Dynamics of Climate Impact on Environment and Health
Dynamiques de l'impact du changement climatique sur l'environnement et la santé
(Org: **Huaiping Zhu** (York))

RICHARD BELLO, York University Department of Geography
Spatial and Temporal Wind Patterns in Ontario, 1980-2010

Wind plays an important role in a host of environmental factors ranging from the Earth's energy and water budgets to the redistribution of snow, soil, atmospheric pollutants and disease. Extreme winds are implicated in damaging events to production and infrastructure in agriculture, forestry, transportation, and the marine environment occasionally accompanied by loss of life. Wind also represents an emerging source of alternate energy production. Using NARR reanalysis model 3-hourly output at 32 km grid resolution, we examine trends and variability in 10 m surface winds over the past 31 years for the Province of Ontario and adjacent Great Lakes, bordering provinces, states and Hudson Bay. Regions which demonstrate statistically significant monthly and seasonal trends between 1980 and 2010 can be identified which may be linked to hemispheric periodic climate variability or to climate change. The dynamical factors responsible for shifting wind patterns are discussed.

YURONG CAO, York University
The Distribution Analysis of Mosquito Abundance in Peel Region with Weather Conditions

The changing climate can significantly affect the mosquito abundance in a region and cause emerging or reemerging of mosquito diseases, including West Nile virus and malaria etc. Using the mosquito data from the surveillance program managed by Ontario Ministry of Health and Long-Term Care, we study the distribution properties of *Culex.pipens/restuans* mosquito abundance in Peel Region, Ontario for the period from 2004 to 2010. The combination of two clustering methods (K-means and agglomerative hierarchical approaches) and multiple linear regression are used to explore the mosquito distribution properties under weather conditions. The traps in Peel Region are classified into two clusters. The results show that the *Culex.pipens/restuans* mosquito abundance in Peel Region follows a Gamma distribution; the mean temperature in summer has significant impact on the distribution properties and the impact of precipitation is not distinct.

DAVID N. FISMAN, University of Toronto
Seasonality of influenza-attributable meningococcal disease in central Ontario, Canada: implications for targeting of influenza

Background: Invasive meningococcal disease (IMD) is an important source of morbidity and mortality in children and adolescents. Seasonality of IMD is aligned with that of influenza, and we have identified a significant surge in IMD risk with elevated influenza incidence in Ontario in a recent publication (RR per 100 unit increase in influenza case activity = 1.18, 95Methods: PARResults: PARConclusions: Studies supporting a causal role for influenza A in the genesis of seasonal changes in meningococcal disease have important implications for the control of both diseases. Immunization of young age groups against influenza likely represents an under-recognized strategy for preventing IMD.

ROBIN GRAS, University of Windsor
Modeling Epidemic Spread in a Predator-Prey Evolutionary Ecosystem Simulation

Epidemics that spread in wide geographic areas for both animals and humans, impose a threat to global public health security. Studying dynamics of the infections in ecosystems and factors regulating the epidemics is of high importance. We have implemented EcoDemics; which extends EcoSim, for modeling the spread of an epidemic. In this simulation we model infectious diseases in prey agents and we study the effects of predation on infection dynamics. We analyzed three different control strategies: quarantine, pharmaceutical interventions and vaccination. We explored the effect of the vaccination technique with various timing and population percentage parameters. Our experiments revealed that there is a threshold value for the percentage of the population which is vaccinated. This is the same result that has been observed in a herd immunity study.

This study highlighted the importance of effective vaccination policies in mitigating the infection and confirms the fundamental role of increasing individuals' immunity over a relatively wide area to inhibit stochastic jumps of infection. EcoDemics can easily be extended to tackle numerous difficult open problems. We will monitor the spread of infection in our virtual world to study the effect of predation in infection dynamics. Sexually transmitted diseases can also easily be integrated. It will permit the study of the specific properties of sexually transmitted diseases in large multi-species populations. Co-evolution of diseases and hosts could also be represented and the way one affects the other and has influence on its evolution could be tracked and analyzed for very long time periods.

