Banff International Research Station
for Mathematical Innovation and Discovery

Climate Change Impacts on Ecology and the Environment
Sunday May 4 to Friday May 9, 2008

MEALS
Breakfast (Buffet): 7:00 – 9:30 am, Sally Borden Building, Monday – Friday
Lunch (Buffet): 11:30 am – 1:30 pm, Sally Borden Building, Monday – Friday
Dinner (Buffet): 5:30 – 7:30 pm, Sally Borden Building, Sunday – Thursday
Coffee Breaks: As per daily schedule, 2nd floor lounge, Corbett Hall

Please remember to scan your meal card at the host/hostess station in the dining room for each meal.

MEETING ROOMS
All lectures will be held in Max Bell 159 (Max Bell Building accessible by walkway on 2nd floor of Corbett Hall). LCD projector, overhead projectors and blackboards are available for presentations.

Please note that the meeting space designated for BIRS is the lower level of Max Bell, Rooms 155-159. Please respect that all other space has been contracted to other Banff Centre guests, including any Food and Beverage in those areas.

SCHEDULE

Sunday 4 May 2008

16:00	Check-in begins (Front Desk – Professional Development Centre - open 24 hours)
17:30-19:30	Buffet Dinner
20:00	Informal gathering in 2nd floor lounge, Corbett Hall Beverages and small assortment of snacks are available on a cash honour-system.

Monday 5 May 2008

7:00-8:30	Breakfast
8:30-8:45	Introduction and Welcome to BIRS by BIRS Station Manager, Max Bell 159
	Charmaine Dean *An Overview of the Workshop* *Introduction to Discussion Point: Best practice approaches for characterizing, communicating, and incorporating scientific uncertainty in decision making* *http://www.climatescience.gov/Library/sap/sap5-2/public-review-draft/default.htm*
8:45-9:45	**Francis Zwiers**, Director, Climate Research Division, Environment Canada *Climate change in the 20th and 21st centuries, and beyond*
9:45-10:15	**Loveday Conquest**, Nian She and Danial Basketfield *Snowpack variability in Washington State*
10:15-10:45	Morning Tea and Informal Discussions, 2nd floor lounge, Corbett Hall
10:45 – 11:15	**Alex Cannon** *Statistical climate models for downscaling and simulation:* *Application in the Pacific & Yukon Region*
11:15-12:00	**Francis Zwiers** *An Introduction to Climate Models*
12:00-13:30	Lunch

Climate Impacts on Forestry

13:30-15:00	**Mike Wotton and Rob McAlpine** *Predicting the potential impact of climate change on fire occurrence and the number of fires that escape initial attack in Ontario*
	Justin Podur and Mike Wotton *Predicting area burned under climate change scenarios*
	Dave Martell, Mike Wotton, Justin Podur and Brian Stocks *Looking for signs of climate change in the historical forest fire record*
15:00-15:30	Afternoon Tea and Informal Discussions, 2nd floor lounge, Corbett Hall
15:30-16:30	**Brian J. Stocks** *General overview of forest fires and climate change - global perspective with emphasis on Canada's forests*
16:30 – 17:00	Guided Tour of The Banff Centre; meet in the 2nd floor lounge, Corbett Hall
17:30-19:30	Dinner

Tuesday 6 May 2008

7:00-9:00	Breakfast
9:00-10:00	Roundtable Discussion: ***Climate Change and Impacts on Forest Disturbances*** Chair: **Dave Martell** Recorder: **Douglas Woolford**

Climate and Climate Models

10:00-10:30	Morning Tea and Informal Discussions, 2nd floor lounge, Corbett Hall
10:30 – 12:00	Tutorial and Discussion: **Myles Allen** ***Tutorial on Climate Models***
12:00-13:30	Lunch
13:30-14:30	**David Higdon** *Simulation-aided inference for physical systems - a perspective from 7 years at Los Alamos*
14:30-15:00	**Zhong Liu, Nhu Le and Jim Zidek** *Calibrating mesoscale models for microscale assessments*
15:00-15:30	**Will Welch and Jason Loeppky** *Quantifying prediction uncertainty in computer experiments with fast Bayesian inference*
15:30-16:00	Afternoon Tea and Informal Discussions, 2nd floor lounge, Corbett Hall
16:00-17:00	**Tilman Gneiting** *Probabilistic weather forecasting*
17:30-19:30	Dinner

