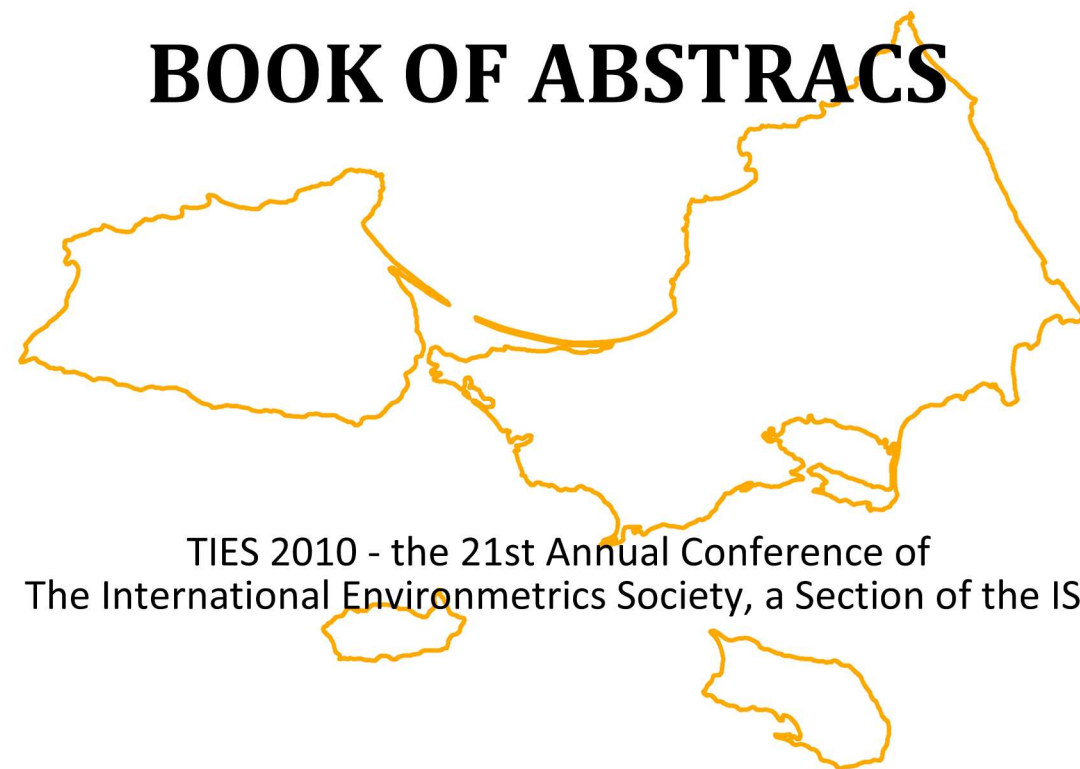


BOOK OF ABSTRACTS



TIES 2010 - the 21st Annual Conference of
The International Environmetrics Society, a Section of the ISI

**SUSTAINING OUR ENVIRONMENT UNDER CHANGING CONDITIONS:
QUANTITATIVE METHODOLOGICAL CHALLENGES**

June 20 - 25, 2010
Hesperia Isla Margarita
Margarita Island, Venezuela

The International **ENVIRONMETRICS** Society - TIES **METRICS**

Book of Abstracts
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XXI TIES
THE INTERNATIONAL ENVIRONMETRICS SOCIETY MEETING
MARGARITA ISLAND, VENEZUELA 2010

The International Environmetrics Society is a nonprofit corporation founded in 1990, and is devoted to the advance and dissemination of quantitative research in the environmental science. The Environmetrics conferences have been attended by individuals from many countries and many disciplines. They have been highly successful in providing a formal means of exchanging ideas and, perhaps more importantly, in providing an atmosphere conducive to informal discussion. In 2008, TIES officially became a section of the International Statistical Institute, (ISI).

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Environmetrics Society, a Section of ISI

June 20-25, 2010
Margarita Island, Venezuela

Editors:
Lelys Guenni and **Isabel Llatas**
CESMa, Universidad Simón Bolívar, Venezuela

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All events otherwise noted are at the Conference Venue (Hesperia Isla Margarita)

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SUNDAY 20th JUNE 2010		
9:30 am	5:30 pm	Workshop in Modeling Spatial and Space-Time Data. Instructors: Johan Lindström, Paul D. Sampson and Peter Guttorp
4:00 pm	9:00 pm	Registration
6:30 pm	9:00 pm	Welcome Reception
MONDAY 21st JUNE 2010		
8:30 am	9:00 am	Registration
9:00 am	9:30 am	Welcome Ceremony
9:30 am	10:30 am	J. Stuart Hunter Lecture: Anders Grimvall. Chair: Daniela Cocchi
10:30 am	11:00 am	Coffee Break
11:00 am	12:15 am	Parallel Sessions T1 and T2
12:15 am	1:30 pm	Parallel Sessions C1 and C4
1:30 pm	2:30 pm	Lunch
2:30 pm	4:10 pm	Parallel Sessions T3 and C3
4:10 pm	5:00 pm	Coffee Break and Poster Session
5:00 pm	6:15 pm	Session C7
6:30 pm		TIES Board of Directors Meeting (by invitation only)
TUESDAY 22nd JUNE 2010		
8:30 am	9:45 am	Parallel Sessions T5 and T14
9:45 am	10:45 am	President's Invited Lecture: Bruno Sansó. Chair: Daniela Cocchi
10:45 am	11:15 am	Coffee Break
11:15 am	12:30 pm	Session T13
12:30 pm	2:00 pm	Lunch
2:00 pm		Tours
WEDNESDAY 23rd JUNE 2010		
8:15 am	9:30 am	Parallel Sessions T6 and T9
9:30 am	10:45 am	Parallel Sessions C2 and C5
10:45 am	11:15 am	Coffee Break
11:15 am	1:00 pm	Parallel Sessions T12 and C6
1:00 pm	2:00 pm	Lunch
2:00 pm	3:15 pm	Parallel Sessions T15 and T16
3:15 pm	4:15 pm	Coffee Break and Poster Session
4:15 pm	5:30 pm	Parallel Sessions T4 and C8
5:30 pm	7:30 pm	TIES ANNUAL GENERAL MEETING
8:00 pm		CONFERENCE DINNER
THURSDAY 24th JUNE 2010		
8:00 am	9:30 am	ENVIRONMENTRICS MEETING (by invitation only)
9:30 am	10:30 am	TIES 2010 Invited Lecture. Speaker: José Rafael León. Chair: Lelys Guenni
10:30 am	11:00 am	Coffee Break
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1:30 pm	2:30 pm	Lunch
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Start time	End time	Event
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FRIDAY 25th JUNE 2010		
9:30 am	5:30 pm	Sampling for Decision Making. Instructors: Ray Correll, Anders Nordgaard and Britt Maestroni (Venue: Universidad de Margarita, Sala de Conferencias 1)
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President's Invited Lecture Bruno Sansó. University of California in Santa Cruz, USA: **Hierarchical Bayesian Ocean Models** Chair: Daniela Cocchi (p49)

TIES 2010 Invited Lecture José Rafael León. Universidad Central de Venezuela: **Transport of pollutants in Lake of Valencia, Venezuela** Chair: Lelys Guenni (p35)

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Affiliation refers to the speaker* author when there is more than one author.

T1 Monitoring of large-scale natural resources. Organizer: Melissa Dobbie. CSIRO, Australia

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- H. Temesgen*, J. Strunk, H-E. Andersen, Oregon State University, USA: **Estimating Biomass Change in Coastal Alaska Forests: Statistical Issues** (p53)
- Melissa Dobbie*, Don Stevens, Charis Burrige, CSIRO, Australia: **Where to put the dots on the map?: Considerations for choosing between different spatial designs for assessing large-scale river networks** (p18)

T2 Change Point Detection Methods. Organizer: Anders Grimvall. Linköpings Universitet, Sweden

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- Du Yang, Anders Nordgaard*, Department of Computer and Information Science, Linköping University, Sweden: **Change-point detection in environmental time series – A Bayesian approach** (p43)
- Anders Grimvall, Linköping University, Sweden: **Bias in the correction for artificial change-points** (p24)

T3 Model based geostatistics. Organizer: Veronica Berrocal. Statistical and Applied Mathematical Sciences Institute, USA

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- Brian Reich, North Carolina State University, USA: **A class of covariate-dependent covariance functions for the analysis of spatio-temporal data** (p46)
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- Enrico Fabrizi, Fedele Greco*, Carlo Trivisano, University of Bologna, Italy: **A sensitivity analysis of prior specification in disease mapping** (p22)

T5 Functional data analysis in environmental problems. Organizer: Daniela Cocchi. University of Bologna, Italy

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- Stefania Ghigo*, Ignacolo Bande, Università degli Studi di Torino, Torino, Italy: **Functional approach to cluster municipalities with respect to air quality assessment** (p22)
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Affiliation refers to the speaker* author when there is more than one author.

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 ORAL PRESENTATION
Modeling of temporal trends and variability in water quality*Bovas Abraham*

T15

University of Waterloo, Canada

Conventional parametric and non parametric statistics such as t-statistics and Kendalls Tau are routinely calculated and tests based on them are employed for change detection and trend assessments of water contaminants. Most of the data collected in these contexts are available in the form of time series, are serially correlated and often non-stationary. In addition, these time series exhibit time-dependent variance. We study the performance of these tests when the data are serially dependent, non-stationary and have variance changing with time. In particular, we consider some 'volatility models such as ARCH and GARCH models to capture the dynamic nature of the variation.

Keywords: Nonstationarity, Serial dependence, Time dependent variance, Trend assessment, Water Quality

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ORAL PRESENTATION

Zero-inflated Spatial Models for Environmental Data: Clustered Zeros versus Spatial Outliers*Laurie Ainsworth, Charmaine Dean*

T10

Simon Fraser University, Canada

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 habitat suitability or resistance to disease. We apply two zero-inflated spatial models to white pine weevil infestation data for spruce trees. The spatial process is modelled with normal conditional autoregressive random effects or discrete random effects. We use a mixture model approach and estimate the probability of belonging to the zero, resistant, component. The two models focus on specific data features: one model focuses on clusters of resistant trees which are likely located in unsuitable habitats, the other on individually resistant trees located among infested trees. Finally, recommendations are made regarding the application of zero-inflation models in general.

Keywords: Autocovariate Discrete Mixture Model, Hierarchical Bayesian Model, Mixed Binomial Model, Pseudo likelihood, Spatial Autocorrelation

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Supporting grant: BCHRF, NSERC

POSTER

Spatial-Temporal Model for Ambient Air Pollutants in the State of Kuwait*Shafiqah A. Al-Awadhi, Fahima Alawadhi*

Department of Statistics and OR, Kuwait University, Kuwait

In this research we consider dynamic Bayesian models for four different pollutants: nitric oxide (NO), carbon monoxide (CO), sulphur dioxide (SO₂) and non-methane hydrocarbon (NCH₄) recorded daily in six different stations in Kuwait from 1999 to 2002. The structure of the models depends on time, space and pollutants dependencies. The approach strives to incorporate the uncertainty of the covariance structure into simulated models and final inference, therefore hierarchical Bayesian model is applied. Association between level of pollutants and different meteorological variables such as wind speed, wind directions, temperature and humidity are considered. The models decompose into two main components: a deterministic part to represent the observed components term and a stochastic term to represent the unobservable components. Our analysis will start with basic model and gradually increase its complexity. At each stage the efficiency of the model will be measured. The resulting models subsequently are tested by comparing the output terms and by comparing and the predictions with the real observations

Keywords: temporal model, hierarchical model, Time series analysis, MCMC

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ORAL PRESENTATION

Graphical Models and Pollination*Ayesha Ali*

T9

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Pollination networks are used to identify which plants are pollinated by which animals or insects (pollinators) in a given ecosystem. Historically, these networks have been qualitative since they are simply based on observed flower visits (during which pollination may or may not take place). Further, it has been well-documented that some flowers have specific traits (e.g. long corolla tube) that require pollinators with a complementary animal trait (e.g. longer proboscis length) to pollinate them. However, these traits are typically underused in the construction of pollination webs. More recently, pollination ecologists have turned attention to quantitative pollination networks, which provide more insight into the interactions between pollinators and the plants they pollinate, but these models do not make full use of ecosystem information to quantify the web. In this talk, we will discuss how pollination webs could be viewed as bi-partite graphs in which the nodes follow some joint distribution. Although estimation of the model parameters can be challenging, we will discuss parameter estimation methods that distinguish between pollination and non-pollination visits. We will also present graphical and computational methods that make use of flower and animal traits to parameterize the graph, and draw connections to hierarchical modelling.

Keywords: pollination webs, graphical modelsPresenting Author's email address: aaali@uoguelph.ca

Supporting grant: NSERC-CANPOLIN

ORAL PRESENTATION

Adaptive Predictive Process Models for Large Spatial Datasets*Rajarshi Guhaniyogi*¹, *Andrew O. Finley*², *Sudipto Banerjee*², *Alan E. Gelfand*³

T3

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With the increasing availability of geocoded scientific data, investigators are increasingly turning to spatial process models for carrying out statistical inference on environmental processes. Over the last few decades hierarchical spatial models implemented through Markov chain Monte Carlo (MCMC) have become especially popular as they enable richer modelling that would be infeasible otherwise. However, fitting hierarchical spatial models often involves matrix decompositions whose complexity increases in cubic order with the number of spatial locations, rendering such models infeasible for large datasets. One approach derives a “predictive process model” that alleviates computational bottlenecks by optimally projecting the spatial process using a smaller set of locations (“knots”). However, selecting these knots is a challenging problem and may become problematic for nonstationary data. To address this problem we devise two different methods for knot selection. The first employs a reversible jump MCMC which allows the Markov Chain to jump between models with different number of knots. The second approach induces a prior distribution on the knots using a point process that avoids reversible jump MCMC. Both these methods allow the knots to learn from the process, thereby considerably decreasing the number of knots needed for effective implementation and eliciting further computational benefits. Some theoretical aspects of the predictive process will be discussed along with practical illustrations.

Keywords: Hierarchical spatial models, MCMC, Spatial DataPresenting Author's email address: baner009@umn.edu

Supporting grant: National Science Foundation DMS-0706870.

ORAL PRESENTATION

Hierarchical modelling - an end in itself or a means to an end*Simon Barry*

T9

Commonwealth Scientific and Industrial Research Organisation, Australia

Hierarchical models are one of the most important classes of models used in either Frequentist or Bayesian analysis. In recent years the popularity of Hierarchical Models (typically analysed in a Bayesian format) has increased across a range of disciplines. In many applications hierarchical models are the best and most natural approach. In other applications alternative approaches such as the use of population averaged estimators (ie averaged over random effects, say) could be considered. In this talk I will give my personal experiences in the use of hierarchical models, both in terms of my methodological research and in terms of practical applications in decision making. I will consider examples including truncated regression, the analysis of ring recovery data and the analysis of expert elicited data in biosecurity applications.

Keywords: hierarchical modelling, truncationPresenting Author's email address: simon.barry@csiro.au

ORAL PRESENTATION

Spatio-temporal functional regression on paleo-ecological data*Liliane Bel, Avner Bar-Hen, Rémi Petit, Rachid Cheddadi*

T5

AgroParisTech, France

The aim of this paper is to model the relationship between genetic diversity in the European beech (*Fagus sylvatica*) forests and past climate. Since Holocene, we face many climate perturbations and the geographical ranges of plant taxa have changed substantially. Actual genetic diversity of plant is a result of these processes and a first step to study the impact of future climate change is to understand the important features of reconstructed climate variables such as temperature or precipitation for the last 15000 years on actual genetic diversity of forest. Our model links the genetic measure to the climate curves of temperature and precipitation. We adapt classical functional linear model to take into account interactions between climate variables as a bilinear form. Since the data are georeferenced, our extensions also accounts for the spatial dependence among the observations. The practical issues of these methodological extensions are discussed.

