2014 Ottawa-Carleton Student Northern Research Symposium Program

Hosted by the University of Ottawa

February 6th, 2014
Time: 8:30 – 4:30
Desmarais Hall, Room 12102

Carleton UNIVERSITY

uOttawa

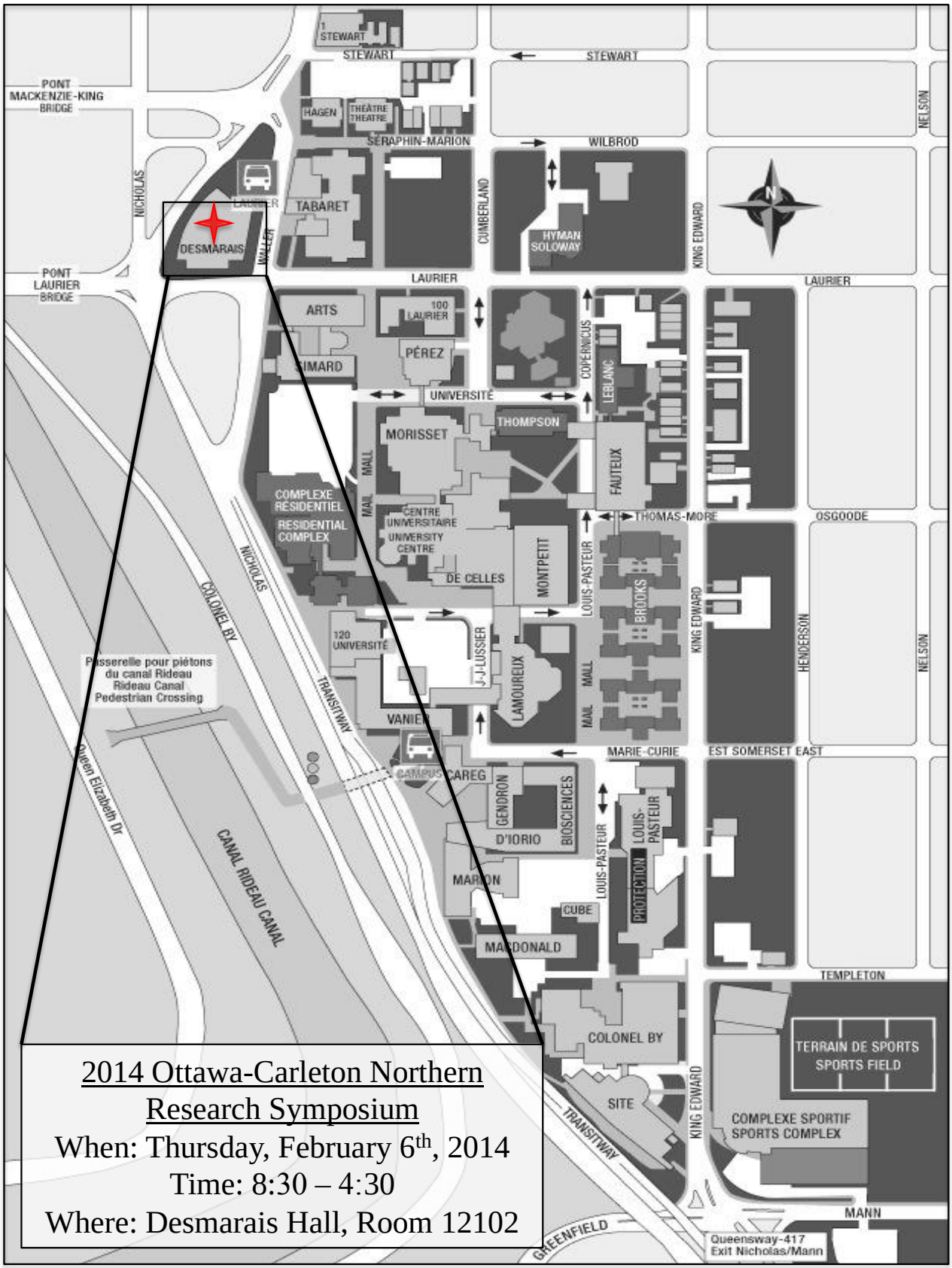
Each year, undergraduate and graduate students from Carleton University and the University of Ottawa participate in high-quality northern research studies, both in the natural and social sciences. As a platform to showcase out excellence and common interests, the University of Ottawa is please to host the 2014 Ottawa-Carleton Northern Research Symposium (OCSNRS).

Thursday, February 6th, 2014
Time: 8:30 – 4:30
Desmarais Hall, Room 12102

RSVP is required.
Further details are available at: http://Carleton.ca/northernresearch/OCSNRS.html

The organizers would like to thank Dr. Antoni Lewkowicz (Dean of Arts, University of Ottawa) for guidance during the organization of the symposium, Dr. Gita Ljubicic (Carleton University) for website support and aiding with communications at Carleton University, Dr. Audrey Giles (University of Ottawa) for aiding with communications within the Faculty of Science, University of Ottawa and Dr. Luke Copland (University of Ottawa) for financial and organizational support. We thank Dr. Martin Sharp (University of Alberta) for providing our keynote address. Finally, the organizing committee would also like to acknowledge Koreen Millard (Carleton University), Anna Crawford (Carleton University) and Laura Thomson (University of Ottawa) for chairing sessions, and thank all those that helped with the organization of the symposium.

