"GEORISK AND CLIMATE CHANGE"

2007 - 08Annual Report of the PIMS Environmetrics Collaborative Research Group..

May 15, 2008

Submitted to the Pacific Institute for the Mathematical Sciences by

Charmaine Dean	**Simon Fraser University**
Sylvia Esterbey	**University of British Columbia, Okanagan**
Peter Guttorp	**University of Washington**
Jim Zidek	**University of British Columbia, Vancouver**

PIMS Environmetrics CRG

The goal of this project is to develop a multi-site, distributed environmetrics research center. Activities of such a center would include conferences, workshops, summer schools, joint courses, a diploma/certificate program, and collaborative research.

Conferences, meetings, summer schools and workshops:

The year began with a meeting held at Semiahmoo in January, 2007. Participants came from a number of institutions, principally Simon Fraser University (SFU), the Universities of British Columbia [Okanagan UBC-O as well as Vancouver UBC - V], the University of Victoria (UV) and the University of Washington (UW). They came not only from academe but also from government. Some were students. Others came from the non-statistical science disciplines. A list of all those participants can be found at

http://www.orca.artsci.washington.edu/sites/NWRCSE/Shared%20Documents/Forms/AllItems.aspx

along with the program. Among the meetings were the "breakout sessions" whose reports appear on the same web page: extremes; governance; policy; space – time processes; educational programs. Overall, this was an extraordinary meeting with lots of good ideas for future directions from the break out groups. A summary follows:

2007: Semiahmoo meeting:
Organizers: Peter Guttorp, U Washington & Jim Zidek, U British Columbia
Location: Semiahmoo conference center
Dates: Jan 23-24
Content: The introductory meeting opened with a presentation of the old NRCSE (by Guttorp) and a presentation of the current PIMS plan (by Zidek). The remainder of the afternoon featured presentations on a variety of current projects:

- ***Policy and decisions regarding climate change***
- ***Agroclimate risk management***
- ***Impacts of climate change:*** *moth prevalence* (with impact on the BC apple industry); fisheries (especially salmon production); forest fires, fire regimes and fire management; forest ecology; human health.
- ***Numerical vs. statistical modeling methods:*** quantifying uncertainty; combining; multi-resolution issues.
- ***Design***

Dinner was devoted to informal discussion. The second day highlighted the breakout group sessions followed by a summary session as well overall discussion about the future of the CRG.

The kick – off meeting paved the way to a very successful first year that involved a number of meetings to be described below along with research that was funded by not only PIMS but other organizations as well.

We list ensuing events below. The web pages can be found on the PIMS activities page where amongst other things one finds their programs, lists of participants as well as their wrap - up reports. The latter include in many cases summaries of issues and future directions.

2007: Workshop on Applications of Climate Statistics in Agriculture Regina,
Organizers: Aston Chipanshi, Agriculture and Agri-Food Canada (AAFC), Regina, Sask, Harvey Hill, AAFC, Saskatoon, Sask, James Ramsay, Dept. of Psychology, McGill University, James Zidek, Dept. of Statistics, University of British Columbia
Location: Regina, Saskatchewan
Dates: June 5-7, 2007
Joint Sponsors: NICDS and Agriculture and Agri – Food Canada.

The attachment to this report, gives a wrap up summary on the meeting along with the detailed program of presentations. Although not funded by PIMS, this workshop addressed one of the areas subsumed under the PIMS Environmetrics CRG.
Purpose: The climate statistics workshop provided a venue for scientific researchers and end users to discuss how statistical information can benefit agriculture, water and other climate sensitive operations. Applied scientific presentations increased understanding of what can be provided analytically using 'easy to understand statistics'. The usefulness and limitations of the tools were assessed by the user community, who engaged researchers in a dialogue aimed at suggesting appropriate statistical techniques for risk reduction. The dialogue was achieved by including users of climate information as workshop participants. Participants include representatives of government departments, commodity brokers, financial representatives and community groups whose activities are impacted by weather and climate.

Theme: Statistical analyses of climate data for risk reduction.

Objectives:

- Clarify types of statistics that can be generated for T and P for risk assessment.
- Consider the strengths and limitations of the climate data available for analysis.
- Share relevant trends and developments in statistical methodology.
- Increase awareness and sensitivity to user needs, both in relation to the statistics required and the preferred format for presenting them.
- Provide an opportunity for face-to-face discussion among scientific researchers and end users.

Background: The climate statistics applications workshop was a first attempt to ask the user community what statistical techniques are needed by agricultural producers to study climate variables for risk reduction.

Prior to this workshop, the National Land and Water Information Service (NLWIS) commissioned a study to interpolate climate data consisting of daily temperature and precipitation at a 10km resolution using three interpolation methods; Annusplin, Daymet and Hybrid. The datasets produced by the three methods were subjected to a rigorous statistical comparison so that model suitability across the diverse regions of Canada could be assessed. That comparison showed that each of the three methods has pros and cons depending on location and time steps used to analyze the data.

