Sentinelle Nord | Sentinel North

RÉSUMÉS 2018 ABSTRACTS

Réunion annuelle | Annual Meeting

QUÉBEC
27-30 août 2018

Manège militaire Voltigeurs de Québec
et Hôtel Château Laurier

QUEBEC CITY
27-30 August, 2018

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Sentinelle Nord permet à l'Université Laval de puiser dans plus d'un demi-siècle d'excellence en recherche nordique et en optique photonique pour développer de nouvelles technologies et améliorer notre compréhension de l'environnement nordique et de son impact sur l'être humain et sa santé.

Le programme Sentinelle Nord est rendu possible grâce, en partie, au soutien financier du Fonds d'excellence en recherche Apogée Canada.

Sentinel North allows Université Laval to draw on over a half-century of northern and optics/photonics research to develop innovative new technology and improve our understanding of the northern environment and its impact on human beings and their health.

Sentinel North is made possible, in part, thanks to funding from Canada First Research Excellence Fund.

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LUNDI 27 AOÛT

MONDAY, AUGUST 27

STUDY OF THE INTESTINAL MICROBIOME COMPOSITION, DIVERSITY AND FUNCTION IN NUNAVIK INUIT YOUTH POPULATION FACING ADVERSITY

Abed, Jehane Y. (1), M. Boissinot (1), J. Corbeil (1,2,3), M.G. Bergeron (1,4), P. Ayotte (5,6,7), M. Hébert (8,9), P. Marquet (10,11,12), C. Mérette (8,12), N. Poliakova (6), M. Lemire (6,7), M. Lucas (6,7), M.-C. Vohl (13,14,15), G. Muckle (6,16) and R.E. Bélanger (6,17,18)

(1) Centre de recherche en infectiologie de l'Université Laval, Axe Maladies infectieuses et immunitaires, Centre de recherche du CHU de Québec-Université Laval, Québec, QC, Canada
(2) Centre de recherche en données massives de l'Université Laval, Québec, QC, Canada
(3) Département de médecine moléculaire, Faculté de médecine, Université Laval, Québec, QC, Canada
(4) Département de microbiologie-infectiologie et d'immunologie, Faculté de médecine, Université Laval, Québec, QC, Canada
(5) Centre de toxicologie du Québec, Institut national de santé publique du Québec, Québec, QC, Canada
(6) Axe santé des populations et pratiques optimales en santé, Centre de recherche du CHU de Québec, Hôpital du Saint-Sacrement, Québec, QC, Canada
(7) Département de médecine préventive et sociale, faculté de médecine, Université Laval, Québec, QC, Canada
(8) Centre de recherche de l'Institut universitaire en santé mentale de Québec, Québec, QC, Canada
(9) Département d'ophtalmologie et d'oto-rhino-laryngologie - chirurgie cervico-faciale, Faculté de médecine, Université Laval, Québec, QC, Canada
(10) CERVO Brain Research Centre, Université Laval, Québec, QC, Canada
(11) Centre d'optique, photonique et laser, Université Laval, QC, Canada
(12) Département de psychiatrie et neurosciences, Faculté de médecine, Université Laval, Québec, QC, Canada
(13) Institut sur la nutrition et les aliments fonctionnels, Université Laval, Québec, QC, Canada
(14) Axe Endocrinologie et néphrologie, Centre de Recherche du CHU de Québec-Université Laval, Québec, QC, Canada
(15) École de nutrition, Faculté des sciences de l›agriculture et de l›alimentation, Université Laval, Québec, QC, Canada
(16) École de psychologie, Faculté des sciences sociales, Université Laval, Québec, QC, Canada
(17) Département de pédiatrie, Faculté de médecine, Université Laval, Québec, QC, Canada
(18) Centre mère-enfant Soleil, CHU de Québec-Université Laval, Département de pédiatrie, Québec, QC, Canada

Inuit communities experience major factors of adversity in their daily life such as mental health, environmental pollution and the rapid westernization of their diet and lifestyle. Dietary habits of Inuit populations reflect a gradient between traditional diet (hunted/ gathered country foods) and western diet (processed foods). There is substantial evidence that the intestinal microbiome has a major impact on human health. In the thematic project 3.6, we will use the gut microbiome as a sentinel of the Inuit population's mental health in a changing northern environment. The goal is to analyze possible links between the intestinal microbiome and mental health. The initial step will determine the bacterial composition and diversity of the digestive tract microbiome of Inuit in Nunavik. In a subsequent step, links between mental health, dietary habits and microbiome will be explored using integrative analyses. From August to October 2017 during the "Qanuilirpitaa 2017?" health study, participants from 14 communities in Nunavik (northern Quebec) donated fecal samples. We presently have over 185 samples providing us with sufficient analytical power to identify putative links between microbiome and mental health. The selected participants are aged between 16 and 30 years old. This age range was chosen because among young Canadian Inuit, the suicide rate is 11 times superior to the national rate. Additionally, participants answered questionnaires about their mental health status and dietary habits. Blood tests were performed and anthropometric data were obtained. The sex ratio was also taken into account. Shotgun metagenomics will be used to sequence the total DNA content of the microbiome. This technique

provides a more comprehensive look into the bacterial composition, diversity as well as function of the fecal microbiome. Using our bioinformatics pipelines, we will obtain a complete microbiome profile including taxonomic and metabolomic profiling. To our knowledge, there are only two published studies on the intestinal microbiome of Inuit. They have used 16S rRNA sequencing to compare the microbiota of participating Inuit from Nunavut to those of controls from European decent eating a western diet in Montréal. This technique is weaker than shotgun metagenomics as it only provides insights on the diversity and composition and not the function of the metagenome. Two cohorts were studied. First, 19 Inuit participants from Nunavut and 26 controls enlisted. They provided one fecal sample. Second, 15 Inuit participants from Nunavut and 9 controls were recruited. They donated fecal samples once a month for seven months. While they found no differences between Inuit from Nunavut and Montrealers' microbiota at a single time point, over time, Inuit microbiota exhibits more variations in composition and diversity. Using metagenomics sequencing to study a much larger and more diverse cohort will allow us to get a broader and deeper view of the microbiome composition, diversity and metabolic pathways of Inuit. We believe that this work will be used as the basis to explore links between mental health, dietary habits and microbiome.

ARCTIC CHAR MICROBIOTA PROJECT: IDENTIFYING FACTORS THAT CONTROL MICROBIAL BENEFICIAL FUNCTIONS FOR HOST ENERGETIC PERFORMANCE

Amill, Flora (1), A. Chaabane (1) and N. Derome (1)

(1) Laboratoire Nicolas Derome, Université Laval, Québec, QC, Canada

Arctic char (*Salvelinus alpinus*) is a key species in the North because it is widespread in the Canadian Arctic and it is the main source of protein and polyunsaturated fatty acids for Inuit. Furthermore, the small-scale fishery of this species is paramount for maintaining the culture and the plurimillennial lifestyle for this community. Nowadays, this species is facing multiple stressors, such as climate change, which negatively affect their health and productivity. Among said stressors, water chemistry modifications, the bioaccumulation of pollutants (mercury, iron, arsenic, lead, cadmium, manganese) in the environment caused by air pollution in North America and Eurasia, and the migration of pathogen populations threaten the Arctic ecosystems by impacting the physiological performance of the organisms. The microbiota (e.g. the microbial community living in the body surface of its host) is known to play an important physiological role and constitutes the first immune barrier to the host, but it is also known to be affected by said contaminations. The objective of my PhD will be to characterize the impact of these disruptions on the host-microbiota interactions and to measure the resilience capacity of those systems threatened by pathogen populations in controlled conditions. We want to assess the role of these microorganisms in the metabolism, phenotype and behaviour modifications of their host, facing environmental stress factors. To understand the different mechanisms of adaptation of Arctic char, we will carry out two sampling campaigns in August 2018 at Cambridge Bay (Ikaluktutiak) and in August 2019 at Resolute Bay (Qausuittuk). During my PhD, I will identify the factors controlling the composition and the functional activity of microbiota (skin, gut, gills) in the natural population of Arctic char and I will determine the key microbial functions corresponding to the different environments. I am also interested in the genomics of Arctic char which control the diversity and the functional activities of microbiota by pangenomics association and metatranscriptomics. Finally, I will identify the bacterial strains which can modify the epigenome of the Arctic char to achieve a better immune performance. This aforementioned will be interesting in order to develop some probiotics to support the sustainable aquaculture industry. During the Sentinel North meeting on August 2018, I will present my project and the expected results but also the results of Amine Chaabane, a master's student who worked on the project characterizing the diversity of microbiota for two populations of Arctic char from Deception Bay (Nunavik) sampled during the summer of 2017 and providing primary information about the physiological states of char stocks.

FUNCTIONAL INFERENCE OF NEURAL NETWORKS: A COMPLETE DEEP LEARNING PIPELINE

Bahdine, Mohamed (1, 2), J.Poirier (1, 2), D. Côté (1, 2), S. Hardy (1, 2) and P. Desrosiers (1, 2)

(1) CERVO Brain Research Centre, Québec, QC, Canada
(2) Université Laval, Québec, QC, Canada

To validate complex network theories on resilience; real, functional and perturbable networks are needed. We develop a complete deep learning pipeline to infer

the zebrafish's connectome from whole-brain calcium imaging. This pipeline first segments the images and extracts time series of activity for each individual neurons, it then detects the spiking activity and finally infers the connections. Classical algorithms are compared to machine learning and deep learning approaches. We find that, although sacrificing the interpretability of the results, the deep learning methods yields the best performance.

TOWARDS A PORTABLE MICRO-CYTOMETER FOR THE QUANTIFICATION OF PICOPLANKTON IN NORTHERN LAKES AND SEAS

Bansept, Marc-Antoine (1,3), W.F. Vincent (1,2) and D. Boudreau (1,3)

(1) Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Québec, QC, Canada
(3) Centre d'optique, photonique et lasers, Québec, QC, Canada

The planktonic microbiome, the ensemble of microbes in natural waters and their functions, is at the base of aquatic food webs and biogeochemical cycles. Just as we now realize that the functioning of the 'human microbiome' plays a major role in human health, the planktonic microbiome controls the healthy functioning of aquatic ecosystems. It is composed of bacteria, archaea, coloured (phytoplankton) and non-coloured protists, and viruses. One of the major groups of microbes in northern waters is picophytoplankton, especially picocyanobacteria in Arctic lakes and rivers, and coloured picoeukaryotes in the Arctic Ocean. For many years, populations of these autotrophic organisms have been assessed by flow cytometry using the intrinsic fluorescence of their photosynthetic pigments in combination with genomic analysis. This flow cytometer measures the optical properties of individual cells, which in turns makes it possible to identify sub-populations within a sample. This information can then be used to produce a limnological or oceanographic profile of the studied environment. Although flow cytometers have been used in field campaigns, these instruments are generally expensive and are optimized for medical laboratories rather than environmental applications. Furthermore, they require a precise optical alignment thus making their tolerance to harsh field conditions limited. To counter this, scientists have resorted to freezing samples for analysis, several thousands of kilometers down south. These manipulations produce obvious practical challenges, can results in erroneous estimates, and limit the researcher's ability to obtain an instantaneous assessment of the microbiota in the environment being studied. Hence, this project, as a part of Sentinel North 3.1 aims at developing a portable instrument for the quantification of picoplankton in northern environments by flow cytometry. To achieve this goal, a new technology using holographic spatial encoding which allows for multiplexed, single detector, measurement s of fluorescence from different photosynthetic pigments has been applied. Furthermore, an approach to on-chip 3D hydrodynamic focusing, an essential component for signal standardization in flow cytometry, has been made based on Dean vortices, with progress towards a fully integrated micro-flow cytometer system. The proposed design reduces weight and volume, and it eliminates the troublesome need for optical alignment in order to provide a robust instrument for northern field research.

SEASONAL DYNAMICS IN THE EXTREME ARCTIC: WARD HUNT LAKE, CANADA

Bégin, Paschale Noël (1), Y. Watanabe (2) and W.F. Vincent (1)

(1) Centre d'études nordiques & Département de biologie, Université Laval, Québec, QC, Canada
(2) National Institute of Polar Research, Tokyo, Japan

Lake ecosystems occur along the far northern coast of the Canadian High Arctic, but almost nothing is known about their seasonal dynamics. Ward Hunt Lake is Canada's northernmost lake, located on Ward Hunt Island (lat. 83 °05'N, long. 74 °10'W), off the northern coast of Ellesmere Island, Nunavut. This region experiences a polar desert climate, with an average air temperature of -17 °C and precipitation around 150 mm. The lake is oligotrophic and perennially ice-covered, but complete loss of ice cover was recorded in 2011, 2012 and 2016. Given its extreme northerly location, is a potentially sensitive indicator of global climate change. The objectives of our limnological studies in Ward Hunt Lake are to determine the structure and functioning of this remote aquatic ecosystem, and to better understand the nature and implications of ongoing change. Our previous work has shown that loss of ice cover over Ward Hunt Lake could have a major effect on primary production by higher light availability and on nutrient availability by wind-induced mixing. We hypothesized that the presence of a permanent ice cover on the Arctic lakes influences the thermal and mixing regimes, gas dynamics and phytoplankton production by limiting

the exchanges with the atmosphere and light penetration in the water column. A mooring installed at the deepest point of the Ward Hunt Lake (10 m) recorded temperature, oxygen, chlorophyll fluorescence and underwater irradiance from July 2016 to July 2017. This information was coupled with data from a nearby meteorological station and images from an automated camera system to track the seasonal variations in ice cover. Consistent with this hypothesis, higher chlorophyll *a* concentrations occurred when light became available in the water column after the long polar winter. However, maximum concentrations were recorded while light was reduced after a higher availability. For example, in the beginning of July 2017, snow accumulation on the ice cover reduced drastically the light in the water column, coinciding with a peak of chlorophyll *a*. This event highlights the importance of snow in light regulation on ice-covered lakes and suggests that the optimal growth of phytoplankton is not necessarily associated with the highest light availability in the season. Contrary to expectation, oxygen concentrations dropped rapidly after ice-up, and anoxia was recorded in the bottom waters in December. The oxygen and temperature records also revealed an internal wave pattern during the period of ice-cover. These high-resolution measurements indicated large-amplitude temporal variations in biogeochemical processes despite the low-nutrient status of this High Arctic ecosystem.

FINE-SCALE HABITAT SELECTION OF FEMALE CARIBOU IN SUMMER, USING CAMERA COLLARS

Béland, Sophiane (1,2), M. Bernier (3), and S. D. Côté (1,2)

(1) Département de biologie, Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(3) Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada

Migratory caribou (*Rangifer tarandus*) is a socioeconomically and culturally important species for Quebec, and its populations are experiencing a sharp decline. Although these caribou herds have been studied for several years, our knowledge of the amount of habitat that must be protected to ensure the persistence of these populations is limited. In this context, the study of habitat selection is a useful tool because it makes it possible to determine the distribution of individuals or populations in a heterogeneous environment and to characterize the habitats and resources they use. For migratory caribou, it is known that females are directly dependent on the availability of summer habitat resources given the very high costs associated with lactation, but also the need to accumulate reserves for other seasons, when resources are less abundant. However, we do not know how these females select the resources and the different habitats at a fine spatial scale. This is what will be determined in this project with the objective of evaluating the summer habitat selection (June to September) of caribou females in the Rivière-aux-Feuilles herd at a fine spatial scale. Specifically, we will focus on habitat selection at the feeding sites. We will also evaluate the effects of environmental variables such as temperature and wind, as well as the effects of insect harassment, on female habitat selection. To do this, we will use camera collars that capture the images in front of the animal equipped with such a collar. This project will provide us with information on the selection of summer habitat by female caribou at a fine spatial scale, which will contribute to the management and conservation of the migratory caribou and its habitats.

DIRECTIONAL CONSTRAINT MEASUREMENT WITH DISTRIBUTED FIBER BRAGG GRATING SENSORS WRITTEN IN MULTICORE FIBERS

Boilard, Tommy (1), J. Habel (1), Y. Messaddeq (1), F. Trépanier (2), R. Fortier (1, 3) and M. Bernier (1)

(1) Université Laval, Québec, QC, Canada
(2) Teraxion, Québec, QC, Canada
(3) Centre d'études nordiques, Québec, QC, Canada

Due to the trend of climate warming recently observed in Nunavik (Québec), Canada, permafrost is currently degrading with major negative impacts on the cold regions ecosystems and man-made infrastructures built on permafrost. For instance, permafrost thawing can lead to the subsidence of ground surface which affect the performance, service life, and maintenance cost of man-made infrastructures such as the access road to Umiujaq Airport in Nunavik [1]. As an unforeseen and positive consequence of climate warming and associated permafrost degradation, water stored as ice is released under its liquid phase into the ground, recharges the aquifer at depth and groundwater can become an important new source of drinking water for the Inuit communities and water consumers such as the mining industry [2]. In comparison to surface water which is the most common source of drinking water in Inuit communities,

groundwater is more reliable and less expensive to treat than surface water [2]. However, the physical processes related to permafrost degradation, release of water and recharge of aquifer in cold regions are not yet well understood. Field observations of these physical processes are needed but this might be challenging since they are taking place at depth in the ground. New sensors have to be developed for monitoring the ground subsidence and groundwater flow. Fiber Bragg gratings (FBGs) written in multicore fibers are a good candidate for this task, since they are small in size, resistant to harsh environments and capable of precisely measuring remotely physical parameters over very long lengths (hundreds of km). A novel method for writing distributed FBGs through the coating with a unique phase mask has been developed [3]. An array of 10 uniform FBGs of 1.5 mm in length and spectrally distributed over 40 nm were written through the coating in polyimide-coated fiber using this method [4]. Also, to simplify the writing process of FBGs in multicore fibers and the interrogation of these FBGs afterward, a new design of a microstructured glass preform adapted to support three fiber links containing the distributed FBG arrays is proposed. The multicore fiber will then be made from the assembly of three separated single core fibers. Numerical modeling of such fiber structure was developed to express the Bragg wavelength shift of this multicore fiber in terms of the different parameters, such as the distance between each fiber, their size, the size of the coating, etc. [1] Fortier, R. and al. “Impacts of permafrost degradation on a road embankment at Umiujaq in Nunavik (Quebec), Canada”. Canadian Geotechnical Journal 2011, 48, 720-740. [2] Lemieux, J.-M. and al. “Groundwater occurrence in cold environments: examples from Nunavik, Canada”. Hydrogeology Journal 2016, 24(6), 1497–1513. [3] Habel, J. and al. “Femtosecond FBG Written through the Coating for Sensing Applications”. Sensors 2017, 17, 2519. [4] Habel, J. and al. “Flexible phase-mask writing technique of robust femtosecond FBG for distributed sensing”. Accepted for oral presentation at BGPP 2018, Zurich, Switzerland.

OPTOGENETIC MODEL TO INVESTIGATE THE IMPACT OF THE MICROBIOTA ON THE DEVELOPMENT AND FUNCTION OF DOPAMINERGIC CIRCUITS

Boily, Vincent (1), T. Herzog (1), C. Salesse (1), M. Lévesque (1,2) and P. De Koninck (1,3)

(1) CERVO Brain Research Centre, Québec, QC, Canada
(2) Département de psychiatrie et de neurosciences, Faculté de médecine, Université Laval, Québec, QC, Canada
(3) Département de biochimie, microbiologie et bio-informatique, Université Laval, Faculté des sciences et de génie, Université Laval, Québec, QC, Canada

It is becoming widely accepted that the intestinal microorganisms hosted by humans and other vertebrates play a central role in maintaining their hosts in healthy conditions. When the host encounters a physiological stress, the microbiota ecosystem equilibrium is broken. This dysbiosis allows opportunistic microbial strains to induce negative effects on the host, including physiological disturbances on neuroendocrine functions and epigenetics modifications and may induce irreversible consequences on brain development and neural function, affecting mental health. Understanding this impact should provide important insight on the developmental factors that affect mental health. Dopaminergic circuits in the mid-brain are involved in motor function, rewards, attention and stress with a critical importance on mental health. In addition to genetic factors that regulate the development of these circuits, the dopaminergic system is highly susceptible to environmental developmental stressors, which may in turn have important consequences on stress response, attention and motor activity. The aim of this project is to investigate the impact of the microbiota on the development and function of the dopaminergic system. The characterization of host-microbiota interactions and their impacts requires the development of models and tools in the laboratory with which we can precisely control the relevant variables in their environment. The zebrafish is an ideal model because it offers many advantages: 1) several genetically controlled lines are available and can be easily generated; 2) its rapid and external development allows a longitudinal follow-up; and, 3) its transparency during the first 2 weeks of life allows unparalleled microscopic observations and offers an opportunity for optogenetic control of development. Using advanced optical microscopy, we will establish zebrafish dopaminergic development models to monitor synapse formation, axonal and dendritic growth, and circuit connectivity. In addition, we will examine the temporal correlations of Ca2+ oscillations across dopaminergic pathways with in vivo multiphoton calcium imaging. The identified morphological and functional developmental markers will be used to identify any changes in dopaminergic development in response to manipulation of the microbiota. The growth of characterized probiotic or opportunistic bacterial strains will be controllable in the fish intestine, either with optogenetics (using light-activatable CRISPR-CAS9 system), bacteriophages,

or prebiotics after inoculation of axenic fish lines. We expect to observe negative impacts on the development of dopaminergic neurons exposed to environmental stress, effects that would be attenuated by the presence of probiotic strains in the fish guts. Learning more on the impact of the microbiota and environmental stress on circuit development and function may provide useful data to be translatable to human health.

NUTRITIVE QUALITIES OF MARINE MICROALGAE IN NUNAVIK

Cameron-Bergeron, Kasey (1), J.-É. Tremblay (1,2), G. Massé (1,2) and J. Lavaud (1,2)

(1) Québec-Océan, Département de biologie, Université Laval, Québec, QC, Canada
(2) Unité Mixte Internationale Takuvik, Département de biologie, Université Laval, Québec, QC, Canada

In the Arctic ecosystem, primary production and its transfer to the food web, the benthic environment or the sediments is largely affected by global changes. Therefore, it is expected that changes in physicochemical parameters (temperature, pH, salinity, nutrients) will affect the growth of microalgae and the quality of the produced organic matter. The latter is extremely important, as marine microalgae are the only organisms capable of producing several essential compounds such as omega-3 fatty acids and carotenoids. These compounds are of first importance for the food web and for the health of the marine animals consumed by the Inuit population. This project is part of the BriGHT program and its goal is to evaluate the variability in the composition of the particulate organic matter and the connections between this variability and the environment along a physicochemical gradient in Nunavik.

COMPLEX NETWORK ANALYSIS OF BIRDS' CO-OCCURRENCE PATTERNS IN BOREAL FOREST

Désy, Béatrice (1), G. St-Onge (1, 2), P. Desrosiers (1,2,3) and L. J. Dubé (1,2)

(1) Université Laval, Québec, QC, Canada
(2) Centre interdisciplinaire en modélisation mathématique de l'Université Laval (CIMMUL), Québec, QC, Canada
(3) CERVO Brain Research Centre, Québec, QC, Canada

Northern ecosystems are complex and evolve under climatic, natural and anthropogenic influences. It is therefore a significant challenge to tackle the structure of ecosystems and identify accurate biodiversity indicators. In this regard, our aim is to make the most of the numerous tools of network science to shed light on prominent interrelations between species using available datasets. In this project, we analyze the co-occurrence patterns of bird species of Quebec's northern forest, using data generously provided by Daniel Fortin and colleagues [1]. Species co-occurrence patterns are described by a presence/absence binary matrix of species versus sites of observation. Network measurements can be made directly on this matrix, for instance correlation between species, characterization of types of observation sites and grouping between species. These measures arise solely from the structure of the underlying network. However, to detect key ecological interconnections requires pruning the co-occurrence data from spurious interactions that can simply be explained by chance. To do so we first generate a null model, namely an ensemble of random graphs with a set of fixed properties based on the observed dataset. It serves as a benchmark to distinguish the significant co-occurrences between bird species. These stronger links are then used to infer a network of significant connections distilling the structure of the initial data. This allows the characterization and identification of indicator species, a subset that is directly related to the biodiversity of a larger group of species. Our results demonstrate that a combination of direct network measurements with null model analysis is an efficient strategy. We have recovered results obtained by statistical analysis of the same dataset [1,2], whilst developing analytical network tools to enrich our understanding of various ecosystem properties. In summary, the complex network approach appears promising for the analysis of co-occurrences of species in northern regions. We are grateful to Daniel Fortin, Frédéric Maps and Louis-Paul Rivest for useful discussions and for sharing with us their experience with the treatment of available datasets. References: [1] Zhao Q. et al. Robust predictive performance of indicator species despite different co-occurrence patterns of birds in natural and managed boreal forests, Forest Ecology and Management, 397 (2017) 108-116. [2] E.E. Sergio. Les «null models» et la détection des modèles de regroupement dans les communautés écologiques, Master's thesis, Université Laval, Faculté des sciences et de génie (2017).

SELENIUM DISTRIBUTION AND SPECIATION WITHIN ARCTIC MARINE ECOSYSTEMS: A MULTI-MARKER APPROACH

Dufour, Francis (1,2,3), G. Massé (1), C. Guilmette (1), A. Achouba (3), N. Ouellet (3), M. Lemire (2) and P. Ayotte (2,3)

(1) Unité Mixte Internationale Takuvik, Département de biologie, Université Laval, Québec, QC, Canada
(2) Axe santé des populations et pratiques optimales en santé, Centre de recherche du CHU de Québec – Université Laval, Québec, QC, Canada
(3) Centre de toxicologie du Québec, INSPQ, Québec, QC, Canada

Traditional marine foods have always been an important component of the diet of Inuit in the Canadian Arctic. Food derived from marine organisms possesses several nutritional benefits, including high levels of energetic fatty acids (including long-chain omega-3 polyunsaturated fatty acids) and microelements such as selenium (Se). Due to its importance in reducing oxidative stress, Se is essential in human health and, Inuit populations exhibit among the highest intakes worldwide. In contrast to other populations, Se is mainly present in Inuit blood as selenoneine, a recently identified organic form of Se and recent studies suggest that selenoneine may participate in methylmercury (MeHg) detoxification mechanisms. Animals cannot synthesize selenoneine and very little is known about the origin and concentration of selenoneine in the Arctic environment. The main aim of this study was to determine total Se, selenoneine and essential fatty acid concentrations in a broad range of marine organisms selected upon their importance in terms of energy transfer in the Baffin Bay area. Two distinctive food webs (i.e. pelagic: phytoplankton and ice algae -> zooplankton -> Arctic cod and sculpin -> seal, pelago-benthic: phytoplankton and ice algae -> clams -> walrus) were studied and compared in terms of stable isotope (δ15N, δ13C), highly branched isoprenoids (HBI) and Se/selenoneine contents. Specimen sampling took place in Nunavut on the ice near the village of Qikiqtarjuaq and aboard the CCGS *Amundsen* as part of GreenEdge field programs, as well as in Nunavik in collaboration with Makivik Corporation and the BriGHT project. Our data revealed relatively high concentrations of Se throughout the samples, especially in marine mammal muscle and liver tissues. Above all else, walrus muscle exhibited high relative amounts of selenoneine with concentrations up to 45% of total Se. Our results also suggest that the different pools of primary producers may not contribute equally to Se inputs at higher trophic levels as higher concentrations of Se are observed in organisms that are relying on ice algae as a primary food source. Further statistical analysis will assess potential relationships between total Se and selenoneine concentrations and ecological characteristics, such as trophic position and feeding behaviors.

NEAR REAL-TIME CLIMATE AND PERMAFROST DATA INTEGRATION IN SUPPORT OF THE DEVELOPMENT OF THE COMMUNITY OF SALLUIT, NUNAVIK

Gauthier, Sarah (1, 2, 3, 4) and M. Allard (1, 2, 3, 4)

(1) Centre d'études nordiques, Québec, QC, Canada
(2) Sentinelle Nord, Québec, QC, Canada
(3) Habiter le Nord québécois, Québec, QC, Canada
(4) Université Laval, Québec, QC, Canada

The fast-growing population in the village of Salluit creates important housing and infrastructure needs that must be fulfilled in a secure way, on a terrain that has difficult topographical constraints and ice-rich permafrost. Under the warming climate, these challenges require that regularly updated information on permafrost temperatures, on rates of summer thawing of the active layer and on georisks be readily available to support land use planning, construction and security assessments in the face of potential landslides. Therefore, it is especially important to have continuous data to observe the evolution of permafrost and the impacts of climate change. This transdisciplinary project is part of the thematic project 1.5: Pitutsimaniq, networked sensor sentinels for real-time surveillance of infrastructures and ecosystems and is also in complementarity with the master's thesis in electrical engineering of Syryn Bouchara. Given the abundance and spatial distribution of monitoring instruments (i.e. thermistor cables, DTS-fiber optic cables, SILA automatic meteo station), integration of data and day-to-day observation of the thermal conditions will allow monitoring of the performance of buildings and help community management. As of now, these installations are working individually and the data must be downloaded from the instrumentation on site on an annual basis. The main goal of this project is to integrate the information of permafrost temperature and climatic monitoring in real time within the existing geospatial information and databases already produced by the Centre d'études nordiques (CEN) in Salluit. This will also provide information on climate factors, such as air temperature, precipitation and wind speeds. Furthermore, it will allow

us to anticipate and predict the risk of hazards such as landslides. In details, the project consists in integrating the collected information in an online database that will be updated in real time and easily accessible. The centralisation of the information using a geographic information system (GIS) represents a valuable asset for the strategic planning of Salluit. This process includes updating the CEN's mapping base to take into account the community's expansion since 2010. This analysis will be conducted using an integrated view of the village of Salluit and the various problems the community is facing as part of the development of its territory. The updated version of the cartography will be available on ArcGIS online for the institutions involved in the planning of the community's development. The expected outcome from this project is improved support for decision-making for community development. The data will be integrated into the master plan of the community produced by the Kativik Regional Government (KRG). The creation of a pre-warning signal of landslide risks in the active layer of permafrost in late summer is also planned. Moreover, this project allowed collaborative work with urban design students from the School of Architecture on developing scenarios for the strategic planning of Salluit.

AEROSOL VIRUSES RELEASED FROM THE MELTING CRYOSPHERE: SENTINEL MICROORGANISMS FOR A CHANGING ARCTIC

Girard, Catherine (1,2), M. Labbé (2), W.F. Vincent (1,2), C. Duchaine (1,3) and A. Culley (1,2)

(1) Sentinelle Nord, Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(3) Institut universitaire de cardiologie et de pneumologie de Québec, Université Laval, Québec, QC, Canada

Viruses have critical roles in the environment and maintain biodiversity and microbial community structures. They drive evolution of their hosts through genetic exchanges, affect microbial populations through lysis, and control the productivity of aquatic ecosystems by redirecting carbon into the microbial loop. Viruses are also of direct importance to human populations, as they can include pathogens that may cause disease. The Arctic cryosphere is a reservoir for viruses - indeed, permafrost and glaciers, with their freeze-thaw cycles, can release viral particles that were previously trapped in ice for thousands of years. These viruses can be transferred to the atmosphere by aerosolization and recolonize modern Northern landscapes. Climate change is accelerating melting of the cryosphere and the production of aerosols from aquatic surfaces, potentially increasing the number of viruses in the air and their ability to disperse in the Arctic. These viruses may then recolonize northern aquatic ecosystems and affect their productivity, or may include potential human or animal pathogens that could impact community and ecosystem health in the North. The "aerosol virome", the atmospheric viral community, has long been studied in the context of health care, as it is of critical importance for the transmission of infectious diseases. However, few studies have investigated environmental aerosol viromes, and none have focused on viruses freed from the thawing cryosphere into the environment. Here, we present preliminary results from the first field season for our project, aiming to characterize the aerosol virome of the surroundings of Thores Glacier (Nunavut) in the High Arctic. This unique site allows us to study how the glacier and surrounding permafrost may be releasing viruses into the atmosphere, and how these viral particles are dispersed to Thores Lake, adjacent to the glacier. Using next generation metatranscriptomic and bioinformatics tools, we aim to describe the viral diversity found in the glacier, the air, the surrounding permafrost and in the lake. We will also determine which viruses are emerging from the melting cryosphere, and how they move between the atmosphere and the lake. Finally, we will attempt to identify viral taxa that may be used as sentinels for change in the North. A better understanding of the aerosol virome of the warming North is critical, as this recycling of viral genomes may allow for a new colonisation of the Arctic environment. This may have consequences on human health in the North, and on productivity and nutrient transfer in aquatic ecosystems.

HISTORICAL AND FUTURE CLIMATE ANALYSES FOR THE WINTER ROAD NETWORKS IN NORTHERN ONTARIO AND MANITOBA

Hori, Yukari (1), V. Cheng (1) and W. Gough (1)

(1) University of Toronto, Toronto, ON, Canada

A network of winter roads in northern Canada connects a number of remote First Nation communities to all-season roads and rails. The extent of the winter road networks depends on the geographic features, socio-economic activities, and the numbers of remote communities so that it differs among the provinces. The most extensive winter road networks below the 60th

parallel south are located in Ontario and Manitoba, serving 32 and 18 communities respectively. For many of these communities, winter roads provide not only the transport of heavy equipment, fuel, and cargo at a low cost, but also expand social and cultural opportunities in the communities. However, in recent years, a warmer climate has resulted in a shorter winter road season and an increase in unreliable road conditions; thus, limiting access among remote communities. The purpose of this study is to identify a temporal trend for the seasonal length of winter roads, as well as to link to meteorological conditions at selected locations throughout northern Ontario and Manitoba. First, the non-parametric Mann-Kendall correlation test and the Theil-Sen method were used to identify any statistically significant trends on the climate indicators over time. The freezing degree-day (FDD) accumulations are of particular interest. Second, future climate scenarios were developed for the study areas using the multi-model ensembles of General Circulation Models (GCMs). This study is part of a larger initiative in developing effective adaptation strategies in response to climate change impacts on community infrastructure and emergency management for First Nation communities in northern Canada.

NUMERICAL MODELLING OF PERMAFROST THAW DYNAMICS AND TRANSPORT OF FINE SEDIMENTS IN POROUS MEDIA

Khadhraoui, Madiha (1), J. Molson (1) and N. Bhiry (2)

(1) Département de géologie et de génie géologique, Université Laval, Québec, QC, Canada
(2) Département de géographie, Université Laval, Québec, QC, Canada

In the context of climate change, thawing of permafrost can have a significant impact on heat distribution and water quality, as well as on fine sediment transport in porous media. Understanding the effects of changes in permafrost thermal dynamics is therefore essential to solve associated environmental problems, particularly in northern areas where natural risks are amplified. Current research on fine sediment loads during permafrost degradation is very limited. This study will help close this gap by focusing on the interactions between groundwater flow, heat transfer and sediment transport processes which can affect water quality, soil stability and discharge of groundwater to surface water. To investigate these processes, we will use the numerical model Heatflow/Smoker (Molson & Frind, 2018) to simulate fluid, heat and mass balance and associated stress changes within natural permafrost-impacted environments. The coupled groundwater flow and heat transfer model will be modified to include transport of dissolved solutes and suspended particles. The model will then be calibrated using existing field data including several years of soil and groundwater temperatures and heat fluxes, as well as, new turbidity data which will be acquired during summer field work. Soil samples will be collected from the discontinuous permafrost area located near Umiujaq, Nunavik, Quebec. Sample analysis will be carried out in the laboratory to evaluate turbidity and the different factors and processes controlling mass transport associated with permafrost thaw. Research on this subject is important as a direct input to our understanding of the scientific issues related to climate-change induced thawing of permafrost. We expect to contribute to better understand the impacts and feedbacks between groundwater flow, heat transfer and transport processes associated with thawing permafrost.

DESIGN AND IMPLEMENTATION OF A WIRELESS OPTICAL MICRO-SPECTROMETER FOR ENVIRONMENTAL MONITORING

Khojasteh Lazarjan, Vahid (1), P. Marquet (1) and B. Gosselin (1)

(1) Université Laval, Québec, QC, Canada

The goal of this project is to develop a wireless microsystem to perform diffuse multi-wavelength spectroscopy in diverse environments, like northern climates, as well as in biological tissues in a minimally invasive fashion. The envisioned device will allow for performing diffuse spectroscopy within a small format for enabling local quantitative measurement in diverse environmental structures or tissues for characterizing the complex interactions and metabolisms involved with minimal invasiveness and in a distributed fashion. Diffuse reflectance optical spectroscopy utilizes small semiconductor light sources in the visible and the near-infrared (NIR) to probe a medium. In this project, the excitation light and the reflected light will be emitted and collected through a single optical fiber for probing deep structures. Then, the collected light will be processed by a low-power microsystem including analog and digital microelectronics circuits. The different wavelengths of the reflected light will be separated using an optical filter microfabricated on top of a complementary metal-oxide-semiconductor (CMOS) microelectronic chips.

A light-emitting diode (LED) will be used as embedded excitation light source, while specialized CMOS circuits, such as a low-noise analog front-end, and a Delta-Sigma digitizer, are used to convert, amplify, and digitize the filtered spectroscopy signals inside the chip, and transmit the digital data to a base station. Combining several technologies, such as fiber optic and microelectronics, will lead to unprecedented levels of miniaturization for an optical spectrometer. The first step consists of designing, fabricating and testing a discrete-component prototype including a commercial micro-spectrometer from Hamamatsu, integrated along with a microcontroller and a wireless transceiver, within a compact platform. This prototype will allow us to validate our models and our approach. Then, a specialized chip solution will be designed and fabricated within CMOS technology to decrease power and size and to increase the quality of measurements. New circuit techniques such as switched bias transistors and current mode circuit design will be leveraged in CMOS technology to decrease the input referred noise without increasing the size and power consumption for enabling the utilization of a small battery as an energy source. Moreover, this project also introduces a new design for direct optical light filtering in a chip using periodic nano-plasmonic filters implemented in CMOS technology. This technology will shrink the size of the spectrometer dramatically as it will avoid the need for discrete optical components. In summary, this project will leverage CMOS microelectronics, optoelectronics, silicon photonics and MEMS technology to build a diffuse spectrometer on a chip, which will not only decrease the cost of the proposed approach, concerning manufacturing and transportation, but will also enable an autonomous and smart solution that will be adaptive in northern climates. A significant benefit of the proposed approach also resides in its label-free, non-destructive and minimally-invasive operation to live tissues and other materials like ice in a distributed fashion.

ACTIVE VIRUSES IN ANCIENT SEAWATER: VIRAL STRATIFICATION IN A HIGH ARCTIC LAKE

Labbé, Myriam (1), W. F. Vincent (1) and A. I. Culley (1)

(1) Centre d'études nordiques, Université Laval, Québec, QC, Canada

Viruses play major roles in Arctic aquatic ecosystems, where microbial life often dominates. They are involved in the regulation of host biomass, drive microbial community evolution and affect the circulation of energy through trophic webs that ultimately impact biogeochemical processes. The northern frontier of Ellesmere Island (Canada) harbours stratified lakes that are unique to polar environments and particularly vulnerable to the effects of climate change as temperatures in the Arctic rise at an unprecedented rate. This study focused on meromictic lake Lake A, composed of a freshwater surface layer fed by the spring run-off of the surrounding catchment, overlying ancient seawater that was trapped by isostatic rebound several thousand years ago. This saltwater layer is particularly resistant to mixing and its physicochemical conditions are extremely stable. Our research shows the presence of highly stratified viral communities, consistent with the observed stratification of other microbial components. As these viral communities are yet undescribed, we used a metagenomic approach based on next-generation sequencing to generate a more comprehensive assessment of viral diversity and viral genetic potential. An environment as complex as Lake A harbours potentially unique genes that may yield insights into viral dynamics and their role in key microbial metabolic processes such as photosynthesis and nutrient assimilation. We anticipate that the differences in dominant metabolic processes in each vertical stratum of the lake, such as aerobic phototrophy in the surface and anaerobic sulphur metabolism at depth, will be reflected in the co-occurring viral communities and viral gene pools.

THE INVOLVEMENT OF GUT MICROBIOTA AND THE ENDOCANNABINOIDOME IN THE ESTABLISHMENT OF AN INSULIN RESISTANT STATE IN MICE

Lacroix, Sébastien (1,2,5), F. Pechereau (1,5), N. Leblanc (1,2,4), A. Houde (1,5), C. Martin (2,5), N. Flamand (2,3,5), C. Silvestri (2,3,5), V. DiMarzo (1,2,3,4,5) and A. Veilleux (1,2,5)

(1) Institut sur la nutrition et les aliments fonctionnels, École de nutrition, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, Québec, QC, Canada
(2) Centre de recherche de l'Institut universitaire de cardiologie et de pneumologie de Québec, Québec, QC, Canada
(3) Faculté de médecine, Université Laval, Québec, QC, Canada
(4) Institute of Biomolecular Chemistry of the National Research Council (ICB-CNR), Pozzuoli, Italy
(5) Chaire d'excellence en recherche du Canada sur

l'axe microbiome-endocannabinoïdome dans la santé métabolique, Université Laval, Québec, QC, Canada

Obesity, insulin resistance and their cardiometabolic comorbidities along with mental health disturbances are disproportionally observed in Northern Canadian populations. This could be reflective of an incompatibility or dysbiosis between bacterial species lining the gut and the recently modified nutritional habits of these populations. The endocannabinoid system is a regulator of the biological and metabolic processes altered in obesity and impacts on mental health as well. Recent studies have identified cross-talk between these systems in adapting host homeostasis in response to change in host environmental factors. We postulate that dietary modifications result in metabolic alterations via gut dysbiosis and consequent local and systemic modulation of the endocannabinoid system's tone, including related lipid mediators, their receptors and several converting enzymes, known as the endocannabinoidome. The main objective of this project is to establish the chronology of disturbances of the microbiome-endocannabinoidome axis in response to an obesogenic high-fat, high-sucrose (HFHS) diet. Six-week old C57BL/6J male mice fed a low-fat, low-sucrose diet (10% fat, 20% protein and 70% carbohydrate [7% sucrose]) were sacrificed at baseline or at 3, 10, 21 and 56 days following the initiation of a HFHS diet (45% fat, 15% protein and 35% carbohydrate [17% sucrose]). Oral glucose tolerance (OGTT) and lipid tolerance (OLTT) tests were performed at each time point. Upon sacrifice, plasma and metabolically-active tissues were harvested (e.g. intestinal segments and luminal content, liver and adipose tissue). Ileal and ceacal microbiota composition was assessed by 16S rRNA sequencing (IBIS, Université Laval). Endocannabinoidome mediators and endocannabinoidome gene expression were measured using LC-MS/MS and a qPCR array (TaqMan), respectively. As expected, significant weight gain and glucose intolerance (increased post-OGTT iAUCglucose) were observed during the HFHS diet. Ileal and caecal microbiota compositions showed distinct profiles and were differentially influenced by the HFHS diet. Expression of several endocannabinoidome genes (e.g. Abhds, Cbr1-2, Faah) in the ileum, the liver and visceral adipose tissue was modified with subsequent variations in levels of some ileal endocannabinoids (e.g. 2-AG and AEA). These data highlight several concomitant gut microbiota and endocannabinoidome modulations in response to a HFHS diet, which suggest that these systems are involved in the establishment of HFHS-induced metabolic disturbances. The observations made to date suggest increased gut permeability, immune response and inflammation as early alterations.