2014 Symposium Coordinator:
Wesley Van Wychen (PhD Candidate, Dept. of Geography, University of Ottawa)
Email: wvanw046@uottawa.ca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When: Thursday, February 6th, 2014
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Where: Desmarais Hall, Room 12102
STEWART
PONT MACKENZIE-KING BRIDGE
PONT LAURIER BRIDGE
NICHOLAS
DESMARAIS
WALLER
HAGEN
THÉÂTRE THEATRE
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2014 Ottawa-Carleton Student Northern Research Symposium Schedule

February, 6th, 2014 - Desmarais Hall, Room 12102, University of Ottawa

8:30 – 8:55	Registration (Larissa Pizzolato and Marielle Fontaine)	
8:55 – 9:00	Opening remarks	
9:00 – 9:50	Keynote Address – Dr. Martin Sharp	
9:50 – 10:10	Break (Coffee, Tea and Light Snacks Provided)	
Oral Presentations – Session 1 Chair: Anna Crawford		
	Title	***Presenter***
10:10 – 10:25	Ice Island Detection with RADARSAT-2 Quad Polarimetry	Gregory Lewis-Paley
10:25 – 10:40	Chemical fingerprinting of Cretaceous bentonites in Canadian Arctic basins and investigation of their potential magma sources	Michel Desjardins
10:40 – 10:55	Internal topography of drained thermokarst lake basins in the Old Crow Flats, northern Yukon	Pascale Roy-Léveillée
10:55 – 11:10	Seasonal variability in groundwater discharge in continuous permafrost and its effect on seasonal carbon flux in the North Klondike River System	Anthony Lapp
11:10 – 11:25	Origins and implications of an ice-rich clay ridge (lithalsa) within the Great Slave Lowlands near Yellowknife, Northwest Territories, Canada	Adrian J. Gaanderse
11:25 – 11:40	The characterization of ground ice deposits using ground-penetrating radar techniques	Laura Thomson
11:40 – 11:55	Soil organic carbon investigations in the Mackenzie Delta Region	Marcus R Phillips
11:55 – 12:45	***Lunch Break***	
Oral Presentations – Session 2 Chair: Laura Thomson		
12:45 – 13:00	Phenology of Arctic plants in the Canadian Arctic Archipelago	Zoe Panchen
13:00 – 13:15	Interannual and multi-decadal velocity variations in the eastern St. Elias Icefields, Yukon Territory, Canada	A. Waechter
13:15 – 13:30	Permafrost conditions across an arctic elevational tree line in the continuous permafrost zone, NWT, Canada	Brendan O'Neill
13:30 – 13:45	A new proxy for bottom water oxygen during the Late Cretaceous Western Interior and Boreal seas	Alex Quesnel
13:45 – 14:00	Parasites and pollution; possible reasons for sex bias in marine birds	J.F. Provencher
14:00 – 14:15	Peatland Hydrology with SAR: current capabilities and future directions	Koreen Millard
14:15 – 14:35	***Break***	

Oral Presentations – Session 3 Chair: Koreen Millard		
14:35 – 14:50	Ice island surface melt model evaluation: An example of error compounding	A.J. Crawford
14:50 – 15:05	Good fortune or Misfortune? Pond Inlet and the Mary River Project	Roger Ritsema
15:05 – 15:20	The Canadian component of the High Arctic Large Igneous Province (HALIP): Preliminary field results from west central Axel Heiberg Island, Nunavut Canada.	Cole G. Kingsbury
15:20 – 15:35	Identifying and Understanding Sea Ice Pressure Events for Winter Shipping in the Eastern Canadian Arctic	Olivia Mussells
15:35 – 15:50	A watershed approach to quantify the impacts of permafrost disturbances on the hydrio-geochemistry of streams in the Richardson Mountains, NWT, Canada	Catherine Paquette
Poster Presentations – Session 4 (Coffee, Tea, Soft Drinks and Snacks Provided)		
15:50 – 16:25	Assessment of sea ice conditions and shipping activity in Canadian Arctic waters between 1990 and 2012	Larissa Pizzolato
	Controls on intra-annual and interannual variations in motion of the Kaskawulsh Glacier, Yukon Territory	Emilie Herdes
	Biogeochemical variations in Pleistocene and Holocene-age permafrost across various ecological landscapes, western Canadian Arctic	Marielle Fontaine
	Discriminating Different Ice Types within Synthetic Aperture Radar (SAR) Satellite Imagery along the Northern Coast of Ellesmere Island, Nunavut, Canada	Miriam Richer McCallum
	The Labrador Permafrost Project	Robert G. Way
	Volume and mass changes over Penny Ice Cap, Baffin Island, from 2005-2013 determined from repeat airborne laser altimetry.	Nicole Schaffer
16:25 – 16:30	***Closing Remarks***	

Keynote Address

The Global Dynamics of Arctic Ice Caps

Dr. Martin Sharp[1]

[1] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada T6G 2E3

Like the large ice sheets in Antarctica and Greenland, the larger ice caps in the Arctic are dynamically complex. They consist of a mixture of fast-flowing outlet glaciers, many of which reach the ocean, and slower flowing interior regions that tend to terminate on land in cases where they extend all the way to the ice cap margin. Studies of individual outlet glaciers suggest that they may contain up to 4 distinct "flow regimes", that are characterized by differences in ice temperature, flow mechanics, hydrology, bed properties, and surface morphology. Multi-year measurements of surface velocity made with continuously recording GPS demonstrate that different flow regimes are characterized by distinct patterns of seasonal velocity variability that can be explained in terms of differences in the extent to which surface meltwater penetrates to the glacier bed, and the processes by which penetration occurs. Depending upon which flow regime occurs in the terminus region of the glacier, outlet glaciers can differ enormously in terms of the sensitivity of their dynamics and geometry to external forcing. In some cases this may allow large changes in geometry and dynamics to occur in response to forcings that are essentially undetectable while, in other cases, larger forcings may have no obvious effect. This suggests that efforts to explain long-term changes in the behaviour of some outlet glaciers and in the rate at which they deliver ice to the oceans by "dynamic discharge" in terms of discernable variability in external forcing factors may prove to be fruitless.