Keywords: Spatial statistic, functional regression, paleoclimatPresenting Author's email address: Liliane.Bel@agroparistech.fr

ORAL PRESENTATION

Fusing space-time data under measurement error for computer model output*Veronica J. Berrocal*¹, *Alan E. Gelfand*², *David M. Holland*³

T3

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In many environmental disciplines, data often arise from two sources: computer models and monitoring networks. The first source provides predictions at the level of grid cells and is characterized by full spatial coverage of the region of interest, high temporal resolution, no missing data, but consequential calibration concerns. The second gives measurements at points, tends to be sparsely collected in space with coarse temporal resolution, often with missing data but, where recorded, provides, essentially, the true value. Combining the two sources of data and accommodating their inherent spatial misalignment is of fundamental importance for both improved predictions and for evaluation and calibration of the numerical model. In this paper, we present two approaches for fusing monitoring data and computer model output. In the first model, we explicitly account for sources of uncertainty in the numerical model output and we assume that there exists a latent Gaussian Markov Random Field driving both the computer model output and the observational data. In the second approach, we do not propose a stochastic model for the numerical model output. However, we develop a spatial linear model that regresses the observational data at each monitoring site on the numerical model output at every grid cell, by appropriately weighting each grid cell using spatially-varying weights. For both approaches, we explore possible ways to extend the modeling framework to the spatio-temporal setting. As an example, we have applied the two fusion models to observations and numerical model output of ozone concentration for the Eastern United States.

Keywords: data fusion, Gaussian Markov Random Field, spatially-varying weights, spatial linear model
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POSTER

Geospatial & temporal modelling of Dengue in Zulia state, Venezuela (2002-2008)*Maritza Cabrera, Gordon Taylor, Michelle Sims*

School for Health University of Bath, UK

Dengue fever is endemic in most tropical and subtropical countries with transmission mainly by mosquito. Of the estimated 50,000,000 world wide cases per year, 1% develops into the most serious DH requiring hospitalization and conveying in 2.5% risk of death [WHO, <http://www.who.int/mediacentre/factsheets/fs117/en/index.html>]. The main risk factors being individual and environmental [Sutherst, *Clinical Microbiology Reviews*, (2004):136-173],[Kouri et al, *WHO Bulletin OMS*, (1989): 375-380]. The first epidemic of DH in America occurred in Cuba 1981, [Kouri et al, *WHO Bulletin OMS*, (1989): 375-380] and the second in Venezuela 1989-1990 [Oletta, *Med Interna* (2006): 247-258]. This increasing incidence has been particularly noticeable in Zulia state [Oletta, *Med Interna* (2006): 247-258]. The spread of Dengue has been researched in a number of areas in Venezuela, including Maracay City [Barrera et al, *Dengue Bulletin*, (2002): 84-95], [Rodriguez et al, *Terra*, (2007): 127-159] and Capital District [Saez, *Terra*, (2006): 123-156]. However, there is a paucity of research concerning dengue fever in Zulia state. Zulia consists of 21 municipalities. It covers an area of 63,100 km², around a lake of 12,780 km², with the majority of the population concentrated in urban areas [INE, <http://www.ine.gov.ve/sintesisestadistica2007/estados/zulia/index.htm>]. Using municipality level data from 2002-2008 we have employed spatial and temporal variation techniques to identify areas of increased risk of dengue including analysis of risk factors by applying generalised linear models. Geospatial & temporal modelling is an appropriate methodology for considering factors relating to the spread of dengue fever and can provide useful data to help predict future epidemics.

Keywords: Dengue fever, Zulia state, spatial and temporal variation, risk factors, generalised linear models

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Supporting grant: Applied for Worl Bank/ISI

POSTER

Biotransformation of the organophosphate fenamiphos by green algae and cyanobacteria*Tanya Caceres¹, Megh Mallavarapu², Ravi Naidu²*

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The degradation of an organophosphorus pesticide, fenamiphos, by ten different species of green algae and cyanobacteria was studied. All the species tested were able to transform fenamiphos to its primary oxidation product fenamiphos sulfoxide (FSO) while the majority of these cultures were able to hydrolyze FSO to fenamiphos sulfoxide phenol (FSOP). Fenamiphos sulfone phenol (FSOP) and FSO were detected in the culture extracts of the algae and cyanobacteria. The ability of these species to detoxify fenamiphos could be used in bioremediation of this pesticide and its toxic metabolites.

Keywords: fenamiphos, biodegradation, algae

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ORAL PRESENTATION

Increasing the accuracy of wind speed forecasts by combining the output of process model ensembles and stochastic models*Petrutza C. Caragea*

T4

Iowa State University, USA

Wind energy has undergone rapid growth in recent years. The current goal of the Department of Energy to have 20% of the nations electrical energy from wind by 2030 will require continued rapid growth. Wind, however, unlike other sources of energy, varies greatly over space and time, such that the production rates of energy can fluctuate much more strongly than with most traditional sources of energy generation. To best take advantage of wind for power generation, accurate forecasts are needed. We present here an approach based on combining the output of process model ensembles and stochastic models at the border of the spatial and temporal resolutions at which each seems most appropriate. The fundamental idea is to adjust the forecasts of meteorological models rapidly in time (and potentially space), thus making the best use of both modeling approaches at resolutions for which each are believed to be superior. This method is tested on simulated examples and applied to data collected at a Midwestern wind farm.

Keywords: Wind forecasts, Model ensembles, ARMA models, LASSO, Hierarchical models

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POSTER

f-Diversity: Statistical tools for functional diversity analysis*Fernando Casanoves*¹, *Laura Pla*², *Julio A. Di Rienzo*³¹CATIE Costa Rica, ²UNEFM Venezuela, ³FCA-UNC Argentina

Functional diversity (FD) defined as the value, range, and abundance of functional traits in a given community or ecosystem is increasingly accepted as a synthetic ecological concept that sheds light on ecosystem functioning. Several synthetic indices have been proposed to describe the FD of a community, or some of its components. The comparative assessment of FD in different ecosystems and for different ecosystem processes would be an invaluable tool for a better and more general understanding of what are the functional roles of biodiversity in the provision of ecosystem services. We have developed a free-access software package, F-DIVERSITY, which implements a user-friendly interface to open source routines for the estimation and analysis of FD indices. The open source platform is R with an interface written in Delphi. The software is free and can be downloaded at www.fdiversity.nucleodiversus.org. The software can handle its own data sets and read files from different sources. The data handling also allows merging and concatenating different data files into synthetic matrices and tables. The software calculates all the major FD indices. It is also possible to obtain summary statistics, fit sophisticated linear models and make comparisons among communities using different a-posteriori tests. F-Diversity has therefore the potential to become a major tool assisting research on the links between biodiversity, functional traits and ecosystem processes and services. We present and illustrate its main features, as well as discuss some of the properties of common and new FD indices.

Keywords: functional diversity indices, species abundance, community weighted mean, biodiversity assessments, linear models

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ORAL PRESENTATION

Nonparametric Multivariate Methods in Studying Impact of Agricultural Pollution on Water Quality*Shojaeddin Chenouri*¹, *Abdel El-Shaarawi*²

T12

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Agricultural activities can adversely affect the quality of surface and ground water so that uses of water are not impaired. In this paper, we use nonparametric multivariate methods to study the impact of animal waste on the microbiological quality of surface water. The design consists of an upstream site (reference) not impacted by the waste and a sequence of sites that receive the waste. Our measurements consist of several microbial indicators (total coliform, e-coli, fecal coliform) as well as a number of explanatory variables. The aim is to measure how the pollutants evolve from upstream to down stream and how it is influenced by seasonality. The nonparametric multivariate techniques we apply, are mainly based on the notion of data depth. Depth-Depth plots, nonparametric multivariate tests and quality indexes are the main toolkits in this study.

Keywords: Agricultural pollution, water quality, data depth, multivariate data, nonparametric methods, Presenting Author's email address: schenouri@uwaterloo.ca

ORAL PRESENTATION

Characterizing the statistical properties and interhemispheric distribution of Dansgaard-Oeschger events*William F. Christensen*¹, *Andrea L. Thomas*¹, *Summer Rupper*²

C2

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Ice core records from Greenland show times of rapid warming, called Dansgaard-Oeschger events, during the most recent glacial period. Characterizing the nature of Dansgaard-Oeschger events is critical to our understanding of past glacial climates, as well as modern climate volatility. Here we present new methods for statistically evaluating two important characteristics of these rapid warming events have been highly debated in the scientific community—whether their occurrence is cyclical and whether they have a regional or global distribution. We find that there is not enough evidence to conclude that Dansgaard-Oeschger events are cyclical; yet, importantly, there is a statistically significant lagged correlation between the Antarctica and Greenland records. These results strongly suggest that rapid warming events in Greenland are driven by internal climate variability, and that rapid climate changes in Greenland are lead by smaller amplitude changes in Antarctica through an oceanic teleconnection.

Keywords: Cyclicity detection, paleoclimate, climate change

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Supporting grant: The work of Andrea Lundrigan was supported by the Rocky Mountain NASA Space Grant Consortium.

ORAL PRESENTATION

Finite population properties of predictors based on spatial patterns*Daniela Cocchi, Francesca Bruno, Alessandro Vaghegini*

C6

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When inference regards a finite spatial pattern, a model-based framework is commonly used, even if the problem of model misspecification may occur. In classical design-based inference, this problem is overcome; nevertheless spatial solutions in this direction are still under development. Generalized regression (GREG) estimators can be regarded as powerful tools which unify both approaches. Through an efficient use of auxiliary information an improvement to the estimates is carried out. In this work we propose a GREG estimator for spatial data, where the set of auxiliary information consists in the spatial locations where observations are taken. Our procedure does not need any model estimation of the spatial pattern since the spatial relationship is exploited exclusively on Euclidean distances between locations which are fixed and do not need any assessment after sample selection. Applications with simulated and real data are here developed.

Keywords: spatial sampling, greg estimator, design based inference, model based inference, spatial information in finite population inference

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POSTER

Detection of inhomogeneities in climatic series: case Nueva Esparta, Venezuela*E. Colloti, A. E. Blanco*

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The main problem for the homogenization of climatic series in Venezuela is the absence of metafiles; consequently, the use of statistical methods as the Alexandersson (1986) SNHT becomes complicated, adding the requirements of application fulfillment: normal distribution, homogenous and highly correlated series. In this sense, from 1972 to 2004 for 13 climatic series of annual precipitation located in the Nueva Esparta State of Venezuela, the Absolute Homogeneity of SNHT Test was applied to detect inhomogeneities, due to the nonexistence of metafiles. Later, the Relative Homogeneity of SNHT Test was applied to correct or homogenize rainfall series with inhomogeneities. Previously, all 13 series had been grouped using Principal Component Analysis (PCA) in order to guarantee series groups with high correlation. By means of absolute homogeneity Test, series 0881, 0885 and 0893 were detected with problems; nevertheless, in the Relative Homogeneity Test new series appeared with problems like 0882 and 1806, because they do not fulfill normality requirement. In the case of PCA clustering using 3 components, in none group were detected inhomogeneities; whereas using 2 components, appeared the series before mentioned. Even though it is a small area (1000 km²) to mesoscale with little physiographic diversity, in some cases was not reached the correlation level suggested by Alexandersson (0,70) condition that limits the homogenization validity. Finally, since they do not exist metafiles, it is difficult to establish if the series with problems must be corrected or if could represent zonal climatic anomalies or extreme events, in some case(s).

Keywords: errors, inhomogeneities, homogenization, Alexandersson

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POSTER

Rainfall characterization in Nueva Esparta, Venezuela from a multivariate method*E. Colloti*

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In the present work monthly rainfall in 13 stations of Nueva Esparta State of Venezuela is characterized, for period 1972-2004, by the application of Principal Component Analysis, in order to find patterns of temporal behaviour and space distribution from the identification and geographic interpretation of three components. Component 1 (single-pole) grouped all the variables towards negative half of the axis. Climatically, this indicates the predominance of general, mesoclimatic or synoptic condition, where the processes that originate rains are influenced by permanent and semi-permanent climatic factors, like the latitude and the displacement of low pressures centres, respectively. The Annual rainfall variable defines the Component 1 given its total correlation (-1.00) like Little Dry Mesoclima, where climatic types BS or BW predominate according to Keppen and whose monthly rain amounts are low, as well as the annual totals. Component 2 (bipolar) showed major discrimination when grouping the variables in both axis (+ and -), suggesting 2 seasons in Nueva Esparta State. The months correlated positively with Component 2 go from November to April and, those correlated negatively go from May to October. Spatially, from the analysis of signs combination of Component 2 was managed to differentiate 2 groups in agreement with the regime from monthly rains: Group 1: (-) 0881, 0882, 0883, 0885, 0897, 1806, 1831 and Group 2: (-+) 0791, 0795, 0893, 1720, 1721, 1740; nevertheless, Component 3 obtained major discrimination conforming 4 groups: a) GROUP 1: 0882, 1721, 1740, 1806, 1831; b) GROUP 2: 0791, 1720; c) GROUP 3: 0795, 0881, 0893; d) GROUP 4: 0883, 0885, 0897. **Keywords:** Principal Component Analysis, temporal study, space distribution, rainfall.

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POSTER

Spatial analysis of malaria outbreaks in Sucre state- Venezuela, and its relation to the surface temperature patterns, in the endemic region of Paria peninsula*Karenia Córdova¹, Laura Delgado², Santiago Ramos²*¹Instituto de Geografía y Desarrollo Regional-Área de Energía y Ambiente-FHE-UCV, Venezuela,²Instituto de Zoología Tropical-Facultad Ciencias-UCV, Venezuela

Reemergence of malaria, a tropical diseases that became endemic in the region of the Paria Peninsula, State of Sucre Venezuela, is a serious public health problem requiring a multidisciplinary study approach, to achieve a better understanding of its complex dynamics. Due to climatic changes and their impacts on regional ecology and human communities. A serious limitation to elucidate environmental variables influence these dynamics, is due to lack of climate records of temperature and other relevant variables, which may be, in part, compensated by the analysis of surface temperatures obtained by processing the thermal bands of the satellital sensor, in this case LANDSAT 7 ETM +. To achieve this purpose, an image from the USGS catalog was selected for March 2003, covering the entire study area. Once the image was restored and geometrically corrected (Lat / Long WGS84), it was proceeded by the technique of image algebra to perform the analysis obtaining surface temperatures (LST). In a GIS the thermal analysis of the peninsula was alternatively displayed with cover of malaria outbreaks incidence models, corresponding to the ENSO climate variability events, for cold, warm and neutral years. To visualize results as spatial relationships between climate variability versus occurrence of outbreaks and surface temperatures recorded. Results under this technique contributes to studies of ecological dynamics of the disease in the state and pinpoint a quantitative temperature range of predominant land surface response related to malaria outbreaks.

Keywords: Thermal analysis, Applied Geomatics, MalariaPresenting Author's email address: karenia@gmail.com

POSTER

Confidence limits with small sample sizes*Ray Correll, Milena Kovarova*

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Sampling in many environmental situations is limited to sample sizes often of ten or less. An examples might be a set of cores taken to ascertain whether dredgings are to be considered as contaminated. It is common for the distribution of such measures to be skewed and often there are outliers. This presents a challenge when estimating confidence intervals. One method of handling non-normality is to log transform the data, and calculate the confidence intervals on the log scale and then backtransform. It is well known that this gives a biased result, and in theory this can be corrected by adding $0.5\sigma^2$ before backtransforming. The result assumes σ^2 is known and that the transformed data are in fact normally distributed. When σ^2 has to be estimated from the data, there is additional uncertainty in the backtransformed data so the resultant confidence intervals are not reliable. Additional problems arise if the data contain outliers. An alternative bias correction is to multiply the backtransformed data by the ratio of the arithmetic mean to the geometric mean. Simulations indicate that this alternative bias correction provides better coverage than the traditional $0.5\sigma^2$ method. Other methods for estimating confidence intervals are also considered.

