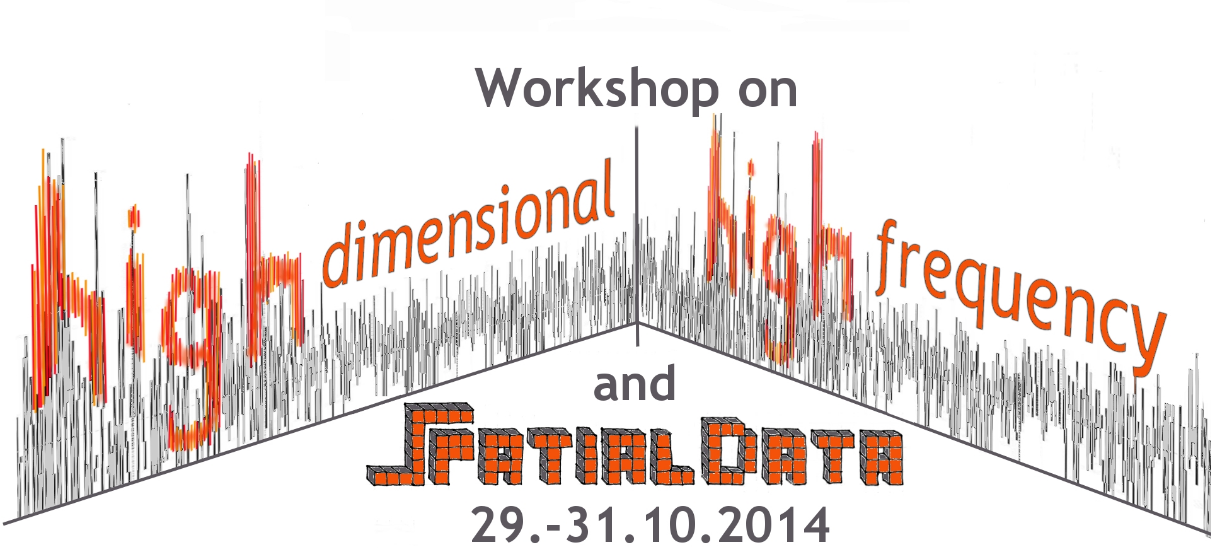

Abstracts

Wednesday:

16.00 - 17.15

Space-time models of precipitation

Hans R. Künsch, Fabio Sigrist and Werner Stahel

The analysis of precipitation data is challenging because precipitation has a skewed distribution with an atom at zero and because it is naturally modeled as a process in continuous time and space. We use models with a Gaussian "potential" precipitation intensity $\xi(s,t)$ which is a solution to a linear stochastic partial differential equation (SPDE) and which determines the real intensity by the transformation $u(s,t) = \max(0, \xi(s,t)^{\lambda})$. I will present two discretizations in space and time of this model which are approximately consistent for different resolutions and which lead to a latent Gaussian vector autoregression with non-Gaussian observations. The first one introduced in Sigrist et al. (2012) is suitable if one has observations at a not too large number of stations and wants to predict values at a small number of additional sites or a small number of areal averages. The second one, discussed in Siegrist et al. (2014), can be used if one has additional information on a dense regular grid from either radar measurements or from a numerical weather prediction or if one wants to infer precipitation on the whole grid. I will also discuss joint estimation of the latent intensity and the unknown parameters in the model by MCMC.

Literature:

F. Sigrist, H. R. Künsch and W. Stahel (2012): A dynamic non-stationary spatio-temporal model for short term prediction of precipitation. Ann. Appl. Statist. 6, 1452–1477.

F. Sigrist, H. R. Künsch and W. Stahel (2014): SPDE based modeling of large space-time data sets. J. Royal Statist. Soc. B 76, in press.