Oral Presentations

Ice Island Detection with RADARSAT-2 Quad Polarimetry

Gregory Lewis-Paley[1] *and D.R. Mueller*[1]

[1]Department of Geography and Environmental Studies, Carleton University, Ottawa, Ontario, K1S 5B6

Ice islands are large tabular icebergs calved from Arctic ice shelves that have been increasing in prevalence in Arctic waters over the last decade. Ice islands have a long lifespan, drift long distances and continuously deteriorate which can present a significant maritime hazard. The Canadian Ice Service (CIS) has been using the Synthetic Aperture RADAR (SAR) capabilities of RADARSAT-2 (RS2) to manually detect ice islands.

This study examined 263 polarimetric parameters to assess their utility in separating ice islands from various background ocean states (first and multiyear ice cover as well as open water). In addition, we evaluated the hypothesis that several key confounding factors such as seasonality, wind, SAR incidence angle (θ), and the azimuth angle (φ) relative to the ice island's surface ridges led to poor separability. Using CIS ice charts, image geometry and meteorological data, the underlying reasons for variability in ice island detection were explored. Each polarimetric parameter was computed for each of the FQ image, and the differing regions were compared using pair-wise Kolmogorov–Smirnov tests (KS) as conditions varied.

Most parameters exhibited some response to the confounding factors of incidence and azimuth angle. Separability of ice types in different polarimetric parameters exhibited different responses to the confounding factors. With the upcoming launch of the RADARSAT Constellation Mission (RCM), the knowledge of FQ separability can be used in Compact Polarimetry (CP) for ice island detection.

Chemical fingerprinting of Cretaceous bentonites in Canadian Arctic basins and investigation of their potential magma sources

Michel Desjardins and Claudia Schroder-Adams

Bentonites are altered volcanic ash layers that can be useful stratigraphic marker beds in shale basins with monotonous lithology. Ancient ashes often contain minerals that can deliver an absolute geological age. Primary igneous textures are often preserved in younger and less altered bentonites. Bentonites are derived from ash produced from a Plinian style volcanic eruption, and are erupted in a short amount of time. This project will analyze bentonites occurring within shales predominantly of Upper Cretaceous age in the Sverdrup Basin, Anderson Plain, Yukon Coastal Plain, Eagle Plain and Western Interior Basin. Geochemical analysis of bulk bentonite material and relict phenocrysts will provide information on the petrogenetic evolution of the parent magma, which will provide a greater understanding of the tectonic origin of these volcanic ash layers. Whereas bentonites are common over this vast region suggesting abundant tectonic plate movement during the Late Cretaceous trace element geochemistry suggests different volcanic sources for Eastern and Western Arctic bentonites. Discriminant analysis suggests Eastern Arctic bentonites have a within-plate tectonic origin, while bentonites of the Western Arctic and Western Interior suggest a complex volcanic origin. The Eastern Sverdrup Basin exposes the High Arctic Large Igneous Province, which might have been related to the volcanic eruptions with intra-plate signature. Future radiometric analysis of some of the bentonites will provide a chronostratigraphic framework that together with the chemostratigraphic and biostratigraphic frameworks then form a basis for much needed refined correlations in Cretaceous polar basins.

Internal topography of drained thermokarst lake basins in the Old Crow Flats, northern Yukon

Pascale Roy-Léveillée[1] *and Christopher R. Burn*[1]

[1] Department of Geography and Environmental Studies, Carleton University, Ottawa, Ontario,
K1S 5B6

Analysis of remotely sensed images suggests that many drained lake basins in the Old Crow Flats (OCF), YT, have wet, depressed margins surrounding elevated ground in the basin center. Similar topography has been described for drained lake basins of the Beaufort Coastal Plain (BCP), and is explained by differential frost heaving of the sorted lake-bottom sediments following lake drainage. Our working hypothesis is that the internal topography of drained basins in the OCF is controlled by spatial variations in rates of ice segregation, as has been described for the BCP. To test this hypothesis, we conducted topographic surveys in two drained basins of the OCF and extracted permafrost cores from basin margins and centers to examine near surface stratigraphy and ground-ice content. Our results confirm the occurrence of depressed margins surrounding raised basin centers but no relation was observed between ground elevation and excess ice content in the top two meters of permafrost. The distribution of coarse and fine sediment observed in the cores suggests that elevation differences between basin centers and margins in the OCF are controlled by patterns of lacustrine sediment deposition near receding thermokarst lakeshores.

Seasonal variability in groundwater discharge in continuous permafrost and its effect on seasonal carbon flux in the North Klondike River System

Anthony Lapp[1] *and Ian D Clark*[1]

[1] Dept. of Earth Science, University of Ottawa

Arctic and subarctic watersheds are undergoing natural climate change, permafrost thawing, and thermokarst formation which have altered groundwater and surface water interactions. Long-term monitoring shows a general upward trend in groundwater, an important contribution to river base flow, but is a poorly constrained component of discharge. We are undertaking a high resolution sampling regimen to sample surface waters in the North Klondike River throughout the year in order to monitor groundwater discharge and correlate its effects on geochemical cycling and carbon flux. We will characterise groundwater using noble gas signatures and stable isotope geochemistry. Carbon-14 will be used to estimate the age of different components of carbon exports in the watershed and the dating of dissolved carbon will help us in the determination of water balances. The development of a tritium enrichment line at uOttawa will help serve as an additional dating tool. The first sampling season was completed in August 2013, with another scheduled for spring 2014. The local community was engaged to help in collecting samples throughout the winter.

Origins and implications of an ice-rich clay ridge (lithalsa) within the Great Slave Lowlands near Yellowknife, Northwest Territories, Canada

Adrian J. Gaanderse[1], *Stephen A. Wolfe*[1], *Christopher R. Burn*[1], *Steven V. Kokelj*[2]

[1] Dept. of Geography and Environmental Studies, Carleton University
[2] NWT Geoscience Office, Yellowknife, NWT, Canada

Newly discovered clay ridges, located within the extensive discontinuous permafrost zone in the Great Slave Lowlands, Northwest Territories, are lithalsas. Lithalsas are mineral-based permafrost mounds with high segregated ground-ice in their cores. The lithalsas are located within glaciolacustrine surficial deposits, originating from glacial Lake McConnell approximately 10,000 years ago, and from subsequent deposition as water levels receded during the Holocene to the present level of Great Slave Lake.

