Recent Advances and Trends in Time Series Analysis: Nonlinear Time Series, High Dimensional Inference and Beyond
Sunday, April 27 - Friday May 2, 2014

MEALS

*Breakfast (Buffet): 7:00–9:30 am, Sally Borden Building, Monday–Friday
*Lunch (Buffet): 11:30 am–1:30 pm, Sally Borden Building, Monday–Friday
*Dinner (Buffet): 5:30–7:30 pm, Sally Borden Building, Sunday–Thursday
Coffee Breaks: As per daily schedule, in the foyer of the TransCanada Pipeline Pavilion (TCPL)
***Please remember to scan your meal card at the host/hostess station in the dining room for each meal.**

MEETING ROOMS

All lectures will be held in the lecture theater in the TransCanada Pipelines Pavilion (TCPL). An LCD projector, a laptop, a document camera, and blackboards are available for presentations.

SCHEDULE

Titles of the talks and abstracts can be found below the schedule.

Sunday	
16:00	Check-in begins (Front Desk - Professional Development Centre - open 24 hours)
17:30–19:30	Buffet Dinner, Sally Borden Building
20:00	Informal gathering in 2nd floor lounge, Corbett Hall Beverages and a small assortment of snacks are available on a cash honor system.
Monday	
7:00–8:45	Breakfast
8:45–9:00	Introduction and Welcome by BIRS Station Manager, TCPL
9:00	Lectures
09:00-09:30	**Peter Robinson**
09:30-10:00	**Liudas Giraitis**
10:00-10:30	Coffee Break, TCPL
10:30	Lectures
10:30-11:00	**Ejaz Ahmed**
10:30-11:00	**Daniel Pena**
11:30–13:00	Lunch
13:00–14:00	Guided Tour of The Banff Centre; meet in the 2nd floor lounge, Corbett Hall
14:00	Group Photo; meet in foyer of TCPL (photograph will be taken outdoors so a jacket might be required).
14:30	Lectures
14:30-15:00	**Rainer Dahlhaus**
15:00-15:30	Coffee Break, TCPL
15:30	Lectures
15:30-16:00	**Piotr Kokoszka**
16:00-16:30	**Eniuce Menezes**
16:30-17:00	**David Stoffer**
17:30–19:30	Dinner

Tuesday

7:00–9:00	Breakfast
9:00	Lectures
09:00-09:30	**Murad Taqqu**
09:30-10:00	**Vladas Pipiras**
10:00-10:30	Coffee Break, TCPL
10:30	Lectures
10:30-11:00	**Gail Ivanoff**
11:00-11:30	**Jens-Peter Kreiss**
11:30–13:30	Lunch
13:30	Lectures
13:30-14:00	**Francois Roueff**
14:00-14:30	**Nozer Singpurwalla**
14:30-15:00	**Mohsen Pourahmadi**
15:00-15:30	Coffee Break, TCPL
15:30	Lectures
15:30-16:00	**Zhengyan Lin**
16:00-16:30	**Bojan Basrak**
16:30-17:00	**Robert Lund**
17:30–19:30	Dinner

Wednesday

7:00–9:00	Breakfast
9:00	Lectures
09:00-09:30	**Thomas Mikosch**
09:30-10:00	**Timothy McMurry**
10:00-10:30	Coffee Break, TCPL
10:30	Lectures
10:30-11:00	**Herold Dehling**
11:00-11:30	**Michael Baron**
11:30–13:30	Lunch
	Free Afternoon
17:30–19:30	Dinner

Thursday

7:00–9:00	Breakfast
9:00	Lectures
09:00-09:30	**Holger Drees**
09:30-10:00	**Gemal Chen**
10:10-10:30	Coffee Break, TCPL
10:30	Lectures
10:30-11:00	**Zhou Zhou**
11:00-11:30	**Martin Wendler**
11:30–13:30	Lunch
13:30	Lectures
13:30-14:00	**Dan Nordman**
14:00-14:30	**Piotr Fryźlewicz**
14:30-15:00	**Sofia Olhede**
15:00-15:30	Coffee Break, TCPL
15:30	Lectures
15:30-16:00	**Lilia Leticia Ramirez Ramirez**
16:00-16:30	**Hernando Ombao**
16:30-17:00	**Slava Lyubchich**
17:30–19:30	Dinner

Friday

7:00–9:00	Breakfast
9:00	Lectures
09:00-09:30	**Edit Gombay**
09:30-10:00	**Rogemar Mamon**
10:00-10:30	**Reg Kulperger**
10:30–11:30	Coffee Break, TCPL; Informal Discussions
11:30–13:30	Lunch
Checkout by 12 noon.	

