4rd ADAPT Workshop
Tuesday, 10 December 2013, 9:00 – 12:00 a.m.
World Trade and Convention Centre in Halifax, NS.
Conference room: **304-305**

8:30	ADAPT updates and integration	W. F. Vincent
8:50	Geophysical implications of snow and liquid water in permafrost landscapes (tutorial)	D. Fortier
9:20	Effects of liquid water on infrastructure in permafrost regions (tutorial)	G. Doré
9:50	Biogeochemical dynamics and gas exchange in permafrost peatlands (tutorial)	N. Roulet
10:20	PAGE 21: Updates and collaboration	H. Lantuit et al.
10:40	Coffee break	
11:00	ADAPT MODULE 1: From land to sea: the impacts of thawing permafrost on sedimentary dynamics	M. Jolivel
11:15	ADAPT MODULE 2 The critical role of snowmelt runoff to shallow lakes in permafrost landscapes	F. Bouchard
11:30	ADAPT MODULE 3 Modeling and experimental analysis of net ecosystem carbon balance change with permafrost thawing in northern peatland	Z. Wang
11:45	ADAPT MODULE 4 Permafrost Disturbance in the High Arctic: Impacts of Retrogressive Thaw Slumps on Ecosystem Fluxes	A. Cassidy
12:00	Workshop adjourns	

Presentation Abstracts

GEOPHYSICAL IMPLICATIONS OF SNOW AND LIQUID WATER IN PERMAFROST LANDSCAPES (TUTORIAL)

Daniel Fortier

Centre d'études nordiques (CEN), ArcticNet, Université de Montréal

Water, under its different phases (vapour, liquid, ice) is the most important component of permafrost biogeosystem dynamics. The objective of this paper is to underscore the importance of water in the thermal dynamics of the permafrost biogeosystem. At the surface, liquid water evaporates, thereby reducing heat intake by permafrost by cooling off the ground surface and promoting turbulent heat and gas exchange with the atmosphere. Snow strongly modulates ground surface heat loss and changes in the crystalline structure and in the liquid water content. Snow therefore likely plays a major role in permafrost degradation. During spring and summer, surface runoff, streamflow, water current and waves are major drivers of heat redistribution within the landscape and can trigger rapid processes of permafrost degradation by convective heat transfer (thermo-erosion). Under the surface, liquid water moves through the soil porosity, which changes the active layer thermal dynamics by conducto-convective heat transfers. Depending on timing of the year and subsurface micro-morphology, both warming and cooling of the active layer can occur. At the surface/subsurface interface, freezing of standing water bodies (e.g. ponds, lakes) is delayed due to the latent heat of liquid water. This phenomenon creates local 'heat islands' within the landscape and eventually triggers thermokarst processes and talik development. Depending on soil types and geochemistry, the thermal regime of 'warm permafrost' (-2 to 0^{o} C) is peculiar due to the co-existence of ice and unfrozen liquid water in the soil column.

EFFECTS OF LIQUID WATER ON INFRASTRUCTURE IN PERMAFROST REGIONS (TUTORIAL)

Guy Doré

Centre d'études nordiques (CEN), Université Laval

Liquid water is one of the major factors affecting permafrost stability. Liquid water is present above the soil surface in the form of lakes, streams and ponds. It is also present in the active layer in the form of interstitial water and in permafrost in the form of unfrozen water. In all cases, water can be in a stagnant state or can be moving under a pressure gradient. By strongly affecting thermal conductivity of soils and by inducing convective effects, liquid water is a key factor of permafrost stability.

By altering natural landscapes, built infrastructure, and more specifically transportation infrastructure, are likely to significantly modify hydrological and hydrogeological systems and consequently, induce permafrost instability.

The presentation will look at the interaction between transportation infrastructure and liquid water in permafrost environments. The main physical processes influencing permafrost stability in the presence of liquid water and the influence of transportation embankments on these processes will be described and discussed. The presentation will highlight the need for a more rigorous approach to surface and sub-surface water management based on heat exchange processes when developing transportation infrastructure in northern Canada.

BIOGEOCHEMICAL DYNAMICS AND GAS EXCHANGE IN PERMAFROST PEATLANDS (TUTORIAL).

Nigel Roulet

Global Environmental and Climate Change Centre (GEC3), McGill University

As active layers depths (ALD) increase in peatlands that contain permafrost, a number of changes occur in the physical setting that lead to changes in the structure and function of the ecosystem. Changes in ALD or the loss of permafrost alters the spatial distribution of water storage: some areas of a peatland will become drier, while other areas will become wetter. At the wet end of these transitions, thermokarst ponds can be created. These structural changes alter the biogeochemical pathways that ultimately control the exchange of CO_2 and CH_4 between the ecosystem and the atmosphere. At the scale of plant communities, there generally is a small increase in the net ecosystem exchange with the loss of permafrost but there can be orders of magnitude increase in the flux of CH_4 from the peatland to the atmosphere. Part of the increase in the CH_4 flux is due to changes in the supply of carbon substrates from the decomposition of organic matter while there can be an increased supply of labile carbon from root exudation, particularly if plants with aerenchyma replace moss, lichens and woody shrubs. Further, with wetter conditions, the potential for CH_4 oxidation relative to the production reduces as the proportion of CH_4 transported through plants and by ebullition increases relative to CH_4 gas diffusion. Spatially integrated annual net ecosystem carbon balances (NECB) based on continuous measurements of NEE, CH_4 and DOC loss for peatlands in permafrost regions do not appear to differ significantly from the NECB of boreal peatlands. However, the relative importance of the NEE, the CH_4 flux and the dissolved organic carbon (DOC) export are very different from that of boreal peatlands. Understanding how NEE, CH_4 flux and DOC loss vary due to environmental change is important because the fate of these different carbon exchanges is very different for biospheric - climate feedbacks over time scales of decades to millennia.