Modelling and estimating Brown-Resnick space-time processes

Sven Buhl, Richard Davis, Claudia Klüppelberg and Christina Steinkohl

Often, in modelling complex systems such as weather events or wind fields, statistical methodology can be applied to reconcile physical phenomena with the data. For an adequate risk analysis, the statistical modelling of extreme events, such as floods or wind gusts is essential. Historically, Gaussian random fields play a central role in modelling spatio-temporal data. When it comes to extremes and extremal dependence, Gaussian processes are not appropriate, since observations at two different locations and time points are in Gaussian models independent at high levels. A natural extension from uni- and multivariate extreme value theory is formed by so-called max-stable random fields. We suggest new statistical models for extreme data measured in space and time. We present the basic aspects and challenges of estimation of isotropic and anistropic max-stable spatio-temporal random fields. We also present some goodness-of-fit procedures.

Literature:

Buhl, S. and Klüppelberg, C. (2014): Anisotropic Brown-Resnick space-time processes: estimation and model assessment. In preparation.

Davis, R.A., Klüppelberg, C. and Steinkohl, C. (2013): Max-stable processes for modelling extremes observed in space and time. *Journal of the Korean Statistical Society* 42(3), 399-414.

Davis, R.A., Klüppelberg, C., and Steinkohl, C. (2013): Statistical inference for max-stable processes in space and time. *JRSSB* **75**(5), 791-819.

Davis, R.A., Klüppelberg, C., and Steinkohl, C. (2014): Semiparametric estimation for max-stable space-time process. In preparation.

17.30 - 18.30

Functional lagged regression

Siegfried Hörmann, Ł. Kidziński and P. Kokoszka

Consider a sequence (Y_k) of real responses, explanatory variables (X_k) taking values in some function space $\mathcal{F}$, iid noise (ε_k) which is independent of (X_k), and a linear operator $\beta : \mathcal{F} \to \mathbb{R}$. The functional linear model $Y_k = \beta(X_k) + \varepsilon_k$ has received a great deal of attention over the last two decades. As in the usual linear regression, to derive inferential properties, the assumption imposed on the above model is that the pairs (Y_k, X_k) are independent and identically distributed. While this assumption is well justified in designed experiments, it may be called into question when the functions X_k form a functional time series.

The objective of this talk is to develop estimation and testing methodology, and the underlying asymptotic theory, for the model

$$Y_\ell = a + \sum_{k\in\mathbb{Z}} b_k(X_{\ell-k}) + \varepsilon_\ell, \quad b_k : \mathcal{F} \to \mathbb{R}, \quad a \in \mathbb{R}. \tag{0.1}$$

Model (0.1) is an extension of the *lagged regression model*, which is the most commonly used regression model in time series analysis.

As with most functional procedures, the main challenge is a suitable dimension reduction technique and the need to deal with unbounded operators, difficulties not encountered in the scalar and vector theory.

Highdimensional Hidden Markov Models

Marc Fiecas, Jürgen Franke, Joseph Tadjuidje Kamgaing, Rainer von Sachs and Conrad Spanaus

Hidden Markov Models (HMMs) are established tools for discrete time series as well as stochastic processes in continuous time which exhibit some form of regime-switching. Applications range from finance, where the regimes correspond to different market states, to speech analysis or genomic analysis. We concentrate on financial applications where even simple HMMs are well-known to be able to model many of the stylized facts of asset price data.

In this talk, we show that in highdimensional situations the proven and tested standard methods for fitting HMMs to data break down. This does not only concern parameter estimates, but even more filters for, e.g., reconstructing the hidden Markov state variables. The main reason for the problems is the instability of covariance matrix estimates in high dimensions. We present an approach which combines the EM algorithm for HMMs with well-conditioned empirical covariance matrices based on shrinkage leading to satisfactory estimation and filtering results for discrete and continuous time HMMs. We illustrate the performance of the method with applications to financial data.

Literature:

M. Fiecas, J. Franke, R. von Sachs, J. Tadjuidje Kamgaing (2012): Shrinkage Estimation for Multivariate Hidden Markov Mixture Models. Discussion Paper DPS 2012/16, Dept. of Statistics, Catholic University of Louvain-la-neuve.