Wednesday 7 May 2008*:* Ecology

7:00-9:00	Breakfast
9:00-10:00	**Marian Scott** *Statistical challenges in answering questions about climate change impacts on the environment*
10:00-10:30	**Rick Routledge** *Why are many coastal sockeye salmon populations declining?*
10:30-11:00	Morning Tea and Informal Discussions, 2nd floor lounge, Corbett Hall
11:00-12:00	**Ron Smith** *Environmental Monitoring to Detect Change*
12:00-12:30	**Richard A. Fleming and Jean-Noël Candau** *Climate change impacts on the outbreak dynamics of insect populations: the spruce budworm as an important case study*
12:30-13:30	Lunch
13:30-17:00	Participants are encouraged to engage in walking or other tours of the region.
17:30-19:30	Dinner

Thursday 8 May 2008

7:00-9:00	Breakfast
9:00-9:30	**Zuzana Hrdlickova, Sylvia Esterby and Steve Taylor:** *Changes in patterns of the historical fire weather index data*
9:30 – 10:30	**Jim Ramsay** *Quantile function estimation*
10:30-11:00	Morning Tea and Informal Discussions, 2nd floor lounge, Corbett Hall
11:00-12:00	Roundtable Discussion: ***Climate Change Impacts in Ecology: Science and Government Policy*** Chair: **Rick Routledge** Recorder: **Sylvia Esterby**
12:00-13:30	Lunch

Thursday 8 May 2008 (continued)

13:00-13:30 Group Photo; meet on the front steps of Corbett Hall

13:30-14:30 **Ulrich Horst**
Risk minimization and optimal derivative design in a principal agent game

14:30-15:30 **Lianne Sheppard, Adam A. Szpiro, Sun-Young Kim, Paul D. Sampson, Joel Kaufman**
Spatio-Temporal Modeling to Predict Intra-urban Variation in Air Pollution Levels and Implications for Health Effect Estimation

15:30-16:00 Afternoon Tea and Informal Discussions, 2nd floor lounge, Corbett Hall

16:00-17:00 Roundtable Discussion:
Best practice approaches for characterizing, communicating, and incorporating scientific uncertainty in decision making
Chair: **Tilman Gneiting**
Recorder: **Jim Zidek**

17:30-19:30 Dinner

Friday 9 May 2008

7:00-9:00 Breakfast

9:00-10:00 **Richard Smith**
Trends in extreme precipitation: are they due to global warming?

10:00-10:30 **Aquila Flower**
On the Pacific Climate Impacts Consortium

10:30-11:00 Morning Tea and Informal Discussions, 2nd floor lounge, Corbett Hall

11:00-12:00 Summaries of Roundtable Discussions:
Issues and Current Directions – Open Discussion of Research Problems

12:00-13:30 Lunch

Checkout by 12 noon.

** 5-day workshops are welcome to use the BIRS facilities (2nd Floor Lounge, Max Bell Meeting Rooms, Reading Room) until 3 pm on Friday, although participants are still required to checkout of the guest rooms by 12 noon. **

ABSTRACTS (in alphabetic order by speaker surname)

Speaker: Cannon, Alex (Meteorological Service of Canada)

Title: Statistical climate models for downscaling and simulation: Application in the Pacific & Yukon Region

Abstract: British Columbia and the Yukon are served by the offices of Environment Canada's Pacific & Yukon Region. In the context of climate change, practitioners in the region look to Environment Canada for guidance on future climate scenarios, whether for determining agricultural suitability of fruit crops in the interior, identifying changes in glacier mass balance in a watershed with a hydro-electric reservoir, developing a plan for managing a sensitive park ecosystem, or some other purpose.