** 5-day workshop participants are welcome to use BIRS facilities (BIRS Coffee Lounge, TCPL and Reading Room) until 3 pm on Friday, although participants are still required to checkout of the guest rooms by 12 noon. **

Recent Advances and Trends in Time Series Analysis: Nonlinear Time Series, High Dimensional Inference and Beyond
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ABSTRACTS
(in alphabetic order by speaker surname)

Speaker: **Ejaz Ahmed** (Brock University/University of Windsor, Canada)
Title: *Big Data, Big Bias, Small Surprise*
Abstract: In high-dimensional statistics settings where number of variables is greater than observations, or when number of variables are increasing with the sample size, many penalized regularization strategies were studied for simultaneous variable selection and post-estimation. However, a model may have sparse signals as well as with a number predictors with weak signals. In this scenario variable selection methods may not distinguish predictors with weak signals and sparse signals. The prediction based on a selected submodel may not be preferable in such cases. For this reason, we propose a high-dimensional shrinkage estimation strategy to improve the prediction performance of a submodel. Such a high-dimensional shrinkage estimator (HDSE) is constructed by shrinking a ridge estimator in the direction of a candidate submodel. We demonstrate that the proposed HDSE performs uniformly better than the ridge estimator. Interestingly, it improves the prediction performance of given candidate submodel generated from most existing variable selection methods. The relative performance of the proposed HDSE strategy is appraised by both simulation studies and the real data analysis.

Speaker: **Michael Baron** (University of Texas at Dallas, US)
Title: *Bayesian and asymptotically pointwise optimal change-point detection in multivariate time series*
Abstract: Bayesian multichannel change-point detection problem is studied for simultaneously observed time series, where each component can experience a sudden change in distribution. The loss function penalizes for false alarms and detection delays, and the penalty increases with each missed change-point. Asymptotically pointwise optimal (APO) rules are obtained, translating the classical concept of Bickel and Yahav to the sequential change-point detection. These APO rules are attractive because of their simple analytic form, direct computation, and weak assumptions. Extensions for the case of nuisance parameters are rather straightforward.

The new methods are applied in environmental science, finance, and energy disaggregation. In epidemiology, APO rules are constructed for the early detection of unusual patterns, epidemics, and pre-epidemic trends. Epidemic models often involve nuisance parameters, time-dependence, nonstationarity, and rather complex prior distributions. Proposed APO rules can operate under these conditions, achieving asymptotic optimality.

Speaker: **Bojan Basrak** (University of Zagreb, Croatia)
Title: *On heavy tailed time series and functional limit theorems*
Abstract: It is well known that stationary distribution of some standard (nonlinear) time series models, like GARCH for instance, exhibits regularly varying tails. Typically, the regular variation property extends to all finite dimensional distributions of such processes. This fact, together with some natural restrictions on dependence within the series, allows one to describe the asymptotic behavior of extremes and partial sums for such models. We discuss this type of results in detail, and show how can use them to obtain new functional limit theorems for various time series models. The choice of topology used in those theorems turns out to be important.

Speaker: **Gemai Chen** (University of Calgary, Canada)
Title: *Dependent Extremes*

Abstract: The literature on extreme values is rich when the extremes are independent or asymptotically independent. When the extremes are dependent, not much experience is available, especially for finite sample data analysis. This talk reports some results obtained in studying finite sample dependent extremes.

Speaker: **Rainer Dahlhaus** (Heidelberg University, Germany)
Title: *Local polynomial fits for locally stationary processes*
Abstract: We develop the concept of local polynomial fits for parameter curves for locally stationary processes. We derive the asymptotic properties of these estimates and discuss how the bandwidth can be chosen. We also discuss local polynomial spectral estimates.

Speaker: **Herold Dehling** ((Ruhr-Universität Bochum, Germany)
Title: *Robust Change-Point Tests for Time Series*
Abstract: We present recent developments on robust change-point tests for time series, both in the short-range as well as in the long-range dependent case. Given the data $X_1, \ldots, X_n$, we test the hypothesis of a level shift at an unknown point in time. Our tests are based on common two-sample tests, such as the Wilcoxon test and the Hodges-Lehmann test. Specifically, we study the test statistics $\max_{1\le k\le n-1} \sum_{i=1}^{k} \sum_{j=k+1}^{n} 1_{\{X_i \le X_j\}}$, and $\max_{1\le k\le n-1} \text{median}\{(X_j - X_i) : 1 \le i \le k < j \le n\}$. We derive the asymptotic distribution of these test statistics, and more generally of two-sample U-processes and U-quantiles of dependent data, both under the hypothesis as well as under local alternatives. (Joint work with Roland Fried (Dortmund), Murad Taqqu (Boston), Aeneas Rooch, Martin Wendler (Bochum).)