KAHO HAYASHI, Toronto

Potential migration corridors and source populations for climate-change induced tree migration in southern Ontario

Although efforts to increase landscape connectivity are widely recognized as important strategies to facilitate climate change-induced migration, little research has addressed where such increases might best occur. We analyzed migration of 127 tree species in the fragmented landscape of southern Ontario, Canada, for six climate change scenarios, and calculated "back-cast" migration paths; i.e., the shortest paths between presumptive future and current range locations. Two migration scenarios were used: a "buffer" approach in which trees could migrate only through forest and land within 1 or 2 km of forests and a "cost-path" approach in which migration through forest was less costly than through other land cover types. The relationships between forest cover and migration path concentration varied for the two methods: the buffer method showed a marked increase in path concentration below 25-30 percent forest cover, whereas the cost-path method showed more-or-less linear increase with decreasing forest cover. We found support for the importance of existing corridors such as the Oak Ridges Moraine and the Niagara Escarpment, suggesting the current efforts to facilitate large-scale connectivity, such as the Adirondack-to-Algonquin initiative, will prove useful in increasing future migration. Source populations showed few differences between the two models, with existing forest cover and connectivity critical in determining their locations. Compared to straight line (crowfly) migration, fragmentation increased migration rates by a factor of 1.6 on average. In general, our results were relatively robust in that important migration routes and sources tended to be similar among climate change scenarios and among calculation methods.

KAZ HIGUCHI, York Univeresity

Climate Change Modellling - Science Is Not Entirely In

There is no comprehensive theory of climate. Modelling of climate system is achieved by meshing together various processes of interaction which we believe to be important in influencing the observed state of various subcomponents of the climate system (such as atmosphere, land, biosphere, oceans, ice, etc.). Many of these interactive processes are highly nonlinear and complicated, and a desired outcome from a model computation could be due to "wrong" reasons. The theoretical and observational foundation of each of the subcomponents is relatively strong. However, there is no analogous "theory of everything" in physics to guide the modeling of the climate system. It is quite possible (and there is evidence to suggest that is the case) that we are not including some of the important processes in the modelling of the climate system; it is quite plausible that there are interactive mechanisms we don't know anything about (yet). And the present state of the modelling is so complicated that it requires a group of climate and computer scientists and mathematicians (particularly statisticians) to construct a model and validate it. Achieving a physics equivalent of TOE (Theory of Everything) of climate where we have a comprehensive and internally consistent mathematical theory is likely not achievable. Perhaps the best analogy of the present state of climate modelling is the modelling of the financial system. And one knows what happened in 2008.

RACHEL HIRSCH, Faculty of Environmental Studies, York University

Simulating food sharing in Sheshatshiu, Labrador: Modelling household versus community level cooperation

Large-scale events, such as intensified resource extraction and climate change, are affecting the traditional, locally-based livelihoods of Northern communities. The ability to share locally acquired foods such as caribou meat, is an important adaptive mechanism that helps promote community well-being in the face of growing political, ecological, economic, and social changes. Cooperation, in the face of these changes, has more often been framed as a macro-level phenomenon under the

purview of international bodies such as the Arctic Council. However, we aim to illustrate the importance of cooperation at the meso- (community) and micro- (household) levels in Arctic resiliency.

To better understand the capacity of Northern communities to cooperate in local food sharing economies, we developed an Agent-Based Model to simulate the effects that participation in household-level versus community-level sharing might have on a caribou meat distribution system. This model is based on the findings from data gathered at the Innu community of Sheshatshiu, Labrador. The preliminary objective of this study is to examine how the relative contributions of household-level versus community-level sharing of caribou affect the uniformity of caribou meat amongst the population. The preliminary results from the application of the ABM approach have shown that the agents operating at the higher scale of the community-level tend to distribute the meat more evenly. This indicates that policies promoting large-scale (or up-scaling) of cooperation may also increase the capacity of Northern communities to build healthy food sharing economies.