This study examines one lithalsa, over 700 m long, located adjacent to Highway 3, 31 km west of Yellowknife. To examine ground ice conditions in these deposits, samples to depths of 8.4 m were obtained from 15 boreholes along a transect of the study area. Boreholes revealed tilted layers of silts, sands, and clays beneath the lithalsa's surface, with the same layers observed horizontally beneath an adjacent peatland. Segregated ice lenses 2 to 19 cm thick were documented in samples below 4 m, creating the lithalsa's deep-seated ice-rich core, and resulting in surficial heave.

Geochemical results indicate free water movement through the substrate. $\delta^{18}O$ values from ice lenses indicate that the ice-based core likely formed from modern water sources. Dates from detrital organics imply that lacustrine deposition continued until approximately 700 years ago. Thus, permafrost aggradation accompanied by ice segregation within the lithalsa was initiated within the last 700 years.

The results of this study become valuable to road builders when considering the 1700 potential lithalsas in the region as well as the known roadway problems associated with building in ice-rich terrain.

Soil organic carbon investigations in the Mackenzie Delta Region

Marcus R Phillips[1] *and Chris Burn*[1]

[1] Dept. of Geography and Environmental Studies, Carleton University

There is a globally-significant amount of carbon in permafrost soils. The soil carbon is generally deeper in permafrost regions than in other parts of the world. The processes of sedimentation, peat accumulation, and cryoturbation (subduction by frost action) are responsible for burying carbon at greater depths within the soil. As a result of its deeper distribution, the carbon is often in waterlogged, cold, or frozen soil, all conditions that inhibit the release of soil carbon as greenhouse gases. Furthermore, the chemical nature of organic carbon may be labile (easily converted to greenhouse gases) or recalcitrant (difficult to convert), and it may be protected by adsorption or binding onto mineral surfaces. The goal of this research is to explore the processes and factors that influence the quantity, quality, and distribution of soil organic carbon both north and south of treeline in the Mackenzie Delta Region, where sedimentation, peat accumulation, and cryoturbation operate in close proximity. Preliminary results indicate that while carbon content in the active layer of sedimentation- and cryoturbation-affected soils is comparable, there is substantially more carbon in the near-surface permafrost of cryoturbation-affected than sedimentation-affected soils. This may indicate a greater vulnerability of permafrost carbon in cryoturbation-affected soils.

The characterization of ground ice deposits using ground-penetrating radar techniques

Laura Thomson[1] *, G. O. Osinski*[2]*, and W. H. Pollard*[3]

[1] University of Ottawa
[2] University of Western Ontario
[3] McGill University

This study explored the capabilities of ground-penetrating radar (GPR) in the task of characterizing ground ice and the role this instrument can play in understanding the geomorphology of Earth's cryosphere as well as the surface of Mars. Exploration of the polar ice caps and apparent glacial and periglacial landforms on Mars will aid our understanding of its ancient climate conditions and the history of water on the planet. Given that GPR is likely to be used to understand these features, we investigated the real component of the complex dielectric permittivity of stratified segregation ice, non-stratified segregation ice, and polygonal ice wedge deposits in the Canadian Arctic. We acquired moveout profiles with a 450 MHz GPR on ground ice formations that had active layer sediments excavated prior to surveying. Using ice core data collected from these sites, we found that the volumetric fraction of ice plays the greatest role in defining the dielectric permittivity of the deposit and that it can be described using a modified complex refractive index method (CRIM) dielectric mixing model. Using the modified CRIM model, we estimate the dielectric permittivity of several ground ice deposits on Earth and present further estimates for similar features on Mars using permittivity values for Martian sediments derived from both theory and laboratory methods.

Permafrost conditions across an arctic elevational tree line in the continuous permafrost zone, NWT, Canada

Brendan O'Neill[1], *Chris Burn*[1] *and Steve Kokelj*[2]
[1] Dept. of Geography and Environmental Studies, Carleton University
[2] NWT Geoscience Office, Yellowknife, NWT, Canada

Permafrost conditions across forest-tundra transitions are predominantly controlled by changes in snow conditions and air temperature. In uplands east of the Mackenzie Delta, annual mean permafrost temperatures (T_{PS}) decline across tree line from about -1 to -3 °C in forest to around -6 to -7 °C in dwarf-shrub tundra in response to lower snow depths, and lower air temperatures near the coast.

Permafrost conditions were studied across an elevational tree line in continuous permafrost on Peel Plateau, SW of the Mackenzie Delta. Ground and air temperature sensors were installed in forest and tundra between 30-500 m ASL. Mean annual air temperatures (MAAT) from three sites across the elevation range were -7.5 to -6.8 °C in 2011-12 and -7.8 to -7.5 °C in 2012-13, with the coldest MAAT in both years occurring at the lowest elevation, due to persistent winter inversions.

T_{PS} at 10 tall- and dwarf-shrub tundra sites (427-494 m ASL) ranged between -0.5 and -4.6 °C between 2010-2013 (n = 14), with a median value of -1.6 °C. In forest (326 m ASL), T_{PS} was between -1.7 and -2.7 °C in 2010-13 (n = 3). In forest on Peel Plain (31 m ASL), T_{PS} was between -2.5 and -2.8 °C (n = 3).

Snow depths were generally lower in tundra than in forest, but more variable. Snow accumulated rapidly at tundra sites during wind events, whereas the accumulation was gradual in forest. This, combined with the temperature inversions, is likely a factor contributing to the lower T_{PS} observed in forest than in tundra.

