational accelerations of the satellite. Moreover, these effects are observed in the gravity gradient tensor components that are used in the development of static gravity field models. It is also seen that the GPS antenna onboard has experienced tracking losses in these regions. This makes the position of the satellite unavailable and may reduce the quality of orbit solution in these regions. All these effects may degrade the accuracy of final products such as gravity field models and geoid. Accordingly, the separation between the gravitational and non-gravitational accelerations should be performed very cautiously. Our study seeks whether it is possible to improve this separation between the common- and differential-mode accelerations by having the geomagnetic field components computed along the satellite track and eliminate any possible correlation between the gravity and geomagnetic fields in GOCE data.

1. Introduction

The Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) mission was launched on March 17, 2009. The objective of the GOCE mission was to model the Earth's static gravity field with an accuracy of 1 cm in geoid heights and 1 mGal in gravity anomalies at a spatial resolution of around 100 km (Drinkwater et al., 2007). Since March 2009, GOCE collected unprecedented details of the gravitational field and almost tripled its planned life due to low solar activity. The satellite completed its mission in November 2013; however, researchers have still been seeking for possible improvements in data processing.

The core instrument making GOCE special is the Electrostatic Gravity Gradiometer (EGG), which is almost perfectly positioned at the center of the mass (COM) of the satellite. EGG consists of 3 accelerometer pairs (A_{1-4} , A_{2-5} , and A_{3-6}), which are placed on three mutually orthogonal axes (see Fig. 1). The three axes (of the Gradiometer Reference Frame) are oriented approximately with the x-axis in flight direction, y-axis orthogonal to the orbit plane (cross-track) and z-axis almost radially downwards

(Gruber et al, 2010). The distance between the accelerometer couples along the same axis is about 50 cm and the distance between the center of the gradiometer and center of each individual accelerometer is about 25 cm. The EGG is rigidly mounted onto the spacecraft that rotates in space with an angular velocity mainly about the y-axis (pitch). Therefore, the accelerometers measure the rotational motion in addition to the gravitational forces.

In this study, two different segments of two-month length each GOCE Level 1b gradiometer data are used for our investigations. These datasets comprise calibrated common- and differential-mode (CM and DM) accelerations and gravity gradients. They are investigated in frequency, space, and time domain in order to identify the characteristics of the EGG Level 1b data. The Level 1b datasets can shortly be described as raw datasets while the well-known spherical harmonic coefficients are Level 2 products. Based on our analyses, it is found that there are signals of non-gravitational origin present in the gravitational gradients (second spatial derivative of the Earth's gravitational potential) derived from GOCE gradiometer around the magnetic poles. It is given in the literature that these imperfections are due to the scale factor applied in the retrieval of the accelerations from control voltages, misalignments of the accelerometers and non-orthogonalities of the gradiometer axes (Siemes et al., 2012). Moreover, they need to be eliminated from the DM accelerations in order to develop a mean gravitational field model.

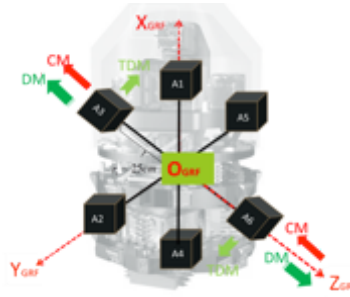


Fig. 1: Configuration of the accelerometers and the axes of the Gradiometer Reference Frame (GRF). CM and DM correspond to common- and differential-mode while TDM represents the transversal differential mode, which is used in the determination of angular acceleration of the satellite together with the three star trackers onboard.

Accelerometer precision is achieved in the measurement bandwidth (MBW), between 0.005 and 0.1 Hz. Inside the MBW, the accelerometers are expected to include white noise while a typical $1/f$ error behavior is observed at lower frequencies outside of the MBW (Rummel et al., 2011). Therefore, in order to eliminate the noise in the MBW from lower frequency components, the data need to be filtered properly.

Our preliminary analyses in spectral domain suggest that orbital and semi-orbital periods are the common components of the gravitational and non-gravitational origin of datasets. It is also observed that there are some other common significant peaks existent in the CM and DM accelerations (see Ince and Pagiatakis, 2013). Results derived from the spectral analyses suggest the separation between the gravitational and non-gravitational fields needs to be re-investigated cautiously and improved, unless the sources of these common peaks are different.

Investigations on geographically located datasets support our discussions from spectral domain analyses such that there are some effects of non-gravitational forces leak into the GGT components around the magnetic poles. This is a known problem with the GOCE data and mentioned in Siemes (2012), Stummer et al. (2012), Peterseim (2011) and Yi (2012). Therefore, we investigate the possible effects of

the geomagnetic field over the GGT components. Initially, geomagnetic field components are computed from a recent global geomagnetic field model, IGRF11 (International Geomagnetic Reference Field) at the satellite altitude and EGG epoch in the ITRF. These components are transformed into the Gradiometer Reference Frame (GRF) and filtered into the EGG MBW. Analyses in spatial domain (presented in section 4) show that the signatures seen in the gravitational field components do not exist in the geomagnetic field components. In order to further our investigations, local observations of the magnetic field and solar activities need to be incorporated in this study to find out whether the source of these signatures are related with the magnetic field.

2. Data

The main datasets used in this study are obtained from GOCE EGG and satellite-to-satellite tracking (SST) instruments. EGG data consist of CM and DM accelerations and gravity gradient tensor (GGT) components that are given in the instrument reference frame (GRF). Moreover, SST data provide the position and velocity of the satellite in an Earth-fixed reference frame (ITRF). The Level 1b EGG data are used in our analyses while Level 1b SST raw data are found to be tricky to be used due to discontinuities and offsets in the data. Based on suggestions from ESA scientists, reduced-dynamic orbits (SST_PSO_2G) are used in our analyses. The reduced-dynamic precise science orbit solutions are provided in 10s interval. These data are interpolated into the epoch of EGG data in order to find the position of the satellite corresponding to the EGG data.

In addition to these datasets, satellite inertial attitude and Earth orientation quaternions are required in order to perform the transformation between the reference systems, such as International Terrestrial Reference Frame (ITRF), inertial reference frame (IRF) and gradiometer reference frame (GRF, body-frame). Inertial attitude quaternions (IAQs) are derived from the gradiometer TDM accelerations and star tracker observations (Stummer et al., 2012). The Earth orientation parameters follow the IERS conventions and include the corrections for precession and nutation of the Earth and are available in SST_PSO_2G component of Level 2 data (ESA, 2006).

In order to investigate possible effects of the geomagnetic field on the GOCE accelerometer data, geomagnetic field components at the satellite altitude and gradiometer epoch are computed along the satellite track, by using the latest global geomagnetic field model, IGRF11 which is represented by spherical harmonic coefficients of degree/order 13 (Finlay et al., 2010). Matlab function `igrf11mag.m` that is converted from a Fortran routine (NGDC-NOAA, 2013a) is used for this purpose.

All the datasets used in our analyses are available in 1s interval, which makes both datasets used in this study comprise about 10,000,000 points. Both, EGG and SST datasets have short and long gaps which make the data processing very challenging and requires an adaptive data processing.

3. Methodology

It is still a question of how best to process the GOCE data as they are the first of their kind. Moreover, it is admitted by other researchers that there is space for improvement in the data processing chain. The instrumental design of GOCE EGG lends itself best performance in some specific measurement bandwidth (0.005 – 0.1 Hz). Accordingly, the measurements obtained from EGG are filtered into the MBW since $1/f$ noise level dominates the gradiometer signal outside the MBW.

In order to determine the main diagonal GGT components, an in-line measurement along the respective gradiometer axis is needed. Acceleration measured by any of the accelerometers can be expressed by

$$a_i = -(V - \Omega^2 - \dot{\Omega})r_i + d \quad (1)$$

where V contains the GGT components, r_i is the distance between the COM and center of accelerometer, Ω and $\dot{\Omega}$ includes the angular velocity and accelerations, respectively and d is non-gravitational accelerations. The CM and DM accelerations derived from these measurements can be expressed by Eq. (2), where n and m represent the ID number of the accelerometers (cf., Fig. 1) and i indicates the measurement direction, x, y, and z.

$$a_{c,n,m,i} = \frac{1}{2}(a_{n,i} + a_{m,i}) \quad \text{and} \quad a_{d,n,m,i} = \frac{1}{2}(a_{n,i} - a_{m,i}) \quad (2)$$

In our analyses, the Gaussian filter is chosen as a low pass filter due to several reasons. For example, Gaussian window in time domain has Gaussian form in the frequency domain which avoids Gibbs phenomena. The general Gauss function and its Fourier transform can be represented as follows, respectively

$$g(x) = \frac{1}{\sqrt{2\pi\sigma_x^2}} e^{-\frac{x^2}{2\sigma_x^2}} \quad \text{and} \quad G(f) = e^{-\frac{f^2}{2\sigma_f^2}} \quad (3)$$

where σ_x and σ_f are standard deviations in time and frequency domain. The value of the cut-off frequency corresponds to -3dB or half-power point; therefore, the size of the Gaussian window in time domain can be represented as,

$$\sigma_x = \frac{\sqrt{2 \ln(1/\sqrt{2})}}{2\pi f} \quad (4)$$

where f is the cut-off frequency, 0.1 and 0.005 Hz in our case.

Two different Gaussian low-pass filters are designed and the difference between the two filtered series is used in order to filter the original data into the EGG MBW. For the filtering process, it is assumed that the observations are continuous and uninterrupted. However, GOCE data have many short and long gaps. The Gaussian filter is restarted after long gaps such as calibration procedure which lasts about one day. Different treatment methods can be developed for the short and long data gaps for the improvement in data processing.