Thursday:

9.30 - 10.30

Cross-covariance functions for multivariate geostatistics

Marc G. Genton and William Kleiber

Continuously indexed datasets with multiple variables have become ubiquitous in the geophysical, ecological, environmental and climate sciences, and pose substantial analysis challenges to scientists and statisticians. For many years, scientists developed models that aimed at capturing the spatial behavior for an individual process; only within the last few decades has it become commonplace to model multiple processes jointly. The key difficulty is in specifying the cross-covariance function, that is, the function responsible for the relationship between distinct variables. Indeed, these cross-covariance functions must be chosen to be consistent with marginal covariance functions in such a way that the second order structure always yields a nonnegative definite covariance matrix. We review the main approaches to building cross-covariance models, including the linear model of coregionalization, convolution methods, the multivariate Matérn, and nonstationary and space-time extensions of these among others. We additionally cover specialized constructions, including those designed for asymmetry, compact support and spherical domains, with a review of physics-constrained models. We illustrate select models on a bivariate regional climate model output example for temperature and pressure, along with a bivariate minimum and maximum temperature observational dataset; we compare models by likelihood value as well as via cross-validation co-kriging studies. The talk closes with a discussion of unsolved problems.

Literature:

M. G. Genton, W. Kleiber (2014): Cross-covariance functions for multivariate geostatistics. Statistical Science, in press.

Causality in time series analysis

Marloes Maathuis

Time series data offer excellent opportunities for inferring causal relationships. Currently used methods for this purpose include Granger causality, vector autoregressive models and graphical models. In this talk, I will try to give an overview of the current state of the field.

11.15 - 12.45

On the sample autocovariance of a continuous time moving average process

Serge Cohen, Alexander Lindner and Felix Spangenberg

Let $L = (L_t)_{t\in\mathbb{R}}$ be a two-sided Lévy process with expectation 0 and finite variance and let $f : \mathbb{R} \to \mathbb{R}$ be an L^2-function. We consider the continuous time moving average process

$$X_t = \int_{\mathbb{R}} f(t-s)\, dL_s, \quad t \in \mathbb{R},$$

which is observed at discrete times $t = 1, 2, 3, \ldots$ We study the asymptotic behaviour of the sample mean $\overline{X}_n = \frac{1}{n}\sum_{t=1}^{n} X_t$ and the sample autocovariances

$$\gamma_n^*(h) = \frac{1}{n}\sum_{t=1}^{n} X_t X_{t+h}, \quad h \in \mathbb{N}_0,$$

as $n \to \infty$, both in the short memory case and in the long memory case. A limit theorem for the sample autocorrelations in the short memory case is also obtained together with a Bartlett-type formula. This formula differs significantly from the corresponding discrete time moving average process case, since in the discrete time setting, the fourth moment of the driving noise sequence drops out, which in general is not the case for the continuous time setting. In the long memory case, the Rosenblatt distribution occurs as limiting distribution.

Literature:

S. Cohen, A. Lindner (2013): A central limit theorem for the sample autocorrelations of a Lévy driven continuous time moving average process. Journal of Statistical Planning and Inference, 143, 1295–1306.

F. Spangenberg (2014+): A central limit theorem for the sample autocovariance of a Lévy driven continuous time moving average process with long memory. In preparation.

Limit theorems for continuous Levy moving average processes

Andreas Basse-O'Connor, Raphael Lacheize-Rey and Mark Podolskij

We present some new asymptotic results for power variation of continuous Lévy moving average processes. We will see that the mode and type of convergence strongly depend on the driving Lévy motion, the kernel function and the power. Apart from critical cases there appear three different types of limits. We will show the idea behind the proofs and shortly discuss statistical applications. We will also present the second order asymptotics.