Microbioturbation as a proxy for benthic oxygen conditions during the mid to late Cretaceous western interior and Boreal seas

Alex Quesnel[1] *and Claudia Schöder-Adams*[1]

[1] Department of Earth Sciences, Carleton University, Ottawa, Ontario, Canada K1S 5B6

Late Cretaceous marine strata of the Arctic Sverdrup and Canadian Western Interior Basin are punctuated by intervals that are interpreted as reflecting anoxic bottom water conditions, which are characterized by lack of benthic fauna. Whether the lack of benthic foraminifera represents true anoxic bottom water conditions, or is simply a result of taphonomic processes, remains an unanswered question in these regions. The Upper Cenomanian to lowermost Turonian barren interval coincides with the established global Oceanic Anoxic Event (OAE 2), during which oceanic bottom waters are depleted in oxygen and large amounts of carbon are buried in marine sediments. Recent facies analysis of dark shales makes it clear that the absence of easily recognizable bioturbation or presence of fine laminations are not an absolute indication of anoxia in fine grained sedimentary rocks. This study examines four Arctic localities as well as the Colorado Group in core from the Cold Lake area in North Eastern Alberta using light microscopy and SEM in order to identify microbioturbation as a proxy for oxygen. A bottom water oxygenation history of selected intervals in Arctic upper Cretaceous outcrop sections is presented and expanded to the Cold Lake area during the late Early to Late Cretaceous. The detection of microbioturbation in the Arctic samples is difficult due to cryoturbation. No microbioturbation was found in previously interpreted anoxic sections that fall within the OAE 2 interval within the Western Interior. Microbioturbation has proven a simple yet effective proxy for bottom water oxygen, especially where shelly fauna has been lost due to taphonomic processes.

Parasites and pollution; possible reasons for sex bias in marine birds

J.F. Provencher[1], *H.G. Gilchrist*[1] *and M. Forbes*[2]

[1] Carleton University, Biology Department
[2] Environment Canada

Although numerous contaminants are of toxicological concern in birds, Mercury (Hg) is of particular interest in northern ecosystems due to increasing levels in the Canadian Arctic, and its negative impacts on organisms. Birds are not only affected by environmental pollutants such as Hg, but also by parasites. Parasites ultimately compete with hosts for resources, and thus can have a negative influence on their host. Interestingly both contaminants and parasites often infect males and female hosts differently. Although a bias in parasite and contaminants is not the rule, a male bias has been found across a number of taxonomic groups and ecosystems. From a population and species management viewpoint, the effects of parasites on female hosts may be the most important. As contaminants and parasites are both trophically transferred the source of sex bias may be related to forage species specialization or foraging divisions between the sexes. In addition, sex biases could be related to physiological differences. My PhD research investigates whether a sex bias patter in mercury and parasites, is found in the northern common eider duck (*Somateria molissima*), and the potential causes for such a pattern.

Peatland Hydrology with SAR: current capabilities and future directions

Koreen Millard[1:] *and Murray Richardson*[1]

[1] Dept. of Geography and Environmental Studies, Carleton University

Remote sensing of peatlands has focused on mapping extents or classifying types of peatlands within a wetland complex (e.g. bog versus fen) based on indicator vegetation. While peatlands exhibit variability in vegetation species, structure and density, they are also variable in their hydrological characteristics, such as in their water table dynamics and in surface soil moisture. Current literature points to Synthetic Aperture Radar (SAR) as being the most promising remote sensing technology for wetland mapping of both vegetation and hydrology due to its all-weather abilities (penetration of clouds), its sensitivity to structural differences in vegetation and to the dielectric constant of objects, which is related to the water content of an object. However, complex interactions between the SAR signal, vegetation structure, density, and vegetation water content, as well as surface roughness and surface moisture are difficult to interpret and quantitatively separate their compounding influences. Additionally, issues of scale and spatial and temporal variability in peatlands also affect relationships between SAR backscatter and measured hydrological parameters. Therefore, the use of SAR for monitoring hydrological characteristics of peatlands is not well developed. This talk will discuss some of the methods that are being developed to overcome the challenges of using SAR for hydrological mapping with examples from work being completed in several northern peatlands.

Ice island surface melt model evaluation: An example of error compounding

A.J. Crawford[1], D.R. Mueller[1], E. Humphreys[1], T. Carrieres[2], G. Crocker[3] and H. Tran[2]

[1] Department of Geography and Environmental Studies - Carleton University, Ottawa, Ont., Canada
[2] Canadian Ice Service - Environment Canada, Ottawa, Ont., Canada
[3] Ballicater Consulting Ltd., Kingston, Ont., Canada

The validation of the Canadian Ice Service (CIS) deterioration model was one objective of a 2011 ice island field campaign. The model's surface melt equation was tested with a four-week microclimate dataset collected by an automatic weather station (AWS) on a small ice island (0.13 km2) adrift in Lancaster Sound, Nunavut. Model output was compared to observed melt recorded by a sonic ranger. The original CIS iceberg deterioration model under-predicted cumulative melt by 68%. The operational ice island energy balance (EB) melt model, which includes the turbulent fluxes, under-predicted cumulative melt by 7.5%. When run with operational environment data (Global Environmental Multiscale (GEM) model), the EB model over-predicted by 75%. A parsimonious temperature index model (TIM) over-predicted by 12% when constants were fit for the dataset. The contribution of environmental variables and energy fluxes to surface melt was examined with correlation and regression tree modeling analyses. Wind speed (U_s) explained the greatest variance in hourly surface melt during tree modeling under normal relative humidity conditions. The importance of U_s is corroborated by the high turbulent flux contribution to available melt energy. This likely explains the EB model error when run with GEM model input, as there was a large difference (2.7 m s^{-1} average) between AWS and GEM model U_s data. These results illustrate error compounding due to running operational models with previously modeled environmental data. It is recommended to continue EB modeling until TIMs are calibrated for evolving surface conditions, yet care must be taken with environmental data input.