Least Squares Spectral Analyses (LSSA) is performed to the GOCE gradiometer data (Pagiatakis, 1999). Gaussian filter is used to assign uncertainties to the each one of the filtered time series, which are then used as weights in the weighted LSSA. It is seen that, unequally weighted series enhance the weaker peaks in the spectrum (not shown in this paper).

Spectral and spatial characteristics of GOCE-derived gravitational and non-gravitational and IGRF11-derived geomagnetic field components need to be compared in the same reference frame. Accordingly, the magnetic field components calculated along the satellite track in the ITRF are transformed into the GRF by

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{GRF} = R_{IRF}^{GRF} \cdot R_{ITRF}^{IRF} \cdot \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{ITRF} \quad (5)$$

where R_{IRF}^{GRF} and R_{ITRF}^{IRF} are the rotation matrices from IRF to GRF and ITRF to IRF, respectively. Rotation matrices are derived from the inertial attitude and earth orientation quaternions (EOQ). One needs to note that the EOQ values are provided for every second of the UTC time. Accordingly, a conversion is needed between the UTC and GPS onboard time and any necessary interpolation needs to be performed between the epochs of different instruments.

4. Analyses

We investigate two different datasets in order to consider any possible seasonal effects on the EGG data. The first dataset are from March-April, 2011 and the second from May-June, 2011. Spectral analyses performed in 2 days data from March-April show that the orbital and semi-orbital periods have the most power of the signal due to the central term and flattening of the Earth's gravity field (see Fig. 2). Within the MBW, DM and V_{yy} (shown in blue and green, respectively) almost coincide. This behaviour indicates that the contribution of the centrifugal part is much smaller compared to the outside of MBW. Below the MBW, it is seen that the contribution of the angular part dominates the gradiometric signal which was also discussed in Stummer (2012). CM accelerations are represented by red and have also significant peaks around the orbital and demi-orbital periods. Moreover, there are also other significant peaks close to these two, which need to be investigated. Our preliminary investigations indicate that the orbital and semi-orbital peaks are commonly found in the magnetic field components too (Ince and Pagiatakis, 2013). This may be related with the ellipticity of the magnetic field.

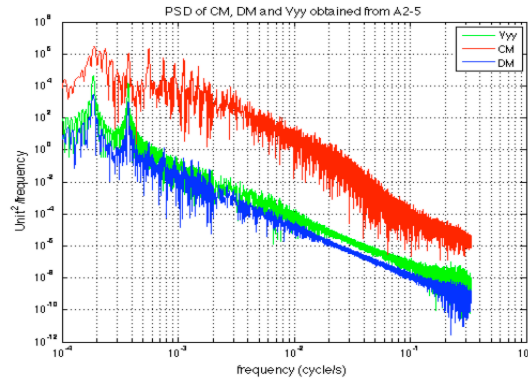


Fig. 2: PSDs of CM and DM accelerations (shown by red and blue, respectively) measured by A₂₋₅ accelerometer couple in the y-axis and V_{yy} component (shown by green).

The CM and DM accelerations derived from (A2, A5) accelerometer couple in the y-direction filtered into the EGG MBW are displayed in Fig. 3 and 4. The signatures around the magnetic poles in the CM accelerations are due to non-gravitational sources acting on the satellite. Despite their reduction, due to the insufficiencies in the data processing chain (e.g. inadequate in-flight calibration of the gradiometer), these signatures exist in the DM accelerations around the magnetic poles and equator in addition to the gravitational field and rotational acceleration of the satellite.

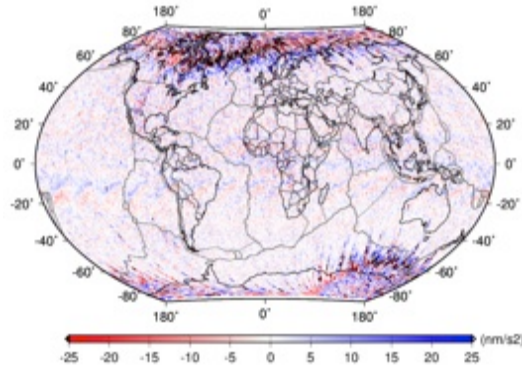


Fig. 3: CM accelerations in y-direction collected from A_{2.5} accelerometer couple in March-April 2011, filtered to the GOCE EGG MBW. Note the signatures of non-gravitational origin around the magnetic poles and equator.

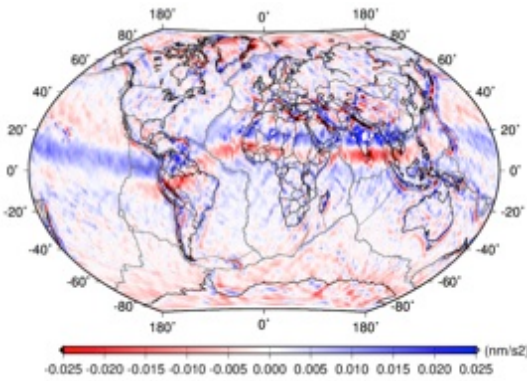


Fig. 4: DM accelerations in y-direction collected from A_{2.5} accelerometer couple in March-April 2011, filtered to the GOCE EGG MBW. Signatures around the magnetic poles are suspected to be related with some non-gravitational origin.

Since the literature focused on V_{yy} component we only include our investigations on this component. A closer look into the V_{yy} component in Polar Regions is provided in Fig. 5 and 6 for the North and South Poles, respectively. The disturbances based on non-gravitational forces are detected in both. The signatures are relatively stronger in the South Pole.

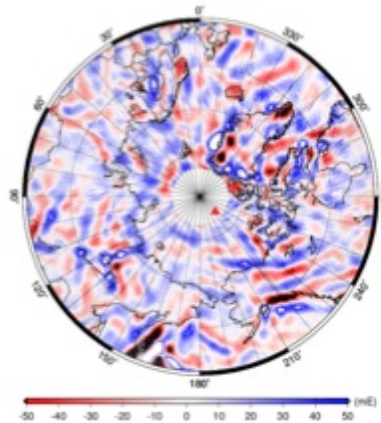


Fig 5 V_{yy} component of filtered GGT during March-April, 2011 in the North Pole for ascending tracks.

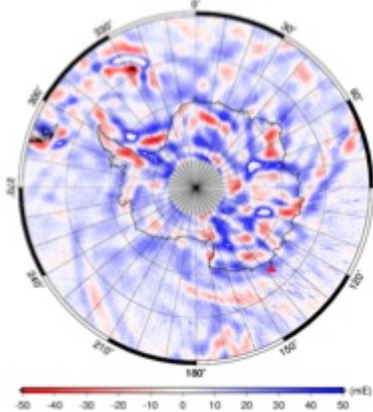


Fig 6: Vyy component of filtered GGT during March-April, 2011 in the South Pole for ascending tracks.

One needs to note that the investigations in space domain should be performed separately for ascending and descending tracks not only because the orientation of the satellite changes but also due to the changes of the atmospheric dynamics (e.g. day and night time temperature changes). A closer look into the South Pole for descending tracks is provided in Fig. 7. It is worth mentioning that these signatures are observed only in the ascending tracks. The signatures are almost negligible in descending tracks compared to the ones existing in the ascending ones. It is tricky to make comparisons between ascending and descending tracks directly, as the attitude and altitude of the satellite change along the track. Accordingly, geographically positioned time series show differences in terms of resolution and magnitude between ascending and descending tracks.

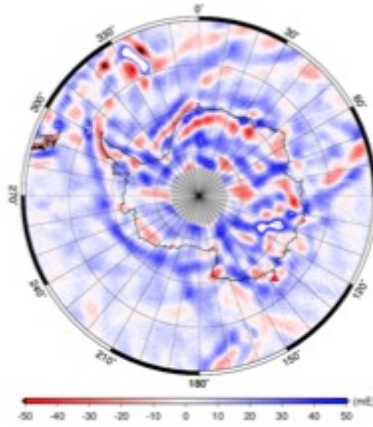


Fig 7: Vyy component of filtered GGT during March-April, 2011 in the South Pole for descending tracks.

The magnetic field components filtered into the GOCE EGG MBW do not show similar signatures around the same regions (see Fig. 8). Based on the current analyses it is not possible to relate these signatures with the geomagnetic field. In other words, global geomagnetic field model provide only long wavelength information in the regions whereas we are interested in higher resolution of components.

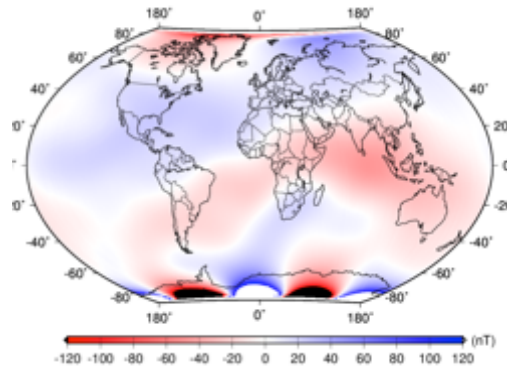


Fig 8: Y component of filtered geomagnetic field during March-April, 2011 for ascending tracks transformed into the GRF.

The reasons behind these signatures can be due to the interaction of the satellite with the magnetic field itself, insufficiency of the method used in the calculation of angular acceleration of the satellite, or insufficiency of the calibration method of the gradiometer.