Geometric Ergodicity of the Multivariate Continuous-time GARCH(1,1) Process

Robert Stelzer and Johanna Vestweber

In this talk we consider the multivariate continuous-time GARCH(1,1) process driven by a Lévy process emphasising stationarity properties. The focus is on the volatility process which takes values in the positive semi-definite matrices.

In the univariate model existence and uniqueness of the stationary distribution as well as geometric ergodicity are well-understood, whereas for the multivariate model only an existence criterion is known as far as strict stationarity is concerned. We shall first review the multivariate COGARCH(1,1) model and its properties focussing on strict and weak stationarity. Thereafter, the main part of the talk is devoted to establishing sufficient conditions for geometric ergodicity and thereby for uniqueness of the stationary distribution and exponential strong mixing.

We follow a classical Markov/Feller process approach based on a Foster-Lyapunov drift condition on the generator. Apart from finding an appropriate test function for the drift criterion, the main challenge is to prove an appropriate irreducibility condition due to the degenerate structure of the jumps of the volatility process, which are all rank one matrices. We present a sufficient condition for irreducibility in the case of the driving Lévy process being compound Poisson.

Literature:

Down, D., Meyn, S. P., Tweedie, R. L. (1995): Exponential and uniform ergodicity of Markov processes. Annals of Probability, 23, No. 4, 1671–1691.

Fasen, V. (2010): Asymptotic results for sample autocovariance functions and extremes of integrated generalized Ornstein-Uhlenbeck processes. Bernoulli, 16, No. 1, 51–79.

Klüppelberg, C., Lindner, A., Maller, R. (2004): A continuous-time GARCH process driven by a Lévy process: stationarity and second-order behaviour. Journal of Applied Probability, 41, No. 3, 601–622.

Stelzer, R. (2010): Multivariate COGARCH(1,1) processes. Bernoulli, 16, No. 1, 80–115.

14.15 - 15.45

TENET: Tail-Event-driven NETwork Risk

Wolfgang Karl Härdle, Natalia Sirotko-Sibirskaya and Weining Wang

We propose a semi-parametric measure for the systemic risk to reveal the spillover effects between the financial companies in tail event situations in ultra-high dimensions. Methodologically we employ variable selection in context of a single-index model for quantile and expectile regressions. The combination of these statistical techniques allows to include more variables into the analysis, to measure their interdependencies in tails and, at the same time, to take into account non-linear relationship between them. Based on publicly available market data we obtain the estimates for the systemic importance of an individual financial company and analyze the evolution of the network linkages formed by these companies.

Literature:

Adrian, T., and Brunnermeier, M. K. (2011): CoVaR. Staff Reports 348, Federal Reserve Bank of New York.

Chao, S. K., Härdle, W. K., and Wang, W. (2014): Quantile Regression in Risk Calibration, in Handbook for Financial Econometrics and Statistics, Springer Verlag.

Fan, J., and Li, R. (2001): Variable selection via nonconcave penalized likelihood and its oracle properties. Journal of American Association, 96, 1348-1360.

Fan, J., Härdle, W. K., Wang, W., and Zhu (2014): CoVaR with very high dimensional covariates. Submitted to Journal of Business Statistics, 2014.

Koenker, R., and Basett, G. W. (1978): Regression quantiles, Econometrica, 46, 33-50.

Li, Y., and Zhu, J. (2008): L1-norm quantile regression. Journal of Computational Graphical Statistics 17, 163-185.

Baxter's inequality and sieve bootstrap for random fields

Carsten Jentsch, Jens-Peter Kreiss and Marco Meyer

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 BaxterÕs inequality for random fields.