This workshop, a sequel to the earlier study, was partially supported by the National Program for Complex Data Structures (NICDS) as a step toward the preparation of a NICDS research funding application to support the development of appropriate statistical theory and to apply it to reduce agriculture risk. The intention was to launch a large scale and long-range project, grouping together research statisticians from across Canada and elsewhere with developers and users of risk assessment tools. The project, initiated with NICDS seed money, was to go on to attract continued funding from the agroclimate community in both the public and private sectors as well as other funding agencies already funding statistical research. A proposal for two years of funding was subsequently to the NICDS and a positive response from the NICDS scientific review panel led to a resubmission of the application based on only one year of funding, since the NICDS's application for a renewal of its NSERC award failed. The outcome is still pending as this report is being written.

Involvement: The target audience included researchers from the agriculture sector, water resource as well as agri-related sub-sectors (energy, transport, finance etc), atmospheric science and statisticians interested in modeling climate data.

General Workshop Agenda:
The previous user oriented workshop on the gridded data in Edmonton in 2005 showed the importance of including time for discussion and questions. That consideration led to the following overall plan for the Regina Workshop:

- The workshop was 1 ½ days in duration.
- It started with a 1/2 day of technical presentations followed by a day of discussions, application studies and pilot project definition
- It concluded with breakout group sessions that defined a number of key research areas for inclusion in the NICDS application.

2007: TIES North American Regional Meeting 2007
Organizer: Peter Guttorp (U of Washington)
Location: University of Washington
Dates: June 19–21, 2007

Ninety registered participants enjoyed a variety of talks, many geared towards the conference theme of “Climate change and its environmental effects: monitoring, measuring, and predicting.

The conference started in the afternoon of the first day with a session on inference for mechanistic models, with Tilmann Gneiting, Mark Berliner and Derek Bingham as speakers. The first keynote address followed, with Paul Switzer presenting Regional time trends in climate model simulations. The opening mixer, with five poster presentations concluded the first day's activities.

The second day saw two invited sessions on Monitoring the environment and biota on landscape to continental scales. The speakers were Jay Breidt, Jason Legg, Gretchen Moisen, Don Stevens and Mevin Hooten. An invited session on Paleoclimatic temperature reconstruction had talks by Edward Cook, David Schneider and Bo Li. Elizabeth Shamseldin, Georg Lindgren and Slava Kharin were invited speakers in a session on Assessing trends in extreme climate events. In parallel, a special session by conference sponsor National Oceanic and Atmospheric Administration included Bill Peterson, Peter Lawson, Kerym Aydin and Lisa Crozier. The conference dinner took place in one of the dorms, but the catered food was several levels above regular dorm food!

The final day had a morning invited session on Agroclimate risk assessment with Nathaniel Newlands, Jim Ramsay and Nhu Le. After the coffee break two parallel invited sessions took place: one on The role of statistics in public policy with Paul McElhany, Tanja Srebotnjak and Marianne Turley, and the other on Measuring biodiversity and species interaction, having speakers Andy Royle and Emily Silverman.

The second keynote address was by TIES president David Brillinger, and was entitled: Probabilistic risk modeling at the wildland - urban interface: the 2003 Cedar Fire. The final invited session was about Forests, fires and stochastic modeling. Speakers were Mike Flannigan, Haiganoush Preisler and Steve Taylor.

Throughout the program there were contributed sessions on Inference for mechanistic and stochastic models; Spatial methods; Methods in ecology; Forest fires, remote sensing and stochastic models; and Climate.

2007: PIMS International Graduate Institute on Modeling Environmental Space – Time Processes

Location: University of Washington
Audience: Senior graduate students and young researchers
Instructors: Peter Guttorp and Paul Sampson (University of Washington), Jim Zidek and Nhu Le (University of British Columbia Vancouver)
Dates: July 9 - 13

Content: Transform tools, such as power spectra, wavelets, and empirical orthogonal functions, are useful tools for analyzing temporal, spatial and space-time processes. We will develop some theory and illustrate its use in a variety of applications in ecology and air quality.

Harmonic (or frequency) analysis has long been the one of the main tools in time series analysis. Application of Fourier techniques work best when the underlying process is stationary, and we develop and illustrate it here for stationary spatial and space-time processes. However, spatial stationarity is rather a severe assumption for environmental models, and we show how the theory can be generalized beyond that assumption. In some circumstances, we can develop formal tests for stationarity.

In geophysics and meteorology, variants of principal components called empirical orthogonal functions (EOFs) are used to describe leading modes of variability in space-time processes. Smoothed EOFs can be used to model the spatio-temporal mean field of a random field, while another type of spatially nonstationary model will be introduced to describe the random part of the field.

Finally, we describe an approach to a fully Bayesian modeling of space-time processes, using several of the tools discussed earlier in the course. This will enable analysis of space-time processes for which the covariance structure is non-separable, an assumption, which has frequently (but incorrectly) been made in the literature.

Funding synergies: In addition to PIMS, this summer school was supported by a UW VIGRE NSF grant.

2008: Data-driven and Physically-based Models for Characterization of Processes in Hydrology, Hydraulics, Oceanography and Climate Change

(Joint with National University of Singapore)

Organizers from PIMS: Sylvia Esterby and Jim Zidek

Dates: Jan 6 – 28

Content: The 3-week program consisted of a full week of seminars/lectures, and two weeks of workshops and research discussions aimed at developing research collaboration. Three main topics were covered in the program: development of a fully integrated data driven and physical-based models for water resources management; dynamic and statistical downscaling for climate change; nonlinear Wave Dynamics and Tsunami Modeling.