PREDICTING BREAKDOWNS OF DYNAMICAL COMPLEX NETWORKS

Laurence, Edward (1,2), N. Doyon (2,3,4), L.J. Dubé (1,2) and P. Desrosiers (1,2,3)

(1) Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada
(2) Centre interdisciplinaire de modélisation mathématique de l'Université Laval, Québec, QC, Canada
(3) CERVO Brain Research Centre, Québec, QC, Canada
(4) Département de mathématiques et de statistique, Université Laval, Québec, QC, Canada

Large dynamical complex systems, such as animal communities, gut microbiota or the brain, can be modelled using networks in which components interact with their neighbors. The underlying structure of the networks are mostly responsible for the resilience to random natural fluctuations. For instance, food webs, which describe the predator-prey interactions, feature redundancy that maintains resilience to natural population fluctuations. But when the structure is damaged, the system stability is altered and a complete dynamical breakdown could occur. Close to the so-called tipping-points, networks are still remarkably resilient to fluctuations of the dynamical populations but extremely fragile to structure perturbations, which makes the imminent catastrophe almost undetectable to noninvasive approach. Moreover, large complex systems are often composed of billions of components, making them practically impossible to study using a direct approach. Fortunately, large complex systems exhibit global behaviors. For instance, in the brain, large populations of neurons synchronize during specific tasks. Thus, complex networks are surprisingly well described by low dimensional formalisms. Constructing a low dimensional effective system is, however, a challenging task; it must represent the global features of the large complex system and provide relevant and correct predictions. In this project, we have developed a dimension reduction formalism that satisfies all the above criteria. Large networks are first decomposed into dynamically independent, but non-exclusive, regions and are then reduced to smaller dynamical networks of few individuals. The resulting networks are constructed so that they model all the independent global behaviors of the original networks, with the advantage that they are interpretable and computationally tractable. To predict

breakdowns, structural network perturbations in a large system are transcribed into equivalent perturbations on the smaller structure, so we can measure the direct impact of perturbations on the global behavior. Moreover, we can predict accurately the impact of individual component removal. We analytically characterize the global bifurcation diagrams and quantify the resilience of the system to structural perturbations. The formalism has been shown to correctly predict catastrophes in all kinds of networks, including random, modular, and heterogeneous networks. It has also been successfully applied to theoretical dynamical models of very different nature, such as models describing the evolution of animal populations, the propagation of infectious diseases, and the activation of neural networks. Moreover, our work provides insights on the fundamental structural causes of complex network resilience and paves the way to design effective strategies of intervention for complex systems, particularly for those of the North that are highly stressed by environmental changes.

SEASONAL DYNAMICS IN THERMAL STRUCTURE AND DISSOLVED OXYGEN OF SMALL ARCTIC THAW PONDS, AND CONSEQUENCES ON GREENHOUSE GAS EMISSIONS

Laurion, Isabelle (1), V. Preskienis (1), M. Bartosiewicz (2), A. Cortes (3) and S. MacIntyre (3)

(1) Centre Eau Terre Environnement, INRS and Centre d'études nordiques, Québec, QC, Canada
(2) Department of Environmental Sciences, University of Basel, Basel, Switzerland
(3) Earth Research Institute, University of California, Santa Barbara, CA, USA

Small ponds associated with permafrost thawing are abundant yet overlooked ecosystems with a high potential to significantly contribute to global carbon cycling. Trough ponds forming on top of ice wedges in the continuous permafrost region of the eastern Canadian Arctic have summer greenhouse gas concentrations (GHG) up to 620 µM CO2 and 32 µM CH4 (median 27 and 1.4 µM). A few m2 in area and shallow, trough ponds remain stratified in summer, which generates hypoxia and influences methanotrophs. Oxygen was on average only 7% (median 0.5%) of saturation during the open-water season (July-Sept) at the bottom of a trough pond featuring active erosion, although in two ponds colonized by brown mosses, averages were 34% and 42%. By comparison, a nearby larger and well-mixed polygonal pond with thick cyanobacterial mats had saturation levels often >50%. Stratification also means colder bottom waters and sediments (0-4 °C). Methanogens are thriving even at such low temperatures as reflected in relatively high ebullition rates, with CH4 always above saturation in surface waters and strongly increasing towards the bottom. Large uncertainties exist on diffusive flux because the gas exchange coefficient k is often computed from wind-based models, but the fetch is small and boundary layer development uncertain for these systems such that cooling may drive near-surface turbulence. Brief periods of mixing and low k imply small diffusive losses and GHG storage, generating seasonal emission patterns not easily captured in remote areas. We aim to provide better estimates of turbulence and its drivers in shallow thaw ponds.

BREEDING DECISIONS IN ARCTIC BIRDS DEPEND ON MULTIPLE STRESSORS ENCOUNTERED ALONG THEIR MIGRATORY ROUTE

Legagneux, Pierre (1), G. Gauthier (1), H.G. Gilchrist (2), F. Jean-Gagnon (3), H. Hennin (4), O. P. Love (4) and J. Bêty (3)

(1) Centre d'études nordiques, Université Laval, Québec QC, Canada
(2) Environment and Climate Change Canada, Ottawa ON, Canada
(3) Université du Québec à Rimouski, Rimouski, QC, Canada
(4) University of Windsor, Windsor, ON, Canada

The Arctic is characterized by a very strong seasonality with a burst of productivity during a short summer season. Migratory birds are wonderfully adapted to exploit these conditions and come to the Arctic in large numbers to reproduce every year. Migration forces these individuals to use several sites along the way, thereby connecting multiple ecosystems across their annual cycle. It also exposes birds to multiple and diverse stressors (e.g. climate warming, anthropogenic activity) that vary in intensity along their migratory route. Therefore, conditions encountered in these different ecosystems may have carry-over effects on their subsequent reproduction and population dynamics. Determining how environmental conditions at these sites interact with individual intrinsic properties is critical to determine underlying mechanisms driving individual variation in reproductive decisions in migratory species. We investigated the influence of

multiple stressors including sea ice conditions (a proxy of prey accessibility) and human disturbance on individual physiology (mainly stress hormones) and body condition in two Arctic-breeding, migratory species: common eiders (*Somateria mollissima*) and Greater snow geese (*Chen caerulescens*). We then examined the potential carry-over effects of these stressors on fitness-related traits including breeding propensity (the decision to reproduce or not within a single breeding season), timing of laying and reproductive success. Our combined correlational and experimental results from both study systems revealed strong carry-over effects from an encountered stressor with repercussions on fitness from 20 days to 9 months later. Carry-over effects can thus have strong impacts on individual reproductive success, and ultimately population trends in long-distance migrants. Furthermore, such effects can be partly compensated for by good environmental conditions on the breeding ground. Our predictive capacity of how Arctic-breeding birds respond to changes in environmental conditions will require incorporating cross-seasonal, cumulative effects.

UNDERSTANDING AND PREDICTING PERMAFROST DEGRADATION TO LIMIT IMPACTS ON TRANSPORTATION INFRASTRUCTURE

Lemieux, Chantal (1,2), G. Doré (1,2) J. Malenfant-Lepage (1,2,3), E. Stephani (4,5) and M. Parent (1,2)

(1) Department of Civil and Water Engineering, Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(3) Department of Civil and Environmental Engineering, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
(4) Alaska Science Center, U.S. Geological Survey, Anchorage, Alaska, USA
(5) Institute of Northern Engineering, University of Alaska Fairbanks, Fairbanks, Alaska, USA

Construction of roads, highways and airstrips in permafrost areas inevitably affects the thermal regime of frozen soils, which may cause thermal degradation of the underlying permafrost, thereby threatening the structural and functional capacities of those infrastructures. Maintaining stable and safe transportation infrastructure in northern regions is a priority, but also a major challenge. This presentation focus on two objectives of our researches on permafrost engineering: 1) To develop new strategies and methodology for the design of drainage systems to minimize permafrost degradation resulting from water accumulation and flow. One of the main causes of degradation of embankments constructed on permafrost is heat transferred to landfills and infrastructure by surface runoff and groundwater. This degradation reduces the structural and functional capacity of the infrastructure and, in some cases, may cause failure of the embankment. This project develops a relationship for flow-convective heat transfer and flow-erosion, in order to assess the allowable volume of water or flow in a ditch to prevent excessive heat transfer to permafrost and soil erosion. This research is part of the sub-project 1.3 of Sentinel North and provides important information to the simulation models developed to predict the impacts of thawing permafrost. 2) To develop a fiber-optic probe measuring temperature, pressure and movement of the ground in order to better understand and predict the mechanisms of two instabilities phenomena associated with permafrost degradation: retrogressive thaw slumps (RTS) and embankment spreading. Management of infrastructure potentially exposed to RTS can be a significant challenge. The possibility to relocate infrastructure at risk may be limited or cost prohibited. While many studies have focused on the development of RTS, the processes of their self-stabilization remain largely unstudied. Meanwhile, longitudinal cracks on embankment and soil movement at the toe of the infrastructure indicates an important degradation of permafrost. The relative importance of three mechanisms causing instability and deformation of the embankment (consolidation, creep shear and frost heave) needs to be quantified. Understanding the mechanisms that manage RTS and embankment spreading will allow for the predicting of their occurrence and for developing efficient mitigation strategies in order to limit their impact on transportation infrastructure. This research is part of the sub-project 1.5 of Sentinel North. The probe is developed in collaboration with researchers from the Electrical Engineering Department and the Centre d'optique photonique et laser of Université Laval.

NUMERICAL MODELLING OF CONVECTIVE AND CONDUCTIVE HEAT TRANSFER IN A TALIK BENEATH THE KUUGULUK RIVER IN SALLUIT, NUNAVIK (QUEBEC) USED AS A SOURCE OF DRINKING WATER

Liu, Weibo (1,2), R. Fortier (1), J. Molson (1), J. M. Lemieux (1) and C. Grenier (3)

(1) Département de géologie et de génie géologique and Centre d'études nordiques, Université Laval, Québec, QC, Canada
(2) State Key Laboratory of Frozen Soil Engineering, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou, China
(3) Laboratoire des Sciences du Climat et de l'Environnement, UMR8212, Université Paris-Saclay, CEA/CNRS/UVSQ, Gif sur Yvette, France

Water availability and management related to the supply of drinking water to communities are problematic in the Canadian North where surface water is the most common source of drinking water. Although rivers and lakes are abundant in the North, their water quality is variable. They are also vulnerable to contamination and climate change, and unreliable as they often freeze or dry up in winter. Groundwater can often provide a more secure and sustainable water source but, being stored as ground ice, its availability is limited in the North due to the presence of permafrost. Among the fourteen Inuit communities in Nunavik (Quebec), twelve rely on rivers and lakes while only two depend on groundwater as sources of drinking water. For instance, until 2012, the source of drinking water of the Inuit community of Salluit was a screened pipe buried in the riverbed of the Kuuguluk River. However, drying of this source was often occurring in winter creating problematic health and safety issues. To fix this problem, even if Salluit is located in the continuous permafrost zone, groundwater was found in a shallow well drilled in fractured bedrock close to the Kuuguluk River. Following a geophysical investigation carried out in 2011, this groundwater well was installed in a suprapermafrost aquifer in a closed talik beneath the Kuuguluk River due to the heat storage effect of running surface water and groundwater flow. Moreover, during each winter, even if the river dries up, ice forms in the floodplain of the Kuuguluk River. For investigating the formation mechanism of this icing, the thermo-hydraulic conditions of the riverbed have been also monitored since 2014 using a mooring composed of water pressure and temperature dataloggers. During the winter, the water pressure measured under the icing is equivalent to a water column height in excess of 2.5 m. Based on the theory of mechanics of plates, this pressure is enough to crack the icing and allow the water pressure release and water seepage through the cracks for forming ice sheets. The physical processes taking place in this complex cryohydrogeological system are not yet fully understood. The objectives of this research project are to: 1) undertake 3D numerical modelling of coupled heat transfer and groundwater flow taking place in the talik beneath the Kuuguluk River, 2) understand the dynamics of this complex cryohydrogeological system, and 3) assess the impacts of climate change on the source of drinking water used by the Inuit community of Salluit. In the zone of continuous permafrost, groundwater is scarce and only occurs in taliks found beneath large water bodies. Understanding the dynamics and future evolution of taliks in the double context of climate warming and fast-growing Inuit communities with important drinking water needs is important because they are the only sources of groundwater available in the continuous permafrost zone and could provide more reliable and better-quality water than surface water to the users.

TROPHIC NETWORK MODELLING REVEALS CONTRASTED PELAGIC ECOSYSTEMS ON BOTH SIDES OF BAFFIN BAY

B. Saint-Béat (1), V. Galindo (2,3), F. Joux (4), C. Lalande (1), M. LeBlanc (1), P. Raimbault (5), J.-E. Tremblay (1), L. Fortier (1), M. Babin (1) and Maps, Frederic (1)

(1) Unité Mixte Internationale Takuvik, Université Laval, Québec, QC, Canada - CNRS, France/Québec-Océan, Département de biologie, Université Laval, Québec, QC, Canada
(2) Centre for Earth Observation Science, Faculty of Environment, Earth and Resources, University of Manitoba, Winnipeg, MB, Canada
(3) Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, Rimouski, QC, Canada
(4) Observatoire océanologique, Université Pierre et Marie Curie, UMR-7621 CNRS, Institut national des sciences de l'Univers, Banyuls-sur-Mer, France
(5) Laboratoire d'Océanographie et de Biogéochimie CNRS UMR 6535, Campus de Luminy, Marseille, France

Baffin Bay is located at the Arctic Ocean's doorstep and acts as a large transition zone with the Atlantic Ocean in the South. It is a heterogeneous environment where a mix of Atlantic and east Greenland seawaters forms an eastern current that flows northward, in the

opposite direction of a cold Arctic current along the west coast of Baffin Bay. This circulation affects the physical environment on both sides of the bay. It has, in particular, a direct impact on the dynamics of the sea ice: the warmer waters cause an earlier melting of sea ice in eastern Baffin Bay, while the cold Arctic waters in the west lengthen the period of ice cover. This study aims to determine whether such contrasted environments lead to contrasted pelagic ecosystem structures and functioning. Both properties emerge from the distribution of carbon flows through the food web. Ecological indices (ENA) calculated from food web flow values, reveal ecosystem properties that are not accessible with direct in situ observations. From new data gathered at different levels of organization during the GreenEdge ice camp and sea campaign, we built a planktonic food web model of each side of Baffin Bay. These models integrate several living compartments from bacteria to Arctic cod larvae through primary producers and several groups of zooplankton. We also considered two non-living compartments, particulate and dissolved organic carbon. Missing flow values were estimated by linear inverse modeling (LIM), a method that allows for obtaining an ensemble of possible food webs. From each one of them, ENA indices were calculated that revealed significant differences in these ecosystems' functioning. The eastern Baffin Bay food web presented a lower activity but a more specialized food web allowing for carbon to be constrained through specific and efficient pathways, while limiting export. On the contrary, the western food web showed redundant pathways and larger exports; carbon is thus less retained within the food web and less efficiently transferred. The higher bacterial production observed in the east was associated with a stimulation of the microbial loop and a dissociation of the microbial loop from the classical grazing chain linking phytoplankton to higher trophic levels through the mesozooplankton. Moreover, indirect effects resulting from the bottom-up and top-down effects differently impacted direct pairwise relations between species. These differences in pairwise relations are very important in the dynamic and evolution of each food web and thus might lead to contrasted response to the ongoing climate changes.

WINTER MEASUREMENTS OF DISSOLVED METHANE AND CARBON DIOXIDE IN SUBARCTIC THAW LAKES

Matveev, Alex (1,2), I. Laurion (1,3) and W.F. Vincent (1,2)

(1) Centre d'études nordiques, Québec, QC, Canada
(2) Université Laval, Québec, QC, Canada
(3) Centre Eau Terre Environnement, INRS, Québec, QC, Canada

Permafrost thaw (thermokarst) lakes are known to emit large quantities of CO2 and CH4, but the variability in these emissions introduces much uncertainty about the total atmospheric burden of greenhouse gases from these northern sources. Here we describe some of the characteristics of thaw lakes that contribute to this variability, with special attention to the winter period of prolonged ice-cover and its implications for gas accumulation and release. We undertook CO2 and CH4 profiling of 18 geomorphologically and limnologically distinct thermokarst lakes in 6 separate sites across a 200 km gradient of permafrost degradation in subarctic Québec. We also used automated submersed water temperature, conductivity and oxygen loggers to evaluate how the annual cycle of stratification and mixing may affect the release of greenhouse gases to the atmosphere. The thaw lakes in the subarctic study region included those derived either from the thawing of palsas (frozen peat mounds) or lithalsas (mineral permafrost mounds), which differ in their soil organic carbon content. All lakes were thermally stratified for most of the year, with strong physico-chemical gradients down the water column. Most of the lakes had anoxic bottom waters year-round, while the thaw lakes in carbon-rich peatlands were completely anoxic during winter. The northernmost lakes on mineral-dominated soils varied in their surface-water CO2 content, from below to above saturation, but the southern lakes in the studied 200 km gradient had much higher surface concentrations that were well above air-equilibrium. Surface-water CH4 concentrations were at least an order of magnitude above air-equilibrium values at all sites, and the diffusive emission fluxes of both gases increased from north to south. The surface waters of carbon-rich peatland lakes at both northern and southern sites were supersaturated in CH4 and CO2, and to a greater extent in the southern lakes, where CH4 concentrations were up to 5 orders of magnitude above air equilibrium. The bottom waters of all lakes were supersaturated in CH4 and CO2, with concentrations 1-3 orders of magnitude higher than at the surface. Our observations of a set of palsa lakes at

the end of winter revealed that the sub-ice concentrations of the two gases were up to 5 orders of magnitude above air-equilibrium. The surface lake ice also contained trapped bubbles of CH4 and CO2, but this amounted to <5% of water column stocks. The continuous logging records indicated potentially large variability in the timing and extent of release of this winter CH4 from the water column to the atmosphere. Greater ventilation of winter stocks may occur during spring mixing in larger, shallow lakes, while in the bottom waters of deeper lakes there can be prolonged retention of these stocks until the period of more intense, convective mixing in fall. This mixing regime may result in emission rates at ice break-up that would be 1-2 orders of magnitude higher than during mid-summer. These results underscore the need for continuous observations of greenhouse gas emissions from thaw lakes, particularly during the winter shoulder periods, to accurately estimate the magnitude of annual carbon fluxes.

A WIRELESS FIBER PHOTOMETRY SYSTEM BASED ON A HIGH-PRECISION CMOS BIOSENSOR WITH EMBEDDED CONTINUOUS-TIME ΣΔ MODULATION

Noormohammadi Khiarak, Mehdi (1), S. Martel (2), Y. De Koninck (3) and B. Gosselin (1)

(1) Smart Biomedical Microsystems Lab, Department of ECE, Université Laval, Québec, QC, Canada
(2) Nano Robotics Laboratory, Polytechnique Montréal, Montréal, QC, Canada
(3) CERVO Brain Research Centre, Université Laval, Québec, QC, Canada

Optical neural interfaces enable targetable control and monitoring of specific intact neural circuits. We present a new head mountable wireless fiber biophotometry microsystem conceived to detect fluorescent signal fluctuations correlated with neuronal activity. Fluorescence biophotometry measurements require wide dynamic range (DR) and high sensitivity laboratory apparatus. Indeed, it is often very challenging to accurately resolve the small fluorescence variations in presence of noise and high background tissue autofluorescence. There is a great need for smaller detectors combining high linearity, high sensitivity, and high-energy efficiency. The proposed system incorporates all aspects of a conventional tethered fiber-based biophotometry system encompassed into a wireless microsystem. The interface includes an excitation light source, a custom designed CMOS biosensor, a multimode fiber, a microcontroller (MCU), and a wireless data transmission which are integrated within a 3D-printed, small foot print, plastic housing. Precisely, the system incorporates a new biophotometry sensor merging two individual building blocks, namely a low noise sensing front-end and a 2nd order continuous-time ΣΔ modulator (CTSDM), into a single module for enabling high sensitivity and high energy-efficiency photo-sensing. In particular, a differential CMOS photodetector associated with a differential capacitive transimpedance amplifier (DCTIA)-based sensing front-end is merged with an incremental 2nd order 1-bit CTSDM to achieve a large dynamic range, low hardware complexity, and high energy-efficiency. The sensor leverages a hardware sharing strategy to simplify the implementation and reduce power consumption. The proposed CMOS biosensor is implemented in a 0.18-µm CMOS technology, consuming 41 µW from a 1.8-V supply voltage, while achieving a peak dynamic range of 86 dB over a 50-Hz input bandwidth at a 20-kS/s sampling rate. This new interface opens new avenues for conducting in-vivo freely moving experiments.

POLYCHROMATIC MICROSCOPY USING THE SPECTRAL BANDWIDTH OF ULTRASHORT LASER PULSES

Pichette, Charles (1,2), P. Marquet (2) and S. Thibault (1)

(1) Centre d'optique, photonique et laser (COPL) and Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada
(2) CERVO Brain Research Centre, Québec, QC, Canada

A good understanding of the northern ecosystem starts with a good knowledge of its microorganisms. These organisms, such as protists, prokaryotes, and viruses, which are the most abundant specimens, play a significant role in regulating the nutrients and the energy of this environment. A better comprehension of their dynamic, their interaction, and their biodiversity is vital for good insight into the northern ecosystem. To achieve this higher understanding, it is of the utmost importance to improve and develop new microscopy techniques capable of investigating the structure and dynamic of these specimens. It is however difficult to do so since the structures of these organisms are often on the scale of tens of nanometers. It is then necessary to surpass the diffraction limit and use techniques that are said to be nanoscopic. It is necessary to develop these techniques to have better insight into the northern ecosystem. To achieve this, the present project proposes to use the spectral modulations in ultrashort laser pulses as signatures

to reconstruct the structures of microorganisms in the context of marker-free microscopy. This should allow for a better investigation of these northern ecosystem organisms. More specifically, since ultrashort laser pulses have a wide spectral bandwidth, we propose to use this feature as a marker to image these structures in 3D. We utilize the analogy that these transparent organisms have a superposition of thin films to investigate the spectral modulations induced by the reflections and the interference between these reflections to retrieve the structures in 3D. To achieve a better understanding of the interaction of these pulses with a microscopic organism, FDTD simulation was performed to simulate the propagation of the pulses through this type of sample. Spectral modulations that correspond to different structures were indeed found and the analysis of these modulations is currently under investigation. This presentation will review these simulations, and how it is indeed possible to use these spectral modulations to retrieve information about the structures of microorganisms. Possible avenues under investigation for the retrieval of this signal will also be presented.

WHY SETTLE FOR THE TIP OF THE ICEBERG? THE UNMINED DEPTH OF MICROBIOMES

Raymond, Frédéric (1,2,3)

(1) École de nutrition, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, Québec, QC, Canada
(2) Institut sur la nutrition et les aliments fonctionnels, Université Laval, Québec, QC, Canada
(3) Associé à la Chaire d'excellence en recherche du Canada sur l'axe microbiome-endocannabinoïdome dans la santé métabolique, Université Laval, Québec, QC, Canada

Taxonomical profiling of microbiomes provides crucial information on microbial communities and how they change when submitted to changes in their environment. It allows for determining the evolution of communities and for correlating groups of microorganisms to phenotypes. Deeper understanding can be attained using functional profiling. After annotating the gene content of microbiomes with known functions like metabolic pathways or enzymatic functions, it is possible to associate specific proteins to changes in ecosystems. Some of the genes encoding these functions are strongly correlated with microbial species, others are common between microbes of different lineages or selected by the environment. Individuals of the same species share a large portion of their genome, specifically genes encoding metabolic pathways, but each strain also contains additional genes that may provide advantages such as resistance to contaminants or production of secondary metabolites. These genes affect virulence. For example, the virulence of *Clostridioides difficile* is influenced by the presence of the clostridial toxin operon. But then, defining this difference is easy, as *C. difficile* has been studied for a long time, the genes have been characterized and thousands of genomes from strains of the species have been sequenced. What happens then when we consider species (or genera or families) that have only a few isolates studied or sequenced? What when several unknown genomes are fragmented and mixed-up within a metagenome? To truly grasp the depth of microbiomes, we must find strategies to take into account these species and genes of unknown functions, which are often forgotten in metagenomic analysis. An approach to do that is to directly compare the gene content of microbiomes. To do so, microbial communities need to be sequenced with sufficient thoroughness to allow the assembly of the metagenomes. Then, genes are annotated on the assemblies and are compared to form groups of orthologs. The distribution of these groups of orthologs between samples can be used to calculate the similarity between samples and to qualify gene distribution between microbiomes and conditions, similar to approaches used in comparative genomics. Questions remain, however, concerning the function of these groups of orthologs, as most genes have not been associated to functions. A way to annotate a large section of these genes is to investigate new and existing microbiome experiments, both environmental or host-associated, to correlate further information with a large proportion of orthologous groups. For example, some genes could be associated to the respiratory tract, others to high-salt environments. Finding genes associated with contaminated soil in the gut microbiome could provide information on potential hazards in the environment of subjects. At the very least, this approach of data-driven gene annotation will provide tools to interpret results from microbiome analysis and bring meaning to data that usually remain hidden underwater.

NON-INVASIVE AND FLEXIBLE ELECTRODES BASED ON MULTIMATERIAL FIBER FOR SEMG SIGNAL DETECTION

C. L. Fall (1), S. Ghafouri-Aian (2), Roudjane, Mourad (2), L. Bouyer (3), B. Gosselin (1) and Y. Messaddeq (2)

(1) Département de génie électrique et de genie informatique, Université Laval, Québec, QC, Canada
(2) Centre d'optique, photonique et laser (COPL), Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada
(3) Centre interdisciplinaire de recherche en réadaptation et intégration sociale (CIRRIS), Département de réadaptation, Faculté de médecine, Université Laval, Québec, QC, Canada

Recent developments in material sciences and microelectronic systems, along with broadband mobile technologies, have empowered the performance and usability of wearable sensors for digital healthcare. Overcoming the rigid form of the transducers used remains a major challenge and limits their wide-scale application. In this work, we will present a novel sensor made of a multimaterial metal-polymer-glass hollow-core fiber connected to a smart wearable sensing device, for continuous monitoring of sEMG signals. The high flexibility of the fibers allows for their easy integration into stretchable garments and textiles, without compromising the comfort of the users. The multimaterial fiber electrodes were first optimized in length and inter-spacing distance by recording different sEMG signals from a volunteer's forearm. A 5 cm long electrode with 2.5 cm inter-spacing distance was adopted leading to a signal-to-noise level of 35 dB. With the first prototype achieved, sEMG signals from the forearm's flexor, the tibialis anterior muscle and the shoulder were recorded. The collected data were compared with a commercial grade electrode, using the frequency content, for validation. The new flexible sensor enables the recording of sEMG signals from different muscle zones, above which the conventional electrodes can not be used due to their rigid form. This opens up a wide range of applications, in particular for assistive technology devices, and telemedicine.

THE CORE MICROBIOME OF POLAR MICROBIAL MATS: COMPARATIVE ANALYSIS OF HIGH ARCTIC AND SUBARCTIC END-MEMBERS

Vigneron, Adrien (1), P. Cruaud (2), A. Culley (1), C. Lovejoy (1) and W. Vincent (1)

(1) Université Laval, IBIS, Département de Biologie, Québec, QC, Canada
(2) Université Laval, IBIS, Département de Biochimie, de Microbiologie et de Bio-informatique, Québec, QC, Canada

Climate warming at more than twice the global average is now occurring in high and low Arctic regions, and has begun to affect freshwater ecosystems and their surrounding permafrost landscapes. To predict the future ecological state of these regions, monitoring potential sentinels of Arctic ecosystems health would be of value. However, the identification of such sentinels is challenging and requires an improved understanding of high-latitude freshwater ecosystems and their potential keystone species, consortia and trophic guilds. Microbial mats (thick biofilms) are a major functional component of polar freshwater ecosystems, driving biological production and associated nutrient cycling in lakes, ponds, streams and glacial habitats. Despite their ecological importance, the genetic composition and functioning of these high-latitude assemblages remain poorly understood. To identify potential sentinels of the North health, we aimed to resolve and compare the structure and the functioning of microbial mats in high and low Arctic freshwaters and their capacity to sustain elevated biomass and productivity under Arctic environmental constraints. Despite their contrasting geographical locations, the two communities shared a taxonomic and functional core microbiome, dominated by phototrophic microorganisms (photosynthetic Cyanobacteria, aerobic anoxygenic phototrophic bacteria and proteorhodopsin-based phototrophic bacteria). Pigment profiles and metagenomic analysis also showed the presence of abundant photoprotective and/or light-harvesting pigments supporting that light utilization and protection are key components of the polar mat microbiome, with light-utilizing bacteria representing up to 80% of the community. Chemoheterotrophic bacteria, heterotrophic microbial eukaryotes and virus (cyanophages and bacteriophages) were also represented, providing diverse mechanisms for nutrient and carbon recycling in these complex light-driven systems. Interestingly, Low-Arctic mats harbored a larger proportion of chemoheterotrophic and anaerobic bacteria, potentially

favored by warmer temperatures. Therefore, the proportion of chemoheterotrophic bacteria could potentially be interpreted as a sentinel of the ongoing warming of high latitude waters.

FROM CHINA TO CANADA: THE SEARCH FOR NOVEL AVIAN INFLUENZA VIRUSES

Wong, Gary (1)

(1) Département de microbiologie-infectiologie et d'immunologie, Université Laval, Québec, QC, Canada

Highly pathogenic avian influenza virus infections can result in severe respiratory disease in humans with a case fatality rate of up to 70%. Due in part to a permissive climate, the practice of backyard farming and the proliferation of the live animal trade, many novel influenza viruses can trace their emergence back to China. Additionally, the interaction of these domestic animals with wild, long/short-distance migratory birds facilitates the geographic spread of these viruses. This was observed early on with H5N1, which killed thousands of bar-headed geese (*Anser indicus*), great black-headed gulls (*Larus ichthyaetus*), and brown-headed gulls (*Larus brunnicephalus*) in Qinghai Lake, China during May 2005. In 2006, H5N1 re-emerged in Qinghai Lake, and was found to possess a high genetic similarity with viruses isolated from other countries on the migratory flyway of wild birds, suggesting that the migration of wild birds played an important role in circulating H5N1 between various avian populations. The virus eventually spread into other parts of Asia, as well as Europe and Africa, resulting in the deaths of millions of birds, and hundreds of cases in humans. Other H5-subtypes, including H5N6 and H5N8, have since followed suit in spreading across continents. The high mutation rates of influenza virus through genetic drift and shift makes it difficult to predict when and where the next outbreak of novel avian influenza will occur. As such, a surveillance network to monitor circulating viruses in animal hosts is necessary. During my post-doctoral studies, I helped establish an avian influenza surveillance network (named CASCIRE – Chinese Academy of Sciences Center for Influenza Research and Early-warning) spanning all provinces of China. Led by researchers at the Chinese Academy of Sciences, the network contains infectious diseases research staff based at universities, local/provincial Centers for Disease Control and Prevention, wildlife conservation organizations as well as selected sentinel hospitals. Samples are taken monthly from wild migratory birds (in the field) and domestic poultry (in live animal markets), as well as human patients (if and/or when available). Samples that tested positive for avian influenza virus are then isolated and analyzed via genetic and phylogenetic means to determine its origins and if deemed necessary, the viruses were also evaluated in vivo (i.e. mice and ferrets). Due to this work, we have made significant progress in understanding the origin, genesis and evolution of H5N6 and H7N9 viruses, as well as pathogenicity and transmission characterization of their variants. In this presentation, I will discuss these results, and how the experiences learned can be applied to current research as my group and I establish an avian influenza surveillance network in northern Canada.

NETWORK ARCHEOLOGY: PHASE TRANSITION IN THE RECOVERABILITY OF NETWORK HISTORY

Young, Jean-Gabriel (1,2), L. Hébert-Dufresne (1,3,4), E. Laurence (1,2), C. Murphy (1,2), G. St-Onge (1,2) and P. Desrosiers (1,2,5)

(1) Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada
(2) Centre interdisciplinaire de modélisation mathématique de l'Université Laval, Québec, QC, Canada
(3) Department of Computer Science, University of Vermont, Burlington, VT, USA
(4) Vermont Complex Systems Center, University of Vermont, Burlington, VT, USA
(5) CERVO Brain Research Centre, Québec, QC, Canada

Networks map out complex systems as simplified objects, where the only information that matters is how the basic elements (nodes) of these systems interact together (via edges). The foundational insight of network science is that much can be learned from this structure alone. For example, it has been observed that many real complex systems – including the North – share universal structural characteristics, and that the emergence of these characteristics can be explained by simple growth rules, i.e., rules for how networks evolve in time from their origin. It is usually understood that these simple growth processes only provide a simplified picture of real networks rather than a detailed description. They do not – nor are they expected to – give a perfect account of reality. But, as we show in this contribution, viewing growth processes as plausible mechanisms for the actual growth of real complex networks can be a fruitful endeavor. In particular, this point of view leads to a natural statistical inference task: That of reconstructing the past states of

a growing network, from its current structure alone. We introduce an importance sampling algorithm that allows us to estimate the distribution of past states, conditioned on the observed structure, for many growth processes. This provides a quasi-automatic method for "network archaeology" across disciplines: Specify a model and the method will return the history of any network, given enough sampling time. Importantly, we show that there are a number of insurmountable limitations to our ability to reconstruct the past of networked system, due to the simplicity of the network representation. But despite these limitations, we show that it is possible to recover a significant quantity of information from incomplete data, and therefore that network archaeology is a worthwhile pursuit – as long as imperfect knowledge is tolerable.

MARDI 28 AOÛT

TUESDAY, AUGUST 28

ARCHITECTURAL TYPOLOGIES OF LIGHT IN THE NORTH: AN INTERDISCIPLINARY APPROACH TO THE DESIGN OF BUILDING FACADES IN COLD CLIMATES

Demers, Claude (1) and A. Potvin (1)

(1) École d'architecture, Université Laval, Québec, QC, Canada

The severity of the North, a cold climate, poses extreme challenges for architects, especially when optimizing the interior-exterior relationship and potential benefits for humans. Ultimately, emergence of energy conservation preoccupations led to determinism producing deep-plan building types and windowless spaces, rejecting the outside environment and possible negotiations with thermal and daylighting issues. This presentation addresses climate responsive insertions of daylighting design strategies and their experimentation in a cold climate. It revisits quantitative validation models in terms of experiential qualities of resulting facade morphologies. The design research explores physical and poetic relations between architecture and climate by developing a combined tactile and numerical approach to creation whilst facing the necessity of low-energy buildings addressing users' comfort and environmental satisfaction. An integrated design studio provided an ideal platform to investigate poetic connections with nature favouring interdisciplinary integration of bioclimatic strategies. The professional master's design studio generated a comprehensive integration of environmental systems and controls in architecture during an entire academic semester. Ten teams of graduate architecture students were paired with mechanical and structural engineering students to explore the form generating power of modeling in relation to high dynamic range imaging techniques. Each team was provided with a generic model measuring 70 cm x 100 cm x 30 cm to perform 1:10 scale parametric daylighting studies of intelligent façade design proposals. Students were invited to use the several simulation tools, from analogical to digital, in accordance with their design goals throughout the semester. Analogical tools require time and craftsmanship but offer unique opportunities for dynamic spatial visualization. When photographed under real skies, analogical models may reveal the unmeasurable character of daylighting ambiences. Benchmarking was performed in outdoor spaces under different conditions: clear skies producing direct sun lighting, and overcast skies generating diffuse light. Testing also occurred in an artificial sky. Illuminance values (lux) were measured to calculate daylight factors (DF) of design solutions. Since numerical values do not provide information of ambiences experienced by users, imaging techniques were developed with Sentinel North graduate students, while simulations were addressed by CIRCERB-NSERC Ph.D. students. Imaging technologies of high dynamic range used Ward's Photosphere software, producing calibrated photographs classified according to luminance maps (cd/m2). Experiments with large scale physical models were a unique occasion to challenge research models applied to actual building program, climatic and technical problematics through interdisciplinarity. Light and colour classifications were developed to illustrate the potential of materials, structural components and filters, combined with the changing nature of daylight to generate interior ambiences. These charts address the essential question of spatio-temporal representations of the variability of daylighting effects of façade systems. Results of façade design strategies and whole building design solutions for cold climates are presented as architectural typologies of Light for the North. Collaboration: Prof David Conciatori (GCI), Prof Mario Fafard (GCI), Prof Louis Gosselin (GMC). CIRCERB-NSERC PhD students: Philippe Charest & Jon Lefaivre. Sentinel North team: Philippe Lalande, Mojtaba Parsaee, Myriam Rodrigue, Prof Marc Hébert (MED), Prof Jean-François Lalonde (GIF). Jean-François Hardy (acoustician EAUL), Sylvain Gagnon (FPinnovations), Yan Laplante (CCM2 Architectes).

MODIFICATION DE LA PHOTOPÉRIODE EN ARCTIQUE : IMPACT SUR LA RYTHMICITÉ CIRCADIENNE DE LA PHOTOSYNTHÈSE CHEZ LA DIATOMÉE POLAIRE FRAGILARIOPSIS CYLINDRUS

Guérin, Sébastien (1), F. Bruyant (1), J. Larivière (1), J. Ferland (1), M. Gosselin (2), M. Babin (1) et J. Lavaud (1)

(1) Unité Mixte Internationale Takuvik CNRS-Université Laval, Québec, QC, Canada
(2) Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, Rimouski, QC, Canada

Dans les régions arctiques, tous les organismes, des microalgues unicellulaires aux humains, sont soumis à une importante variation saisonnière de la durée du jour au cours de l'année. Ces modifications drastiques de leur environnement lumineux ont un effet majeur sur leurs rythmes de vie et leur santé. L'impact de la photopériode dans la régulation des processus photo physiologiques chez les microalgues eucaryotes est largement inconnu. Parce qu'elles subissent des changements drastiques de photopériode saisonnière, les diatomées arctiques sont un modèle pertinent pour étudier la rythmicité circadienne des processus photo-physiologiques. Leur adaptation à ces changements pourrait être l'une des clés de leur succès écologique dans les régions polaires. De plus, les diatomées ont de nombreuses caractéristiques génomiques «animales», et une meilleure compréhension de leur rythmicité circadienne physiologique pourrait nous permettre de mieux comprendre l'effet spécifique de la lumière dans l'entraînement et le maintien de l'horloge biologique animale (et potentiellement humaine). Le but de cette étude était de caractériser la phénologie et la rythmicité de la réponse de F. cylindrus à différentes photopériodes avec un éclairement optimal pour sa croissance (30 µmol de photons m-2 s-1). F. cylindrus a été acclimatée pendant trois semaines dans des photobioréacteurs sous des photopériodes représentatives des différentes conditions saisonnières à 67 ° N, soit vers la mi-décembre (Light-Dark 0 : 24 heures), début février (LD 6 : 18 heures), fin mars (LD 12 : 12 h), début mai (LD 18 : 6 h) et fin mai (LD 24: 0 h). Nos données mettent en évidence que certains aspects de la photophysiologie de F. cylindrus, en particulier la photoprotection (quenching non photochimique et pigments xanthophylles), et le rendement photochimique (Fv/Fm) montrent une forte rythmicité circadienne. En changeant soudainement des cellules de F. cylindrus d'une photopériode (LD 18 : 6 h) à l'obscurité totale (LD 0 : 24 h) ou à la lumière continue (LD 24 : 0 h), on peut observer que la rythmicité photophysiologique semble être basée sur une régulation endogène qui dépend de l'alternance régulière des phases claires et sombres. F. cylindrus présente des capacités de photoacclimation remarquables qui lui permettent de se développer sous les différentes conditions de lumière saisonnière arctique, notamment grâce à un degré de photoprotection finement régulé.