Good fortune or Misfortune? Pond Inlet and the Mary River Project

Roger Ritsema[1]

[1] Dept. of Geography, University of Ottawa

As a warming Arctic unlocks previously unfeasible resource development, mining in Nunavut is gaining momentum. With land claims settled and provisions for Inuit Impact and Benefit Agreements (IIBA's), adjacent communities appear to be in a good position to benefit from mineral projects. What is much less clear is how the opportunities will play out at the community level. Drawing on interviews conducted in 2013 with key informants in Pond Inlet and regional decision makers in Iqaluit, this research uses Pond Inlet as a case study to examine emerging economic opportunities from the Mary River Project. In particular: How can new economic opportunities be harnessed? What are the main challenges and barriers and how can they be overcome? Using the Harvard Project on American Indian Economic Development's (HPAIED) 'Nation Building' as a theoretical framework, themes of governance, cultural match, leadership, and future vision are used to shed light on a community with a new mega-project in its backyard.

The Canadian component of the High Arctic Large Igneous Province (HALIP): Preliminary field results from west central Axel Heiberg Island, Nunavut Canada.

Cole G. Kingsbury[1], *Richard E. Ernst*[1,2], *Brian L. Cousens*[1] *and Marie-Claude Williamson*[3]

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[2] Ernst Geosciences; 43 Margrave Avenue, Ottawa, ON K1T 3Y2
[3] Geological Survey of Canada; 601 Booth Street, Ottawa, ON, K1A 0E8

Regionally extensive volcanic rocks and associated upper-level intrusive igneous rocks of Cretaceous age (130 – 80 million years) occur on Axel Heiberg Island and Ellesmere Island, Canada as well as northern Greenland, Svalbard and Franz Josef Land, Russia. The present day distribution of these rocks throughout the circum-Arctic is thought to be the result of intervening tectonic activity that split apart a once contiguous High Arctic Large Igneous Province. Owing to its remote circum-Arctic location, HALIP is poorly understood when compared to other Mesozoic LIPs throughout the Earth (e.g. Central Atlantic Magmatic Province).

Field work carried out in July 2013 on western Axel Heiberg Island (base camp at N79.372, W93.639) revealed that most tabular intrusions manifest as thin (< 5 m) mafic sills and dykes which are variably perturbed by intruding evaporite domes. Furthermore, basaltic lava flows of the early Cretaceous Walker Island member of the Isachsen formation are in contact with black shales and sandstones. Black shales globally are a major source rock for hydrocarbon generation. Rocks collected from the 2013 field season are being processed in order to expand the limited number of robust uranium-lead age determinations together with field, geochemical and isotopic studies that will (1) help constrain the timing of Canada Basin opening, (2) elucidate mantle source chemistry, crustal contamination models and volcanology of the Walker Island member basalts and associated upper-level intrusions, and (3) assess potential links to hydrocarbon resource development as well as for nickel – copper –platinum group element style mineralization.

Identifying and Understanding Sea Ice Pressure Events for Winter Shipping in the Eastern Canadian Arctic

Olivia Mussells[1], Jackie Dawson[1] and Stephen Howell[2]

[1] University of Ottawa, Department of Geography, Ottawa, Ontario, Canada
[2] Environment Canada, Climate Research Division, Toronto, Ontario, Canada

Ongoing resource extraction and economic development in the Canadian Arctic, along with reductions in sea ice extent, has increased the potential for winter destinational shipping. Currently, FedNav, a Canadian cargo shipping company, operates ships out of Deception Bay, QC through the Hudson Strait all winter. Ice concentrations in the Hudson Strait can be at 9 to 10 tenths in winter. Ice that is not land-fast is in constant motion and subjected to divergent and convergent forces. Ice deformation patterns and situations where ice is under pressure can beset ships and halt their progress. This is environmentally and economically costly. Ice charts published by the Canadian Ice Service that are used for ship navigation provide information about the ice thickness, concentration and form but do not show pressure events. This study will focus on Deception Bay, QC and the Hudson Strait. Synthetic Aperture Radar (SAR) imagery from November to March 1997 to 2012 will be used in order to identify the patterns of pressure ridging and features caused by ice deformation. SAR provides very detailed images of the sea ice and is not limited by cloud cover and winter darkness. Weather data and ships' logs from FedNav will then be used to try and understand the causes of the pressure conditions and identify patterns that could be used to predict them. The results will be used to promote safer, more economical and environmentally responsible shipping through ice-infested waters.

A watershed approach to quantify the impacts of permafrost disturbances on the hydrio-geochemistry of streams in the Richardson Mountains, NWT, Canada

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Retrogressive thaw slumps and other thermokarst features form due to the degradation of ice-rich permafrost. The development and growth of these features leads to an increase of organic and inorganic material matter in nearby fluvial systems. This can lead to changes in the geochemical composition of water and can have immense impact on the hydrology of the watershed as well as on aquatic ecosystems. Retrogressive thaw slumps are common occurrence in the Richardson Mountains and their impacts on local streams has been documented. Streams and lakes having been impacted by thermokarst activity show higher levels of dissolved ions (mainly Ca, Mg, SO4) as well as an increase in sediment load and turbidity.

The objectives of this research are to determine the impacts of retrogressive thaw slumps on stream hydro-geochemistry at a larger more regional scale. While work has been done to establish a link between thaw slumps and the local environment, this research will attempt to see if the same observations can be made at a larger watershed scale.

To do this a database of slumps was compiled (currently and previously active slumps as well as now stabilized slumps were included) using both aerial photographs and satellite imagery to identify their location. A pre-existing database of the hydro-geochemistry of streams in the study area was added to by taking samples during the summer of 2013 and analyzing them for ionic concentrations (Cl, SO4, NO3, Al, As, Ca, Fe, K, Mg, Na, S and Zn), δD, δ18O, pH and conductivity. When these results become available, they will be compared with the concentration of slumps and watershed characteristics to further understand the relationship.