WILLIAM LANGFORD, University of Guelph

Hadley Cell Changes in Today's Climate and Paleoclimates

A mathematical model has been constructed for the study of convection in a rotating hemispherical shell of fluid, with radial gravity and a pole-to-equator temperature gradient on the inner boundary. The fluid in the model satisfies the Navier-Stokes Boussinesq PDE. For moderately strong values of the temperature gradient, convection cells appear that resemble the Hadley, Ferrel and polar cells of the present day climate of the Earth. The model reproduces the trade winds, westerlies, jet stream and polar easterlies of today's climate. As the temperature gradient is decreased, the Hadley cell slows in circulation velocity and expands poleward; also the jet stream moves poleward. All these changes have been observed recently in the atmosphere of Earth. Eventually, for still smaller values of the temperature gradient in the model, the Ferrel and polar cells disappear and the resulting circulation resembles that of the "greenhouse" paleoclimate that dominated the Earth for much of geological time. Application to the Pliocene Paradox will be discussed. This is joint work with Greg Lewis of UOIT.

YIJUN LOU, Department of Mathematics and Statistics, York University

The Impact of Climate Warming on the Establishment of Lyme Disease Tick Vector Ixodes Scapularis

A stage-structured periodic deterministic model is formulated to assess the climate warming impact on the tick (Ixodes scapularis) population at Long Point, Ontario, Canada. The model is parametrized by using Fourier analysis, and the tick development and questing activity data are complied from the laboratory and field experiments conducted in Canada. These validated estimations provide the basis for our study using the deterministic model with periodic coefficients to describe the influence of climate warming on the Lyme disease establishment in the considered region. The basic reproduction number for the tick population is derived and this number serves as a threshold parameter for tick invasion: the tick is doomed to extinction when this number is less than unity; and the tick can successfully invade into the study region and may stabilize at a positive seasonal equilibrium state when this number is greater than one. Both temperatures and host densities influence the value of the basic reproduction number, thereby influencing the risk of tick establishment in a habitat, specifically, climate warming promotes tick survival in favorable habitats and affiliates tick invasion to previously non-endemic areas. This is joint work with Xiaotian Wu, Venkata R. Duvvuri, Nicholas H. Ogden and Jianhong Wu.

ASIT MAZUMDER, University of Victoria

Modeling impacts of climate and landuse variability on waterborne pathogens and diseases: Issues and challenges.

Global effort to sustain clean and healthy water for communities is being challenged by a variety of stressors, such as pathogens, contaminants, toxins, pharmaceuticals associated with land- and resource-use and development, and changing climate. Over 4 million people die a year from contaminated drinking water, and 35 out of 1000 children in the rural and slums of developing countries die before the age of 5 from water related illnesses. More and more freshwater sources are becoming unacceptable for public consumption. Unfortunately, the lack of long-term data in climate variability, landuse and waterborne pathogens makes it difficult to develop robust models and predictions on climate impacts on waterborne pathogens, and our task gets even more complicated under changing landscape exploitation. We fail to recognize that there could be significant economic and health benefits from sustaining our freshwater environment for clean and health water, rather than intensifying treatment

and disinfection to protect public health. Currently most climate models linked to water focus on water quantity rather than quality, and there are major challenges in modeling the impacts of climate variability on waterborne pathogens and waterborne diseases. In addition to providing a general overview of these issues and challenges for global communities, I will present results on some of the innovative tools that could be used to develop strategies to optimize and manage public health risks from water and aquatic resources under variable and extreme climate and environmental changes.