SENTINEL NORTH RESEARCH CHAIR ON THE RELATIONSHIP WITH INUIT SOCIETIES

Hervé, Caroline (1)

(1) Université Laval, Québec, QC, Canada

The Arctic is experiencing major physical, political, and social changes. For these changes to ensure the development of a sustainable society, it is important for Inuit to be given centre stage. Since the report by the Truth and Reconciliation Commission of Canada was published, reconciliation with Aboriginal peoples has become a priority in governmental and institutional action plans. With this in mind, it is important to analyze the nature of relationships between Aboriginal and non-Aboriginal people and grasp the historical, political and cultural origins of many cultural misunderstandings. This presentation will introduce the main objectives and activities of the Sentinel North Research Chair on the Relationship with Inuit Societies. This Chair's mission is to support the development of good social relations with Inuit societies. It seeks to produce new knowledge on relationships between Inuit and non-Inuit and on how these relationships have changed in recent decades. There are three objectives: to produce new knowledge on the history and social dynamics of Inuit societies; to develop trainings and educational tools for non-Inuit; and to put Inuit at the forefront of research and educational projects.

DESIGN AND IMPLEMENTATION OF WIRELESS MICROELECTRONICS SENSORS TO MEASURE MICROORGANISM'S GROWTH IN DIVERSE ENVIRONMENT

Hosseini, Seyedeh Nazila (1), B. Gosselin (1) and Y. Messaddeq (1)

(1) Université Laval, Québec, QC, Canada

This project aims to build a multi-technology microsystem to measure bacterial growth and environmental parameters in diverse environments,

such as northern climates. We intend to design and fabricate a microelectronic chip to perform local bioimpedance measurement and imaging, as well as to measure several environmental parameters, including temperature, humidity, luminosity, etc. In the long term, this chip has two purposes: it is intended 1) to identify sentinel microorganisms that are signposts of specific environments across a northern region under the influence of global warming and human interventions, and 2) to identify unique molecules with possible medical or industrial applications. The cold climate of the northern regions brings a particular challenge as bacteria growth can be slow and difficult to measure precisely, which requires innovative sensing solutions. In fact, at low temperature, the activity of microorganisms like bacteria and microbes decreases dramatically. Hence, we will design a customized high-precision bioimpedance measurement system that can address a precision to measure bacteria diluted down to several millions of CFU/ml. Our approach will leverage the design of a new fully integrated bioimpedance measurement circuit that will enable high-precision and placement in hard areas of the northern regions and the human body. Additionally, an integrated system to precisely monitor and measure the microorganisms will increase autonomy, decrease the manufacturing and transport cost, and be capable of working under temperatures below -40 °C. We will design a high-sensitivity dual-phase lock-in amplifier (LIA), within microelectronic circuits, capable of extracting small bioimpedance signals down to 1 pA of amplitude to measure growth rate in cold climates. The chip will be designed in a 0.18-µm CMOS microelectronic process at Laval.

CHARACTERIZING THE ANNUAL ENERGY AND WATER BUDGETS OF A FOREST-TUNDRA ECOTONE IN NORTHERN QUEBEC

Lackner, Georg (1,2), D. Nadeau (1), F. Domine (2,3), F. Anctil (1), A.-C. Parent (1), J.-M. Lemieux (2,4) and R. Fortier (2,4)

(1) Département de genie civil et de genie des eaux, Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(3) Département de chimie, Université Laval, Québec, QC, Canada
(4) Département de géologie et de genie géologique, Université Laval, Québec, QC, Canada

The forest-tundra ecotone represents the transition zone between the Arctic tundra and the boreal forest, and it hosts species from its two adjacent biomes. Since climate change is expected to affect high latitude regions most heavily, this ecotone will very likely experience profound changes. The tundra portion will progressively disappear in favor of forested areas, thus affecting biodiversity and the life of Indigenous people, and also drastically change the energy and water budgets. These two budgets describe how the local air and soil temperatures evolve as a result of an equilibrium between all incoming and outgoing energy fluxes at the surface, and how water circulates through the landscape following precipitation events, respectively. Although the forest-tundra ecotone is present all around the Arctic and thus plays an important role in the world's climate, detailed data about the energy and water budgets are sparse. Here, more than a year of comprehensive measurements of the fluxes of radiation, ground heat and sensible heat as well as evaporation in a forest-tundra ecotone are presented. Additionally, the precipitation, surface runoff, and the groundwater flows are also directly measured in order to set up a detailed water budget. The research site, a 2.1 km2 watershed near the village of Umiujaq in Northern Quebec (56°32'N 76°33'W), exhibits discontinuous permafrost with shrub tundra in the upper part of the watershed and forest in its lower part. We found that while evaporation was less important for the energy budget than sensible heat fluxes and stayed relatively constant over the course of summer 2017, it had a large impact on the water budget and a similar magnitude as the direct runoff. Such studies are useful because they help to improve climate models used to anticipate the evolution of these fragile ecosystems.

EXPERIENCING NORTHERN LIGHTS: AN IMMERSIVE TOOL FOR THE VISUAL ASSESSMENT OF DAYLIT SPACES

Lalande, Philippe (1), C. M.H. Demers (1), M. Hébert (2), J.F. Lalonde (3), M. Blais (1) and A. Potvin (1)

(1) École d'architecture, Université Laval, Québec, QC, Canada
(2) Département d'ophtalmologie et d'ORL-chirurgie cervico-faciale, Université Laval, Québec, QC, Canada
(3) Département de génie électrique et génie informatique, Université Laval, Québec, QC, Canada

Daylight is a vector of information, also playing the role of the main vector of human well-being and comfort. In extreme climates, daylighting design strategies that

enhance the quality and inhabitability of an interior space remain a challenge to allow a better relationship between architecture and the exterior environment responding to its particular photoperiod and solar geometry. Targeting light needs according to the seasonal cycle is the first step in optimizing architectural forms favouring the creation of biophilic spaces in Nunavik. The main objective of this research is to characterize the quality and availability of northern daylight to optimize its integration into the architecture of Nunavik. The research develops an immersive method of representation of the human field of vision that better reflects the spatiotemporal reality of the perceived and lived lighting environments. It moreover addresses the potential of integrating the circadian metrics of light in architecture. Immersive use in virtual reality will allow the visualization, among Inuit communities and designers not necessarily located in the North, of the photographic and luminous data collected. Visual assessment through high dynamic range (HDR) imagery in virtual reality will serve as a decision support tool that will help understand the needs and challenges related to architectural daylighting in Nunavik. Visual and lighting sensors, based on Raspberry Pi microcomputers, are adapted to generate HDR images and calibrated representations of existing environments. Light is represented as luminance values, expressed in false colors for the visible (photopic) as well as the circadian portion (melanopic) portions of the light spectrum. While static daylight representations are assessment tools that are relevant for specific cases, they must be enhanced or accompanied by other tools in order to reflect the dynamic changes in lighting conditions on an annual basis. Ultimately, the research proposes a novel method of representation and visualization of northern light that integrates the spectral, spatial and temporal components of the built environment. References: Arendt, Josephine. "Biological Rhythms During Residence in Polar Regions." Chronobiology International 29, no. 4 (2012): 379-94. Chamilothori, Kynthia, Jan Wienold, and Marilyne Andersen. "Adequacy of Immersive Virtual Reality for the Perception of Daylit Spaces: Comparison of Real and Virtual Environments." Leukos 14 (2018): 1-24. Inanici, Mehlika N. "Evaluation of High Dynamic Range Photography as a Luminance Data Acquisition System." Lighting Research & Technology 38, no. 2 (2006): 123-34. Jung, Bo Yun. "Measuring Circadian Light through High Dynamic Range (HDR) Photography." M. Sc. thesis, University of Washington, 2017. Lucas, Robert J., Stuart N. Peirson, David M. Berson, Timothy M. Brown, Howard M. Cooper, Charles A. Czeisler, Mariana G. Figueiro, et al. "Measuring and Using Light in the Melanopsin Age." Trends in Neurosciences 37, no. 1 (2014): 1-9. Mead, Alex Robert, and K. Mosalam. "Ubiquitous Luminance Sensing Using the Raspberry Pi and Camera Module System." Lighting Research and Technology 49, no. 7 (2016): 904-21.

DYNAMIQUE SAISONNIÈRE DES ÉTANGS THERMOKARST SUBARCTIQUES : LE CAS DES VIRUS

Langlois, Valérie (1,2,4), W. F. Vincent (1,3,4) et A. Culley (1,2,4)

(1) Centre d'études nordiques, Kuujjuarapik, QC, Canada
(2) Département de biochimie, microbiologie et bio-informatique, Université Laval, Québec, QC, Canada
(3) Département de biologie, Université Laval, Québec, QC, Canada
(4) Sentinelle Nord, Université Laval, Québec, QC, Canada

Dans les conditions actuelles de réchauffement climatique, les environnements arctique et subarctique sont touchés par une augmentation significative de la température moyenne. Cela se traduit par d'importants changements du paysage, notamment le dégel du pergélisol et la croissance des étangs thermokarst. Ces étangs sont connus pour leur libération importante de gaz à effet de serre (GES), un processus conduit par l'activité microbienne. Ce projet de métagénomique utilise comme modèle les étangs thermokarstiques de la région de Whapmagoostui-Kuujjuarapik pour tracer un portrait des populations virales de ces milieux dans l'optique de permettre une meilleure compréhension des changements importants liés au dégel du pergélisol. Les étangs thermokarst sont peu profonds (<3 m) et chargés en matière organique. Durant la saison estivale, leur colonne d'eau est stratifiée présentant une eau chaude et bien oxygénée en surface et plus fraîche et entièrement anoxique en profondeur. Durant la saison hivernale, la colonne d'eau se retrouve isolée, empêchant les échanges avec l'atmosphère, et devient entièrement anoxique. Ces conditions anoxiques favorisent l'activité de micro-organismes méthanogènes et la formation de GES. Les virus, de petits parasites intracellulaires, sont connus pour avoir un impact considérable sur leurs hôte et environnement. Ils peuvent affecter la chaîne alimentaire, l'équilibre des populations microbiennes et les cycles biogéochimiques. Puisque la grande majorité des virus sont encore inconnus et leur impact sur l'écosystème arctique est encore largement sous documenté, ce projet

représente une occasion de combler une grande lacune dans les connaissances actuelles. Dans ce projet, nous analysons la communauté virale des étangs thermokarst du nord du Québec. Trois échantillonnages ont été effectués entre 2015 et 2017 dans la vallée de la rivière Sasapimakwananisikw. Les échantillons de colonne d'eau de surface et profondeur ont été filtrés afin de récupérer les particules virales. Les virus extraits ont ensuite été séquencés par séquençage de type Illumina et analysés à l'aide de divers outils bio-informatiques. L'objectif de ces analyses est de révéler les souches connues et, surtout, inconnues de virus présent dans les étangs de fonte subarctiques. L'utilisation d'outils de détection sur les métagénomes enrichis en séquences virales permet de déceler tant des souches virales bien décrites que certaines souches jusqu'à présent entièrement inconnues. Les outils actuellement à notre disposition permettent de tracer un portrait global des communautés virales et de mieux comprendre leur rôle dans ces environnements en changement. Nous nous attendons à identifier diverses souches virales jusqu'ici non répertoriées et, vu l'importance de l'activité métabolique microbienne de ces étangs, à identifier divers gènes issus de séquences virales liés à la production de GES. Une perspective de ce projet sera l'étude des changements que subissent les communautés virales des étangs thermokarstiques au cours des saisons. Nous nous attendons à retrouver des communautés virales différentes en surface d'une saison à l'autre et à observer une certaine similarité entre les communautés estivales trouvées dans les eaux anoxiques en profondeur et celles échantillonnées lors de la saison hivernale. Nous nous attendons également à retrouver des gènes liés à la production de GES différents selon les conditions du milieu échantillonné.

DEVELOPMENT OF A CIRCADIAN CLOCK MODEL IN AN ARCTIC DIATOM: FIRST STEP TOWARD THE GENERATION OF NEW LIGHT THERAPY TREATMENT

Lavoie, Michel (1), A. Falciatore (2), S. Hardy (1), D. Forger (3), J. Strauss (4), M. Hébert (1), M. Babin (1) and J. Lavaud (1)

(1) Université Laval, Québec, QC, Canada
(2) Sorbonne Université, CNRS, Paris, France
(3) University of Michigan, Ann Arbor, Michigan, USA
(4) European Molecular Biology Laboratory, Hamburg, Germany

Light availability in the Arctic is a key factor calibrating circadian clock in both diatom microalgae and human populations, which share several molecular clock features. The study of circadian clock timing in diatoms, which are easy to grow in the laboratory and are especially sensitive to blue light shift, has the potential to catalyze discoveries of the molecular interactions between blue light and circadian rhythms in eukaryotic organisms. Such knowledge is essential to help develop new light therapy treatments for human seasonal depression, a disease potentially prevalent in the North, and resulting in annual socio-economical costs on the order of a billion dollars. The objective of my postdoctoral project is to gain insight on the non-linear interactions among components of the circadian clock in eukaryotic organisms (diatoms and mammals) through modeling and experimental approaches in order to help the further development of experimental studies on the efficiency of light therapy in humans. We are currently working on a molecular network of the sea-ice microalgae *Fragilariopsis cylindrus* metabolism. Our aim is to model steady-state and dynamic metabolism as a function of different photoperiods found in Arctic during the productive winter to summer transition. We use laboratory-measured physiological parameters (photosynthetic rate, biochemical composition) and gene transcriptomic data as model constraints. This whole metabolism model will be coupled to a model describing the molecular network of circadian oscillations in *F. cylindrus*, when molecular components of this network will be confirmed. In a further step, the experimentally measured influence of blue light on *F. cylindrus* circadian oscillations will be modeled and added to the algal metabolism model. In the last stage of the project, the processes by which blue light modulates the circadian clock of *F. cylindrus* will be incorporated (qualitatively) in a mathematical model of the circadian clock of a diurnal mammal and/or human.

SHAPING THE FUTURE OF POLAR RESEARCH: EMERGING VIEWS FROM AND FOR EARLY CAREER SCIENTISTS

Lizotte, Martine (1), M. Falardeau (2) and J. Holloway (3)

(1) Département de biologie, Québec-Océan/Unité Mixte Internationale Takuvik, Université Laval, Québec, QC, Canada
(2) Department of Natural Resource Sciences, McGill University, Ste. Anne-de-Bellevue, QC, Canada
(3) Department of Geography, Environment and Geomatics, University of Ottawa, Ottawa, ON, Canada

Early Career Scientists (ECS) play a major role in shaping our increasingly global and knowledge-based societies. More than ever, universities, institutions, research programs and other capacity-building entities seek to foster the development of young researchers that will hold the multi-, inter- and transdisciplinary skills to tackle and help resolve complex issues related to our changing physical, biological and societal environment. Interdisciplinary and international, the Association of Polar Early Career Scientists (APECS) is tailored towards engaging, informing and providing tools to early career researchers, practitioners, educators, and other individuals who have interest in polar, alpine regions and the wider cryosphere. APECS strives to offer resources for career development such as mentorship and support, as well as resources for skill building including best practices in science communication, community engagement and public speaking with the aim of promoting representation of ECS in all strata of research. Emerging views from and for ECS will be discussed in the specific context of Sentinel North's overarching goal: shedding light on the North, its peoples and its multifaceted changing environment.

NEUROVASCULAR AND IMMUNE MECHANISMS INVOLVED IN THE DEVELOPMENT OF DEPRESSION, STRESS VULNERABILITY AND RESILIENCE

Menard, Caroline (1)

(1) Department of Psychiatry and Neuroscience, Faculty of Medicine, CERVO Brain Research Centre, Université Laval, Québec, QC, Canada

Major depressive disorder (MDD), the most prevalent mood disorder, s the leading cause of worldwide disability and the most significant risk factors for suicide completion. One out of five people will suffer from depression during their lifetime. Core symptoms of MDD include depressed mood, irritability, anhedonia, difficulty concentrating, and disrupted appetite and sleep habits. Several clinical studies report higher prevalence of MDD comorbidity with inflammatory diseases including cardiovascular diseases, diabetes and obesity. Underscoring these data is the finding that subsets of MDD patients display higher levels of circulating inflammatory markers such as cytokines. Blood-brain barrier (BBB) is the critical divide between deleterious peripheral immune signals and the brain. Our recent findings show that chronic social defeat stress, a mouse model of mood disorders, disrupts BBB integrity in stress-related brain regions. In rodents, repeated exposure to social defeat stress induces a depression-like phenotype characterized by anhedonia and social avoidance, which can be reversed only by chronic antidepressant treatment. However, a subpopulation of mice does not develop depression-like behaviors and is considered resilient allowing us to study the biological mechanisms involved in depression but also resilience to chronic stress. In depressed mice, reduced BBB integrity in the brain resulted in direct passage of peripheral pro-inflammatory cytokines and subsequent expression of depression-like behaviors highlighting a direct link between neurovascular health and depression. Interestingly, these biological adaptations were not observed in resilient mice. We also confirmed that BBB integrity is altered in postmortem brain of depressed patients highlighting the potential of novel therapeutic strategies targeting neurovascular health and stress-induced neuroimmune responses. Social defeat stress has been extensively studied in humans in the context of bullying, as higher prevalence of mood disorders and suicide attempt were reported in victims. Early life adversity was associated with death by suicide among northern populations reinforcing the relevance of investigating social stress and early life stress to discover biological mechanisms possibly unique to these populations. Indeed, northern populations are exposed to an exclusive form of stress due to important environmental, cultural and socio-economic changes. The general objective of our research program is to study the neurobiology of stress vulnerability and resilience using state-of-the art technologies, such as neurophotonic tools, to develop novel intervention strategies. To relate our findings from our pre-clinical models on the biological mechanisms underlying efficient coping strategies under stressful conditions to the clinical situation, we plan to collaborate with clinicians to explore biomarkers of these mechanisms from blood samples. More specifically, we will evaluate the impact of chronic social defeat stress and early life stress combined with diet on neurovascular health, immune response and the microbiome to unravel the biological mechanisms underlying stress vulnerability and resilience. The Sentinel North Chair in the Neurobiology of Stress and Resilience aims to shed light on biological mechanisms underlying stress response in order to develop innovative treatments to treat or even prevent depression and mood disorders. A comprehensive look at the biological changes caused by chronic stress will be combined with population studies in order to identify personalized treatments.

SYNTHESIS OF NEW ORGANIC SEMICONDUCTORS FOR SOLAR CELL APPLICATIONS

Morin, Jean-François (1), M. Leclerc (1), C. Aumaître (1), F. Lirette (1) and F. Gagnon (1)

(1) Département de chimie and CERMA, Université Laval, QC, Canada

In the past thirty years, a plethora of conjugated building blocks with precise properties have been developed and introduced into oligomeric and polymeric materials for applications in organic electronics. Surprisingly, only few commercially available dyes and pigments have been used as building blocks for these materials. Some of these are very low cost and are produced in very large scale in pure form. Recently, we have reported the synthesis and characterization of vat orange 3 derivatives. Vat Orange 3, or 4,10-dibromoanthanthrone, is a particularly interesting dye since it can be functionalized through C-C cross-coupling reaction and other organic transformations. Using few steps, we have also been able to extend the conjugation of this dye by fusing electron-rich heterocycles to it in order to tune its optoelectronic properties. Soluble and stable n-type, p-type and ambipolar oligomeric and polymeric materials have thus been prepared and the best candidates have been in organic solar cells (OSCs). The presentation will include the synthesis, characterization and devices testing for new conjugated materials based on vat orange 3 in the context of Sentinel North project 2.5.

BIOPHILIC DESIGN AND PHOTOBIOLOGICAL DEVELOPMENT OF ADAPTIVE BUILDING ENVELOPES

Parsaee, Mojtaba (1), C. MH. Demers (1), M. Hébert (2), J.-F. Lalonde (3) and A. Potvin (1)

(1) Groupe de recherche en ambiances physiques, École d'architecture, Université Laval, Québec, QC, Canada
(2) CERVO Brain Research Centre, Department of Ophthalmology and Otorhinolaryngology, Faculty of Medicine, Université Laval, Québec, QC, Canada
(3) Computer Vision and Systems Lab, Electrical and Computer Engineering Department, Université Laval, Québec, QC, Canada

The biophilic design approach has recently been developed to confront adverse effects of the built environment development and improve human well-being by redefining the human-nature relationship. However, suggested biophilic design recommendations are rarely discussed in extreme climatic conditions such as very cold climates in which harsh nature, especially in terms of availability of natural light and seasonal photoperiod, endangers human well-being. Critically reviewing the body of knowledge and identifying the shortcomings and gaps between knowledge and action, this research intends to promote climate-adaptability, photobiological effects and energy efficiency and ultimately optimize biophilia in buildings by architecture through developing adaptive envelope systems. The intended strategies will be developed for extreme climatic conditions of Northern Quebec's cities and territories as a case study. In fact, the nature-friendly design of built environments, as proposed by biophilic design theories, has arguably extensive economic and environmental as well as physiological, psychological, and emotional benefits. Biophilic architecture claimed having economic benefits as a consequence of increasing the productivity of occupants, improvement of property value and employee attraction, decreasing energy consumption and carbon footprints. More importantly, Biophilic design has significant benefits where people spent most of their time within the buildings such as extreme cold or hot climates. Meanwhile, adapting the built environment spaces to a climatic context potentially outweighs the advantages in mitigating negative effects of the built environment and simultaneously gaining maximum benefits from the natural environment. As climate factors and conditions substantially change from very hot (-humid/dry) to subarctic climates, the adaptation strategies of building envelopes should be developed to address local climatic factors and conditions as well as respective inhabitants' needs. From all factors, solar radiation and photoperiod are identified as the main climate-causing factors triggering many biological seasonal events. Indeed, seasonal and daily photoperiod variations, in particular lack of solar radiation and light in winter months as well as darkness in summer months especially in northern regions, makes people to spend most of their times inside the buildings and hence energy consumption increases. This situation also has adverse effects on human well-being. In this regard, previous studies reported several light-related complains of sub-Arctic or very cold inhabitants such as desynchronized circadian systems, sleep problems, lower physical activity seasonal affective disorder (SAD), winter depression, mood disturbances, and higher UV light exposure. As one potential solution to confront aforementioned problems, biophilic design approaches could be developed to be practical and applicable to

extreme climatic conditions in territories of Northern Quebec. To this end, this research intends to optimize biophilia and develop human-friendly lighting scenarios in buildings regarding photobiology and drawing attention to image-forming and non-image-forming effects of light and daylighting as one of the bases of nature-oriented built environment design. Standing as an in-between matter and transient space in human-nature relationship, this research attempts to attain the intended objectives by developing adaptive and intelligent building envelope systems in responses to extreme outdoor environment conditions and human needs, in particular for extreme climate in northern regions.

PHOTOBIOLOGICAL ARCHITECTURE LIGHTING

Rodrigue, Myriam (1)

(1) Groupe de recherche en ambiances physiques, CERVO Brain Research Centre, Université Laval, Québec, QC, Canada

This thesis develops smart lighting strategies in response to extreme lighting conditions in northern cities. It develops lighting scenarios. The research will present case studies achieved in artificially lit architectural scaled models placed under an artificial sky to determine the advantages and limitations of the developed method. The artificial sky will be calibrated to emit the spectral distribution of skies similar to the ones of northern cities at diverse time of days and period of the year. Luminance and wavelength distributions of the scenarios will be compared with a developed multifactorial method. It will allow for analyzing in tridimensionvisual and physical comfort, alertness, glare risks and perceived luminance in relation to the materiality, geometry and position of windows, walls, lighting fixtures and the lighting sources of real artificially and naturally built environments. Results will be presented through 3D models, named point clouds, and images similar to architectural presentation drawings such as plans, cross-sections and axonometric views. Colorimetric, melanopic and high dynamic range imageries will be projected on fused tridimensional laser scans for achieving such analysis. Artificial lighting scenarios will adapt to the spaces' natural lighting conditions. The method provides powerful visualization results and facilitates the understanding, analysis and the design of architectural spaces and lighting installations for well beings.

MONITORING ANTHROPOGENIC ACTIVITIES IN MARINE ECOSYSTEMS USING BLUE MUSSELS (*MYTILUS* SPP.) AS SENTINEL ORGANISMS: THE KERGUELEN EXPERIENCE

F. Caza (1), P. Granger de Boissel (1), R. Villemur (1), S. Betoulle (2) and St-Pierre, Yves (1)

(1) INRS-Institut Armand-Frappier, Laval, QC, Canada
(2) Université de Reims Champagne-Ardenne, UMR-INERIS 02 Stress Environnementaux et Biosurveillance des Milieux Aquatiques, Reims, France

Our laboratory has recently been involved in the development of molecular biomarkers for monitoring the impact of climate change on marine ecosystems of Kerguelen using the *Mytilus* spp. as sentinel organisms. The Kerguelen Islands are part of the French Austral and Antarctic Territories (TAAF). Often referred to as the "Desolation Islands", the Kerguelen Archipelago is located at the northern limit of the Antarctic Ocean. Because of its strategic geographical position and the presence of a permanent research station since 1951, it has been used as a research site for measuring the impact of climate change from a geological and ecological perspective in the Southern Hemisphere. Kerguelen mussel populations (*Mytilus desolationis* and *Aulacomya ater*) are abundant and constitute major sentinels for measuring the impacts of global change on marine ecosystems in the Subantarctic region. The remoteness, absence of air support, and the severely cold, windy weather represent major obstacles for sampling of mussel beds located at environmentally distinct habitats scattered across the islands. To overcome these difficulties, we are assembling a multidisciplinary team of investigators with the aim of developing simple, low-cost, and logistically efficient stress biomarkers for assessing the impact of climate change on marine ecosystems. For this purpose, we are proposing to take advantage of the tremendous progress that has been achieved in the development of human multi-omics biomarkers for diagnostic, prognostic and monitoring treatment efficacy and prevent recurrence in the area of cancer. Particular attention is paid to the use of semi-invasive and non-lethal liquid biopsies that are being developed for cancer management. Using this approach, we have recently developed a small and portable laboratory unit and tested its efficiency in Kerguelen. We have also conducted a series of proof-of-principle studies aimed at testing the compatibility of a new sampling method with multi-omics analyses and its potential for long term storage for biobanking. The combination of logistically-optimal and new omics methods will

contribute to long term monitoring of the impact of climate change on marine ecosystems. It will also help in establishing a biobank containing a large collection of data and biological samples that will be accessible by the research community.

L'ECOCHIP : UNE PLATEFORME DE CAPTEURS SANS FIL POUR LA SURVEILLANCE ENVIRONNEMENTALE

Sylvain, Matthieu (1), F. Lehoux (1), S. Morency (1), F. Faucher (1), E. Bharucha (1), D.M. Tremblay (1), F. Raymond (1), S. Moineau (1), M. Allard (1), J. Corbeil (1), Y. Messaddeq (1) et B. Gosselin (1)

(1) Université Laval, Québec, QC, Canada

L'EcoChip est une plateforme de capteurs sans fil pour la surveillance environnementale conçue pour permettre la culture et l'analyse de la croissance de micro-organismes ainsi que leur environnement naturel. Le système peut être déployé dans des environnements difficiles, tels que le climat nordique. L'EcoChip présente des puits de croissance multicouches permettant la croissance de micro-organismes obtenus à partir d'échantillons d'habitats nordiques à l'intérieur d'un des 96 puits du système. Le dispositif peut être déployé sur le terrain pour la surveillance en continu de croissance microbienne dans ses 96 puits à l'aide de son système de mesure d'impédance électrochimique multicanal. Des capteurs additionnels sont inclus dans l'EcoChip pour mesurer des paramètres externes tels que la luminosité, l'humidité, la température, le pH du milieu ainsi que le niveau de CO2 environnant. Le circuit électronique embarqué est équipé d'un microcontrôleur basse puissance, une mémoire flash embarquée et un système de gestion de la puissance. L'EcoChip est aussi équipé d'un système de communication sans fil permettant la transmission des résultats de mesure lorsqu'un récepteur est proche.

NATURAL PRODUCT CHEMISTRY IN THE NORTH

C. Carpentier (1), E. Ferreira Queiroz (2), L. Marcourt (2), J.-L. Wolfender (2), J. Azelmat (3), D. Grenier (3), Stéphane Boudreau (4) and Voyer, Normand (1)

(1) Département de chimie, PROTEO and Centre d'études nordiques, Université Laval, Québec, QC, Canada
(2) School of Pharmaceutical Sciences, University of Geneva, University of Lausanne, Geneva, Switzerland
(3) Groupe de recherche en Écologie buccale, Faculté de médecine dentaire, Université Laval, Québec, QC, Canada
(4) Département de biologie and Centre d'études nordiques, Université Laval, Québec, QC, Canada

Natural products have been a source of amazing drugs for treating efficiently a variety of diseases and illnesses. For good reasons, the Amazon and other rain forests have long been recognized as the "drug cabinet" of the planet. This is mainly due to the impressive biodiversity of living organisms they contain, but also to the easy accessibility of these forests year-round. Therefore, it is not surprising that the majority of natural product studies focused on plants from rain forests. However, to identify novel natural products with useful bioactivities, there has been a growing interest in studying organisms from other ecosystems. This is the case with marine ecosystems. Surprisingly, very little natural product research focused on organisms from northern environments. We will present our recent results on the identification of natural products from Northern Quebec organisms and discuss why they could be the sources of bioactive compounds with unique structures. This project is part of Sentinel North 3.2 Comprehensive environmental monitoring and valorisation: From molecules to microorganisms.

DAPHNIA CARBON COMPOSITION AND HEALTH IN A CONTEXT OF INCREASING TERRIGENOUS INPUTS DUE TO PERMAFROST THAW

Wauthy, Maxime (1,2) and M. Rautio (1,2)

(1) Département des sciences fondamentales, Université du Québec à Chicoutimi, Chicoutimi, QC, Canada
(2) Centre d'études nordiques, Université Laval, Québec, QC, Canada

As high latitudes warm, vast stocks of terrestrial organic carbon stored in permafrost become potentially available to polar freshwater systems. Here we tested the hypotheses that increasing exposure to terrigenous matter would change *Daphnia* body composition and condition in thermokarstic ponds. Using Bayesian mixing models based on stable isotopes (SI) and fatty acids (FA), we evaluated the effects of thawing permafrost on *Daphnia* carbon composition and health for 10 ponds in the vicinity of Kuujjuarapik, Subarctic Quebec (Canada). The SI analyses showed that *Daphnia* were more allochthonous

(mean of 33%) in ponds influenced by permafrost thaw, compared to waterbodies with tundra soils unaffected by thermokarstic processes (6%) in the catchment. However, despite the dominance of terrestrial organic matter in the thaw ponds, *Daphnia* were mostly supported by autochthonous sources (57%). Besides, thawing permafrost appears to have no influence on *Daphnia* health, as their content in high quality polyunsaturated FA from algal diet was similar with and without thawing catchment. Our results emphasize that despite the increasing importance of terrestrial carbon in high latitude freshwater ecosystems, *Daphnia* seem to mostly feed and grow on good quality algal food.

MERCREDI 28 AOÛT

WEDNESDAY, AUGUST 29

MODELLING THE IMPACT OF CHANGING CLIMATE AND INCREASING DISSOLVED ORGANIC CARBON LOADS ON ICE PHENOLOGY, ANOXIA, AND OXYTHERMAL HABITATS IN BOREAL LAKES

Couture, Raoul-Marie (1), M. Côté (1), K. Tominaga (2), H. De Wit (3), B. Laken (4), F. Stordal (3) and G. Englund (5)

(1) Université Laval, Québec, QC, Canada
(2) University of Oslo, Oslo, Norway
(3) NIVA, Oslo, Norway
(4) Vizzuality, Madrid, Spain
(5) Umeå University, Umeå, Sweden

Northern lakes are impacted by climate change and changing loads of dissolved organic carbon (DOC) from the catchment. We set to explore how these changes modulate ice phenology, dissolved oxygen (DO) and light penetration in lakes across a gradient of water clarity, water residence time and lake size. Our process-oriented modelling approach consists of model calibration at one data-rich site, where trends in ice phenology, daily air temperature (+0.045 °C yr-1) and weekly DOC concentration (0.1 mg C yr-1, +1% annually) were measured over the 1974-2015 time period, as well as year-round time series of water temperature and DO from a high-frequency lake buoy since 2011. The model was then validated against monitoring data from 9 lakes for the 2001-2010 time period and finally applied to a set of 212 lakes for the 2010-2100 time period. Future weather over each lake was computed from the CORDEX (Coordinated Regional Climate Downscaling Experiment) dataset. At the data-rich site, a back-cast of ice freezing and break-up dates reveals that ice break-up occurs on average 8 days earlier in 2014 than in 1974. An earlier ice break-up enhances water column ventilation, resulting in higher DO in the spring. Later in the season, warmer water in late summer led to longer anoxic periods, as microbial DOC turnover increases. Increase in DOC concentrations causes decline in lake DO, leading to 15% more hypoxic days (< 3 mg L-1) and 10% more anoxic days (< 15 ug L-1) at the present day than three decades ago. Regional simulations on 212 lakes under scenarios of climate change suggests that climate warming and increasing DOC loads are antagonistic with respect to their effect on DO availability, and that small, shallow lakes have more potential for a reduction of their oxythermal habitat under increasing DOC and climate change than larger, deeper lakes.

SYNERGISTIC EFFECTS OF ENVIRONMENTAL ARCTIC CONTAMINANTS ON EPIGENETIC MARKS IN THE PATERNAL GERMLINE ARE PARTLY CORRECTED BY OMEGA-3

Dalvai, Mathieu (1), P. Ayotte (2) and J. L. Bailey (1)

(1) Centre de recherche en reproduction, développement et santé intergénérationnelle, Département des sciences animales, Université Laval, Québec, QC, Canada
(2) Centre de toxicologie de Québec, INSPQ, Québec, QC, Canada

Environmental contaminants such as persistent organic pollutants (POPs) and methyl-mercury (CH3Hg) have been associated with changes in epigenetic marks following in utero and adult exposure. While it is well known that maternal exposure can affect child health and development, recent research indicates that the effects of environmental exposure can be transmitted to future generations via the fathers. Nevertheless, little is known about potential synergetic effects of a pollutants combination on germline paternal genome and subsequently, the impact on future generations. Due to natural weather trajectories and bioaccumulation, the Arctic food chain is highly and persistently contaminated with POPs and CH3Hg contaminants. This pollution may be related to the major health discrepancy between Inuit and non-Aboriginal Canadians, which includes poor fetal growth, placental abnormalities, stillbirths, congenital defects, neurodevelopmental alterations and

several neurological outcomes, culminating in a 13-year shorter lifespan. We use mouse spermatogonial stem cells (SSCs) as an in vitro model to test the hypothesis that an environmentally-relevant Arctic POPs mixture, alone or in combination with CH3Hg, even at low doses, perturb cell proliferation and induce epigenetic alterations. Since country foods are central to Inuit culture and replete in long-chain omega-3 polyunsaturated fatty acids (n−3 PUFA) that are known to modulate gene expression, cell signalling or influence epigenetic mechanisms, we further hypothesize that phenotypes observed in SSCs can be offset by protective effect of n-3 (DHA, EPA). Time- and dose-dependent experiments showed that POPs decrease SSC proliferation while n-3 has no effect ($n=3$; $P < 0.01$). MeHg induced a small dose-dependent increase in SSC proliferation until 50 nmol/L at 72h ($n=3$; $P < 0.05$) and a decrease in proliferation at 100 nmol/L after 72h of exposure ($n=3$; $P < 0.01$). Inclusion of n-3 at 25 or 50 nmol/L completely reversed the proliferative phenotypes observed with POPs or MeHg contamination ($n=3$; $P < 0.01$). Surprisingly a combination of POPs and CH3Hg at doses equal or lower than basal contamination observed in Europe or in Canada induced an increase of proliferation of SSC cells after 48 h of treatment ($n=3$, $p < 0{,}001$) which is completely reversed by a n-3 treatment ($n=3$, $p < 0{,}05$). Cell cycle analysis, apoptosis rate or reactive oxygen species (ROS) quantification didn't show any differences but the doubling time was modified. The transcriptomic analysis revealed that POPs+CH3Hg modified multiple genes and these changes were reversed by omega-3. Gene Ontology analysis revealed that the affected biological process and pathways are closely related to health effects that are experienced by Inuit populations. Chromatin Immunoprecipitation experiments on transcription start site of target genes show a modulation of histone marks H3K4me3 and H3k27me3, which correlated with transcriptional gene activity. In sum, low dose of POPs, CH3Hg or a combination exposure modified both the proliferation and epigenetic patterns of SSC in vitro, which are prevented/reversed by n-3. These synergistic effects challenge the relevance of guidance values when contaminants are considered separately. As well, does an n-3 complementation may represent a nutritional strategy against some environmental pollutants?

A MICROFLUIDIC METHOD WITH IN SITU MEASUREMENT METHODS FOR DEVELOPMENT AND CHARACTERIZATION OF CYANOBACTERIA

Deng, Tianyang (1), J. Greener (1) and W.Vincent (2)

(1) Département de chimie, Université Laval, Québec, QC, Canada
(2) Département de biologie, Université Laval, Québec, QC, Canada

Cyanobacteria in Artic regions and elsewhere play a critical role in local ecology as autotrophs and primary carbon and nitrogen fixers. It is interesting and necessary to learn their reciprocal interaction with the environment especially at this moment as they are facing challenges like temperature shifting, decrease of water body and pollution. They can be capitalized as sensing material for indicating the change in locality. In addition, cyanobacteria offer a new approach to solar energy conversion based on the highly efficient photosystems. These systems include chlorophyll *a* P680 and excited chlorophyll *a* P700, excited states of which are, respectively, the strongest biological oxidizing and reducing agents and can drive electrochemical processes that power the cells. New microbial photovoltaic cells use cyanobacteria as an electroactive material in which surplus current is siphoned off to generate usable power. To understand and potentially optimize cyanobacteria as a new material, microfluidics can be a powerful tool based on its inherent capability to precisely and dynamically control liquid phase properties with excellent spatial and temporal resolution. Controllable factors include hydrodynamics such as flow velocity and shear forces; control over mass and heat transfer, and chemical conditions such as concentration and type of dissolved molecular species. However, in situ characterization remains a challenge. In this work we demonstrate the use of standardized characterization techniques into a microfluidic format. Fluorescence spectroscopy and other related measurements can now assess fluorescence information of individual cells. Under confocal laser scanning microscope (CLSM), cyanobacteria of different strains can be distinguished and identified in vivo, which is useful for studying the cyanobacteria biofilm community as a whole. Infrared spectroscopy (IR) quantitatively reflects information of its chemical components such as hazardous excreted toxins or lipid as biofuel products. An electrochemical approach may demonstrate its potential as an energy source, leading toward harnessing cyanobacteria and thus building up a harmonious relationship with the Artic ecological system.

Our preliminary experiment has successfully inoculated a strain of cyanobacteria and confirmed its continuous survival in such a system. Both single and multiple cell monitoring was achieved, characterizing its population density. Different strains inside a cocktail of cyanobacteria were discriminated individually.

AIRBORNE HYPERSPECTRAL REFLECTANCE FOR BATHYMETRY AND BOTTOM ANALYSIS IN THE ARCTIC

Fournier, Georges (1) and J.-P. Ardouin (1)

(1) DRDC Valcartier Research Laboratory, Québec, QC, Canada

We have recently developed and tested a new model for bathymetry and bottom analysis using airborne hyperspectral reflectance measurements. This model uses a new extensive parametric analysis of the physics basis for the irradiance of minerals, vegetation and their non-linear interactions. We have recently carried out a one-week aerial hyperspectral measurement campaign in Lake Ontario. During the overflights, the intrinsic optical properties of the water column were measured by a WetLabs ACS and the depth references were obtained with the HydroBall system developed by CIDCO in Rimouski. To date, the results of the model are extremely encouraging and indicate the feasibility of precise simultaneous analysis of the depth and composition of the bottom without having to make any extensive use of pre-existing data on the environment. We are planning another measurement campaign of two weeks at the beginning of August around Iqaluit to verify the performance of this new model in the Canadian Arctic environment.

MID-INFRARED SUPERCONTINUUM FOR REMOTE SENSING OF ATMOSPHERIC POLLUTANTS

Gauthier, Jean-Christophe (1), L.-P. Pleau (1), P. Paradis (1), V. Fortin (1), R. Vallée (1) and M. Bernier (1)

(1) Université Laval, Québec, QC, Canada

An impressive amount of knowledge and new applications emerged from the widespread use of lasers in various fields of fundamental and applied research, including chemistry, biology and medicine, to name a few. This success led to a growing need for new types of laser sources as researchers and industry are now trying to use light to solve an increasing number of problems. Due to its strong application potential in spectroscopy, the 3-8 µm spectral region known as mid-wave infrared (MWIR) has become a fertile ground for laser research over the past decade. Home to many fundamental ro-vibrational absorption lines of atmospheric pollutants such as carbon oxides (CO, CO2), nitrogen oxides (NOx) and hydrocarbons like methane (CH4), which can be one to two orders of magnitude stronger than their short-wave infrared (1.4-3 µm) counterparts, the MWIR also happens to overlap with an atmospheric transparency window between 3 and 5 µm. While Optical Parametric Oscillators / Amplifiers (OPO/OPA) and Interband Cascade Lasers (ICL) can provide a tunable wavelength output, namely over the whole 3-5 µm region, applications involving hyperspectral measurements or multi-gas simultaneous detection would benefit from a broadband emission spectrum. As opposed to thermal sources (i.e. blackbody, solar), supercontinuum (SC) sources offer both a superior brightness and a good beam quality while producing a large and relatively flat spectrum over several microns in the mid-infrared. At present, the method for producing the broadest SC spectra is based on high energy femtosecond pulses produced by solid-state lasers (e.g. Ti: Sapphire) launched in a nonlinear medium such as crystals or centimetre-long optical fibers. Despite the impressive spectral coverage generated, these approaches remain complex and costly, preventing them from addressing several practical applications outside of research laboratories. In contrast, fiber-based systems are much cheaper and robust, making them ideal candidates for compact application systems. While silica-based step-index and photonic crystal fibers (PCFs) have been extensively used for SC generation, their transparency in the infrared is limited to wavelengths below 2.5 µm (~1 dB/m @ 2.3 µm) due to multiphonon absorption. To solve this issue, many researchers have turned themselves towards commercially available low-phonon energy materials such as fluoride glass (FG) fibers which are providing extended transparency in the mid-infrared (~1 dB/m @ 4.2 µm (ZrF4) and 5.2 µm (InF3)). However, most fiber-based techniques are unable to convert more than 30% of their total SC energy beyond 3 µm. In this presentation, a novel approach to SC generation based on spectral broadening inside of an erbium-doped fluoride fiber amplifier seeded directly at 2.8 µm will be discussed, allowing mid-infrared conversion efficiencies reaching up to 95% and spectral coverage approaching the transparency limit of ZrF4 (4.2 µm) and InF3 (5.5 µm) fibers. Its simple design and low electrical consumption

make it an interesting candidate for off-the-grid applications such as gas sensing in remote areas.