Speaker: **Holger Drees** (University of Hamburg, Germany)
Title: *Improved Estimation of the Distribution of a Tail Chain*
Abstract: Consider a stationary Markov process $(X_t)_{t\in\mathbb{Z}}$ with regularly varying marginal distributions. Then the conditional distribution of $(X_{-s}/|X_0|, \ldots, X_{+t}/|X_0|)$ given that $|X_0| > u$ converges to the distribution of the so-called (spectral) tail chain $(M_{-s}, \ldots, M_t)$ for all $s, t \ge 0$. Segers (2007) established a relationship between the distribution of the tail chain $(M_{-s}, \ldots, M_t)$ and the distribution after an arbitrary time shift, i.e. of $(M_{i-s}, \ldots, M_{i+t})$; see also Janßen and Segers (2014) and Basrak and Segers (2009). In particular, if $X_t \ge 0$ a.s., then $P\{M_1 > x\} = E\big(M_{-1}^{\alpha} 1_{\{M_{-1}<1/x\}}\big)$ with α denoting the index of regular variation.

A natural estimator of the survival function $P\{M_1 > x\}$ is its empirical counterpart

$$\hat{\bar{F}}^{(f)}(x) := \frac{\sum_{t=1}^{n-1} 1_{(x,\infty)}(X_{t+1}/X_t) 1_{(u_n,\infty)}(X_t)}{\sum_{t=1}^{n-1} 1_{(u_n,\infty)}(X_t)}$$

for a sufficiently high threshold u_n. However, using the above relationship one may estimate $P\{M_1 > x\}$ also by

$$\hat{\bar{F}}^{(b)}(x) := \frac{\sum_{t=2}^{n} (X_{t-1}/X_t)^{\alpha} 1_{[0,1/x)}(X_{t-1}/X_t) 1_{(u_n,\infty)}(X_t)}{\sum_{t=2}^{n} 1_{(u_n,\infty)}(X_t)}$$

if α is known, and replace α with some estimator otherwise. We prove asymptotic normality of these two estimators (as a function of x) using the theory of empirical processes of cluster functionals developed in Drees and Rootzén (2010). It turns out that for sufficiently large values of x, the estimator $\hat{\bar{F}}^{(b)}(x)$ has a smaller asymptotic variance. Moreover, we discuss how to combine both estimators to improve the estimation error.

The results demonstrate that one may construct more efficient estimators of the serial extremal dependence structure of a time series by exploiting the specific structure of its tail chain.

References

Basrak, B., and Segers, J. (2009). Regularly varying multivariate time series. *Stoch. Proc. Appl.* **119**, 1055-1080.

Drees, H., and Rootzén, H. (2010). Limit theorems for empirical processes of cluster functionals. *Ann. Stat.* **38**, 2145–2186.

Janßen, A., and Segers, J. (2014). Markov tail chains. *J. Appl. Probab* **51**, to appear.

Segers, J. (2007). Multivariate regular variation of heavy-tailed Markov chains. Institut de statistique, Université catholique de Louvain, Discussion Paper 0703, arXiv:0701411.

(joint work with Johan Segers and Michał Warchoł, Université catholique de Louvain)

Speaker: **Piotr Fryźlewicz** (London School of Economics, UK)
Title: *Modelling multivariate financial returns using changepoint-induced multiscale bases*
Abstract: Low-frequency financial returns can be modelled as centered around piecewise-constant trend functions which change at certain points in time. We propose a new stochastic time series framework which captures this feature. The main ingredient of our model is a hierarchically-ordered oscillatory basis of simple piecewise-constant functions. It differs from the Fourier-like bases traditionally used in time series analysis in that it is determined by change-points, and hence needs to be estimated from the data before it can be used. The resulting model enables easy simulation and provides interpretable decomposition of non-stationarity into short- and long-term components. The model permits consistent estimation of the multiscale change-point-induced basis via binary segmentation (or other methods), which results in a variable-span moving-average estimator of the current trend, and allows for short-term forecasting of the average return (joint work with Anna Louise Schroeder).