The wrap up report on line includes a long list of issues and future research directions in this area.

Participants: These included students from SE Asian countries along with researchers from a variety of disciplines as well as geographical regions including Thailand, Vietnam, Japan, Switzerland and Holland.

Linkages:
The CRG has aimed at extending links with international collaborators.

- The Principle Investigators (PIs) worked on building contacts with Pacific Rim universities, in particular the Institute of Mathematical Sciences (IMS) and the Tropical Marine Science Institute at the National University of Singapore. Those efforts led to the jointly sponsored Workshop at the IMS in Jan 2008. Moreover the Director of the IMS attended the PIMS sponsored BIRS Workshop in May 2008.
- While in Tokyo, Nov 2006, Jim Zidek explored linkages between the Institute of Statistical Mathematics and PIMS, leading to a member of the Institute attending the IMS – PIMS workshop described above along with a possible research collaboration about predicting the high of a tsunami.
- In Mar 2008 Doug Nychka, the Director of the Geophysical Statistics Program at the National Center for Atmospheric Research (NCAR) in Boulder, Colorado led a series of discussions and lectures at SFU and a roundtable discussion session at UBC followed by planning sessions on the PIMS co-sponsored summer school being organized for the summer of 2008.
- With PIMS support, Jim Zidek (UBC) spent two weeks at Statistical and Applied Mathematical Sciences Institute at Research Triangle Park, North Carolina in the spring of 2007. Consequently he is co – leading a 2009 –10 (one – year) thematic session in about statistical analysis for environmental space – time modeling, environmental epidemiology and climate change.
- Charmaine Dean and Ivar Ekeland engaged in discussions with colleagues from Chile on the creation of a centre for the mathematical and statistical study of forests and forest products (CTBNS). The CTBNS was created in response to the lack of knowledge and use of technologies for generating goods and services from the Chilean native forests. CTBNS is a consortium of four public universities: Universidad de Chile (Center for Mathematical Modeling and Forestry Faculty), Universidad de La Frontera (UFRO), Universidad de Los Lagos (ULA) and Universidad de Magallanes (UMag). Fangliang He (U Calgary – representing Charmaine Dean) participated in the opening of the centre and gave a talk on forest ecology. He also provided discussions on the sort of statistical modeling and analysis conducted by the forestry sector of the CRG. His travel was supported by the PIMS CRG funds at SFU.
- Charmaine Dean engaged in a two-day roundtable discussion held at the Pacific Climate Impacts Consortium in Victoria on Forest Pests and Climate Change. The Pacific Climate Impacts Consortium held this symposium as part of a Forest Science Program project, in order to initiate a dialogue on the scientific requirements for research on forest pests and climate change. In light of considerable uncertainty about forest pests, accelerated or unanticipated changes in the forests, and a potentially short time span to react and adapt it was hoped to focus research resources across disciplines and organizations. A small number of experts were gathered and asked to consider five topic areas, including economic modeling, biological models of pests and hosts, overviews of available forest and pest outbreak databases, including a discussion of spatial statistical methods,

climate databases and methods for downscaling to a biologically meaningful scale, and, finally, ways to move forward in our research, including filling gaps in knowledge and solutions to some of the problems brought up in other sessions. Participants created a list of the top 10 pests that will impact forests in BC in the future and identified methodological needs.

Research progress:

Agroclimate modeling. (Reza Hosseini, PhD Student, Department of Statistics, UBC)
Although not supported by PIMS, Reza, with NSERC support, worked on models for climate data. That work began with an analysis of Canadian climate data from 1895 to 2006. In a pre-analysis of that data, he found that the daily minimum temperature over the summer has increased over the past century in the province of Alberta.

Following that he investigated the Markovian character of the precipitation process (dry/wet) since long sequences in the dry state characterize drought. He has proposed a new method for selecting the order of Markov chain using the logistic function and using the generalized linear models for time series. An advantage of this model over existing competitors is it does not need the stationarity assumption and it reflects the spatial nature of the process. The model can be used to investigate extreme climate events (both precipitation and temperature) by letting the binary process to be extreme/not extreme for a given day.

In future work Reza will use dynamic linear models (DLMs) to study the spatial temporal process of precipitation. DLMs have been used to model various processes most of which are Gaussian, not a feature of the precipitation response field. He will study the performance of such models in describing the climate variables.

Deterministic vs statistical modeling (Zhong Liu, PhD Thesis, 2007).
Partially funded by PIMS as a Graduate Research Assistant, Zhong completed his PhD in Statistics late in 2008 and began an NSERC Postdoctoral Fellowship at UBC working with Jim Ramsay, Adjunct Professor of Statistics. He has manuscripts in preparation that are now summarized:

An Appraisal of Bayesian Melding for Physical-Statistical Modeling.
Abstract. This manuscript reviews the Bayesian melding model (Fuentes and Raftery, Biometrics 2005) and uses it to combine data and simulated data (deterministic model output). Technical details are provided on how to use Gibbs sampling to fit the model and critically assesses it through various simulation experiments as well as applications where ozone measurements are combined with simulated ozone levels from a deterministic model called AQM.