Nationally, Environment Canada is responsible for the development and operation of Regional Climate Models (RCMs) and Global Climate Models (GCMs), which are physically-based numerical models that operate with grid-spacings on the order of tens to hundreds of kilometers. Regionally, due in large part to the complex terrain of B.C. and the Yukon, climate scenarios are needed on much finer spatial scales, either at specific observation sites or on grids with a spatial scale of kilometers or less. This need has led to the development of specialized statistical models for "downscaling" from GCM or RCM outputs, along with methods for stochastic simulation of weather data at observation sites.

Statistical climate models should not only respond in a realistic manner to changes in the large-scale climate forcing, but they must also generate series with realistic spatial and temporal dependence structure. The goal is therefore one of passing a "climatological Turing test". This talk outlines recent research to address this goal, touching briefly on the development of (i) a coupled neural network/k-nearest neighbour model for multivariate climate downscaling; (ii) a Bernoulli-gamma density neural network model for multi-site precipitation downscaling; (iii) a censored quantile regression neural network for precipitation downscaling; (iv) a multivariate ridge regression model for specifying the covariance structure of multivariate linear downscaling models; and (v) an iterative nonlinear Gaussianization technique for stochastic climate simulation.

Speaker: Conquest, Loveday (University of Washington)

Shen, Nian (Seattle Public Utilities)

Basketfield, Danial (Silverado, Inc.)

Title: Snowpack variability in Washington State

Abstract: Snow water equivalent (SWE) is used to measure seasonal snowpack accumulations. The annual maximum SWE and the rate of snowpack accumulation and melt-off determine the volume of spring runoff. We conducted some exploratory analyses to investigate the effect of variation in the El Nino-Southern Oscillation (ENSO) and the Pacific Decadal

Oscillation (PDO) on annual maximum SWE and its associated timing. Snowpack has traditionally been thought to peak around April 1 in the Pacific Northwest. Twenty-five snowpack telemetry (SNOTEL) sites with more than 20 years of daily records in Washington State were examined for timing of the peak. In most SNOTEL sites, peaks did not occur within 10 days before or after April 1, the traditionally accepted peak period in the Pacific Northwest. Analysis using Pearson's correlation revealed moderate correlation between current year SWE and the previous year's ENSO indices for certain months. Finally, a linear regression model was used to analyze the combined effects of ENSO and PDO on the annual maximum SWE.

Speaker: Fleming, Richard A. (Canadian Forest Service) and Jean-Noël Candau

Title: Climate Change impacts on the outbreak dynamics of insect populations: the spruce budworm as an important case study

Abstract: Tree ring studies show that the spruce budworm (*Choristoneura fumiferana*) has been outbreaking on a fairly regular 30-35 year cycle since the mid-1600s in Eastern Canada. This is long before humans had any substantial impacts on these forests. This defoliating insect is embedded deep in a complex ecosystem with well over 30 natural enemies, and it is fluctuations in the effects of these natural enemies which are widely considered as the driving force behind the insect's population cycles. During outbreaks, balsam fir and white (and sometimes black) spruce can be killed over vast areas and growth loss is even more extensive. This extensive disturbance constitutes an important fire hazard and shifts the forest toward younger age-classes which contain less biomass (and store less carbon). Over the long term, the spruce budworm (SBW) has caused more depletions to Canada's forests than any other forest insect.

Geo-referenced defoliation, vegetation, and climate data were used to develop spatially explicit regression tree models describing how climate and forest structure have influenced the patterns of moderate-severe defoliation caused by the SBW. Climatic predictions were then input into these models. The results suggest a northward extension of defoliation either to the limit of balsam fir and white spruce distributions or, especially in the northwest, beyond the limit of available vegetation data. Overall, the total area defoliated increases. These results also predict a latitudinal gradient in defoliation frequency: areas of medium-to-high frequencies are limited to the north, areas of medium frequencies are in the centre, and low-to-medium frequencies are located in the south. However, in the north, the artificial limitation of the defoliation due to the absence of vegetation data doesn't allow us to present a complete picture of the predicted distribution of defoliation. In particular, we are not able to assess if the predicted distribution corresponds to a simple northward shift of the historical distribution, or if climate change will induce a complete change of defoliation patterns.

We also examined the relationship between fire occurrence and SBW defoliation by including geo-referenced historical fire records in our data set. Statistical randomization procedures indicated that there is an increased probability of fire occurring 3-9 years after a SBW outbreak. The way that this time window varies geographically across Ontario has climate change implications. We are only starting to put all of this together.

