College of Letters and Science
Department of Statistics
UC Davis

Statistical Sciences
Symposium, 2014

Spatial-Temporal Statistics: Methods and Applications

SATURDAY
April
26

8:30 a.m. – 5:15 p.m.
Mathematical Sciences Building 1147
399 Crocker Lane, UC Davis

Followed by a reception starting at 6:00pm at the **U.S. Bicycling Hall of Fame,** 303 3rd Street

UC**DAVIS**

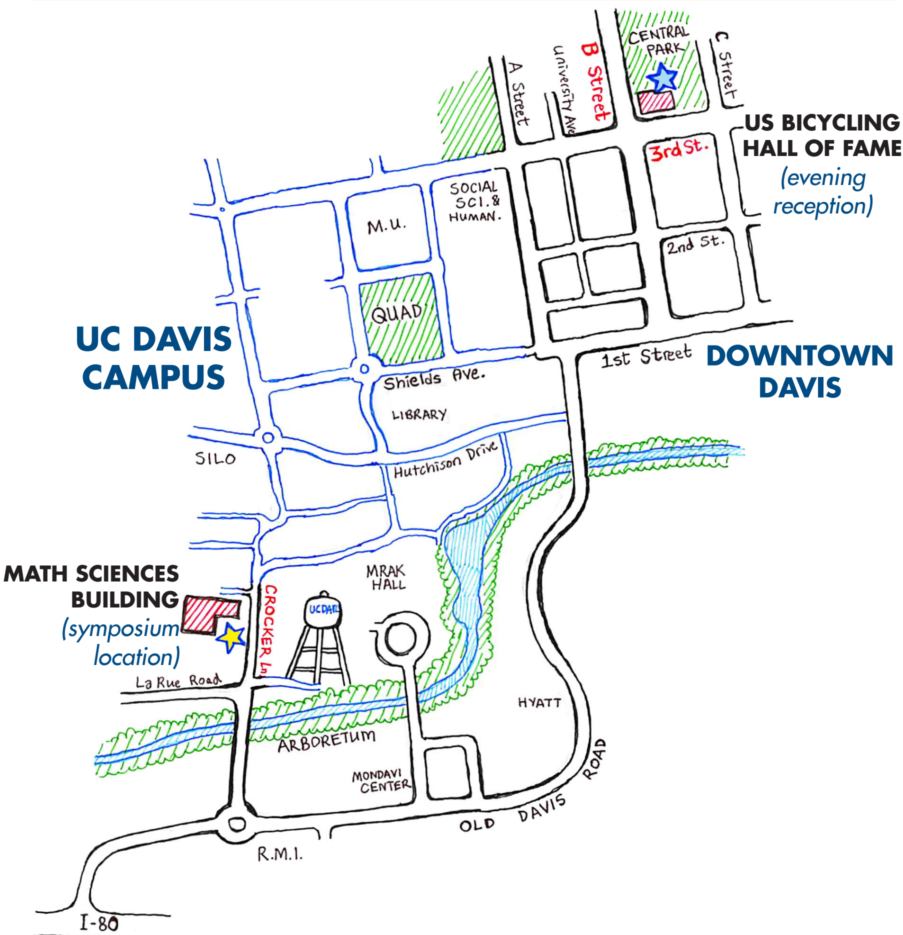
UC Davis Statistical Sciences Symposium 2014

Spatial-Temporal Statistics: Methods and Applications

Co-sponsored by the MPS Dean's Office of UC Davis, NSF via an RTG training grant, and the Graduate School of Management of UC Davis

Saturday, April 26, 2014

Location: Room 1147, Mathematical Sciences Building



PROGRAM

8:30 - 9:00 AM: Registration, Breakfast, **Room 1147**

Session 1 (Chair : Thomas Lee)

9:00 - 9:15 AM: Welcome address
Alexandra Navrotsky, Dean, Mathematical and Physical Sciences
Hans-Georg Müller, Chair, Department of Statistics
9:15 - 9:45 AM: Douglas Nychka (Natl Center for Atmospheric Research)
9:45 - 10:15 AM: Curtis Storlie (Los Alamos National Laboratory)

Break

Session 2 (Chair : Paul Baines)

10:40 - 11:10 AM: Alexander Aue (University of California, Davis)
11:10 - 11:40 AM: Chris Fassnacht (University of California, Davis)
11:40AM - 12:10 PM: Ethan Anderes (University of California, Davis)

Lunch at **Tercero Dining Commons**

Session 3 (Chair : Hao Chen)

1:40 - 2:10 PM: Peter Guttorp (University of Washington, Seattle)
2:10 - 2:40 PM: Bala Rajaratnam (Stanford University)
2:40 - 3:10 PM: Mikyoung Jun (Texas A&M University)

Break

Session 4 (Chair : Jie Peng)

3:35 - 4:05 PM: Alan Hastings (University of California, Davis)
4:05 - 4:35 PM: Cari Kaufman (University of California, Berkeley)
4:35 - 5:05 PM: Debashis Paul (University of California, Davis)