Speaker: **Liudas Giraitis** (Queen Mary University of London, UK)
Title: *Autoregressive conditional duration and FIGARCH models: origins of long memory*
Abstract: Although properties of ARCH(∞) model are well investigated, existence of long memory FIGARCH and IARCH solution was not established in the literature. These two popular ARCH type models which are widely used in applied literature, were causing theoretical controversy because of suspicion that other solutions besides the trivial zero one, do not exist. Since ARCH models with non-zero intercept have a unique stationary solution and exclude long memory, existence of finite variance FIGARCH and IARCH models and, thus, possibility of long memory in ARCH setting was doubtful. The present paper solves this controversy by showing that FIGARCH and IARCH equations have a non-trivial covariance stationary solution, and that such solution exhibits long memory. Existence and uniqueness of stationary Integrated AR(∞) processes is also discussed, and long memory as inherited their feature is established. Summarizing, we show that covariance stationary IARCH, FIEGARCH and IAR(∞) processes exist, their class is wide, and they do not have short memory (joint work with D Surgailis and A Skarnulis).

Speaker: **Edit Gombay** (University of Alberta, Canada)
Title: *Change Detection for Time Series Following Generalized Linear Models*
Abstract: The models considered are of great practical importance as they are used in measuring health care performance, in following financial markets, analysing industrial processes, and in climate studies. We survey recent theoretical developments concerning logistic and other regression models that allow AR(p)-type dependence structure together with the presence of covariates. Conditions are set for the Maximum Partial Likelihood Estimators existence and its convergence to the true value. We can prove that this convergence is at the optimal rate. The performance of the score vector of the partial likelihood function is analysed. We can use it for change detection and in sequential monitoring. Its usefulness will be demonstrated on data from clinical studies.

Speaker: **Gail Ivanoff** (University of Ottawa, Canada)
Title: *Asymptotics for Causal Linear Fields*
Abstract: An elegant martingale method due to Gordin may be used to analyze the asymptotic behaviour of the empirical distribution $F_n(x) = \frac{1}{n}\sum_{i=1}^{n} I(X_i \le x)$ of a stationary stochastic process $(X_1, X_2, ...)$. In the case of a short range dependent causal linear process $X_i = \sum_{u=0}^{\infty} a_u \xi_{i-u}$, this technique yields simple sufficient conditions for a functional central limit theorem. Provided that the innovations (ξ_i)

have a moment of any order and there is corresponding summability of the coefficients (a_u), the usual assumptions of mixing or association are not required.

Until recently, Gordin's martingale argument was restricted to stationary processes. Here, we illustrate how it can be extended to a short range dependent causal linear field $(X_{ij} = \sum_{u=0}^{\infty}\sum_{v=0}^{\infty} a_{uv}\xi_{i-u,j-v})$, proving for the first time weak convergence of the empirical process under exactly the same moment and summability conditions as in one dimension. Again, no assumptions on mixing or association are needed. The technique developed is of independent interest, as it can likely be applied to more general stationary fields.

Speaker: **Piotr Kokoszka** (Colorado State University, US)
Title: *Functional framework for high frequency financial data with focus on regression and predictability of intraday price curves*
Abstract: The talk will introduce the concept of a functional time series and focus on two specific statistical problems for such series, both motivated by intraday price curves. We explain how intraday price curves can be transformed to form an approximately stationary functional time series. We consider a contemporaneous regression of such transformed daily curves on risk factors, which may be daily functions as well. We then present a significance test designed to determine if the shape of an intraday price curve can be predicted from the past shapes of such curves.

Speaker: **Jens-Peter Kreiss** (Technical University of Braunschweig, Germany)
Title: *Baxter's inequality and sieve bootstrap for random fields*
Abstract: The concept of autoregressive sieve bootstrap for time series is extended to random fields. Given a finite data sample of rectangular shape, the procedure fits a finite-order autoregressive model to the sample using Yule-Walker-type estimators. The residuals of this fit are resampled, which allows for construction of a bootstrap sample in order to approximate the distribution of the statistic of interest. The distinctive feature of the sieve bootstrap is that the order of the AR fit is chosen depending on the sample size; in particular, it increases to infinity as the sample

Size tends to infinity, but at a much slower rate. A general check criterion is presented which allows for a large class of statistics to determine whether the proposed bootstrap procedure works or not. This work depends largely on two general results for random fields which may be of interest of its own: The first one is a one-sided autoregressive representation of the underlying spatial process with summable autoregressive coefficients (which goes back to the early work of Whittle), while the other one is a kind of Baxters inequality for random fields. This is a joint work with Marco Meyer and Carsten Jentsch.