Keywords: Confidence limits, non-normality, bias correction

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ORAL PRESENTATION

Climate Change-Caused Shifts in Canadian Forest Fire Ignitions: Models, Tests, and Their Power*Charmaine Dean¹, Doug Woolford², Jiguo Cao¹, Dave Martell³*

T8

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We propose a mixture model framework to investigate climate change signals in forest fire ignitions in Ontario, Canada. A three-component mixture of logistic generalized additive models is employed, with components reflecting the zero-heavy, seasonal and extreme nature present in the data. Models with fixed and non-linear mixing weights are compared. The general modelling framework, a discussion of model selection, and a test statistic for increasing extremes in ignitions are presented. Seasonal and annual changes in ignition risk are observed and discussed, and we identify significant outstanding confounding factors that need to be addressed before one can assess the extent to which those changes can be attributed to climate change. We develop methods for assessing the length of historical data series required to detect specific effects with a specified level of precision and also discuss statistical power broadly in the context of climate change investigations.

Keywords: Climate Change, Fire Ignitions, Models, Tests, Power

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Supporting grant: GEOIDE, NSERC

ORAL PRESENTATION

Where to put the dots on the map? Considerations for choosing between different spatial designs for assessing large-scale river networks*Melissa Dobbie, Don Stevens, Charis Burridge*

T1

CSIRO Australia, Oregon State University, CSIRO Australia

River systems are complex monitoring domains, in part due to their dynamic nature and their potentially sparse coverage of the landscape. Their complexity leads to numerous challenges when it comes to designing an efficient and statistically-valid spatial monitoring program for making condition assessments. These include defining an appropriate population frame from which to sample and taking into account the various fieldwork constraints. A good spatial design tries to allocate sparse sampling resources across space to maximise information available and to ensure reliable, credible and meaningful inferences can be made about the condition of the system of interest. In this talk we discuss some of the statistical, operational and logistical challenges that arise when focussing on developing the spatial component of a large-scale stream monitoring program. We look into the appropriateness of choosing between several spatial designs from statistical and practical standpoints, but also demonstrate and discuss their application to a generic large-scale stream network.

Keywords: Generalised random-tessellation stratified (GRTS) design, probability-based sampling, spatial monitoring design, stream health status,

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ORAL PRESENTATION

How effective is water quality monitoring using microbial indicators? A Canadian case study on agricultural pollution*Abdel H. El-Shaarawi*

T15

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Traditionally, microbial indicators are monitored to control the risk of illness from waterborne diseases. Pathogens, the prime cause of illness, are difficult and more expensive to monitor because they require specialized techniques and laboratory environment. Thus, they are not appropriate for use in routine monitoring. Water and health authorities set their standards based on the level of one or more indicator organisms. A three year study was recently conducted in Canada to evaluate the relationship between three indicators (total coliform, fecal coliform and *E. coli*) and several pathogens (*Campylobacter* spp., *Salmonella* spp., *E. coli* 0157:H7, *Cryptosporidium* spp., *Giardia* spp.) with the intention of using the relationship to derive a national *E. coli* environmental benchmark for waterborne pathogen contamination in agricultural watersheds. Water samples were collected on 902 occasions from 27 sites in four intensive agricultural watersheds across Canada during the years 2005-2007. In each watershed, a site not impacted by livestock and human fecal pollution sources was selected to act as a reference site. The objective of the paper is to discuss the study design, describe the data and present the issues involved in the statistical analysis and the logic used to derive the *E. coli* standard.

Keywords: water quality monitoring, multivariate analysis of quality indicators

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ORAL PRESENTATION

Estimation of Parameters from Environmental Data with Below-Detection-Limit Observations*Sylvia R. Esterby*¹, *Mohammad Shahidul Islam*², *Abdel H. El-Shaarawi*³ T12¹University of British Columbia Okanagan, Canada, ²National Water Research Institute, Canada, ³McMaster University, Canada

Environmental data sets often contain values reported as less than the detection limit when some samples contain concentrations that are too low to be determined by the analytical laboratory method. Organic contaminants and metals in water and aquatic organisms are examples where this occurs and where low concentrations are of concern because of toxicity. This is a case of type I left censoring since the detection limit is fixed. Statistical methods for inferences in the one and two population problems have been extensively investigated and compared to commonly used replacement methods, where values below the detection limit are replaced by an arbitrary fraction of the detection limit. The performance of robust and likelihood methods are reviewed, with reference to water quality examples. Under the assumption that the data are from a bivariate normal distribution, the estimation of and inference about the correlation coefficient is considered and illustrated with water quality data.

Keywords: Type I censoring, detection limit, water quality data, correlation coefficient

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ORAL PRESENTATION

Accounting for interspecific competition when building longline relative abundance indices*Marie-Pierre Etienne*¹, *Shannon Obradovich*², *Lynne Yamanaka*³, *Murdoch McAllister*⁴ C7¹AgroParisTech, France, ²UBC, France, ³DFO, France, ⁴UBC, France

Fisheries stock assessment studies the consequences of management policies by modeling abundance of target fish populations. Often a dynamic population model is fit using relative abundance indices. The basic relative abundance index for longline fisheries is catch per unit effort (CPUE), here defined as the number of target fish caught per hook. Longline CPUE is highly affected by interspecific competition, which could lead to very biased population dynamics models. Furthermore, when the longline is retrieved several hooks returned empty without bait or fish on the hook. This outcome is ignored in all current treatments of longline CPUE. Under the assumption that all hooks are independent, we propose two new relative abundance indices, based on a waiting time process. These indices take into account interspecific competition and empty hooks in the reconstruction of the catch. Asymptotic behavior of the estimators is analytically studied and their response to a variety of competition/empty hook scenarios is simulation tested. These indices are then applied to yelloweye rockfish in the Strait of Georgia, British Columbia. The basic CPUE index behaves poorly in every scenario. Understanding the source of empty hooks allows the selection of the appropriate index.

Keywords: interspecific competition, Exponential model, Fisheries

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POSTER

Spatio-temporal covariance model estimation of the Caroni River Basin rainfall*Yessica Fermín*

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The space-time variability of rainfall in the Caroni River Basin is analyzed for the period 1975-1991, based on 52 hydrometeorological stations irregularly distributed over the basin. Rainfall is considered as the realization of a space-time Gaussian process. For analyzing the spatial-temporal covariance structure, we considered the centered observations. From the analysis of rainfall variability in the spatial and temporal domain, we found that the centered process is nonstationary in space and temporal correlations present in each station differ significantly between stations. Thus, we considered appropriate to apply the method of space deformation of Sampson and Guttorp (1992) [JASA, 87: 108-119] for each of the months, subsequently adjusting the isotropic variogram model by a power law, resulting as the best within a group of variograms considered as possible candidates. Then, to express the interaction between space and time, we adjusted functions that relate the parameters of the variograms to time. Finally, to predict the average monthly rainfall of non-monitored hydrometeorological stations, Simple Kriging and Thin Plate Spline interpolation methods it were applied. Although both interpolators yield excellent results, the Kriging was superior in predicting a greater proportion of the total variability in precipitation.

Keywords: rainfall spatio temporal models, non parametric models, Gaussian processes, variogram, Kriging, Caroni river basin

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ORAL PRESENTATION

A hierarchical mixture model for estimating zero inflated continuous forest variables*Andrew O. Finley¹, Sudipto Banerjee²*

T8

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We are commonly interested in predicting one or more continuous forest variables (e.g., biomass, volume, age) at a fine resolution (e.g., pixel-level) across a specified domain. Given a definition of forest/non-forest, this prediction is typically a two step process. The first step determines which prediction units are forested. The second step predicts the value of the variable for only those forested units. Rarely is the forest/non-forest predicted without error. However, the uncertainty in this prediction is typically not propagated through to the subsequent prediction of the continuous forest variable of interest. Failure to acknowledge this error will result in biased and perhaps falsely precise estimates. In response to this problem, we offer a modeling framework that will allow propagation of this uncertainty. Here, we envision two latent processes generating the data. The first is a continuous spatial process while the second is a binary spatial process. We assume that the processes are independent of each other. The continuous spatial process controls the spatial association structure of the forest variable of interest, while a binary process indicates presence of "measurable" quantity at a given location. Finally, we explore the use of a predictive process for both the continuous and binary processes to reduce the dimensionality of the data and ease the computational burden. The proposed models are motivated using georeferenced National Forest Inventory (NFI) data and coinciding remotely sensed predictor variables.

Keywords: Bayesian, multivariate spatial process, nonstationarity, ecology, predictive process

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ORAL PRESENTATION

Reducing the environmental impact of a toilet paper factory in the North-Central area of Venezuela using clarified water

Teodoro García, José García, María Yezpez
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T12

The North-Central area in Venezuela has two restrictions for installing toilet paper factories: First, the only fresh water available in the area should be used for human consumption. On the other hand, all effluents from the area are poured into Valencia Lake. The lake ecosystem presents significant damage due to the effect of biological and chemical wastes. To minimize the environmental impact and simultaneously supply the huge amounts of water required for the toilet paper factory under study, it is recommended to build two closed circuit water treatment plants. These treatment plants allowed water to be reused through applying the clarification procedure. The water coming from this type of treatment plant should meet certain quality standards if it is going to be used to manufacture toilet paper. Both, the monitoring of quality variables and the results obtained from mixture experiment designs allow controlling the quality of the water through the dosage of flocculants, coagulants and sulfuric acid. This closed circuit has an efficiency of 95%, a 4.77% of paper sludge which is deposited in a landfill and 0.23% of water that must be restored. The combined effects of both plants produce a daily volume of 5,000,000 cubic meters of clarified water. Comparing this figure with the value of 50 liters proposed by the United Nations as the estimate daily amount required by a person for consumption, cooking and cleaning, this complete process creates a saving equivalent to the daily water requirement for 100 million people.

Keywords: water reuse, water clarification, environmental impact, mixture experiments, toilet paper industry.

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ORAL PRESENTATION

Managing uncertainties associated with dispersal models in predicting the spread gaseous waste after an accident

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C8

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A quick and accurate predictions of the dispersion of the contaminated material is crucial in case of environmental disasters (Nuclear or chemical accidents). Conventional atmospheric dispersion models (physical models) are widely used for forecasting toxic contamination and obtaining results in real-time with varying degrees of accuracy. These models are deterministic, and one of the most significant problems associated with their use in prediction is the large degree of uncertainty inherent in their predictions. The objective of this work is to present a Bayesian model (see Smith and French, 1993) which embeds a dispersal model in a description of the uncertainties associated with the dispersal model. This both allows the assimilation of data to update current forecasts and also expresses an appropriate degree of uncertainty associated with any forecasts or estimates.

Keywords: Dispersion models, Dynamic linear models, Bayesian forecasting

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ORAL PRESENTATION

Functional approach to cluster municipalities with respect to air quality assessment*Stefania Ghigo, Ignaccolo Bande*

T5

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We propose a land classification, so-called zoning, in zones featured by different criticality levels of atmospheric pollution considering pollutants time series as functional data. Our proposal meets a request of European laws that impose to distinguish zones which need further actions from those which only need maintenance. To carry out Piemonte (northern Italy) zoning, we consider the main pollutant hourly concentration fields produced by a deterministic model implemented in ARPA Piemonte. Since municipalities are the reference territorial administrative units for undertaking actions, we propose to upscale data from a regular grid (4 km resolution) to municipalities. Three different aggregation alternatives are presented: firstly the average of the field values weighted by areas over the cells belonging to a certain municipality, secondly by the building percentage for every cell (a point in the grid represents a cell), and lastly the 90th percentile over the cell values in a municipality. The pre-processing of data and the municipality upscaling procedures are applied singularly for each pollutant. In order to look at the global air quality status, we propose two strategies to summarize time series (getting pollutants aggregation): evaluating an air quality index and carrying out a Multivariate Functional Principal Component Analysis (MFPCA). Then clustering on air quality time series and on MPFCA scores is applied to obtain groups of municipalities. We will discuss and compare the results of the different analysis strategies. For this goal, we also quantify the migration of municipalities among clusters and visualize it constructing three-color maps of differences.

Keywords: Functional Data Analysis, B-splines, Cluster Analysis, PAM, Atmospheric PollutionPresenting Author's email address: ghigo@econ.unito.it

ORAL PRESENTATION

A sensitivity analysis of prior specification in disease mapping*Enrico Fabrizi¹, Fedele Greco², Carlo Trivisano¹*

T4

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In this work we study sensitivity to hyperprior specification of the dispersion parameter in the convolution model proposed in Besag York and Molli (1991) and widely used in spatial disease mapping. In the fully Bayesian approach to disease mapping, hyperprior choice in such model sensibly affect inferences. In this work we critically review the most common hyperprior specifications. Moreover we propose a new hyperprior choice based on an idea explored in the estimation of the mean for iid log-Normal observations. In this context it is well known that hyperprior parameters have to be set accurately in order to avoid infinite moments of the posterior distribution. The performances of various hyperprior choices are compared via simulation studies. In particular we investigate the sensitivity of the relative risk estimates.

Keywords: Disease mapping, Prior distribution, Sensitivity analysis, MCMCPresenting Author's email address: fedele.greco@unibo.it

ORAL PRESENTATION

Functional Cluster Analysis for particulate matter vertical profiles*Francesca Bruno, Fedele Greco, Daniela Cocchi*

T5

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Clustering of trajectories of compositional data, that is, sequences of composition measurements along a domain has received little attention nowadays. In this work, we extend FCA techniques to the analysis of compositional data by using a suitable compositional algebra. The present work centres on the following question: given a sample of compositional data trajectories, how can we formulate an appropriate segmentation procedure in order to determine homogeneous groups? The methods are illustrated via the application to an environmental problem concerning trajectories of particulate matter size distribution along the atmosphere.

Keywords: Functional cluster analysis, compositional data, PM vertical profilesPresenting Author's email address: fedele.greco@unibo.it

ORAL PRESENTATION

Generating Useful Pseudoproxies*Peter Green*

C2

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The performance of a palaeoclimate reconstruction method can be tested in a pseudoproxy experiment. The method is used to reconstruct a model climate from simulated proxies, and then the result can be compared to the known target. The results of these experiments depend on the properties of these pseudoproxies; a higher signal to noise ratio will result in a better score for the reconstruction, or a more complicated noise structure will result in a lower score. In order to get an accurate assessment of the relative strengths and weaknesses of the various methods it is important that the properties of the pseudoproxies are as realistic as possible. But to facilitate interpretation the proxy model should also be as simple as possible. Many pseudoproxy models add random errors – often either independent normal or AR(1) errors – to a gridbox temperature series. A pseudoproxy may record temperature information via a number of climate variables, and so the total climate signal in a proxy record may be significantly underestimated if we limit the pseudoproxy's climate signal to a single gridbox temperature. In fact temperature plus noise pseudoproxies, with realistic correlations between the proxy and the local temperature, produce pseudo-reconstructions with unrealistically low calibration and validation performance. This suggests that more climate information needs to be included in pseudoproxy models

Keywords: palaeoclimate reconstruction, pseudoproxyPresenting Author's email address: pgreen@maths.otago.ac.nz

Supporting grant: Bright Future Top Achiever Doctoral Scholarship, NZ Tertiary Education Commission

Environmetrics for a data-rich world*Anders Grimvall*

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Massive datasets and detailed models of complex environmental systems must be compressed into simple statements and messages in order to be accessible to the public and decisionmakers. Along with enormous advances in communication technologies, this sets the frame for environmetrics in a data-rich world. It is obvious to anyone that the Internet has revolutionized communication in practically all sectors of society. It is also generally recognized that developments in computer technology and computing greatly facilitate the handling of data and favour computer-intensive methods. Statistical tools such as the bootstrap and Markov chain Monte Carlo (MCMC) simulations have extended data analysis far beyond previous limits. Process-oriented models are run using higher resolution and a larger number of processes than could be imagined only a couple of decades ago. Nevertheless, it is often overlooked that advances in computer technology and computing have an even more profound impact on how science is performed. Instead of being limited by insufficient access to data, we are now frequently facing situations in which the major problem is to explore and summarize huge amounts of data or information. This calls for greater emphasis on visualization techniques, strategies for assessing data quality, and algorithms that can handle large datasets. In addition, we need information arenas where data from many different sources can be integrated, and producers and users of data can interact. Here, we shall use data and models from the marine sciences to illustrate the need for new perspectives on environmetrics and environmental monitoring. Special attention will be paid to eutrophication and acidification of marine environments, as well as the combined effect of trends in nutrient inputs and atmospheric CO₂ concentrations.

