3rd ADAPT Workshop – Final Program

Tuesday December 11, 14:30 – 17:30 p.m.
Stanley Park Ballroom Salon 1, The Westin Bayshore,
Vancouver, British Columbia, Canada

14:30	ADAPT overview and updates	W. F. Vincent
15:10	**PAGE21** Program presentation and opportunities for collaboration; Student presentation	Hugues Lantuit and Stefanie Weege, Alfred Wegener Institute, Germany
15:30	Creation of the **AECRA**	Michel Paquette
16:10	**ADAPT MODULE 1** Development of a methodology for the design of low-impact drainage systems along transportation infrastructure in permafrost environments.	Julie Malenfant-Lepage and Guy Doré, CEN, U. Laval
16:20	**ADAPT MODULE 1** Soil organic matter distribution in the outer Mackenzie Delta Region, NWT.	Marcus Philipps and Chris Burn, Carlton University
16:30	**ADAPT MODULE 1 and 4** Thermal and geomorphologic impacts of the increasing shrub cover over a permafrost landscape, Umiujaq, Nunavik.	Maude Pelletier, Michel Allard and Esther Lévesque, CEN, U. Laval and UQTR
16:40	**ADAPT MODULE 2** Impact of permafrost disturbance and active layer deepening on the mobilization of solute and nutrients in continuous permafrost zones.	Montross, S.N., Lamoureux, S.F., Lafrenière, M., Queen's University
16:50	**ADAPT MODULE 3** Linking thermokarst microbial diversity to methane emissions in Subarctic Quebec.	Jérôme Comte, Alex Matveev, S. Crevecoeur, C. Lovejoy, W. F. Vincent, CEN, Québec-Océan and Takuvik, U. Laval
17:00	**ADAPT MODULE 3** Modeling the impacts of warming on the long-term trends in ecosystem productivity in arctic regions of North America.	Zelalem Mekonnen, Robert Grant, U. of Alberta
17:10	**ADAPT MODULE 3** Which deep soil biogeochemical properties drive microbial diversity and functionality in tundra soils?	Casper Christiansen and Paul Grogan, Queen's University
17:20	Discussions	
18:30	Happy Hour	

Presentation Abstracts

WHICH DEEP SOIL BIOGEOCHEMICAL PROPERTIES DRIVE MICROBIAL DIVERSITY AND FUNCTIONALITY IN TUNDRA SOILS?

Casper T. Christiansen and Paul Grogan

Queen's University

Soil microbial activities determine organic matter decomposition rates and thus nutrient availability to plants and respiratory soil-atmosphere carbon losses. How microbial activity is affected in a changing climate is therefore a critical determinant of the carbon balance of arctic terrestrial ecosystems. As soils warm, changes in microclimate will vary with soil depth which together with biogeochemistry will drive differences in microbial activity. However, few studies have investigated microbial diversity down through the active layer and into the permafrost. Here, we aim to explore links between the primary components of tundra soil biogeochemistry, i.e. soil microbial community composition and functionality, microbial biomass, nutrient availability and carbon fraction content, at 5-10 cm intervals throughout the active layer and upper permafrost. Via ADAPT and their collaborators, we seek to obtain soil cores from a broad range of sites to identify similarities and main drivers of microbial diversity and functionality. Microbial activities in surface and subsurface soil horizons may respond differently to a changing climate and understanding whole belowground ecosystem properties and function is essential if we want to better predict how the tundra will respond to climate warming and associated deep soil thaw and permafrost degradation.

LINKING THERMOKARST MICROBIAL DIVERSITY TO METHANE EMISSIONS IN SUBARCTIC QUÉBEC.

Jérôme Comte, Alex Matveev, Sophie Crevecoeur, Connie Lovejoy and Warwick F. Vincent

Centre d'études nordiques (CEN), ArcticNet, Québec-Océan and Takuvik, Université Laval

One major impact of rapid climate change in the North is the accelerated landscape dynamics of permafrost thaw ponds (thermokarst), which may play a major role in circumpolar and global biogeochemical cycles via the release of CO_2 and methane (CH_4) to the atmosphere. Yet little is known about the microbial communities and biogeochemical processes responsible for these emissions. In this component of ADAPT, our aims are to determine the full microbial diversity (Bacteria, Archaea and Eukarya) of thaw ponds as complex microbial bioreactors, and to link the diversity patterns with ecosystem function, in particular methane emissions. We hypothesize that thaw pond functioning is dependent on microbial community structure and the metabolic performance of key taxa (methanotrophs versus methanogens) under aerobic and anaerobic conditions. To test this hypothesis, we sampled in August 2012 a set of thaw ponds in different regions in Nunavik that vary in terms of their main limnological characteristics, and the extent of permafrost degradation in their surrounding watersheds. CH_4 concentrations and exchange rates with the atmosphere were measured in situ, and preliminary estimates range from a net influx of 0.004 mmol m^{-2} d^{-1} per day by highly turbid lakes overlaying discontinuous to continuous permafrost, to a net efflux of 17.6 mmol m^{-2} d^{-1} by organic-rich lakes in a palsa valley. In parallel, microbial community composition, is being evaluated by high throughput DNA and RNA 454-pyrosequencing of the microbial communities.