PAGE 21: UPDATES AND COLLABORATION

Hugues Lantuit et al.

Alfred Wegener Institute for Polar and Marine Research, Germany

PAGE21 (Changing Permafrost in the Arctic and its Global Effects in the 21st Century) is a Large-scale integrating collaborative project funded by the European Union Framework Programme 7. The project brings together 17 partners from several European countries and was granted 13 million dollars of funding. The project aims to understand and quantify the vulnerability of permafrost environments to a changing global climate, and to investigate the feedback mechanisms associated with increasing greenhouse gas emissions from permafrost zones. It makes use of a unique set of Arctic permafrost investigations performed at stations that span the full range of Arctic bioclimatic zones. In November 2012, PAGE21 signed an agreement with ADAPT to create synergies between the research strategies of both projects, creating de facto the largest permafrost project ever funded. Together, both projects developed partner research activities but also put a large emphasis on the support of young researchers. In this presentation, we provide an update on the development of the partnership between both projects and show how this partnership is necessary to address issues that are circum-Arctic by nature.

FROM LAND TO SEA: THE IMPACTS OF THAWING PERMAFROST ON SEDIMENTARY DYNAMICS

Maxime Jolivel and M. Allard

Centre d'études nordiques (CEN), ArcticNet, Université Laval

Permafrost thawing, or thermokarst, has impacts on the stability of ecosystems and man-made infrastructure. The hydrological cycle is affected and greenhouse gas emissions may be enhanced. However, there is a scarcity of knowledge about the translocation from land to sea of sediment and carbon released by thermokarst. Field-based studies using an integrated geomorphological approach are needed in order to better understand land processes involved in permafrost thawing on the geosystem, such as deepening of the active layer, slope processes and thermokarst lake formation. Filling this knowledge gap is one of the primary objectives of ADAPT.

The Sheldrake River catchment in the discontinuous permafrost zone is an area of rapid permafrost decay. It lies at the core of the ADAPT super region. Thermokarst landforms and processes were mapped and observed in the 76 km2 catchment and the study also includes a ≈ 15 km2 marine area on the coast of Hudson Bay, north of Umiujaq, where 26 sediments cores where recovered. Post-glacial marine silty clay is the most widespread surficial sediment in the catchment and extensive peat covers are found on palsas. The decay of lithalsas, palsas, permafrost plateaus and peat plateaus leads to the formation of thousands of new thermokarst ponds, which now dominate the landscape. Ongoing thermokarst results in an increased hydrological connectivity in the stream network generated by new and expanding thermokarst ponds, landslides and erosion gullies thus enhancing inputs of sediment and organic carbon in the fluvial network. All of these features have become increasingly active as the permafrost thaws, as measured on air photographs from 1957 and on recent satellite images. Gauging river discharge and turbidity near the river mouth revealed that maximum discharge occurs at spring melt, but the suspension load of the river reaches its maximum later in July when the active layer deepening rate is the fastest. Therefore, year to year permafrost thawing could have a greater impact on river sediment loads than spring floods. For instance, in 2010 warm temperatures in July caused a rapid thaw front progression in the active layer reaching about 85-90% of the maximum thaw depth, which resulted in the annual peak of the Sheldrake River suspension load. Periods of increased flow associated with summer rainfalls facilitate the transport of suspended sediment and carbon to Hudson Bay where they are dispersed by strong marine currents in Nastapoka Sound. Finally, dating and isotopic analysis of the sedimentary organic matter in the marine cores showed an increase of the terrestrial carbon fraction in the coastal environment since the Little Ice Age, with a still increasing trend. This rise in terrestrial carbon content in marine sediments is likely linked to changes in the ecosystem, among which thermokarst is an important contributor. This systemic study relates to modules 1, 2 and 3 of ADAPT and results exemplify the complex downstream sediment and carbon transfer mechanisms resulting from permafrost decay.

THE CRITICAL ROLE OF SNOWMELT RUNOFF TO SHALLOW LAKES IN PERMAFROST LANDSCAPES

Frédéric Bouchard[1,2], K.W. Turner[2,3], L.A. MacDonald[4], C. Deakin[2], H. White[2], N. Farquharson[2], A.S. Medeiros[2], B.B. Wolfe[2], R.I. Hall[4], R. Pienitz[1], and T.W.D. Edwards[5]

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Snowfall and the duration of snow cover are changing in the Arctic, ADAPT is addressing the implications of these changes on shallow, lake-rich permafrost landscapes. Snowmelt is important for replenishing shallow lakes and is likely to become even more crucial as evaporative drawdown intensifies with continued warming.