Keywords: data-rich world, MCMC, large datasets, process-oriented models

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Bias in the correction for artificial change-points*Anders Grimvall*

T2

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Temporal trends in time series of environmental data are often severely distorted by systematic errors in measurements, sampling, or reporting. Accordingly, numerous methods have been developed to homogenize observational data by removing level shifts that have been deemed artificial. In particular, a variety of algorithms have been constructed to fit piecewise constant functions to sequences of data. If it is known when level shifts have occurred, the currently used methods can provide unbiased estimates of their size. However, if the homogenization algorithm involves a search for level shifts at unknown time points the magnitude of such shifts can be overestimated. This is particularly true when change-points occur close to the beginning or end of the data series, or the error terms have a significant autocorrelation. We performed a simulation study to examine the bias and dispersion of least squares estimators of level shifts. Our results demonstrated that, when the underlying mean function is piecewise constant, the performance of such estimators can be improved by introducing a shrinkage factor that is a function of the time of the change-point, the level-shift-to-noise ratio, and the autocorrelation of the error terms. Further studies showed that, when the mean function contains a linear trend of unknown slope or a smooth component of unknown shape, abrupt level shifts can easily be absorbed into the continuous part of the mean function.

Keywords: Temporal trends, change-points, bias correction

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ORAL PRESENTATION

Probabilistic Estimation of Climate Change in Venezuela using a Bayesian Approach*Alexis Durán*¹, *Lelys Guenni*²

T13

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The climate change problem is one of the main environmental problems facing humanity, since slight variations in the climatic variables might bring terrible consequences in the economic activities and human well being in general. Atmospheric Global Circulation Models (GCMs) are the main tools to study climate change. The Ministry of Environment and Natural Resources (MENR) led in the year 2005 the First Communication in Climate Change of Venezuela, using the outputs of 16 GCMs at a global scale of five degrees by five degrees, whose projections estimate increasing temperature and diminishing precipitation in the coming years. Each GCM gives different results generating uncertainty in the future climate change signal. This work uses a Bayesian approach and an extension of the Reliability Ensemble Average (REA) method, combining the outputs (present and future) of precipitation and temperature of the 16 GCMs with observations of present climatic conditions, in order to determine the probability distributions of future climate change for these two climatic variables in 9 regions of Venezuela. For this study two criteria are used: bias, which considers the difference between the model outputs and the present climate; and convergence, which quantifies the differences among the simulated changes of future climate by the multiple models. The main result of this work is that a large amount of uncertainty still exists in the GCMs projections used for that study. It was also concluded that the lower the natural variability of the climatic variable the more effective is its projection.

Keywords: Probabilistic Estimation, Climate Change, Bayesian ApproachPresenting Author's email address: lbravo@cesma.usb.ve

ORAL PRESENTATION

Trying to sell Bayesian hierarchic models to climatologist*Peter Guttorp*

T9

University of Washington, USA and Norwegian Computing Center, Norway

The Seventh International Meeting on Statistical Climatology took place in Whistler, Canada, in 1998. I was the program chair, and decided to set up the program so that climatologists would get a sense of how modern statistical tools, such as Bayesian hierarchic models, could be used in climate science. I will describe our approach, tell a little about what applications were used, and whether or not our selling job was successful.

Keywords: hierarchic models, climatologyPresenting Author's email address: peter@stat.washington.edu

ORAL PRESENTATION

Robust Zero-inflated Poisson Regression*Daniel B. Hall*¹, *Jing Shen*²

T10

¹University of Georgia, USA ²Merial Ltd., USA

The zero-inflated Poisson regression model is a special case of finite mixture models that is useful for count data containing many zeros. Typically, maximum likelihood (ML) estimation is used for fitting such models. However it is well known that the ML estimator is highly sensitive to the presence of outliers and can become unstable when mixture components are poorly separated. In this talk, I propose an alternative robust estimation approach, robust expectation-solution (RES) estimation. I compare the RES approach with an existing robust approach, minimum Hellinger distance (MHD) estimation. Simulation results indicate that both methods improve on ML when outliers are present and/or when the mixture components are poorly separated. However the RES approach is more efficient in all the scenarios considered. In addition the RES method is shown to yield consistent and asymptotically normal estimators and, in contrast to MHD, can be applied quite generally.

Keywords: Excess zeros, outliers, expectation-solution algorithm

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ORAL PRESENTATION

Resource Selection from Animal Movement Models*Mevin B. Hooten*¹, *Devin S. Johnson*², *Ephraim M. Hanks*¹

T7

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Contemporary ecologists often find themselves with an overwhelming amount of data to analyze. For example, it is now possible to collect nearly continuous spatio-temporal data on animal locations via global positioning systems and other satellite telemetry technology. In addition, there is a wealth of readily available environmental data via geographic information systems and remote sensing. We present a modeling framework that utilizes these forms of data and builds on previous research pertaining to the quantitative analysis of animal movement. This approach provides additional insight into the environmental drivers of residence and movement as well as resource selection while accommodating path uncertainty.

Keywords: spatio-temporal

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ORAL PRESENTATION

On Gaussian process models for learning about climate model parameters*Murali Haran*

T4

Pennsylvania State University, USA.

Computer model calibration involves combining information from simulations of a complex computer model with physical observations of the process being simulated by the model. Increasingly, computer model output is in the form of multiple spatial fields, particularly in climate science. We study a flexible modeling approach for computer model calibration with multivariate spatial data. Our two stage approach emulates the computationally expensive climate model using a flexible hierarchical model to connect the tracers. We then infer the parameter using our emulator and the observations via a Bayesian approach, accounting for observation error and model discrepancy. We utilize kernel mixing and matrix identities in our Gaussian process model to considerably reduce the computational burdens imposed by the large data sets. We demonstrate the application of this approach to the problem of inferring background ocean vertical diffusivity, a key parameter in climate models that predict the behavior of the Atlantic meridional overturning circulation (AMOC). AMOC predictions are of great interest since a possible collapse of the AMOC may result in major temperature and precipitation changes and a shift in terrestrial ecosystems

Keywords: calibration, multivariate spatial process, Gaussian process, hierarchical model, MCMC

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ORAL PRESENTATION

Discretized and aggregated: Hierarchical models for ordered categorical multinomial data with temporal autocorrelation*Megan D. Higgs*¹, *Jay Ver Hoef*²

T7

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Ordered categorical data are pervasive in environmental and ecological data, frequently arising from practical constraints imposed at data collection. Often, a potentially continuous variable is discretized into ordered categories. For example, dive depths from marine mammals are stored as depth categories in Time-Depth Recorders (TDRs) rather than depths measured continuously in meters. Additionally, data storage or transmission constraints may also necessitate the aggregation of data over time. For example, TDRs aggregate the categorical dive depth data over fixed time intervals (e.g. 6 hours). Thus, for each individual, resulting data are a time series of multinomial counts from ordered categories. We develop hierarchical models to assess the relationship of covariates, such as sex, age, and time of day, with dive behavior. We model the ordered nature of the response using the notion of clipping, or thresholding, a latent continuous Gaussian distribution. The means and variances of the clipped distributions are modeled as functions of covariates, allowing assessment of key characteristics of general dive behavior. We also account for serial correlation among the multinomial counts through autocorrelation imposed on the means and variances of the clipped distributions. We demonstrate the utility of our models for dive depth data acquired from TDRs affixed to Harbor seals by the NOAA National Marine Mammal Lab.

Keywords: ordinal, Bayesian, multi-level, satellite radio telemetry

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ORAL PRESENTATION

Statistical modeling of agroecosystems in a changing climate*Nathaniel K. Newlands, Reza Hosseini*

T11

Agriculture and Agri-Food Canada (AAFC), Lethbridge Research Centre, Canada

We discuss statistical methods for agroclimate risk analysis. We present statistical models for the precipitation and temperature processes over time. These models enable us to estimate the probability of the occurrence of extreme weather events such as droughts and frosts at a given location. Finally we highlight collaborative research advancements being made in high-resolution agroclimate downscaling and extreme event analysis, alongside methods for precision agriculture using remote sensing data

Keywords: climate, agriculture, agroclimate, extreme events, risk analysis, Markov chainPresenting Author's email address: reza1317@gmail.com

Supporting grant: Sustainable Agriculture Environmental Systems (SAGES) Federal Government of Canada

ORAL PRESENTATION

Bayesian Hierarchical Modeling of Salmon Migration*Carolyn Huston, Carl Schwarz, Steve Thompson*

C6

Simon Fraser University, Canada

Modeling sockeye salmon migration patterns is critical to understanding and protecting this keystone species on the Pacific west coast. In addition to maintaining a healthy overall population size, the Pacific Salmon Commission has also identified the goal of preserving genetically distinct stock groupings of sockeye that migrate through the river. As is often the case with observational data on biological systems, our data presents challenges that are poorly addressed with standard statistical models. These challenges include sparse observations in subgroups, restrictive sample sizes at temporal sampling points, and sampling points with missing data. This presentation will describe the implementation of a multivariate conditional autoregressive (MVCAR) model in a hierarchical Bayesian framework to address the sockeye salmon migration problem. Theoretical issues and estimation results will be described, using salmon migration data from Fraser River to illustrate key ideas. Further, aspects of study design aimed at improving estimation and data reproducibility will be discussed.

Keywords: hierarchical model, MVCAR, compositional dataPresenting Author's email address: chuston@sfu.ca

ORAL PRESENTATION

The Role of Topography in Environmental Analysis*Michael F. Hutchinson*

T6

Australian National University, Australia

The land surface plays a fundamental role in modulating land surface and atmospheric processes across a range of spatial scales. Digital elevation models (DEMs) are used to represent the land surface in various ways, depending on the nature of the application. Of central importance for environmental modelling is the accuracy and spatial coverage that can be achieved by incorporating dependencies on the land surface. Mesoscale representations of surface climate have a strong direct dependence on elevation, making such representations truly 3-dimensional. Modelling applications at finer scales often depend on representations of the shape of the land surface. This presentation first reviews recent progress in the generation of grid DEMs, from high resolution data sources. An essential shape-based attribute for hydrological applications is drainage connectivity. Coupling automatic drainage enforcement to the interpolation and filtering of DEMs improves elevation accuracy and facilitates hydrological applications. Accuracy can also be improved by applying filtering to reflect errors in source data. The presentation then discusses the incorporation of dependencies of environmental variables on elevation and landscape shape. This is the domain of multivariate statistical analysis, usually performed by various forms of thin plate smoothing splines and geostatistics. These models normally apply data smoothing to allow for fine scale variability in the data and to produce spatial models with minimal error. The relative merits of various forms of analysis are discussed. Short range correlation in data errors is often overlooked, but can have a significant impact on these analyses. Ways to address this are also discussed.

Keywords: DEMs, multivariate smoothing, correlated error, topography

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ORAL PRESENTATION

Identifying sources of PM10 pollution in the Taranto area*Alessio Pollice¹, Giovanna Jona Lasinio²*

T6

¹Università degli studi di Bari "Aldo Moro", Italy, Università di Roma "La Sapienza", Italy

Air quality management strategies can be improved by the identification of the major sources contributing to air pollution. Multivariate receptor models aim at this objective by factoring the air pollution data into components associated with different sources. Ambient pollutant concentration measurements taken at a receptor are apportioned into identifiable sources, deriving both the source profiles and their contributions. Traditionally multivariate receptor models have been applied to the measurements of multiple chemical species collected at a monitoring station. To now, few studies have investigated formal statistical procedures for identifying the spatial location of major pollution sources. Some notable exceptions consider data for one pollutant (namely particulate matter) collected at some spatially dispersed receptors as a multivariate dataset and extend the multivariate receptor model to obtain the spatial profiles of the sources of PM, i.e. the relative amounts of the pollutant conveyed from the source to the monitoring sites. Explicit consideration of the spatial variability implied by the location of the receptors is not addressed by the former studies and is one of the purposes of this work. Here we adopt a multivariate receptor model in the form of mixed multiplicative log-normal factor analysis with spatially modelled profiles. Estimation is performed in the Bayesian framework. For the geographic identification of PM10 pollution sources each profile is mapped and areas corresponding to high relative amounts of pollutant indicate the source location. To illustrate this approach average daily PM10 concentrations for 13 monitoring sites in Taranto, Italy, for the period April-December 2005 were analyzed.

Keywords: multivariate receptor models, multiplicative factor analysis, gaussian spatial random fields, MCMC

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ORAL PRESENTATION

Characterisation of the habitat of an endangered species (*Azelia africana* Sm.) in the Lama Forest reserve (Benin, West Africa)*R. Glèlè Kakai, W. Bonou*

C7

Laboratory of applied ecology, Faculty of agronomic sciences, Université d'Abomey-Calavi, Bénin.

The study was carried out in the Lama Forest reserve of Benin to characterize the habitat of *Azelia Africana* Sm, an endangered African multipurpose tree species found, in order to define a sustainable conservation strategy. An estimation of species density was done on 100 square plots of 1 ha each, while tree height and dbh of all the species were measured on subplots of 50 m x 30 m within the square plots. The regenerations of *A. africana* were counted in the diagonal quadrats of the principal plots. Presence-absence data of the species was subjected to multidimensional scaling and results showed four vegetation communities: young fallow, old fallow, typical dense forest and degraded dense forest. Significant differences were noted between the four communities with respect to dendrometric parameters of the species. High values of these parameters were noted for the species in typical dense forest (5.2 stems/ha, 66.7 cm, 17.9 m, 7.9 m^2 /ha for the tree-density, the mean diameter, the mean height and basal area of the species, respectively) whereas the lowest values were obtained for the old preforest fallow as far as the mean diameter (59.7 cm) and the mean height (15.7 m) of the species were concerned. No *A. africana* tree was found in the young preforest fallow while more than 80 % of its trees were found in the typical dense forest. Stem diameter and height structures of the species in all the four communities showed a left dissymmetric Gaussian shape and well adjusted to Weibull distribution.

Keywords: *Azelia africana* Sm, habitat characteristics, population structure, Lama Forest reserve, Benin

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Supporting grant: World Bank

Structural description of two *Isobertia* dominated vegetation types in the WariMaro Forest Reserve (Benin)*R. Glèlè Kakai, B. Sinsin*

C7

Faculty of Agronomic Sciences, University of Abomey-Calavi (UAC)

An inventory of *Isobertia* natural mixed stands was carried out in the tree-savannas and woodlands of the WariMaro Forest Reserve (Republic of Benin) to serve as basis to improve existing management strategies. Measurements were done in 96 rectangular plots of 3050 m with a cumulative area of 14.4 ha. The two vegetation types were mainly distinguished by the overall tree-density (225.2 stems/ha in tree-savannah against 202.8 stems/ha in woodland), the overall mean height of the stands (13.1 and 14.6 m, respectively) and the mean height of *Isobertia* trees (14.1 and 16.8 m respectively). The other parameters (mean diameter, basal area, basal area contribution of *Isobertia* trees, bark thickness, tree density of *Isobertia* trees as well as the Shannon diversity index and Pielou evenness index) had essentially the same values for the two vegetation types. The stem diameter structure of *Isobertia* stands in the two vegetation types had an inverse-J shape for the whole stand and well adjusted to the negative exponential distribution (log linear analysis) and the I shape (normal truncated distribution) for *Isobertia* trees (log linear analysis). The stem diameter of *Isobertia* decreased on average 1.9 cm/m tree-height. *Isobertia* seedlings were more abundant below the canopy of mature trees than further away. The main dispersal mode of the species consisted of dropping the seeds from pods under the mother tree, and suckering which resulted in the observed aggregated distribution of the trees. These results were used to propose management strategies for the two vegetation types.

