Abstracts:

9:00 – 10:00 **Gordon C Ashton Memorial Lecture, Keynote Speaker:**

James V Zidek, Department of Statistics **,** University of British Columbia **,** Vancouver, Canada
Coauthors: Song Cai, U British Columbia, Nathaniel Newlands, Agriculture and Agro-Foods Canada

Forecasting Phenological Events in Agroclimate Risk Management

Although it is certain that world climate is changing, the degree, nature and impact of that change is not. Thus attention has increasingly turned to dynamically managing the risks of that change as it progresses in the future. Declining food production is one such risk and the subject of this talk, which falls under the heading of agroclimate risk management. More specifically it concerns the prediction of phenological change as a function of cumulative temperature, either for use in current year forecasting for operations planning, or for use with downscaled climate models in future planning. As an example, in any one season an apple tree bears fruit after a sequence of other phenological events including bud - burst and blooming. The successive times of these events will vary randomly from year - to - year due to weather, while exhibiting trends over time due to climate. Modelling such sequences lies in the domain of time – to – event analysis, a branch of survival analysis. However, it has special features that put it outside the ambit of existing theory. First the events are progressive, i.e. irreversible, if they occur at all. Second the time to occurrence of any one event, becomes a predictor to the time to the next. Third the covariates are time – varying and the occurrence of any one event depends not just on the covariate's value at that time, but on the whole sequence of its values since the beginning of the year of interest. Finally, the goal is prediction, not hypothesis testing, the usual goal of survival analysis. Thus the work to be described in this talk will consist first of a description of an extension to time - to – event theory to cover this application. Then I will describe its application to prediction of the bloom dates of perennial crops in the Okanagan region of British Columbia. That application entails the construction of a predictive distribution for the relevant within year covariates (climate variables). I will conclude by briefly describing other current work in agroclimate risk management.

10:15 – 10:45 **Dr. Lev Tarasov**, Dept of Physics and Physical Oceanography, Memorial University of Newfoundland.

Bayesian Artificial Neural Network assisted calibration of Earth Systems Models with structural error estimation

10:45 – 11:15 **Dr. Yulia Gel**, Department of Statistics & Actuarial Sciences, University of Waterloo.
Coauthors: Kimihiro Noguchi, UC Davis, Yulia R. Gel, University of Waterloo, Claude R. Duguay, University of Waterloo

Detecting Trends in Hydrological Time Series, with Application to Ice Phenology Data

Studying trends in ice freeze-up and break-up dates as well as ice cover duration on lakes, which are sensitive to the air temperature, provides us useful information about climate change and linkages to atmospheric teleconnection patterns. Such data, however, typically show a positive serial correlation, which implies that a positive/negative observation tends to be followed by a positive/negative observation in the future. Such serial correlation among data is known to lead to deflation of p-values and related inflation of significance levels of most statistical procedures and tests, making the obtained results unreliable. In particular, we show that the classical statistical approaches, e.g., Student's t- and Mann-Kendall tests, which assume independence of data, are inappropriate when a serial correlation is present. To overcome the

problem, we suggest sieve bootstrap approaches which take into account the serial correlation of data for trend tracking in order to obtain more accurate and reliable estimates. We compare and discuss the results on the classical and newly proposed statistical approaches for the trend analysis using freeze-up and break-up dates as well as ice cover observations from Lake Baikal for the period 1869-1996 and Lake Kallavesi freeze-up dates data from 1834 to 1996. Remarkably, some recent studies of the Kallavesi freeze-up and the Baikal break-up dates, performed under the assumption of independence, report p-values that are relatively close to the border of statistical significance and, hence, provide some doubts in existence of a linear trend; while, after taking into account the dependence structure of the observed data, the newly derived p-values have raised to an insignificant level, which implies no evidence for existence of a linear trend. The new bootstrap-based approaches also yield substantially less significant results for freeze-up and ice cover duration for Lake Baikal than reported earlier.

11:30 – 12:00 **Dr. Alexander Brenning**, Department of Geography, University of Waterloo.
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Spatiotemporal analysis of remotely-sensed snow cover patterns: Insights from survival models and generalized additive models

The spatiotemporal distribution of snow cover in mountain areas is an important environmental variable as it controls spring streamflow and is sensitive to climatic fluctuations and climate change. Statistical data analysis methods are required to identify and quantify spatial and temporal trends and patterns in snow cover that are related to the underlying physical processes. We use two contrasting approaches, generalized additive models (GAMs) and survival models, and compare the utility of both. While the GAM with a logistic link function allows us to model the presence/absence of snow and thus create a snowline-based snow climatology, the proportional hazards survival model enables us to characterize snow disappearance dates directly based on approximately monthly satellite data. To our knowledge, the latter method has not been applied previously in this context. We apply these techniques to a 17-year time series of Advanced Very High Resolution Radiometer (AVHRR) snow cover data in order to characterize the seasonal and interannual variation of snow cover and snow disappearance related to climatic and topographic attributes. The GAM provides a very good model fit (area under the ROC curve, estimated by year-level cross-validation, 0.88 for September and 0.94 for February snow presence/absence). As one of the results, the interannual variation in snowline altitude during austral winters amounts to ~600 m, which can be partly attributed to precipitation differences. In terms of snow disappearance dates, a two-month difference between dry(-warm) and moist(-cool) years was detected. Both statistical methods discussed provide complementary insights into the spatiotemporal patterns, survival models being able to deal with the interval-type satellite-based observation of snow disappearance. Among the challenges in the statistical treatment of this spatiotemporal data set is the presence of spatial autocorrelation and image-level grouping of the data, which have implications for model development and predictive performance assessment.