The intensity of these particular signatures is found weaker in the May-June data. Our analyses on March-April and May-June, 2011 data led us to investigate the solar activities during the same period. It is seen that the solar activities in March and April are stronger (NGDC-NOAA, 2013b) which might be an indication of a possible correlation between the solar activities and non-gravitational effects seen in the diagonal GGT components. Also, these activities causes the GPS signal loss, therefore the position of the satellite. Van den IJssel et al. (2011) suggested that there is a visible correlation between the level of ionospheric scintillation and the level of unexpected L2 GPS signal losses in the magnetic poles and equator.

5. Conclusions and Discussions

The aim of this study was to identify and understand the characteristics of GOCE EGG derived Level 1b datasets. Spectral analyses show that the orbital and semi-orbital periods of GOCE dominate other spectral components. These two periodicities are related to the ellipticity of the Earth. It is observed that the CM accelerations are affected by atmospheric dynamics, which leak into the DM accelerations and gravity gradients most probably due to the poorly determined calibration parameters. Our results indicate that a revision of the calibration parameters is necessary. Moreover, it is seen that the short and long gaps are problematic. Accordingly, new data processing techniques (e.g filtering) can be designed considering the length of the gaps.

Our ultimate goal is to develop improved Canadian static geoid models from GOCE Level 1b data. A combination of correctly treated satellite observations with accurate regional terrestrial and airborne gravity data may lead to more accurate regional geoid models. Especially, considering the fact that these disturbances are located around the magnetic poles, it might be expected that the GOCE data over Canada can be improved. It is also found that the proposed improvement over the datasets is challenging by using a very low-resolution magnetic field model. Instead, local terrestrial magnetic field observations need to be incorporated in order to study the strength of these non-gravitational forces.

This problem has not been solved by any of the institutes working with ESA – GOCE project. Any improvement on this issue will require reprocessing the GOCE data from the very beginning (personal communication, Floberghagen and Haagmans, 2013).

Our future studies will include the comparison and replacement of some specific bandwidth of GOCE EGG data with the ones derived from GRACE and terrestrial data. This approach will help to support our analyses and behave as an external calibration process of the data as well. Moreover, comparison between the ascending and descending ground tracks need to be studied very carefully in order to investigate the systematic differences between the two. A direct comparison considering the atmospheric dynamics and satellite attitude need to be investigated in detail which might be useful for the improvement of the data processing

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D. M. Gray Award: Best Student Paper in Hydrology

Wetting the sponge: Storage, rainfall and runoff relationships in a Mexican tropical dry forest

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Abstract

Catchment water storage and rainfall thresholds that are required for the generation of runoff are the subjects of intense study in the recent catchment hydrology literature. Yet, to our knowledge, these threshold relationships remain undescribed in tropical dry forest catchments. The extent of these systems, the sensitivity of their associated intermittent streams to strongly seasonal precipitation inputs, and forecasted climate change in these regions make the application of a threshold analysis of streamflow generation essential for predicting future water availability in these water-limited catchments. We examined the water storage and hydrometeorological threshold controls of streamflow activation and event-scale runoff response in a tropical dry forest catchment in Mexico. Our results showed that the mechanisms required for streamflow activation were not principle factors in stormflow generation. During the transition from the dry to wet season, soil water movement was dominated by vertical percolation until a threshold volumetric soil moisture of 22% was measured 100 cm below the surface, satisfying a 103 mm storage deficit and activating streamflow. Through the wet season, high antecedent soil water conditions were maintained and had little influence on stormflow magnitude. Using a piecewise regression model, a threshold value of 185 mm of summed event rainfall and antecedent soil water needed to generate more than 3mm of stormflow runoff. Above this threshold, rainfall event characteristics, and not antecedent soil moisture conditions govern the stormflow response. Understanding these thresholds and runoff responses will allow for more informed decision-making under the warmer and drier climate forecasts that are anticipated for this region due to climate change.

Introduction

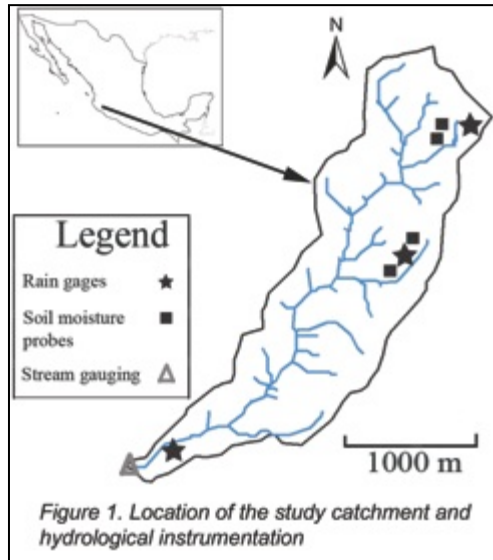
The lack of understanding regarding the controls that govern runoff generation in tropical dry forests represent a critical gap in the catchment hydrology literature. Tropical dry forests account for approximately 42% of the global tropical forests and 19% of the total world forested area, but represent <1% of the forest hydrology literature (Farrick and Branfireun, 2013). These forests are characterised by a distinct 3 – 7 month dry period and intermittent streamflow that persists for 4 – 5 months. It has clearly been demonstrated in humid temperate catchments that specific thresholds of rainfall are required to initiate runoff (Buttle *et al.*, 2004); however most studies indicate that this threshold is only exceeded after storage deficits are satisfied, thereby connecting hillslopes to streams (McGuire and McDonnell, 2010). Recent work has therefore focused on combining both the event precipitation and antecedent soil water content, which represents the storage deficit, to assess stormflow generation at the catchment scale (Detty and McGuire, 2010). Despite the important role that storm event characteristics and catchment storage play in controlling runoff, no such research has been conducted in tropical dry forests. Characterising these threshold relationships is particularly important in tropical dry forests as expected reductions in rainfall will likely have a strong impact on runoff generation.

Therefore, the overall objective of this research was to investigate the relationship between rainfall, soil water storage and runoff in a Mexican tropical dry forest catchment. The specific objectives are to: (1) identify the hydrometeorological and water storage controls on streamflow activation and (2)

determine if the dominant controls on streamflow activation are the primary control on stormflow generation.

Study site

The study was conducted in a 3.15 km² catchment in the lake Zapotlán watershed, Jalisco, Mexico (19°46N – 103°25W) (Fig. 1). The climate is Tropical Savannah with a distinct wet and dry season. The average annual precipitation (1972 – 2003) is 813 mm, of which 95% falls between June to September. Mean annual temperature is 19.6°C with maximum temperatures occurring in July. The



average ratio of potential evapotranspiration to rainfall is greater than one, indicating an arid and water limited climate. Elevation ranges from 1557 metres above sea level (masl) at the primary outflow channel to 2170 masl at the headwater sub-basin. The catchment is steep with slopes ranging from 30° to over 40°. The channel width ranges from <0.20 m in the headwater sub-basins to 1.0 – 1.5 m at the primary outflow channel. The stream channels are highly incised and steep, with a narrow riparian zone. Soil textures range from sandy loams in the upper A horizons to loams and sandy-clay loams at depths below 50 cm. The catchment is dominated by two distinct forest types. The pine-oak forest (almost exclusively *Pinus montezumae*, *Quercus laeta*) occurs at elevations greater than 1800 masl and occupies 82% of the catchment area. The highly heterogeneous mixed deciduous forest (dominated by *Carpinus caroliniana*, *Mimosa adenantheroides*, with a complex mix of

understorey and herbaceous vegetation) occurs at elevations between 1600 – 1800 masl and covers 13% of the catchment.

Methods

Open field precipitation was measured using tipping bucket gauges from May to September, 2012. Soil moisture measured at four soil pits installed across the catchment at depths of 10, 30, 50 and 100 cm below the surface (Fig. 1). The pits were located 20–60 m upslope of the stream. The total depth equivalent of soil water (mm) was determined from the mean soil moisture from the four instrumented pits following Haga *et al.* (2005). Catchment discharge was calculated from the stream water level at the primary outflow channel using the end-depth method.

Storm runoff events were separated into quickflow (QF) and baseflow components using the local minimum method. Twenty-one storm events were identified during this period. The effect of antecedent wetness conditions on QF was assessed using: 1) The antecedent soil water; depth equivalent soil water prior to a storm event and; 2) The sum of the antecedent soil water and event rainfall (mm). Piecewise regression analysis (PRA) was used to examine the threshold behaviour of QF versus antecedent soil water and the sum of antecedent soil water and event rainfall. The PRA was performed using WinBUGS1.4, an interactive Windows based program for Bayesian analysis of complex statistics.

Results

From May 1 to June 10, a total of 15 mm of rainfall was recorded. During this period a stable mean soil moisture of 13.8% over the 100 cm soil profile was recorded (Fig. 2b). The size and frequency of storm events increased after June 10 with a total of 176 mm of rainfall recorded from June 10 to July 7. During this transition phase or wetting up period, there was a progressive increase in soil moisture from the 10 to 100 cm layer (Fig. 2b). Streamflow was absent during this period and was only activated after the soil moisture 100 cm below the surface increased to a mean threshold value of 22% from all hillslope locations (Fig. 2b-c). The activation of streamflow occurred after a cumulative input of 191 mm of rainfall over 30 days. More importantly, a 103 mm soil storage deficit over the 100 cm soil profile was satisfied before streamflow was activated (Fig. 3). The deficit was calculated as the daily cumulative increase in the depth equivalent soil water (mm) of the 100 cm soil profile at the start of the transition phase until streamflow was activated.