Speaker: Flower, Aquila (Pacific Climate Impacts Consortium)

Title: On the Pacific Climate Impacts Consortium

Abstract: The Pacific Climate Impacts Consortium (PCIC) was formed to identify climate change impacts that are relevant to planning and decision-making in British Columbia and Pacific North America. Recent results from a climate overview of BC are the foundation for future work, with a focus on hydrologic impacts. For example, increases of up to 3.5oC in minimum daily temperature over the past century have been observed. In a complex environment containing several hydro-climatic zones, estimates of current trends and future projections of accumulated snowpack, glacier area, and streamflow are included. Results are neither certain nor homogeneous within BC, and they present a challenge to resource managers. In particular, PCIC has been investigating the potential effect of climate change on tree species suitability, pest outbreaks, and the combined economic impacts of these changes. Preliminary results from this ongoing project will be presented.

Speaker: Gneiting, Tilmann (University of Washington)

Title: Probabilistic weather forecasting

Abstract: Probabilistic weather forecasting consists of finding joint predictive probability distributions of future weather quantities or events, which is critical for weather-related decision-making. It is typically done by using a numerical weather prediction model, perturbing the inputs to the model (initial conditions and physics parameters), and running the model forward for each perturbed set of inputs. The result is then viewed as an ensemble of forecasts and often interpreted as a sample from the joint predictive probability distribution. However, forecast ensembles typically are underdispersed and subject to biases, so statistical postprocessing is required to obtain calibrated probabilistic forecasts. I will review recent joint work in this area, focusing on the Bayesian model averaging (BMA) approach to temperature and precipitation forecasting. These methods have been applied to the University of Washington mesoscale ensemble over the Pacific Northwest, and postprocessed probabilistic BMA forecasts are available in real time at http://probcast.washington.edu.

Speaker: Higdon, David (Los Alamos National Laboratory)

Title: Simulation-aided inference for physical systems - a perspective from 7 years at Los Alamos

Abstract: Inference regarding complex physical systems (e.g. subsurface aquifers, charged particle accelerators, physics experiments) is typically plagued by a lack of information available from relevant, experimental data. What data is available is usually limited and informs indirectly about the phenomena of interest. However, when the physical system is amenable to computer simulation, these simulations can be combined with experimental observations to give useful information regarding calibration parameters, prediction uncertainty, and model inadequacy. This talk will discuss useful approaches for such problems and comment on their applicability for climate applications.

Speaker: Horst, Ulrich (University of British Columbia)

Title: Risk Minimization and Optimal Derivative Design in a Principal Agent Game

Abstract: We consider the problem of Adverse Selection and optimal derivative design within a Principal-Agent framework. The principal's income is exposed to non-hedgeable risk factors arising, for instance, from weather or climate phenomena. She evaluates her risk using a coherent and law invariant risk measure and tries minimize her exposure by selling derivative securities on her income to individual agents. The agents have mean-variance preferences with heterogeneous risk aversion coefficients. An agent's degree of risk aversion is private information and hidden from the principal who only knows the overall distribution. We show that the principal's risk minimization problem has a solution and illustrate the effects of risk transfer on her income by means of two specific examples. This talk is based on joint work with Santiago Moreno.

Speaker: Hrdlickova, Zuzana and Sylvia Esterby (University of British Columbia – Okanagan) and Steve Taylor (Canadian Forest Service, Pacific Forestry Centre)

Title: Changes in patterns of the historical fire weather index data

Abstract: The Fire weather index (FWI) system is used across Canada to evaluate ignition potential and probable fire behavior and guides both temporal and spatial allocation of fire management resources. Calculations in the FWI system are based on the consecutive daily weather measurements accumulated into fuel moisture codes and fire behavior indices. Since the 1970s a network of automated electronic fire weather stations has been operating in British Columbia. There are now about 200 stations with records of daily fire weather where some of the stations have records as long as 25 years. The study of the changes in patterns of these historical FWI data provides further understanding of spatial and temporal variation in fire danger which may inform longer term strategic fire management planning. The paper compares different characteristics of the FWI time series across years. The possibility of detecting changes in clusters of the stations, based on trends in the fire weather index, is also discussed.