DOES THE APPLE FALL FAR FROM THE TREE? IN UTERO EXPOSURE TO PERSISTENT ORGANIC POLLUTANTS ALTERS SPERM MIRNA EXPRESSION ACROSS MULTIPLE, UNEXPOSED GENERATIONS

Herst, Pauline (1), M. Lessard (1), P.L. Charest (1), M. Vallée (2), A. Droit (2), M. Dalvai (1) and J.L. Bailey (1)

(1) Laboratoire de fonction spermatique et de toxicologie, Département des sciences animales, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, Québec, QC, Canada
(2) Computational Biology Laboratory Research Centre, Faculté de médecine, Université Laval, Québec, QC, Canada

INTRODUCTION: Great concern has arisen concerning high levels of persistent organic pollutants (POPs) in the Arctic food chain – as they may be associated with multigenerational changes in epigenetic marks following in utero exposure. HYPOTHESES: (1) In utero exposure to POPs alters miRNA expression in sperm and the sperm of his subsequent generations. (2) Nutritional folic acid (FA) supplementation moderates the POPs-induced dysregulation of miRNA expression. METHODS: Four groups of Sprague-Dawley founder females were gavaged with environmentally-relevant POPs (500µg/kg) or corn oil (control) and received 1X or 3X FA representing intake from fortified foods ± additional supplementation, 5 weeks before mating and until parturition. F1 males were bred with untreated females to obtain F2 offspring. Likewise, F3 and F4 generation offspring were generated. For each generation, sperm were collected from males (n=12/treatment group). RESULTS: In utero POPs exposure reduces overall miRNA expression in F1 sperm. This pattern dilutes in generation F2 until F4. 47 differentially-expressed miRNAs, due to POPs exposure, are conserved in F1 and F2 sperm – of which 4 miRNAs are conserved until F3. These conserved miRNAs are indirectly involved in reproductive structure development, developmental growth and pathways in cancer. Combining POPs+FA results in fewer differentially regulated miRNAs in F1-F4 compared to POPs exposure. Although less differentially-expressed miRNAs (23) were conserved, due to POPs+FA; there were still 5 miRNAs conserved until F3. FA alone affects miRNA expression until F2 – no transgenerational effect was observed. CONCLUSION: Sperm miRNA expression is perturbed transgenerationally due to in utero POPs and POPs+FA exposure. Data indicate a moderating effect of dietary FA against POPs. FUTURE PERSPECTIVES: Investigate sperm histone modifications, DNA methylation in F1-F4 and two-cell embryo transcriptome analysis in F2-F4.

SEA-ICE DETECTION FOR AUTONOMOUS UNDERWATER VEHICLES AND OCEANOGRAPHIC LAGRANGIAN PLATFORMS BY CONTINUOUS-WAVE LASER POLARIMETRY

Lagunas, José (1), C. Marec (1,2), É. Leymarie (3), C. Penkerc'h (3), E. Rehm (1), P. Desaulniers (4), D. Brousseau (4), P. Larochelle (4), G. Roy (5), G. Fournier (5), S. Thibault (4) and M. Babin (1)

(1) Unité Mixte Internationale Takuvik (UMI 3376), Université Laval-CNRS, Québec, QC, Canada
(2) Laboratoire d'Océanographie Physique et Spatiale (UMR 6523), CNRS - IFREMER - IRD -UBO, Plouzané, France
(3) Sorbonne Université, CNRS, Laboratoire d'Océanographie de Villefranche, Villefranche-sur-Mer, France
(4) Centre d'optique photonique et laser, Université Laval, Québec, QC, Canada
(5) Defence Research and Development Canada, Valcartier, QC, Canada

The use of Lagrangian platforms and Autonomous Underwater Vehicles (AUVs) in oceanography has increased rapidly over the last decade along with the development of improved biological and chemical sensors. These vehicles provide new spatial and temporal scales for observational studies of the ocean. They offer a broad range of deployment and recovery capabilities that reduce the need of large research vessels. This is especially true for the ice-covered Arctic ocean where surface navigation is only possible during the summer period. Moreover, safe underwater navigation in icy waters requires the capability of detecting sea ice on the surface (ice sheets). AUVs navigating in such conditions risk collisions, RF communication shadowing, and being trapped by ice keels. In this paper, an underwater sea-ice detection apparatus is described. The source is a polarized continuous wave (CW) diode-pumped solid-state laser (DPSS) module operating at 532 nm. The detector is composed of a polarizing beam splitter, which separates light of S and P polarization states and two photodetectors, one for each polarized component. Since sea-ice is a strong depolarizer,

the ratio P/S is an indicator of the presence or absence of sea-ice. The system is capable of detecting sea-ice at a distance of 12m. This apparatus is designed to be used by free drifting profiling floats (e.g., Argo floats), buoyancy driven vehicles (e.g., sea gliders) and propeller-driven robots (e.g., Hugin class AUV).

ON THE AUTONOMOUS, OPTICAL MEASUREMENT OF SNOW DENSITY

Lévesque-Desrosiers, Félix (1), S. Lambert-Girard (1), Q. Libois (2), F. Domine (1) and S. Thibault (1)

(1) Université Laval, Québec, QC, Canada
(2) Météo-France, Toulouse, HG, France

Lemmings are a key link of the Arctic food chain. During the winter, these rodents do not hibernate, they live in the snow. Digging tunnels allow them to seek for food, hide and reproduce. Annually, their ease to dig tunnels is key for the evolution of the lemming population. Physical properties of snow, such as the density, are therefore fundamental spatiotemporal data to measure. Snow density is currently measured by weighing a known volume. This process requires the presence of scientists in the field which is complex and expensive given the Arctic's logistical constraints. Therefore, this property cannot be characterized throughout the winter and on a large spatial scale. This project focuses on developing an autonomous, optical method to measure snow density. Light propagation in snow, a complex medium composed of air and ice grains, depends on its density and on the size and shape of its grains. The project explores the possibility of determining these properties by studying the transport of a light pulse in this media. As a first step, a method to numerically simulate the propagation of a light pulse in snow has been developed and validated. This will lead to the design and fabrication of an instrument and an inversion algorithm that will be tested and validated with snow phantoms. Finally, after testing the device on snow in a cold room, it will be deployed in the Arctic.

GAIN-SWITCHED ALL-FIBER LASER AT 2.8MM FOR HIGH POWER SUPERCONTINUUM GENERATION

Paradis, Pascal (1), V. Fortin (1), Y. Ozan-Aydin (1), R. Vallée (1) and M. Bernier (1)

(1) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

Powerful mid-IR pulsed fiber lasers operating near 3 μm are of great interest to efficiently pump high average power supercontinuum sources operating in the mid-IR, particularly for broadband remote spectroscopy of atmospheric pollutants [1]. In addition, such sources have great perspective for biological tissue processing given their proximity to the peak absorption of water at 2.94 μm [2]. Gain-switching of the laser cavity is an attractive approach for pulse generation since it can be implemented in a robust all-fiber design [3]. Recently, we have demonstrated a 10 W-level gain-switched all-fiber laser [4] operating at 2.8 μm that produced high energy pulses with an exceptional reliability. Such source presents great potential for producing a high average power mid-IR supercontinuum in a robust all-fiber architecture [5] to cope with the requirements of remote gas spectroscopy systems under development in the Sentinel North project 2.6. The gain-switched laser cavity design simply consists of a rare-earth-doped fluoride fiber bounded by two fiber Bragg gratings (FBGs). These FBGs are written through the protective coating of the 6.45 m long heavily (7% mol.) Erbium-doped double clad fluoride fiber to preserve the integrity of the fiber assembly. Using this FBG writing technique, a splice-less all-fiber laser cavity is obtained, which minimizes the intracavity losses and therefore leads to the highest possible efficiency. The system is pumped with a fiber-coupled commercial pump diode (nLight, element e18), emitting up to 220 W of peak power between 960 nm and 976 nm. The silica-based pump delivery fiber is directly spliced to the laser cavity. An endcap is spliced at the output end of the active fiber to prevent long-term degradation at high powers. Stable pulsed regimes were obtained for repetition rates ranging from 5 kHz to 140 kHz with average powers from 75 mW to 11.2 W, pulse energies from 60 μJ to 80 μJ, peak powers up to 420 W and pulse durations from 250 ns (5 kHz) to 170 ns (140 kHz). The optical conversion efficiency of the laser was around 28% at 140 kHz, which is close to the Stokes efficiency of 34%. Future investigations include the optimization of the laser cavity design to shorten the pulse duration as well as the amplification of those pulses to generate a high-power supercontinuum source with a spectral overlap with the pollutants of interest for Northern

research (i.e. methane, carbon dioxide, etc.). 1. X. Zhu et al., J. Opt. Soc. Am. B 34, A15 (2017). 2. S. D. Jackson and A. Lauto, Lasers Surg. Med. 30, 184–190 (2002). 3. V. Fortin et al., Opt. Lett. 40, 2882 (2015). 4. P. Paradis et al., submitted to Opt. Lett. (2018). 5. J.-C. Gauthier et al., Opt. Lett. 40, 5247–5250 (2015).

DEVELOPMENT OF A REFLECTANCE PROBE TO MEASURE SEA ICE INHERENT OPTICAL PROPERTIES

Perron, Christophe (1,4), S. Lambert-Girard (1), Erik Bélanger (4,5), P. Després (2,3), D.Côté (3,4,5), P.Marquet (4,5) and M. Babin (1)

(1) Unité Mixte Internationale Takuvik, Université Laval, CNRS, Québec, QC, Canada
(2) Département de radio-oncologie et Centre de recherche CHU de Québec, Université Laval, Québec, QC, Canada
(3) Département de physique, de genie physique et d'optique and Centre de recherche sur le cancer, Université Laval, Québec, QC, Canada
(4) Institut Universitaire en santé mentale de Québec, Québec, QC, Canada
(5) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

Expanded, more detailed and in situ spatiotemporal characterization of sea ice inherent optical properties (IOPs) is necessary to better predict sea ice energy and mass budgets and under ice primary production. This project aims to develop an active probe measuring non-invasively IOPs of a small volume of ice (mm3 - cm3) with fast processing. The precision, efficiency and ruggedness of the concept would allow scientists to obtain ice IOP values directly in the field within minutes. The probe is based on the diffuse reflectance technique used to measure IOPs of human tissues. Conceptually, the instrument emits light guided through ice by an optical fiber. Backscattered light is measured at different distances from the source and compared to Monte Carlo modeled reflectances. An inverse algorithm allows for inferring the absorption coefficient, the scattering coefficient and the phase function of the scanned sea ice. This presentation summarizes the probe functioning and the first performance tests of the probe on sea ice in the laboratory.

REMOTE SENSING OF METHANE USING A TUNABLE ALL-FIBER LASER OPERATING NEAR 3.4 MM

Pleau, Louis-Philippe (1), V. Fortin (1), F. Maes (1), P. Paradis (1), R. Vallée (1) and M. Bernier (1)

(1) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

With the acceleration of global warming, increasing interest is turned towards the degradation of permafrost in northern regions and the release of the methane contained therein. However, to date, there have been limited convenient means of remotely measuring the emission of methane – or other pollutants – over the large areas covered by northern lakes and ponds, which account for a large portion of releases. With methane absorption lines up to 100 times greater than in the near infrared, the mid-infrared spectrum (MIR), especially the region between 3 µm and 5 µm in wavelength, shows a strong untapped potential for remote laser detection applications with a high signal-to-noise ratio. At the same time, fiber lasers possess unmatched qualities for field deployment when compared with other laser types, including robustness, compactness and power efficiency. As such, MIR fiber lasers are a promising avenue for measuring methane releases in the northern environment. We present a novel approach to remote methane detection using an all-fiber tunable laser source emitting around 3.4 µm. The laser precisely targets a narrow absorption line of methane at a wavelength of 3.427 µm, which is isolated from the absorption lines of other atmospheric gases such as water vapor and carbon dioxide. The laser wavelength is tuned between local extrema of the methane absorption spectrum, achieving a differential measurement of gas concentration. Laser tuning is performed by mechanically stretching a highly reflective fiber Bragg grating, acting as a narrow linewidth filter at the entrance of the laser cavity, using a piezo-electric actuator, enabling fast electronic control of the laser wavelength over a range slightly larger than the identified isolated methane line. The laser can emit up to 3 W of continuous optical power, allowing remote measurement through a highly concentrated medium at a large distance (km range). Measurements performed by propagating the laser through a gas cell containing varying amounts of methane show a clear relationship between methane concentration and absorption of the laser power at different wavelengths, allowing for a calibration of the instrument. Future steps for this project include long-distance detection tests, development of an adapted laser/detector packaging to facilitate transportation and testing in harsh environment conditions.

LIDAR TECHNIQUES FOR DETECTING ALGAL BIOMASS WITH APPLICATIONS TO ARCTIC SUBSTRATES

Rehm, Eric (1), F. Dalgleish (2), M. Huot (1), J. Lagunas-Morales (1), S. Lambert-Girard (1), P. Archambault (1), P. Lajeunesse (1) and M. Piché (1)
(1) Université Laval, Québec, QC, Canada
(2) BeamSea LLC, Vero Beach, FL, USA

The physical and biological properties of Arctic ice and coastal benthos remain poorly understood due to the difficulty of accessing these substrates in ice-covered waters. Using the absorption, inelastic scattering (fluorescence), and elastic scattering properties of photosynthetic micro- and macro-algae excited by lasers, our objectives are to image the morphology (3-D surface) of the target substrate (ice, benthos) as well as confirm and quantify algal biomass from an autonomous underwater vehicle (AUV) with constrained volume, power, and navigation. The fluorosensor approach uses chlorophyll *a* fluorescence (~685 nm) as a proxy for algal biomass. However, the quantum yield of fluorescence of chl *a* is small (< 30%) and is subject to strong water column absorption. Distance, laser power, and "pump and probe" fluorescence techniques are evaluated to increase the red photon return. The second approach uses only elastic scattering, estimating the relative difference in absorption by chlorophyll *a* at blue versus green wavelengths, a technique used by ocean color satellites and atmospheric DIAL. However, two lasers are required, increasing system complexity and power requirements. Here we present results of initial in situ tank tests using a two-wavelength (473 nm, 532 nm) prototype to evaluate both fluorosensor and differential absorption (DIAL) approaches using reflectance standards as targets and selected macroalgae. LiDAR design parameters are considered in light of spectral measurements of macroalgal absorption, fluorescence, and bidirectional radiance distribution function (BRDF), as well as and AUV constraints.

OPTIMIZATION OF FIBER TAPER DESIGN FOR METHANE SENSING IN NORTHERN REGIONS

Rodriguez, Antonio (1,2,3), A. Castillo (1,2,3), R. Wang (1,4,5), A. Gervais (1,4,5) and S. LaRochelle (1,4,5)

(1) Sentinelle Nord, Université Laval, Québec, QC, Canada
(2) School of Physical and Mathematical Sciences (FCFM), Autonomous University of Nuevo León, San Nicolás de los Garza NL, México
(3) Physical and Mathematical Sciences Research Center (CICFIM), Autonomous University of Nuevo León, San Nicolás de los Garza NL, México
(4) Département de génie électrique et de génie informatique, Université Laval, Québec, QC, Canada
(5) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

Greenhouse gas emissions as a result of thawing Arctic permafrost, are influencing the global climate. It is important to accurately measure the emission of these greenhouse gases in particular methane, in order to evaluate the potential hazards to the environment. To be able to achieve more precise quantification of methane emissions, we are optimizing the design of optical fiber taper methane sensor based on absorption spectroscopy. Using a commercial software, the power fraction propagating in the air around fiber tapers, which is an important parameter for evanescent wave sensing, is calculated for different fiber taper geometries, including the length and the diameter. The HITRAN database is also used to find the absorption coefficient of methane. Optimized length of fiber tapers at different fiber diameters is determined for various values of propagation loss. To further improve sensitivity, we investigate the addition of a coating with different refractive indices.

FINE-SCALE VARIABILITY IN OCEANIC DIMETHYLSULFIDE DISTRIBUTION ACROSS ICE-COVERED AND ICE-FREE WATERS OF THE CANADIAN ARCTIC ARCHIPELAGO IN SUMMER

St-Onge, Joanie (1), M. Lizotte (1), G. Massé (1), J-É. Tremblay (1), M. Levasseur (1) and P. Massicotte (1)

(1) Université Laval, Québec, QC, Canada

The sources and strength of oceanic dimethylsulfide (DMS) emissions, a climate-active biogenic gas, could be modified in the Arctic as a result of reductions in snow cover, sea ice extent and thickness. Understanding the impacts of climate change on DMS dynamics is crucial since DMS-derived sulfate is thought to be the key precursor to secondary marine aerosol mass above biologically productive regions that potentially lead to cloud formation and climate forcing. Using a novel automated instrument (ACT-MIMS), DMS samples were collected at high frequency in the surface waters of the Canadian Arctic Archipelago (CAA) during the summer (July-August) of 2017 aboard the Canadian Coast Guard

Ship *Amundsen*. More than 2500 DMS observations were collected alongside ancillary measurements of salinity, temperature, fluorescence (chlorophyll *a* proxy), light, ice concentration (satellite images) and the algal precursor of DMS, dimethylsulfoniopropionate. DMS concentrations ranged from ca. 1 to 32 nmol L-1 (average of 6 nmol L-1) over an area of approximately 10 000 km covering a wide range of contrasting marine environments from coastal to open ocean ice-free waters, as well as under-ice waters. These values are comparable to previous studies conducted in the CAA during the summers of 2015 (ca. 1 to 18 nmol L-1) and 2016 (ca. 1 to 30 nmol L-1), using similar high-frequency measuring systems and confirm that existing DMS climatology underestimate, by at least two-fold, summer levels of DMS in this part of the Arctic. Surface water DMS hotspots were measured in association with oceanographic thermohaline features, with high-productivity coastal waters, as well as with the presence of ponded first-year sea ice (FYI). Overall, our results strengthen the view that aqueous DMS cycling in the Arctic is intimately linked with sea ice dynamics. As such, future changes in the seasonality of the Arctic cryosphere will likely play an important role in shaping DMS emissions, although the sign and magnitude of the change remain highly uncertain.

INSTRUMENT DEVELOPMENT TECHNOLOGY PLATFORM - SERVING THE SENTINEL NORTH COMMUNITY

Trudeau, Jean-Marie (1) and É. Bharucha (1)

(1) Sentinelle Nord, Université Laval, Québec, QC, Canada

We will review the Platform's first year of activities by summarizing the Platform's realisations and its contributions to the current projects, including its own internal projects, for the development of a portfolio of solutions addressing issues that are common to multiple projects in the Sentinel North program. The Platform's expanded team and its facilities in systems development, engineering, prototyping, fabrication, assembly and testing will be presented, as well as the planned activities for the coming year.

AFFICHES | POSTERS

STUDY OF THE INTESTINAL MICROBIOME COMPOSITION, DIVERSITY AND FUNCTION IN NUNAVIK INUIT YOUTH POPULATION FACING ADVERSITY

Abed, Jehane Y. (1), M. Boissinot (1), J. Corbeil (1,2,3), M.G. Bergeron (1,4), P. Ayotte (5,6,7), M. Hébert (8,9), P. Marquet (10,11,12), C. Mérette (8,12), N. Poliakova (6), M. Lemire (6,7), M. Lucas (6,7), M.-C. Vohl (13,14,15), G. Muckle (6,16) and R.E. Bélanger (6,17,18)

(1) Centre de recherche en infectiologie de l'Université Laval, Axe Maladies infectieuses et immunitaires, Centre de recherche du CHU de Québec-Université Laval, Québec, QC, Canada
(2) Centre de recherche en données massives de l'Université Laval, Québec, QC, Canada
(3) Département de médecine moléculaire, Faculté de médecine, Université Laval, Québec, QC, Canada
(4) Département de microbiologie-infectiologie et d'immunologie, Faculté de médecine, Université Laval, Québec, QC, Canada
(5) Centre de toxicologie du Québec, Institut national de santé publique du Québec, Québec, QC, Canada
(6) Axe santé des populations et pratiques optimales en santé, Centre de recherche du CHU de Québec, Hôpital du Saint-Sacrement, Québec, QC, Canada
(7) Département de médecine préventive et sociale, faculté de médecine, Université Laval, Québec, QC, Canada
(8) Centre de recherche de l'Institut universitaire en santé mentale de Québec, Québec, QC, Canada
(9) Département d'ophtalmologie et d'oto-rhino-laryngologie - chirurgie cervico-faciale, Faculté de médecine, Université Laval, Québec, QC, Canada
(10) CERVO Brain Research Centre, Université Laval, Québec, QC, Canada
(11) Centre d'optique, photonique et laser, Université Laval, QC, Canada
(12) Département de psychiatrie et neurosciences, Faculté de médecine, Université Laval, Québec, QC, Canada
(13) Institut sur la nutrition et les aliments fonctionnels, Université Laval, Québec, QC, Canada
(14) Axe Endocrinologie et néphrologie, Centre de Recherche du CHU de Québec-Université Laval, Québec, QC, Canada
(15) École de nutrition, Faculté des sciences de l›agriculture et de l›alimentation, Université Laval, Québec, QC, Canada
(16) École de psychologie, Faculté des sciences sociales, Université Laval, Québec, QC, Canada
(17) Département de pédiatrie, Faculté de médecine, Université Laval, Québec, QC, Canada
(18) Centre mère-enfant Soleil, CHU de Québec-Université Laval, Département de pédiatrie, Québec, QC, Canada

Inuit communities experience major factors of adversity in their daily life such as mental health, environmental pollution and the rapid westernization of their diet and lifestyle. Dietary habits of Inuit populations reflect a gradient between traditional diet (hunted/ gathered country foods) and western diet (processed foods). There is substantial evidence that the intestinal microbiome has a major impact on human health. In the thematic project 3.6, we will use the gut microbiome as a sentinel of the Inuit population's mental health in a changing northern environment. The goal is to analyze possible links between the intestinal microbiome and mental health. The initial step will determine the bacterial composition and diversity of the digestive tract microbiome of Inuit in Nunavik. In a subsequent step, links between mental health, dietary habits and microbiome will be explored using integrative analyses. From August to October 2017 during the "Qanuilirpitaa 2017?" health study, participants from 14 communities in Nunavik (northern Quebec) donated fecal samples. We presently have over 185 samples providing us with sufficient analytical power to identify putative links between microbiome and mental health. The selected participants are aged between 16 and 30 years old. This age range was chosen because among young Canadian Inuit, the suicide rate is 11 times superior to the national rate. Additionally, participants answered questionnaires about their mental health status and dietary habits. Blood tests were performed and anthropometric data were obtained. The sex ratio was also taken into account. Shotgun metagenomics will be used to sequence the total DNA content of the microbiome. This technique provides a more comprehensive look into the bacterial composition, diversity as well as function of the fecal microbiome. Using our bioinformatics pipelines, we will obtain a complete microbiome profile including taxonomic and metabolomic profiling. To our knowledge, there are

only two published studies on the intestinal microbiome of Inuit. They have used 16S rRNA sequencing to compare the microbiota of participating Inuit from Nunavut to those of controls from European decent eating a western diet in Montréal. This technique is weaker than shotgun metagenomics as it only provides insights on the diversity and composition and not the function of the metagenome. Two cohorts were studied. First, 19 Inuit participants from Nunavut and 26 controls enlisted. They provided one fecal sample. Second, 15 Inuit participants from Nunavut and 9 controls were recruited. They donated fecal samples once a month for seven months. While they found no differences between Inuit from Nunavut and Montrealers' microbiota at a single time point, over time, Inuit microbiota exhibits more variations in composition and diversity. Using metagenomics sequencing to study a much larger and more diverse cohort will allow us to get a broader and deeper view of the microbiome composition, diversity and metabolic pathways of Inuit. We believe that this work will be used as the basis to explore links between mental health, dietary habits and microbiome.

ON THE DESIGN OF AN OPTICAL DETECTOR TO MEASURE NITRATES IN SEA-ICE

Alikacem, Yasmine (1,2), S. Lambert-Girard (1), S. Thibault (2,3) and M. Babin (1)

(1) Unité Mixte Internationale Takuvik, Université Laval, Québec QC, Canada
(2) Centre d'optique, photonique et laser, Université Laval, Québec QC, Canada
(3) Département de physique, de genie physique et d'optique and Centre de recherche sur le cancer, Université Laval, Québec QC, Canada

Sea ice blooms are important contributors to polar marine primary production and the food web. To grow, ice algae requires sufficient light and nutrient levels. Reduced sea ice thickness due to global warming is enhancing light level but is not necessarily resulting in higher primary production because nutrient inputs may not be sufficient. Understanding in ice primary production dynamics requires that the flux of nutrients from the water column to the ice is monitored. In both polar oceans, nitrate is the most limiting nutrients to ice algae growth. This project aims to develop a detector to measure in-ice nitrate concentration. The sensor will be integrated to the Sea Ice Endoscope (SIE) platform which aims to develop a non-destructive endoscope to characterize sea ice radiative transfer and the brine biophysical system. Current in situ oceanographic nitrate measurements are performed with UV absorption hyperspectral spectroscopy. This conventional instrument is bulky, requires the application of many corrections, has a low limit of detection and involves an optical path of known length which is not compatible with an endoscopic support. This presentation reviews, according to defined specifications, novel optical techniques (DRS, Raman, SERS) to resolve these technical issues and monitor sea ice nitrate dynamics.

THE POLAR DATA CATALOGUE: INCREASING ACCESS TO ARCTIC AND ANTARCTIC DATA

Alix, Gabrielle (1), E. LeDrew (1), C. Ridsdale (1), J. Friddell (1), D. Friddell (1), K. Sudarshanakumar (1) and S. Rochon (1)

(1) Canadian Cryospheric Information Network/Polar Data Catalogue, University of Waterloo, Waterloo, ON, Canada

Accelerated scientific discovery and an expanded understanding of Antarctic, Arctic and Subarctic regions are critical to addressing environmental and social challenges, as these regions are seeing drastic environmental changes earlier than others. By improving public access to cold regions data and information, the Canadian Cryospheric Information Network and Polar Data Catalogue (CCIN/PDC) seek to facilitate advancement in research and knowledge so that societal needs can be effectively addressed. For the last decade, the PDC has been supporting Arctic and Antarctic research programs in Canada and for polar science organizations around the world to archive and serve their data and information products. The PDC serves more than 2.8 million online data files from more than 300 datasets that include over 28,000 RADARSAT satellite images of the Arctic and Antarctic. The datasets and projects are described in the PDC's metadata collection of 2,600 records covering natural, social, and health sciences as well as education, policy and other fields. To enhance the value of the data in our archive for the users, the PDC and CCIN websites showcase a variety of interactive data visualizations to facilitate use and understanding of several collections of data on snow, ice, and marine environment. In 2017, our data visualizations were updated, along with the entire CCIN website, to improve the user experience and to increase the accessibility to specific datasets. In recent years, the CCIN/PDC have been engaged in a variety of projects and activities to make the data in our archive more visible and publicly accessible through adoption of international interoperability standards.

The PDC is currently discoverable through a variety of avenues, including re3data.org and Compute Canada/ Portage Network's Federated Research Data Repository (FRDR). The CCIN/PDC has established a reputation as an international leader in polar data community collaboration, encouraging and coordinating organizations, institutions, and stakeholders from all areas of polar data to improve communication and best practices. In 2015 and 2017, we hosted Canadian Polar Data Workshops to coordinate the polar data community in Canada, develop a governance structure for our community, and produce a position paper which represents the group in advocating for good and consistent data management within the country and with our international partners. We hope to continue this dialogue and hold a 2019 workshop in northern Canada so that more Inuit and other residents, rights holders and stakeholders of northern Canada can freely participate. The CCIN/PDC collaborated with federal agencies on a new document, Data Management Principles and Guidelines for Polar Research and Monitoring in Canada, outlining requirements for researchers funded by several government organizations. This initiative unifies the data management tasks to simplify the work of funded researchers and ensure proper stewardship of the resulting data product. This encourages a culture of ethical data sharing in the research community, furthers scientific innovation, and facilitates access to valuable data products for future generations.

ESTABLISHMENT OF A SURVEILLANCE NETWORK FOR CHARACTERIZING INFLUENZA VIRUS DISTRIBUTION, EVOLUTION AND PATHOGENICITY IN MIGRATORY BIRDS IN THE NORTHERN REGIONS OF CANADA

Auclert, Lisa (1) and G. Wong (1)

(1) Maladies infectieuses et immunitaires, CHU de Québec, Université Laval, Québec, QC, Canada

INTRODUCTION: Avian influenza virus infections can be highly pathogenic to humans with high fatality rates. In 2014, H5N8 was found to have spread from Asia to Europe and the USA. The intercontinental spread of H5N8 from Asia to North America was found to have occurred through Beringia, meaning these birds must have passed through northern Canada before entering the USA. Canada is crossed by 4 flyways of migratory birds, and these birds are known to be a potential source of highly pathogenic viruses. Indeed, influenza viruses are able to evolve in asymptomatic carrier birds by single nucleotide polymorphism and rearrangement of influenza virus segments of RNA. Surveillance of circulating viruses in migratory birds in northern Canada is essential to provide the earliest warning against a potential influx of highly pathogenic influenza. Predictions on how viruses are circulating through birds are essential to evaluate the risk of widespread diffusion and to provide information for pandemic preparedness surveillance. Knowing which viruses are a threat for humans will allow for the development of suitable antiviral drugs and vaccines. OBJECTIVES: The main goal of the research project will be to establish a surveillance network in order to determine the distribution, evolution and pathogenicity of influenza viruses in migratory birds in northern Canada (Yukon, Northwest Territories, Nunavut and northern Quebec). In particular, we have to determine strategic sampling sites (easy to access, near large lakes and human settlements), implement collaborations with bird studying scientists (we already have contacted the researchers Gilles Gauthier, Jim Leafloor, Jean Rodrigue and Josée Lefebvre who band birds and could participate to this project and gather samples from geese at 7 sampling points in the Northwest Territories, Nunavut and Nunavik. We still need collaborators for Yukon and Northwest Territories samplings). We want to collect cloacal and nasopharyngeal swabs from apparently healthy wild birds including wild ducks, geese, swans, gulls. Environmental samples, and if available, the major organs from wild birds that could have died from AIV infections will also be collected. Then we will characterize in the lab the viruses sampled via PCRs and genome sequencing to find out potential mutations which may change pathogenicity, transmissibility, or confer resistance to anti-influenza drugs in the strains collected. We will analyze and chart the evolution of the viruses and their origins and be able to estimate, with the collaboration of Gilles Gauthier (Université Laval), through bird populations analysis, the survival rate of influenza viruses infected birds compared to uninfected birds. We will also evaluate the effects of these mutations in cell culture to chart viral kinetic growth and for the mutations suspected to impact virulence, viruses can also be tested in mice (assessing survival, time to death, clinical signs, or viral loads). CONCLUSION: In conclusion, we hope to get a spatial and temporal map of influenza viruses in northern Canada and are willing to find collaborators interested in emerging viruses. Indeed, the network, once settled, doesn't have to be restricted to influenza viruses and our samplings could reveal other risky pathogens present in northern Canada.

NOVEL "SENSOR-IN-FIBRE" OPTICAL PROBES FOR MOLECULAR SENSING IN THE GASTRO-INTESTINAL TRACT OF MURINE MODELS OF CARDIOMETABOLIC DISEASES

Azzi, Victor (1,2), A. Grégoire (1), J.P. Bérubé (1), J. Lapointe (1), A. Sepulveda (1,2), R. Vallée (1), A. Marette (2) and D. Boudreau (1)

(1) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada
(2) Institut universitaire de cardiologie et de pneumologie de Québec, Université Laval, Québec, QC, Canada

Obesity and cardiometabolic diseases (CMD) are major public health issues throughout the world and of greater magnitude among Canada's northern populations. It is believed that the exponential rise in CMD incidence is due to numerous environmental factors, including excessive intake of unhealthy foods, which are driving important changes in the gut microbiome. This microbial community that populates our intestinal tract plays a key role in nutrient and energy absorption but can also drive pathogenic mechanisms of CMD when its interaction with the host is disrupted. This new understanding has recently highlighted the lack of predictive tools and biomarkers for rapid and efficient diagnostics of many chronic diseases within the medical field. Current analysis of the gut microbiota is mostly based on time- and cost-consuming sequencing technologies to determine microbial composition and gene expression, while functional analyses are limited to plasma and stool metabolites, which are surrogate markers of gastro-intestinal microbial activities. The goal of this study is to develop a "Sensor-in-Fibre" intestinal probe with the capacity to detect key microbiome-derived molecules in real-time in vivo, thus permitting rapid and cost-effective monitoring of host-bacteria interactions relevant to CMD pathogenesis. Unlike most traditional fibre-based sensors, the optical probe takes advantage of evanescent fields generated on its peripheral interface to interact with elements in its vicinity. This field can be used to excite species-selective surface-grafted sensing nanomaterials that have varying fluorescent properties based on their surrounding environment. The light emitted by these sensors in response to the presence of the targeted molecules can be coupled back into the fibre and efficiently transmitted to appropriate detectors. As a model system, we grafted fluorescein isothiocyanate (FITC) functionalized with aminopropyltriethoxysilane (APS) on a biologically relevant sensing length of the fibre. This sensing material provided a proof-of-concept for the use of this technology through appropriate spectral responses as a result of variations in the surrounding fluid's pH. In time, this multichannel fibre architecture will be combined with fluorescent sensing structures responsive to various microbial molecules, hence making this a flexible tool for sensing the intestinal microbiome with unprecedented space-time resolution.

TOWARDS A PORTABLE MICRO-CYTOMETER FOR THE QUANTIFICATION OF PICOPLANKTON IN NORTHERN LAKES AND SEAS

Bansept, Marc-Antoine (1,3), W.F. Vincent (1,2) and D. Boudreau (1,3)

(1) Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Québec, QC, Canada
(3) Centre d'optique, photonique et lasers, Québec, QC, Canada

The planktonic microbiome, the ensemble of microbes in natural waters and their functions, is at the base of aquatic food webs and biogeochemical cycles. Just as we now realize that the functioning of the 'human microbiome' plays a major role in human health, the planktonic microbiome controls the healthy functioning of aquatic ecosystems. It is composed of bacteria, archaea, coloured (phytoplankton) and non-coloured protists, and viruses. One of the major groups of microbes in northern waters is picophytoplankton, especially picocyanobacteria in Arctic lakes and rivers, and coloured picoeukaryotes in the Arctic Ocean. For many years, populations of these autotrophic organisms have been assessed by flow cytometry using the intrinsic fluorescence of their photosynthetic pigments in combination with genomic analysis. This flow cytometer measures the optical properties of individual cells, which in turns makes it possible to identify sub-populations within a sample. This information can then be used to produce a limnological or oceanographic profile of the studied environment. Although flow cytometers have been used in field campaigns, these instruments are generally expensive and are optimized for medical laboratories rather than environmental applications. Furthermore, they require a precise optical alignment thus making their tolerance to harsh field conditions limited. To counter this, scientists have resorted to freezing samples for analysis, several thousands of kilometers down south. These manipulations produce obvious practical challenges, can results in erroneous estimates, and limit the researcher's ability to obtain an instantaneous assessment of the microbiota in the environment being studied. Hence, this project,

as a part of Sentinel North 3.1 aims at developing a portable instrument for the quantification of picoplankton in northern environments by flow cytometry. To achieve this goal, a new technology using holographic spatial encoding which allows for multiplexed, single detector, measurement s of fluorescence from different photosynthetic pigments has been applied. Furthermore, an approach to on-chip 3D hydrodynamic focusing, an essential component for signal standardization in flow cytometry, has been made based on Dean vortices, with progress towards a fully integrated micro-flow cytometer system. The proposed design reduces weight and volume, and it eliminates the troublesome need for optical alignment in order to provide a robust instrument for northern field research.

FINE-SCALE HABITAT SELECTION OF FEMALE CARIBOU IN SUMMER, USING CAMERA COLLARS

Béland, Sophiane (1,2), M. Bernier (3), and S. D. Côté (1,2)

(1) Département de biologie, Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(3) Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada

Migratory caribou (*Rangifer tarandus*) is a socioeconomically and culturally important species for Quebec, and its populations are experiencing a sharp decline. Although these caribou herds have been studied for several years, our knowledge of the amount of habitat that must be protected to ensure the persistence of these populations is limited. In this context, the study of habitat selection is a useful tool because it makes it possible to determine the distribution of individuals or populations in a heterogeneous environment and to characterize the habitats and resources they use. For migratory caribou, it is known that females are directly dependent on the availability of summer habitat resources given the very high costs associated with lactation, but also the need to accumulate reserves for other seasons, when resources are less abundant. However, we do not know how these females select the resources and the different habitats at a fine spatial scale. This is what will be determined in this project with the objective of evaluating the summer habitat selection (June to September) of caribou females in the Rivière-aux-Feuilles herd at a fine spatial scale. Specifically, we will focus on habitat selection at the feeding sites. We will also evaluate the effects of environmental variables such as temperature and wind, as well as the effects of insect harassment, on female habitat selection. To do this, we will use camera collars that capture the images in front of the animal equipped with such a collar. This project will provide us with information on the selection of summer habitat by female caribou at a fine spatial scale, which will contribute to the management and conservation of the migratory caribou and its habitats.

DEVELOPMENT OF TOOLS MEASURING CHANGES IN MOVEMENT COORDINATION AND NEUROMUSCULAR FATIGUE IN THE REAL ENVIRONMENT: A PRELIMINARY STUDY

Bielmann, Mathieu (1,2), J.S. Roy (1,2) and L. Bouyer (1,2)

(1) Center for Interdisciplinary Research in Rehabilitation and Social Integration, Québec, QC, Canada
(2) Département de réadaptation, Université Laval, Québec, QC, Canada

BACKGROUND: In the context of Sentinel North project 2.8: "Development, implementation and use of miniature portable technologies for the prevention, assessment and treatment of chronic diseases in northern areas", an important challenge is to have the ability to measure the risk of development of musculoskeletal injuries in northern workers. The prevalence of musculoskeletal disorders increases when performing non-optimal movements induced by the development of muscular fatigue (awkward posture, and repetitive movement). Our general hypothesis is that continuous monitoring during activities of daily living (including at the workplace) with portable technologies to measure movement quality and muscle fatigue would be an effective means to help reduce such risks. Few portable data acquisition systems currently allow continuous recording of muscular effort and related movements. Furthermore, the reliable detection of fatigue during complex movements is very challenging and few data processing methods have been validated to date. The objective of the current study was therefore to adapt quantitative laboratory methods to measure the development of muscle fatigue and changes in movement coordination "outside of the lab". More specifically, this work focused on 2 indicators, a drop in Median Frequency of the power spectrum of surface electromyography and a drop-in movement patterns coherence, as means of

measuring muscle fatigue/movement quality in real time during gait. METHODS: 30 healthy participants performed a 6-minute walk test before and after completing a muscle fatigue protocol consisting of repetitive ankle dorsiflexions to the pace of a metronome. Muscle fatigue was quantified by a decrease in the median frequency of the power spectrum of electromyographic activity (EMG) in the muscles targeted by the exercise of fatigue, recorded during gait using wireless EMG amplifiers (Delsys Trigno). Other lowerlimb muscles were also recorded as a control. Degradation in the kinematic walking pattern was also measured, using an algorithm of cross correlation between a template of joint angular excursions (created from 30 to 60 baseline strides) and individual gait cycles. RESULTS: A significant drop in median frequency (25 ± 8%; $p<0.05$) post fatigue exercise was observed specifically in the fatigued muscles. A significant degradation of the kinematic walking pattern was also observed at the ankle post fatigue ($p<0.05$). CONCLUSION: The use of wearable sensors and the adaptation of laboratory analysis methods, such as falls in EMG median frequency and decreases in kinematic walking pattern coherence can be an efficient approach to detect small reductions in movement quality and the onset of muscle fatigue "outside of the laboratory". ACKNOWLEDGEMENTS: This work was supported by Sentinel North.