CHANGING PERMAFROST IN THE ARCTIC AND ITS GLOBAL EFFECTS IN THE 21ST CENTURY (PAGE21).

Hugues Lantuit and Stefanie Weege

Alfred Wegener Institute, Germany

PAGE21 is the largest European Union research project to date on permafrost and relies on a 9 M€ budget 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. The project brings together the best European permafrost researchers and eminent scientists from Canada, Russia, the USA, and Japan.

It combines field measurements of permafrost processes, pools, and fluxes, with remote sensing data and global climate models at local, regional and, for the first time, pan-Arctic scales. The output from this research will help to advance our understanding of permafrost

processes at multiple scales, resulting in improvements in global numerical permafrost modeling and the ensuing future climate projections, as well as in the assessment of stabilisation scenarios.

PAGE21 has already established partnerships with the GRENE-TEA (Japan) and the ADAPT projects (Canada) and an Letter of Agreement with the latter was signed in November 2011. In this presentation we highlight the scientific objectives of PAGE21, the spatial distribution of its sites, its data management framework, outreach strategy and activities put forward by its early career researchers and we propose synergies with the ones of ADAPT.

DEVELOPMENT OF A METHODOLOGY FOR THE DESIGN OF LOW-IMPACT DRAINAGE SYSTEMS ALONG TRANSPORTATION INFRASTRUCTURE IN PERMAFROST ENVIRONMENTS

Julie Malenfant-Lepage and Guy Doré

Centre d'études nordiques (CEN), Université Laval

Currently, engineering methods for the design of drainage systems are limited to a set of "good practice" recommendations to avoid excessive heat transfer under embankments. The project intends to develop practical methods to calculate the quantity of heat transferred through convective surface and sub-surface water flows in the design of a drainage system. In particular, a method to assess the maximum quantity of water that can be concentrated in one channel in order to control heat transfer to permafrost and erosion of soils will be developed. The approach will lead to the optimal number of crossings (culverts) to consider for a given structure, the thermal design of these crossings as well as the need and the design of an appropriate flow diffusion system downstream from the structure. The project involves soil temperature profile logging as a function of water flow, heat flux measurements, thermal modelling and small scale laboratory testing. Field work will be done at one Nunavik site in Salluit as well as at several sites in the Yukon (Beaver Creek; Alaska highway) and in the North-West Territories (Highway 3).

MODELING THE IMPACTS OF WARMING ON THE LONG-TERM TRENDS IN ECOSYSTEM PRODUCTIVITY IN ARCTIC REGIONS OF NORTH AMERICA

Zelalem Mekonnen and Robert Grant

Department of Renewable Resources, University of Alberta

Rises in average air temperatures for the Arctic region in particular have been twice as rapid as the global average during the last century. Despite a general warming in most arctic regions, there is large spatial and temporal variation in this warming that affects the productivity of different ecosystems. In this study, we investigated long-term (1979 – 2010) spatial and temporal trends of air temperature change in northern higher latitudes (North of 60^0N) using climate data from the North American Regional Reanalysis (NARR) with 3-hourly time step at spatial resolution of 0.25 degrees. Trend analysis of temperatures in different regions of the arctic shows a contrasting pattern along latitudinal and longitudinal gradients. The highest warming trend was observed in the northeast arctic with a trend of +0.72 ^{0}C/ decade, demonstrating amplified warming in the Arctic in the recent decades. The NARR climate data were used to drive a comprehensive mathematical ecosystem model ecosys which simulated land-atmosphere energy and carbon exchange. Spatial and temporal trends in changes of ecosystem productivity attributed to warming over the last three decades were then investigated. Maps of changes in temperature and in ecosystem productivity over the North American arctic during the past 3 decades will be presented.