Keywords: Dominance, *Isobertia* spp., Structure, Vegetation type, WariMaroPresenting Author's email address: gleleromain@yahoo.fr

Supporting grant: World Bank

ORAL PRESENTATION

Spatio-temporal dynamics of the Cariaco upwelling system: the sea surface temperature through a self organizing approach*Eduardo Klein*¹, *Iliana Chollett*²

T13

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The south-eastern margin of the Caribbean Sea is influenced by the output of major rivers and seasonal coastal upwellings. In the Cariaco system, the upwelling plume, defined under the 24.75C horizontal isotherm, covers up to 135.861 km². The upwelling phenomena starts with the increase of the zonal wind stress produced by the Trade winds in December until late April, with a second upwelling lasting a few weeks in June-July, this last event not discernible in all years. By using time series of remote sensing derived maps (AVHRR) of sea surface temperature (SST), we characterized the dynamics of the upwelling plume around the Cariaco trench. A spatial Kohonen's self organized map (SOM) produced from images since 1993, identified nine well delimited areas. The analysis suggests a spatial structure associated with the main upwelling foci. Using a temporal SOM classification, we established a set of seven different prototype states of surface of the sea, connected in a sequence from maximum upwelling extension (cold sea) to non upwelling (warm sea). Image analysis suggests a large inter annual variation in duration and extension of the upwelling plumes. The years of 1997, 2001 and 2003 showed strong upwelling while 1994-1995 and 2004-2005 were particularly weak. The time series evidenced a significant raise in SST over the last three years, values that correspond very well with the global increment of sea temperature registered in the Cariaco oceanographic station. A major phase-shift in plankton communities might be originated by this temporal variability.

Keywords: Kohonen SOM, Cariaco upwelling, temporal classification, AVHRR SST

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ORAL PRESENTATION

Identification of ecosystem parameters by SDE-modelling*Jan Kloppenborg Møller*¹, *Henrik Madsen*¹, *Jacob Carstensen*²

C5

¹DTU-Informatics, Richard Petersen Plads, Technical University of Denmark, Denmark, ²National Environmental Institute, Aarhus University, Denmark

Stochastic differential equations (SDEs) for ecosystem modelling have attracted increasing attention during recent years. The modelling has mostly been through simulation experiments in order to analyse how system noise propagates through the ordinary differential equation formulation of ecosystem models. Estimation of parameters in SDEs is, however, possible by combining Kalman filter techniques and likelihood estimation. By modelling parameters as random walks it is possible to identify linear as well as non-linear interactions between ecosystem components. By formulating a simple linear SDE describing interactions between phytoplankton and water-column nitrogen with light as forcing, using data from a Danish estuary covering a 16 years period (1988-2003), and modelling primary production as a random walk, it is demonstrated how non-linear relationships between states can be identified by plotting the (random) production parameter as a function of the states in the system and global radiation. The resulting SDE model (that does not contain random walks), is analysed by simulation studies, to determine the properties of the seasonal distribution of phytoplankton.

Keywords: Marine ecosystems, Stochastic differential equations, Parameter Estimation, Parameter Identification, Nitrogen Phytoplankton models

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ORAL PRESENTATION

Metrics and indices describing spatial patterns of agricultural landscape change at different ontological levels*Sotirios Koukoulas*

C4

University of the Aegean, Dept. of Geography, Greece

This paper describes a methodological framework for assessing the spatial patterns of agricultural landscape change applied in the case of Lesbos (Greece). A combination of exploratory analysis in GIS, landscape metrics, spatial statistics applied to classified satellite images for this purpose. Remote sensing techniques were employed in order to map agricultural land use changes that have taken place in the last 25 years. The latter was achieved by devising a simple and operational rule-based approach to map land cover changes, based on the classification of Landsat imagery and the conceptual analysis of the information regarding change detection. The use of ancillary GIS data such as a Digital Elevation Model, existing thematic maps and the knowledge of the island's vegetation dynamics, formed the basis for setting the rules for the post-processing of the classified images that led to a more accurate assessment and mapping of land cover changes. The analysis was applied at three levels: patch, pixel and quant. For each level different metrics/statistics were used aiming at the same goal – the understanding of the spatial distribution of changes (quantifying spatial autocorrelation, connectivity, density, intensity, as well as isolation and proximity). Landscape metrics were used at a patch level, spatial statistics at a pixel and quant level. The comparison of the results revealed striking similarities at first glance, giving however different insights for further analysis and modeling allowing for an integrated conceptualizations and quantification of landscape dynamics.

Keywords: landscape dynamics, spatial patterns, spatial metrics, exploratory spatial analysis, land cover/use change, Lesbos-Greece

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Supporting grant: Matching funds GGET 2007

ORAL PRESENTATION

Hidden Markov Models for incomplete multivariate environmental data*Francesco Lagona, Antonello Maruotti, Marco Picone*

T6

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Hidden Markov models provide a parsimonious framework for modelling multivariate, environmental time series, when contemporary observations can be assumed to be conditionally independent given a latent state, which evolves according to a Markov chain. Standard E-M algorithm can be easily adapted to allow for ignorable missing values, which occur when the probability of not observing a value does not depend on the unobserved data. When however the data are not ignorably missing, unobserved values are informative of the model parameters and the mechanism that generates the missing values should be taken into account. We propose to include missing indicators as additional variables in a hidden Markov model, assuming that both the missing indicators and the environmental variables of interest are conditionally independent given a latent state, which evolves according to a Markov chain. Taking this approach, missingness is assumed to be informative of latent-class membership, and each latent state summarizes latent features of the joint distribution of the environmental variables and the missing data mechanism. Advantages and disadvantages of this approach are illustrated on incomplete marine data of wave height and direction, obtained from the Italian buoy network. Missing values occur because of device malfunctioning or transmission errors under severe sea conditions.

Keywords: hidden Markov models, marine data, nonignorably missing data

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ORAL PRESENTATION

Mixtures of truncated distributions for validating marine data*Francesco Lagona, Antonello Maruotti, Marco Picone*

C6

University Roma Tre, Italy

Sea conditions are often monitored by buoys that measure a number of linear and circular variables, such as wave height and direction. These data are disseminated for a variety of purposes, which include sediment transport studies, the design of marine structures and studies of coastal erosion. The analysis of wave height is often complicated by the presence of outliers that occur because of buoy malfunctioning, device transmission errors or severe sea conditions. For outlier identification and data validation, we propose a mixture model with a noise component. Under this model, inliers are clustered into a number of wavemetric latent regimes, while outliers are included in a noise-component class. Within each latent class, wave height and direction are jointly modeled by the product of a truncated Weibull distribution and a von Mises distribution, while the noise component is modeled by exploiting a uniform distribution. As a result, the marginal distribution of wave height is a mixture of a number of truncated Weibull distributions and a uniform distribution. Maximum-likelihood estimates of the model are obtained by a suitable E-M algorithm that allows for missing at random values. Examples of data validation and outlier detection are illustrated on the basis of hourly wave data, obtained from the Italian wavemetric network

Keywords: wave height, Mixture models, Outliers, Truncated distributionsPresenting Author's email address: lagona@uniroma3.it

ORAL PRESENTATION

Agricultural Research in the Caribbean: Challenges for the Biometrician*Bruce Lauckner*

T11

Caribbean Agricultural Research and Development Institute, University Campus, St Augustine, Trinidad and Tobago

Agricultural research in the Caribbean has a long history, originating in the 19th century when the British had a network of botanical gardens at which informal research activities were carried out. By the early 20th Century formal research was being carried onto at research stations in Barbados and Puerto Rico. In 1922, the Imperial College of Tropical Agriculture (ICTA) opened in Trinidad and soon became world renowned for research in tropical agriculture. ICTAs successors today are the Faculty of Science and Agriculture of the University of the West Indies and the Caribbean Agriculture Research and Development Institute. Puerto Rico continues to have a strong research centre at the University of Puerto Rico and most Caribbean nations have some sort of agricultural research capability. ICTAs golden years coincided with the work of R. A. Fisher and F. Yates at Rothamsted in the U.K. This work established the important role of biometry in agriculture research. It also had an effect on ICTA as early publications from that institute contained details of how to carry out some of the statistical methods developed at Rothamsted. Despite this, ICTA did not employ any biometrician or statistician until 1955 and this person left in 1962 and was not immediately replaced. Since that time the ratio of biometricians to research in agriculture in the region has been very low. This has created a number of challenges for the biometrician including: .- Difficulty in serving all researchers, particularly those in countries without a resident biometrician, .-Researchers have usually been exposed to statistics courses as part of degree training, but are not aware of developments in biometry since they graduated, .-The ease of statistics software has led to researchers doing inappropriate or incorrect analyses.

Keywords: Biometry, Caribbean, ICTA, Agricultural researchPresenting Author's email address: blauckner@cardi.org

ORAL PRESENTATION

Joint segmentation using mixed linear models: application to detect changes in harvest dataEmilie Lebarbier¹, Franck Picard², Eva Budinska³, Stéphane Robin¹ T21UMR INA P-G/ENGREF/INRA MIA 518, France, ²UMR CNRS-8071/INRA-1152/Universit'e d'Evry, France, ³Centre of Biostatistics and Analysis Masaryk University, France

We consider the joint segmentation of multiple series in the sense that each series has its own segmentation which is achieved jointly with others. We use a mixed linear model with breakpoints which allows us to take into account for both covariates and correlations between series. The parameters are estimated by maximum likelihood. Since linear mixed models can be viewed as a model with incomplete data, we use the Expectation/Conditional Maximization algorithm. Among the CM steps, one is dedicated to the estimation of the breakpoints location. To obtain the optimal solution, we propose a new Dynamic Programming (DP) algorithm since DP can not be used directly when the size or the number of series become too large. Moreover the joint segmentation raises the model selection issue. To this end, we generalize three penalized criteria, proposed in the univariate segmentation case, to the multiple series case. These criteria are compared in a simulation study. This method is applied to harvest data. The aim is to detect changes in grapes harvest dates across several stations due to changes in agricultural practices. As harvest are made earlier in hot years, we typically want to distinguish station-specific from those due to variations of the climate.

Keywords: Joint segmentation, Mixed linear model, Dynamic programming, EM algorithm

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PLENARY SESSION

Transport of pollutants in Lake of Valencia, Venezuela

José R. León R.

Universidad Central de Venezuela, Venezuela

The Valencia Lake is the second lake of Venezuela and for some time it has experienced a degradation of its waters. It is an inland lake with no outlet to the sea, having a surface of 3.140km². It is localized between 67°07' and 68°12' west longitude and 09°57' and 10°26' north latitude.

The Venezuela's environment ministry (Ministerio del Ambiente y de los Recursos Renovables) has been monitoring the quality of the lake's waters since 1997. The concentration of several substances is studied in 13 stations. One of these substances is the concentration of Chlorophyll-a. This substance measures the quality of the inland waters. Chlorophyll-a is a green pigment found in plants. It absorbs sunlight and converts it to sugar during photosynthesis. Important concentrations of this substance is a sign of eutrophication. High levels often indicate poor water quality and low levels often suggest good conditions. In this talk we will present the results of a research project conducted for modeling the concentration of Chlorophyll-a in all the lake and also its diffusion.

The work contains two parts. In the first one the measures of Chlorophyll-a are correlated with the reflectance parameters in satellite images. This procedure allows us to extend the taken in situ measures to all the lake's surface, by using a regression model and Kriging. The satellite images used in the study are those obtained from the MODIS satellite. In the second part we study, using as initial conditions these concentrations, a model of diffusion of this Phytoplankton drifted by the water flows in the lake's surface and some noise. We are interested in answer a question: What is the kind of diffusions we deal? In what follows we shall compare two diffusion hypothesis: Brownian diffusion, *i.e* each particle satisfies a stochastic differential equation w.r.t a Gaussian white noise, versus fractionary pseudo-diffusion, in this case the particles are moved by a fractionary noise (the derivative in the distributional sense of a fractional Brownian motion).

Keywords: pollutant transport, remote sensing of chlorophyll-a, diffusion models

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POSTER

Monitoring water levels at upper and middle Orinoco Basin from ENVISAT virtual gauge stations*J.G. Leon*¹, *A. Puerta*¹, *J. Rubiano*², *S. Calmant*³, *F. Seyler*⁴¹Universidad Nacional de Colombia, Colombia, ²Universidad del Valle, Colombia, ³IRD-LEGOS, France, ⁴IRD-ESPACE, France

The reduction and lack of maintenance of hydrometric stations in developing countries is currently affecting the quantity and quality of available information required for the understanding of the hydrology of river basins. One of the key challenges in current hydrology is to solve this problem, in particular when facing climate and hydrological changes due to global warming. For more than a decade, the use of satellite radar altimeter and the implementation of virtual stations appear as an alternative and complementary technology to the in situ hydrological monitoring. This technology has allowed the densification of control points for the observation of water levels in continental waters. The current study concentrates in the identification of virtual stations for the high and middle sections of the Orinoco watershed from ENVISAT records. It has been possible to identify 120 virtual stations in this region increasing up to three times the number of control points. This in turn will facilitate a better understanding of the basin behavior in space and time. Validation has been conducted by comparing the results with stages measured at 20 in-situ gauges available and 33 ENVISAT virtual stations. The 33 time series compared, produced water error levels ranged between 10 and 17% in the lower and upper basin respectively.

Keywords: Hydrological monitoring, virtual stations, water stages, orinoco basin

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ORAL PRESENTATION

Do source dispersion models improve predictions of air pollution?

C1

Johan Lindström, Adam A Szpiro, Lianne Sheppard, Paul D Sampson, Assaf Oron, Tim Larson

University of Washington

There is growing interest in the long-term effects of exposure to air pollution on human health. Studies suggest that intra-urban variability in air pollution exposure may be very important in explaining cardiovascular health effects. However accurately predicting long-term exposure for individual subjects is challenging. The MESA Air study is a major cohort study focused on the association between cardiovascular disease and chronic exposure to ambient air pollution. To provide predictions of the subjects' long-term exposure, MESA Air uses a complex spatio-temporal model that combines geographic covariates with data from the regulatory AQS monitoring system and study-specific supplementary monitoring data [Szpiro et. al.; *Environmetrics* (2010):to appear]. To improve the predictions and more accurately account for roadway effects, we expand the spatio-temporal model to include output from a source dispersion model, Caline3, as a spatio-temporal covariate. The Caline3 model provides estimates of air pollution based on local meteorology and traffic data. Our hope is that the added information from Caline3 will improve predictions by increasing the ability of our model to capture intra-urban variation. The expanded model is used to evaluate the potential gain provided by Caline3 output for predicting long-term average concentrations of oxides of nitrogen (NO_x) in the Los Angeles area.

Keywords: spatio-temporal modelling, air pollution, dispersion model, exposure modelling

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ORAL PRESENTATION

Bayesian Adjustment for Misclassification in Matched Case-Control Study*Juxin Liu¹, Paul Gustafson², Nicola Cherry³, Igor Burstyn³*

T14

¹University of Saskatchewan, Canada, ²University of British Columbia, Canada, ³University of Alberta, Canada

We propose a Bayesian adjustment for the misclassification of a binary exposure variable in a matched case-control study. The method admits a priori knowledge about both the misclassification parameters and the exposure-disease association. The standard Dirichlet prior distribution for a multinomial model is extended to allow separation of prior assertions about the exposure-disease association from assertions about other parameters. The method is applied to a study of occupational risk factors for new-onset adult asthma.

Keywords: Bayesian method, misclassification, matched case-control study, job-exposure matrix, odds ratio

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Supporting grant: University of Saskatchewan start-up

POSTER

Spatial dependence of rainfall maxima. Two case studies*Freddy López*

Instituto Venezolano de Investigaciones Científicas (IVIC), Venezuela

The spatial dependence of rainfall maxima is studied for two data sets: the Caroni river basin in Venezuela and the state of Guanajuato, Mexico based on 26 spatial measurements of yearly maxima sampled between 1960 and 1999 and 22 measurements of monthly maxima sampled between 1960 and 1997, respectively. Dependence models are established in terms of the madogram (rescaled madogram, F-madogram and lambda-madogram. Cooley et al., 2006, Naveau et al. 2009) and the extremal coefficient function (based on least squares and maximum of likelihood estimators. Smith, 1990, Schlather and Tawn, 2003). In order to assure stationarity the models are applied to the residuals of a regression model obtained considering months as a covariate (Le y Zidek, 2006) for each of the sampling sites. Maxima of residuals are seen to behave as Frechet random variables at most sites.

Keywords: spatial models for extremes, madogram, F-madograms and lambda-madograms, extremal coefficient function.