15.45 - 17.00 **Poster session**

Stationary solutions of spatial ARMA equations

Martin Drapatz

Consider the d-dimensional spatial ARMA model defined by the equations

$$Y_{\mathbf{t}} - \sum_{\mathbf{n}\in R} \phi_{\mathbf{n}} Y_{\mathbf{t}-\mathbf{n}} = Z_{\mathbf{t}} + \sum_{\mathbf{n}\in S} \theta_{\mathbf{n}} Z_{\mathbf{t}-\mathbf{n}}, \quad \mathbf{t} = (t_1, \dots, t_d) \in \mathbb{Z}^d, \tag{0.2}$$

where $(Z_{\mathbf{t}})_{\mathbf{t}\in\mathbb{Z}^d}$ is a weak white noise random field and R and S are finite subsets of $\mathbb{Z}^d_+$. It is known that a sufficient and necessary condition for the existence of a weakly stationary solution of (0.2) is given by

$$\frac{\Theta(e^{-i\cdot})}{\Phi(e^{-i\cdot})} \in L^2(\mathbb{T}^d), \tag{0.3}$$

see for example Rosenblatt (2000).

In this work we study the case, where $(Z_{\mathbf{t}})_{\mathbf{t}\in\mathbb{Z}^d}$ is an i.i.d. random field with not necessarily finite moments, and give necessary and sufficient conditions for the existence of a linear strictly stationary solution of (0.2), i.e. a random field $(Y_{\mathbf{t}})_{\mathbf{t}\in\mathbb{Z}^d}$ with a representation

$$Y_{\mathbf{t}} = \sum_{\mathbf{n}\in\mathbb{Z}^d} \psi_{\mathbf{n}} Z_{\mathbf{t}-\mathbf{n}}, \quad (\psi_{\mathbf{n}})_{\mathbf{n}\in\mathbb{Z}^d}, \quad \mathbf{t} \in \mathbb{Z}^d, \tag{0.4}$$

where (0.4) converges almost surely absolutely. A sufficient condition for the almost sure absolute convergence of (0.4) is also specified, in terms of log-moment conditions and zeros of the autoregressive polynomial.

Furthermore we study sufficient and necessary conditions for the existence of causal solutions of (0.2), i.e. a strictly stationary random field $(Y_{\mathbf{t}})_{\mathbf{t}\in\mathbb{Z}^d}$ for which each $Y_{\mathbf{t}}$ is measurable with respect to $\sigma(Z_{\mathbf{s}} : \mathbf{s} \leq \mathbf{t})$. The results generalize the work of Brochwell and Lindner (2010), who considered the time series ARMA model ($d = 1$).

Literature:

P. J. Brockwell and A. Lindner (2010): *Strictly stationary solutions of autoregressive moving average equations.* Biometrika 97, 765-772.

M. Rosenblatt (2000): *Gaussian and Non-Gaussian Linear Time Series and Random Fields.*

Tests for equal predictive accuracy using proper scoring rules

Kira Feldmann, Tilmann Gneiting and Mikyoung Jun

Statistical postprocessing addresses systematic shortcomings in ensemble predictions systems, which typically show biases and are uncalibrated. Various methods have been proposed for doing this, with Bayesian model averaging and heterogeneous regression being state of the art approaches. However, these techniques focus on forecasts at single locations, ignoring spatial correlation between different observational sites. When forecasting composite quantities, such temperature minima or maxima over a region, spatial dependence structures are of great importance. For this task we use heterogenous regression in concert with ensemble copula coupling as a reference standard. In a more sophisticated approach, we utilize Gaussian random fields to represent the forecast error fields, where we fit covariance functions on the globe that account for land-water differentials in predictive ability and correlation length. In a case study, we apply these methods to temperature forecasts with the TIGGE multi model ensemble and demonstrate improvements in forecast skill.

Tests for equal predictive accuracy using proper scoring rules

Alexander Jordan

Traditionally, forecasts have been mainly issued as point forecasts and evaluated using the absolute or squared error. In this context, Diebold and Mariano (1995) proposed a test of equal predictive performance that is popular in econometrics with a vast strain of literature attached. However, with the shift to proper scoring rules (the logarithmic score being a prime example) it is more common now to have high excess kurtosis in the distribution of the score differentials, which is a scenario where the Diebold-Mariano test may have difficulties. We investigate the performance of this test in comparison to simple non-parametric tests in simulation and real data examples.