MICROBIOME GRADIENTS AND IMPLICATIONS FOR GREENHOUSE GAS CYCLING IN A HIGH LATITUDE RIVER: THE GREAT WHALE RIVER, NUNAVIK, CANADA

Blais, Marie-Amélie (1), A. Matveev (1), M.-A. Bansept (2), D. Boudreau (2) and W.F. Vincent (1)

(1) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(2) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

Watersheds of Arctic and Subarctic rivers are undergoing profound transformations in response to climate change and the associated impacts such as shifting hydrological patterns, permafrost thawing and changes in vegetation. One of the consequences of these landscape changes is that a large pool of organic carbon is becoming more available, however its ultimate fate is uncertain. Rivers are likely to play a substantial role in transportation and transformation of carbon, from terrestrial to marine ecosystems, and in the emission of greenhouse gases in the atmosphere. Microbial activities dominate these biogeochemical processes, but microbiome structure and function are still poorly understood in river ecosystems in general, and particularly at high latitudes. This project aims to gain an improved understanding of carbon biogeochemistry of the Great Whale River, a large Subarctic river discharging into southeastern Hudson Bay. The watershed of this river is characterized by heterogeneous landscapes, including sporadic permafrost areas in an advanced stage of thawing and erosion. We will apply flow cytometry to characterize the gradients in microbial cell concentrations along this river, including the application of a novel multimodal microfluidic system under development by Sentinel North. We will combine these measurements with molecular and pigment analysis of the microbiome, and measure the carbon dioxide concentrations and fluxes across physico-chemical gradients, including across the freshwater-saltwater transition zone. The information gained during this project will yield valuable new insights into how higher latitude river ecosystems will respond to the ongoing transformation of their watersheds in the warming northern climate.

PATHOPHYSIOLOGICAL MODULATION OF ASTHMA BY SPHINGOLIPIDS

Blais Lecours, Pascale (1) and D. Marsolais (1,2)

(1) Centre de recherche de l'institut universitaire de cardiologie et de pneumologie de Québec, Québec, QC, Canada
(2) Faculté de médecine, Université Laval, Québec, QC, Canada

INTRODUCTION: Asthma is a chronic airway pathology characterized by inflammation, airway hyperresponsiveness and airway remodeling. Genetic factors and environmental conditions, including hygiene and nutrition, can contribute to the inception, but also the prevention of this complex syndrome. Genes regulating metabolism of sphingolipids, which are bioactive lipids known to have beneficial impacts on inflammatory pathologies, have been strongly associated with asthma. OBJECTIVE: In view of the de-traditionalization of nutritional intake of northern populations, which likely results in modified intakes of sphingolipids, the goal of this study is to elucidate if the deregulation of sphingolipid metabolism impacts at different stages of asthma pathogenesis. METHODS: We used a genetic mice model that mimics increased circulating levels of sphingosine-

1-phosphate (S1P), i.e. sphingosine kinase 2 (SPHK2) knock out mice, in acute and chronic allergic asthma models induced by house dust mite (HDM), an allergen that is routinely found in homes. After 10 days or 5 weeks of exposure to this allergen, we quantified inflammatory cells in bronchoalveolar lavage and measured respiratory functions using the FlexiVent apparatus in wild type and SPHK2 KO mice. As a control, we used mice lacking sphingosine kinase 1 (SPHK1) that don't have modified circulating S1P. RESULTS: We showed that mice lacking the enzyme SPHK2 present mild increase of Th2 inflammation markers compared to wild type mice, after 10 days of HDM exposure. However, SPHK2 deletion leads to a 50% reduction of airway resistance to methacholine after 5 weeks of antigenic exposure, which was not observed in SPHK1 KO mice. CONCLUSION: These results highlight the potential association between sphingolipid levels and the pathogenesis of asthma, and suggest that conditions favoring increased S1P might yield protection.

OPTOGENETIC MODEL TO INVESTIGATE THE IMPACT OF THE MICROBIOTA ON THE DEVELOPMENT AND FUNCTION OF DOPAMINERGIC CIRCUITS

Boily, Vincent (1), T. Herzog (1), C. Salesse (1), M. Lévesque (1,2) and P. De Koninck (1,3)

(1) CERVO Brain Research Centre, Québec, QC, Canada
(2) Département de psychiatrie et de neurosciences, Faculté de médecine, Université Laval, Québec, QC, Canada
(3) Département de biochimie, microbiologie et bio-informatique, Université Laval, Faculté des sciences et de génie, Université Laval, Québec, QC, Canada

It is becoming widely accepted that the intestinal microorganisms hosted by humans and other vertebrates play a central role in maintaining their hosts in healthy conditions. When the host encounters a physiological stress, the microbiota ecosystem equilibrium is broken. This dysbiosis allows opportunistic microbial strains to induce negative effects on the host, including physiological disturbances on neuroendocrine functions and epigenetics modifications and may induce irreversible consequences on brain development and neural function, affecting mental health. Understanding this impact should provide important insight on the developmental factors that affect mental health. Dopaminergic circuits in the mid-brain are involved in motor function, rewards, attention and stress with a critical importance on mental health. In addition to genetic factors that regulate the development of these circuits, the dopaminergic system is highly susceptible to environmental developmental stressors, which may in turn have important consequences on stress response, attention and motor activity. The aim of this project is to investigate the impact of the microbiota on the development and function of the dopaminergic system. The characterization of host-microbiota interactions and their impacts requires the development of models and tools in the laboratory with which we can precisely control the relevant variables in their environment. The zebrafish is an ideal model because it offers many advantages: 1) several genetically controlled lines are available and can be easily generated; 2) its rapid and external development allows a longitudinal follow-up; and, 3) its transparency during the first 2 weeks of life allows unparalleled microscopic observations and offers an opportunity for optogenetic control of development. Using advanced optical microscopy, we will establish zebrafish dopaminergic development models to monitor synapse formation, axonal and dendritic growth, and circuit connectivity. In addition, we will examine the temporal correlations of Ca2+ oscillations across dopaminergic pathways with in vivo multiphoton calcium imaging. The identified morphological and functional developmental markers will be used to identify any changes in dopaminergic development in response to manipulation of the microbiota. The growth of characterized probiotic or opportunistic bacterial strains will be controllable in the fish intestine, either with optogenetics (using light-activatable CRISPR-CAS9 system), bacteriophages, or prebiotics after inoculation of axenic fish lines. We expect to observe negative impacts on the development of dopaminergic neurons exposed to environmental stress, effects that would be attenuated by the presence of probiotic strains in the fish guts. Learning more on the impact of the microbiota and environmental stress on circuit development and function may provide useful data to be translatable to human health.

HYDROGEOPHYSICS OF PERMAFROST MOUNDS IN NUNAVIK (QUEBEC) AND RELIC TRACES OF PERMAFROST DEGRADATION IN AQUITAINE (FRANCE) – AN ANALOG STUDY TO UNDERSTAND THE PALEO-RECHARGE OF REGIONAL AQUIFERS IN THE AQUITAINE SEDIMENTARY BASIN

Bussière, Léa (1,2,3), A. Dupuy (2), R. Fortier (1,3), JM. Lemieux (1,3) and M. Schmutz (2)

(1) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(2) EA 4592 Géoressources & Environnement, Pessac, France
(3) Département de géologie et de génie géologique, Université Laval, Québec, QC, Canada.

The Aquitaine region (France) is a large sedimentary basin containing regional multi-layer aquifers used for drinking water supply. During the Pleistocene, this region has been affected by a succession of climate changes due to the global glacial cycles which have influenced the groundwater recharge of these aquifers. Based on evidence from the geochemistry of groundwater, the low recharge during the Last Glacial Maximum (LGM - 20 000 years ago) may be due to permafrost limiting the water infiltration. According to the paleo-climatic reconstructions available for the Aquitaine region during the LGM, a periglacial environment, with possibly associated discontinuous permafrost, was occurring at that time. Moreover, in the recharge areas of the Aquitaine region, the land surface currently hosts numerous circular ponds with morphology similar to the thermokarst ponds, which are remnants of ice-rich permafrost mounds characteristic of permafrost environments after degradation, found in the discontinuous permafrost zone in Nunavik (Quebec), Canada. One of the hypotheses in regard to the origin of these circular ponds is that they are due to permafrost degradation in this periglacial environment in the Aquitaine region following climate warming at the end of the LGM and leaving relic traces under the form of thermokarst ponds. Since the current climate in Nunavik, is similar to one severing in the Aquitaine region during the LGM, the degrading permafrost and related thermokarst ponds in Nunavik can be used as analogs for the Aquitaine ponds. Therefore, the objective of this study is to test the thermokarst origin of the Aquitaine ponds with a comparative analysis with the thermokarst ponds found in Nunavik. The Umiujaq area has been selected since degrading ice-rich permafrost mounds and thermokarst ponds due to the current trend to climate warming affecting Nunavik are abundant and it is located in the discontinuous permafrost zone similar to one expected in the Aquitaine region during the LGM. A second objective is to understand groundwater recharge dynamics in the discontinuous permafrost environment of Umiujaq in order to better understand the groundwater recharge dynamics that occurred during the LGM in the Aquitaine regional aquifers. And, finally, this comparative study between these Aquitaine and Nunavik ponds will allow us to better understand the consequences of the freeze-thaw processes occurring in the discontinuous permafrost zone on the hydrogeologic fluxes between surface and groundwater.

DEVELOPMENT OF TOOLS FOR THE CONTROL OF BACTERIAL POPULATIONS IN ZEBRAFISH SYNTHETIC GUT MICROBIOTA

Byatt, Gabriel (1,2,3), M. Dion (1,3), A. Lévesque (1,3), M.-E. Paquet (2,3) and S. Moineau (1,3)

(1) Groupe de recherche en écologie buccale, Université Laval, Québec, QC, Canada
(2) CERVO Brain Research Centre, Université Laval, Québec, QC, Canada
(3) Département de biochimie, de microbiologie et de bio-informatique, Faculté des sciences et de génie, Université Laval, Québec, QC, Canada

Microorganisms found in the intestinal tract have a great influence on host health. These combinations of microbes, called the gut microbiota, can have beneficial or negative impact on host health. Dysbiosis, for example, is an imbalance in the population of the gut microflora. Recently, studies have demonstrated that these changes in the microbiota may even have an impact on brain development. In fact, specific bacterial populations were found in the gut of people with mental illnesses. To understand the gut-brain axis, we must develop new tools to observe these changes in the gut microbiota. By analysing the roles of bacteria in the development of a mental illnesses, it will be easier to develop novel ways to prevent, contain or maybe even cure some of these illnesses. To observe the effects of the microbiota on the brain, a synthetic microbiota will first be implanted in the gut of zebrafish, a model animal for brain development. Then, variations of the bacterial populations will be induced through various means and the impact of these variations on the development of the zebrafish will be monitored. The first tool will be developed with phages (viruses infecting bacteria). These phages are highly specific and attack only specific strains of bacteria. It will

be possible to target a bacterial population that we want to eliminate from a microbiota. As such, specific phages lethal to the bacteria must be isolated and integrated into to the gut flora. Prior to administrating phages, we must make sure that the selected phages are specific and they don't attack any other bacterial strains found in the microbiota and that the targeted bacteria do not readily develop phage resistance. In vitro assays are underway to select the most promising virulent phages. The second tool to be developed will be a photo-activable CRISPR-Cas9. CRISPR-Cas9 is a genome editing tool used to cut genomic DNA at a specific location. The Cas9 nuclease is guided to its dsDNA target by a sequence-specific guide RNA (gRNA). To control a specific bacterial population, the CRISPR-Cas9 tool will be engineered to target an essential bacterial gene. Upon its activation by light, at a specific wavelength, the CRISPR-Cas9 system with cut the bacterial genome leading to its death. By precisely controlling the bacterial gut microbiota, we hope to better understand the microbial dynamics and its links with brain development.

THE FAITH OF PERSISTENT ORGANIC POLLUTANTS DURING WEIGHT LOSS: IS THERE A PROTECTIVE ROLE FOR THE GUT MICROBIOME?

Choi, Béatrice S.-Y. (1,2), L. Daoust (1,2), T. Varin (2), G. Pilon (1,2), P. St-Pierre (1,2), A. Tremblay (1,2,3) and A. Marette (1,2,4)

(1) Institut universitaire de cardiologie et de pneumologie de Québec, Université Laval, Québec, QC, Canada
(2) Institut des nutraceutiques et des aliments fonctionnels, Université Laval, Québec, QC, Canada
(3) Département de kinésiologie, Université Laval, Québec, QC, Canada
(4) Département de médecine, Université Laval, Québec, QC, Canada

The dramatic increase in the global occurrence of obesity and associated cardiometabolic diseases (CMD), especially in northern populations worldwide, calls for new strategies to promote weight loss. However, while the beneficial effects of weight loss are well known, they often do not take into consideration the fate of liposoluble molecules such as persistent organic pollutants (POPs) that have been shown to increase in the circulation of obese subjects after weight loss. Throughout the years, pollutants classified as POPs have been used in a variety of products, such as insecticides, flame-retardants, coolant fluids and occasionally released as by-products by the industry. While nowadays POPs are mostly banned or highly regulated, they are still widely present in the environment due to their persistent nature. Their high solubility in lipids gives them the ability to accumulate in adipose tissue and, given their long half-life (e.g. months to years), they can remain stocked for decades once they are absorbed. Hence, bioaccumulation of these pollutants along the food chain makes humans prone to an increased exposure to POPs throughout their lifetime, given that our main exposition is through ingestion of contaminated food, such as fatty fish. Because northern communities have a traditional diet consisting of large amounts of fatty marine products (e.g. fish, seal and whales), they are considered especially at risk for POP accumulation and their devastating consequences on cardiometabolic health. Indeed, these pollutants are known to be endocrine disruptors and can contribute not only to CMD but also to the development of certain types of cancer and impairing the reproductive system. POPs may exert some of these detrimental effects through perturbations of the gut microbiota, e.g. the community of microorganisms living in our digestive system, which is known to represent a key player in the development of CMD, cancer and reproductive dysfunction. Additionally, POPs are known to induce epigenetic changes that can be transmitted through several generations and can predispose offsprings to metabolic problems. Unfortunately, no treatments are known to counteract the detrimental effects of these contaminants. It has recently been suggested that prebiotics and probiotics may help reduce the disruptive actions of POPs, possibly through their impact on the gut microbiota, leading to reduced absorption, enhanced degradation or by releasing microbial metabolites than can dampen their actions on metabolic targets. We propose that prebiotics and probiotics can positively modulate the gut microbiota and enhance the abundance of bacteria that are beneficial for our health, and that may also exhibit a POP detoxifying effect. Studies are underway using cranberry extracts that exert major prebiotic effects on the gut microbiota to test whether they can protect against the adverse effects of POPs on CVD in animal models. Such studies may help us discover a novel means to prevent the epigenetic effects of POPs and thus prevent the predisposition of future generations to CMD.

FAST WHOLE MOUSE BRAIN IMAGING USING HILO TECHNIQUE ON A WIDE-FIELD FLUORESCENCE MICROSCOPE

Côté, François (1,2,3), C. Gora (1), M. Lévesque (1,3) and D. C. Côté (1,2,3)

(1) Cervo Brain Research Centre, Québec, QC, Canada,
(2) Centre d'optique, photonique et Laser, Québec, QC, Canada
(3) Université Laval, Québec, QC, Canada

Imaging whole mouse brains can provide a wealth of information for understanding neuronal development at both the microscopic and macroscopic scale. Furthermore, visualizing entire brain samples allows us to better conceptualize how different diseases affect the brain as a whole, rather than only investigating a certain structure. Currently, two main challenges exist in achieving whole mouse brain imaging: 1) Long image acquisition sessions (on the order of several hours) and 2) Big data creation and management due to the large, high resolution image volumes created. To overcome these challenges, we present a fast 1-photon system with a slightly decreased resolution allowing for whole brain, optically sectioned imaging on the order of minutes by using a mathematical algorithm termed "HiLo". Our large field of view (1 square centimeter) allows us to see an entire newborn mouse brain in a single snapshot with a resolution of about 5 µm in lateral direction. This resolution still allows for visualization of cells and some large axonal projections. This technological advancement will first and foremost allow us to rapidly image large volume samples and store them in a smaller format without losing the integral information, which is mainly stained-cell quantity and location. Secondly, the design will allow for increased successful high-resolution imaging by screening for well stained samples before commencing their multi-hour acquisitions. Lastly, since the microscope has a large field of view and does not require collection objectives needed in 2-photon high resolution microscopes, we can use this device to image expansion microscopy (a technique which can grow samples while keeping their structural integrity) samples as they are quickly gaining interest in the biological field. To give an idea a mouse expanded brain is often larger than a golf ball.

LATE QUATERNARY PATTERNS OF DEGLACIATION IN CLYDE INLET, EASTERN BAFFIN ISLAND (ARCTIC CANADA)

Couette, Pierre-Olivier (1), P. Lajeunesse (1), B. Dorschel (2), E. Brouard (1), C. Gebhardt (2) and J.-F. Ghienne (3)

(1) Centre d'études nordiques & Département de géographie, Université Laval, Québec, QC, Canada
(2) Alfred Wegener Institute (AWI) Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
(3) Institut de Physique du Globe de Strasbourg (IPGS), UMR 7516 CNRS - Université de Strasbourg/EOST, Strasbourg, France

The maximum extent of the Laurentide Ice Sheet (LIS) on eastern Baffin Island has been widely debated during the last decades as different palaeoglaciological models have been proposed, ranging from a single-domed ice sheet extending beyond the shelf break to an ice sheet margin barely reaching the head of the fjords. Spatial and temporal variability of ice sheet extension on eastern Baffin Island during Quaternary glaciations complicates the establishment of a reliable reconstruction of the ice margin. Furthermore, the lack of geophysical data in most of the fjords, and seaward, makes it difficult to reconcile the proposed terrestrial and marine glacial margins at the Last Glacial Maximum (LGM). Here we use high-resolution swath bathymetry imagery combined with acoustic stratigraphy data collected during various oceanographic expeditions of the RV Maria S. Merian, CCGS *Amundsen* and RV Nuliajuk to: (1) define the maximum extent of the LIS margin in Clyde Trough during the LGM; (2) reconstruct ice-flow variations and glacial dynamics while the ice retreated on the shelf and in Clyde Inlet; and (3) identify phases of stillstand and/or readvance during deglaciation of the sector. Geomorphological mapping of Clyde Inlet and its adjacent continental shelf allowed for the identification of subglacial landforms, such as crag-and-tails and mega-scale glacial lineations (MSGLs), which are indicators of fast-flowing ice (i.e., ice streams). The swath bathymetry imagery also allowed for delineating four grounding-zone wedges (GZWs) in the trough, indicating positions of stability of LIS margins during the LGM and early deglaciation. Several moraines observed in the fjord suggest that ice retreat occurred by steps in a less catastrophic way than previously proposed. The data show five different moraine systems in Clyde Inlet. Sediments cores collected during the summer of 2017 will provide additional insight on the deglacial history and processes on eastern Baffin Island.

HARSH WINTER CONDITIONS IN QUEBEC LEAD TO DRAMATIC CHANGES IN RIVERINE BACTERIAL COMMUNITIES

Cruaud, Perrine (1, 2, 3), A. Vigneron (1), C. Dorea (3, 6), A. Culley (1, 2, 7), M. Rodriguez (5, 8) and S. Charette (1, 2, 4)

(1) Institut de biologie intégrative et des systèmes, Université Laval, Québec, QC, Canada
(2) Département de biochimie, de microbiologie et de bio-informatique, Faculté des sciences et de génie, Université Laval, Québec, QC, Canada
(3) Département de génie civil et de génie des eaux, Université Laval, Québec, QC, Canada
(4) Centre de recherche de l'institut universitaire de cardiologie et de pneumologie de Québec, Québec, QC, Canada
(5) École supérieure d'aménagement du territoire et de développement régional, Université Laval, Québec, QC, Canada
(6) Department of Civil Engineering, University of Victoria, Victoria, BC, Canada
(7) Groupe de recherche en écologie buccale , Faculté de médecine dentaire, Université Laval, Québec, QC, Canada
(8) Centre de recherche en aménagement et développement, Université Laval, Québec, QC, Canada

Bacteria are key players of biogeochemical cycles and control water quality in freshwater ecosystems such as lakes and river. Despite this, little is known about the identity and ecology of riverine bacteria. This lack of knowledge is particularly true for ice-covered periods as a result of the traditional view of ecosystems subjected to low temperature are characterized by negligible biological processes. Here we present a 2-year sampling campaign covering the main source of drinking water for Quebec City (Canada), the Saint-Charles river. As a large number of lakes and rivers, particularly those situated at high altitude and high-latitude in the temperate and boreal climate zones, the Saint-Charles river and its source, the Saint-Charles lake, are seasonally covered by ice for much of the year. In this study, the Saint-Charles river has been sampled weekly or once every two weeks to assess the effects of environmental conditions on planktonic bacterial community structure and diversity. Analysis of microbial communities from 16S rRNA Illumina sequencing showed strong seasonal differences within community composition. While bacterial communities during the ice-free period were dominated by typical freshwater microorganisms such as *Limnohabitans* (Betaproteobacteria), Sportichthyaceae hgcI clade (Actinobacteria) or *Pseudarcicella* (Bacteroidetes), potential methanotrophic Gammaproteobacteria, such as Crenothrix (up to 14% of the total bacterial population) or Methylobacter (up to 11%), and Parcubacteria (formerly known as Candidate division OD1 - up to 9%) contributed greatly to the composition of bacterial communities during the cold season. Our results suggest that the lower temperatures in the cold season combined with other prevailing conditions such as minimal inputs of phytoplankton-derived organic substrates could be a conducive environment for methanotrophs, acting as potential biofilter for methane release to the atmosphere, while other bacteria seem to be less competitive. This study contributes to better understand how frozen rivers interact with the rest of the biosphere and how seasonal freshwater dynamics may change in the future with significantly altered freezing and thawing patterns due to climate change.

MONITORING THE PHYSICAL CHANGES IN PERMAFROST ENVIRONMENTS VIA A DISTRIBUTED FIBRE-OPTIC SENSING SYSTEM

Cui, Long (1,3,5), R. Wang (1,3,5), C. Lemieux (4,5), Y. Messaddeq (2,3,5), G. Doré (4,5) and S. LaRochelle (1,3,5)

(1) Département de genie électrique et de génie informatique, Université Laval, Québec, QC, Canada
(2) Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada
(3) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada
(4) Département de génie civil et de génie des eaux, Université Laval, Québec QC, Canada
(5) Sentinelle Nord, Université Laval, Québec, QC, Canada

Permafrost systems in northern Canada are strongly disturbed by the warming climate; the thawing permafrost is in turn affecting the northern environments and communities. This project is focused on developing a sensor network to monitor physical changes in the soil that affect the stability of infrastructures. More specifically, the system will perform real-time measurement of pore-water pressure, temperature and displacement, in permafrost environments. We propose to use a distributed fibre-optic sensing system, based on Brillouin Optical Time-Domain Analysis (BOTDA) employing stimulated Brillouin scattering (SBS), for distributed sensing of those physical parameters. Compared to the existing point sensors, such

as Fibre Bragg Gratings (FBGs) or interferometers, the proposed approach can provide continuous measurement along the entire length of a fibre with high spatial resolution and sensitivity over a long range. This target system's specifications are to simultaneously detect several parameters in the range of -100 kpa to +100 kpa for pore-water pressure, -10 to +10 °C for temperature, and about 10 cm for displacement; with an objective of 5 cm in terms of spatial resolution. We are working to design a fibre transducer that will monitor both negative and positive pore-water pressures depending on the water level in permafrost, which is not currently available with existing sensors. One of main challenges for this technique is the appropriate discrimination among these physical parameters within a single transducer. This could be resolved by deploying a novel transducer with well-designed multi-core fibers or other specialty fibre designs for simultaneous multi-parameter sensing as our ultimate goal.

PROJET D'OPTIMISATION DES PARAMÈTRES DE LA QUALITÉ DE L'AIR INTÉRIEUR (QAI) DANS LES HABITATIONS DU NUNAVIK ET SON IMPACT SUR LA SANTÉ RESPIRATOIRE DES OCCUPANTS (PROJET VENT-NUNAVIK) : VOLET MICROBIOLOGIQUE

Degois, Jodelle (1,2), M. Veillette (2), P. Poulin (3), B. Lévesque (3), D. Aubin (4), B. Ouazia (4), L.-P. Boulet (2), F. Maltais (2) et C. Duchaine (1,2)

(1) Département de biochimie, microbiologie et bio-informatique, Université Laval, Québec, QC, Canada
(2) Institut universitaire de cardiologie et de pneumologie de Québec, Université Laval, Québec, QC, Canada
(3) Direction de la santé environnementale et de la toxicologie, Institut national de santé publique du Québec, Québec, QC, Canada
(4) Construction, Conseil national de recherches Canada, Ottawa, ON, Canada

Le Conseil National de recherche du Canada (CNRC) en collaboration avec l'Institut national de santé publique du Québec (INSPQ), les facultés des sciences et génie et de médecine de l'Université Laval, la Société d'Habitation du Québec (SHQ), la Direction de santé publique du Nunavik et l'Office municipal d'habitation Kativik (OMHK) mènent une étude portant sur la ventilation dans des habitations du Nunavik, ses retombées sur la qualité de l'air intérieur (QAI) et la santé respiratoire des enfants. L'objectif principal du projet de recherche interdisciplinaire est d'évaluer l'impact de l'optimisation des dispositifs de ventilation sur la QAI et les bénéfices sanitaires potentiels pour les occupants, dont les jeunes enfants, dans des habitations du Nunavik. De façon plus spécifique, l'étude vise à comparer deux groupes logements abritant au moins un enfant de 10 ans et moins avec des systèmes de ventilation différents (avec récupération de chaleur [n = 17] ou d'énergie [n = 24]) et un autre groupe de 15 logements dépourvus de système de ventilation (ntot = 56). Deux campagnes de mesures de la qualité de l'air (débits d'air, renouvellement d'air, CO, CO2, COV, aldéhydes, PM10, PM2.5, humidité relative, température, charge microbienne totale, endotoxine) ont été effectuées au cours de la saison hivernale 2018. Entre ces deux campagnes d'échantillonnage, des travaux d'optimisation (fournaises, échangeurs d'air, systèmes d'extraction) ont été appliqués pour améliorer la qualité de l'air dans les deux premiers groupes de logements. Les variables en lien avec la qualité de l'air seront comparées avant et après l'optimisation. On vérifiera la présence de consultations pour infections respiratoires et asthme dans les dossiers médicaux des enfants de moins de 10 ans pour une période allant de deux ans avant l'optimisation jusqu'à un an après les modifications réalisées. À terme, les résultats de cette étude visent à identifier les meilleures pratiques pouvant être appliquées au milieu de l'habitation nordique au regard de l'amélioration de la QAI, dans un souci d'efficacité énergétique. Pour l'exposition humaine aux bioaérosols, des échantillons d'air et de poussières sédimentées ont été récoltés dans les logements investigués avant et après l'intervention. Les prélèvements ont été effectués à l'aide d'un échantillonneur SASS 3100 (20m3 d'air intérieur à un débit de 300 L/min) et d'un micro-aspirateur (méthode ASTM D7144 appliqués sur une superficie de 225 cm2 à un débit d'aspiration de 15L/min). La biodiversité bactérienne et fongique sera évaluée par le biais de techniques de séquençage de nouvelle génération et de PCR quantitatifs alors que le dosage d'endotoxines et de glucans seront effectués dans les échantillons de poussières sédimentées grâce à la technique de LAL cinétique. Les analyses seront effectuées au cours de l'été 2018 et les résultats seront ultérieurement croisés avec les différentes variables environnementales et comportementales pertinentes documentées par le biais de formulaires d'inspection et de questionnaires. Ce volet permettra de caractériser le microbiote de l'air intérieur d'habitations du Nunavik et d'évaluer l'impact de la ventilation sur celui-ci. Cette présentation permettra de présenter le protocole de recherche général de l'étude ainsi que certaines données préliminaires sur l'exposition domestique aux bioaérosols.

STRATEGIC PLANNING SCENARIOS FOR SALLUIT, NUNAVIK – FUTURE VISIONS BASED ON GEOMORPHOLOGICAL HYPOTHESES

M. Avarello (1,3), Delucinge, Nicolas (1,3) and Gauthier, Sarah (1,2,3), directed by: G. Vachon (1,3) and M. Allard (1,2,3)

(1) Living in Northern Quebec, Québec, QC, Canada
(2) Centre d'études nordiques, Québec, QC, Canada
(3) Université Laval, Québec, QC, Canada

The development of the community of Salluit faces major geomorphological constraints, such as a rugged topography, ice-rich permafrost, and a generalized depletion of gravel pits. Thawing of the permafrost is a direct consequence of climate change and has impacts on the ground and, consequently, on the integrity of building foundations. Salluit's relatively high population growth rate, paired with overpopulation and the inadequacy of most existing dwellings, also implies a pressing need for adapted and culturally sensible housing and infrastructure. This thesis project is a collaborative work involving two urban design master's students from the School of Architecture and one master's student in geography. Our main goal was to imagine a wide range of planning scenarios that would lead to specific long-term, realistic, "strategic" land uses for the planning of northern villages. In order to grasp the various challenges enumerated above, ranging in fields from the technical to the sociocultural, combining multiple disciplines was essential to elaborate sustainable planning solutions for the village. A main part of the process was to build a graphical tool that would facilitate collaborative work sessions around planning. That tool identified five major domains of reflection – geomorphology, urban form, urban experience, construction, and infrastructure – which were further broken down into "planning variables". These variables were then allowed to vary based on realistic or idealistic hypotheses, which were either geomorphological or sociocultural in nature. Therefore, a "scenario" would result from the combination of hypotheses, which, graphically, could be illustrated as a "trajectory" through the "planning variables". In addition to the linking of different technical or quantifiable factors, such as climatic hazards and construction methods, this process has the advantage of introducing design values and collective aspirations, which can involve governance and the valorisation of traditional practices into the formulation of hypotheses. As a preliminary application of this method, various meetings with the key planning bodies helped identify some urgent needs for the community. In this regard, and with the geomorphological context of Salluit in mind, the one strategic planning scenario developed was oriented towards pragmatic concerns, namely the geomorphological hypotheses. It also had to illustrate how a denser urban form could efficiently delay the imminent saturation of the village's constructible areas, while simultaneously enhancing the quality of living spaces. The poster will therefore illustrate this scenario and the process that produced it. The expected outcome of this collaborative project was the elaboration of a sustainable planning scenario for Salluit and the modelling of the complexity of urban design in villages in Nunavik, which would result in a planning tool for further collaborative or participatory processes. The project also illustrated the intricacy of the interactions between the various planning and governing bodies.

A MICROFLUIDIC METHOD WITH IN SITU MEASUREMENT METHODS FOR DEVELOPMENT AND CHARACTERIZATION OF CYANOBACTERIA

Deng, Tianyang (1), J. Greener (1) and W.Vincent (2)

(1) Département de chimie, Université Laval, Québec, QC, Canada
(2) Département de biologie, Université Laval, Québec, QC, Canada

Cyanobacteria in Artic regions and elsewhere play a critical role in local ecology as autotrophs and primary carbon and nitrogen fixers. It is interesting and necessary to learn their reciprocal interaction with the environment especially at this moment as they are facing challenges like temperature shifting, decrease of water body and pollution. They can be capitalized as sensing material for indicating the change in locality. In addition, cyanobacteria offer a new approach to solar energy conversion based on the highly efficient photosystems. These systems include chlorophyll *a* P680 and excited chlorophyll *a* P700, excited states of which are, respectively, the strongest biological oxidizing and reducing agents and can drive electrochemical processes that power the cells. New microbial photovoltaic cells use cyanobacteria as an electroactive material in which surplus current is siphoned off to generate usable power. To understand and potentially optimize cyanobacteria as a new material, microfluidics can be a powerful tool based on its inherent capability to precisely and dynamically control liquid phase properties with excellent spatial and temporal resolution. Controllable factors include hydrodynamics

such as flow velocity and shear forces; control over mass and heat transfer, and chemical conditions such as concentration and type of dissolved molecular species. However, in situ characterization remains a challenge. In this work we demonstrate the use of standardized characterization techniques into a microfluidic format. Fluorescence spectroscopy and other related measurements can now assess fluorescence information of individual cells. Under confocal laser scanning microscope (CLSM), cyanobacteria of different strains can be distinguished and identified in vivo, which is useful for studying the cyanobacteria biofilm community as a whole. Infrared spectroscopy (IR) quantitatively reflects information of its chemical components such as hazardous excreted toxins or lipid as biofuel products. An electrochemical approach may demonstrate its potential as an energy source, leading toward harnessing cyanobacteria and thus building up a harmonious relationship with the Artic ecological system. Our preliminary experiment has successfully inoculated a strain of cyanobacteria and confirmed its continuous survival in such a system. Both single and multiple cell monitoring was achieved, characterizing its population density. Different strains inside a cocktail of cyanobacteria were discriminated individually.

USING SPECTROSCOPY TO IDENTIFY TISSUE DURING DEEP BRAIN STIMULATION NEUROSURGERY

DePaoli, Damon (1,3), N. Lapointe (1), L. Goetz (1), D. Gagnon (1), L. Cantin (2), M. Prudhomme (2), Y. Messadeq (3), M. Parent (1) and D. Côté (1,3)

(1) CERVO Brain Research Centre, Université Laval, Québec, QC, Canada
(2) Hôpital de l'Enfant-Jésus, Québec, QC, Canada
(3) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

Deep brain stimulation's (DBS) effectiveness in providing symptomatic treatment in Parkinson's diseases (PD) relies on the ability of the stimulating electrode to be properly placed within a small target area of the brain, known as the subthalamic nucleus. Optical guidance techniques that can increase the accuracy of the procedure, without causing any additional harm, are therefore of great interest. We have designed an affordable optical fiber device that is small enough to be placed within commercially available DBS stimulating electrodes' hollow cores and that is capable of sensing biological information from the surrounding tissue, using low power white light. We will show here pre-clinical results of our guidance system in in vivo primates, specifically showing its ability to distinguish white and grey matter as well as blood vessels, through the plastic electrode during DBS implantations. We are also designing and validating a second fiber optic device that will result in label free, molecular level sensing capabilities, using coherent Raman spectroscopy. The final objective will be to use both spectroscopies in real time, during deep brain stimulation neurosurgery in humans, to increase the safety and accuracy of the procedure.

ADVANCED NON-DESTRUCTIVE SAMPLE CHARACTERIZATION IN COMPUTED TOMOGRAPHY

Di Schiavi Trotta, Leonardo (1), P. Després (1) and P. Francus (2)

(1) Université Laval, Québec, QC, Canada
(2) INRS Eau Terre Environnement, Québec, QC, Canada

The X-ray Computed Tomography (CT) is used extensively in medicine for diagnoses purposes and provides 3D density data from 2D projections acquired at different angles around a sample. This technology has been used as a non-destructive testing modality in non-medical applications. The Multidisciplinary Laboratory of CT-Scan for Natural Resources and Civil Engineering, located at INRS Eau Terre Environnement in Quebec City, is a facility dedicated to the use of a medical CT scanner in a non-medical context, which innovative research activities in Earth and Environmental Sciences and in Engineering and Oil and Gas exploration. It is particularly well suited to scan core samples, whether they come from land, ocean or lake drillings. Building on our previous achievements in medical X-ray, in this work we proposed to develop model-based algorithms that integrate fundamental physics phenomena into the reconstruction process: X-ray spectrum considerations, Compton and Rayleigh scattering, and expected Poisson detection statistics. It can easily be extended to multi-spectral imaging, where materials can be identified by resolving the ambiguity on the measured attenuation: a high-Z/low-density material is sometimes indistinguishable from a low-Z/high-density material in single spectrum imaging. The proposed approach, therefore, promises to better-characterize samples currently archived in drill core libraries and future cores from Sentinel North projects at Université Laval. Regarding the methods, this work is in the initial phase of development and the initial approaches are under

development, however, we are trying to develop a physics-rich image reconstruction algorithm to tackle the problems inherent to highly attenuating samples. We expect to reduce beam hardening artifacts while multi-spectral information will provide information on the effective atomic number of each voxel in addition to their density. Statistical approaches with iterative schemes will be used to obtain images from the advanced model of radiation/matter interaction/detection that will be developed. The numerical burden associated with advanced modeling will be offloaded by the use of massively parallel Graphics Processing Units (GPUs) available on the Helios cluster of Calcul Québec. Fast Monte Carlo simulation of radiation scattering with our in-house code GPUMCD will provide additional image improvements. At the end of this project, we aim to construct a platform capable of rapidly imaging potentially long drill cores or other samples that will be available to researchers. Compared to the existing platform, the proposed one will provide enhanced, artifact-free images that will also contain information on the nature of the material (effective atomic number). This is of crucial importance to many sectors of activity including mining, oil and gas exploration and civil engineering. The characterization of permafrost, compact snow or ice samples, among others, appears particularly interesting from perspectives ranging from biology and climate to infrastructures.

"FLEXIBLE IMAGING DEVICE": PACKAGING AN OPTIC-BASED CITIZEN SCIENCE SOLUTION FOR MAPPING HABITATS IN COASTAL AREAS

Ferrario, Filippo (1), P. Archambault (1), P. Giguere (1), Y. Rzhanov (2), S. Daniel (1), J.F. Lalonde (1) and P. Lajeunesse (1)

(1) Université Laval, Québec, QC, Canada
(2) Center for Coastal and Ocean Mapping/Joint Hydrographic Center, University of New Hampshire, Durham, NH, USA

Just by browsing Google Earth we realize how easy it is to map forests or farmed land, while for marine areas shades of blue and bottom relief is the most we can get. This reflects the differences between optic (terrestrial) vs acoustic (underwater) data gathering approaches. When it comes to nearshore marine areas we are basically blind. Coastal areas, though, are where the majority of the human population lives, exploits resources, develops infrastructures, and causes and are subject to environmental change. This happens in densely populated coasts and it is even more relevant in the North. Whether we want to detect, manage or adapt to changes affecting coastal ecosystems and their services, data availability is essential. Today the wealth of small, cheap but powerful sensors integrated in every day-use devices, such as action cameras, is inspiring new ways of collecting data, boosting so-called citizen science where non-experts contribute scientific data. Meanwhile, computer vision developed algorithms to obtain orthogonal photomosaics covering wide areas and Structure-from-Motion (SfM) enable the reconstruction of 3D models from partially overlapping 2D images. Thus, we now have the ability to obtain the underwater equivalent of aerial photographs with low cost off-the-shelf tools. Here we present how to turn common action cameras (i.e. GoPro and Garmin Virb) into useful habitat mapping tools for the underwater environment. We will present protocols for the acquisition of optical data (i.e. videos) by both SCUBA divers and ROVs with a focus on georeferencing and track-reconstruction. In addition, we will present how videos should be pre-processed and photomosaics built using an automatized algorithm. Our approach tries to minimize the need of specific training and manual intervention - particularly during the photomosaic construction process – in the attempt to allow data acquisition and processing by non-expert citizen scientists. Optical imagery-derived photomosaics can be used to map biological and geomorphological features over continuous and wide areas. Making the building of photomosaics cheap and easy will help our effort to describe patterns of local distribution of benthic species, to assess biodiversity and to evaluate the environmental status in coastal areas.

A METAL-ENHANCED FLUORESCENT SENSOR FOR LYSOPHOSPHATIDIC ACID IN VIVO DETECTION BASED ON FLUORESCENT MOIETY AGGREGATION

Fontaine, Nicolas (1), D. Boudreau (1) and A. Marette (2)

(1) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada
(2) Institut universitaire de cardiologie et de pneumologie de Québec and Institut sur la nutrition et les aliments fonctionnels, Université Laval, Québec, QC, Canada

Change from a traditional to a "western" diet is believed to contribute to the greater prevalence of cardiometabolic diseases (CMD) and mental illness among indigenous populations in the Canadian North. Dysregulation of the gut microbiota's host-bacteria

interactions, being the community of micro-organisms involved in several functions including immune system regulation and nutrient metabolism, may be involved in these pathologies. To properly understand this phenomenon, there is a need for analytical tools allowing real-time measurements at high spatial resolution of microbial processes in the gastrointestinal tract, critical information that cannot be obtained from a posteriori molecular analysis of fecal samples. Among metabolites of interest, lysophosphatidic acids (LPA) are known to be present in the GIT in addition to being linked to CMD and some cancers. In this study, we are developing a fluorescent sensor composed of a core-shell nanoparticle with luminescent moieties covalently linked onto the surface. Silver nanoparticles are synthesized by a seed-growth method by reducing metallic salts in solution, resulting in low size polydispersity. A silica shell is then formed over the metallic cores by a modified Stöber process to facilitate further functionalization and shield them from chemical etching in the physiological media. A fluorescent species having a complementary structure to the LPA has been synthesised for detection based on formation of fluorophore aggregates. A silane moiety at the end of the compound allows for covalent grafting to the silica-coated nanoparticles while the Metal-Enhanced Fluorescence in these nanocomposites results in improved emission intensity, photostability and detection limit. In time, this nanoparticle-based LPA sensor will be combined with a multichannel optical fibre architecture for in vivo measurements of LPA in animal models relevant to CMD.