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ORAL PRESENTATION

Spatio-temporal models for the mean and extreme values rainfall fields in the Caroni river basin in Venezuela*Carenne Ludeña*

T13

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The Caroni river basin is a major hydrological system located to the south of Venezuela covering an area of 95.000 km^2 . It is responsible for the production of 10 million kw/h over a series of hydroelectric power plants located along its course. Developing models for estimating the Caroni river basin rainfall as well as the Caroni river discharge is becoming increasingly important due to global climate change and mining and forestry activities which have apparently had an effect on the mean and extreme rainfall field values. This talk reviews work that has been done in this direction in the last years exploring different parametric and non-parametric spatio-temporal models in each case based on available data.

Keywords: rainfall spatio temporal models, extreme value spatio temporal models, Caroni river basin
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ORAL PRESENTATION

Analysis of Serially Correlated Semi-continuous Data with Environmental Applications*Renjun Ma, Guohua Yan, Tariqul Hasan*

T12

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Serially correlated data with non-detectable values are often encountered in environmental, biological and medical studies. Environmental contaminants measurements are usually positive, but often with substantial portions of measurements being below the detection limits. These data are traditionally analyzed assuming log-normal distribution. In this study, we propose a random effects compound Poisson modeling approach to the analysis of this type of data. Data generated from compound Poisson distribution are generally positive and continuous, but with substantial portions of zeros. This approach is illustrated by analysis of environmental data.

Keywords: Best linear unbiased predictors, censored data, compound Poisson distribution, mixed models, non-detectable values

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Supporting grant: NSERC grant, Canada

POSTER

Sampling surface waters to monitor the effectiveness of good agricultural practices at a catchment scale

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Agriculture is a dominant component of the global economy. Pressure to produce adequate food for rapidly expanding populations and to meet varied consumer preferences has resulted in an increased use of pesticides and, at the same time, calls for stronger control and compliance with maximum residue limits in agricultural products. Reduction of pesticide contamination can be achieved through the application of Good Agricultural Practices (GAP), including adherence to national requirements on the use and application of pesticides in the field. Appropriate air and water monitoring schemes can help identify compliance with GAP by identifying specific pollutants, their sources and occurrences. In addition, they may detect peak pesticide concentrations that are most damaging to aquatic organisms and help focus preventive measures or corrective actions more effectively than end-product testing of foods. To elaborate the concepts and tools, the IAEA is currently conducting a coordinated research project (CRP) on Integrated analytical approaches to assess indicators of the effectiveness of pesticide management practices at a catchment scale. The CRP aims to integrate risk assessment tools and targeted analytical monitoring. The elements of the strategy include: conducting a 1st-tier pesticide risk assessment; harmonizing methodologies; working directly with stakeholders; monitoring GAP application/effectiveness by the presence of high impact rating pesticides; identifying positive samples by mass spectrometry; and feeding back results to farmers and land managers. The CRP is developing case studies by providing sampling guidelines for water that link the output result to pesticide use at a landscape scale.

Keywords: sampling, indicator, good agricultural practice, integrated approaches

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ORAL PRESENTATION

Simulation-based optimal design for estimating weed density in agricultural fields

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T16

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The purpose of this paper is to present a method for optimizing the locations of weed density measurements in agricultural field in order to manage herbicide treatment. Consider an agricultural field divided into N quadrats and assume that weed density measurements were already collected in M out of the N quadrats, $M \leq N$. Our practical problem is to estimate weed density in each one of N quadrats by using i) the M available weed density measurements and ii) Q additional measurements, $Q \leq N - M$, collected in other quadrats located in the same field, and by estimating the weed density in the unmeasured quadrats with a statistical technique. Potentially, the use of Q additional measurements can lead to improved weed density estimates, but the degree of improvement depends on the experimental design i.e. on the number of additional measurements Q and on their locations in the field. This paper presents a method for defining, assessing, and selecting experimental designs in order to determine an appropriate number Q of additional measurements and optimize their locations in the field. The proposed method consists in three main steps: 1) Fit a statistical model to the M available measurements, 2) Define possible locations of the Q additional measurements using a simulated-annealing algorithm, 3) Assess the designs using weed density values simulated using the fitted statistical model. This method was applied to several wheat fields and the results showed that it could improve weed density predictions. Sensitivity to several tuning parameters is discussed.

Keywords: protection, experimental design, simulated annealing, spatial statistics, weed

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ORAL PRESENTATION

Predicting concentrations of oxides of nitrogen in Los Angeles, CA using universal kriging C1
*Laina Mercer*¹, *Adam Szpiro*¹, *Lianne Sheppard*¹, *Sara Adar*², *Ryan Allen*³, *Ed Avol*⁴, *Assaf Oron*¹,
*Tim Larson*¹, *L-J Sally Liu*¹, *Joel Kaufman*¹

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Epidemiological studies to assess the health effects of long-term ambient exposure to air pollution are used to inform public policy. These studies rely on exposure models that relate data collected from pollution monitoring sites to subject locations. The development of good prediction models is an important feature of this research. Land use regression (LUR) and universal kriging (UK) have been suggested as valid prediction methods. We evaluate these approaches in a dataset from Los Angeles, CA (LA). Measurements of NO_x in LA are from a snapshot campaign that is part of the Multi-Ethnic Study of Atherosclerosis and Air Pollution (MESA Air). The campaign was comprised of three two-week measurement periods in the summer, autumn, and winter, each with approximately 145 measurement sites in the LA area. The design included clusters of monitors on either side of busy roads to capture nearfield gradients. LUR and UK prediction models were created with GIS-based variables and selected based on leave-out-one-cluster cross-validated (CV) R² and root mean square error. Kriging models consistently performed better than the analogous LUR models. The best CV R² values were 0.70, 0.53, and 0.59 for summer, autumn, and winter, respectively. There was no uniformly best model, but a nearly optimal model for all season was also developed. Reasonable UK prediction models for NO_x in LA were developed for the three seasons. Differences in these best models and variation in the coefficients for nearly optimal models suggest that modeling spatial and temporal trends may improve long-term exposure predictions

Keywords: Universal Kriging, oxides of nitrogen, prediction US EPA. "Biostatistics, Epidemiologic and Bioinformatic Training in Environmental Health" (BEBTEH), funded by NIEHS. Discover Center: Cardiovascular Disease and Traffic-Related Air Pollution (P50 ES 015915) (NIEHS). MESA Air: Study of Atherosclerosis, Cardiovascular Disease & Exposure to Ambient Particulate Matter (RD 831697010) (EPA) Note: Although this research was partially supported by the EPA, it does not necessarily reflect the policy of the EPA. BEBTEH: Biostatistics, Epidemiologic and Bioinformatic Training in Environmental Health (T32 ES 015459) (NIEHS)

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Supporting grant: Air pollution, Universal kriging, Land use regression, GIS, Nitrogen oxides

ORAL PRESENTATION

Modelling aboveground tree biomass while achieving the additivity property*T. Goicoa, A.F. Militino, M.D. Ugarte*

C4

Public University of Navarra, Spain

Measuring forest tree biomass is becoming a very important issue due to the general environmental awareness motivated by global warming and climate change. However, weighing a tree is a very complicated, expensive, and destructive process. The tree is divided into several parts, and the total weight is obtained by adding the weight of the different components. The biomass information of a forest is obtained using statistical models, but one of the main difficulties is that the additivity property is not generally satisfied, i.e., when adding the predicted weights for the different tree components, the result does not match up with the total weight predicted for the tree. In this work, alternative methods for obtaining biomass predictions satisfying the additivity property are analyzed. In particular, segmented regression models with a common break point and penalized splines with the same smoothing parameter achieve the additivity property without any further adjustments. Some classical models will be also used for comparison purposes. Results are illustrated with real data from a beech forest (European project FORSEE-020) in the province of Navarra, Spain.

Keywords: Allometry, Beech forest, Penalized splinesPresenting Author's email address: lola@unavarra.es

Supporting grant: This research has been supported by the Spanish Ministry of Science and Innovation (project MTM2008-03085)

POSTER

Risk assessment of the pesticide residues from conventional agriculture in the catchment*Rositsa Mladenova, Aleksandra Neykova, Deyana Shtereva*

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Pesticides application is worldwide used approach to obtain crop production with good technological quality but it results in numbers of adverse effects on the environment. For this control of surface waters and catchment is required for protection of the environment. In our study, a sensitive analytical method was developed for 13 active substances used in conventional agriculture at residue levels based on solid-phase extraction clean up and pre-concentration. Method was optimized by comparison of three types of sorbent (LiChrolut EN, LiChrolut RP-18 and C18) at two spike level 0.05 and 0.1 ppb. LiChrolut EN was found to be most efficient for all analytes as the obtained recoveries were in the range 70 - 120 % with relative standard deviations up to 20 %. The developed method was used for control of impact of agricultural plot (5 ha) on the water quality in Blato river (3 m away) during the vegetation season in 2009 in 4 control points. PIRI approach was applied in order to rank the mobility and toxicity impact. River water control was performed each month from March to October. The obtained results have indicated low levels of water pollution for most of the pesticides. Sampling in August has shown the concentrations of chlorpyrifos, cypermethrin and metalaxyl at inside control point were 2-7 times higher than its concentrations in reference point which correspond to recorded use of the product. Total pesticide level do not exceed permitted level of 0.5 g/l.

Keywords: pesticide residues, GC-MS, PIRI, watersPresenting Author's email address: rmladenova@gmail.com

ORAL PRESENTATION

Comparing permanent versus random line-transect surveys in a geostatistical model-based framework: application to annual change monitoring of Mediterranean fin whale abundance*Pascal Monestiez*¹, *Nathalie Di-Méglio*², *Léa David*²

T16

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The monitoring of protected species like fin whale is a basic need for conservation purposes. But the vast areas occupied by this population cannot be followed permanently, so a strategy consists in monitoring key sites - hot spots - where whales concentrate during summer. Our objective consists in quantifying interannual changes of the fin whale abundance in the Liguro-Provencal Sea (Northwestern Mediterranean Sea). Over a four year period, data were recorded through two kinds of survey; the first one based on few permanent line transects several times per year, the second one pooling randomly located line transects from different opportunity platforms without planned sampling scheme. Summer abundance was assessed each year using a model based approach, i.e. a block Poisson Kriging approach to get an abundance estimate in a given area. The results show all the advantages that give a larger number of random line transects to cover the targeted area. In general, smaller confidence intervals are obtained and random transects give more robust estimates if populations are strongly structured and spatially moving in the area from year to year. Conversely, permanent line transects need probably less assumptions (distributional, stationarity in space) to give quantitative year to year comparisons so this latter approach will be more conservative when little is known and more robust face to model misspecification. However, a problem remains when the number of permanent transect is too low and when populations show high local concentrations that move from one year to the next.

Keywords: survey, distance sampling, abundancePresenting Author's email address: monestiez@avignon.inra.fr

ORAL PRESENTATION

From Institutions to Environmental performance: In the fight against ecological degradation*Hugo Faria*¹, *Hugo Montesinos*², *Daniel Morales*³

C8

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We explore correlations between environmental indicators and social, economic and political measures using a sample of up to 133 countries. We further investigate causal relations using instrumental variables to uncover direction channels from the type and quality of institutions to environmental performance. We find that nations with capitalist and democratic institutions have positive and statistically significant effects on overall environmental performance and human health protection. We find no effect from institutions quality to ecosystem vitality and mixed results with less aggregated ecosystem variables. The findings have economic and policy implications and question the general belief that environmental health is hindered by development.

Keywords: Environmental Performance Index, Institutions, causalityPresenting Author's email address: hugomoises@cesma.usb.ve

ORAL PRESENTATION

Assessment of water quality in a tropical wetland to maintain local water security*Shadananan Nair*

C3

Nansen Environmental Research Centre, India

This paper explains the success story of water quality improvement using low-cost, environment friendly technologies in a wetland region in Kerala, south India. Climate change and anthropogenic impacts highly degraded the water quality, leading to serious shortage of safe water. Industrial development associated with economic expansion, demands of fast rising population, encroachment into water bodies for real estate business etc are some of the factors affecting water quality. Monthly analysis of water sample from the sixteen locations for twelve months showed that presence of organic and inorganic pollutants are very high, water quality is much below safety limits and serious health hazards could be expected in near future. Hardness of water shows that water is totally unfit for human use. Amount of dissolved oxygen has become so low that organisms such as fish and frog disappeared from most of the region. Vector-borne and water-borne diseases affected thousands. Change in rainfall seasonality and a project to multiple crop production affected natural flushing of water. Rainfall is becoming more seasonal, causing erosion and sedimentation in water bodies and making parts of the wetland dry for a few months. However, experiments in the test plot with local technology using locally available material like charcoal and lime shell, and locally made cheap aerators prove that condition can be made better without much financial expense. Deepening and cleaning of the canal to enhance water circulation and erosion control using local plants made a lot of changes. Guidelines for the protection of wetland have been provided

Keywords: Water quality, wetland, India, climate change, sedimentationPresenting Author's email address: nair59@yahoo.com

ORAL PRESENTATION

Change-point detection in environmental time series A Bayesian approach*Du Yang, Anders Nordgaard*

T2

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The success of change point detection facilitates various types of monitoring of environmental and climate change. In this work we use an implementation of a Bayesian method originally proposed by Barry and Hartigan [Journal of the Am. Stat. Assoc. (1993) 88: 309319] that searches for an unknown partition of the series into homogeneous blocks (with respect to the mean value). The method is compared with a segmentation tree algorithm proposed by Grimvall et al. [TIES2009 presentation] in which a dynamic programming solution is employed to search for changes in mean value. Comparisons are made with respect to predictive power using simulation studies with different levels of the signal-to-ratio (SNR) and various patterns of change-point locations. Aspects of complexity in applying the methods to real data sets are also investigated. The results show that the Bayesian approach can outperform the tree algorithm at all levels of the SNR. However both methods show unsatisfactory results under a highly noisy scenario.

Keywords: change-point detection, environmental time series, MCMC, dynamic programmingPresenting Author's email address: anders.nordgaard@liu.se

ORAL PRESENTATION

Water quality in inland waterways of low-lying areas of Vembanad wetlands and the low cost purification strategies*Joseph Sebastian Paimpillil*

C3

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The Vembanad wetlands ((Cochin Backwater), which is the largest wetland system on the west-coast of India is facing environment degradation due to lack of civic sense, poor living standards and unawareness of best and alternate practices in water quality control. Many stretches of the waterways did not have the required flow due to neglect, which leads to environment degradation. The canal bank erosions and silting have reduced the draft, which has resulted in the gradual reduction of flow. The water quality in canals of upper Vembanad was monitored in 2007-2009 and trials of low cost water purification materials and herbs available in the region were performed. Based on DO and BOD, 62.77% of the area was moderately suitable for aquatic life existence and 37.23% was unsuitable for life during the full year. During the pre-monsoon months, only 43.17% was moderately suitable and 56.83% was unsuitable for life. As per BIS guidelines, the water in the canal during monsoon months is classified as Category A and in post monsoon season it is classified as B. During the entire year, the water in the canal is in class C. The perennial grass vetiveria zizanioides was tested to have high sediment holding capacity to control canal bank erosion with high root growth and has high medicinal and economic values. The oxygenating device fabricated from locally available materials and working with wind was found to be suitable for Rejuvenation of canal with improved water quality and it provided trained manpower on water resources management.

Keywords: oxygenating device, Rejuvenation of canal, Vembanad wetlands

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Supporting grant: Grant for developing country participants requested

POSTER

Bayesian Univariate Space - Time Hierarchical Models for Mapping Pollutant Concentrations in the municipal Area of Taranto*Serena Arima*¹, *Lorenza Cretarola*², *Giovanna Jona Lasinio*³, *Alessio Pollice*⁴

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An analysis of air quality data is provided for the municipal area of Taranto (Italy) characterized by high environmental risks as decreed by the Italian government in the 90s. In the context of an agreement between Dipartimento di Scienze Statistiche Università degli Studi di Bari and the local regional environmental protection agency air quality, data were provided concerning six monitoring stations and covering years from 2005 to 2007. In this paper we analyze the daily concentrations of three pollutants highly relevant in such an industrial area, namely SO₂, NO₂ and PM₁₀, with the aim of reconstructing daily pollutants diffusion surfaces for the town area. Taking into account the large amount of sparse missing data and the nonnormality affecting pollutants' concentrations, we propose a full Bayesian separable space-time hierarchical model for each pollutant concentration series. The proposed model allows to embed missing data imputation and prediction of pollutant concentration in a unitary framework. We critically discuss the results, highlighting advantages and disadvantages of the proposed methodology.