Spatial-Temporal Models To Combine Measurements and Deterministic Model Outputs For The Prediction Of Ozone.

Abstract. This paper proposes univariate and multivariate spatial-temporal models in Bayesian hierarchical frameworks. These two models are inspired by Guillas et al. (Atmospheric Chemistry and Physics 2006) These spatial-temporal models can provide forecasts and spatial predictions of ground level ozone along with their credible intervals by combing observed data and deterministic model output. As an application, these spatial-temporal models are used on ozone data from the eastern and central USA. Hourly ozone data are analyzed using univariate model and daily ozone data using multivariate model. The forecasts and predictions of the spatial-temporal models are compared with those of other approaches such as Kriging.

Multivariate Spatial-Temporal Model For the Prediction of Ozone Fields.

Abstract. This manuscript extends the univariate spatial-temporal model above to a multivariate model. We present the model specifications and the Gibbs sampling algorithm to fit the model. This multivariate spatial-temporal model is also used for the spatial and temporal prediction of day- and night - time ozone.

Calibration of Deterministic Models for Ozone Fields.

Abstract. Deterministic models are used widely to infer the ozone's policy relevant background (PRB) level. However, the deterministic model outputs need to be calibrated. This manuscript shows how to use Bayesian melding model and the spatial-temporal model we proposed to calibrate the model outputs. The calibration results from these two models for the daily average ozone are compared.

Combing Measurements with an Ensemble of Deterministic Model Outputs for Probabilistic Weather Forecasting.

Abstract. This manuscript extends the Bayesian melding to combine observed data with ensemble deterministic model output. We apply the extension to the sea - level temperature data in the Pacific Northwest. This model provides an alternative to a Bayesian average model (Raftery and Gneiting et al., Monthly Weather Review, 2005). The predictions of the BEM model are compared with those obtained by simply averaging ensemble outputs and by classical Kriging.

Modeling space – time environmental fields (Yiping Dou, PhD Thesis, 2008).

Although not funded by PIMS, Yiping completed her PhD in statistics early in 2008 and began her PIMS Postdoctoral Fellowship research on Apr 1, 2008. She has manuscripts in preparation that are now summarized:

Modelling hourly ozone concentration fields

Abstract: This manuscript presents a dynamic linear model for modeling hourly ozone concentrations over the eastern United States. That model, which is developed within an Bayesian hierarchical framework, inherits the important feature of such models that its coefficients, treated as states of the process, can

change with time. Thus the model includes a time--varying site invariant mean field as well as time - varying coefficients for 24 and 12 diurnal cycle components. This cost of this model's great flexibility comes at the cost of computational complexity, forcing us to use an MCMC approach and to restrict application of our model domain to a small number of monitoring sites. We critically assess this model and discover some of its weaknesses in this type of application.

Model comparison: DLM and BSP

Abstract: This paper presents a comparison between two known methods in modelling state--space processes: the DLM (dynamic linear model) and the BSP (Bayesian spatial prediction after pre--filtering), using the AQS database for the ground--level ozone concentrations in Chicago area. This comparison includes the spatial interpolation at ungauged sites as well as one--day--ahead temporal prediction at gauged sites using both methods. We thus accept the BSP model rather than the DLM from results obtained in this paper.

Temporal prediction using the Bayesian spatial prediction after pre--filtering

Abstract: We propose the temporal prediction at any time point using a spatial model, BSP. The interest of this paper is to present the advantage of this approach and good model performance as compared to other model like the DLM. We accept this method when using the BSP in the framework of temporal prediction due to its advantages.

Bayesian empirical orthogonal function method and its application

Abstract: We propose a Bayesian version empirical orthogonal function method to overcome a potential problem often ignored in literature in representing spatial--temporal variations in space--time fields. This methodology, comparing with the usual approach, better captures main spatial patterns during our simulation studies. In simulation examples, we show the severe problems for highly temporally correlated space--time fields using the usual method. An MCMC algorithm will be implemented and verify our conclusion about our Bayesian method.

Generalized Bayesian spatial prediction method and its application

Abstract: This paper presents a generalized version of the Bayesian spatial prediction after pre--filtering (GBSP) by integrating it into the fully Bayesian hierarchical framework. We also use the Bayesian empirical orthogonal function method to obtain the principal spatial patterns in spatial--temporal fields. The GBSP method can incorporate some other important approaches in this field. We implement this method into a real data analysis using the new software we develop

Environmental impacts (Zuzana Hrdlickova, PDF, UBC O)
Post-doctoral stay within the Collaborative Research Group, June 1 2007 – May 31 2008
Location: University of British Columbia Okanagan, Kelowna
Supervisor: Sylvia Esterby
Supporting grants:

- Pacific Institute for the Mathematical Sciences
- GEOIDE - Geomatics for Informed Decisions, a Network of Centres of Excellence
- Natural Sciences and Engineering Research Council of Canada

Analysis of fire weather index time series.

Sylvia Esterby and Zuzana Hrdlickova are working on the project aiming at the analysis of the fire weather index, which is conducted in cooperation with Steve Taylor, Canadian Forest Service, Pacific Forestry Centre. The research focuses on clustering of the fire stations according to the temporal fire weather index trends.