Speaker: **Reg Kulperger** (University of Western Ontario, Canada)
Title: *GARCH in mean process: estimation and asymptotics*
Abstract:

Speaker: **Zhengyan Lin** (Zhejiang University, China)
Title: *On weak convergence of stochastic processes to stochastic integrals*
Abstract: Weak convergence of various general functionals of partial sums of dependent random variables (statistics) to stochastic integrals now plays an important role in the modern probability theory and statistics theory. In this talk, we introduce the weak convergence of various general functionals of partial sums of causal processes to stochastic integrals driven by both the Brownian motion and Levy-stable process.

Speaker: **Robert Lund** (Clemson University, USA)
Title: *Renewal Methods of Generating Stationary Count Time Series*
Abstract: This talk introduces a new method that generates integer-valued stationary time series having a pre-specified marginal distribution. The methods are built from discrete time renewal processes and are very flexible and parsimonious. We show how to model stationary series having Poisson, binomial, and geometric marginal distributions. Negatively correlated series values can be obtained at any desired lag.

Speaker: **Slava Lyubchich** (University of Waterloo, Canada)
Title: *Detecting Non-Monotonic Trends and Testing for Synchronism*
Abstract: In this talk, we explore a new statistical test for synchronism of trends exhibited by multiple time series, i.e., test whether two or more time series follow the same common trend. The core idea of our new approach is based on employing the local regression test statistic of Wang et al. (2008), which allows to detect possibly nonmonotonic (non)linear trends. The finite-sample performance of the test statistic is enhanced by employing robust data-driven bootstrap approach and m-out-of-n selection algorithm of Bickel and Sakov (2008). We illustrate the proposed methodology by simulations and case studies on assessing joint dynamics of various climatic variables.

Speaker: **Rogemar S. Mamon** (University of Western Ontario, Canada)
Title: *Filtering of an HMM-based multivariate Ornstein-Uhlenbeck model with application to forecasting market liquidity*
Abstract: The modelling of risk due to market and funding liquidity is investigated. This is carried out by capturing the joint dynamics of three time series: the Treasury-Eurodollar spread, the VIX and a metric derived from the S&P 500. A two-regime mean-reverting model is developed to explain the behaviour of the three time series, which mirror liquidity levels for financial markets. We construct optimal parameter estimates of the proposed model using an expectation-maximisation algorithm in conjunction with the multivariate HMM filters. The selection of the modelling set-up is justified by balancing the best-fit criterion and model complexity. We demonstrate the model performance on historical market data by producing accurate prediction of market illiquidity states.

Joint work with Matt Davison and Anton Tenyakov.

Speaker: **Eniuce Menezes** (Maringá State University, Brazil)
Title: *Non-Stationary Time Series Multiscale Analysis*
Abstract: Non-stationary time series analysis is difficult from some classical statistical methodologies. On the other hand, wavelet multiscale time series analysis has allowed a very important advance in the investigation of these data. Depending on the application decimated wavelet transform can be more appropriated or the shift invariant, unbiased, and consistent spectrum estimator can be indispensable to obtain reliable results. In this presentation, some details and challenges in artificial satellite multiscale time series analysis are discussed. Innovative applications with real data are presented to illustrate the benefits of this methodology that allows reaching so different goals.

Speaker: **Timothy McMurry** (University of Virginia, USA)
Title: *High-dimensional autocovariance matrices and optimal linear prediction*
Abstract: We introduce a new methodology for optimal linear prediction of a stationary time series. Given a sample $X_1, \ldots, X_n$, the optimal linear predictor of X_{n+1} is $\tilde{X}_{n+1} = \phi_1(n)X_n + \phi_2(n)X_{n-1} + \ldots + \phi_n(n)X_1$. In practice, the coefficient vector $\phi(n) \equiv (\phi_1(n), \phi_2(n), \ldots, \phi_n(n))'$ is routinely truncated to its first p components in order to be consistently estimated. By contrast, we employ a consistent estimator of the $n \times n$ autocovariance matrix in order to construct a consistent estimator of the optimal, full-length coefficient vector $\phi(n)$. Asymptotic convergence of the proposed predictor to the oracle one is established, and finite sample simulations are provided to support the applicability of the new method.

Speaker: **Thomas Mikosch** (University of Copenhagen, Denmark)
Title: *Convergence of the largest eigenvalues in a sample covariance matrix for multivariate time series*
Abstract: This is joint work with Richard A. Davis (Columbia) and Oliver Pfaffel (Munich). We consider the sample covariance matrix of a multivariate time series with infinite 4th moment, where the dimension of the series increases with the sample size. We study the limit behavior of the eigenvalues of this matrix and show convergence of the point process of the scaled eigenvalues towards a Poisson process. We derive the weak limit of the ratio of largest eigenvalue and trace of the matrix, the joint convergence of the largest eigenvalues, the limit of the spectrl gap and other results. They heavily depend on large deviation theory for sums of heavy-tailed random variables.