5:05 - 5:15 PM: Closing Remarks
Jane-Ling Wang (University of California, Davis)

6:00 - 9:00 PM: Reception at the **US Bicycling Hall of Fame**
(303 3rd Street, corner of B Street)

LIST OF ABSTRACTS

ETHAN ANDERES (University of California, Davis)

Title : **"Bayesian estimates of CMB gravitational lensing"**
Estimating the gravitational lensing of the Cosmic Microwave Background (CMB) has become an exciting new probe of dark matter and for constraining cosmological models of universe. Nearly all of the recent statistical results on gravitational lensing utilized the, so called, quadratic estimator developed by Hu and Okamoto (2001, 2002). However, the results of Hirata and Seljak (2003) demonstrate that the quadratic estimate based on the polarization fields can be significantly sub-optimal to the maximum likelihood estimate. Unfortunately likelihood inference becomes computationally prohibitive when masking and nonstationary noise corrupt the observations. In this talk we present some new techniques that circumvent some of these computational challenges. We present two new FFT based algorithms which make an approximate Gibbs sampling from the posterior feasible. One of the algorithms uses a message passenger approach which is specifically designed to handle large masking and nonstationary noise for fast conditional simulation of the de-noised lensed CMB field. The second algorithm utilizes a FFT characterization of the gradient of the likelihood with respect to the anti-lensing gravitational potential.
This is a joint work with Benjamin Wandelt and Guilhem Lavaux.

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ALEXANDER AUE (University of California, Davis)

Title : **"On the prediction of stationary functional time series"**
This talk addresses the prediction of stationary functional time series. Existing contributions to this problem have largely focused on the special case of first-order functional autoregressive processes because of their technical tractability and the current lack of advanced functional time series methodology. It is shown here how standard multivariate prediction techniques can be utilized. The connection between functional and multivariate predictions is made precise for the case of vector and functional autoregressions. The proposed method is easy to implement, making use of existing statistical software packages, and may therefore be attractive to a broader, possibly non-academic, audience. Its practical applicability is enhanced through the introduction of a novel functional final prediction error model selection criterion that allows for an automatic determination of the lag structure and the dimensionality of the model. The usefulness of the proposed methodology is demonstrated in a simulation study and an application to environmental data, namely the prediction of daily pollution curves describing the concentration of particulate matter in ambient air.

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CHRIS FASSNACHT (University of California, Davis)

Title : **"Gravitational lens time delays : an exercise in matching time series"**
The measurement of time delays in gravitational lens systems is a key component

to using these systems to measure the distance scale in the Universe. I will briefly describe the lensing technique, and then focus on the mechanics of measuring the time delays. The inputs to the time delay determinations are light curves, which are measurements of brightness as a function of time, of the multiple lensed images. Each light curve is a magnified and time-shifted version of the light curve of the lensed object. The basic idea is to find the delay and magnification that provides the best match between pairs of light curves, in the presence of noise, irregular sampling, and contaminating signals. I will discuss the techniques that have been used in the astrophysics community, and present the Time Delay Challenge that is being used to assess the various approaches.

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PETER GUTTORP (University of Washington, Seattle)

Title : **"Visualization of uncertainty in climate science"**

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ALAN HASTINGS (University of California, Davis)

Title : **"Spatio-temporal dynamics and Tribolium"**

In joint work with Brett Melbourne and Ty Tuff, we have been investigating the spatio-temporal dynamics of Tribolium using highly replicated (by ecological standards) laboratory experiments. In order to understand the results, we have developed careful models that have required the incorporation of different forms of variability. I will discuss both the models and the application to the experimental results.

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MIKYOUNG JUN (Texas A&M University)

Title : **"Assessing fit in Bayesian models for spatial processes"**

Gaussian random fields are frequently used to model spatial and spatial-temporal data, particularly in geostatistical settings. As much of the attention of the statistics community has been focused on defining and estimating the mean and covariance functions of these processes, little effort has been devoted to developing goodness-of-fit tests to allow users to assess the models' adequacy. We describe a general goodness-of-fit test and related graphical diagnostics for assessing the fit of Bayesian Gaussian process models using pivotal discrepancy measures. Our method is applicable for both regularly and irregularly spaced observation locations on planar and spherical domains.

The essential idea behind our method is to evaluate pivotal quantities defined for a realization of a Gaussian random field at parameter values drawn from the posterior distribution. Because the nominal distribution of the resulting pivotal discrepancy measures is known, it is possible to quantitatively assess model fit directly from the output of MCMC algorithms used to sample from the posterior distribution on the parameter space. We illustrate our method in a simulation study and in two applications.

This is joint work with Matthias Katzfuss and Valen Johnson (Texas A&M University) and Jianhua Hu (MD Anderson Cancer Center).