- First an overview of the available statistical methods for clustering time series was prepared. Some of the methods were programmed in R.
- Special attention was paid to an approach based on k-means and principal component analysis.
- New method of the clustering based on the Maximum Autocorrelation Factors was derived and programmed in R.
- Preliminary results were presented by Sylvia Esterby at the Fields Workshop on Disturbances: Modelling Spread in Forests (University of Western Ontario, 22-23.11, 2007) in the talk with title "Classifying historical fire weather patterns"
- At the BIRS meeting (Banff International Research Station for Mathematical Innovation and Discovery, Climate Change Impacts on Ecology and the Environment, May 4-9, 2008) Zuzana Hrdlickova presented a talk on "Changes in patterns of the historical fire weather index data"**.**
- An abstract on **"**Annual patterns in the historical fire weather index" was submitted for presentation by Zuzana Hrdlickova at the International Environmetrics Society meeting, hold in June 8-13, 2008 in Kelowna.
- In March, 2008 the paper on "Modeling of trends in time series based on maximum autocorrelation factors" focusing on application of the maximum autocorrelation factors analysis in modeling trends of ozone data in chosen European stations was accepted for presentation at the 18th Summer School of Biometrics, June 23-27,2008, Slovakia.

Modelling of codling moths.

The second project Zuzana Hrdlickova is involved in focuses on the Sterile Insects Releases (SIR), method used in the Okanagan Valley for the reduction of population of the Codling Moth. She's working on the analysis of SIR program together with Sylvia Esterby and Paramjit Gill, UBC O. This project is conducted in cooperation with Howard Thistlewood, Istvan Losso, Grace Frank and Denise Neilsen from the Pacific Agri-Food Research Centre, Summerland.

Previous research suggested that the efficiency of the SIR program depends on the temperatures in the orchards, therefore the research aims first at the modeling of the microclimate in Summerland and later on at incorporating the temperatures in the model describing the efficiency of the SIR program.

An abstract of poster "Kriging for a thermal microclimate network in the Okanagan Valley " to be presented at the meeting of The International Environmetrics Society, June 8-13, 2008 was submitted.

Other academic activities during Zuzana's post-doctoral stay

- Presentation of a talk prepared together with Lucie Doudova, University of Defense in Brno, on "One-way ANOVA with negative binomial distribution" at The International Environmetrics Society North American Regional Meeting (University of Washington, Seattle, June 19-21, 2007)
- Attendance at the summer school International Graduate Institute on Modeling Environmental Space – Time Processes (University of Washington, July 9-13, 2007)
- Attendance at a day course on Statistical Evaluation of Medical Tests and Biomarkers for Classification given by M.S. Pepe (University of Washington) within the Joint Statistical Meeting (Salt Lake City, July 29 - August 2, 2007)
- Attendance at the statistical talks at the West Coast Optimization Meeting (Kelowna, October 27, 2007)
- Teaching of the course Elementary Statistics (STAT 121) at UBC O three hours a week in the fall semester 2007, which was attended by about 50 students.
- Submission of the paper Vesely, Tonner, Hrdlickova, Michalek, Kolar: "Analysis of PM10 Air Pollution in Brno based on Generalized Linear Model with Strongly Rank-Deficient Design Matrix" in December, 2007.
- Publishing a paper "Approximation of powers in one-way MANOVA type multivariate generalized linear model" in the Computational Statistics and Data Analysis in February, 2008. The paper is based on Zuzana's PhD thesis, but was finalized at UBC O.
- Submission of the paper Hrdlickova, Michalek, Vesely, Kolar: "Identification of Factors Affecting Air Pollution with Dust Aerosol in Brno City, Czech Republic" in February, 2008.
- Presentation of a talk on "Generalized Linear Multivariate Model and Application" at the seminar of the University of British Columbia Okanagan, February 12, 2008.
- Presentation of a talk on "Comparison of different approximations of powers of some tests in multivariate generalized linear model" at the Simon Fraser University, Vancouver, April 23, 2008, within Zuzana's one week stay at the department of Statistics and Actuarial Sciences.
- Member of the local organizing committee of The International Environmetrics Society

Assesing the Evidence and Impact of Climate Change on Area Burned by Forest Fires and Seasonality Trends (Doug Woolford, PDF SFU)

This research develops methods for studying the trends in area burned, in the seasonality of the probability of a fire event and in the probability of an extreme fire event and applies these methods to large forested areas in Canada. Currently the focus is on Ontario because of the availability of a database on fire events and lightning strikes over the last century; however, this work will extend to study BC in the future. Statistical techniques utilized include penalized splines with varying coefficients, mixture models, and fire ignition process models. Woolford has presented his research at the annual meeting of the Statistical Society of Canada in 2007 and at a workshop on forest disturbances in Ontario in 2007. Three manuscripts are under preparation: one on the spatio-temporal characteristics of area-burned, a second on modeling climate change effects and a third on the use of mixture models for handling the sort of extreme events seen in the distribution of area-burned.