Here, we use lakewater oxygen-isotope data ($\delta^{18}O$) across gradients of terrestrial vegetation cover (open tundra to closed forest) and topographic relief to identify lakes that are vulnerable to desiccation under conditions of low snowmelt runoff in two subarctic permafrost landscapes: Old Crow Flats (Yukon) and Hudson Bay Lowlands (Manitoba). Lakes located in low-relief, open-tundra catchments in both landscapes displayed a systematic, positive offset between directly measured lakewater $\delta^{18}O$ over multiple sampling campaigns and lakewater $\delta^{18}O$ inferred from cellulose in recently deposited surface sediments. We attribute this offset to a strong evaporative ^{18}O-enrichment response to lower-than-average snowmelt runoff in recent years. Notably, some lakes underwent near-complete desiccation during mid-summer 2010 following a winter of very low snowfall. Based on the paleolimnological record of one such lake, the extremely dry conditions in 2010 may be unprecedented in the past ~200 years. Findings fuel concerns that a decrease in snowmelt runoff will lead to widespread desiccation of shallow lakes in these landscapes.

For regions that experience a decline in snow-cover extent and reduction in snowmelt runoff with continued warming, our isotope data coupled with field observations from two of Canada's largest lake-rich permafrost landscapes, indicate that shallow lakes located in low relief, open-tundra terrain are particularly vulnerable to desiccation by evaporation. Such hydrological changes will have profound impacts on wildlife habitat, carbon cycling, and other aquatic ecosystem services.

MODELING AND EXPERIMENTAL ANALYSIS OF NET ECOSYSTEM CARBON BALANCE CHANGE WITH PERMAFROST THAWING IN NORTHERN PEATLAND

Zheng Wang and Nigel Roulet

Global Environmental and Climate Change Centre (GEC3), McGill University

With the ongoing climate change, permafrost thawing is expected to make northern peatlands a major contributor of changes in atmospheric greenhouse gases and hence positive feedbacks to climate change. However, as northern peatland carbon biogeochemistry processes are intimately coupled to environmental conditions and have complex interactions with environmental change, the relationship between permafrost thaw, the environmental changes it causes, and the resultant change in the carbon fluxes are not clear. My research objective is to assess the changes in the components of the net ecosystem carbon balance (NECB) with permafrost thaw in northern peatlands, and in particular how changes in the carbon biogeochemistry (e.g. exudates with vegetation change, liability of DOC, and organic matter availability) influence NECB. I will conduct field research in permafrost thawing peatlands to measure the exchange of CO_2 and CH_4, the structure of vegetation, the carbon biogeochemistry associated with vegetation groups, and the physical and chemical variables across a transect from an intact palsa, to peatland lawn? of various wetness, to several thermokarst ponds to investigate how the NECB and biogeochemistry are influence by permafrost thaw. Based on my field research, I will parameterize, modify and adapt two peatland carbon models (McGill Wetland Model and the Holocene Peatland Model) to establish a process-based model that focuses on the biogeochemistry processes and ecosystem carbon dynamics in the permafrost peatland. The major adaptations are the addition of appropriate vegetation dynamics and associated liable carbon release, functions to establish the liability and turnover of DOC, and the CH_4 emission process. My NECB field research and some long-term field records will be used to evaluate how this new model performs with changing environmental conditions.

PERMAFROST DISTURBANCE IN THE HIGH ARCTIC: IMPACTS OF RETROGRESSIVE THAW SLUMPS ON ECOSYSTEM FLUXES

Alison Cassidy and Greg Henry

ArcticNet and University of British Colombia

Land surface disturbances, including active layer detachment slides and retrogressive thaw slumps, are an indicator of thawing permafrost and climate change in the Arctic. This research examines the dynamics of these disturbances and the recovery of tundra ecosystems over short and long time scales at Hot Weather Creek, located on the Fosheim Peninsula, Ellesmere Island. Both forms of permafrost disturbance, retrogressive thaw slumps and active layer detachment slides, were present at the study site and studied during the 2012 and 2013 growing seasons. Research objectives include monitoring tundra ecosystem recovery, as initial site characterization was undertaken 20 years ago, and determining the ecosystem effects of disturbance. Landscape recovery of slumps and slides was monitored at stable sites, with vegetation indicator species differing between disturbances of varying ages. Nutrient data and site soil properties were also collected. The impact of active disturbances on CO_2 fluxes was quantified using the eddy covariance technique, where one active retrogressive thaw slump was compared with the surrounding undisturbed tundra during July 2012. Partitioning of wind direction allowed for the separation of fluxes from disturbed and undisturbed tundra. Preliminary results indicate differences in Net Ecosystem Exchange (NEE) dependent on disturbance status, as fluxes from the active slump represent a total release of carbon to the atmosphere, whereas undisturbed tundra acts as a net sink.