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CARI KAUFMAN (University of California, Berkeley)

Title : **"Inference for spatial extremes"**
I will discuss the problem of Bayesian inference for the location of the global extreme of a nonparametric regression function or latent spatial field. Modeling the unknown function using a Gaussian Process (GP) prior, I will describe a novel algorithm that makes use of existing optimization routines to simultaneously sample and optimize the GP realizations in a computationally efficient manner. I will demonstrate our method on a spatial data set with non-Gaussian observations as well as an application in astronomy in which the location of the extreme varies temporally. R code for the examples is available.
This is a joint work with Wayne Lee.

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DOUGLAS NYCHKA (National Center for Atmospheric Research)

Title : **"Spatial methods that combine ideas from wavelets and lattices"**
Kriging is a non-parametric regression method used in geostatistics for estimating curves and surfaces and forms the core of most statistical methods for spatial data. In climate science these methods are very useful for estimating how climate varies over a geographic region when the observational data is sparse or the computer model runs are limited. A statistical challenge is to implement spatial methods for large sample sizes, a common feature of many geophysical problems. Here a new family of covariance models is proposed that expands the field in a set of basis functions and places a Gaussian Markov random field (GMRF) latent model on the basis coefficients. The idea, in contrast to fixed rank Kriging, is to use many basis functions organized on lattices. In addition, the basis functions add more smoothness and larger scale spatial dependence that a GMRF alone. A practical example is also presented for a subset of the North American Regional Climate Change and Assessment Program model data. Here fields on the order 104 observations are compared within the R data analysis environment.

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DEBASHIS PAUL (University of California, Davis)

Title : **"A random matrix perspective of separable covariance models"**
We consider the separable covariance model often used in spatio-temporal statistics. Accordingly, we assume that the data, represented as a matrix, where the rows represent spatial locations and columns represent time points, is expressed as $X = A^{1/2}ZB^{1/2}$, where A is a $p \times p$ positive semi-definite matrix, B is an $n \times n$ positive semi-definite matrix, and Z is an $n \times p$ matrix with i.i.d. standardized entries. We prove that under suitable regularity conditions, if $p, n \to \infty$ such that $p/n \to 0$, then the distribution of eigenvalues of the normalized sample covariance matrix $\sqrt{n/p}(S - E(S))$ where $S = n^{-1}XX^T$ converges almost surely to a nonrandom limiting distribution related to the semi-circle law. We use this result to propose a test for the hypothesis that the data have a specific separable covariance structure and illustrate its performance through simulations.
This is a joint work with Lili Wang (Zhejiang University).

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BALA RAJARATNAM (Stanford University)

Title : **"A spatial modeling approach to high dimensional statistical paleoclimate reconstructions"**

The study of climate over the earth's history is a topic of current interest whose relevance has increased rapidly with the growing concern over climate change. Reconstructing climates of the past (sometimes referred to as the "hockey stick" problem) has been used to understand whether the current climate is anomalous in a millennial context. To this end, various statistical climate field reconstructions (CFR) methods have been proposed to infer past temperature from (paleoclimate) multiproxy networks. We propose a novel statistical climate field reconstruction method that aims to use recent advances in statistics, and in particular, high dimensional sparse covariance estimation to tackle this problem. The new CFR method provides a flexible framework for modeling the inherent spatial heterogeneities of high-dimensional spatial fields and at the same time provide the parameter reduction necessary for obtaining precise and well-conditioned estimates of the covariance structure of the field, even when the sample size is much smaller than the number of variables. Our results show that the new method can yield significant improvements over existing methods, with gains uniformly over space. We also show that the new methodology is useful for regional paleoclimate reconstructions, and can yield better uncertainty quantification. We demonstrate that the increase in performance is directly related to recovering the underlying structure in the covariance of the spatial field. We also provide compelling evidence that the new methodology performs well even at spatial locations with few proxies.
This is a joint work with D.Guillot and J. Emile-Geay.

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CURTIS STORLIE (Los Alamos National Laboratory)

Title : **"Spatiotemporal modeling of node temperatures in supercomputers"**

Los Alamos National Laboratory (LANL) is home to many large supercomputing clusters. These clusters require an enormous amount of power (2000 kW each), much of which is required for cooling. Recently a project was initiated to increase the supply temperature of the cooling system used to cool one of the rooms housing three of these large clusters. This work focuses on the statistical approach used to quantify the effect that several sequential supply temperature increases had on the temperatures of the individual nodes of the computers. The largest cluster in the room has 1600 nodes that run a variety of jobs during general use. A Gaussian Markov random field (GMRF) model is used to model the trend of the node temperatures as the cooling changes take place. A t-copula along with a generalized Pareto distribution is used to model the tail behavior of the random fluctuation of node temperatures over time while running a particular job. This model is then used to (i) assess the condition of the node temperatures after each temperature increase, (ii) predict the effect of subsequent increases, and (iii) ultimately decide when any further temperature increase would become unsafe. This same process will also be applied to reduce the cooling expenses for the other supercomputing rooms at LANL.

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