A minimum rainfall (P) threshold of 4 mm was needed to generate quickflow from the catchment (Fig. 4a). Quickflow ranged from 0.2 to 32.2 mm and was

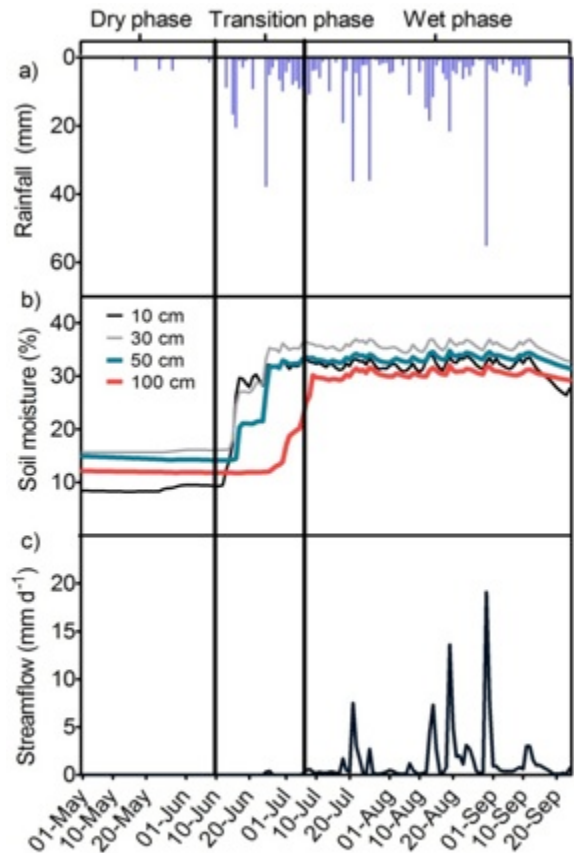


Figure 2. Daily variation in a) rainfall, b) soil moisture and c) streamflow from the primary outflow channel from May to September, 2012.

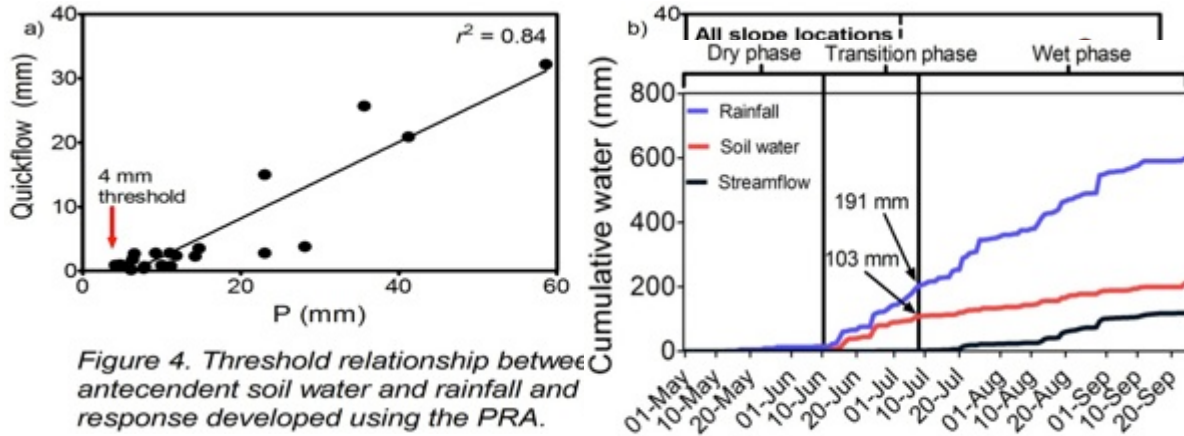


Figure 4. Threshold relationship between antecedent soil water and rainfall and response developed using the PRA.

Figure 3. Cumulative rainfall, soil water and streamflow from May to September, 2012.

strongly influenced by the event rainfall depth, increasing linearly with P ($r^2 = 0.84$) (Fig. 4a).

The mean QF/P was 0.26 and ranged from 0.04 to 0.72 and had a strong linear relationship with P ($r^2 = 0.40$), which was statistically significant and showed low scatter throughout the relationship when P was less than 14 mm.

The depth equivalent antecedent soil water over the 100 cm profile ranged from 153 – 177 mm with a mean of 168 ± 5 mm during the wet phase. The influence of the antecedent soil water content on stormflow generation was weak with no significant linear relationship ($r^2 = 0.001$; $p < 0.89$) or threshold response observed. Using the PRA, a threshold response was observed for the QF and antecedent soil water + P relationship at the convex and concave hillslope; however, the difference in the threshold

value between the sites was not substantial. We used the mean value from all slope locations to show a breakpoint in the non-linear relationship between QF and antecedent soil water + P at 185 mm (Fig. 4b). Below threshold events produced stormflow ≤ 2.8 mm and a mean QF/P of 0.18, while above threshold events produced QF from 3.5 – 32.2 mm with a mean QF/P of 0.47. The volume of stormflow produced from above threshold events (101 mm) was 81% of the total stormflow generated over the wet season (124 mm).

From the PRA, we were able to demonstrate how the expected reduction in rainfall will alter the currently observed stormflow response. During the wet phase, when above threshold events occur, the regional climate model developed by Karmalkar *et al.* 2011 estimated a 27 and 13% decrease in daily rainfall in July and August. By applying the estimated decrease in rainfall to our observed values and using the linear equation ($y = 0.9212x - 167.23$) for above threshold events, we estimated that stormflow may be reduced by as much as 34%, decreasing the 101 mm of above-threshold stormflow to 66 mm.

Discussion and Conclusion

A threshold soil moisture of 22% at the 100 cm soil layer was necessary to activate streamflow from the catchment. Below the threshold, streamflow was not generated; however the increase in soil moisture through the upper 50 cm of soil in the upslope areas indicates that vertical flow processes were active. Above the threshold, streamflow activation signals the occurrence of lateral flow from the hillslope. Grayson *et al.* (1997) described this *change of state* as a switch in the dominant direction of soil water movement from vertical flow under dry antecedent conditions to lateral flow under wet antecedent conditions. Unlike the shallow, near-surface (0-30 cm) soil moisture response observed in temperate humid catchments, we showed that soil water at deeper layers (100 cm) were necessary for streamflow activation. These differences may reflect the variability in the depth of saturation or near-saturated conditions.

The use of the soil water deficit as a metric of streamflow activation accounts for the annual rainfall variability by assuming the deficit is a consistent value that does not vary yearly. By the end of the dry phase the lowest soil moisture values were recorded, indicating the maximum storage deficit. The seven month dry phase is part of the annual cycle in this region and we expect these low and stable moisture contents and maximum soil water deficit to be achieved annually (Farrick and Branfireun, 2013). Because similar dry periods are observed at other tropical dry forests catchments, we recommend using the soil storage deficit approach presented in this paper when examining streamflow activation.

As the catchment wetness increased over the wet phase the size of the storm event had the strongest control on the stormflow response. By summing antecedent soil water with event rainfall we identified a threshold response in stormflow similar to Detty and McGuire (2010). The increase in both QF and QF/P above the threshold represents an increase in the hydrological connectivity across the catchment. During the wet season, high antecedent soil water contents produced hydrologically active areas across the hillslope, where lateral subsurface flow could occur rapidly. Above the threshold, large storms were able to connect the hydrologically active areas, generating substantial amounts of stormflow over an increasing contributing area. The mean QF/P of 0.47 recorded above the threshold suggest that ca. 47% of the catchment area contributes to stormflow. These findings are supported by other research in steep humid catchments which show that the expansion of upslope contributing areas through increased saturated subsurface connectivity lead to a threshold response in stormflow (Detty and McGuire, 2010; McGuire and McDonnell, 2010).

To our knowledge, this study represents the first recorded storage and rainfall thresholds required to activate streamflow and generate stormflow in a tropical dry forest catchment. These findings have important implications with regards to the ecological and human systems that are supported by these dry forest catchments. Runoff produced from this and other dry forest catchments is

the primary water source to lake and wetland systems and is important for agriculture through direct extraction and shallow ground water recharge. The expected reduction in stormflow volume under the projected change in rainfall will reduce the supply of water and jeopardise the functioning of these systems. These results are therefore important to the mitigation and adaptive strategies needed for these regions and should strongly be looked at by land managers and policy developers.

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Campbell Scientific Award for Best Student Poster in Hydrology

Fluorescence fingerprinting of dissolved organic matter in the Attawapiskat River Watershed – Towards the development of *in situ* proxies for mercury in northern waters

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Introduction

The peatlands of the Hudson Bay Lowlands (HBL) occupy most of Ontario's Far North, contributing substantial freshwater and solute inputs to downstream aquatic ecosystems, notably the James/Hudson Bay. Despite concerns over present and future impacts of climate and land-use changes in the region, comprehensive surface water quality monitoring programs are sparse, largely due to the high costs and logistical constraints associated with implementation in such a vast and remote landscape. Spectroscopic measurements of dissolved organic matter (DOM) have been effective proxies for dissolved organic carbon (DOC) and mercury in many environments (*e.g.*, Bergamaschi et al., 2011), however, to our knowledge, these have yet to be implemented in surface waters that drain northern peatland complexes. Laboratory-based fluorescence measurements of surface waters have also been conducive to resolving seasonal changes in DOM sources and quality that result from variation in hydrological connectivity of a watershed over time, and have been successfully used in arctic and subarctic watersheds (*e.g.*, Spencer et al., 2008), and elsewhere (*e.g.*, Singh et al., 2013). The main objective of this study is to assess the viability of *in situ* optical measurements for widespread use in the HBL to improve the resolution and breadth of water quality data and monitoring in the region. Additionally, we aimed to evaluate temporal changes in DOM optical properties as a reflection of watershed contributors throughout the ice-free season to help elucidate the hydrological behaviour and functioning of peatlands in the HBL.