Speaker: **Dan Nordman** (Iowa State University, USA)
Title: *A frequency domain empirical likelihood method for irregularly spaced dependent data*
Abstract: This talk describes an empirical likelihood methodology for irregularly spaced data in the frequency domain, which includes spatial data as well as time series. Unlike the frequency domain empirical likelihood (FDEL) methodology for time series (on a regular grid), the formulation of FDEL needs special care due to lack of the usual orthogonality properties of the discrete Fourier transform for irregularly spaced data and due to presence of nontrivial bias in the periodogram under different spatial asymptotic structures. A new FDEL is formulated which accounts for the effects of these factors. The main results show that Wilks' phenomenon holds for a scaled version of the logarithm of the proposed empirical likelihood ratio statistic in the sense that it has a chi-squared limit. As a result, the proposed spatial FDEL method can be used to build nonparametric, asymptotically correct confidence regions and tests for covariance parameters that are defined through spectral estimating equations. A major advantage of the method is that it does not require explicit estimation of the standard error of an estimator, which is itself a difficult problem as the asymptotic variances of many common estimators depend on intricate interactions among several population quantities, including the spectral density of the spatial process, the spatial sampling density and the spatial asymptotic structure. Some simulation results illustrate the finite sample properties of the method. This is joint work with Soutir Bandyopadhyay and Soumendra Lahiri.

Speaker: **Sofia Olhede** (University College London, UK)
Title: *Whittle likelihood for nonstationary bivariate processes*
Abstract: We shall discuss using Whittle likelihood for estimation of non-stationary bivariate processes. The Whittle likelihood is formulated in the frequency domain, and relies on a number of asymptotic results for applicability. Real data analysis challenges such assumptions, especially if the frequency domain understanding of shorter segments of time or smaller spatial domains is to be arrived at. We propose modifications to the Whittle likelihood that improve estimation. The first takes the form of a complex-valued representation of bivariate structure that is only evident by separating negative and positive frequency behaviour, see Sykulski (2013). Flexible inference methods for such parametric models are proposed, and the properties of such methods are derived. Secondly we propose an adjustment to Whittle likelihood suitable for ameliorating sampling effects semi-parametrically, thus advancing the state-of-the-art in frequency domain modelling and estimation of time series in general, see Simons (2013); Sykulski (2013). This reduces small sample bias, and can be interpreted as extending Whittle likelihood to a composite likelihood method.

Speaker: **Hernando Ombao** (University of California, Irvine, USA) Title: *Modeling Cross-Oscillatory Interactions with Applications to Multivariate Brain Signals*
Abstract: The brain science community is keenly interested in studying how neurons and neuronal populations interact while processing complex cognitive tasks. In fact, there is a growing body of evidence suggesting that altered brain functional connectivity may be associated with various mental and neurological disorders. Motivated by these important problems, our group has been developing statistical models for studying cross-oscillatory dependence between components of a multivariate time series. These models explain how dependence between components in a network may change across experimental conditions and patient groups.

The classical approach to characterizing cross-oscillatory dependence between channels is coherence analysis. The main limitation of this approach is that is confined to capturing dependence between oscillations at only the same frequency band. To overcome this serious limitation, we are developing new approaches to modeling dependence between oscillations at different frequency bands (e.g., between theta oscillations in one channel and gamma oscillations in another). In this talk, we first present an exploratory analysis of local field potential data from a macaque monkey. To study dependence between oscillations, we propose a vector-autoregressive model of the band-specific time-segmented Fourier periodograms. Next, we propose a unified framework, based on harmonizable processes, under which we can rigorously approach scientific questions on lead-lag oscillatory interactions between components in a network. Finally,

we discuss a number of still open theoretical questions on this investigation.

This is a joint work with C. Gorrostieta (UC Irvine) and R. von Sachs (UCL Belgium) and

our brain science collaborators (E. Eskandar at MGH, D. Moorman at MUSC, D. Dickstein at Brown and S. Cramer at UCI).

Speaker: **Daniel Pena** (Universidad Carlos III Madrid Spain)
Title: *Dynamic Principal Components in the Time Domain for non Stationary Time Series*
Abstract: We propose an explicit solution in the time domain for the dynamic principal components proposed by Brillinger for stationary time series. We generalize the procedure for non-stationary time series and present a robustification of this dynamic principal components. The procedure is illustrated in several examples. It is a joint work with Victor Yohai.