Speaker: Liu, Zhong, Nhu Le & Jim Zidek (University of British Columbia)

Title: Calibrating mesoscale models for microscale assessments.

Abstract: Deterministic models such as chemical transport models (CTMs) and climate models (GCMs) produce so-called "simulated data" at the mesocale level of resolution. Although the methods presented in this talk have general application, we will focus on ozone, an air pollutant thought to be harmful to human health that is regulated in many countries. Those regulations, that attempt to control ozone levels from anthropogenic sources, need to set above the "policy related background (PRB)" level, i.e., the level produced by non-anthropogenic sources. However, the pervasiveness of ozone means no area in many developed countries is pristine, making the PRB a non-measured quantity. Hence it is some times inferred from CTM output with anthropogenic sources "turned off".

But are these outputs meaningful? To decide, the output of such a model with the sources "turned on" is compared with microscale (measured) values to recalibrate them. This talk will explore three approaches for doing so and demonstrate the results using the CTM for inferring ozone's PRB level. The first, "Bayesian melding" is a spatial model while the latter two are regression approaches with bias parameters that calibrate the CTM outputs to

the measured ozone levels.

Finally the results are compared in a case study involving an ozone field over the central and eastern US. Conclusions of the comparison are also given.

Speaker: Ramsay, Jim (McGill University) and Giles Hooker (Cornell University)

Title: Estimating the Quantile Function

Abstract: The quantile function Q(u) is the inverse of the probability density function F(x); that is, Q[F(x)] = x and F[Q(u)] = u. John Tukey championed its use, point out that ordinary folks often present us with a probability u and want to know the event x that is associated with it, rather than with an event whose probability they don't know. Our particular interest is providing helpful information about rainfall on the Canadian prairies, and we want to be able to tell a producer about extremes of precipitation that they will only see, for example, once in a century. We will review the quantile function and its many interesting properties.

Emanuel Parzen and many others have discussed the problem of estimating Q from a sample of data. The definition of a strictly monotone function developed by Ramsay (JRSS-B, 1996) leads to an especially neat formulation of this estimation problem, and to some new approaches. In particular, we are working on the problem of estimating a distributed quantile function Q(u,t,r) where t indexes time and r indexes space. This generalizes the usual data smoothing problem, which only attempts to estimate the expectation of x, and quantile regression, which estimates a single quantile value.

Speaker: Routledge, Rick (Simon Fraser University)

Title: Why are many coastal sockeye salmon populations declining?

Abstract: Many coastal sockeye salmon populations have declined in recent years. Most notable, was the demise of both Oweekeno and Long Lake sockeye salmon on the BC Central Coast. The presentation will highlight ongoing analyses of (i) 50 years of direct observations on salmon abundance, lake levels, and other climate-related factors for Oweekeno Lake, and (ii) approximately two centuries of natural records laid down in the sediments of Long Lake. Functional data analysis of the historic records shows evidence of strong climate influence on Oweekeno Lake sockeye salmon; locally weighted regression analyses of the sediments from Long Lake are highlighting evidence of accelerating changes to the lake ecology - changes which are possibly linked to a century of intense commercial fishing and the retreat of a headwater glacier.

Speaker: Scott, Marian (University of Glasgow)

Title: Statistical challenges in answering questions about climate change impacts on the environment

Abstract: Many of the environmental challenges confronting society today are posed as questions about change – how fast is global temperature rising, what is the rate of biodiversity loss, are floods becoming more frequent and what is driving these changes? Monitoring programmes and observational studies are often at the cornerstone of much of the quantitative information about environmental change, but the data series may be incomplete, short, and subject to changes in measurement methods and in limits of

detection. Often the sampling frame for the monitored data on which any effects are evaluated is mis-matched to the spatial and temporal scale at which the changes may operate. Confounding elements may also make the attribution of observed effects to any single factor difficult.