Study Site and Methods

The study focused on the surface waters of North Granny Creek (NGC; catchment size 30 km²), a first order peatland stream, and the Nayshkootayaow River (NR; catchment size 1721 km²), a fourth order river with a substantial groundwater component and a large outlet of peatland chemistry to the Attawapiskat River, into which it flows. The sites are located in the Attawapiskat River Watershed near the De Beers Victor Diamond Mine (52.83 °N, 83.93 °W), approximately 90 km west of the James Bay coastline in the HBL. The landscape is comprised of a mosaic of peatland landforms (*e.g.*, bogs, fens, and ponds) with an average peat thickness of 2 m, thinning noticeably near riparian areas.

In situ RBRmaestro loggers were deployed in the two rivers, collecting continuous measurements of chromophoric DOM fluorescence (FDOM) and other standard water quality parameters during the ice-free season. Discrete samples were collected every 1-2 days for DOC, total mercury (THg) and methylmercury (MeHg) analysis and ancillary chemistry (stable water isotopes and major ions) over the course of three ~two-week long sampling campaigns (*i.e.*, spring freshet, summer, and fall). Excitation-emission matrices were generated and used in combination with parallel factor (PARAFAC) analysis to derive fluorescence indices for each surface water and additional terrestrial samples collected (Cory and McKnight, 2005).

Results

Peak discharge in both rivers occurred during spring freshet. The lowest flows of the ice-free season occurred in the summer months (late-July to early-August). The highest DOC concentrations occurred during the peak flows of spring freshet in the NR and NGC, although water sampling began after peak freshet flows in the NR.

Linear regression yielded several significant relationships between *in situ* and PARAFAC-derived fluorescence indices, DOC and THg (Figure 1), although no such relationships existed for MeHg. The strongest correlation was observed between *in situ* FDOM measurements and DOC in the NR only ($r^2 = 0.93$, $p < 0.0001$), with no apparent link with THg. In the NGC, there was no observable relationship between *in situ* FDOM and DOC or THg. Conversely, relationships between specific UV absorbance (SUVA) and fluorescence index (FI) and THg were significant and comparable in both streams, while the correlation with DOC was only present for the NGC. However, when fall data from the NR were excluded from the regressions of FI and SUVA with DOC, relationships emerged that resembled their counterparts in the NGC, in both strength and direction. A strong correlation also materialized between THg and *in situ* FDOM when only freshet and summer data were analyzed from this site.

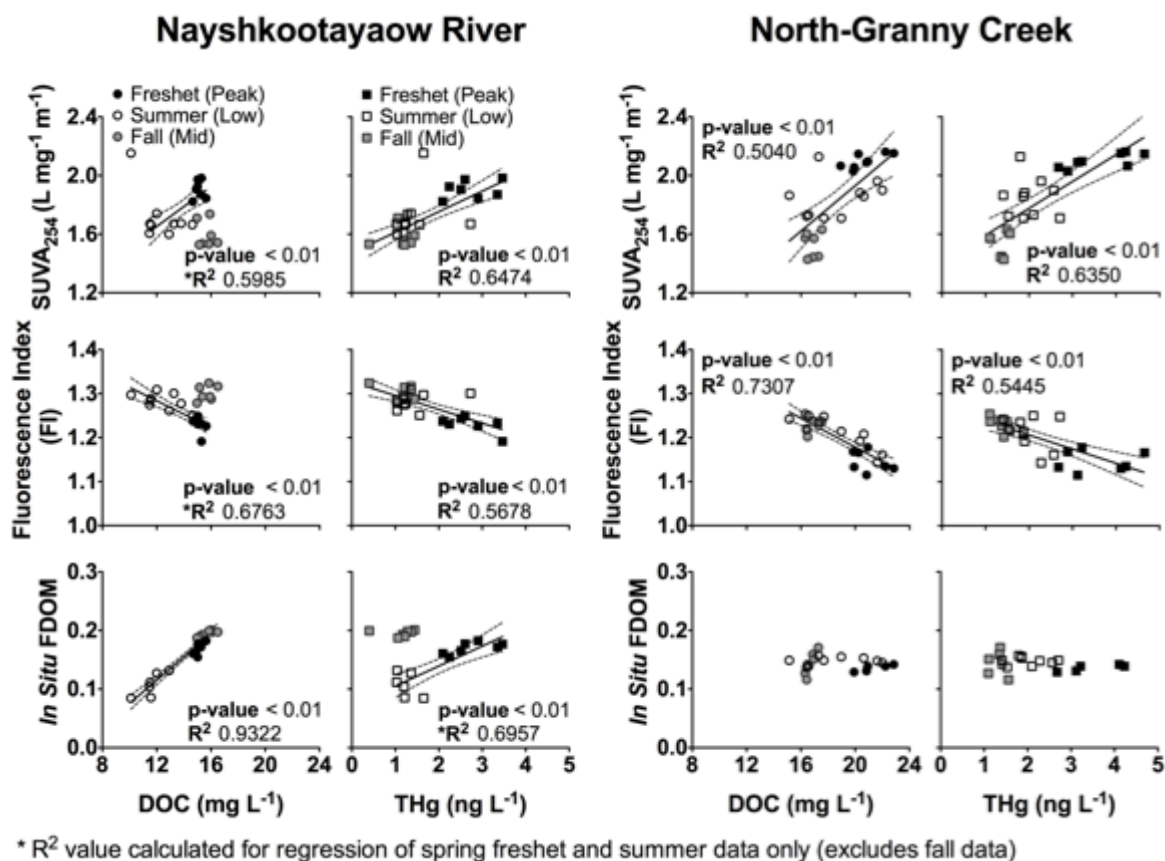


Figure 1. Linear regressions of DOC and THg analytical results with *in situ* and selected laboratory-derived spectroscopic indices showing significant correlations (p -value < 0.01; black lines) and 95% confidence band (dotted black lines). Data are plotted according to season and associated flow condition: spring freshet (peak flow), summer (low flow), and fall (intermediate flow).

Seasonal trends in DOC concentration and DOM quality showed some similarities between sites. SUVA and FI decreased and increased, respectively, with time in both streams, indicating a progressively

lessened influence of aromatic terrigenous DOM. Humification index (HIX) at both study sites decreased during summer baseflow conditions, rising again in the fall in the NR, but staying relatively consistent from summer onward in the NGC, similar to FI at this site.

Discussion and Conclusions

Differences in seasonal trends of spectroscopic measurements (*e.g.*, SUVA, FI, HIX) between the NGC and the NR were expected given the dominance of peat sources at the NGC watershed, and the largely groundwater-dominated baseflow of the NR. During spring freshet, litter frozen in place on the peat surface over the winter contributed to the DOM pool during snowmelt in the NR. The increased influence of deeper soil horizons, generally associated with enhanced microbial processing, was observed over the season (especially in the NR) through a slight rise in FI values, indicative of increased mixing of terrigenous and microbial sources. In the NGC, FI values suggested more constant terrigenous sources (< 1.3). The changes in fluorescence during baseflow in the NR suggest that the contributing deep groundwaters underwent preferential removal of humic and aromatic DOM.

An increased breakdown and accumulation of humic DOM during dry summer conditions and subsequent flushing in the fall may have resulted in more labile and humified DOM contributing to the NR in the late portions of the ice-free season. Higher HIX values at this time may also be attributed to fall leaf litter and runoff from the forested riparian areas adjacent to the NR. The relatively unchanging HIX and FI values from late summer to fall in the NGC reflect that DOM source was likely consistent during this time. Around the NGC, the dry summer led to extensive peat drying, thus fall precipitation would have been added to storage, and may not have been sufficient to achieve connectivity between the peatland and stream. Instead, the same peat layers persisted as the dominant sources of water and DOM to the NGC.

The inconsistent nature of correlations in streams of this study suggests that, while *in situ* fluorescence measurements may serve as a valuable proxy for solute monitoring in surface waters of the HBL, the method is site specific. Deviation from relationships in the NR in the fall may have occurred due to interference in the fluorescence signature, likely caused by an unexpected algae bloom that appeared at this time. An assessment of the effectiveness of this monitoring strategy over several distinct flow conditions must therefore be performed prior to deployment in areas where little data exists.

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Solid Earth Section Best Student Paper Award

Detection and Analysis of Microearthquakes in Alberta Using Regional Broadband Arrays

R. Wang & Y. J. Gu

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Stress changes in crustal rocks due to tectonic forces or industrial activities are known to cause microearthquakes, especially in regions with pre-existing faults and increased fluid content. The mechanisms and effects of these small magnitude events vary from region to region, though it is well documented that the process of stress accumulation and release could potentially impact the elastic properties, hence seismic velocities, in and around the seismogenic zone. The understanding of microearthquakes, especially in view of the broad range of industrial applications involving fluid injection (e.g., fracking and waste water disposal) in Alberta, will require detailed information on sediment/crustal elastic structures as well as on the background seismicity.