Phenology of Arctic plants in the Canadian Arctic Archipelago

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Phenology is the timing of nature's seasonal events including the timing of flowering and fruiting. Plasticity enables plants to respond to climate change through phenological changes. Phenology-climate change research has focused on temperate regions and indicates plants are flowering earlier due, in part, to rising temperatures. Temperate region temperatures are rising predominantly in the spring, however Arctic regions are seeing unprecedented climate change with temperatures rising predominantly at the end of the growing season. To understand how Arctic plants are responding to climate change we must first understand their phenology. We monitored the bi-weekly phenological progression of Arctic plants through photography and field notes. We recorded the start, peak, finish and duration of flowering, fruit set and seed dispersal dates of 53 plant species near Iqaluit, Baffin Island and 42 species near Lake Hazen, Quttinirpaaq National Park, Ellesemere Island with 27 species common to both sites. Our analyses indicates species at Iqaluit start flowering earlier and finish flowering later but are in peak flower at the same time as at Lake Hazen. We also see a good correlation of species' order of flowering at Iqaluit and Lake Hazen. Our results will be used as a baseline for an Arctic plant phenology-climate change study using herbarium specimens collected in the Canadian Arctic Archipelago. Herbarium specimens record the timing of flowering and fruiting of plants species in the past and will allow us to investigate how the timing has changed over time and with temperature changes.

Interannual and multi-decadal velocity variations in the eastern St. Elias Icefields, Yukon Territory, Canada

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Gulf of Alaska glaciers, including the St. Elias Icefields contained in the Yukon Territory and adjoining Alaska and British Columbia, have been the largest contributor to sea level rise outside of Greenland and Antarctica (Jacob et al., 2012). Significant mass losses may be expected to engender changes in the rate and nature of flow of these glaciers, but long-term records of ice dynamics are particularly limited in the St. Elias Mountains. This work will present the most comprehensive velocity mapping of the eastern portion of the St. Elias Icefields to date, derived from speckle tracking of Radarsat-2 imagery acquired in winter 2011 and 2012. The technique employs a cross-correlation approach to determine the displacement of the 'speckle' pattern of phase returns between two repeat-pass SAR images. Further reconstruction of past velocities is performed on several key glaciers using feature tracking of Landsat-5 imagery, allowing for the investigation of variability in glacier motion on interannual and decadal time scales. Differential GPS measurements from four stations on the Kaskawulsh Glacier permit both validation of the remote sensing analysis and an assessment of the range of seasonal and interannual variability in glacier velocity. An updated estimate of the Hubbard Glacier ice flux is presented. With the exception of the non-surge-type Kaskawulsh Glacier and the 29 upper Hubbard Glacier trunk, all major glaciers in the region experienced significant interannual variability, typically related to surge activity (e.g. Logan, Lowell, Donjek Glaciers). At the Kaskawulsh Glacier, a long-term reduction in velocity relative to field measurements from the 1960s was noted, the pattern of which is broadly congruent to measurements of surface elevation change over a similar period. The magnitude of this decrease (200 m a^{-1} near the ELA) cannot be explained by seasonal or interannual variability and most likely represents a dynamic response to mass loss.

Poster Presentations

Assessment of sea ice conditions and shipping activity in Canadian Arctic waters between 1990 and 2012

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Declining sea ice area in the Canadian Arctic has gained significant attention with respect to the prospect of increased shipping activities. To investigate relationships between recent declines in sea ice area with Arctic maritime activity, trend and correlation analysis was performed on sea ice area data for total, first-year ice (FYI), and multi-year ice (MYI), and a comprehensive shipping dataset of observed vessel transits through the Vessel Traffic Reporting Arctic Canada Traffic Zone (NORDREG zone) from 1990 to 2012. Links to surface air temperature (SAT) and the satellite derived melt season length were also investigated. Between 1990 and 2012, statistically significant increases in vessel traffic were observed within the NORDREG on monthly and annual time-scales, coincident to declines in sea ice area (FYI, MYI, and total ice) during the shipping season and monthly. Similarly, the NORDREG zone is experiencing increased shoulder season shipping activity, alongside an increasing melt season length and warming SAT. Despite these trends, only weak correlations between the variables were identified, although an increasing step change in shipping activity is apparent following the former summer sea ice extent minimum in 2007. Other non-environmental factors have also likely contributed to the observed increase in Arctic shipping activity within the Canadian Arctic, such as tourism demand, community re-supply needs, and resource exploration trends.

Controls on intra-annual and interannual variations in motion of the Kaskawulsh Glacier, Yukon Territory

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The Kaskawulsh Glacier is a large alpine glacier (~80 km long) located in Kluane National Park, Yukon. Little is currently known about the velocity response of glaciers in this region to climate change, yet this information is crucial for properly assessing their contribution to sea level rise. Previous studies have demonstrated that variations in ice motion can cause substantial losses from the large ice sheets (particularly Greenland), but we currently don't know whether large valley glaciers such as the Kaskawulsh will respond to velocity changes in the same way. The objective of this project is therefore to determine the relationships between mass balance and long-term evolution of glacier motion, and whether short-term (hourly) variations in motion occur during the summer. Data has been collected from a network of four high-resolution differential GPS (dGPS) stations running since summer 2007 across the lower Kaskawulsh Glacier. These stations provide the longest continuous velocity record available for any Yukon glacier, and will be used to analyze horizontal and vertical velocity patterns, and to assess the controls on them. Weather stations (installed in 2006) and automated snow depth sensors (installed in 2010) are used to model and measure surface melt and accumulation rates to assess controls on surface motion. Preliminary analysis of annual and seasonal velocities indicates that velocity events vary significantly between seasons, apparently responding to different triggers. Spring and summer speed-up events begin at the lower station and propagate upglacier, while winter events propagate downglacier.