Keywords: Bayesian hierarchical model, Bayesian prediction, MCMC, Pollutant diffusion

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ORAL PRESENTATION

Measuring e-Waste as an Integral of Environment Degradation Measurements*Ramachandran Ramasamy*

C4

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Governments are green technology as one of the strategies in combating the environment degradation. In particular, the deployment of information communications technology (ICT), which presumed to reduce pollution through reduction of travel; and reduce destruction of forests through promoting paperless office, where texts and messages are increasingly sent through SMS, via e-mails, softcopy publications, on line business transactions and real time social networking. However, the new age technology revolution has created another problem that is, disposal of e-waste. The e-waste includes disposals of all kinds of electronic equipment such as TVs, , PCs, monitors, printers, batteries, scanners and mobile phones. Indeed, they are highly toxic. When disposed randomly and irresponsibly they can affect the quality of air, water and soil, causing detrimental effects to the environment and ecology as well as huge threat to our health. But, close scrutiny of ICT policies of many countries revealed that they lack explicit policies and measurement activities in addressing the e-waste disposal incidences. This paper provides a methodology, involving small area estimation procedures (SAE) on how to formulate a concerted policy strategy in combating the e-waste menace in an organized and systematic manner. In particular, the paper ranks and classifies the 924 lowest administrative units in Malaysia under a 8-S Framework, namely skaters, striders, sprinters, sliders, strollers, shufflers, starters and sleepers respectively. The statistical procedures considered include ranking, Goal-Post Method and Dalenius-Hodges method of stratification. In policy terms, such area prioritization is crucial for effective and efficient resource allocation in e-waste management.

Keywords: e-Waste, Small Area Estimation, 8-S Framework, Goal-Post Method, Dalenius-Hodges Stratification

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ORAL PRESENTATION

Probabilistic Weather Forecasting using the Geostatistical Output Perturbation Method on Hierarchical Bayesian space-time Models*Lilia L. Ramirez, Ziming Huang, Yulia Gel*

T15

University of Waterloo, Canada

Nowadays probabilistic weather forecasting becomes 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, which is of particular importance for an accurate and reliable assessment of weather related 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 illustrate its application by constructing probabilistic scenarios of temperature in North American Pacific Northwest.

Keywords: probabilistic weather forecasting, spatio-temporal analysis of atmospheric variables

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Supporting grant: NSERC, MITACS Accelerate, SHARCNET

ORAL PRESENTATION

Bayesian Inference for Spatial Zero-Inflated Poisson Regression Models: Oak Regeneration*Stephen L. Rathbun*

T10

University of Georgia, USA

Ecological counts data are often characterized by an excess of zero counts and spatial dependence among sample sites. Excess zeros can occur in regions outside the distribution of a given species, or in habitats unsuitable for that species. A zero-inflated Poisson regression model is developed, under which the species range is determined by a spatial probit model, including physical variables as covariates and spatial dependence among sites. Within that range, species counts are drawn from a Poisson distribution whose mean depends on environmental variables. A Monte Carlo Markov Chain algorithm is developed to implement Bayesian inference for this model. The model is illustrated using data on oak seedling counts from Pennsylvania, U.S.A.

Keywords: Bayesian hierarchical model, MCMC algorithm, Spatial probit model

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ORAL PRESENTATION

Robust Regression Analysis*Hannah Regis; Smail Mahdi*

C8

University of the West Indies, Cave Hill Campus, Barbados

Regression Analysis is a statistical tool that can be used in Environmental Science to analyze data and draw up conclusions. It is used to form a relation between two or more sets of variables. Outliers occur very frequently in data due to faulty equipments and human error. Robust methods give results that are unaffected by these outlier points. In this presentation, we will discuss the method of Partial Least Squares Regression and other robust methods which handle outliers and multicollinearity. Examples will be given to illustrate the effectiveness of the method.

Keywords: Regression, Robust

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ORAL PRESENTATION

A class of covariate-dependent spatiotemporal covariance functions*Brian Reich*

T3

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In geostatistics, it is common practice to model spatially distributed phenomena through an underlying stationary and isotropic spatial process. However, these assumptions are often untenable in practice due to the influence of local effects in the correlation structure. Therefore, it is of prolonged interest in the literature to provide flexible and effective ways to model non-stationarity in the spatial effects. Arguably, due to the local nature of the problem, we might envision that the correlation structure would be highly dependent on local characteristics of the domain of study, namely the latitude, longitude and altitude of the observation sites, as well as other locally defined covariate information. In this work, we provide a flexible and computationally feasible way for allowing the correlation structure of the underlying processes to depend on local covariate information. This is obtained by means of a convenient specification of the mean spatial effects, and their reinterpretation in the covariance domain. We discuss the properties of the induced covariance functions and discuss methods to assess its dependence on local covariate information by means of a simulation study and the analysis of data observed at ozone-monitoring stations in the North-East of the United States

Keywords: covariance estimation, non-stationarity, ozone, spatial data analysis

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Spatial models with applications to forestry inventory*Paulo Ribeiro*

T8

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Geostatistical models describes continuous spatial variation by means of stochastic processes over the space typically characterised by correlation functions. In forestry applications such models can be used in commercial fields to describe rates of growth, spatial variation of biomass, to access relevant information for forestry inventory, spatial analysis of forestry experiments, among others. They can also be used on studies on natural forests on topics such as assessment of biomass, richness and diversity and sampling designs. A sequence of case studies adopting geostatistical models is presented and discussed. Analysis includes systematic experiments, sampling designs and analysis for forestry inventory, bivariate modelling for forestry growth, design and analysis for studies in natural forestry and models and inference for spatial compositional data analysis for modelling proportions of a whole.

Keywords: geostatistics, forestry inventory, spatial statistics, bivariate modelling

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Supporting grant: World Bank

Estimation of PM10/TSP Ratio: Air Quality Puerto La Cruz city, Venezuela*Glady Rincón*^{1,2}, *Lázaro V. Cremades*², *Josep Font*³

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Since 1987, U.S. EPA and WHO rescinded the regulation about total suspended particles (TSP) that the impact of their particle size on health was considered not significant compared with the effect of smaller particles. In spite of that, Venezuela only regulates TSP on 2010. In the Venezuelan city of Puerto La Cruz, TSP is measured daily since 1997, while PM10 has been measured since April 2007 at a sampling station located 3 km from the one that for TSP. This study has established the relationship between PM10 and TSP measured daily in the city of Puerto La Cruz, to estimate the behavior of historical levels of PM10 and compare them with the threshold considered safe by WHO. With the proposed methodology, we have been able to find the daily PM10/TSP ratio in the city, which was equal to 0.402 0.122. Its standard error was high possibly because both sizes of particles are not measured in the same sampling station. Evolution of historical values of PM10-24 hours estimated from measured TSP-24 hours values, shows that levels of PM10 concentrations considered safe by WHO ($= 50\mu\text{g}/\text{m}^3$) have increased up to be permanently over the standard value. This indicates a worsening of air quality in the city.

Keywords: PM10/TSP ratio, PM10, TSP, air quality, Venezuela.

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ORAL PRESENTATION

Best subset selection of variables for analyzing weather ozone*Sara Rodríguez, Hortensia Reyes, Gladys Linares, Humberto Vaquera, Paulino Pérez*

C1

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In this paper, an analysis of extreme values to model the ozone concentrations. The procedure is applied to the Pedregal station data, part of the Atmospheric Monitoring System (SIMAT) Mexico City, these data are highest in three days from 1990 to September 2009. The importance of studying these concentrations of ozone, is that cause health problems short term and long life, especially for humans who live in megacities. Because the wind, temperature variations, the amount of solar radiation and rainfall are the main meteorological factors that influence and determine the distribution, spatial dispersion and concentration of pollutants, the aim of our study is to determine which of several variables weather is more important in explaining the trend in ozone concentrations and thus choose the best subset of environmental variables involved are time, temperature, relative humidity, wind speed, wind direction, chemical variables such as carbon monoxide, carbon dioxide sulfur and nitrogen dioxide with ozone concentrations. Finally we get the variables that most impact in the high ozone concentrations have continued to decline in 2009.

Keywords: generalized extreme value distribution, ozone, selection of variables.

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ORAL PRESENTATION

Pricing Area Yield Crop Insurance Contracts: Spatio-Temporal Approaches*Ramiro Ruiz Cárdenas, Elias Teixeira Krainski*

T11

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Area yield crop insurance is a recent insurance product, in which farmers collect an indemnity whenever the county average yield falls beneath a yield guarantee, regardless of the farmers actual yields. The pricing methodology for this kind of insurance requires the estimation of the expected crop yield at the county level. In this work we develop an integrated approach to pricing this type of contracts based on the space-time modeling and forecasting of county crop yield data series using a hierarchical Bayesian framework, as well as a dynamic modeling approach. Suitable covariates based on the combination of agro-climatic indices were constructed from the seasonal forecasting (four months ahead) of weather data. A huge number of models including regional effects, time trends and time-space interactions as well as different combinations of covariates must be fitted and compared in order to identify the more suitable one to be used in the calculation of the premium rates. To achieve this we adopt a fast inference procedure based on integrated nested Laplace approximations (Rue et al. [Roy. Statist. Soc. Ser. B (2009): 319–392]). Issues related to missing values imputation, change of support problems and seasonal forecasting of covariates are discussed. The methodology is illustrated with a real application where the premium rates of an areal crop yield insurance contract for maize in Paraná state (Brazil) are estimated. An R package that implements the proposed methodology is currently being developed.

Keywords: Bayesian hierarchical models, dynamic models, Laplace approximations, seasonal weather forecast

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ORAL PRESENTATION

Social vulnerability in the risk assessment of groundwater contamination in peri-urban areas. Mar del Plata Balcarce Corridor. República Argentina*Marisa Sagua, Héctor Massone, Mónica Tomás*

C3

Centro de de Investigaciones Ambientales, Centro de Geología de Costas y del Cuaternario. Universidad Nacional de Mar del Plata. República Argentina

Mar del Plata Balcarce corridor covers an urban-rural interface area, with route 226 as a road axis. Connects the cities of Mar del Plata and Balcarce (65 km) with 600,000 and 42,000 people respectively. Complex, dynamic and diverse area, offering extensive biophysical support, fundamentally groundwater, followed by surface water, soil and landscape, is subject to changes in the use of natural resources and human settlements. Intensive and extensive agricultural activities area developed, so like agribusiness, mining of soil, recreation and tourism in mountains ranges, lagoons, near the sea. There are small settlements of first and second home residence, with high social segregation and spatial fragmentation. Uncontrolled growth habitat, unplanned urban expansion, with vulnerable social groups. The aim of this study is to apply a methodology for assessing the risk of contamination of aquifers to incorporate a weighting of the social vulnerability of the exposed population. It plans to make adjustments in selection of variables and processing, taking account previous experiences.(Tiburzio C.2000, Massone H.et al, 2004). The methodology includes: selection of indicators of vulnerability and risk of contamination, application of multivariate spatial analysis techniques to obtain the respective index and contamination index of aquifers. Elaboration of thematic maps(G.I.S.). The results will identify critical areas with vulnerability and risk. The information comes from field survey and statistics of population, housing and household census INDEC (2001). It is expected to contribute to the redefinition and adjustment of an Instrument to provide for decision making, articulating knowledge and tools of natural and social sciences.

Keywords: social vulnerability, risk, contamination, spatial analyse

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Supporting grant: World Bank

PLENARY SESSION

Hierarchical Bayesian Ocean Models*Bruno Sansó**University of California, Santa Cruz, USA*

Hierarchical Bayesian models (HBM) allow for the representation of complex systems in a layered fashion. We start by considering a model to link the observed quantities to unobserved, underlying processes. The next step is to describe the evolution of such processes in space and time. The third is to input information about the parameters that regulate the evolution of the processes. Within the model fitting process, estimation uncertainty is propagated at all levels of the hierarchy. In this talk we will give a review of the use of process convolutions as a general tool to obtain flexible, non-stationary processes in space for environmental data. We will then focus on applications of HBM that use process convolutions for oceanic data. We will consider applications to the estimation of ocean climatologies and detection of long-term trends as well as the problem of merging information from different data sources at different spatial resolutions.

Keywords: Hierarchical Bayesian Models, process convolutions, ocean models

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ORAL PRESENTATION

Analysis of the dependence between large scale climatic variables and rainfall in Venezuela using copulas*Pedro Sequera, Lelys Guenni*

C6

Universidad Simón Bolívar, Caracas, Venezuela

El Niño is a climatic phenomenon widely studied in the last few years and it is currently considered as one of the most important mechanisms of seasonal and decadal climatic variability in the world. Such phenomenon is related to the unusual warming of the sea surface temperature (SST) across the Central and Eastern Tropical Pacific which originates major climate changes on a global scale. The purpose of this work is to measure the impact of this phenomenon in Venezuela, specifically, quantifying the influence of ENSO related variables such as ENSO, SOI and NAO indexes and the sea surface temperature anomalies of both the Pacific and Atlantic Oceans over the rainfall in Venezuela. Previous studies using log-linear Bayesian models and dependence maps showed that the Southern Amazonas and Eastern Bolivar regions have a very high prediction capacity for rainfall during the July-August-September and January-February-March trimesters, whereas the coastline and Eastern part of Venezuela are the high prediction capacity regions in April-May-June. In this work, copulas are used to analyze the empirical bivariate distribution between the large scale climatic variables and the rainfall anomalies. The tail dependence coefficients, estimated through non-parametric methods, showed upper tail dependence in most of the cases which confirms the influence of these variables over the rainfall once the latter reach anomalously high levels. The fact that the results are concordant with previous studies about the effects of El Niño on Northern South-America and the Caribbean make this new line of work an important step to generate statistical robust models which are very important to explain the climate phenomena.

Keywords: El Niño phenomenon, copulas, non-parametric statistics, rainfall.

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ORAL PRESENTATION

A new trend analysis for seasonal time series with consideration of data dependence*Quanxi Shao, Ming Li*

C5

CSIRO Mathematics, Informatics and Statistics, Australia

Trend analysis has been an important tool in assessing hydrological process. However, statistical approaches employed for trend analysis frequently assume independence in hydrological time series. To satisfy the independence assumption, the hydrological series of interest are usually summarized to large scale data (eg. annual) for long-term trend. To assess intra-annual variability, the hydrological series are summarized to several periods within year (eg. season or month) and then analysed separately for each period. Unfortunately, for those seasonal and monthly data, the trend analysis must be conducted using periodic regression for individual periods in order to avoid data dependence. However, the setting of periodic models cannot guarantee the smoothness in model coefficients. In this paper, we develop a trend analysis tool by including a period component in the method. By doing this, the data dependence and seasonality will not be issues but become advantages as information gain for each period. The proposed method treats the change in hydrological series as the interaction between long-term trend and seasonal variation. Functional coefficient models with a periodic component are used for model development. Unlike the traditional functional coefficient models which extend the threshold regression model, our functional coefficient model with periodic components enjoys smoothing changes from year to year. As case studies, the models are applied to Australian streamflows in three typical climate conditions

Keywords: Non-parametric functional-coefficient regression model, Periodic regressive model, Periodicity.

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Supporting grant: the Water Information Research and Development Alliance (WIRADA) between the Australian Bureau of Meteorology's Water Division and CSIRO's Water for a Healthy Country Flagship.