This study focuses on new results from an integrated analysis of earthquake and mining explosion data recorded by broadband stations from the Canadian Rockies and Alberta Network (CRANE) and Canadian National Seismic Network (CNSN). In addition to constraining the location and timing of these events, the network of 20+ local stations also provides a rare opportunity to 1) link their occurrences to natural and/or anthropogenic origins, and 2) determine their effects (both in space and time) on the surrounding crustal elastic properties. Through the compilation and careful examination of the travel times and waveforms of P, S and surface waves, we are able to improve the model constraints on the timing and locations of local events.

The mechanisms of a number of microearthquakes are highly correlated, which suggest a common origin and/or location. Some of the recorded events exhibit temporal changes in seismic velocity, likely in the vicinity of the seismogenic zone, within short time scales ranging from a few months to a few years. Challenges remain, however, in validating and interpreting these results, as location and precise timing of the microearthquakes could improve with increased station coverage. In short, better knowledge of the stress, crustal velocity and event occurrence would be paramount for the accurate assessment of induced seismicity and seismic hazard mitigation in Alberta.

Biogeosciences Best Student Paper Award

Does Restoration Reduce Wildfire Vulnerability in Drained and Mined Peatlands?

M.C. Lukenbach¹, G. Granath¹, H. K. MacDougall¹, K. Hokanson¹, P.A. Moore¹,
M. Strack², D.K. Thompson³ & J. M. Waddington¹

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³Northern Forestry Centre, Canadian Forest Service, 5320-122 Street N.W. Edmonton, AB, T6H 3S5

Wildfire is the largest disturbance affecting peatlands in Canada and under future climate scenarios the amount of area burned is forecast to increase by 25-100%, potentially converting these ecosystems into a regional net source of carbon to the atmosphere. During wildfire, the majority of carbon released from peatlands is attributable to peat smouldering with peat burn depths generally ranging from 5-20 cm. However, no study has documented the incidence of extreme smouldering events in drained and mined peatlands. Here we report on a smouldering event in August 2011 at Wainfleet Bog in Southern Ontario, where peat burn depths exceeded 50 cm (range: 0 to 80 cm, mean = 25 cm). Depth of burn was lowest in areas with higher moss recolonization and more recently abandoned post-mining. We parameterized the Peat Smouldering and Ignition model (PSI) at an adjacent unburned area to characterize the hydrological and hydrophysical conditions necessary for these burn depths to occur. Model outputs indicate that the coupling of dense peat (bulk density > 100 kg m⁻³) and low peat moisture (GWC < 250 %) allow for severe smouldering to propagate deep within the peat profile. We then used this modelling approach to determine whether mined peatland restoration practices reduce peat burn severity and vulnerability. These results suggest that restoration not only increases peat moisture and enables moss recolonization, but also facilitates the re-establishment of low-density peat that maintains high GWC under dry conditions. We argue that reduced fire risk and the associated reduction in potential carbon losses from wildfire should be accounted for when restoring peatland ecohydrological function.

Report on the CGU-CSSS Joint Annual Scientific Meeting in Banff, May 4-7, 2014

Rod Blais

The 2014 Joint Meeting of CGU and CSSS was held together with a 2014 Mantle Convection and Lithosphere Dynamics Workshop on May 4-7 at the Banff Park Lodge, Banff, Alberta. The scientific theme was '**Advances in Geophysical & Soil Sciences**' and the general program and related information can be found at the conference website www.ucalgary.ca/~cguconf.

The three Invited Plenary Speakers at the Opening Presidential Session were:

- D.S. Chanasyk (University of Alberta) on '**Identifying Water Management Alternatives as We Approach 2050**';
- E. Wohl (Colorado State University) on '**Messy Rivers are Healthy Rivers: The Role of Physical Complexity in Sustaining Ecosystem Processes**';
- C. Soulsby (University of Aberdeen) on '**Integrating Hydrology, Hydraulics and Ecology in Mountain Rivers**'.

Abstracts of those presentations can be found on the conference website mentioned above.

The CGU-CSSS Technical Program on May 5-7 had 48 oral sessions in four parallel streams with some 120 posters in three sessions. Participation was estimated at 245 for CGU and 165 for CSSS. The Technical Program and the Abstracts can be found on the conference website and the USB keys distributed to the participants. A number of sessions were joint sessions of CGU and CSSS especially in the Biogeosciences.

The Workshop which was sponsored by the Computational Infrastructure for Geodynamics (CIG) had a full three-day program with some 12 invited speakers and 29 posters. The Workshop participation was estimated at 28, including a number of graduate students. Again more information on the program and the Abstracts can be found on the conference website and the USB keys, as well as on the CIG website www.geodynamics.org.

Other activities included a very successful Field Trip to the Columbia Icefield on Sunday, May 4th, led by Scott Munro with some 35 participants. CSSS also had a 'Soils and Landscapes of the Foothills and Front Ranges Tour' on Thursday, May 8th. Other social activities including a Student Trivia Night and special post-Banquet entertainment by 'Professor Endeavour' are described on the conference website.

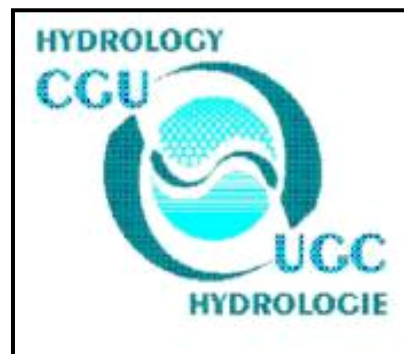
Considering the comments from numerous participants, this Joint Meeting was very successful and enjoyable. Of course, many thanks go to our sponsors and exhibitors. All the members of the SPC and LOC Committees are also recognized on the conference website and sincerely thanked for the contributions.

HYDROLOGY SECTION NEWS

Prepared by Daniel Peters

President's Report

The CGU Hydrology Section (CGU-HS) continues with a busy schedule of activities and initiatives. The CGU-HS was a prominent contributor to the Joint Congress of the CGU and the Canadian Society of Soil Science (CSSS) in Banff, where the attendance at our broad range of sessions was very high. The annual Woo Lecture entitled "Always Connected? Hydrological Connectivity and Water Storage Dynamics in Northern Watersheds " was presented by Dr. Doerthe Tetzlaff of the School of Geosciences, University of Aberdeen. Her talk focussed on the processes controlling the spatial integration of producing areas of drainage basins, and how these processes and hydrological connectivity vary over space and time. In addition, hydrologists David Chanasyk, Ellen Wohl and Chris Soulsby delivered plenary presentations for the Joint Congress.



The CGU-HS presides and adjudicates over three awards. The Campbell Scientific Award for Best Student Poster in Hydrology was awarded to MSc. Candidate Tara Despault, Department of Earth Sciences, University of Western Ontario. The D.M. Gray Award for Best Student Paper in Hydrology was awarded to PhD Candidate Kegan Farrick, Department of Earth Sciences, University of Western Ontario. The D.M. Gray Scholarship (a Union award) was awarded to PhD Candidate Colin McCarter, Department of Geography and Environmental Management, Waterloo University. In addition, the Shell Canada Best Student Poster Award was awarded to hydrology student Kelly Biagi, School of Geography and Earth Sciences, McMaster University. As in previous years, competition was strong in all categories with many high-quality submissions.

As in previous years, the CGU-HS has prepared a special issue of selected papers to be published in Hydrological Processes. The issue was published in July and highlights 15 papers presented at the 2013 meeting on a range of topics from climate change impacts on regional hydrology to hydrological process studies. Once again, Hydrological Processes has agreed to host a special issue for papers presented at the 2014 meeting. A reminder that papers also presented in 2013 at the Saskatoon meeting are also eligible for the special issue. Manuscripts should be submitted via the normal online procedure by 30 September 2014. Additional details as to the special issue number will be provided soon. The CGU-HS continues to sponsor annual student meetings. This year's student meeting was held at the University of Toronto in early February. The 2015 CGU-HS student meeting will be held at the Western University.

Finally, changes made to the executive and a new slate was adopted for this year. The 2014/2015 CGU-HS Executive and their length of term are:

President: Bill Quinton (Wilfrid Laurier University) wquinton@wlu.ca

Vice President: Daniel Peters (Environment Canada) daniel.peters@ec.gc.ca

Past President: Sean Carey (McMaster University) careysk@mcmaster.ca

Secretary: Andrew Ireson (University of Saskatchewan) andrew.ireson@usask.ca

Treasurer: Laura Brown (University of Toronto) laura-brown@rogers.com

Member-at-Large Claire Oswald (Ryerson University)

Member-at-Large: Tim Duval (University of Toronto) tim.duval@utoronto.ca

Student representative: Justin Adams (University of Guelph) jadams@uoguelph.ca

I wish to thank outgoing executive members April James (Nippising University) and Colin McCarter (University of Waterloo) for their service on the executive.

CNC-IAHS Annual Report to CGU

Perhaps the most important news regarding IAHS activities is the start of a new decade-long program to follow up the success of the PUB initiative: Panta Rhei (Everything Flows). The program will be active from 2013 to 2022. There are currently 26 Working Groups listed on the Panta Rhei web site, of which four have one or more Canadians listed as participants. Details can be found via the following link:

<http://distart119.ing.unibo.it/pantarhei/>

At the CGU-HS business meeting at Banff, Gordon Young, Executive Director of CGU and former President of IAHS, provided an overview of Panta Rhei and its current activities. During general discussion following Gordon's presentation, there was some interest expressed in forming a committee to provide a focal point for Canadian activities in support of the Panta Rhei objectives. Dan Moore will be following up, and will report back via the mailing lists of the four organizations within which CNC-IAHS operates: CGU-HS, Canadian Water Resources Association/Canadian Society for Hydrological Sciences, Canadian National Chapter of the International Association of Hydrogeologists, and Canadian Meteorological and Oceanographic Society.