1:30 – 2:30 **Keynote Speaker**
Dr. Marie-Josée Fortin, Department of Ecology and Evolutionary Biology, University of Toronto.

Species geographical range shifts due to global change: adding the temporal dimension to species distribution models

Spatial patterns in landscape features and environmental attributes are highly dynamic due to global change and natural disturbances which in turn affect species distribution. This is especially true in southern Ontario where several species reach either the northern or southern edge of their geographical range. A synthetic indicator of the influence of these combined effects is the observed spatial distributions of focal species. Although species distributions have been well studied across gradients, more attention needs to be directed towards what determines the species' geographical ranges and its limits. In order to ensure the persistence of species in Ontario given global change, it is critical to first quantify what are the types of geographical range changes encountered and determine which environmental factors most influence range expansion and contraction. To do so regional statistical models that account for the presence of spatial autocorrelation in the ecological data needs to be used. Here I present how statistical models and dynamic species distribution models can be used to study species range shifts.

2:45 – 3:15 **Dr. William Langford**, Dept. of Mathematics & Statistics, 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 spherical shell of fluid, with radial gravity and a pole-to-equator temperature gradient on the inner boundary. The fluid of 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 streams and polar easterlies of today's climate. As the temperature gradient is decreased, the Hadley cells slow in their circulation velocity and expand poleward, a change recently reported on Earth. Eventually, for still smaller values of the temperature gradient, 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.

3:15 – 3:45 **Dr. Lilia Leticia Ramirez Ramirez**, Department of Statistics and Actuarial Sciences, University of Waterloo.

Use of GOP and hierarchical space-time models to derive probabilistic weather forecasts

Probabilistic weather forecasting are becoming increasingly popular among meteorologists and weather users as it enables to produce predictive intervals for a future atmospheric quantity with a prespecified confidence level rather than a single point forecast. These confidence levels are of particular importance for an accurate and reliable assessment of weather uncertainties for risk management tasks. However, typically statistical weather scenarios focus either on capturing a spatial or temporal dynamics.

In order to introduce more general non-stationary spatio-temporal effects, we propose to employ a hierarchical Bayesian model and the Geostatistical Output Perturbation method (GOP, Gel et al. 2004) to obtain calibrated probabilistic weather forecasts. We illustrate its application in the case of temperature forecast in North American

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Gel, Y.; Raftery, A. E. and Gneiting, T. (2004) Calibrated Probabilistic Mesoscale Wather Field Forecasting: The Geostatiscial Output Perturbation Method. Jasa 99, (467).

4:00 – 4:30 **Dr. Jay Malcolm**, Faculty of Forestry, University of Toronto.

Potential migration corridors for climate-change induced tree migration in southern

Global warming has the potential to force large shifts in species ranges, but the magnitude of the associated migration, and migration routes that might best facilitate the migration, are poorly understood. We describe two efforts to estimate required migration rates and routes. In one, we coupled results from General Circulation Models (GCMs) and Global Vegetation Models (GVMs) to investigate migration rates and routes for major biome types at a global scale. In another, we used a variety of climate envelope modelling techniques to model current ranges of 127 eastern North American tree species, and, coupled with climate projections from GCMs, to investigate future migration rates and routes. In both cases, migration rates and routes were based on "back-cast" migration paths; i.e., the shortest paths between presumptive future and current range locations. Also, we calculated shortest possible migration rates (crowfly) and contrasted them with shortest terrestrial-path migration routes in which barriers to migration were incorporated. At the global scale, relatively high crowfly rates (>1 km/year) were relatively common for all models (c. 20% of grid cells) and were much higher in boreal and temperate biomes than in tropical biomes. To obtain migration rates in the Boreal biome similar in magnitude to those observed followed the retreating North American Glacier, a decrease in the rate of warming of approximately an order of magnitude was required. Large water bodies and human development had regionally important effects in increasing migration rates. Modelling of tree range shifts indicated even higher required crowfly rates, averaging 4-6 km/yr across species. Terrestrial-path modelling indicated that forest fragmentation in southern Ontario increased migration rates by a factor of 1.6 on average. Examination of terrestrial paths found support for the importance of existing corridors such as the Oak Ridges Moraine and the Niagara Escarpment in facilitating future migration, suggesting that current efforts to facilitate large-scale connectivity, such as the Adirondack-to-Algonquin initiative, will prove useful in increasing future migration. In general, our results were robust in that important migration routes tended to be similar among climate change scenarios and among calculation methods, which should make conservation efforts easier. A key future question is the extent to which strategic corridor enhancement can increase migration capabilities.

4:30 – 5:00 **Dr. Dalhai He**, Dept. of Mathematics & Statistics, McMaster University.

Mechanistic modelling of the three waves in the 1918 influenza pandemic in the UK: effects of school term, weather and human behavioral response

Multiple waves have been observed in the initial phase of influenza pandemics, notably the 1918 pandemic. The mechanisms that account for this phenomenon remain unclear. Here, we show that we can fit the three mortality waves observed in the 1918 pandemic in the UK using a simple compartmental disease model which allows transmission rate to be affected by school terms, weather, and behavioral responses to mortality. Using a likelihood-based inference method, we found that all three factors are needed to reproduce the observed pattern. In particular, behavioral response to mortality is required for a model to display three waves.