Speaker: **Valdas Pipiras** (University of North Carolina, USA)
Title: *Multivariate long-range dependence and self-similarity*
Abstract: The focus of this talk is on multivariate (vector-valued) time series exhibiting long-range dependence. When working with long-range dependence, a number of new interesting issues arise in the multivariate context. Some of these issues will be discussed in the talk, including the definitions of multivariate long-range dependence, new parameters modeling the cross spectrum, linear representations and appropriate models, and connections to multivariate fractional Brownian motions.

Speaker: **Mohsen Pourahmadi** (Texas A & M University, USA)
Title: *Thresholded Generalized Principal Component Regression: Forecasting with Many Predictors*
Abstract: Multiple time series, panel data and many other modern data matrices have dependence in their rows and columns, and the classical principal component analysis for low-rank ap- proximation of such data matrices does not account for such two-way correlations. We develop a thresholded generalized principal component methodology to recover sparse and low-rank components of a data matrix by accounting for its two-way dependencies simultaneously. For computing the components, we rely on orthogonal subspace iterations instead of the traditional power method and sparsity is attained by thresholding the components rather than solving penalized optimization problems. Our methodology is applicable to the multivariate regression and canonical correlation analysis for two-way dependent data, these connections enable us to improve prediction accuracy in regression with many predictors, and to facilitate interpretation of the components of the data matrix. We illustrate our methodology by forecasting the data in Stock and Watson (2012) consisting of quarterly data on 144 U.S. macroeconomic time series with 109 predictors, which is known to exhibit strong dependencies among the variables (columns) and temporal dependencies among observations (rows). The effectiveness of the method is further demonstrated through simulations inspired by the superior performance of a predictor based on the first five principal components of the transformed macroeconomic time series data (Stock and Watson, 2012), and the age-old question of whether to forecast a (multiple) time series directly or after transforming to (near) stationarity. (Joint work with Ranye Sun)

Speaker: **Lilia Leticia Ramirez Ramirez** (ITAM, Mexico)
Title: *Trend estimation of multivariate time series with controlled smoothness*
Abstract: Several devices have been used and produced to estimate the trend of a time series (Penalized Least Squares, Wiener-Kolmogorov filtering, and splines, for example). The basic idea is to filter an observed time series to get another one that keeps fidelity to the observed data but is smoother than the original series. In this work we use Generalized Least Squares to estimate the trends of multivariate time series without relying on specific models for the trend and noise components. We only use the first two sample moments and an adequate amount of smoothedness, set in advance, for the estimated trends. In the talk we present the development of this work, which produces: 1. closed form expressions for calculating adequate trend estimates, as well as their corresponding variance-covariance matrices, 2. an algorithm for smoothing a bivariate time series, including the preliminary and final estimation of some parameter matrices involved, 3. a simulation study that gives support to the theoretical results and sheds some light

on how to decide an adequate percentage of smoothness for the trends, and 4. an application to real data of the Mexican macroeconomy that allows to verify the adequacy of the suggested procedure in practice. This is a joint work with Victor Guerrero Guzman (ITAM) and Alejandro Islas Camargo (ITAM).

Speaker: **Peter Robinson** (LSE, UK)
Title: *Efficient Inference on Fractionally Integrated Panel Data Models with Fixed Effects*
Abstract: A dynamic panel data model is considered that contains possibly stochastic individual components and a common stochastic time trend that allows for stationary and nonstationary long memory and general parametric short memory. We propose four different ways of coping with the individual effects so as to estimate the parameters. Like models with autoregressive dynamics, ours nests I(1) behaviour, but unlike the nonstandard asymptotics in the autoregressive case, estimates of the fractional parameter can be asymptotically normal. For three of the estimates, establishing this property is made difficult due to bias caused by the individual effects, or by the consequences of eliminating them, which appears in the central limit theorem except under stringent conditions on the growth of the cross-sectional size N relative to the time series length T, though in case of two estimates these can be relaxed by bias correction, where the biases depend only on the parameters describing autocorrelation. For the fourth estimate, there is no bias problem, and no restrictions on N. Implications for hypothesis testing and interval estimation are discussed, with central limit theorems for feasibly bias-corrected estimates included. A Monte Carlo study of finite-sample performance is included. It is a joint work with Carlos Velasco.