XIN QIU, Novus Environmental Inc
Climate Change Downscaling and Probabilistic Analysis

Novus and York University are conducting a research project funded by the Ontario Ministry of Environment to investigate climate change downscaling for Canada and also focus on probabilistic analysis. Major climate parameters include temperature, precipitation and degree days. This study provides an in-depth understanding of climate change impacts on local scale of Ontario, along with uncertainty analysis. This talk will present the recent work on high resolution (CRCM resolution) changes in two temperature indices: heating degree days (HDD) and cooling degree days (CDD), which are all related to the energy demanding and many other adaptation studies. In this study, based on the work and method developed in Li et al. (2011), using the temperature simulated by the RCM and its driven GCM, we established the high resolution statistical downscaling model for annual-accumulated HDD and CDD, then applied this tools to other GCM runs to project the future changes in HDD and CDD. The source of uncertainty in this high resolution projection was also investigated.

GRAHAM SMITH, St. Michael's Hospital
Spatial Patterns of Severe Rainfall in Southern Ontario

It is generally accepted that one of the predicted effects of climate change will be shifts in the intensity, the frequency and the spatial distribution of severe storm events. Government in regions affected by these changes will need to make adjustments to their water and land management practices and to make use of existing knowledge and technology to adapt to change. The climate in Southern Ontario is expected to shift to earlier snow melt, earlier spring storms and increased storm severity throughout the summer season. The region is particularly vulnerable to the combined effects of these climate factors in the spring months of March, April and May when the risk of flooding and erosion is at its greatest. The predicted increase in summer rainfall intensity will have negative impacts for soil erosion and flood damage. This talk presents an analysis of 46 years of climate data in Southern Ontario. The spatial distribution of intense rainfall is examined to determine the extent to which rainfall exhibits localized patterns and whether there have been changes in the patterns over the period of data. The spatial patterns of severe rainfall between the months of March and September are also examined with the use of 13 years of radar data. A comparison of one hour rainfall measured from NEXRAD radar data to Environment Canada's intensity duration frequency (IDF) data demonstrates a technique of spatial analysis that could aid in revising IDF values and identifying areas that experience a higher frequency of intense rainfall events.

RANGA SUDARSAN, University of Guelph, Guelph, Ontario, Canada
"Effect of temperature changes on micro-environment inside a Beehive – a modeling study"

Honey bees have been in the news grabbing head-lines (e.g, "EU Plan Bee for bee recovery", BBC news) world over due the sudden collapse in honey bee colony size also called as Colony Collapse Disorder(CCD). In parallel with efforts to find the source of this collapse, this event has initiated studies aimed at understanding conditions inside a beehive, which are difficult to monitor. Honeybees work hard to maintain temperature and humidity levels inside their beehive within narrow limits to ensure optimal growth conditions for their off-springs as well as to optimize their finite energy resources. Understanding and ensuring good ventilation of a beehive has been long recognized by beekeepers as a way to help honeybees maintain a healthy colony.

Despite the long history of beekeeping and its extensive use in honey bee farming practice, little information is available about the conditions inside a honey beehive. In this study, using field data and observations, we constructed for the first time a realistic physical model of a beehive, and modeled the relevant heat and mass transfer processes describing the interaction of the honeybees with the air and simulated the 3-D flow inside the beehive. In our talk, we will discuss the challenges involved

in modeling this problem as well as our findings regarding conditions inside the beehive at different ambient temperatures and its implication for the honeybees.

JIAFENG WANG, York University

Clustering of the Abundance of West Nile Virus Vector Mosquitoes in Peel Region, Ontario

The spatial-temporal distribution of West Nile virus (WNV) vector mosquitoes is helpful for mosquito control and prevention of mosquito-borne diseases. In this study, we apply a non-parametric clustering method CLUES to the data of WNV vector mosquito collected by light traps in Peel Region, Ontario, during the mosquito seasons in 2004-2010. It is found that the mosquito trap sites can be clustered into three groups. Each group shares similar response to the seasonality on mosquito abundance, while the inter-annual variability and the highest abundance and peak time in different mosquito season are different. The impact of weather factors on this clustering was investigated. This is a joint with Steven Wang, Curtis Russell, Kaz Higuchi, Rick Bello and Huaiping Zhu.