The evidence base for environmental change includes results from observational and experimental studies, process-based models and expert knowledge. The evaluation of the evidence in a statistical framework remains challenging. Statistical challenges includes design and evaluation of monitoring and sampling networks and appropriate sampling strategies, the analysis of observational records and evaluation of trends, in both space and time, modelling of extreme events, and assessment of uncertainty.

Statistics provides a rigorous framework to make inference on the evidence of environmental change, yet still statements such as '"How much or how little we know about the links between environmental policy measures and their actual impact in the environment" (Nigel Haigh, foreword of Environmental Issues, Report 25/EC) or "there is a prevailing lack of reliable, accessible and comparable environmental information across the pan-European region", (Professor J McGlade of the EEA, Oct 2007) are being made. Good statistical science to counter these statements and engagement by the statistical community in environmental policy debates are essential.

This presentation will highlight a number of case studies where statistical science, environmental science and policy intersect.

Speaker: Sheppard, Lianne, Adam A. Szpiro, Sun-Young Kim, Paul D. Sampson, Joel Kaufman (University of Washington)

Title: Spatio-Temporal Modeling to Predict Intra-urban Variation in Air Pollution Levels and Implications for Health Effect Estimation

Abstract: Background: We believe health effect estimates from cohort studies of long-term exposure to air pollution will be improved by accurate prediction of intra-urban variation of individual average pollutant concentration levels. Air pollution data are typically limited by sparse measurements. This talk describes two components of our research for the MESA Air study – development of a spatio-temporal air pollution prediction model and assessment of health effect estimate properties with predicted concentration.

Spatio-temporal pollutant prediction of NOx concentration: In measured data we modeled estimated NOx concentrations using a spatio-temporal ("land use") regression model that includes covariates derived from physics-based plume modeling to account for meteorology in the mean model structure. Data consisted of routine AQS network monitoring measurements supplemented with two-week averaged NOx concentration "snapshots" clustered near major roadways, roving sets of 4 two-week average concentrations at about 100 subject homes, and a small number of fixed sites in each of six cities. In simulated data we employed a Bayesian hierarchical model implemented using an optimized Markov Chain Monte Carlo (MCMC) sampling algorithm.

Analyses of real and simulated data validate the appropriateness and predictive power of our modeling approach. On a spatial subset of measured data, we find that including physics-based plume modeling for traffic in the "land use" regression results in improved cross-validated predictions (R2=0.60), compared to using simpler traffic-related covariates (R2=0.51). This regression model also results in an interpretable spatial correlation pattern that can be exploited by universal kriging to further improve the prediction accuracy

(R2=0.71). In a simulation study with representative spatio-temporal data, we find that our MCMC estimation procedure for the Bayesian hierarchical model is successful and can be used to obtain accurate predictions of long-term average exposures (R2=0.91) along with appropriate uncertainty estimates for each simulated subject.

Health effect estimation: In separate simulation studies we assessed the properties of health effect estimates given universal kriging predictions of PM2.5. We simulated individual PM2.5 exposure and associated time to cardiovascular event for hypothetically-sampled subjects at 2,000 locations the Los Angeles area. Exposure was described by a mean model (constant or second order function of location) and a spherical covariance model with varying range and partial sill parameters, and no nugget. We kriged simulated realizations of PM2.5 at 22 monitoring sites to predict individual PM2.5 exposure and then compared health effect estimates (relative risk of cardiovascular effect) conditional on true vs. kriged individual PM2.5. We found the smooth universal kriging predictions resulted in increased variability of the health effect estimates. There was some attenuation bias, particularly for fields with short range. This behavior was less pronounced for exposure fields with more spatial structure. Coverage of the health effect estimates was highest for fields with large range, but coverage was always less than the nominal 95% because estimation did not incorporate the uncertainty of the prediction.

Speaker: Smith, Richard (University of North Carolina, Chapel Hill rls@email.unc.edu)

Title: Trends in extreme precipitation: are they due to global warming?

Abstract: Numerous papers in the climatology literature have claimed that extreme precipitation events are becoming more frequent, and that this is directly related to increases in greenhouse gases and of temperatures. In this talk, I propose a method combining spatial statistics and extreme value theory to examine such theories more closely. In particular, I use seasonal covariates to allow for variations in the extreme value distributions over the year, and geostatistical methods to obtain a finer spatial resolution than most of the papers in the climatology literature. The results confirm an overall increase in US extreme precipitations over 1970-1999, but also highlight differences between the observational record and the corresponding results obtained from climate models.