Biogeochemical variations in Pleistocene and Holocene-age permafrost across various ecological landscapes, western Canadian Arctic

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The western Canadian Arctic is one of the most rapidly warming regions on Earth. In this region, the uppermost 3-5m of permafrost is predicted to thaw within the next century. Such a change in permafrost conditions is expected to have significant biogeochemical impacts on local and regional terrestrial and aquatic ecosystems. To assess the potential geochemical implications of anticipated permafrost thaw, we undertook a study across glaciated terrain from the westward margin of ice extent in the Richardson Mountains to tundra areas near the Beaufort Sea coast in the Tuktoyaktuk Coastlands. In the Peel Plateau, adjacent to the Richardson Mountains, active layer and permafrost exposed in the headwall of 12 thaw slumps were collected to depth of 5-20m. Permafrost cores were also collected to depth of 3-5m using a SIPRE corer in upland terrain east of the Mackenzie Delta. The water extracted from the samples at 5cm vertical resolution was analyzed for major soluble ions and trace metals; while the sediments were analyzed for concentration of C_{org}-N-S and δ^{13} C_{org} and $\delta^{34}S_{SO4}$. Preliminary results show that the concentration of major soluble ions is ca. 2-5 times higher in the transient layer than the overlying, contemporary active layer, but concentrations are 10-100 times higher in the permafrost below the early Holocene thaw unconformity (typically found 150-200cm below the surface). A similar dramatic gradient is observed in the concentration of S (mainly present as F_eS_2 and $CaSO_4$), where [S] is absent from the active layer, but reaches its highest concentration of ca. 2% below the early Holocene thaw unconformity. The concentration of C_{org} and N is highest in the active layer, reaching values of 20 and 1%, respectively, and lowest below the thaw unconformity (<2%). These data provide the necessary context for assessing potential biogeochemical impacts of permafrost thaw on terrestrial and aquatic ecosystems. For example, these preliminary results suggest non-linear geochemical responses to active layer deepening and intensification of thermokarst activity.

Discriminating Different Ice Types within Synthetic Aperture Radar (SAR) Satellite Imagery along the Northern Coast of Ellesmere Island, Nunavut, Canada

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The purpose of this study is to validate the ice types, as interpreted using SAR imagery, adjacent to Purple Valley (82°28.983'N, 80°59.983'W), northern Ellesmere Island, by using thin sections of ice and cross polarized light to examine its fabric. The knowledge of ice crystal properties (bulk salinity, sediment concentration, air inclusions, and crystal orientation) is central to the understanding of its microwave scattering mechanisms. It is the microwave scattering that makes the ice shelves, and other ice types, discernible from their surrounding environment. However, the backscatter observed across the ice shelves varies considerably. The aim of the study study is to address the main question: what are the geophysical properties, surface and internal characteristics, of the different ice types across the ice cover of northern Ellesmere Island that influence the radar return, microwave scattering, within Synthetic Aperture Radar (SAR) satellite imagery (RADARsat-2). My hypothesis is that the differences in the backscatter are caused by varying physical ice properties in the top few meters. The ice microstructure data, along with field measurements (May 2012-2013) of ice core bulk salinity and temperature will allow me to evaluate this hypothesis and validate the identification and delineation of different ice types across the ice shelves using RADARsat-2 imagery. Once we have confirmed the range of return for each ice type it will be possible to observe the changes of ice cover through time (e.g. with RADARsat-1)

The Labrador Permafrost Project

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The Labrador Permafrost Project was launched in 2013 with the goal of mapping the distribution of permafrost in the Labrador region of northeastern Canada. The Permafrost Map of Canada shows the southernmost limit of sporadic permafrost lying close to 50°N in eastern Quebec and Labrador. The main objective of this research project is to document the current distribution of permafrost at high resolution across Labrador's complex terrain where there is little baseline information, and to assess changes in the distribution and thickness of regional permafrost. To interpret local-to-regional scale permafrost-climate relations, over 20 meteorological stations have been established in the region following latitudinal and coastal-continental gradients. The climate data from these loggers is also being used in conjunction with topographic data to spatially model the distribution of permafrost-relevant climate metrics. *In situ* validation of permafrost presence will use instantaneous and permanent ground temperature profiling in addition to frost table probing. At selected sites, DC electrical resistivity tomography surveys will be used to evaluate subsurface ground conditions and permafrost thickness. Limited field observations during 2013 reveal that the southern fringe of regional permafrost is controlled by localized factors such as snow depth, soil composition, drainage and vegetation cover. A composite map of historical and contemporary palsas in Labrador has been created from various published works. Initial field surveys and aerial photo analysis' show that palsas are present in the maritime regions of southeastern Labrador, even where the mean annual air temperature exceeds 0°C.

Volume and mass changes over Penny Ice Cap, Baffin Island, from 2005-2013 determined from repeat airborne laser altimetry.

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Recent observations of accelerated glacier wastage in Greenland and Alaska have prompted reassessments of mass balance trends and volume changes on Canadian Arctic glaciers and ice caps. While long surface mass balance measurements are available from glaciers and ice caps in the Queen Elizabeth Islands (e.g., White Glacier, Devon Ice Cap, Meighen Ice Cap), no such records exist for Baffin Island glaciers. In the absence of such data, air- and space-borne measurements can be used in combination with in situ data to evaluate historical and recent trends in ice cover changes. Here, we use repeat laser airborne altimetry surveys conducted in 2005 and 2013 by NASA to estimate recent volume and mass changes of Penny Ice Cap, the southernmost large ice cap on Baffin Island (~66°N). These data are validated against in-situ surface mass balance measurements from 2013 and IceSat derived elevation change from 2003-2009. Once validated, surface elevation changes along altimetry lines are extrapolated to the entire ice cap using a digital elevation model (DEM). Changes in areal extent of the ice cap are constrained using satellite imagery (e.g. Landsat). From these data we estimate the total mass wastage of the ice cap and its recent contribution to sea level rise. This work builds on previous surveys for the period 1995-2005 [Abdalati *et al.* (2004) *JGR* 109: F04007; Gardner *et al.* (2012) TC 6:1103-1125.]