Literature:

F. X. Diebold, R.S. Mariano (1995): Comparing predictive accuracy. Journal of Business and Economic Statistics, 13, 258–270.

Order selection criteria for multivariate continuous-time ARMA (MCARMA) models

Sebastian Kimmig and Vicky Fasen

Multivariate continuous-time ARMA (MCARMA) processes of order p and q are the continuous-time equivalent to the well-known vector ARMA processes and have attracted a considerable amount of research over the last years. Specifically, there exist a few papers which investigate parameter estimation for the MCARMA model. For example, the maximum likelihood method is treated by Schlemm and Stelzer (2012), while García, Klüppelberg and Müller (2011) treat the case of stable CARMA models and Fasen and Fuchs (2013) consider the periodogram.

However, all of these estimation methods assume that the orders p and q of the autoregressive and moving-average polynomial, respectively, are known. For this reason we develop information criteria to choose p and q from data at hand. We study a general criterion based on the maximum likelihood method and investigate the question under which conditions and in which sense this criterion can identify the true order of the data-generating process, a property referred to as consistency.

The well-known Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are presented as special cases.

Literature:

V. Fasen, F. Fuchs (2013): On the Limit Behavior of the Periodogram of High-Frequency Sampled Stable CARMA Processes. Stochastic Process. Appl., 121(1), 229–273.

I. García, C. Klüppelberg, G. Müller (2011): Estimation of stable CARMA models with an application to electricity spot prices. Statistical Modelling, 11(5), 447–470.

E. Schlemm, R. Stelzer (2012): Quasi maximum likelihood estimation for strongly mixing state space models and multivariate Lévy-driven CARMA processes. Electronic Journal of Statistics, 6, 2185–2234.

Probabilistic Forecasting based on MCMC Output

Tilmann Gneiting, Fabian Krüger, Sebastian Lerch and Thordis L. Thorarinsdottir

We conduct a systematic analysis of how to make and evaluate probabilistic forecast distributions based on Markov Chain Monte Carlo (MCMC) output. We first survey a variety of approches proposed in the interdisciplinary, rapidly growing literature. We then use analytical arguments, simulation evidence and empirical analysis in order to evaluate these proposals. In particular, we compare different methods of estimating the stationary distribution underlying the MCMC output. Given such an estimate and a realizing outcome, we consider forecast evaluation based on proper scoring rules as in Gneiting et al. (2007). We find that an attractive option is to use the Continuous Ranked Probability Score Matheson et al. (1976).

Literature:

Gneiting, T., and A. E. Raftery (2007): "Strictly Proper Scoring Rules, Prediction, and Estimation", *Journal of the American Statistical Association* 102(477), 359-378.

Matheson, J. E., and R. L. Winkler (1976): "Scoring Rules for Continuous Probability Distributions", *Management Science* 22(10), 1087-1096.

Forecaster's Dilemma: Extreme Events and Forecast Evaluation

Tilmann Gneiting, Sebastian Lerch, Francesco Ravazzolo and Thordis L. Thorarinsdottir

In discussions of the quality of forecasts in the media and public, attention often focuses on the predictive performance in the case of extreme events. Intuitively, accurate predictions on the subset of extreme events seem to suggest better predictive ability. However, it can be demonstrated that restricting conventional forecast verification methods to subsets of observations might have unexpected and undesired effects and may discredit even the most skillful forecasters. Hand-picking extreme events is incompatible with the theoretical assumptions of established forecast verification methods, thus confronting forecasters with what we refer to as the forecaster's dilemma. For probabilistic forecasts, weighted proper scoring rules provide suitable alternatives for forecast evaluation with an emphasis on extreme events. Using theoretical arguments, simulation experiments and a case study on time series forecasts of U.S. inflation and gross domestic product growth, we illustrate the forecaster's dilemma and the use of weighted proper scoring rules.