In the last year, Canadians were active as officers in several IAHS Commissions, as listed below:

International Commission	Canadian Officer	Position
Groundwater	René Therrien, Université Laval	Vice president
Continental Erosion	Mike Stone, University of Waterloo	President
Snow and Ice Hydrology	John Pomeroy, University of Saskatchewan	Past president

The current executive of CNC-IAHS is listed below:

Position	Representative
Senior Representative and Chair	Dan Moore, UBC
Junior Representative and Secretary	Bill Quinton, Wilfrid Laurier University
President, CGU-HS	Bill Quinton, Wilfrid Laurier University
Vice-President, CGU-HS	Dan Peters, Environment Canada
President, CMOS	Harinder Ahluwalia
President, CWRA/CSHS	Wayne Jenkinson (representing the president)
President, CNC-IAH	Garth van der Kamp, Environment Canada
Member-at-large, CGU-HS	Masaki Hayashi, University of Calgary

The Canadian Representatives to IAHS Commissions are listed below:

International Commission	Canadian Representative
Surface Water	<i>Vacant</i>
Groundwater	Masaki Hayashi, University of Calgary
Water Quality	<i>Vacant</i>
Continental Erosion	Mike Stone, University of Waterloo
Coupled Land-Atmosphere Systems	Rich Petrone, Wilfrid Laurier University
Remote Sensing	Al Pietroniro, Environment Canada
Water Resources Systems	<i>Vacant</i>
Snow and Ice Hydrology	Sean Carey, McMaster University
Tracers	John Gibson, Alberta Research Council
Statistical hydrology	<i>Vacant</i>

GEODESY SECTION NEWS

Prepared by Robert Kingdon, Secretary, CGU Geodesy Section

CGU Annual Meeting 2014:

The CGU Geodesy Section was represented at the CGU–CSSS Annual Meeting, taking place in Banff, Alberta from May 1 to 7, 2014. Our presence comprised 9 oral and 1 poster presentation. Topics included the Canadian Geoid Workshop, CGVD2013 in New Brunswick, DEM analysis, PPP for monitoring vertical terrain velocity, GOCE data processing and analysis, determination of high resolution spherical harmonic models, geoid analysis using Helmert orthometric heights, and use of GOCE for height system unification. Of special note is the contribution of E. Sinem Ince of York University, whose paper “Improvement of GOCE Level 1b Gradiometer Data Processing over Magnetic Poles” won the Geodesy Section Student Paper Award. Appreciation is extended on behalf of the Geodesy Section to the organizers of the meeting, whose effort have again furthered scientific discourse among Canadian geodesists.

The attendance at the Annual Meeting this year was somewhat low, and a need to increase Geodesy Section membership has been identified. It has been proposed that low membership may be addressed by encouraging more involvement in the area of GNSS, while holding combined sessions with other sections or organizations associated with CGU might bring larger audiences for our activities.

Geodesy Section Annual General Meeting:

The Geodesy Section Annual General Meeting was held May 5 at 5:00 pm in the Banff Park Lodge, attended remotely via teleconference by absent members. During the meeting, voting took place for the incoming Geodesy Section Executive. The new members are:

- President: Joe Henton (Natural Resources Canada) Joe.Henton@NRCan-RNCan.gc.ca
- Vice-President: Jeong Woo Kim (University of Calgary) jw.kim@ucalgary.ca Past President: Patrick Wu (The University of Hong Kong) ppwu@hku.hk
- Secretary: Robert Kingdon (University of New Brunswick) robert.kingdon@unb.ca
- Treasurer: Elena Rangelova (University of Calgary) evrangel@ucalgary.ca
- Member-at-large: Daniel R. Roman (US National Geodetic Survey) dan.roman@noaa.gov
- Member-at-Large: Georgia Fotopoulos (Queen's University) georgia.fotopoulos@queensu.ca

Also at the Annual General Meeting, a competition for a new Geodesy Section logo was approved, with a \$100 prize. Parameters of the competition will be communicated to members once determined.

Miscellaneous News:

A key news item is the release in November 2013 of the Canadian Geodetic Vertical Datum of 2013 (CGVD2013), the first new vertical datum since the adoption of CGVD28 in 1935. This cutting edge geoid-based vertical datum provides a continuous vertical reference across all of Canada, unlike conventional datums that have values assigned only at sparse ground markers. The new datum will support precise heighting from GNSS observations, especially important with improvements in the vertical component of GNSS accuracy. Further information on CGVD2013 is available at: <http://www.nrcan.gc.ca/earth-sciences/geomatics/geodetic-reference-systems/10781>

In other news, members of the Geodesy Section from University of Calgary will be participating in a European Space Agency sponsor project for Height System Unification using GOCE (<http://www.goceplushsu.eu/>). Some members of the Geodesy Section will be contributing papers of the IGFS meeting in Shanghai from June 30 to July 6, 2014, in Shanghai, China (<http://202.127.29.4/meetings/igfs2014/>).

Geodetic Corner: The UNB-VMF1 Service

The University of New Brunswick has been maintaining a service in support of satellite-based geodetic positioning and navigation as a potential component of the Global Geodetic Observation System. This service provides geodetic-quality corrections to the signal propagation delays caused by the troposphere—the lowest-most portion of the Earth’s atmosphere—that are experienced by radio-based space-geodetic techniques such as GPS, other global navigation satellite systems, and very long baseline interferometry. It provides hydrostatic and non-hydrostatic zenith delays as well parameters for evaluating the Vienna Mapping Functions to correct for the slant delay.

The service is based on the Vienna Mapping Functions developed by the Institute of Geodesy and Geophysics at the Vienna University of Technology. While tropospheric delay corrections using the mapping functions together with data from the European Centre for Medium-Range Weather Forecasts are already available, UNB will offer an alternative service with some distinctive advantages.

The mission of the UNB-VMF1 service is to:

- Support the geodetic and other scientific communities through research providing state-of-the-art corrections to the tropospheric delay for space-geodetic techniques.
- Improve the availability of tropospheric delay products with the addition of an independent source derived from independently acquired data and independent ray-tracing algorithms.
- Achieve greater compatibility with other derived corrections, such as those for atmospheric pressure loading, using numerical weather prediction models.
- The UNB-VMF1 service utilizes state-of-the-art numerical weather model datasets from the U.S. National Centers for Environmental Prediction and the Canadian Meteorological Centre, as well as state-of-the-art ray-tracing algorithms developed by GGE researchers.

The output of the UNB-VMF1 service has been approved as a provisional product by the directing boards of the Global Geophysical Fluids Centre (GGOS) and its parent organization, the International Earth Rotation and Reference Systems Service. The UNB-VMF1 service is under a mandatory two-year evaluation period with the goal of obtaining full approval by GGOS.

Further details about the UNB-VMF1 service and datasets for corrections can be obtained from the official website: unb-vmf1.gge.unb.ca.

BIOGEOSCIENCES SECTION NEWS

Prepared by Carl Mitchell, Vice-President, CGU-Biogeoscience Section

The Biogeosciences Section (BGS) was active in two conferences in the past year. BGS jointly held the Eastern Student Conference with the Hydrology Section at the University of Toronto in January, and was involved with seven sessions at the 2014 Joint Meeting with CSSS in Banff, Alberta from May 4-7. Approximately 100 students attended the joint student conference and 25 students presented talks in BGS sessions at the Banff meeting. At the Joint Meeting, the section elected (all unopposed for 2-year terms) the following executive members:

Dr. Merrin Macrae (President, University of Waterloo; mmacrae@uwaterloo.ca)
Dr. Brett Eaton (Past-President, University of British Columbia; brett.eaton@ubc.ca)
Dr. Carl Mitchell (Vice-President, University of Toronto; carl.mitchell@utoronto.ca)
Dr. Altaf Arain (Treasurer, McMaster University; arainm@mcmaster.ca)
Dr. Tim Duval (Secretary, University of Toronto; tim.duval@utoronto.ca)
Dr. Elyn Humphreys (Member at Large, Carleton University; elyn_humphreys@carleton.ca)

Dr. Mark Johnson (Member at Large, University of British Columbia; mark.johnson@ubc.ca) continues onto the 2nd-year of his 2-year term.

The Section continues to broaden its position with the CGU by increased participation, particularly by students, at meetings and conferences within BGS sessions. The Section continues to target BGS special sessions and invited speakers at conferences. The Joint CGU-AGU meeting next year in Montreal will be a platform for significant cooperative session proposals and field trips with our American colleagues. Tim Moore, Nigel Roulet, and Elyn Humphreys have offered to organize a Mer Bleue field trip and microbrewery visit for the meeting. Several joint CGU-AGU BGS session ideas were discussed, including DOC in the St. Lawrence, environmental drivers of physical habitat, trace gas exchange, reservoirs, peatland development, and mercury cycling. Members are encouraged to contact their American colleagues to promote international session proposals. A BGS SWIRL interdisciplinary collaborative session may also be proposed.