Design of Monitoring Programs (Wendell Challenger, MSc, SFU)

To better understand the affect global warming has on the world's ecosystems, monitoring programs are needed that are relatively inexpensive and easy to employ. The rockfish occupancy model aims to provide a framework for a monitoring program that is easy implement, yet be powerful enough to detect subtle environmental changes attributable to environmental changes such as global warming. While direct measures of abundance are often sought after, in a monitoring context, they can be prohibitively costly to implement on a long-term scale. Therefore, we put forth an approach for monitoring rockfish species changes that measures relative abundance, while estimating misdetection through repeat visits to selected sites. The abundance classes are recorded as an ordinal response of $0 < 1 < 2 < 3$, based on the count per unit effort of rockfish measured on randomly selected sites. A multinomial mixture model is then used to model the ordinal response, based on the idea that each sampled site possesses a ''latent abundance class,'' defined as the maximum index value that the site's population could generate (Royle and Link 2005; A general class of multinomial mixture models for anuran calling survey data. Ecology 86 (9): 2505-2512). Derived parameters such as the average occupancy level are also estimated, so that long-term changes in relative abundance can be monitored. Finally, we will be conducting an in-depth power and sample size analysis to determine the optimal design for detecting relevant biologically changes over time. Two different design approaches will be investigated, the first, which puts an emphasis on obtaining new sampling sites versus, a second, which puts the focus on the replication of previously sampled sites. Each design approach is then considered within the context of differing detection probability schemes of the underlying latent abundance classes. The results from the power and sample investigation will assist in the design of other similar monitoring programs.

Further Modelling of Coding Moths (Jason Nielsen, PHD, SFU)
Modelling of codling moths and its importance was described above in discussing the research of Zuzana Hrdlicova at UBC-O. Jason Nielsen has also been investigating the use of mixtures of nonhomogeneous spline intensity functions to model the arrival rate of moths and to determine the effect of covariates discussed above. Jason Nielsen graduated in 2007 and the methodology for the analysis of such mixtures has been accepted for publication (three papers on this topic have been accepted). Work is ongoing in refinements required for the codling moth analysis.

The Analysis of Zero-heavy Data (Laurie Ainsworth, PhD, SFU)
Many environmental applications, such as species abundance studies, rainfall monitoring or tornado count reports, yield data with a preponderance of zero counts. This leads to what is called zero-inflation. Such zeros are interesting as they provide important clues to physical characteristics associated with, for example, habitat suitability or resistance to disease or pest infestations. This research develops models for correlated zero-inflated spatial data. A specific focus is to unite the literature conceptually through a discussion of how different zero-inflation models highlight specific data features. The spatial process is modelled with normal conditional autoregressive random effects, discrete random effects or autocovariates. Models are formulated in the exponential family framework to encompass a variety of distributions for the data. The analysis of white pine weevil infestation data for spruce trees illustrates the unique features distinguished by each model. Of particular interest are the features identified by the probability of belonging to the zero component, resistance. For instance, one model focuses on individually resistant trees located among infested trees, while another focuses on clusters of resistant trees which are likely located in unsuitable habitats. We discuss such unique features identified by the zero-inflated spatial models and make recommendations regarding application. Laurie Ainsworth graduated in 2007 and two papers on this research have been accepted for publication while a third is under review.

Spatial Distribution of Asthma (Laurie Ainsworth, PhD, SFU)
This research is conducted jointly with colleagues at Vancouver General Hospital and with Paramjit Gill (UBC-O)
Asthma is a chronic inflammatory disease of the human respiratory system. It is characterized by recurrent exacerbations of symptoms, which include coughing, wheezing and shortness of breath. Though there have been advances in the understanding of asthma and the availability of improved medications, morbidity of asthma patients continues to increase and these increases are expected to be substantial under some scenarios of climate change. At present, about 2.5% of the adult Canadian population are diagnosed with asthma annually. In addition, the incidence and prevalence of asthma has been increasing steadily in Canada over a period of about 20 years although the mortality rate has been decreasing over the past decade.

Hierarchical or multilevel models allow for accommodation of multiple sources of variation using random effects models and account for spatial heterogeneity are used to develop spatio-temporal models for describing asthma outcomes. In this investigation, we study the spatial variation and identify areas of greatest risk with respect to a number

of asthma-related outcomes. The main aim of our analysis is to measure the magnitude of variation and to assess the role of contributing factors at the small-area level. Developing a better understanding of outcome trends and regional differences is important for developing targeted policies and interventions to improve patient care and reduce hospitalization costs. The BC population of about four million is scattered over a vast geographical area of 948,600 sq. km., residing in densely-populated metropolitan cities to small rural communities. These areas differ widely with respect to climate, air pollution and socio-demographics. Some of the regions have population centers around paper and pulp and other mills which may provide a higher exposure to air pollution. In addition, there exists a disparity in the accessibility to health services in various parts of the province. Some of these factors may lead to distinct differences in asthma exacerbations spatially across the province. This research is currently ongoing.

Future planning:

Certificate/diploma program

We have explored the possibility of a joint program wherein graduate students at any of the participating universities may get a certificate or diploma, signifying that, in addition to their graduate degree, they have successfully completed an approved program in the quantitative analysis of environmental problems. While the details of this program remain to be worked out, we anticipate that students will be able to take courses that count towards this program at any of the campuses. We also hope that we will be able to offer some of these courses over the web or using other remote technologies. The development of these courses will enhance the quality of the graduate education at all the campuses. In order to work out the details of these courses we will have interested faculty from all the sites meet during two half-day meetings, one each year.