ALLUMO: A PREPROCESSING AND VISUALIZATION TOOL FOR PROCESSING IMU DATA AT SCALE

Fortin-Côté, Alexis (1), J.-S. Roy (1,2), L. Bouyer (1,2), A. Campeau-Lecours (1,2) and P. Jackson (1,2)

(1) Université Laval, Québec, QC, Canada
(2) Centre interdisciplinaire de recherche en réadaptation et intégration sociale, Québec, QC, Canada

Allumo is a visualization and pre-processing tool to prepare IMU data used in human posture monitoring and assessment. In the context of Sentinel North project 2.8: "Development, implementation and use of miniature portable technologies for the prevention, assessment and treatment of chronic diseases in northern areas", an important challenge occurred during the assessment of the IMU data obtained in the field. Indeed, while the typical use case is a relatively short acquisition duration - minutes to hours long -, the Sentinel North project has a goal of recording data during long northern expeditions, for instance data from the scientific personnel on board the CCGS *Amundsen*. Corresponding time series data sets are thus quite large and require a tedious and time-consuming manual preprocessing where sustained sensor calibration becomes an issue. Average file duration during the 2017 *Amundsen* experiment was one to two weeks of continuous recording at 60 Hz (6 data channels). While this data file size may not be considered large in a big data context, the amount of manual preprocessing required using existing commercial tools precludes them from being used at the scale required for our project. Indeed, as each participant removes and reinstalls the equipment at least twice a day, a manual recalibration of the devices is required each time. Finding these calibrations in the data stream in the field without direct surveillance from an external observer is impracticable. There are also many events that results in erroneous readings stemming from an erroneous calibration, which also requires identification and sensors recalibration (for instance, unwanted shift of the sensor on the participant). Identifying such erroneous readings is difficult with available commercial tools, as they tend to only present time-series plots of the data, an unintuitive method for detecting erroneous calibration by most observers. The Allumo tool aims to expedite the identification and recalibration of accelerometer readings by showing an intuitive graphical interface to the observer. An animated humanoid form illustrates the estimated posture of the participant at selected time points in the data stream. It makes it easy to identify erroneous calibrations, as an abnormal posture of the body will be displayed (e.g. walking at a skewed angle). The tool also automatically identifies data segments requiring human intervention using a decision tree by detecting unnatural or impossible postures. It also tackles the problem of displaying long duration files by slicing time in hours and days to intuitively guide the observer. Furthermore, it includes pre-processing steps such as a Kalman filter to automatically correct for small calibration mistakes and smooth out the data. Pre-processing parameters can be adjusted and their effect viewed instantly as the humanoid form animates to illustrate the changes. This tool was designed for researchers in the field of motor function, motor rehabilitation and pain prevention as part of Sentinel North project 2.8, and is open source and available at https://github.com/alexisfcote/allumo.

OPTOGENETIC CONTROL AND MONITORING OF GUT MICROBIOTA

Fouré, Marion (2), P. Lemieux (1), S. Moineau (1), P. de Koninck (1), D. Côté (3) and M.-E. Paquet (1)

(1) Département de biochimie, microbiologie et bio-informatique, CERVO Brain Research Centre, Université Laval, Québec, QC, Canada
(2) Département de biologie, Faculté des sciences et technologies, Université de Lille, France
(3) Département de physique, génie physique et d'optique, Faculté des sciences et génie, Université Laval, Québec, QC, Canada

As demonstrated in recent years, microbiota can influence different aspects of the nervous system, including its activity and development – this communication is known as gut-brain axis (GBA). The zebrafish is one of the animal models used to study microbiota owing to its transparency at the larvae stage. In order to understand the microbiota's influence on brain development, we are proposing two strategies: an optogenetic CRISPR-Cas9 system to control bacterial growth with light and different fluorescent bacterial strains to observe microbiota modifications. CRISPR-Cas9 is a genome editing tool which can target modification of a genomic sequence. The system is based on the nuclease Cas9 in complementarity with a 20bp guide RNA (sgRNA) sequence which can bind and cleave a homologous target. A modified version, called dead-Cas9 (dCas9), is also available. It can bind DNA and block the transcription without cleaving the double-stranded DNA. In this study, we are using two different light activatable Cas9 systems which we are testing in *E. coli*: The first one is based on Streptococcus pyogenes Cas9 (spCAS9) and molecular magnets developed for genome editing in mammalian cells (Nihongaki et al (2015)) which we have adapted for expression in bacteria. It consists of paired photoswitchable proteins, named positive Magnet (pMag) and negative Magnet (nMag), fused to Cas9 fragments, which heterodimerize upon blue light irradiation thus enablling split Cas9 fragments to reassociate and become active. The second photo-activable Cas9 was initially developed by A. Möglich (Richter et al., 2016) and uses the homodimeric Rhodobacter sphaeroides light oxygen-voltage (LOV) domain (RsLOV) that dissociates upon blue-light exposure. This domain fused with a dCas9 stops the transcription of a specific gene. Multiple sgRNAs targeting either genes essential to cell survival or genes encoding fluorescent proteins were designed and cloned with one of the Cas9 system to validate the strategies. The main goal of developing a photo-inducible CRISPR-Cas9 system is to inactivate an entire population of bacteria with light and follow the direct impact on the entire microbiota structure as well as its downstream impact on health and brain development. The other approach we are proposing to study the GBA in zebrafish is to establish of a fluorescent microbiota with different bacterial strains. These strains will allow us to observe in real time the consequence of outside stress on bacterial growth and the interactions between strains in the gut. Understanding the stability in the gut is indeed another objective of the study. To achieve this goal, a range of fluorescent proteins (FPs) are first expressed in *E. coli* under an inducible promoter to evaluate their toxicity at different levels of expression. Their compatibility with the imaging of the zebrafish gut is also validated as each FP is inoculated in the gut of zebrafish. After the first step of colonization with *E. coli*, which will be done in axenic animals, other strains of the gut microbiota will be tested and imaged with two-photon microscopy.

SEASONAL AND MULTI-ANNUAL CHANGES IN ARCTIC MICROBIAL EUKARYOTIC COMMUNITIES IN NORTHERN BAFFIN BAY

Freyria, Nastasia J. (1), N. Joli (1,2) and C. Lovejoy (1)

(1) Département, de biologie, Université Laval, Québec, QC, Canada
(2) Institut de Biologie de l'Ecole Normale Supérieure, Paris, France

Climate warming now occurring in the polar regions threatens ice-dependent ecosystems and could be expected to affect marine phytoplankton communities. Ice conditions across the Arctic influence the geographic distribution, intensity and timing of phytoplankton production and consequently the Arctic food chain and higher trophic levels, including marine birds and mammals. Phytoplankton and other microbial species assemblages are key for understanding ecosystem responses in the face of global change. For these reasons, recent changes in ice conditions mean historical patterns are not reliable indicators of present day seasonal and spatial patterns. In particular, remote sensing and in situ data has shown that the highly productive Northern Baffin Bay (NBB), has undergone marked changes in regional biomass and productivity patterns over the last 15 years. However, there have been few studies focusing on occurrence patterns of the phytoplankton and associated microbial heterotrophic communities, and the changes in the microbial food web associated with these changes is unknown. Here, we hypothesized that the marked

seasonality and stratification in NBB during summer and autumnal periods would be sufficient to lead to niche partitioning and select different species assemblages at different depths and over time. Then, we examined the seasonal pattern of microbial eukaryotic communities and performed an in-depth analysis of multi-annual species variability between two contrasting sides of NBB. We investigated samples collected during ArcticNet missions (2005-2017) aboard the CCGS *Amundsen*. Microbial species composition in the communities were identified using high throughput amplicon sequencing (HTS) of the V4 region of 18S rRNA and the 18S rRNA gene. We applied multivariate statistics to link changes in community structure and composition with prevalent environmental drivers, to provide a high-level overview on how microbial phytoplankton communities respond to seasonal changes and multi-annual variability. We found marked changes in the community of cells < 3 µm over time and space, potentially indicating ecosystem responses or adaptation to a regime of environmental perturbation in the face of ongoing change. In our first results, on the one hand, we found that the species complex *Chaetoceros socialis-gelidus*, characteristic of this region, was common in surface waters on both sides of NBB, with a higher proportion of reads toward summer and near the western side (Canada). On the other hand, the proportion of *Micromonas polaris* reads increased in surface waters and at the subsurface chlorophyll maxima toward summer specifically near the eastern side (Greenland), where salinity and temperatures are higher than on the Canadian side. The persistence of these diatoms and chlorophytes suggests ongoing surface production on both sides of NBB. Changes in the heterotrophic community suggested that heterotrophs were more responsive to environmental drivers. Combined spatial and temporal studies exploiting HTS, together with improved bioinformatics tools and large-scale sampling methods, will continue to enable researchers to improve their understanding of the variability of microbial communities. Similar projects within Sentinel North will bring us a step closer to predicting both the temporal and spatial patterns of diversity at multiple trophic levels within microbial food webs that support ecosystem services in the Arctic.

SUBWAVELENGTH GRATING WAVEGUIDE: IMPROVING ON-CHIP SPECTROSCOPY FOR MINIATURE METHANE SENSORS IN NORTHERN ENVIRONMENTS

Gervais, Antoine (1, 2), W. Shi (1, 2) and S. LaRochelle (1, 2)

(1) Département de genie électrique et de genie informatique, Université Laval, Québec, QC, Canada
(2) Sentinelle Nord, Université Laval, Québec, QC, Canada

Positive feedback to climate warming due to the release of methane, a greenhouse gas having a high global warming potential, from thawing permafrost and Arctic lakes is expected to accelerate climate warming. Reliable integrated sensors are thus needed for precise, remote and real-time monitoring of methane emissions in northern environments for climate change data collection. Here, the application of subwavelength grating (SWG) waveguide integrated on a silicon photonic chip compatible with CMOS fabrication is proposed for methane sensing by near-infrared tunable diode laser spectroscopy. The subwavelength segmentation of the waveguide increases the light-analyte interaction due to a high modal overlap with the air while having a low propagation loss. Simulations show an enhancement factor γ=0.6 in the deep subwavelength region, corresponding to a threefold improvement relative to a conventional strip waveguide. When approaching the Bragg period, a SWG waveguide no longer acts as a metamaterial with homogeneous index, but as a 1D photonic crystal, in which slow-light effect occurs and this physical property can be exploited to enhance the absorption by several factors of magnitude. The use of SWG waveguide could enhance both the sensitivity and the limit of detection of on-chip trace-gas sensors which represent a compact, fabrication-tolerant, inexpensive and selective sensing technology.

PROJET PILOTE D'ÉLABORATION D'UN PLAN DE GESTION DE LA SÉCURITÉ SANITAIRE DE L'EAU AU NUNAVIK

Guilherme, Stéphanie (1), M. Rodriguez (1), B. Lévesque (2), P. Levallois (2), M. Lemire (1) et C. Dorea (3)

(1) Université Laval, Québec, QC, Canada
(2) Institut national de santé publique du Québec, QC, Canada
(3) University of Victoria, Victoria BC, Canada

Au Nunavik, les petits systèmes d'eau potable sont particulièrement vulnérables à la contamination de leur eau. L'approvisionnement se fait à partir d'eau de surface et le traitement consiste généralement à une simple désinfection. L'aménagement de conduites souterraines est impossible en raison de la présence du pergélisol. L'eau est donc distribuée, au sein d'un village, à l'aide de camions-citernes dans des réservoirs situés chez l'habitant. Ce mode de distribution présente un haut risque de contamination aussi bien lors de la distribution que lors de l'entreposage de l'eau. Aussi, ce mode de distribution limite la quantité d'eau disponible pour la population. Les bris de camions-citernes peuvent causer des interruptions de distribution d'eau qui peuvent avoir des conséquences sanitaires importantes pour la population. Malgré ces risques pour la santé humaine, peu d'informations sont disponibles sur l'accès à l'eau potable, en termes de quantité et de qualité, au Nunavik. Aussi, aucune stratégie générale d'évaluation et de gestion des risques pour la santé humaine de la consommation d'eau potable n'a été développée pour ces systèmes. Le développement d'un outil d'analyse de risque tel qu'un Water Safety Plan, plan de gestion de la sécurité sanitaire de l'eau (PGSSE) serait complémentaire à l'approche réglementaire actuelle. Un PGSSE permettrait d'identifier, d'évaluer et de localiser les sources de risques et de se préparer en avance à la gestion des événements dangereux. Bien que plusieurs PGSSE aient été développés dans certaines communautés nordiques, aucun PGSSE n'a été développé au Nunavik. Notre projet propose donc de mettre en place un PGSSE comme outil d'évaluation et de gestion des risques pour la santé humaine de la consommation d'eau potable, couvrant toutes les étapes de l'approvisionnement en eau, de la source au consommateur. Cet outil sera adapté au contexte particulier du Nunavik. Pour cela, un portrait de l'accès et de la qualité de l'eau potable au sein de tous les villages nordiques du Nunavik sera tout d'abord réalisé à partir des données historiques. Par la suite, ce portrait sera complété dans quelques villages sélectionnés par des nouvelles données collectées lors d'une campagne d'échantillonnage et des entrevues réalisées au cours de l'été 2019. Ce portrait complet permettra d'identifier les principales sources de risques à la santé humaine liés à la consommation de l'eau potable qui permettront finalement de développer des PGSSE sur les villages sélectionnés. Ce plan intégrera des stratégies d'évaluation et de gestion des risques, couvrant toutes les étapes de l'approvisionnement en eau, de la source au consommateur (stratégies de traitements, de gestion et de surveillance de la qualité de l'eau, de gestion d'interruptions de production ou de distribution d'eau ou d'entreposage de l'eau).

DESIGN AND IMPLEMENTATION OF WIRELESS MICROELECTRONICS SENSORS TO MEASURE MICROORGANISM'S GROWTH IN DIVERSE ENVIRONMENT

Hosseini, Seyedeh Nazila (1), B. Gosselin (1) and Y. Messaddeq (1)

(1) Université Laval, Québec, QC, Canada

This project aims to build a multi-technology microsystem to measure bacterial growth and environmental parameters in diverse environments, such as northern climates. We intend to design and fabricate a microelectronic chip to perform local bioimpedance measurement and imaging, as well as to measure several environmental parameters, including temperature, humidity, luminosity, etc. In the long term, this chip has two purposes: it is intended 1) to identify sentinel microorganisms that are signposts of specific environments across a northern region under the influence of global warming and human interventions, and 2) to identify unique molecules with possible medical or industrial applications. The cold climate of the northern regions brings a particular challenge as bacteria growth can be slow and difficult to measure precisely, which requires innovative sensing solutions. In fact, at low temperature, the activity of microorganisms like bacteria and microbes decreases dramatically. Hence, we will design a customized high-precision bioimpedance measurement system that can address a precision to measure bacteria diluted down to several millions of CFU/ml. Our approach will leverage the design of a new fully integrated bioimpedance measurement circuit that will enable high-precision and placement in hard areas of the northern regions and the human body. Additionally, an integrated system to precisely monitor and measure the microorganisms will increase autonomy, decrease the manufacturing and transport cost, and be capable of

working under temperatures below -40 °C. We will design a high-sensitivity dual-phase lock-in amplifier (LIA), within microelectronic circuits, capable of extracting small bioimpedance signals down to 1 pA of amplitude to measure growth rate in cold climates. The chip will be designed in a 0.18-µm CMOS microelectronic process at Laval.

MULTISPECTRAL LASER SERIAL IMAGING TECHNIQUES FOR HIGH SPATIAL RESOLUTION AND SPECTRAL DISCRIMINATION OF MACROALGAE

Huot, Matthieu (1), A. Dalgleish (2), F. Dalgleish (2,3), E. Rehm (1), P. Archambault (1) and M. Piché (1)

(1) Université Laval, Québec, QC, Canada
(2) HBOI at Florida Atlantic University, Fort Pierce, FL, USA
(3) Harris Corporation, Melbourne, FL, USA

Noticeable climate-mediated changes are occurring in the Arctic and affecting various ecosystem components in the process. These changes in environmental conditions can be important for coastal water components such as macroalgae, which provide essential ecosystem services ranging worldwide. A better understanding of spatial distribution patterns in primary producers such as macroalgae can guide us in anticipating effects of future changes. The development of innovative underwater detection and imaging methods, such as multispectral serial laser imaging techniques, may provide solutions for studying Arctic substrates as macroalgae in coastal environments when coupled with proven and available deployment platforms, such as AUVs (Autonomous Underwater Vehicles). In this context, the objective of the current work is to develop an automated classifier designed for detection and identification of macroalgae and other underwater substrates. By using multiple laser wavelength sources as a means to illuminate recreated benthic environments composed of macroalgae and other substrates, it will be possible to characterize elastic and inelastic spectral responses at different wavelengths in observed substrates. The information gained through this process will enable us to begin development of an automated benthic substrate classifier.

FLUORESCENT OPTICAL SENSOR FOR DIMETHYL SULFIDE DETECTION AT NM LEVEL IN SEA WATER

Iden, Hassan (1), T. Bura (2), M. Leclerc (2) and Y. Messaddeq (1)

(1) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada
(2) Département de chimie, Université Laval, Québec, QC, Canada

Dimethyl sulfide (DMS) is a biogenic gas belonging to the family of volatile organic compounds (VOCs), generally emitted by phytoplankton and it has influence on air quality and may have significant impact on climate change. Numerous measurement techniques such as gas chromatography have been used to detect DMS at nM concentration. However, these techniques are time-consuming, expensive and impractical. To our knowledge there is no optical sensor for DMS measurement on the market. Therefore, this work aims to develop an optical instrument capable of rapid and continuous measurement of DMS at nM level. The novel optical sensor fabrication is undertaken based on the attachment or incorporation of fluorophore as a DMS host into a glass substrate or an optical fibre by using sol-gel or deep coating methods. The detection will be based on reversible interaction between the fluorophore and DMS.

MICROBIAL DIVERSITY ACROSS THE GREAT WHALE RIVER: A RIVER-TO-SEA CONTINUUM?

Jacquemot, Loic (1), D. Kalenitchenko (1) and C. Lovejoy (1)

(1) Université Laval, Québec, QC, Canada

Many of the key physical, biological and geochemical processes occurring in Hudson Bay, including sea ice growth and decay are strongly linked to freshwater input. Freshwater within the Hudson Bay System originates from rivers with large drainage basins and is modified by sea ice formation and melting. Similar to other estuaries, gradients in light, heat and salinity through freshwater and seawater mixing, are predicted to influence microbial community structure. Here, we sampled microbial assemblages using marker genes and high throughput sequencing, along a salinity gradient in the Great Whale River (Inuit: Kuujuaraapiup Kuunga, Cree: Kwakutuy) estuary to Hudson Bay to investigate how these gradients affect microbial assemblages from the

three domains of life: Archaea, Bacteria and planktonic microbial eukaryotes, which includes phytoplankton and protist grazers. Data on the distribution and composition of microbial communities was compared with environmental parameters along the salinity gradient to identify factors potentially controlling the distribution of the microbes. Additional work is planned using shotgun metagenomic analysis to explore the genetic potential of these microorganisms to adapt to environmental gradients and to assess putative metabolic pathways that facilitate adaptation of Hudson Bay System organisms to changing freshwater conditions. This information will be of use to managers by inferring whether present day organisms will be able to adjust to increased freshwater inputs or whether new invading organisms will more likely replace current species.

NUMERICAL MODELLING OF PERMAFROST THAW DYNAMICS AND TRANSPORT OF FINE SEDIMENTS IN POROUS MEDIA

Khadhraoui, Madiha (1), J. Molson (1) and N. Bhiry (2)

(1) Département de géologie et de génie géologique, Université Laval, Québec, QC, Canada
(2) Département de géographie, Université Laval, Québec, QC, Canada

In the context of climate change, thawing of permafrost can have a significant impact on heat distribution and water quality, as well as on fine sediment transport in porous media. Understanding the effects of changes in permafrost thermal dynamics is therefore essential to solve associated environmental problems, particularly in northern areas where natural risks are amplified. Current research on fine sediment loads during permafrost degradation is very limited. This study will help close this gap by focusing on the interactions between groundwater flow, heat transfer and sediment transport processes which can affect water quality, soil stability and discharge of groundwater to surface water. To investigate these processes, we will use the numerical model Heatflow/Smoker (Molson & Frind, 2018) to simulate fluid, heat and mass balance and associated stress changes within natural permafrost-impacted environments. The coupled groundwater flow and heat transfer model will be modified to include transport of dissolved solutes and suspended particles. The model will then be calibrated using existing field data including several years of soil and groundwater temperatures and heat fluxes, as well as, new turbidity data which will be acquired during summer field work. Soil samples will be collected from the discontinuous permafrost area located near Umiujaq, Nunavik, Quebec. Sample analysis will be carried out in the laboratory to evaluate turbidity and the different factors and processes controlling mass transport associated with permafrost thaw. Research on this subject is important as a direct input to our understanding of the scientific issues related to climate-change induced thawing of permafrost. We expect to contribute to better understand the impacts and feedbacks between groundwater flow, heat transfer and transport processes associated with thawing permafrost.

DESIGN AND IMPLEMENTATION OF A WIRELESS OPTICAL MICRO-SPECTROMETER FOR ENVIRONMENTAL MONITORING

Khojasteh Lazarjan, Vahid (1), P. Marquet (1) and B. Gosselin (1)

(1) Université Laval, Québec, QC, Canada

The goal of this project is to develop a wireless microsystem to perform diffuse multi-wavelength spectroscopy in diverse environments, like northern climates, as well as in biological tissues in a minimally invasive fashion. The envisioned device will allow for performing diffuse spectroscopy within a small format for enabling local quantitative measurement in diverse environmental structures or tissues for characterizing the complex interactions and metabolisms involved, with minimal invasiveness and in a distributed fashion. Diffuse reflectance optical spectroscopy utilizes small semiconductor light sources in the visible and the near-infrared (NIR) to probe a medium. In this project, the excitation light and the reflected light will be emitted and collected through a single optical fiber for probing deep structures. Then, the collected light will be processed by a low-power microsystem including analog and digital microelectronics circuits. The different wavelengths of the reflected light will be separated using an optical filter microfabricated on top of a complementary metal-oxide-semiconductor (CMOS) microelectronic chips. A light-emitting diode (LED) will be used as embedded excitation light source, while specialized CMOS circuits, such as a low-noise analog front-end, and a Delta-Sigma digitizer, are used to convert, amplify, and digitize the filtered spectroscopy signals inside the chip, and transmit the digital data to a base station. Combining several technologies, such as fiber optic and microelectronics, will lead to unprecedented levels of miniaturization for an optical spectrometer. The first step consists of

designing, fabricating and testing a discrete-component prototype including a commercial micro-spectrometer from Hamamatsu, integrated along with a microcontroller and a wireless transceiver, within a compact platform. This prototype will allow us to validate our models and our approach. Then, a specialized chip solution will be designed and fabricated within CMOS technology to decrease power and size and to increase the quality of measurements. New circuit techniques such as switched bias transistors and current mode circuit design will be leveraged in CMOS technology to decrease the input referred noise without increasing the size and power consumption for enabling the utilization of a small battery as an energy source. Moreover, this project also introduces a new design for direct optical light filtering in a chip using periodic nano-plasmonic filters implemented in CMOS technology. This technology will shrink the size of the spectrometer dramatically as it will avoid the need for discrete optical components. In summary, this project will leverage CMOS microelectronics, optoelectronics, silicon photonics and MEMS technology to build a diffuse spectrometer on a chip, which will not only decrease the cost of the proposed approach, concerning manufacturing and transportation, but will also enable an autonomous and smart solution that will be adaptive in northern climates. A significant benefit of the proposed approach also resides in its label-free, non-destructive and minimally-invasive operation to live tissues and other materials like ice in a distributed fashion.

STUCKBERRY VALLEY LAKES: SENTINELS OF ENVIRONMENTAL CHANGE AT CANADA'S EXTREME NORTHERN LIMIT

Klanten, Yohanna (1,2), D. Antoniades (1,2), S. E. Bonilla (3), W. F. Vincent (2,4), K. Triglav (1,2), C. Marois (2,5) and A. Culley (2,5)

(1) Département de géographie, Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Québec, QC, Canada
(3) Universidad de la República, Montevideo, Uruguay
(4) Département de biologie, Université Laval, Québec, QC, Canada
(5) Département de biochimie, de microbiologie et de bio-informatique, Université Laval, Québec, QC, Canada

Despite being at the northernmost fringe of land on Earth, the northwest coast of Ellesmere Island is a highly dynamic region at the interface of the Canadian Arctic Archipelago and the Arctic Ocean ice pack. The region contains a variety of aquatic ecosystem types, including fiords, meromictic lakes, epishelf lakes, and supraglacial meltwater ponds. Many such ecosystem types exist at the climatic limits of their viability and when environmental thresholds are crossed they are often manifest as ecosystem regime changes. The region has seen important Holocene climate variability, however little is known about the history of ice shelves or sea ice prior to the late 19th century. This information is critical for assessing the recent degradation of coastal ice in the context of long-term natural variability. Eight km to the west of Clements Markham Inlet, Stuckberry Valley (82° 54' N, 66° 56' W) ascends from the ocean to encompass a series of four unnamed lakes, the last of which is situated 56 m asl. The marine limit in this region was 124 m asl and these lakes were thus submerged sea floor depressions when glaciomarine environments appeared following glacial retreat ~11.4 cal ka BP. Isostatic uplift later sequentially separated the lakes from the ocean. To our knowledge, it is the only chain of coastal lakes spanning such an altitudinal gradient on the northern coast of Ellesmere Island. With their different time spans in isolation, these lakes present a unique opportunity to reconstruct past sea ice cover and to evaluate natural climate variability as well as to test hypotheses related to microbial diversity. In the summers of 2017 and 2018, we sampled the water and sediments of four lakes which were previously completely unexplored. Here we present preliminary results from our project, a multidisciplinary study that seeks to understand the ecology and history of these lakes through studies of photosynthetic pigments, genomic microbial analysis, hyperspectral imaging spectroscopy and paleomagnetic analyses.

IMPACT OF SPRUCE BUDWORM OUTBREAKS ON HABITAT SELECTION BY BOREAL CARIBOU

Labadie, Guillemette (1) and D. Fortin (1)

(1) Université Laval en sylviculture et faune, Centre d'étude de la forêt, Département de biologie, Université Laval, Québec, QC, Canada

The boreal populations of woodland caribou (Rangifer tarandus caribou, hereafter boreal caribou) are considered as threatened in Canada. Most plans for population recovery focus on the protection or restoration of their critical habitat. While the impact of wildfires and human activities on caribou populations have been largely characterized, little information exists on how insects influence the distribution of caribou. Yet, insect outbreaks affect areas larger than those impacted by

wildfires and logging activities combined. Understanding the response of caribou to insect outbreaks can provide critical information for their conservation, especially given that outbreaks are expected to become more severe and to occur at increasingly higher latitude following climate change. In Canada, spruce budworm (Choristoneura fumiferana) outbreaks modified forest composition by selectively attacking mature balsam fir (Abies balsamea), and forest structure by creating patches with different levels of tree mortality. The canopy gaps created by tree mortality can be colonized by deciduous vegetation that provides high-quality food for moose (Alces alces), which can change wolf (Canis lupus) distribution, and impact predation risk for boreal caribou. Spruce budworm outbreaks can thus have a complex influence on food webs, and empirical research is needed to clarify the role of this insect on trophic interactions involving boreal caribou. We investigated the combined impact of spruce budworm outbreaks, wildfires and forest harvesting on the habitat selection of boreal caribou in the Côte-Nord region of Quebec. Sixty-two boreal caribou were monitored with Global Positioning System (GPS) collars. Habitat was characterized by a using Landsat Thematic Mapper image that have been taken in 2000 with 25 m resolution. The satellite image was updated every year with information on forest harvesting and wildfires. Local severity of spruce budworm infestation was estimated by the rate of defoliation of forest stands, each year since the beginning of the outbreak. Preliminary analysis revealed that, relative to open conifer forests without lichen (the reference category), caribou selected open mature conifer forests with lichen, while avoiding closed-canopy mature conifer forests, burned areas, mixed/deciduous forests, open areas, roads and harvested areas. The effect of spruce budworm on habitat selection of boreal caribou depended of outbreak severity, with caribou displaying only a strong aversion for areas with a high severity of insect damage. Our preliminary analysis demonstrates that caribou alter their distribution in response to spruce budworm activities. To gain a more comprehensive understanding of the impact of insect outbreaks on caribou populations, we will assess the interplay between caribou survival and spruce budworm outbreaks. In this context, the next steps will involve the analysis of the response of wolf to the same disturbances, together with an investigation of how spruce budworm outbreaks impact the food supply of caribou. Finally, we will evaluate the proposed caribou recovery strategy in the context of environmental changes by assessing the cumulative and specific impact of forest harvesting and climate-induced changes on wildfires and spruce budworm outbreaks.

ACTIVE VIRUSES IN ANCIENT SEAWATER: VIRAL STRATIFICATION IN A HIGH ARCTIC LAKE

Labbé, Myriam (1), W. F. Vincent (1) and A. I. Culley (1)

(1) Centre d'études nordiques, Université Laval, Québec, QC, Canada

Viruses play major roles in Arctic aquatic ecosystems, where microbial life often dominates. They are involved in the regulation of host biomass, drive microbial community evolution and affect the circulation of energy through trophic webs that ultimately impact biogeochemical processes. The northern frontier of Ellesmere Island (Canada) harbours stratified lakes that are unique to polar environments and particularly vulnerable to the effects of climate change as temperatures in the Arctic rise at an unprecedented rate. This study focused on meromictic lake Lake A, composed of a freshwater surface layer fed by the spring run-off of the surrounding catchment, overlying ancient seawater that was trapped by isostatic rebound several thousand years ago. This saltwater layer is particularly resistant to mixing and its physicochemical conditions are extremely stable. Our research shows the presence of highly stratified viral communities, consistent with the observed stratification of other microbial components. As these viral communities are yet undescribed, we used a metagenomic approach based on next-generation sequencing to generate a more comprehensive assessment of viral diversity and viral genetic potential. An environment as complex as Lake A harbours potentially unique genes that may yield insights into viral dynamics and their role in key microbial metabolic processes such as photosynthesis and nutrient assimilation. We anticipate that the differences in dominant metabolic processes in each vertical stratum of the lake, such as aerobic phototrophy in the surface and anaerobic sulphur metabolism at depth, will be reflected in the co-occurring viral communities and viral gene pools.

FATHER'S EXPOSURE TO ENVIRONMENTAL POLLUTANTS IN THE NORTH: FOLIC ACID AS A NUTRITIONAL SOLUTION FOR THE HEALTH OF HIS OFFSPRING

L. Charest, Phanie (1), M. Lessard (1), P. Herst (1), P. Navarro, M. Dalvai1, M.O. Benoit-Biancamano (2) and J.L. Bailey (1)

(1) Département des sciences animales and Centre de recherche en reproduction, développement et santé intergénérationnelle, Université Laval, Québec, QC, Canada
(2) Faculté de médecine vétérinaire, Université de Montréal, Montréal, QC, Canada

INTRODUCTION: Although Inuit have never used Persistent Organic Pollutants (POPs), their traditional diets contain up to 17X more than those of non-aboriginal Canadians. This is due to POPs being transported to the Arctic by natural meteorological currents where they bioaccumulate and biomagnify in the food chain. Moreover, Inuit diets are often deficient in folic acid (FA), which is known to reduce the incidence of congenital anomalies. These factors could partly explain why Inuit have a life expectancy of 10 to 15 years shorter, are subject to more chronic and circulatory diseases, and have higher rates of preterm birth, and neonatal and infant mortality compared to other Canadians. Since it has been recently shown that the father's lifestyle also influences the health of his offspring, our hypothesis is that FA supplementation could attenuate the phenotypic effects observed following paternal prenatal exposure to POPs by preventing/reducing congenital, developmental and placental anomalies associated with them over several generations. METHODS: Our previously established Sprague-Dawley rat model was used to reproduce a paternal prenatal exposure within a factorial 2x2 experimental design. F0 females were gavaged 3x/week for 5 weeks with corn oil (control) or an environmentally-relevant mixture of Arctic POPs before being mated to untreated males until parturition (total of 9 weeks of treatment). Half of these females received 1X FA representing normal Canadians diets, while the other was supplemented with 3X FA, corresponding to recommendations for periconceptional women. Their F1 male pups (n=12) were mated to untreated females to produce F2 rats and so on until F4. Only F0 founder mothers (n=10) received POPs and FA supplementation. After birth of the F1 litters, all animals were untreated (1X FA chow; no POPs). For each generation, GD19.5 placentas and fetuses were assessed for congenital pathologies, including macroscopic and histopathologic examination. The junctional and labyrinth zones of the placenta were identified, and their area were measured. Male descendants (n=12) of every generation underwent necropsies and blood analysis at PND150. RESULTS: For F1 litters at GD19.5, placental and fetal weights were unaffected by treatment. The basal zone area, however, was smaller with POPs, whereas the labyrinth zone was bigger ($p=0.03$). At PND150, kidney ($p=0.01$) and brain ($p=0.09$) weights were augmented due to prenatal POPs exposure in F1 males, whereas brain weight ($p=0.04$) was reduced in F2 male from POPs treated lineage. Blood analysis performed on F1 males at PND150 revealed that blood platelet count and hematocrit were decreased by POPs, a change which was corrected by FA supplementation ($p=0.01$). Erythrocyte counts were higher with FA supplementation ($p=0.05$). CONCLUSION: These results demonstrate that prenatal POPs and FA exposures alter the development and function of the placenta during development and kidney and brain during life. Also, the altered blood parameters could be representative of the high rates of circulatory diseases observed in Inuit populations. Overall, it is essential to consider the effects of paternal exposures and their impact on the developmental origins of health and diseases across multiple generations. (Funded by CIHR.)

DEVELOPMENT OF AN ANALYTICAL STRATEGY FOR THE FIELD DISSOLUTION OF TARGETED SPECIES IN COUNTRY FOODS

Laberge-Carignan, Audrey (1), D. Larivière (1), J. Ruel (1), A. Bégin-Drolet (1) and M.-A. Plourde-Campagna (1)

(1) Université Laval, Québec, QC, Canada

In spite of the presence of imported products, traditional foods derived from hunting and fishing play an important role in the diet of northern communities. These foods are a good source of essential nutrients. However, they may also contain amounts of contaminants such as lead (Pb) and mercury (Hg), which pose a health risk for these communities. It is therefore important to provide consumers with food quality data to guide them in their intake choices. In order to do that, our project in the Sentinel North strategy is to develop a portable device to quantify certain target elements in traditional foods. To be able to carry out the quantification of potential contaminants or essential nutrients, it is first necessary to carry out the dissolution of the foodstuffs. In our project, we are focusing on the dissolution of Arctic char meat. Acid or microwave dissolutions are the most widely used

methods in the laboratory, but they require large amounts of acid, high pressures and elevated temperature, which are ill-adapted to field-deployable conditions. Alkaline dissolution using tetramethylammonium hydroxide (TMAH) and ultrasonic frequencies is a fast and simple technique that requires little energy consumption and a small fraction of chemicals compared to the typical dissolution approaches. In order to be able to have an effective dissolution in a short period of time, we have designed and produced a new ultrasound probe. The dissolution of elements in Arctic char meat was optimized by factorial design in order to achieved the highest recovery while reducing the dissolution time. The impact of the parameters as well as the optimal conditions according to the constraints imposed by the type of analyses will be discussed.

DESIGN AND TESTING OF AN AUTONOMOUS, UNDERWATER PAR-SENSING ARRAY

Lachance, Gabriel (1), S. Larochelle (1), S. Thibault (1), W. F. Vincent (2), J.-M. Trudeau (1) and E. Bharucha (1)

(1) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Université Laval, Québec, QC, Canada

Underwater sunlight controls many physical, chemical and biological processes in the aquatic environment, including primary production via the Photosynthetically Active Radiation (PAR) waveband from 400 to 700 nm. PAR availability directly affects the survival, growth and reproduction of photosynthetic organisms, which lie at the base of aquatic food webs and thereby affect the functioning of the entire ecosystem. In northern lakes, PAR varies not only as a function of depth, but also as a result of changes in ice and snow-cover and through the large seasonal fluctuations of incident irradiance, from 24 hours of daylight in summer to continuous winter darkness. Continuous in situ measurements of underwater PAR are therefore essential to track that variability and to understand and model northern freshwater and marine ecosystems. PAR irradiance is usually measured with an underwater sensor that is lowered down the water column on a cable, or via a moored radiometer that measures solar radiation continuously at a specific depth. The moored instruments are costly and are typically deployed for a limited time at one or two depths. Our aim in this project is to develop a new type of moored PAR sensing system that minimizes cost, while also allowing the simultaneous measurement of underwater PAR from an array of sensors that can be positioned at multiple depths. The first phase of this project focused on setting the design specifications for an instrument appropriate to autonomous deployment in northern ice-covered lakes. For this we examined hyperspectral data from underwater PAR profiles obtained at ice-capped Ward Hunt Lake in the Canadian High Arctic (Nunavut). We also analyzed continuous records from radiometers deployed at two depths throughout the year in this lake, along with continuous incident irradiance records from the Centre d'études nordiques SILA tower on Ward Hunt Island (latitude 83°N). For fabrication of the instrument, we evaluated different materials and thicknesses of fibre optic design, and considered how the distribution of angles of incidence of light (parameterized as the volume scattering function in natural waters) would affect the efficiency of capture by the light sensor. We also considered how measurements at discrete wavelengths could be scaled up to full PAR waveband estimates. In the second step of this project, the first prototype of a single fiber optic sensor was built based on simulations and experiments done in the lab to test the measurement capacity of a simple detector. This prototype was tested in the field at a southern lake during winter (Lake St-Charles, Quebec), and during a visit to a northern lake in late winter (Iqaluit, Nunavut). These initial tests indicated the need to increase the sensitivity of the sensor and led to the ongoing development of a second prototype that will focus on increasing the sensitivity of the first prototype and lead to the final design of the sensor. The ultimate goal is to develop a robust multi-depth PAR-sensing array that can be reliably deployed in the Arctic.

EXPERIENCING NORTHERN LIGHTS: AN IMMERSIVE TOOL FOR THE VISUAL ASSESSMENT OF DAYLIT SPACES

Lalande, Philippe (1), C. M.H. Demers (1), M. Hébert (2), J.F. Lalonde (3), M. Blais (1) and A. Potvin (1)

(1) École d'architecture, Université Laval, Québec, QC, Canada
(2) Département d'ophtalmologie et d'ORL-chirurgie cervico-faciale, Université Laval, Québec, QC, Canada
(3) Département de génie électrique et génie informatique, Université Laval, Québec, QC, Canada

Daylight is a vector of information, also playing the role of the main vector of human well-being and comfort. In extreme climates, daylighting design strategies that

enhance the quality and inhabitability of an interior space remain a challenge to allow a better relationship between architecture and the exterior environment responding to its particular photoperiod and solar geometry. Targeting light needs according to the seasonal cycle is the first step in optimizing architectural forms favouring the creation of biophilic spaces in Nunavik. The main objective of this research is to characterize the quality and availability of northern daylight to optimize its integration into the architecture of Nunavik. The research develops an immersive method of representation of the human field of vision that better reflects the spatiotemporal reality of the perceived and lived lighting environments. It moreover addresses the potential of integrating the circadian metrics of light in architecture. Immersive use in virtual reality will allow the visualization, among Inuit communities and designers not necessarily located in the North, of the photographic and luminous data collected. Visual assessment through high dynamic range (HDR) imagery in virtual reality will serve as a decision support tool that will help understand the needs and challenges related to architectural daylighting in Nunavik. Visual and lighting sensors, based on Raspberry Pi microcomputers, are adapted to generate HDR images and calibrated representations of existing environments. Light is represented as luminance values, expressed in false colors for the visible (photopic) as well as the circadian portion (melanopic) portions of the light spectrum. While static daylight representations are assessment tools that are relevant for specific cases, they must be enhanced or accompanied by other tools in order to reflect the dynamic changes in lighting conditions on an annual basis. Ultimately, the research proposes a novel method of representation and visualization of northern light that integrates the spectral, spatial and temporal components of the built environment. References: Arendt, Josephine. "Biological Rhythms During Residence in Polar Regions." Chronobiology International 29, no. 4 (2012): 379-94. Chamilothori, Kynthia, Jan Wienold, and Marilyne Andersen. "Adequacy of Immersive Virtual Reality for the Perception of Daylit Spaces: Comparison of Real and Virtual Environments." Leukos 14 (2018): 1-24. Inanici, Mehlika N. "Evaluation of High Dynamic Range Photography as a Luminance Data Acquisition System." Lighting Research & Technology 38, no. 2 (2006): 123-34. Jung, Bo Yun. "Measuring Circadian Light through High Dynamic Range (HDR) Photography." M. Sc. thesis, University of Washington, 2017. Lucas, Robert J., Stuart N. Peirson, David M. Berson, Timothy M. Brown, Howard M. Cooper, Charles A. Czeisler, Mariana G. Figueiro, et al. "Measuring and Using Light in the Melanopsin Age." Trends in Neurosciences 37, no. 1 (2014): 1-9. Mead, Alex Robert, and K. Mosalam. "Ubiquitous Luminance Sensing Using the Raspberry Pi and Camera Module System." Lighting Research and Technology 49, no. 7 (2016): 904-21.

IMPACT OF SNOW, ICE, MELT PONDS AND CLOUDS ON LIGHT AVAILABILITY FOR PHYTOPLANKTON UNDER FIRST-YEAR LANDFAST ICE DURING THE GREEN EDGE PROJECT

Laliberté, Julien (1) and M. Babin (1)

(1) Unité Mixte Internationale Takuvik, Université Laval, Québec, QC, Canada

Arctic marine ecosystems are fueled by the production of algal biomass. While the growth of phytoplankton (single-celled algae suspended in seawater) was believed to be largely limited to the period when Arctic Ocean seasonal ice cover was decreasing (Jul-Oct), massive blooms of phytoplankton occurring under sea ice in the spring were recently documented. It is currently impossible to determine the extent of this phenomenon and its contribution, perhaps major, to annual marine primary production, as the mechanisms controlling the dynamics of phytoplankton blooms under sea ice are poorly understood. The most recent observations to understand this phenomenon suggest that phytoplankton growth under sea ice is largely conditioned by access to underwater light, which is determined by the presence of snow, sea ice, leads and melt ponds. However, the impact of clouds on light and, in turn, on the spring bloom dynamics of phytoplankton, has never been closely examined. Yet, the omnipresence of clouds in the Arctic strongly constrains light. Many environmental components were measured at a coastal Baffin Bay location during the Green Edge 2015 and 2016 field campaign. Using in situ and satellite observations, we evaluate how the snow, sea ice, melt ponds, and clouds impact light availability for phytoplankton at a very local scale for the spring and summer seasons.