Speaker: **Francois Roueff** (TELECOM ParisTech, France)
Title: *Constrained Hawkes processes for modeling limit order books*
Abstract: The limit order book of a financial asset contains a set of limit prices at which volumes of the asset are available for buying or selling. It evolves according to limit and market orders (or cancellations) executed along the time. We consider a simplified limit order book limited to the best bid and best ask limit prices and propose to model the events controlling the dynamics of these two prices. The set of "physical" time instants of the events that modify the best bid and best ask prices can be seen as a multivariate point process. Hawkes processes are multivariate point processes that are easy to estimate and forecast. However they cannot suitably describe the evolution of the prices, since under such a model, the spread between the best bid and best ask prices would eventually diverge with probability one. Therefore, we introduce a class of constrained Hawkes processes which do not suffer from this drawback while still enjoying quite simple estimation and forecasting procedures. We will present necessary and sufficient conditions for the stability of such models when the fertility function has an exponential form. Joint work with Ban Zhen and Frédéric Abergel.

Speaker: **Nozer Singpurwalla** (George Washington University, US)
Title: *Filtering Reliability and Tracking Survivability*
Abstract: The motivation for this work was to address a commonly encountered problem in enginering reliability, namely, assessing reliability growth of a complex system, like an missile or software code. Indeed, the problem was brought to the speaker's attention by an Editor of Technometrics who wanted a discussion for a paper on tracking missile reliability. It turns that problems of this type are generic, and arise in the context of actuarial science, biostatistics, and finance. Filetring and tracking is a natural way to address such problms, but to do so, one needs a proper framework. In the process of developing one it became apparent that one needs to re-think the foundations of reliability and of survival analysis.

The import of this talk, is a discourse on some writings of Pierce, Popper, deFinetti and Kolmogorov, followed the need for a paradigm shift in reliability and survival analysis. This is then illustrated by a methodological piece on filtering reliability, and some problems that it spawns, namely,the treatment of censored observations. The talk is germane to the theme of this workshop because our position is that is that time series methods are quintessential for addressing problems in reliability and in survival analysis, something which appears to have not been recognized.

Speaker: **David Stoffer** (University of Pittsburgh, USA)
Title: *Adaptive Spectral Estimation for Nonstationary Time Series*
Abstract: We propose a method for analyzing possibly nonstationary time series by adaptively dividing the time series into an unknown but finite number of segments and estimating the corresponding local spectra by smoothing splines. The model is formulated in a Bayesian framework, and the estimation relies on reversible jump Markov chain Monte Carlo (RJMCMC) methods. For a given segmentation of the time series, the likelihood function is approximated via a product of local Whittle likelihoods. The number and lengths of the segments are assumed unknown and may change from one MCMC iteration to another. This is based on ongoing joint work with Ori Rosen (UTEP) and Sally Wood (U. Melbourne).

Speaker: **Murad Taqqu** (Boston University, US)
Title: *Multivariate limit theorems involving short-range and long-range dependence*
Abstract: Consider a vector of multilinear polynomial-form processes with either short or long memory components. The components have possibly different coefficients but same noise elements. We study the limit of the normalized partial sums of the vector and identify the independent components. These results are extended to generalized Hermite processes.

Speaker: **Martin Wendler** (Ruhr-Universität Bochum, Germany)
Title: *Bootstrap for dependent Hilbert space-valued random variables*
Abstract: Statistical methods for functional data are of interest for many applications. This talk will be about limit theorems and nonparametric statistical methods for random variables taking their values in a Hilbert space. The random variables are assumed to be weakly dependent in the sense of near epoch dependence, where the underlying process fulfills some mixing conditions. Under these very general assumptions, we prove a central limit theorem. As parametric inference in an infinite dimensional space is difficult, we show that the nonoverlapping block bootstrap is consistent. Furthermore, we show how these results can be used for degenerate von Mises-statistics. For example, we can obtain critical values of the Cramér-von-Mises-Test, which compares the empirical distribution function to given distribution function (joint work with H. Dehling and O.Sh. Sharipov).

Speaker: **Wei Biao Wu** (University of Chicago, US)
Title:
Abstract:

Speaker: **Zhou Zhou** (University of Toronto, Canada)
Title: *Inference of weighted V-statistics for nonstationary time series and its applications*
Abstract: We investigate the behavior of Fourier transforms for a wide class of nonstationary nonlinear processes. Asymptotic central and noncentral limit theorems are established for a class of nondegenerate and degenerate weighted V-statistics through the angle of Fourier analysis. The established theory for V-statistics provides a unified treatment for many important time and spectral domain problems in the analysis of nonstationary time series, ranging from nonparametric estimation to the inference of periodograms and spectral densities.