Attachment

Report on the Workshop on Applications of Climate Statistics in Agriculture

Regina, Sask., June 6-7, 2007

Principal organizers:

- Aston Chipanshi, Agriculture and Agri-Food Canada (AAFC), Regina, Sask.
- Harvey Hill, AAFC, Saskatoon, Sask.
- James Ramsay, Dept. of Psychology, McGill University
- James Zidek, Dept. of Statistics, University of British Columbia

Workshop summary:

The conference brought together about three dozen participants from three communities in roughly equal numbers:

- Members of the government agencies providing climate information, risk management and other services to producers in the prairie provinces.
- Experts on prairie climate, climate modeling, climate data and communicating climate information to client communities.
- Statisticians interested in opportunities for climate modeling.

The participants and their email addresses are provided on an attached list, and further information is available on the web site for the workshop. The presence of several graduate students from each of these three areas was considered to be especially valuable.

The workshop began at 1:00 PM on July 6th, continued through that evening, and occupied the entire day of July 7th. Conference facilities, lunch, coffee break supplies and a conference dinner were provided at the hotel housing participants, so that participants were together for the entire time, and had more than ample occasion for informal communications.

The goal of the workshop was to provide an opportunity for each of these communities to inform the others about problems, needs and possibilities for future research on climate within the framework of aiding prairie agriculture. It was recognized that there had been substantial challenges in understanding each other on previous encounters, and that moving forward towards fruitful new collaborations would require an extended occasion for informing one another on many issues. It was expected that an outcome of the workshop would be a proposal to NPCDS and other agencies for seed funding for collaborative research involving substantial statistical research input.

The carefully crafted program (attached) and the happy choice of participants resulted in a level of discussion, collegiality and excitement about new collaborations that exceeded the expectations of the organizers.

It was resolved that some version of the workshop should be repeated each year, and that the development of a research proposal should begin at once. To the latter end, three break-out groups met to discuss possible projects, and outlined nine pressing projects achievable within a two-year time frame.

Data sharing:

An immediate outcome of the workshop was the sharing of several interesting datasets, papers and information about issues that arose during the meeting, among those interested in working with them:

- 800 years of climate information reflected in tree-ring measurements collected by Prof. D. Sauchyn, Dept. of Geography, University of Regina.
- Geographical information systems polygon data on boundaries of the prairie growing regions along with internal geographical features such as lakes and rivers made available by Richard Warren of Agriculture and Agri-Food \Canada (AAFC), Regina.
- Results from two attempts to grid prairie precipitation data provided by Dr. Nathaniel Newlands, AAFC, Lethbridge, Alta, along with the data used in the project.
- A list of important references from Doug Wilcox, Manager, Program Development – Insurance Research Division, Manitoba Agriculture Services Corporation, Portage La Prairie.
- Clarifications on the nature of Environment Canada climate data from William Richards, Environment Canada, Fredericton.

Some problems identified for immediate statistical input:

The Workshop was effective at focussing attention on many problems where statistical methodology was sure to contribute something of value. However, a remarkable amount of consensus during informal discussion and between the three breakout groups was concentrated on these issues:

- Better methods for estimating weather characteristics at a specified location within the prairie agricultural region, both for the present and the future, from current data and historical records at neighboring weather stations. While efforts have been made over the past year to solve this problem by estimating temperature and precipitation on a ten kilometre grid using two different interpolation methods, it was acknowledged that: (1) the accuracy of these interpolations is well below what is needed, (2) estimates of expected levels must be supplemented by credible statements of uncertainty that take into account the non-Gaussian distribution of many of these characteristics. The need for better local estimation arises especially from the fact that popular insurance schemes are based on weather data from a single pre-specified weather monitoring site that may, for various reasons, have only limited relevance to conditions at the desired location.
- Description and prediction of extreme events, especially for precipitation. Precipitation records have at least a bivariate structure in that, with a certain probability, no precipitation whatever will occur, but that given precipitation can occur, one needs to describe the entire distribution of possible levels, including some statement of the probability of an extreme event. Consequently, two types of extremes are of particular interest: (1) conditional on rain being possible, the probability of an extreme level, and (2) an extreme number of days with no rain. For example, Jim Ramsay showed by means of quantile function estimates that, for Regina, both types of extremes are much more likely in the critical month of June than in August.
- Locally specific hindcasting of historical weather characteristics based on data following the specified target date. This complement to the better-known forecasting problem is also important for crop insurance payouts as well as for reviews of crop management practices and crop choices.
- Better use of collatoral information. Each of these above objectives as well as others must make more use of existing and emergent information, including elevation, South Pacific oscillations, tree rings and other biological proxies for historical weather, and ice and seabed core samples.

Workshop support:

- National Program for Complex Data Structures: travel, accommodation , coffee breaks and dinner, and audio-visual expenses
- Agriculture and Agri-Food Canada: web site support, rental of conference room for two days, travel and accommodation expenses

Conference web site:

- http://www.agr.gc.ca/pfra/drought/Regina_workshop/climstat_index_e.html
- The web site provides access to most of the talks that were presented at the workshop.