For maintaining and increasing student participation within the biogeosciences, the Section has found a mentorship dinner to be too logistically difficult to carry out. At the joint meeting in Montreal, the focus will likely be on a pub-crawl social event. The logo competition for BGS will continue through the end of November 2015, with a cash prize of \$100 being offered. One student award (\$500 prize) was given out at this year's meeting in Banff, for best oral presentation in the biogeosciences, to Max Lukenbach (supervised by Mike Waddington) of McMaster University for his talk "Does Restoration Reduce Wildfire Vulnerability in Drained and Mined Peatlands". Congratulations Max! We are actively seeking a corporate sponsor for student awards (one for oral presentation; one for poster) and executive will approach companies this year for implementation at the Montreal meeting.

SOLID EARTH SECTION NEWS

Prepared by Phil McCausland, President, CGU Solid Earth Section

“You *can* get there from here.” –Peter Jedicke

This quote comes from a friend of mine in London, Peter Jedicke, who is a physics instructor and an amateur astronomer ...and much more. As you might infer from the quote, he is relentless about finding ways to pursue those things that he is interested in achieving! I take it as an inspiration to look for ‘outside of the box’ solutions to difficult challenges.

In the Solid Earth Section, we have at face value become a success as a thematic group within the Canadian Geophysics community. Within the CGU, our Section membership now stands at 65 regular members and 27 student members, representing about 25% of the CGU. Last year

at this time we had 44 regular and 14 student members, so we have seen a marked growth in the Section. The Solid Earth Section is generally in good shape, being on a sound financial footing with per-member income from the parent CGU organization. We offer a Student Best Presentation Award for Solid Earth geophysics at the annual meeting and we also provide financial sponsorship for regional geophysical meetings, assessed on a case-by-case basis.



The annual CGU meeting on May 4-7 in Banff, Alberta is a good example of current Section successes and challenges. This year our meeting was jointly held between the CGU and the Canadian Soil Science Society, with over 400 participants in all taking part in the four-day programme. The Solid Earth Section sponsored four well-attended oral and poster sessions, including topical themes such as induced seismicity, developments in rock physics, west coast tectonics and geodynamics and deep earth dynamics. Of particular interest for our Section, the annual meeting was joined by the 2014 Mantle Convection and Lithosphere Dynamics Workshop, sponsored by Computational Infrastructure for Geodynamics (CIG). The Workshop had a full three-day program in parallel with the CGU-CSSS meeting, with some 12 invited speakers and 29 poster presentations. I would very much like to thank Vice President Julian Lowman for taking on the challenge of coordinating the Solid Earth sessions as well as doing the yeoman’s job of bringing the CIG Mantle Convection and Lithosphere Dynamics Workshop to meet with us in Banff! ...The challenge is now before us to make this unusually rich Solid Earth geophysics meeting more ‘usual’ at future CGU annual meetings.

A highlight of the meeting for the Section was the CGU Solid Earth Section's 2014 Best Student Presentation Award. This year there was a strong field of 14 candidate presentations from both the Solid Earth sessions and the CIG Workshop. The winning presentation, "Detection and Analysis of Microearthquakes in Alberta Using Regional Broadband Arrays," by Ruijia (Jairy) Wang (PhD candidate, University of Alberta) was deemed by our judges to be the best Solid Earth geophysics student presentation at the meeting. The Award consists of a \$750 prize and a colour plaque. Congratulations, Jairy! In the photo Ms. Wang is presented with the Award on behalf of the CGU Solid Earth Section by her supervisor, Dr. Y. Gu. Much thanks to all of the

volunteer judges who took part in assessing student presentations during the meeting. I would also like to recognize the outstanding efforts of Section Secretary Karen Assatourians, VP Julian Lowman and other members for ably executing the Student Award and other functions of the meeting during my unexpected inability to take part this year. This is a true measure of the developing depth of the Section!

With the Section counting nearly 100 members, we are perhaps now in the best position looking over the last twenty years or more to further Solid Earth geophysics in Canada. Our Section bylaws (and website) lay out these challenges as:

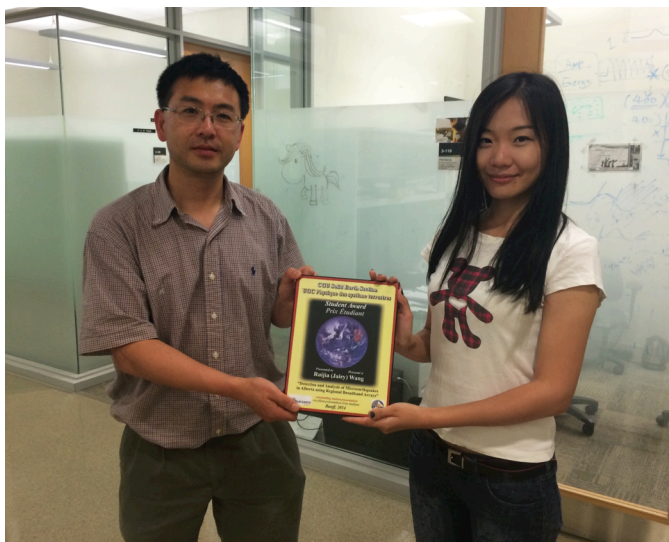
- 1) facilitating Solid Earth geophysics research and development in Canada, in support of scientific, economic and social activities;
- 2) building links with national and international organizations with similar interests;
- 3) promoting the results and applications of Solid Earth geophysical research to the wider geophysical and other communities and encouraging multidisciplinary research; and,
- 4) encouraging the timely communication of scientific results and related information through conferences, workshops, special lectures and the internet.

As part of changes within the CGU over this past year, we have a new website:

<http://cgu-ugc.ca/sections/solid-earth/>

I encourage you to take a look, and especially to suggest changes that will improve its usefulness. More generally, there are many areas that we could -and should- improve in, recalling the “difficult challenges” that I alluded to in the opening paragraph. A more fully developed website is one way to diversify the Section activities and benefits, but as one of the members pointed out in a recent discussion, websites are fairly passive! With some ongoing effort, we can make our website an excellent resource for Solid Earth geophysics job postings, for instance, but I suspect that something more ‘outside the box’ will be required to meet the challenges that we have set out for ourselves.

Please get in touch with myself or any of the Section Executive if you would like to discuss possible changes in the Section that will help Canadian Solid Earth geophysics advance. We have a large meeting coming up next year in Montreal, joint with the AGU and with fellow Canadian societies GAC and MAC. The AGU-style meetings are always diverse and interesting, offering the opportunity to propose a thematic session that grows out of your research interests! The Solid Earth Section is a major link in this 2015 Montreal meeting with all of the partner societies, so we have an excellent opportunity to develop and sponsor a large number of meeting sessions. Note also that we will have an Executive election coming up next year in Montreal for our next set of two-year terms; this is a good chance to make a key contribution to Canadian Solid Earth geophysics, bringing your experience and talents to the CGU Solid Earth Section.



...Finally, I will close with a happy new development: Solid Earth Section T-shirts! Now, these are not going to solve all of our challenges, but for sure we can look good while we work on them! The T-shirts (pictured below) are now available from Section Secretary Karen Assatourians or myself, following the e-mail addresses in the back of Elements or on the website. Each T has that snazzy Solid Earth logo proudly across the chest, and they are available in a variety of quality Hanes sizes and in white or black fabric colour. Cost is \$20 per T-shirt, or \$10 for students.

So our work is cut out for us, but these comfortable and snappy T-shirts are definitely a step in the right direction! I look forward to joining you in strengthening the Solid Earth Section in future endeavours, in Montreal next year and beyond.



Solid Earth Geophysics: You've been there – but do you have the T-shirt...?

CGU Solid Earth Section T-shirts, now available in white or black, in sizes S,M,L,XL. \$20 each / \$10 students + shipping. Order soon, while stock & variety last!

EARTH SURFACE PROCESSES SECTION NEWS

Announcement and Statement of Intent

At the recent CGU AGM in Banff, the newly-proposed Earth Surface Processes Section was approved. Brian Branfireun, Brett Eaton, and Ian Walker are to be thanked and congratulated for bringing this initiative to a successful outcome. The formation of this new Section is consistent with similar sections and divisions of AGU and EGU, and recognizes the growing importance of earth surface processes within Canadian geoscience and in the broader geophysics community. The ESP Section is formed partly from the former Erosion and Sedimentation Committee of the Hydrology Section, but it will expand its mandate to cover all aspects and contexts of earth surface processes and dynamics.

The NAP publication “Landscapes on the Edge”

http://www.nap.edu/openbook.php?record_id=12700

illustrates the scope and importance of this area of geosciences to past, present and future landscapes of Earth, including the interactions with human activities, and identifies the ‘grand challenges’ for future research and action. These grand challenges provide a focus for the activities of the ESP Section through: national and international research projects; dissemination of research methods and results at regular conferences and workshops; education and communication initiatives in earth surface dynamics; and applications to contemporary and future earth surface environments.

The section will also foster connections among earth surface process communities in Canada and internationally, and encourage further collaboration within the CGU. The inaugural ESPS executive includes:

President:	Peter Ashmore, University of Western Ontario
Vice-President:	Chris Hugenholtz, University of Calgary
Secretary:	Jaclyn Cockburn, University of Guelph.

We anticipate adding members to the executive (treasurer and members-at-large) in the coming months.

ESPS looks forward to our inaugural sessions and AGM at the joint CGU-AGU meeting in Montreal spring 2015 (VP Chris Hugenholtz is a member of the Program Committee), and we welcome any ideas about the Section and activities between now and then.

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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:

Gordon Young, Executive Director CGU, 34 Vincent Av., PO Box 878, Niagara on the Lake, Ont, L0S1J0; Telephone: 905 468 5896; email: gordonyoung_wwap@yahoo.com

Electronic submission is encouraged.