DYNAMIQUE SAISONNIÈRE DES ÉTANGS THERMOKARST SUBARCTIQUES : LE CAS DES VIRUS

Langlois, Valérie (1,2,4), W. F. Vincent (1,3,4) et A. Culley (1,2,4)

(1) Centre d'études nordiques, Kuujjuarapik, QC, Canada
(2) Département de biochimie, microbiologie et bio-informatique, Université Laval, Québec, QC, Canada
(3) Département de biologie, Université Laval, Québec, QC, Canada
(4) Sentinelle Nord, Université Laval, Québec, QC, Canada

Dans les conditions actuelles de réchauffement climatique, les environnements arctique et subarctique sont touchés par une augmentation significative de la température moyenne. Cela se traduit par d'importants changements du paysage, notamment le dégel du pergélisol et la croissance des étangs thermokarst. Ces étangs sont connus pour leur libération importante de gaz à effet de serre (GES), un processus conduit par l'activité microbienne. Ce projet de métagénomique utilise comme modèle les étangs thermokarstiques de la région de Whapmagoostui-Kuujjuarapik pour tracer un portrait des populations virales de ces milieux dans l'optique de permettre une meilleure compréhension des changements importants liés au dégel du pergélisol. Les étangs thermokarst sont peu profonds (<3 m) et chargés en matière organique. Durant la saison estivale, leur colonne d'eau est stratifiée présentant une eau chaude et bien oxygénée en surface et plus fraîche et entièrement anoxique en profondeur. Durant la saison hivernale, la colonne d'eau se retrouve isolée, empêchant les échanges avec l'atmosphère, et devient entièrement anoxique. Ces conditions anoxiques favorisent l'activité de micro-organismes méthanogènes et la formation de GES. Les virus, de petits parasites intracellulaires, sont connus pour avoir un impact considérable sur leurs hôte et environnement. Ils peuvent affecter la chaîne alimentaire, l'équilibre des populations microbiennes et les cycles biogéochimiques. Puisque la grande majorité des virus sont encore inconnus et leur impact sur l'écosystème arctique est encore largement sous documenté, ce projet représente une occasion de combler une grande lacune dans les connaissances actuelles. Dans ce projet, nous analysons la communauté virale des étangs thermokarst du nord du Québec. Trois échantillonnages ont été effectués entre 2015 et 2017 dans la vallée de la rivière Sasapimakwananisikw. Les échantillons de colonne d'eau de surface et profondeur ont été filtrés afin de récupérer les particules virales. Les virus extraits ont ensuite été séquencés par séquençage de type Illumina et analysés à l'aide de divers outils bio-informatiques. L'objectif de ces analyses est de révéler les souches connues et, surtout, inconnues de virus présent dans les étangs de fonte subarctiques. L'utilisation d'outils de détection sur les métagénomes enrichis en séquences virales permet de déceler tant des souches virales bien décrites que certaines souches jusqu'à présent entièrement inconnues. Les outils actuellement à notre disposition permettent de tracer un portrait global des communautés virales et de mieux comprendre leur rôle dans ces environnements en changement. Nous nous attendons à identifier diverses souches virales jusqu'ici non répertoriées et, vu l'importance de l'activité métabolique microbienne de ces étangs, à identifier divers gènes issus de séquences virales liés à la production de GES. Une perspective de ce projet sera l'étude des changements que subissent les communautés virales des étangs thermokarstiques au cours des saisons. Nous nous attendons à retrouver des communautés virales différentes en surface d'une saison à l'autre et à observer une certaine similarité entre les communautés estivales trouvées dans les eaux anoxiques en profondeur et celles échantillonnées lors de la saison hivernale. Nous nous attendons également à retrouver des gènes liés à la production de GES différents selon les conditions du milieu échantillonné.

MEASUREMENT OF IN-ICE ANGULAR RADIANCE DISTRIBUTIONS

Larouche, Raphaël (1,2), S. Lambert-Girard (1), S. Thibault (2) and M. Babin (1)

(1) Unité Mixte Internationale Takuvik, Université Laval, CNRS, Québec, QC, Canada
(2) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

Climate change critically impacts the Arctic ecosystem. A substantial decrease in sea-ice extent and thickness results in modified ocean/atmospheric exchanges and annual primary production. Improved understanding of sea ice radiative transfer is required to better understand the availability of light for primary production and sea ice mass/energy budgets. Researchers have been relying on the measurements of spectral surface albedo and transmittance for the various ice types and surface conditions. These two measurements are not sufficient to correctly infer IOPs (Inherent Optical Properties) of sea ice layers, notably in the bottom 10 cm where ice algae

are concentrated. Few studies have tried to measure in-ice irradiance downwelling profiles or radiance distributions. Their conclusions were constrained by standard bulky radiometers that limited the vertical resolution, provided limited angular resolution, destroyed the medium or induced shadowing. The aim of this project is to design, build and test a miniature instrument measuring radiance within ice. The sensor is to be included in the Sea Ice Endoscopic platform (SIE). Simultaneously, the platform will measure sea ice structural properties and thus allow for establishing important structural-optical relations. The goal is to develop better light transport models and possibly, make predictions about climate change perturbations. This presentation will discuss specifications and requirements. We will also present some probe concepts.

REDUCING RISK IN A CHANGING CLIMATE

R. Couture (1) and LeBlanc, Anne-Marie (1)

(1) Natural Resources Canada, Ottawa, ON, Canada

Natural-resource development is being undertaken in northern and coastal areas that are vulnerable to rapidly changing climate and for which there is limited geoscience knowledge. In these areas, sustainable development of natural resources - which is vital to lasting economic, social, and environmental development - requires sustainable infrastructure. To unlock natural-resource potential effectively, and to ensure community well-being in northern and coastal areas, it is critical that transportation and community infrastructure be resilient to climate change and to harsh environments. This requires new geoscience knowledge to inform climate-change risk-reduction strategies. Within the framework of its Climate Change Geoscience Program (CCGP), NRCan is working with federal, territorial, provincial, Indigenous, and academic partners to produce geoscience-based information and tools in order to support decision-makers in the identification of priorities for preparedness and adaptation activities. The three main project areas supported by the CCGP are: 1) Supporting Adaptation in Permafrost Regions: Permafrost projects improve the understanding of permafrost/climate/infrastructure interactions that are critical for development of climate-change adaptation strategies in the vicinity of major existing and proposed transportation routes and for natural-resource development in both Arctic and Subarctic environments. Priority areas for project activities include improving the Canadian permafrost map and analyzing geoscientific data in the vicinity of major existing and proposed northern transportation routes such as the Inuvik-Tuktoyaktuk Highway. 2) Supporting Adaptation in Coastal Regions: Coastal projects improve understanding of the sensitivity and vulnerability of coastal regions across Canada to climate change in order to develop effective adaptation strategies related to existing and proposed infrastructure and communities. Project activities focus on refining Canada's sea-level change projections and associated hazard risks, improving understanding of coastal erosion on land and the nearshore environment in ice-rich permafrost terrain in the western Arctic, and developing a national digital database that combines data on different coastal physical features to generate indices of coastal sensitivity to climate change. 3) Advancing Climate Adaptation through Improved Drought Indices and Flood Forecasting in the Context of Extreme Events. Activities within this project include improving flood forecasting for the Hudson Bay Lowlands to provide advance warning to First Nations communities and developing drought indices to provide support for improved hydroelectric water management in central Quebec-Labrador Peninsula and northeastern Manitoba. This presentation provides an overview of these three CCGP project areas, along with further information on activities and initiatives within the projects.

DEVELOPMENT OF NEW SURFACE-ENHANCED RAMAN SPECTROSCOPY (SERS) FIBER PROBES FOR IN VIVO AND REAL-TIME IDENTIFICATION OF BILE ACID MARKERS OF THE MICROBIOTA ACTIVITY

Lebrun, Alexis (1,2), H. Fortin (2), M. Lamarre (2), N. Fontaine (2), O. Barbier (1) and D. Boudreau (2)

(1) Laboratoire de pharmacologie moléculaire, Axe endocrinologie-néphrologie, Centre de recherche du CHU de Québec - Faculté de pharmacie, Université Laval, Québec, QC, Canada
(2) Département de chimie and Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

In Canada's northern populations, nutrition is targeted as an important cause of many cardiometabolic and mental diseases. Scientific evidence increasingly supports the conclusion that environmental factors, such as changes in diet from traditional to western foods, are at the origin of important disturbances in the intestinal microbiome, which could potentially drive pathogenic mechanisms of these diseases. Cholic acid (CA), is a

primary bile acid formed from cholesterol in the liver, stored in the gallbladder and secreted in the intestine during the meal. Bacteria from the intestine efficiently convert primary bile acids into hydrophobic secondary acids such as deoxycholic (DCA) and lithocholic (LCA) acids, which exert physiological roles distinct from their parent molecules. Because the bioconversion of CA into derivatives is crucially dependent on the microbiota composition, this molecule is currently viewed as a potential marker of microbiome disturbances. Current analytical methods rely on downstream feces sampling coupled with mass spectroscopy, a costly and time-consuming procedure, in a posteriori analytical process that integrates cholic acid species along the entire gastric pathway. The present project aims to develop and validate CAD-selective chemical sensors based on Surface-enhanced Raman spectroscopy (SERS), a label-free molecular identification technique. These sensors, once immobilized at the tip of optical fibers and implanted in the gastrointestinal tract of mice with cardiometabolic and mental disorders, will allow a real-time study of the microbiota with unsurpassed spatial and temporal resolution. The first step of this project consists of the fabrication and characterization of a nanostructured plasmonic surface capable of capturing and enhancing the Raman signal from adsorbed CADs. The plasmonic material's composition and geometry will be chosen so as to maximize signal amplification and coupling with the excitation laser wavelength. We will also evaluate various anti-fouling surface coating strategies to minimize non-specific adsorption of matrix species. In a second step, we will acquire Raman spectra from various CADs using this SERS substrate to build a spectral database that will be used for digital spectral analysis using machine learning algorithms. The algorithms will be tested with single-component and multi-analyte mixtures in simple aqueous solutions as well as in complex matrices such as feces aqueous suspensions. In a third step, we will immobilize the SERS sensor on a custom-made optical fiber. The geometry of this fiber-based sensor will be chosen to maximize the coupling efficiency of the excitation laser source with the SERS nanomaterial, as well as the signal collection efficiency of the Raman signal from the captured CADs. Ultimately, the fiber optrode will be implanted in animal models. The results from this project are likely to lead to important changes in the health of Canada's northern population. The real-time monitoring system that we will develop is designed to improve our understanding of how environmental factors affect gut microbiota, and by doing so, impact one's health. These real-time measurements will be essential to developing faster and more specific intervention aimed at reducing the burden of cardiometabolic and mental diseases in northern populations.

GÉOCHIMIE DE L'ARSENIC DANS LES LACS DE LA RÉGION DE YELLOWKNIFE SOUS L'INFLUENCE DE LA MINE GIANT

Leclerc, Émilie (1), J. Telford (2), R-M. Couture (1), J. Venkisteswaran (2) and B. Wolfe (2)

(1) Département de chimie, Université Laval, Québec, QC, Canada
(2) Department of Geography and Environmental Studies, Wilfrid Laurier University, Waterloo, ON, Canada

Dans les années 1940, l'exploitation minière était le principal moteur économique dans les Territoires du Nord-Ouest. L'une des plus grandes mines abandonnées est la mine Giant dans la région de Yellowknife. Les activités de la mine ont généré des émissions de trioxyde d'arsenic entre 1948 et 2004. La pollution par l'arsenic provenant de l'exploitation minière s'étend au-delà des sites miniers immédiats par le biais du transport atmosphérique et des dépôts subséquents dans les sols et les lacs. Cependant, son étendue est mal connue. Il est attendu que la concentration maximale en arsenic dans les sédiments devrait coïncider avec le pic d'émission de la mine Giant. Il devrait également y avoir une réduction de la concentration en arsenic avec l'arrêt des activités de la mine. Dans chaque lac, trois carottes de sédiment seront prélevées. Une carotte servira à la datation et à l'analyse des paramètres géochimiques, une autre servira à l'analyse des phases réactives du fer et de l'arsenic, et une dernière à prélever les eaux porales. L'eau porale est un indicateur sensible des réactions chimiques et biologiques, qui peuvent conduire à la formation de phases minérales nouvelles ou altérées ainsi qu'à des changements dans la composition des eaux elles-mêmes. L'eau porale sera soustraite de la carotte par des lysimètres de 2 mm de diamètre avec une porosité de 0.2 µ et les concentrations d'arsenic y seront mesurées par ICP-MS. Je vais interpréter les profils de concentrations d'eau porale à l'aide d'un modèle inverse pour évaluer l'effet de la diagenèse sur le profil historique de l'arsenic dans les sédiments. Ces informations me permettront de conclure sur les risques posés par l'arsenic enfouis dans les sédiments des lacs.

HYDROGEOLOGY OF THE TASIAPIK VALLEY (UMIUJAQ, NUNAVIK)

Jean-Michel Lemieux (1,2), R. Fortier (1,2), R. Murray (1,2), S. Dagenais (1,2), H. Delottier (1), R. Therrien (1,2), M. Cochand (1,2), A. Pryet (3) and M. Parhizkar (1,2)

(1) Département de géologie et de génie géologique, Université Laval, Québec, QC, Canada
(2) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(3) EA 4592 Georessources & Environment, Bordeaux INP and Université Bordeaux Montaigne, ENSEGID, Pessac, France

Climate change is currently affecting the global water cycle and its future impact is likely to be more important in Arctic environments since temperatures are rising faster than the global average. The Arctic climate is progressively shifting toward a warmer, wetter, and more variable environment which will likely have important implications for northern communities, water resources, and ecosystems. Currently, water supplies for northern communities mostly originate from surface water such as rivers and lakes. While these sources of water are usually abundant, their water quality is variable, they are vulnerable to contamination and unreliable as they often freeze or quickly dry up in winter. In contrast, groundwater is generally of better quality, is less vulnerable to contamination, and minimal treatment is usually required. Therefore, the increased availability of groundwater in the context of climate change could potentially improve water quality and security for northern communities. However, our understanding of groundwater distribution and dynamics in Arctic environments along with their interaction with permafrost and surface water is currently limited. Current information is missing, for example, on how climate change in the Arctic will affect the water cycle, and more importantly, how it will impact water consumption, water quality and groundwater resources. Such knowledge is essential for future sustainable and multi-use of Arctic water resources. Here, groundwater distribution and dynamics are studied in a small discontinuous permafrost watershed located in the Tasiapik Valley (Umiujaq, Nunavik). The objective is to provide a quantitative analysis of the water cycle in a cold environment and capture its seasonal variations. The results will provide a baseline to study the long-term impact of climate change on the water cycle and provide a detailed dataset that can be used to feed numerical models. It will also contribute to a better general understanding of groundwater dynamics in cold environments that is needed to support long-term sustainable management of groundwater. Finally, it will provide the necessary hydrogeological context needed to better understand the interaction between groundwater and permafrost dynamics. The presentation will provide an overview of the physical environment of the Tasiapik Valley where an extensive instrumentation network has been deployed since 2013. A hydrogeological conceptual model of the basin is then presented using field observations including precipitation, air temperature, water levels in observation wells and river discharge measurements. Finally, a water budget is presented in order to quantify recharge and groundwater flow through the aquifers, as well as interactions with surface water, atmosphere and surrounding watersheds.

CAN FOLIC ACID SHIELD AGAINST ARCTIC CONTAMINANTS TO PROTECT MALE REPRODUCTIVE FUNCTION?

Lessard, Maryse (1), P. Charest (1), P. Herst (1), M. Richard (1), M. Dalvai (1) and J. L. Bailey (1)

(1) Laboratoire de fonction spermatique et de toxicologie, Centre de recherche en reproduction, développement et santé intergénérationnelle, Département des sciences animales, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval, Québec, QC, Canada

Persistent organic pollutants (POPs) have bioaccumulated and biomagnified in the Arctic, therefore, traditional Inuit foods are contaminated leading to high body burdens in these people. These POPs levels may contribute to the health disparity between Inuit and non-Aboriginal Canadians, including adverse pregnancy outcomes. Our laboratory has shown that paternal prenatal exposure to POPs causes reproductive disorders over two generations and induces changes in the sperm epigenome by modifying DNA methylation. A simple therapeutic strategy to reduce the impact of POPs is desirable to counteract the effects of POPs and improve Inuit health. We hypothesize, therefore, that prenatal exposure to POPs disrupts reproductive parameters and fertility of males beyond two generations and that dietary folic acid (FA) mitigates these effects of POPs to improve male reproductive parameters. To test this hypothesis, four treatment groups of Sprague-Dawley F0 founder females (n = 6) were gavaged with an environmentally-relevant mixture of Arctic POPs (500µg/kg) or corn oil (Control) and received either 1X or 3X FA representing intake from fortified foods (1X) + a daily multivitamin containing folic acid (3X). F0 females were treated for 5 weeks to

establish a body burden of POPs, then mated to untreated males and POPs/FA treatments continued until birth of the F1 litters. All rats were then fed control chow (1X FA). Reproductive development and function were assessed in F1 and F2 males (n=12/treatment group) following mating with untreated females. Our results suggest that prenatal POPs exposure influences male sexual development for the first generation of F1 sons as anogenital distance was higher in the POPs 1X and 3X treatment groups. Sperm function parameters were also decreased due to POPs, but partly rescued by FA: sperm motility (Control 78% versus POPs 64% and POPs with 3X FA 72%), sperm viability (Control 48% versus POPs 34% but POPs with 3X FA 44%). Seminal vesicle weights were greater due to FA supplementation irrespective of POPs treatment. Moreover, prenatal POPs exposure in the F1 sons altered the sex ratio of their F2 offspring (Control 60% males/litter versus POPs with either 1X or 3X FA 40% males per litter). The reproductive parameters and fertility of the F2 sons with POPs and/or with 3X FA seem to be normal and comparable to Controls. Since we know that poorer sperm quality is associated with a long-term morbidity and a higher risk of cardiovascular disease and diabetes, our overall objective is to evaluate if the effects of POPs or FA supplementation persist beyond the first generation until the fourth generations and if their descendants present a different phenotype after paternal prenatal exposure to contaminants. We ultimately aim to minimize POPs effects by providing nutritional strategies and improve health for Inuit fathers and their sons.

ON THE AUTONOMOUS, OPTICAL MEASUREMENT OF SNOW DENSITY

Lévesque-Desrosiers, Félix (1), S. Lambert-Girard (1), Q. Libois (2), F. Domine (1) and S. Thibault (1)

(1) Université Laval, Québec, QC, Canada
(2) Météo-France, Toulouse, HG, France

Lemmings are a key link of the Arctic food chain. During the winter, these rodents do not hibernate, they live in the snow. Digging tunnels allow them to seek for food, hide and reproduce. Annually, their ease to dig tunnels is key for the evolution of the lemming population. Physical properties of snow, such as the density, are therefore fundamental spatiotemporal data to measure. Snow density is currently measured by weighing a known volume. This process requires the presence of scientists in the field which is complex and expensive given the Arctic's logistical constraints. Therefore, this property cannot be characterized throughout the winter and on a large spatial scale. This project focuses on developing an autonomous, optical method to measure snow density. Light propagation in snow, a complex medium composed of air and ice grains, depends on its density and on the size and shape of its grains. The project explores the possibility of determining these properties by studying the transport of a light pulse in this media. As a first step, a method to numerically simulate the propagation of a light pulse in snow has been developed and validated. This will lead to the design and fabrication of an instrument and an inversion algorithm that will be tested and validated with snow phantoms. Finally, after testing the device on snow in a cold room, it will be deployed in the Arctic.

NUMERICAL MODELLING OF CONVECTIVE AND CONDUCTIVE HEAT TRANSFER IN A TALIK BENEATH THE KUUGULUK RIVER IN SALLUIT, NUNAVIK (QUEBEC) USED AS A SOURCE OF DRINKING WATER

Liu, Weibo (1,2), R. Fortier (1), J. Molson (1), J. M. Lemieux (1) and C. Grenier (3)

(1) Département de géologie et de génie géologique and Centre d'études nordiques, Université Laval, Québec, QC, Canada
(2) State Key Laboratory of Frozen Soil Engineering, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou, China
(3) Laboratoire des Sciences du Climat et de l'Environnement, UMR8212, Université Paris-Saclay, CEA/CNRS/UVSQ, Gif sur Yvette, France

Water availability and management related to the supply of drinking water to communities are problematic in the Canadian North where surface water is the most common source of drinking water. Although rivers and lakes are abundant in the North, their water quality is variable. They are also vulnerable to contamination and climate change, and unreliable as they often freeze or dry up in winter. Groundwater can often provide a more secure and sustainable water source but, being stored as ground ice, its availability is limited in the North due to the presence of permafrost. Among the fourteen Inuit communities in Nunavik (Quebec), twelve rely on rivers and lakes while only two depend on groundwater as sources of drinking water. For instance, until 2012, the source of drinking water of the Inuit community of Salluit was a screened pipe buried in the riverbed of the Kuuguluk River. However, drying of this source was

often occurring in winter creating problematic health and safety issues. To fix this problem, even if Salluit is located in the continuous permafrost zone, groundwater was found in a shallow well drilled in fractured bedrock close to the Kuuguluk River. Following a geophysical investigation carried out in 2011, this groundwater well was installed in a suprapermafrost aquifer in a closed talik beneath the Kuuguluk River due to the heat storage effect of running surface water and groundwater flow. Moreover, during each winter, even if the river dries up, ice forms in the floodplain of the Kuuguluk River. For investigating the formation mechanism of this icing, the thermo-hydraulic conditions of the riverbed have been also monitored since 2014 using a mooring composed of water pressure and temperature dataloggers. During the winter, the water pressure measured under the icing is equivalent to a water column height in excess of 2.5 m. Based on the theory of mechanics of plates, this pressure is enough to crack the icing and allow the water pressure release and water seepage through the cracks for forming ice sheets. The physical processes taking place in this complex cryohydrogeological system are not yet fully understood. The objectives of this research project are to: 1) undertake 3D numerical modelling of coupled heat transfer and groundwater flow taking place in the talik beneath the Kuuguluk River, 2) understand the dynamics of this complex cryohydrogeological system, and 3) assess the impacts of climate change on the source of drinking water used by the Inuit community of Salluit. In the zone of continuous permafrost, groundwater is scarce and only occurs in taliks found beneath large water bodies. Understanding the dynamics and future evolution of taliks in the double context of climate warming and fast-growing Inuit communities with important drinking water needs is important because they are the only sources of groundwater available in the continuous permafrost zone and could provide more reliable and better-quality water than surface water to the users.

MONITORING TURBIDITY IN THE RIVERS OF LAKE TASIUJAQ (UMIUJAQ REGION, NUNAVIK)

Manseau, Frédéric (1), N. Bhiry (1) and J. Molson (1)

(1) Centre d'études nordiques, Université Laval, Québec, QC, Canada

Northern communities are struggling with large societal change due to the effects of climate change. In the North, climate change is causing increases in temperature that can be observed more quickly and abruptly than in other regions of the world. This global warming is inducing rapid melting of permafrost. The melting of permafrost causes an increase in the mineral and organic sediment load that is transported by rivers to lakes or the sea. Furthermore, during episodes of spring flooding and high rainfall in autumn, the sediments are transported by runoff, increasing the sediment load and the turbidity of the rivers and lakes. This turbidity increase can have negative effects on fish and other aquatic life. The Tasiapik Valley is situated a few kilometers from the village of Umiujaq in Nunavik. The valley is cut by a small stream that flows into Tasiujaq Lake which is part of the Tursujuq National Park and a popular place for fishing and outdoor activities, for both members of the community and tourists. The stream crosses permafrost mineral mounds in its upstream part and palsas and thermokarst ponds in its downstream part. Several studies are currently being conducted in the region, including research on groundwater and slope movement. Some studies have also been carried out in other regions of the Arctic focussing on the acceleration of the thermokarst process and the degradation of permafrost mounds, palsas and lithalsas over the last few decades. This project aims to document the evolution of turbidity in the stream and at Tasiujaq Lake, in conjunction with other field parameters such as water and air temperature. This study forms part of sub-project 1.3 of Thematic Project 1: Characterization and modeling of the key interrelationships of northern water systems under climatic, geosystemic and societal pressures. Thematic Project 1 is part of Sentinel North, the newly established institutional research program. Fieldwork began in June 2018 with the installation of turbidity meters at various locations along the stream. These will record the turbidity of the river in real time during the summer and autumn months before the stream begins to freeze in October. We will conduct geomorphological surveys and analyze the sedimentology of the lake and fluvial sediments. A gauging station has already been set up in the stream that will inform us about its flow rate. Sediments sampled in June, August and October at this gauging station will be studied in terms of grain size and loss-on-ignition

DIVERSITÉ DES COMMUNAUTÉS MICROBIENNES DES LACS DE LA VALLÉE DE STUCKBERRY (NUNAVUT, CANADA) DANS UN CONTEXTE DE CHANGEMENTS CLIMATIQUES

Marois, Catherine (1,2,3), Y. Klanten (2,3), K. Triglav (2,3), D. Antoniades (2,3) and A.I. Culley (1,2,3)

(1) Viral Discovery and Ecology Laboratory, Québec, QC, Canada
(2) Université Laval, Québec, QC, Canada
(3) Centre d'études nordiques, Québec, QC, Canada

La température globale augmente deux fois plus rapidement en Arctique qu'ailleurs. Une meilleure compréhension des régions polaires est donc cruciale afin de détecter et de discerner les conséquences éminentes des changements climatiques. Plus précisément, ce projet se concentre sur l'impact de ces dérèglements sur les communautés microbiennes et virales puisqu'elles forment la plus grande biomasse de l'océan Arctique et jouent des rôles considérables dans les environnements aquatiques. L'île d'Ellesmere (Nunavut) est celle la plus au nord de l'archipel arctique canadien et borde l'océan Arctique. La vallée de Stuckberry, située sur la rive nord de cette île, a subi une importante variabilité climatique au cours de l'Holocène. Le glacier de tête s'est retiré progressivement et plusieurs lacs se sont formés par le phénomène de rebond post-glaciaire. En raison de l'intervalle de temps qui sépare l'isolement de ces lacs, ils représentent une opportunité unique d'étudier l'historique des communautés microbiennes et leurs réponses face aux changements climatiques. L'objectif central du projet est donc de comparer les communautés microbiennes de ces milieux aquatiques changeants de l'Arctique en fonction du temps d'isolement du lac, de la stratification de la colonne d'eau et des années. Au cours des étés 2017 et 2018, l'eau de chaque lac de la vallée a été échantillonnée à plusieurs profondeurs caractéristiques puis filtrée pour récupérer les parties microbienne et virale. Une approche métagénomique sera utilisée pour l'étude de la diversité virale, alors que le séquençage des gènes ribosomaux 16S et 18S sera réalisé pour celle de la diversité microbienne. Après avoir séquencé le tout avec la technique Illumina, des analyses bio-informatiques et statistiques seront effectuées pour découvrir la composition microbienne et virale de ces lacs arctiques. Connaître les impacts de ces bouleversements sur notre environnement pour réaliser d'éventuelles prévisions environnementales, sociales et économiques est l'un des avantages du projet.

BILIOPANCREATIC DIVERSION WITH DUODENAL SWITCH ALTERS BACTERIAL DIVERSITY AND RICHNESS IN WISTAR RATS

Mukorako, Paulette (1), C. Lopez (1), E.D. Baraboi (1), M.C. Roy (1), J. Plamondon (1), N. Lemoine (1), T. Varin (2), A. Marette (1,2) and D. Richard (1)

(1) Institut universitaire de cardiologie et de pneumologie de Québec, Québec, QC, Canada
(2) Institut sur la nutrition et les aliments fonctionnels, Québec, QC, Canada

Background: Obesity is a chronic condition which affects one in four adult northern Canadians. Biliopancreatic diversion with duodenal switch (BPD/DS) has been used for several years to treat severe obesity (BMI ≥ 50 kg/m2). It represents the most effective procedure in the treatment of morbid obesity and associated type-2 diabetes. The mechanisms whereby the surgery exerts its positive metabolic effects have however yet to be fully delineated. The objective of this study was to distinguish the effects of the two components of BPD/DS, namely sleeve gastrectomy (SG) and DS, on gut microbiota and to establish the link between gut microbiota shifts and metabolic variables. Methods: Three types of surgery BPD/DS, DS and SG were performed in Wistar rats fed a standard chow diet. Body weight and energy intake were measured daily during the eight weeks of the study. Glucagon-like peptide 1 (GLP-1), peptide tyrosine tyrosine (PYY), insulin and glucose were measured at the eighth week post-surgery. Fecal samples were collected prior to surgery and at 2 and 8 weeks after surgery. Specimens of the alimentary, biliopancreatic and common limbs (resulting from BPD-DS) were taken from the proximal portion of each limb. In SHAM and SG-operated rats, gut samples were obtained from the corresponding levels of the intestine. Fecal and gut samples were analyzed by 16S ribosomal RNA gene sequencing. Results: BPD/DS and DS achieved lower weight gain, while reducing body fat and digestible energy intake, improved glucose metabolism and also increased GLP-1 and PYY levels. 16S ribosomal RNA gene sequencing performed on fecal and gut samples revealed that alterations of the gut microbiota were due to a decrease in bacterial richness and diversity at 2 and 8 weeks post-surgery in BPD/DS and DS resulting in increased proportions of Bifidobacteriales and reduced Clostridiales. Those effects were not seen in SG rats. Conclusion: The metabolic benefits following BPD/DS are seemingly due to the DS component of the surgery. Furthermore, BPD/DS causes marked alterations in gut microbiota resulting in reduced bacterial diversity

and richness. The increased abundance of Bifidobacterium after BPD/DS may be one of the contributors to the positive outcomes of the surgery.

A WIRELESS FIBER PHOTOMETRY SYSTEM BASED ON A HIGH-PRECISION CMOS BIOSENSOR WITH EMBEDDED CONTINUOUS-TIME ΣΔ MODULATION

Noormohammadi Khiarak, Mehdi (1), S. Martel (2), Y. De Koninck (3) and B. Gosselin (1)

(1) Smart Biomedical Microsystems Lab, Department of ECE, Université Laval, Québec, QC, Canada
(2) Nano Robotics Laboratory, Polytechnique Montréal, Montréal, QC, Canada
(3) CERVO Brain Research Centre, Université Laval, Québec, QC, Canada

Optical neural interfaces enable targetable control and monitoring of specific intact neural circuits. We present a new head mountable wireless fiber biophotometry microsystem conceived to detect fluorescent signal fluctuations correlated with neuronal activity. Fluorescence biophotometry measurements require wide dynamic range (DR) and high sensitivity laboratory apparatus. Indeed, it is often very challenging to accurately resolve the small fluorescence variations in presence of noise and high background tissue autofluorescence. There is a great need for smaller detectors combining high linearity, high sensitivity, and high-energy efficiency. The proposed system incorporates all aspects of a conventional tethered fiber-based biophotometry system encompassed into a wireless microsystem. The interface includes an excitation light source, a custom designed CMOS biosensor, a multimode fiber, a microcontroller (MCU), and a wireless data transmission which are integrated within a 3D-printed, small foot print, plastic housing. Precisely, the system incorporates a new biophotometry sensor merging two individual building blocks, namely a low noise sensing front-end and a 2nd order continuous-time ΣΔ modulator (CTSDM), into a single module for enabling high sensitivity and high energy-efficiency photo-sensing. In particular, a differential CMOS photodetector associated with a differential capacitive transimpedance amplifier (DCTIA)-based sensing front-end is merged with an incremental 2nd order 1-bit CTSDM to achieve a large dynamic range, low hardware complexity, and high energy-efficiency. The sensor leverages a hardware sharing strategy to simplify the implementation and reduce power consumption. The proposed CMOS biosensor is implemented in a 0.18-µm CMOS technology, consuming 41 µW from a 1.8-V supply voltage, while achieving a peak dynamic range of 86 dB over a 50-Hz input bandwidth at a 20-kS/s sampling rate. This new interface opens new avenues for conducting in-vivo freely moving experiments.

ESTIMATION DU STRESS MUSCULOSQUELETTIQUE À PARTIR DES DONNÉES ISSUES DE CAPTEURS INERTIELS : PROTOCOLE DE RECHERCHE

Pairot de Fontenay, Benoit (1), R. Willy (2), B. Gosselin (1), L. Bouyer (1) and J.-S. Roy (1)

(1) Centre interdisciplinaire de recherche en réadaptation et intégration sociale, Québec, QC, Canada
(2) School of Physical Therapy and Rehabilitation Science, University of Montana, Missoula, MT, USA

Dans le cadre du projet d'études postdoctorales s'intitulant « Caractérisation du niveau d'activité physique et du stress musculosquelettique chez les habitants du Nord », nous souhaitons présenter le protocole de recherche du premier volet de ce projet : « Estimation du stress musculosquelettique à partir des données issues de capteurs inertiels ». Le développement de capteurs inertiels miniaturisés dans le cadre du projet 2.8 de Sentinelle Nord offre la possibilité de collecter des données hors laboratoire. Cependant, l'estimation du stress mécanique sur le système musculosquelettique à partir des données issues de ces capteurs reste un défi majeur. À l'automne 2018, il est prévu de collecter des données à la course chez 30 sujets sains au CIRRIS. Les enregistrements seront effectués à la fois grâce au gold standard (analyse vidéo 3D et plateformes de force) et également grâce aux capteurs inertiels miniaturisés. En collaboration avec le Dr Richard Willy, professeur adjoint à l'Université du Montana et expert en biomécanique des membres inférieurs et dans l'utilisation des capteurs inertiels, le stress mécanique sur le système musculosquelettique des membres inférieurs sera ensuite déterminé : 1) à partir des données cinématiques 3D et dynamiques avec le logiciel The Motion Monitor (gold standard), et 2) grâce au développement d'un modèle adapté aux données issues des capteurs inertiels. Les données des deux systèmes seront ensuite comparées. Grâce à ce travail de collaboration internationale, il est attendu que les données issues des capteurs inertiels permettent une estimation du stress mécanique sur le système musculosquelettique des membres inférieurs similaire à celle obtenue avec le gold standard (coefficient de corrélations multiples > 0.90). Les

résultats de ce travail permettront d'envisager une collecte de données en situation écologique, deuxième volet du projet d'études postdoctorales.

BIOPHILIC DESIGN AND PHOTOBIOLOGICAL DEVELOPMENT OF ADAPTIVE BUILDING ENVELOPES

Parsaee, Mojtaba (1), C. MH. Demers (1), M. Hébert (2), J.-F. Lalonde (3) and A. Potvin (1)

(1) Groupe de recherche en ambiances physiques, École d'architecture, Université Laval, Québec, QC, Canada
(2) CERVO Brain Research Centre, Department of Ophthalmology and Otorhinolaryngology, Faculty of Medicine, Université Laval, Québec, QC, Canada
(3) Computer Vision and Systems Lab, Electrical and Computer Engineering Department, Université Laval, Québec, QC, Canada

The biophilic design approach has recently been developed to confront adverse effects of the built environment development and improve human well-being by redefining the human-nature relationship. However, suggested biophilic design recommendations are rarely discussed in extreme climatic conditions such as very cold climates in which harsh nature, especially in terms of availability of natural light and seasonal photoperiod, endangers human well-being. Critically reviewing the body of knowledge and identifying the shortcomings and gaps between knowledge and action, this research intends to promote climate-adaptability, photobiological effects and energy efficiency and ultimately optimize biophilia in buildings by architecture through developing adaptive envelope systems. The intended strategies will be developed for extreme climatic conditions of Northern Quebec's cities and territories as a case study. In fact, the nature-friendly design of built environments, as proposed by biophilic design theories, has arguably extensive economic and environmental as well as physiological, psychological, and emotional benefits. Biophilic architecture claimed having economic benefits as a consequence of increasing the productivity of occupants, improvement of property value and employee attraction, decreasing energy consumption and carbon footprints. More importantly, Biophilic design has significant benefits where people spent most of their time within the buildings such as extreme cold or hot climates. Meanwhile, adapting the built environment spaces to a climatic context potentially outweighs the advantages in mitigating negative effects of the built environment and simultaneously gaining maximum benefits from the natural environment. As climate factors and conditions substantially change from very hot (-humid/dry) to subarctic climates, the adaptation strategies of building envelopes should be developed to address local climatic factors and conditions as well as respective inhabitants' needs. From all factors, solar radiation and photoperiod are identified as the main climate-causing factors triggering many biological seasonal events. Indeed, seasonal and daily photoperiod variations, in particular lack of solar radiation and light in winter months as well as darkness in summer months especially in northern regions, makes people to spend most of their times inside the buildings and hence energy consumption increases. This situation also has adverse effects on human well-being. In this regard, previous studies reported several light-related complains of sub-Arctic or very cold inhabitants such as desynchronized circadian systems, sleep problems, lower physical activity seasonal affective disorder (SAD), winter depression, mood disturbances, and higher UV light exposure. As one potential solution to confront aforementioned problems, biophilic design approaches could be developed to be practical and applicable to extreme climatic conditions in territories of Northern Quebec. To this end, this research intends to optimize biophilia and develop human-friendly lighting scenarios in buildings regarding photobiology and drawing attention to image-forming and non-image-forming effects of light and daylighting as one of the bases of nature-oriented built environment design. Standing as an in-between matter and transient space in human-nature relationship, this research attempts to attain the intended objectives by developing adaptive and intelligent building envelope systems in responses to extreme outdoor environment conditions and human needs, in particular for extreme climate in northern regions.

OPTIMIZATION AND CHARACTERIZATION OF IPSC DERIVED NEURONS TO STUDY THE ENDOPHENOTYPES FOR SCHIZOPHRENIA USING DIGITAL HOLOGRAPHIC MICROSCOPY

Patel, Niraj (1), P. Lavergne (2), H. Poulin (3), A. Correia (4), S. Lévesque (5), J. Mugnes (6), M. Maziade (7) and P. Marquet (8)

(1) Psychiatry and Neurophotonics Research Laboratory, Québec, QC, Canada

Schizophrenia (SZ) is a severe and chronic brain disorder which affects about one percent of the entire

world population. The disorder is characterized by difficulty thinking clearly, abnormal social behavior and a difference between one's own interpretation of reality and actual reality. It can be caused by genetic as well as environmental factors. The schizophrenia phenotypes and characteristics of symptoms are still not clear due to extremely large heterogeneity in clinical phenotype. However, the recent study shows SZ is a highly heritable disorder and siblings, relatives and family members are more susceptible to developing these disorders. Further, due to altered gene regulation, the cellular changes start appearing in very early age before the clinical symptoms occur. Therefore, my aim is to study the finding of important cellular biomarkers to understand the early SZ pathogenesis and develop new therapeutic models. Recent advancements in cellular reprogramming techniques, microscopic tools, and non-invasive methods have made it possible to directly study brain cells from patients. By using advanced tools, we have successfully developed human induced pluripotent stem cells (Hu-iPSCs) in vitro from urothelial cells obtained from schizophrenia patients as well as healthy controls by using integration-free methods. Generation of neuronal cells was achieved by following a commercially available protocol and medium from STEMCELL-Technology. Neuronal cell characterization has been done by using immunocytochemistry and electrophysiological (whole cell patch clamp) tools. To study the cellular level differences, we will use the digital hologram microscopy which allows us to study quantitative image cell morphology, cell dynamics at the nanoscale, refractive index, volume changes and transmembrane water permeability changes without using any invasive agents. The first step of my study is to look for refractive index changes in the neuronal cells by using a decoupling method. A successful identification of well-defined cellular phenotypes during the neuronal developmental process will constitute a source of potential biomarkers which could represent invaluable help in the development of novel therapeutic approaches for schizophrenia disorder.

DEVELOPMENT OF A REFLECTANCE PROBE TO MEASURE SEA ICE INHERENT OPTICAL PROPERTIES

Perron, Christophe (1,4), S. Lambert-Girard (1), Erik Bélanger (4,5), P. Després (2,3), D.Côté (3,4,5), P.Marquet (4,5) and M. Babin (1)

(1) Unité Mixte Internationale Takuvik, Université Laval, CNRS, Québec, QC, Canada
(2) Département de radio-oncologie et Centre de recherche CHU de Québec, Université Laval, Québec, QC, Canada
(3) Département de physique, de genie physique et d'optique and Centre de recherche sur le cancer, Université Laval, Québec, QC, Canada
(4) Institut Universitaire en santé mentale de Québec, Québec, QC, Canada
(5) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

Expanded, more detailed and in situ spatiotemporal characterization of sea ice inherent optical properties (IOPs) is necessary to better predict sea ice energy and mass budgets and under ice primary production. This project aims to develop an active probe measuring non-invasively IOPs of a small volume of ice (mm3 - cm3) with fast processing. The precision, efficiency and ruggedness of the concept would allow scientists to obtain ice IOP values directly in the field within minutes. The probe is based on the diffuse reflectance technique used to measure IOPs of human tissues. Conceptually, the instrument emits light guided through ice by an optical fiber. Backscattered light is measured at different distances from the source and compared to Monte Carlo modeled reflectances. An inverse algorithm allows for inferring the absorption coefficient, the scattering coefficient and the phase function of the scanned sea ice. This presentation summarizes the probe functioning and the first performance tests of the probe on sea ice in the laboratory.