Attendees along with email addresses:

Statistics and other academic disciplines

Qingfang Dai	qdai@math.ualberta.ca
Sylvia Esterby	sylvia.esterby@ubc.ca
Nancy Heckman	nancy@stat.ubc.ca
Reza Hosseini	m.hossei@stat.ubc.ca
Suzan Lapp	lapp200s@uregina.ca
Jason Loeppky	jason.loeppky@ubc.ca
Jim Ramsay	ramsay@psych.mcgill.ca
David Sauchyn	sauchyn@uregina.ca
Bruce Smith	bsmith@mathstat.dal.ca
Carolyn Taylor	cgtaylor@stat.ubc.ca
Hao Zhang	zhanghao@wsu.edu
Jim Zidek	jim@stat.ubc.ca

Agriculture and Agri-Food Canada

Aston Chipanshi	chipanshia@agr.gc.ca
Ryan Cossitt	rcossitt@agr.gov.sk.ca
Herb Cutforth	cutforthh@agr.gc.ca
Andrew Davidson	Davidsona@agr.gc.ca
Harvey Hill	hillh@agr.gc.ca
Allan Howard	howarda@agr.gc.ca
Nancy Lee	leen@agr.gc.ca
Nathanial Newlands	newlandsn@agr.gc.ca
Trevor Proskie	proskiet@agr.gc.ca
Budong Qian	qianb@agr.gc.ca
Lawrence Townley-Smith	townleysmithl@agr.gc.ca
Richard Warren	warrenr@agr.gc.ca
Ross Weiss	weissr@agr.gc.ca
Mei Yin	yinh@agr.gc.ca

Environment Canada and other government agencies

Richard Carr	rcarr@nrcan.gc.ca
Kai Chen	kai.chen@ec.gc.ca
Dr. Wenjie Dong	Wenjie.Dong@ec.gc.ca
Daniel Intenfisu	daniel.itenfisu@gov.ab.ca
Ken Kwok	ken.kwok@ec.gc.ca
William Richards	william.richards@ec.gc.ca
Paul Screpnek	paul.screpnek@scic.gov.sk.ca
Dale Wotherspoon	dale.wotherspoon@scic.gov.sk.ca
Doug Wilcox	dwilcox@masc.mb.ca
Ralph Wright	ralph.wright@gov.ab.ca
Xuebin, Zhang	Xuebin.Zhang@ec.gc.ca

Other participants

Holly Hartmann hollyoregon@juno.com
Kevin Hursh kevin@hursh.ca
Larry Weber larry@webercommodities.com

Program:

June 6th Afternoon	
Session 1: Progress in Statistical Analysis	
1:45-2:00	**Chair: Jim Ramsay** Welcome and Introduction to the Workshop **Stephen Locke (Director, Ag Water, PFRA, Agriculture and Agri-Food Canada)**
2:00-2:35	**Ashley Steele**, National Oceanographic and Atmospheric Agency Title: Mind the Gap: Communicating quantitative information for use in decision-making
2:35-3:10	**Hao Zhang**, Washington State University "A Public Agricultural Weather Network in Washington"
3:10-3:25	*Break / refreshments*
3:25-4:00	**Chair: Hao Zhang** **Jim Ramsay**, McGill University "Risk estimation over space and time"
4:00-4:20	**Carolyn Taylor**, University of British Columbia "SCARL: A Consultation & Collaborative Research Support Senter"
4:20-4:55	**Jim Zidek**, University of British Columbia "Modelling climate fields for agroclimate risk management"
4:55-5:15	**Discussion, Day 1 recap and close**
5:30-6:30	*Cash Bar*
6:30-8:00	***Banquet Speaker - Kevin Hursh (Broadcaster/Farmer)***

June 7th - Morning		
Session 2: Application of Statistics for Risk Abatement		
8:30-9:00	**Chair: Aston Chipanshi** **Holly Hartmann**, CLIMAS, University of Arizona The use of climate information for decision making	
9:00-9:30	**Harvey Hill**, Agriculture and Agri-Food Canada Exploring the benefits of linking statistical/biophysical tools to agricultural systems	
9:30-10:00	**Larry Weber**, Weber Commodoties Ltd, Saskatoon "Climate information needs for the agri-business	
10:00-10:30	**Dale Wotherspoon**, Saskatchewan Crop Insurance "Weather based insurance programs in Saskatchewan"	
10:30-10:45	*Break / Refreshments*	
10:45-11:15	**Chair: Andrew Davidson** **Open Microphone (a chance to let non scheduled presenters to make statements)**	
11:15-12:15	**Panel Discussion** Scientist/User Dialogue Panelists: 2 scientists and 2 users A forum for information exchange on the science and user needs	
12:15-1:30	Lunch - *Supplied on site*	

June 7th - Afternoon	
Session 3: Project(s) Definition	
1:30-3:00	**Chair: Harvey Hill** **What we heard loudest** - Breakout groups and reports Focus on urgent issues that require immediate or future action
3:00-3:15	*Break / Refreshments*
3:15-4:15	**Priority setting and the next steps** Focusing on what we do next

4:15-4:30	**Wrap up** Closing remarks by STATS/USER representatives **Allan Howard** - NAIS **Jamie Stafford** - NPCDS

Report prepared by:

Jim Ramsay, McGill University
Jim Zidek, University of British Columbia

28 June 2007