Speaker: Smith, Ron (Centre for Ecology and Hydrology)

Title: Environmental Monitoring to Detect Change

Abstract: The Centre for Ecology and Hydrology has two initiatives to assess change in the UK landscape. The Countryside Survey undertakes a field survey involving an in-depth study of a sample of now over 600 1km squares across Great Britain with data collected in 2007, 1998, 1990, 1984 and 1978. The individual squares are chosen so that they represent all major habitat types in the UK and enough squares are selected for each type to make sure that the statistical analysis for that habitat is robust and reliable. A range of information is recorded in a single visit including mapping Broad and Priority habitats as well as linear and point features, recording vegetation plots of different types (29 per square on average), collecting measurements and samples from streams and ponds and collecting soil samples. This provides a snapshot with significant detail and spatial coverage and allows a statistically robust assessment of change in the environment. A linked product combines satellite images with various other data sources to provide a spatial database of land cover

and broad habitats at a 'field-by-field' scale, but this does not provide backward compatibilty to estimate change at present.

To provide better temporal detail, CEH coordinates the Environmental Change Network, a series of 12 terrestrial and 45 freshwater Long Term Ecological Research sites across the UK. At the terrestrial sites, for example, a number of potential drivers of change (meteorology, precipitation chemistry, soil solution chemistry, etc.) are measured frequently throughout the year while responses to change (surveys of vegetation, birds, bats, vertebrates and invertebrates, etc.) are done less frequently or as appropriate. This network has been running for 12 years and we are currently looking at trends over the period. There have been changes in environmental drivers but a confounding effect can be changes in land management, either on the site or within the surrounding area.

Air pollution monitoring in Europe has covered a period of changing emissions over the period since 1970, but good quality data on a reasonable spatial coverage are available from 1987 onwards in the UK. Detection of change in the pollution monitoring and relating it to change in emissions has prompted considerable debate in Europe focussing on an improved understanding of atmospheric processes, but fairly simple statistical methods have underpinned the interpretation of the data. These data do illustrate some of the issues in monitoring for detection of change, and we have recently drawn on some of this experience to collaborate with the modification of an air quality network for Alberta.

Speaker: Welch, William (University of British Columbia) and Jason Loeppky (University of British Columbia - Okanagan)

Title: Quantifying Prediction Uncertainty in Computer Experiments with Fast Bayesian Inference

Abstract: Complex computer codes often require a computationally less expensive surrogate to predict the response at new, untried inputs. Treating the computer-code function as a realization of a random function or Gaussian process is now a standard approach for building such a surrogate from limited code runs. Scientific objectives such as visualization of an input-output relationship and sensitivity analysis can be conducted relatively quickly via the surrogate. The random function approach respects the deterministic nature of many computer codes, yet it also provides statistical confidence or credibility intervals around the predictions to quantify the prediction error. Whether these
intervals have the right coverage is a long-standing problem, however. In this talk we introduce a new, simple, and computationally efficient Bayesian method for constructing prediction intervals that have good frequentist properties in terms of matching nominal coverage probabilities. This is demonstrated by simulation and illustrated with climate-model codes.

Speaker: Zwiers, Francis (Director, Climate Research Division, Environment Canada)

Title: Climate change in the 20th and 21st centuries, and beyond.

Abstract: I will summarize the findings of the IPCC Working Group 1 contribution to 4th Assessment Report from the perspective of one of the convening lead authors of the chapter entitled

"Understanding and Attributing Climate Change". I will also describe some the statistical issues that emerge from the IPCC report. The body of observational and modelling evidence now available leads to the inescapable conclusion that human influence was the dominant cause of climate change on global and continental scales during the 20th century, and that it will continue to be the dominant cause of change during the 21st century barring large, unforeseen natural external forcing on the climate system. Emissions reductions made over the next few decades will not substantially affect the rate of warming of the planet over the short to medium term, but our collective choices in making reductions during this period will have a profound effect on the climate of the late 21st century.