ENABLING COUNTRY FOOD MONITORING THROUGH A FLUORESCENT HG(II)-RESPONSIVE SENSOR

Picard-Lafond, Audrey (1), L. Jacobs (1), D. D'Astous (1), D. Larivière (1) and D. Boudreau (1)

(1) Université Laval, Québec, QC, Canada

Mercury pollution in water sources and its bioaccumulation in marine species is a worldwide issue. Since mercury exposure can lead to multiple negative

health effects, probing this contaminant in water and marine animals is essential to ensure and monitor their wholesomeness. Although North Americans are generally not at risk from poisoning, diets rich in fish and marine mammals can lead to an increased hazard. Currently, the conventional approaches to quantify mercury are efficient, but are costly and require bulky instrumentation. Hence, many research advances rely on colorimetry and fluorimetry as more portable alternatives for rapid and selective in-the-field sensing. Thanks to their interesting photophysical properties and commercial availability, many organic fluorophores have been chemically modified to yield Hg(II)-responsive probes. Generally, an increase or shift in fluorescence due to an interaction with the analyte allows for quantification of the latter. Nonetheless, these molecular probes are still not practical for real life applications. In fact, most chemical structures reported are not sensitive enough to reach detection limits matching the maximum allowable mercury concentration in drinking water, which is set at 1 ng/mL in Canada. Moreover, the Hg(II) detection mechanism is often irreversible, preventing an extensive and ecofriendly lifetime of the probe. Thus, the project targets the development a Hg(II)-responsive fluorescent probe providing an enhanced performance in terms of sensitivity and reusability to replace the bulky lab-based instruments for in-field applications. As this thesis is part of the thematic project 3.4 of Sentinel North, aiming to enable tools for the monitoring of food quality in the northern environment, the chemosensor proposed must also fit criteria ensuring a concerted operation with the sample preparation and microfabrication steps. A review of interesting molecular probes and the progress regarding the development of sensitive and reusable strategies will be discussed. More specifically, the presentation includes the synthetic route to yield coumarin and rhodamine-based probes, their response efficiency towards Hg(II), their potential for covalent immobilization and the enhancement of their properties by the use of Metal-Enhanced Fluorescence (MEF).

STRATEGIES FOR THE GENERATION OF MID-INFRARED LASER SIGNALS SUITABLE FOR REMOTE SENSING

Piché, Michel (1), M. Olivier (1,2), V. Boulanger (1) and F. Guilbert-Savary (2)

(1) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

(2) Département de physique, Cégep Garneau, Québec, QC, Canada

Essentially all molecules of interest for climate studies have a distinctive absorption spectrum in the mid-infrared, more specifically in the spectral window between ~ 3 and 20 microns. Many tunable and/or broadband mid-infrared laser sources are developed in order to identify the chemical species present in the atmosphere and map their spatial distribution. Recent progress has recently been achieved with broadband fiber lasers emitting in the first window of atmospheric transparency above 3 microns. The second transparency window between 8 and 12 microns, sometimes called the "fingerprint" window, is of particular interest since it is highly sensitive to molecular composition and structure. However, the development of efficient and practical solid-state sources for this spectral band is far from being mature. In this presentation, strategies for the generation of mid-infrared laser signals suitable for remote sensing will be presented. The first method uses a pair of spectral filters to boost the power emitted by mode-locked fiber lasers using the so-called Mamyshev solitons. The second method takes advantage of the high nonlinearity of periodically-patterned GaAs crystals inserted in optical parametric oscillators to generate spectra covering more than one octave. Finally, quantum cascade lasers can be designed to emit FM waves that have a broad spectrum of discrete modes. Basic analysis of the performance of these sources will be discussed, as well as their future experimental implementation.

WHOLE-BRAIN CALCIUM IMAGING IN LARVAL ZEBRAFISH: A DEEP LEARNING APPROACH FOR NEURON SEGMENTATION

Poirier, Jasmine (1), Bahdine, M (1), D. Côté (1), S. Hardy (1) and P. Desrosiers (1)

(1) CERVO Brain Research Centre, Québec, QC, Canada

Calcium imaging has become the standard method of neurophotonics for monitoring the activity of large neuron populations. Current technologies allow for recording, more than two times per second, the activity of each single neuron in the whole brain of the larval zebrafish. This provides scientists a rare opportunity to study, in controllable experimental conditions, the dynamics of real, complete, and functional complex networks. However, the amount of data generated in each experiment is considerable (typically more than 1TB),

which makes the analysis a highly demanding task. New mathematical and computational tools are thus required. The goal of our project is to use deep learning to ease and improve the analysis of calcium imaging data. We have developed a deep learning pipeline that reduces the size of the data in three main steps: (1) Image segmentation to detect all neuronal nuclei, (2) Spike train inference to assess the times of emission of major calcium events (action potentials or bursts), and (3) Connectome inference to assess the weight of connection (influence) between each pair of neurons. The artificial neural networks used for deep learning have been trained on both simulated data and zebrafish calcium imaging data, generously provided by Paul De Koninck's team at CERVO Brain Research Centre. For the image segmentation, we have compared the performance of many algorithms against the performance of a deep convolutional neural network. The latter turns out to outperform four classical and well-accepted methods, such as adaptive thresholding and constrained non-negative matrix factorization. Adaptive thresholding, for instance, has proven to perform well to identify only the more active neurons, while its performance is poor when asked to identify less active/and non-active neurons with a F1 score equal to 25.44%. On the contrary, the pre-trained deep convolutional neural network has reached a global F1 score of 59.25%. This is competitive with the state-of-the-art algorithm (3dCNN) that has a F1 score of 59.78%, averaged over nine datasets. Further training of the deep convolutional neural network on real data produced at CERVO is expected to increase considerably the accuracy. Once the first step of the pipeline is completed, the neurons are spatially located and we can readily extract time series that describe the evolution of the calcium activity of each neuron. Then, using a second convolutional neural network, these time series are reduced to simple spike trains (binary sequences). At this stage, functional connectivity inference methods are applied to assess the connectivity between each pair of neurons, which leads to a functional connectome for the zebrafish. We have compared the performance of well-established methods that infer connectivity, such as Granger causality, with the performance of a deep residual convolutional neural network. We have found that the deep learning approach's average precision (92%) is better than that of the classical methods (84%). Interpretability of the convolutional neural network has also been studied by weight analysis and attention models.

PHYSICAL PROPERTIES OF SNOW GUIDE THE MOVEMENTS OF LEMMINGS UNDER THE SNOWPACK

Poirier, Mathilde (1, 2), G. Gauthier (1, 2), F. Domine (1, 3, 4) and M. Barrère (1, 3, 4, 5)

(1) Centre d'études nordiques, Université Laval, Québec, QC, Canada
(2) Département de biologie, Université Laval, Québec, QC, Canada
(3) Département de chimie, Université Laval, Québec, QC, Canada
(4) Unité Mixte Internationale Takuvik, Université Laval, Québec, QC, Canada
(5) Département de géographie, Université Laval, Québec, QC, Canada

Lemmings are key species of the Arctic terrestrial food web and fluctuations in their populations can have dramatic effects on many predators that depend upon them for their survival. During the long Arctic winter, lemmings live under the snowpack, which provides insulation against the cold air temperature, and they build nests in which they can reproduce. To access food, they move across a network of burrows in the snowpack where they can reach plants to eat. The presence of depth hoar, a friable type of snow that can develop in the Arctic, is thought to help lemmings digging through the snow and reduce their energy expenditure. Depth hoar results from water vapor exchange among snow particles in response to a thermal gradient between the ground and the air. Minimizing energy expenditure is important for lemmings because it could increase the chances of reproducing in winter. However, the influence of snow conditions on lemmings' movement in the snowpack is poorly documented due to the difficulty of studying them during winter in the High Arctic. The aim of this study is to improve our understanding of the impact of snow physical properties on lemming's behavior. We expected to find most lemming burrows in the basal layer of the snowpack, where access to food and insulation are the highest and where snow is generally softer due to the formation of the depth hoar. Our data were collected in spring 2017 on Bylot Island, Nunavut, before snowmelt. We dug 11 snow pits where we observed attacks on lemmings though the snowpack by Arctic foxes. We were able to find and characterize lemming tunnels and measure snow properties (i.e. density and thermal conductivity) in several recognizable snow layers, including those where tunnels were dug. A strong positive relationship ($R^2=0.70$, $n= 35$) was found between the height of burrows and the height of the depth hoar, showing that lemmings had a

strong preference to dig through the depth hoar. Contrary to our predictions, the burrows were not always dug in the basal layer, but often higher in the snowpack. This was apparently due to the presence of a hard basal snow layer as we found that the snow density selected by lemmings to dig burrows was significantly lower than the density of the basal ground layer at those sites. Presence of a hard basal snow layer was probably a consequence of melt-freeze events that occurred early during winter 2016-17. This supports the idea that lemmings choose to dig in low density snow layers when moving, even if it is not at the ground level where food is most accessible. Our results suggest that snow physical properties play a key role in lemming movements under the snowpack. Understanding how lemmings interact with their winter habitat is important to anticipate their response to climate change in the Arctic.

VALIDATION OF INERTIAL MEASUREMENT UNIT TO ASSESS SHOULDER MOVEMENT DURING COMPLEX LIFTING TASKS

Poitras Isabelle (1,2), M. Bielmann (1,2), C. Mercier (1,2), L.J. Bouyer (1,2) and J.-S. Roy (1,2)

(1) Centre interdisciplinaire de recherche en réadaptation et intégration sociale, Québec, QC, Canada
(2) Département de réadaptation, Université Laval, Québec, QC, Canada

Introduction: Motion capture systems are the gold standard for precise measurement of human movements during complex tasks. These systems lack portability however and can only be used in laboratory settings. Recent improvement in inertial measurement unit (IMU) hardware and software have made these systems a potentially good alternative to quantify human movement outside of the laboratory, i.e. in more ecological settings where participants are more likely to use natural movement strategies. IMUs have been validated in several contexts and for different joints, including the shoulder. However, the majority of tasks used for shoulder validation focused on simple planar movements. Yet, during activities of daily living, most shoulder movements require more complex movements in 3D-space. The aim of this study was therefore to test the criterion validity of an IMU system compared to a camera-based motion capture system to assess shoulder movements during complex upper limb lifting tasks. Methods: Data were collected using the VICON system (7Mx T20 and 2 MxT10 cameras) and Xsens system (MVN Awinda). Shoulder joint excursions were estimated based on their respective biomechanical models: Kingait (Vincon) and ISB modify (Xsens). First during simple shoulder movements (humeral flexion, scaption and abduction) performed with different trunk positions, and second during standardized simulated lifting tasks using the standardized Valpar Component Work Sample 19 test. Participants had to lift trays of different weights (2.2 kg, 6.8 kg, 13.6 kg and 22.7 kg) at different heights (0.45 m, 1.2 m and 1.73 m). Each participant performed a total of 32 movements. Data analysis: Correlation coefficients between arm movements measured by Xsens and by VICON were calculated for each movement axis (sagittal axis - X: vertical axis - Y; frontal axis - Z). Root mean square error (RMSE) was also calculated. Results: Sixteen healthy subjects participated in this study (8 men, 12 right-handed, mean age of 26.4 years). Correlation coefficients were high for all three axes for the simple movements (X: r= 0.96 ± 0.04; Y: r= 0.87 ± 0.19; Z: r= 0.92 ± 0.12) as well as for the lifting tasks (X: r= 0.92 ± 0.10; Y: r= 0.88 ± 0.07; Z: r= 0.83 ± 0.06). RMSE was large across axes, being quite high in the Y and Z axes for both the simple movements (X: 8.5°± 4.6°; Y: 44.3° ± 9.7°; Z: 31.7°± 9.1°) and the lifting tasks (X: 9.5°± 8.4°; Y: 43.1° ± 14.4°; Z: 33.4°± 9.4°). Conclusion: The correlations between the Vicon and the Xsens were good to excellent during simple shoulder movements and standardized simulated lifting tasks, while RMSE was moderate to large, suggesting that the IMU system is valid/reliable but that angular values obtained differ from that of a camera-based system. The different biomechanical models used for anatomical reconstruction during data analysis is likely a major contributor to this difference, especially at the shoulder.

ADAPTIVE CAMERA FOR SUBNIVAL OBSERVATION OF LEMMINGS

Pusenkova, Anastasiia (1), T. Galstian (1), M. Poirier (1), G. Gauthier (1), D. Kalhor (1) and X. Maldague (1)

(1) Université Laval, Québec, QC, Canada

Lemmings are essential species in the Arctic ecosystem and their role in the food chain is fundamental. It is known that their population fluctuates intensely, peaking about every four years and then decreasing almost to extinction. The key to understanding such oscillations is the winter dynamics of reproduction, and presently there is very little data on this season. There are few methods available to observe lemmings below the snow, while most studies of subnivean processes use comparisons of data

before and after the snow season. This is the reason why we are working on creating an adaptive camera that can be used for continuous lemming observation during winter. A first prototype of the camera was made this year and three devices will be installed and tested during the winter 2018-2019. They are based on Raspberry Pi boards and near-infrared cameras, equipped with motion sensors, to detect animal presence and are powered by high-capacity batteries. They will be installed in the boxes under snow for 9 months in sites with a high probability of lemmings' presence during winter. To prevent depth hoar formation on the camera lens due to temperature gradient and high humidity, we place our cameras on the lateral sides of the boxes. However, for this configuration, distance to the object varies depending on animal position, so optical power should change to achieve maximum image quality (for the recognition of individual features). To make these cameras more flexible and universal, we shall design a Liquid crystal (LC) - based lens and smart shutter. LCs are anisotropic materials and their optical and dielectric properties can be changed by applying external control voltage. The LC lenses are commonly used for adaptive cameras with variable focal distance that will enable us to capture pictures of these rodents at different focal distances. It would also be possible to assess the relative size of the observed individuals and categorize them. There are a couple of challenges in using LC lenses at low temperatures. We shall select the optimal LC materials for our variable focus lens as well as proper lens design that should hopefully work equally well both at relatively high temperatures of +10°C - +20°C (autumn and spring) and low temperatures of -20°C - -30°C (winter months). We have chosen special LCs with ultra-low viscosity to ensure small response times at low temperatures (around 30 ms depending on cell thickness) and high shutter speed. There are 2 possible ways to control the lens's optical power that can be used: by frequency and voltage. Advantages and drawbacks of using both of them are being studied and theoretical modeling is being performed using measured LC parameters at low temperatures. The current study will help us to create a prototype of a small adaptive camera, based on the above-mentioned LC that can work in extreme cold environments during long periods of time with high durability. Obtained data will provide new opportunities to explore subnivean interactions between predators and prey, and other factors impacting lemmings' reproduction cycle.

RAPID PROTOTYPING OF MONOLITH INTEGRATED PLASTIC MICROFLUIDIC DEVICES FOR FOOD SAMPLE ANALYSIS: COUPLED WITH ICPMS

Rahman, Md Ramim Tanver (1), D. Larivière (2) and J. Greener (1,3)

(1) Département de chimie, Faculté des sciences et de génie, Université Laval, Québec, QC, Canada
(2) Laboratoire de radioécologie, Département de chimie, Université Laval, Québec, QC, Canada
(3) Centre de recherche du CHU de Québec, Université Laval, Québec, QC, Canada

Food analysis is essential to ensure food safety, which is a public health concern. Environmental changes and pollution can especially affect the food safety of northern communities who subsist on country foods via hunting, for example. Microfluidic devices have enormous potential in miniaturizing and improving conventional methods for specific target separation, detection, and analysis. Poly dimethylsiloxane (PDMS) is widely used for the fabrication and prototyping of microfluidic chips. However, disadvantages include swelling by exposure to organic solvents as well as the mass transfer of small molecules and even water into and out of the micro channel. This can lead to changes to channel dimensions, evaporation of liquid phase, and channel contamination. As well, there are practical problems associated with integration into larger analytical platforms due to elastomeric material posing difficulties for integration. Here we report on the fabrication of a microfluidic device in polypropylene by hot embossing. Polypropylene (PP) is cheap, highly resistant to strong solvents and acidic solutions, and eliminates nearly all contamination problems experienced in PDMS. After optimization of processing parameters (embossing temperature, embossing pressure, embossing time, de-molding temperature, bonding time, bonding temperature and bonding pressure) to reduce the replication error, a silicon-based porous scaffold was integrated into the channel for chemical separations. To demonstrate the device utility for analytical separations and measurements of trace elements, the microfluidic device coupled with the ICPMS injection system will be presented.

PHOTOBIOLOGICAL ARCHITECTURE LIGHTING

Rodrigue, Myriam (1)

(1) Groupe de recherche en ambiances physiques, CERVO Brain Research Centre, Université Laval, Québec, QC, Canada

This thesis develops smart lighting strategies in response to extreme lighting conditions in northern cities. It develops lighting scenarios. The research will present case studies achieved in artificially lit architectural scaled models placed under an artificial sky to determine the advantages and limitations of the developed method. The artificial sky will be calibrated to emit the spectral distribution of skies similar to the ones of northern cities at diverse time of days and period of the year. Luminance and wavelength distributions of the scenarios will be compared with a developed multifactorial method. It will allow for analyzing in tridimensionvisual and physical comfort, alertness, glare risks and perceived luminance in relation to the materiality, geometry and position of windows, walls, lighting fixtures and the lighting sources of real artificially and naturally built environments. Results will be presented through 3D models, named point clouds, and images similar to architectural presentation drawings such as plans, cross-sections and axonometric views. Colorimetric, melanopic and high dynamic range imageries will be projected on fused tridimensional laser scans for achieving such analysis. Artificial lighting scenarios will adapt to the spaces' natural lighting conditions. The method provides powerful visualization results and facilitates the understanding, analysis and the design of architectural spaces and lighting installations for well beings.

OPTIMIZATION OF FIBER TAPER DESIGN FOR METHANE SENSING IN NORTHERN REGIONS

Rodriguez, Antonio (1,2,3), A. Castillo (1,2,3), R. Wang (1,4,5), A. Gervais (1,4,5) and S. LaRochelle (1,4,5)

(1) Sentinelle Nord, Université Laval, Québec, QC, Canada
(2) School of Physical and Mathematical Sciences (FCFM), Autonomous University of Nuevo León, San Nicolás de los Garza NL, México
(3) Physical and Mathematical Sciences Research Center (CICFIM), Autonomous University of Nuevo León, San Nicolás de los Garza NL, México
(4) Département de génie électrique et de génie informatique, Université Laval, Québec, QC, Canada
(5) Centre d'optique, photonique et laser, Université Laval, Québec, QC, Canada

Greenhouse gas emissions as a result of thawing Arctic permafrost, are influencing the global climate. It is important to accurately measure the emission of these greenhouse gases in particular methane, in order to evaluate the potential hazards to the environment. To be able to achieve more precise quantification of methane emissions, we are optimizing the design of optical fiber taper methane sensor based on absorption spectroscopy. Using a commercial software, the power fraction propagating in the air around fiber tapers, which is an important parameter for evanescent wave sensing, is calculated for different fiber taper geometries, including the length and the diameter. The HITRAN database is also used to find the absorption coefficient of methane. Optimized length of fiber tapers at different fiber diameters is determined for various values of propagation loss. To further improve sensitivity, we investigate the addition of a coating with different refractive indices.

UTILISATION D'ALGORITHME DE DÉTECTION D'ACTIVITÉ NEURONALE DANS L'ANALYSE DES STRUCTURES DE NEURONES DANS LA LARVE DE POISSON ZÈBRE

Rondy-Turcotte, Jean-Christophe (1)

(1) Université Laval, Québec, QC, Canada

La modélisation de réseaux complexes tels qu'un écosystème du nord peut être modélisé par les réseaux de neurones. Cependant, le fonctionnement et l'organisation des réseaux de neurones est encore mal compris. Une approche consiste à effectuer l'analyse statistique de l'activité des neurones d'un animal tel que le poisson zèbre. En modifiant génétiquement cet animal il est possible de faire briller chaque neurone au moment de l'activité. En filmant l'évolution de la lumière dans le temps pour chaque neurone, des séries temporelles de fluorescence sont acquises, qui présentent les moments d'activités comme des pics soudains de fluorescence. Selon les patterns observés de décharges des neurones, il est possible d'inférer la structure des connexions entre les neurones de l'animal. Toutefois, obtenir le moment précis de décharge de chaque neurone est une tâche difficile en temps de calcul. En effet, les données sur les neurones sont très bruitées. En reprenant l'algorithme MLSpike présenté par Deneux et al. et en l'adaptant

aux données expérimentales de Sentinelle Nord, nous souhaitons améliorer la qualité des données utilisées pour l'inférence des connexions. De plus, l'analyse des données reçues en laboratoire permet de guider l'acquisition de nouvelles données en trouvant les critères les plus utiles dans un ensemble de données utilisé pour l'inférence. La calibration de l'algorithme est effectuée en comparant son efficacité sur des données expérimentales ainsi que sur des données simulées par rapport à d'autres méthodes utilisées dans la littérature pour déterminer précisément les moments de décharges de neurones. L'algorithme MLSpike utilise les chaînes de Markov à états cachés ainsi qu'une analyse automatique de chaque nouvelle série temporelle d'activité neuronale pour augmenter la vitesse et la précision du traitement des données.

OPTOGENETIC MODEL TO STUDY THE ROLE OF MICROGLIA IN THE MICROBIOTA-BRAIN INTERACTION

Salesse, Charleen (1), T. Herzog (1), D. Côté (1,2) and P. De Koninck (1,3)

(1) CERVO Brain Research Centre, Québec, QC, Canada
(2) Département de physique, de génie physique et d'optique, Faculté des sciences et de génie, Université Laval, Québec, QC, Canada
(3) Département de biochimie, microbiologie et bio-informatique, Faculté des sciences et de génie, Université Laval, Québec, QC, Canada

The intestinal microbiota in humans and other vertebrates plays a key role in maintaining the host's health. However, when the host undergoes physiological stress, the balance of this microbial ecosystem is broken, allowing the proliferation of opportunistic microorganisms, which triggers negative effects on the host, including infections and physiological disturbances. During host development, an unstable microbiota could also have consequences on brain development, affecting mental health. Intensification of human activities is causing major changes in northern ecosystems that are altering host-microbiotic systems. The relationship between these complex systems is still poorly understood. The characterization of host-microbiota interactions and their impacts on mental health requires the development of models and tools in the laboratory with which we can precisely control the relevant variables for the environment. The objective is to develop a zebrafish (ZF) model with which we can control the factors that modulate host-microbiota functional interactions and measure the impact of the evolution and the functioning of the microbiota, as well as brain and gene expression of the host. To do this, we will develop molecular tools to control microbial growth with optogenetics and to study the impact of the gut microbiota on the development and functioning of neural networks with optical methods. For this project the ZF is an ideal model because it offers many advantages: 1) at the genetic level, several genetically controlled lines are available or can be easily generated; 2) its rapid and external development allows a longitudinal follow-up; 3) its transparency during the first 2 weeks of life allows for unparalleled microscopic observations and offers an opportunity to optogenetically control development processes. A new optogenetic approach is being proposed in this project to control the intestinal microbiota of ZF larvae. The specific objectives are to study the role of microglia in this microbiota-brain interaction. Indeed, microglial cells, which are very dynamic in the brain, play a specific immune role to the brain in response to stress. Microglia could also influence synaptogenesis, plasticity and neuronal functions. Microglia may play a preponderant role in the impact of the microbiota on neuronal development and connectivity. An experimental model for cell imaging and microglia control in ZF larvae while controlling the ZF environment and microbial growth to measure impacts at the level of the nerve circuits is being developed.

POST-SYNAPTIC TRANSLOCATION OF CAMKII DURING SYNAPTIC POTENTIATION REQUIRES CALPAIN ACTIVITY

Sehgal, Kapil (1), C. Salesse (1), M. Lemieux (1), S. Labrecque (1) and P. De Koninck (1)

(1) CERVO Brain Research Centre, Université Laval, Québec, QC, Canada

Synaptic potentiation relies on NMDA receptor (NMDAR) activation and Ca2+ influx. Changes in cytosolic Ca2+ are detected by effectors such as calpain and Ca2+/calmodulin-dependent protein kinase II (CaMKII), transforming this information into signals inducing synaptic potentiation. Once activated by Ca2+ influx, calpain cleaves many cytosolic proteins, receptors and scaffolding proteins, thereby remodeling the synaptic structure, as well as the activity and/or dynamics of many proteins. Meanwhile, CaMKII responds to Ca2+ by translocating to synaptic sites, where it phosphorylates many plasticity-related proteins, enabling synaptic potentiation. In this study we aimed to investigate the

relationship between calpain activity and CaMKII in the induction of plasticity. We first observed that calpain inhibitor MDL28170 blocked LTP in hippocampal slices. Further, using hippocampal and cortical cultures we induced LTP by chemical method (0Mg2+/ Glycine/ Bicuculline) and found an increase in ERK phosphorylation and insertion of synaptic AMPA receptors, in agreement with the previous reports. Inhibition of calpain activity blocked ERK phosphorylation and insertion of synaptic AMPA receptors - two CaMKII-regulated processes involved in synaptic potentiation. Using time-lapse imaging we found that activity-dependent post-synaptic CaMKII translocation is decreased by calpain inhibitors. We hypothesized that calpain promotes CaMKII translocation either by influencing i) Ca2+ influx, ii) the activation of the holoenzyme or iii) by affecting other proteins that are essential for the translocation process. By performing Fluorescence Lifetime Imaging with a FRET-based sensor (Camui) of CaMKII activation, our findings indicate that calpain does not influence CaMKII activation. In support of this, our preliminary results indicate that calpain inhibition does not affect activity-dependent Ca2+ influx, as quantified by GCaMP6 imaging. Next, we measured diffusion rates of CaMKII by SPT-PALM using CaMKII-meos2 and the results show that calpain inhibition decreases the mobility of the holoenzyme. Together these results suggest that calpain does not affect the activation of CaMKII but its synaptic translocation process. Currently we are investigating whether calpain facilitates CaMKII translocation to synaptic sites via cytoskelatal remodelling that changes mobility and hence access of CaMKII to synaptic sites. Our work not only furthers the understanding of the role of calpain in plasticity but also NMDAR dependent signalling cascade involved in synaptic potentiation.

MICROBIOMES AS SENTINELS FOR THE ENVIRONMENT AND CARDIOMETABOLIC HEALTH IN THE NORTH: ROLE OF THE GUT MICROBIOME AND ITS IMPACT ON ENDOCANNABINOIDOME-CONTROL OF METABOLISM

Manca, C. (2,5), Boubertakh, B. (2,5), Leblanc, N. (2,3,5), Martin, C. (2,5), Houde, A. (3,5), Veilleux, A. (2,3,5), Flamand, N. (1,2,5), Di Marzo, V. (1,2,3,4,5), Silvestri, Cristoforo (1,2,5)

(1) Faculté de médecine, Université Laval, Québec, QC, Canada
(2) Centre de Recherche de l'Institut Universitaire de Cardiologie et de Pneumologie de Québec, Québec, QC, Canada
(3) Faculté des sciences de l'agriculture et de l'alimentation, Institut de la Nutrition et des Aliments Fonctionnels, Québec, QC, Canada
(4) Institute of Biomolecular Chemistry of the National Research Council (ICB-CNR), Pozzuoli, Italy
(5) Chaire d'excellence en recherche du Canada sur l'axe microbiome-endocannabinoïdome dans la santé métabolique, Université Laval, Québec, QC, Canada

Northern populations have undergone a rapid transition to a westernized lifestyle with an increasing prevalence of obesity and related disorders. However, exposure to cold and the variation in the daily light cycle results in adaptive responses and management of fuel that profoundly affect human physiology and are not exclusively due to genetic factors. For the same level of adiposity, Inuit have lower absolute levels of blood pressure, HDL cholesterol, triglycerides, postprandial glucose and insulin compared with Europeans. Indigenous circumpolar groups showed a systematic elevation in basal metabolic rate not due to dietary factors. Acute and chronic exposure of experimental animals to cold protects from diet-induced obesity, in association with increased brown adipose tissue (BAT) thermogenesis and changes in the gut microbiota. Transplantation of caecal material from mice reared at low temperatures to germ free (GF) recipients improved their metabolic phenotype, reduced obesity and improved insulin sensitivity. The gut microbiota 'interacts' with adipose tissue development and metabolism through the endocannabinoidome (eCBome), a complex lipid signaling system with important functions in cardiometabolic health. The gut microbiota modifies endocannabinoid signaling by modulating the expression of endocannabinoid metabolic enzymes (resulting in changes in endocannabinoids and related mediator levels) as well as the expression of the cannabinoid receptor type-1 (CB1) in the intestine and adipose tissue of mice. The intestinal microbiome and the eCBome show also differences in sex and age that may affect people's susceptibility to obesity-related complications. Given the interconnection between obesity, the microbiome and the eCBome, we aim at understanding how this complex crosstalk can modulate the activity of various adipose tissues with subsequent consequences on cardiometabolic health. No study has been conducted to define how the eCBome is altered in obesity model organisms in the absence of an intestinal microbiome. Thus our first goal is to measure the basal eCBome gene profiles within GF

and conventionally reared (CR) male and female mice at 4 (juvenile) and 13 (adult) weeks of age within metabolically relevant tissues and to correlate these results with eCBome lipid levels. Our preliminary qPCR-array results show that the absence of the microbiome is accompanied by relevant modifications in eCBome related genes in the ileum and BAT of 4 and 13 week old male mice. In the BAT of 4 week old GF mice, we observed increased expression of CB1 and TRPV1 and TRPV4 channels compared to CR mice at the same age, all receptors that are involved in energy metabolism and are able to influence the activity of white and brown adipose tissue following temperature changes. Once we have elucidated how the absence of the microbiome can impact the eCBome system, we will investigate microbiome changes induced by the interplay between cold and photoperiod and by different dietary regimes, and consequent modulation of eCBome and adipose tissue activity. The overall study will provide us a deeper knowledge about how cold temperatures and photoperiod variance, but also the dietary regimen at northern latitudes, can influence the microbiome-eCBome-adipose axis, and its impact on the cardiometabolic health of Northern populations

FINE-SCALE VARIABILITY IN OCEANIC DIMETHYLSULFIDE DISTRIBUTION ACROSS ICE-COVERED AND ICE-FREE WATERS OF THE CANADIAN ARCTIC ARCHIPELAGO IN SUMMER

St-Onge, Joanie (1), M. Lizotte (1), G. Massé (1), J-É. Tremblay (1), M. Levasseur (1) and P. Massicotte (1)

(1) Université Laval, Québec, QC, Canada

The sources and strength of oceanic dimethylsulfide (DMS) emissions, a climate-active biogenic gas, could be modified in the Arctic as a result of reductions in snow cover, sea ice extent and thickness. Understanding the impacts of climate change on DMS dynamics is crucial since DMS-derived sulfate is thought to be the key precursor to secondary marine aerosol mass above biologically productive regions that potentially lead to cloud formation and climate forcing. Using a novel automated instrument (ACT-MIMS), DMS samples were collected at high frequency in the surface waters of the Canadian Arctic Archipelago (CAA) during the summer (July-August) of 2017 aboard the Canadian Coast Guard Ship *Amundsen*. More than 2500 DMS observations were collected alongside ancillary measurements of salinity, temperature, fluorescence (chlorophyll *a* proxy), light, ice concentration (satellite images) and the algal precursor of DMS, dimethylsulfoniopropionate. DMS concentrations ranged from ca. 1 to 32 nmol L-1 (average of 6 nmol L-1) over an area of approximately 10 000 km covering a wide range of contrasting marine environments from coastal to open ocean ice-free waters, as well as under-ice waters. These values are comparable to previous studies conducted in the CAA during the summers of 2015 (ca. 1 to 18 nmol L-1) and 2016 (ca. 1 to 30 nmol L-1), using similar high-frequency measuring systems and confirm that existing DMS climatology underestimate, by at least two-fold, summer levels of DMS in this part of the Arctic. Surface water DMS hotspots were measured in association with oceanographic thermohaline features, with high-productivity coastal waters, as well as with the presence of ponded first-year sea ice (FYI). Overall, our results strengthen the view that aqueous DMS cycling in the Arctic is intimately linked with sea ice dynamics. As such, future changes in the seasonality of the Arctic cryosphere will likely play an important role in shaping DMS emissions, although the sign and magnitude of the change remain highly uncertain.

L'ECOCHIP : UNE PLATEFORME DE CAPTEURS SANS FIL POUR LA SURVEILLANCE ENVIRONNEMENTALE

Sylvain, Matthieu (1), F. Lehoux (1), S. Morency (1), F. Faucher (1), E. Bharucha (1), D.M. Tremblay (1), F. Raymond (1), S. Moineau (1), M. Allard (1), J. Corbeil (1), Y. Messaddeq (1) et B. Gosselin (1)

(1) Université Laval, Québec, QC, Canada

L'EcoChip est une plateforme de capteurs sans fil pour la surveillance environnementale conçue pour permettre la culture et l'analyse de la croissance de micro-organismes ainsi que leur environnement naturel. Le système peut être déployé dans des environnements difficiles, tels que le climat nordique. L'EcoChip présente des puits de croissance multicouches permettant la croissance de micro-organismes obtenus à partir d'échantillons d'habitats nordiques à l'intérieur d'un des 96 puits du système. Le dispositif peut être déployé sur le terrain pour la surveillance en continu de croissance microbienne dans ses 96 puits à l'aide de son système de mesure d'impédance électrochimique multicanal. Des capteurs additionnels sont inclus dans l'EcoChip pour mesurer des paramètres externes tels que la luminosité, l'humidité, la température, le pH du milieu ainsi que le niveau de CO2 environnant. Le circuit électronique embarqué est équipé d'un microcontrôleur basse puissance, une mémoire flash embarquée et un système

de gestion de la puissance. L'EcoChip est aussi équipé d'un système de communication sans fil permettant la transmission des résultats de mesure lorsqu'un récepteur est proche.

SUPER-RESOLUTION FOR ENDOMICROSCOPIC SYSTEM

Tabourin, Loïc (1) and T. Galstian (1)

(1) Centre d'optique, photonique et laser, Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada

Endomicroscopes are very useful tools for motion-free in vivo imaging of the mouse brain. Unfortunately, due to the need of miniaturization they are limited by their low resolution, around 1 µm. We propose to develop an autonomous module for endomicroscopic probes allowing a super-resolution by applying structured illumination to get higher spatial frequencies. While SLM and DMD are usually used to generate the periodic pattern, we intend to increase the lateral resolution using smaller and cheaper liquid crystal devices.

THE IMPACT OF COMMUNITY STRUCTURE ON NETWORK DYNAMICS: THE CASE OF SYNCHRONIZATION

Thibeault, Vincent (1,2), X. Roy-Pomerleau (1,2), G. St-Onge (1,2), J.-G. Young (1,2), L. J. Dubé (1,2) and P. Desrosiers (1,2,3)

(1) Département de physique, de génie physique et d'optique, Université Laval, Québec, QC, Canada
(2) Centre interdisciplinaire de modélisation mathématique de l'Université Laval, Québec, QC, Canada
(3) CERVO Brain Research Centre, Québec, QC, Canada

Determining how the network structure affects its function remains one of the great challenges of Network Science. Among the numerous network functions studied so far, synchronization has attracted much attention over the last two decades, partly due to its simplicity - as an observable phenomenon - and to its fundamental significance in many fields of applications, including neuroscience, ecology, and sociology. For instance, in neuroscience, synchronization of neurons plays a crucial role in many brain functions such as memory and consciousness. In ecology, flocks with tens of thousands of birds have been observed to fly in unison at high speeds and execute collectively complex maneuvers. Studies have revealed that the relationship between the structure of a network and its capacity to synchronize is rich and subtle. For instance, networks sharing the same degree distribution can have very different synchronization behaviours. Despite recent advances showing that significant changes in the network structure may result in the incapacity of a global synchronization, much has to be done to further understand how structure - especially at the mesoscale (communities) - affects synchronization. We study the synchronization of dynamics in networks with clear community structures, such as those generated by the stochastic block model (SBM). We find new regions in the structural parameter space where chimeras exist, which are dynamical states characterized by a simultaneous cohabitation of full synchronization in certain communities and partial synchronization in others. We also measure the effect of structure on the chaotic behavior of chimeras. Finally, we use structural information to successfully predict the critical coupling above which the synchronization of the whole network can occur.

DOES THE CHANGING ICE DYNAMIC IN THE ARCTIC OCEAN INFLUENCE THE NUTRITIONAL VALUE OF THE BENTHIC FOOD WEB IN NUNAVIK, CANADA?

Van Doorn, Catherine (1), P. Archambault (1), J.-É. Tremblay (1), M. Lemire (2) and G. Massé (1)

(1) Université Laval, Québec, QC, Canada
(2) Centre de recherche du CHU de Québec, Québec, QC, Canada

In Canada, global changes are of particular concern for northern populations that depend on the Arctic Ocean. This ocean is affected more rapidly by climate change than others. My project, within the BriGHT program (Bridging Global change, Inuit Health and Transforming Arctic Ocean), will focus on the benthic food wed, particularly on species consumed by Inuit populations. The primary source of food for many benthic organisms is changing from ice algae to plankton because of the loss of the ice cover in the Arctic Ocean. Since ice algae produce fatty acids that have important roles in the reduction of cardiovascular diseases, the change in food source is affecting the quantity of fatty acids in organisms and thereby has impacts on Inuit health. We will characterize the fatty acid, selenium and carotenoid quantity found in benthic organisms, in walruses and in common eiders. Walruses and common eiders are considered because they

feed directly on benthic organisms and are part of the traditional foods of Inuit. Our project aims to determine if fatty acid quantity and quality in organisms changes with the variation in food source. It should contribute to understanding the impacts of climate changes on health problems and help find solutions.

SLOPE MORPHOLOGY AND FROST-INDUCED MASS MOVEMENTS IN TASIAPIK VALLEY, NUNAVIK

Veilleux, Samuel (1,2), N. Bhiry (1,2) and A. Decaulne (3)

(1) Centre d'études nordiques, Québec, QC, Canada
(2) Université Laval, Québec, QC, Canada
(3) CNRS-LETG, Nantes, France

This project focused on scree slope development during the Holocene period on Hudson Bay cuestas in Nunavik. Located near the Inuit community of Umiujaq and at the edge of Tursujuq National Park, the study site includes hillsides in the Tasiapik Valley. The apical rock wall exposes volcano-sedimentary rocks and reaches as high as 300 meters above sea level. Several slope deposits are located at the bottom of the rock wall on the west side of the valley and at the "Umiujaq Butte" in the upper part of the valley. The slope deposits are concentrated near the rock wall, but many of them were carried a long distance downstream. Thus, many blocks have been deposited only a few meters from the road that connects Umiujaq to Lake Tasiujaq. The road is used by people in the community, tourists and park staff who access the lake, and by scientists. Heavy machinery also travels on this road due to the presence of a borrow pit in the valley. The evidence suggests that falling rocks may pose a significant risk to road users. The main objective of this study was to document the gravity processes that affect the slopes of the valley and to assess the risk of falling debris toward the road. The specific objectives were: 1) to characterize the topography of the scree slopes and to analyze the petrography of the sediments and the vegetation covering the sediments; and 2) to trace the extent and recurrence of these gravity processes after the regression of the post-glacial Tyrrell Sea during the Holocene. Analysis of various parameters such as the height of the rock wall, the lithology and size of the debris on the scree, and the topography and geological setting of the talus, provides a framework with which to identify the different types of slopes in the valley. Based on preliminary results and observations from previous fieldwork, two main processes were identified. First, smaller sedimentary rock debris fall and accumulate directly at the bottom of the rock wall, creating a large talus. In addition, large basalt blocks fall from the upper part of the rock wall near the cornice and travel to the base of the talus and further down. As part of the research project, we seek to link these processes to the evolution of the slopes in the valley. Therefore, we assessed the influence of climate change, local geology and processes such as glacio-isostasy and gelifraction as geomorphic agents involved in the slope processes.

THE WINTER MICROBIOME OF PERMAFROST THAW LAKES

Vigneron, Adrien (1) and W. Vincent (1)

(1) Département de biologie, Université Laval, Québec, QC, Canada

Permafrost thaw lakes (thermokarst lakes and ponds) occur in high abundance across the Arctic. These lakes have been implicated in major climate feedbacks, including degradation of stored old carbon and subsequent release of greenhouse gases such as methane and CO2, with consequences for environmental health and climate warming. Although the methane-emitting nature of thaw lakes has been well established, the emissions shown a strong temporal variability and the potential for under-ice accumulation of CH4 has been suspected. Arctic thermokarst lakes are ice-covered 8 months per year leading to significant geochemical and limnological changes, with potential consequences for the lake microbiome. However, despite their ecological importance, current knowledge of thaw lake microbiomes relies exclusively on summer, open-water samples and the under-ice microbiome remains completely unexplored. Here we applied metagenomic and genome centric metagenomics to resolve and compare the structure and the functioning of the thaw lake microbiome during the winter versus summer seasons. Microbial community composition and metabolic potential differed greatly between seasons, with predominantly Betaproteobacteria and Actinobacteria in summer, and methanogens, Chloroflexi and various Candidate Divisions in winter. Although the potential for complex carbohydrate degradation was omnipresent, aerobic metabolic pathways (methane and sulfide oxidation) predominated in summer, whereas anaerobic reactions (sulfate and arsenic reduction, methanogenesis, fermentation) were predominant during the winter season. Draft genomes of thaw lake uncultured lineages revealed different ecological strategies. During summer, microbial strategies were based on micro-diversification and multipotentiality suggesting adaptation to highly dynamic

freshwater systems. By contrast, in winter dominant strategies were based on syntrophic metabolisms and metabolic cooperation among the microbial community for the degradation of refractory organic substrates coupled with methanogenesis supporting methane accumulation under ice.