POSTER

Effects of land use change on surface water regime (Case study: Orumieh Lake of Iran)*Shahram Khalighi Sigaroodi, Shiva Ebrahimi*

University of Tehran, Iran

Land use change from rangeland and forest to agriculture and orchard areas which affected water regime, are widely occurred in many parts of Iran. The above mentioned problem has happened in one of Orumieh Lake basin for an area of 1146 km^2 which is located in northwest of Iran. The recent land use map was resulted through satellite images of 1990, 1998 and 2007 as well as field observations and the previous period map was performed by using the aerial photographs of 1955 (which is considered as the oldest documents). In this period 14 % of rangeland is changed into dry farming and 7% of irrigated farming is converted to orchard. The results show that due to land use change in this area, the mean annual discharge has not changed but maximum daily increased and minimum reduced.

Keywords: land use change, Orumieh Lake, Water regime, Regional Development

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ORAL PRESENTATION

Surface-NMR Technology for Hydrogeophysical Exploration in South America and Southern Africa: Adaptive Neuro-Fuzzy Inference Systems for Detection of Very-Weak and Very-Noisy Groundwater Relaxation Signals*Rafik Soltani, Lizhi Xiao*

C3

Faculty of Natural Resources and Information Technology, China University of Petroleum-Beijing

The surface nuclear magnetic resonance (surface-NMR) is a recent technology intended for hydrogeophysical exploration, as well as, a variety of other hydrogeological and subsurface environmental investigations. South America, likewise Southern Africa, are seen as the most challenging regions for the applicability of the current surface-NMR technology, e.g., [Springer-Verlag (2007), ISBN 978-3-540-74669-0: 403-430]. Indeed, throughout those regions, the local Earth's magnetic field has its lowest values. This renders the groundwater relaxation signals very difficult to detect, especially in cases of low groundwater occurrence and relatively strong local electromagnetic noise. Advanced signal processing techniques are key for the detection of surface-NMR relaxation signals from their noisy measurements. In [4th International Workshop on the Magnetic Resonance Sounding Method (2009): 213-218], we have proposed the first Adaptive Neuro-Fuzzy Inference System (ANFIS) for mitigating Surface-NMR noise. In this article, our attempt is to demonstrate new developments of ANFIS for the detection of very-weak Surface-NMR relaxation signals buried into relatively strong electromagnetic noise. We propose new developments for the reduction of the measurement stacking rates. We also propose a new estimator for the parameters of groundwater relaxation signals, namely, the initial amplitude, the decay-time constant, the phase, and the frequency shift. Such parameters are related to aquifer properties, such as the water content, the hydraulic conductivity, and the electrical conductivity which itself provides information on groundwater quality. Therefore, our developments rise the prospect for the applicability of surface-NMR technology for hydrogeophysical assessments throughout challenging regions in South America and Southern Africa.

Keywords: Groundwater, Hydrogeophysics, Surface-NMR, Electromagnetic noise, ANFIS

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ORAL PRESENTATION

Spatial predictive distribution for precipitation based on numerical weather predictions (NWP)*Ingelin Steinsland¹, Veronica J. Berrocal², Brian J. Reich³*

T3

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This work is motivated by a need from hydro power producers in Norway. Their short-term run-off predictions depend on precipitation and temperature forecasts. To quantify the uncertainty in run-off forecast, the uncertainty in the precipitation forecast is needed. A dataset for four and a half years of daily NWP from the European Centre for Medium-Range Weather Forecasts (ECMWF) and precipitation observations for 436 locations in Southern Norway is used in this study. The aim is to find a spatial predictive distribution for precipitation that is calibrated and sharp, as discussed in Gneiting et al [J. Roy. Statist. Soc. Ser. B (2007): 243-268]. For single sites the continuous rank probability score (CRPS) is used to evaluate models, while the spatial performance is evaluated using the energy score. From exploratory analysis we find that the forecasts are biased, and that this bias has a spatial structure. Further it varies with season and weather system. We construct a model by combining and extending the single site model of Bremnes [Mon. Weather Rev. (2004):132: 338-347] and the spatial model of Berrocal et al [The An. of Appl. Stat. (2008):2, 1170-1193]. In addition to the NWP we also allow season and weather system proxies as covariates.

Keywords: Precipitation, probabilistic model, Numerical weather predictions, spatial predictions

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ORAL PRESENTATION

Assessing the Regularity of Occupancy Patterns for Spawning Coho Salmon*Don Stevens*¹, *Julie Firman*², *Quinn Payton*¹, *Lisa Madsen*¹

T1

¹Statistics Department, Oregon State University, USA²Oregon Department of Fish & Wildlife, USA

The manner in which spawning Coho salmon are distributed within the freshwater portion of a population's home range is an important consideration in assessing the conservation status of a population. Healthy populations will experience periods when the distribution of spawners becomes spatially compressed (e.g., during poor marine survival periods) and periods when the spatial distribution of spawners expands (e.g., during good marine survival). The distribution is also influenced by factors that are unrelated to Coho population size, such as weather patterns. The challenge is to select a criterion that will identify restrictions in spawner distribution greater than expected for a healthy population under given marine survival conditions. We propose a statistic to assess the spatial regularity of a point pattern based on the shape of the polygons in a Dirichlet tessellation of the pattern. The SVB statistic measures the departure from maximal regularity of a point pattern on a spatial domain with an irregular boundary. We illustrate the use of the SVB statistic to evaluate the regularity of occupancy patterns for Coho spawners. We apply the statistics to assessing the spatial pattern of Coho spawners in Oregon coastal streams.

Keywords: spatial regularity, salmon, spatial point patternPresenting Author's email address: stevens@stat.oregonstate.edu

ORAL PRESENTATION

Estimating Biomass Change in Coastal Alaska Forests: Statistical Issues*H. Temesgen*¹, *J. Strunk*¹, *H-E. Andersen*²

T1

Oregon State University, USA, USDA Forest Service, USA

Increasingly, large-scale estimates of biomass change play significant roles in providing critical information to forest resource management and policy decision-making. Biomass change estimates are required to monitor CO₂ mitigation projects, characterize forest productivity, and estimate carbon stock change. Yet, estimating biomass change for large-scale inventory and monitoring is a very difficult task, especially in remote areas of the world. Emerging technologies such as light detection and ranging (LiDAR) offer unprecedented opportunities to quantify status and change of forest attributes. Using remote sensed and ground data collected in Coastal Alaska Forests, we demonstrate selected approaches that integrate different data sources and estimate biomass change. Differences over successive measurement periods provided estimates of biomass change, which can vary widely by forest types and productivity classes. In this presentation, we discuss the (1) suitability and predictive abilities of selected estimators to quantify and analyze biomass change in Coastal Alaska forest types, and (2) challenges and opportunities in using successive remotely sensed and ground data to meet resource management challenges, including forest monitoring and assessments.

Keywords: Forest Monitoring; Forest Sampling; LiDAR; Change Inventory; Remote sensingPresenting Author's email address: hailemariam.temesgen@oregonstate.edu

ORAL PRESENTATION

Hidden Markov Models for Gumbel Maxima*Gwladys Toulemonde*¹, *Armelle Guillou*², *Philippe Naveau*³

C5

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Extreme weather and climate events cause huge human and economic damages. Due in part to intrinsic rarity of extreme events, their statistical modeling in time and space remains a difficult challenge. In this talk, we propose innovative statistical models motivated by a problematic in data assimilation of extreme events. More precisely, we plan on focusing on maxima stemming from light-tailed distributions, that means we consider the Gumbel family, one special case of the Generalized Extreme Value distribution. First we will briefly present Gumbel-extended linear autoregressive (AR) models [Toulemonde et al., *Environmetrics* (2010)] and their properties when the process is directly observed. This link between linear AR processes and extreme value theory allows the statistical treatment of extreme environmental recordings in which temporal dependencies are present. As an example, our model is fitted to daily maxima of methane in France. Secondly we present a work in progress focusing on hidden markov models. In other words, the process is only indirectly observed through an other process. In this state space models context, we will propose new models adapted to maxima. Then a comparison of different filtering methods (Kalman filter and different particle filters) will be detailed with regards to quality of estimation of the hidden state but also from a distribution point of view.

Keywords: Extremes, Gumbel distribution, Temporal dependencies, State-space models, Particle filters
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ORAL PRESENTATION

Logistic Models for Large Data Sets with Temporal Autocorrelation for Multiple Animals: Marine Mammal Haul-out Models*Jay M. Ver Hoef*

T7

National Marine Mammal Lab NOAA, USA

In this paper, I discuss several challenges in modelling satellite telemetry data from animals. The data sets are often massive collections of space-time locations on multiple animals. I consider ways to increase computational speed in generalized linear mixed pseudo-models for the case of many repeated measurements on subjects. By developing an analytical inverse for the exponential autocorrelation function for time series data, I developed an estimation algorithm whose time increases linearly with sample size. For most commercial software, computing time increases as the cube of sample size because of covariance matrix inversion. I also find a surprising result; that incomplete optimization for covariance parameters within the larger parameter estimation algorithm actually decreases time to convergence. After comparing various computing algorithms and choosing the best one, I fit a generalized linear mixed model to a percentage time series data set with over 100 fixed effects, 50 random effects, and approximately 150000 observations.

Keywords: pseudo-likelihood, ShermanMorrisonWoodbury, sparse matrix, exponential autocorrelation
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POSTER

Spatio-Temporal models for risk mapping of malaria incidence in Sucre State, Venezuela*Desireé Villalta, Lelys Bravo de Guenni*

Universidad Simón Bolívar, Caracas, Venezuela

A hierarchical Bayesian space-time regression log-Poisson areal model is used to model malaria incidence in 15 municipalities of Sucre state, Venezuela, for the period 1990-2002. Model implementation was done using the software WinBUGS. A conditional autoregressive component (CAR) is included in the model to consider spatial dependence, and a model selection strategy is implemented to select climatic and socio-economic covariables. Assumption of independence of the model residuals is checked by the I de Morán. Model performance is assessed through the Bayesian p-value. Model parameter posterior distributions suggests a high relative risk in more than half of the study years, being agriculture and maximum precipitation the covariables which better explain the spatial patterns of malaria incidence in the study area, followed by poverty indicators covariables

Keywords: Malaria, hierarchical Bayesian models, log-Poisson regression, area models

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POSTER

Principal components analysis for corn (*Zea mays*) producers farms characterization in Guanare municipality, Portuguesa state, Venezuela in 2008 winter cycle*Danny Villegas¹, Tonny García², Luis Piñero², Yary Pérez¹*¹UNELLEZ Guanare-Venezuela, ²UCLA Lara-Venezuela

In this paper presents a corn (*Zea mays*) producers farms and plots characterization, in order to interpret and grading this entry production systems in the Guanare municipality of Portuguesa state in 2008 winter cycle, for which was selected a 41 farms or plots sample, using technical information, socioeconomic, agroecological and institutional of producers association (ASOGUANARE) records. In this regard, were considered twenty six (26) variables, of which were discarded sixteen (16) for not reporting variability. On up data matrix for ten (10) variables was applied a principal components analysis (PCA) and statistical description. In this way, the PCA enabled identify five (5) factors affecting corn production: farm or plot size, planted surface, equipment and machinery limitations, labor constraints limitations and sowing date. Similarly was observed a sowing date (rainfall distribution) and equipment and machinery limitations negative effect on yield. Finally, were identified or classified the 41 farms or plots into three groups discriminated mainly for farm dimension or size.

Keywords: Principal components, characterization, farms and corn

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ORAL PRESENTATION

Network Design for Ozone Monitoring over France: Reduction of Redundant Stations and Displacement of Background Stations*Lin Wu , Marc Bocquet*

T16

Université Paris-Est, CEREAs, joint laboratory École des Ponts ParisTech, France, EDF R&D

In the network reduction problem, we examine how well a subset of the BDQA network can represent the full network. By this way, the efficiency of the complete BDQA network is evaluated. Significant improvements can be obtained through optimal reduction. For instance, removing optimally half the stations leads to an estimation error of the order of the standard observational error. In the network displacement problem, a set of design objectives are assessed, e.g. geometrical criteria of space-filling type, minimization of kriging error, and performance of the reconstruction of ozone fields (generated by simulations of a chemistry-transport model or by data assimilation experiments). By displacing background stations to regular grid points over France, significant improvements against the original background BDQA network have been found under all the proposed criteria. The impact of the different criteria on displacement is also discussed.

Keywords: Network design, ozone, geostatisticsPresenting Author's email address: Lin.Wu@cerea.enpc.fr

POSTER

Spatial and Space-time models for historical monthly rainfall in Venezuela*Lelys Guenni, Pedro Sequera, Jesus Yerena*

Depto. de Cómputo Científico y Estadística, Centro de Estadística y Software Matemático, Universidad Simón Bolívar

Developing spatially continuous high quality climatic surfaces for different geographic regions has always been a data intensive effort and a very challenging task. Poor data quality and data sparsity are two important constraints in this analysis. Two well known approaches for spatial prediction are Kriging and Thin Plate Smoothing Splines. Both methods are considered to develop monthly rainfall surfaces for Venezuela. Thin Plate Smoothing Splines are used to interpolate monthly time series of historical rainfall measured at a set of fixed locations. In this case a smooth function is fitted to the point data values for each month, and the degree of smoothness is estimated by minimizing the Generalized Cross Validation (GCV). This unknown function might depend on several covariables in a non-parametric form. Spatial dependence on elevation is carefully explored due to its crucial influence on rainfall variability. However, the spatial and temporal dependence are difficult to separate and usually temporal information enhances spatial estimation specially in data sparse regions. A hierarchical Bayesian Kriging approach is used considering the space-time nature of the data. For this approach all available years of monthly data are assembled into homogeneous sub domains assuming a common covariate model for each sub domain. The squared root of rainfall data is assumed to be normally distributed with mean function depending on unknown parameters of a covariate model. A non-stationary covariance structure without a specific form is assumed. Model uncertainty is incorporated in the posterior predictive distribution. Both methodologies are compared by estimating the root mean squared residuals and the absolute mean square error at the gauged locations and results are presented for the Bolívar state located at the south-east of Venezuela.

Keywords: Hierarchical Bayesian Kriging, Thin Plate Smoothing Splines, Space-time modelling, Monthly RainfallPresenting Author's email address: jyerena@cesma.usb.ve

ORAL PRESENTATION

Asymptotic Analysis of Correlated Data from Adaptive Designs*Yanqing Yi*

T14

Memorial University of Newfoundland, Canada

Adaptive design, which uses sequentially available information to modify the original design without undermining the validity and integrity of the study, is gaining popularity due to its potential efficiency or ethical advantages. However data collected from adaptive designs have a certain dependency structure. We explore this dependency and investigate asymptotic properties of parameter estimators. The asymptotic efficiency of consistent estimators is established by means of large deviation. Ideas used in the asymptotic methods are potentially applicable to spatially or temporally correlated environmental data.

Keywords: Adaptive Design, Correlated Data, Asymptotic EfficiencyPresenting Author's email address: Yanqing.Yi@med.mun.ca

Supporting grant: IRIF Start-Up

ORAL PRESENTATION

An information-theoretic approach to quantify source of uncertainty in climate predictions*Stan Yip*

C2

Exeter Climate Systems, University of Exeter, UK

We present a novel information-theoretic approach to interpret uncertainty in climate predictions. The method, which is analogous to variance decomposition in ANOVA, compares distance between probability distributions rather than variance between different simulation runs. In this talk, we provide two examples that how to decompose sources of uncertainty in terms of entropy.

Keywords: Climate prediction, information theory, entropyPresenting Author's email address: c.y.yip@ex.ac.uk

ORAL PRESENTATION

Design and Relative Efficiency in Two-Phase Studies*Yang Zhao¹, Jerald F. Lawless², Donald L. McLeish²*

T14

University of Regina, Canada, University of Waterloo, Canada

This research compares two-phase sampling design with one-phase design in regard to obtaining efficient estimates of regression parameters while minimizing the cost of data collection. It derives closed form expression of the asymptotic relative efficiency of the maximum likelihood estimators from the two designs based on fully parametric normal models which allows us to have insight into the available information for regression models contained in the observed data sets from the two designs. It further discusses when we should apply the two-phase sampling design instead of the one-phase sampling design and how to decide the sample sizes for the two-phase samples.

Keywords: Asymptotic relative efficiency, Maximum likelihood, Normal model, Surrogate variable, Two-phase designPresenting Author's email address: zhaoyang@uregina.ca

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