IMPACT OF PERMAFROST DISTURBANCE AND ACTIVE LAYER DEEPENING ON THE MOBILIZATION OF SOLUTE AND NUTRIENTS IN CONTINUOUS PERMAFROST ZONES

Scott N. Montross, Scott F. Lamoureux and Mélissa Lafrenière

Queen's University

Research in 2012 included fieldwork and sample collection at Cape Bounty Arctic Watershed Observatory (CBAWO), Sabine Peninsula, and Char Lake in the Canadian High Arctic. At CBAWO, soil stations instrumented with moisture, conductivity, and temperature sensors were deployed in areas with varying degrees of permafrost disturbance, measurements of active layer thickness were conducted, using the CALM protocol, and deep (7-10m) temperature bore holes were installed to expand the extensive permafrost monitoring work currently underway. Permafrost cores were also collected from CBAWO and are currently being processed for measurements of water isotopes, nutrient concentrations, and microbial community composition (in collaboration with Paul Grogan). A comprehensive set of water and soil samples were collected from mud boils, streams, ponds, and groundwater seeps found at all three locations. On the Sabine Peninsula, we extended sampling of water and soil to reflect land that was undisturbed and disturbed by active layer detachments in different geological settings, and adopted a similar approach to initial water and sediment sampling around Char Lake. Water and soil samples were collected from all locations to examine the nature of soil organic matter. Sediment was also collected from streams and ponds for microbial pigment analysis (U. Laval) and DNA analysis.

THERMAL AND GEOMORPHOLOGICAL IMPACTS OF THE INCREASING SHRUB COVER IN THE TUNDRA, UMIUJAQ, NUNAVIK

Maude Pelletier, Michel Allard and Esther Lévesque

Centre d'études nordiques (CEN), ArcticNet, Université Laval and Université du Québec à Trois-Rivières

Since a few decades, the increase in mean annual temperatures of the air induces active layer thickening and therefore, the rate of permafrost thawing. The heat flow between the atmosphere, the soil surface and the active layer influences the rate of permafrost degradation as thaw spreads deeper and deeper. Topography, , vegetation and snow cover, as well as soil thermal are factors of permafrost degradation. My research project incorporates ecological and geomorphological approaches, studying interactions at interfaces between three layers in the ecosystem: the vegetation/ snowpack layer, the active layer and permafrost.

The study takes place in Vallée-des-Trois near Umiujaq, Nunavik, in the discontinuous permafrost zone. Six plots were surveyed and instrumented along an array representative of the successional stages that likely lead to permafrost disappearance as climate warming induces active layer thickening, vegetation growth and a thicker snow cover. The stages range from intact permafrost covered by lichen tundra at plot no. 1 to highly degraded permafrost under trees at plot no.6, with the intermediate plots showing progressively higher and denser shrubs, steeper slopes and correspondingly thicker snow covers. By instrumentally recording temperatures above ground in the canopy and the snow cover, at the ground surface, in the active layer and at the permafrost table, our goal is to determine the changes that occur in heat fluxes between the three layers of the ecosystems and the interface between them when permafrost degrades, i.e. the vegetation/ snow cover layer, the ground surface, the active layer, the permafrost table and the top layer of the permafrost. Soil water content in the active layer is also monitored. Our methodology is an application of the ADAPT protocol. The six plots were first located on a high resolution air photograph and finely selected in the field. They measure 10 m in diameter. The organic layers and the soil were sampled at selected spots and depths linked to species. Vegetation specific composition and structure were surveyed. Topography was surveyed at a precision of ± 1cm and active layer depth was checked with a temperature probe. Snow cover will be measured at topographic saturation in March-April 2013. Stems of shrubs (birch and willow) and of spruce trees were sampled for tree-ring analysis. Along with time-lapse air photographs, dendrochronology shall provide the time frame for the successional dynamics of permafrost degradation along the array. The temperature and humidity recordings are made at each plot with a Decagon ECH20 model five-channel datalogger, complemented by Pendants one-channel Onset Computer dataloggers. Local and regional climate parameters such as air temperature, wind speed and direction, incoming solar radiation, precipitation and snowfall are provided by a nearby SILA station of Centre d'études nordiques located in the valley. Ultimately, the data acquired at the site shall serve as input and validating information for a numerical model reproducing the dynamics of the permafrost ecosystem in transition.

SOIL ORGANIC MATTER DISTRIBUTION IN THE OUTER MACKENZIE DELTA REGION, NWT

Marcus Philipps and Chris Burn

Carlton University

The northern permafrost regions contain globally significant amounts of below-ground organic matter, and represent a significant potential feedback to climate change. Because of alluvial sedimentation in syngenetic permafrost environments and cryoturbation in frost-susceptible soils, much of this organic matter is located in the uppermost permafrost. This carbon-rich material is largely dormant under perennially frozen conditions; however, under a changing climate, the organic matter in upper permafrost is vulnerable to thawing and subsequent decomposition and production of greenhouse gases. While the importance of this potential feedback is recognized, our knowledge of organic matter content in the upper permafrost remains coarse. This research examined the amount of carbon-rich organic matter in the upper permafrost in upland frost-susceptible and lowland alluvial soils in the outer Mackenzie Delta region. Results indicate that while active layer organic matter contents are comparable, there is substantially more organic matter vulnerable to thawing in upland permafrost than in nearby deltaic permafrost. The implications of these results and plans for future research will be discussed.