Likelihood- and residual-based evaluation of medium-term earthquake forecast models for California

Robert Clements, David Rhoades, Max Schneider and Danijel Schorlemmer

In this work, we statistically evaluated seven competing models for forecasting medium-term earthquake rates in California using the framework of the Collaboratory for the Study of Earthquake Predictability (Schorlemmer and Gerstenberger (2007)). The model class consists of contrasting versions of the Every Earthquake a Precursor According to Size and Proximity to Past Earthquakes modeling approaches (Rhoades (2013)). Models are ranked by their performance on likelihood-based tests, which measure the consistency between a model forecast and observed earthquakes. To directly compare one model against another, we run a classical paired t-test and its non-parametric alternative on an information gain score based on the forecasts (Rhoades et al. (2011)). These test scores are complemented by residual-based methods, which offer detailed spatial information (Clements et al. (2011)). The experiment period covers 2009 June–2012 September, when California experienced 23 earthquakes above the magnitude threshold. Though all models fail to capture seismicity during an earthquake sequence, spatio-temporal differences between models do emerge. The overall best-performing model has strong time- and magnitude-dependence, weights all earthquakes equally as medium-term precursors of larger events and has a full set of fitted parameters. In addition, models that down-weight aftershocks when forecasting larger events have a desirable feature in that they do not overpredict following an observed earthquake sequence. This tendency towards overprediction differs between the simpler model, which is based on fewer parameters, and more complex models that include more parameters.

Literature:

Schorlemmer, D. and Gerstenberger, M.C. (2007): RELM testing center. Seismological Research Letters, 78, No. 1, 30–35.

Rhoades, David A (2013): Mixture models for improved earthquake forecasting with short-to-medium time horizons. Seismological Society of America, 103, No. 4, 2203–2215.

Rhoades, D.A., Schorlemmer, D., Gerstenberger, M.C., Christophersen, A., Zechar, J.D. and Imoto, M. (2011): Residual analysis methods for space–time point processes with applications to earthquake forecast models in California. The Annals of Applied Statistics, 5, No. 4, 728–747.

Clements, R.A., Schoenberg, F.P. and Schorlemmer, D. (2011): Efficient testing of earthquake forecasting models. Acta Geophysica, 59, No. 4, 2549–2571.

Cointegrated Multivariate Continuous-Time Autoregressive Moving Average (MCARMA) Processes

Vicky Fasen and Markus Scholz

The well known vector-ARMA models are commonly used as linear stochastic models in discrete time. The concept of cointegration, which was introduced by Engle and Granger (1987), describes the phenomena, that two or more non-stationary processes, which are integrated, can have a stationary linear combination. Cointegration models therefore stochastic trends of some or all the variables. There is empirical evidence that cointegration arises e.g. in financial data. For example exchange rates or the relation between long-term and short-term interest rates show such a common stochastic behaviour. The obvious extension of this framework to a continuous-time setting are cointegrated MCARMA processes. Brockwell and Lindner (2013) introduced integrated processes, the first step to cointegrated processes, in the univariate setting.

First of all we consider two different approaches to multivariate integrated processes in continuous-time. In both cases we examine the possibility of cointegration. Moreover, we explore representations of the integrated process sampled at discrete time points. Furthermore, a block decomposition of an MCARMA process is presented.

Literature:

R. F. Engle and C. W. J. Granger (1987): Co-integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55(2), 251–76.

P. J. Brockwell, and A. Lindner (2013). Integration of CARMA processes and spot volatility modelling Lévy-driven CARMA processes. Journal of Time Series Analysis, 34(2), 156–167.

Sequential change-point procedures based on estimating functions

Claudia Kirch and Silke Weber

We propose a general construction principle for detecting a change point if the data is observed sequentially. This includes examples as diverse as mean change, linear, non-linear, autoregressive and binary models.
The key assumption in this setup is the existence of a training period without a change, which is used to get an initial estimator for the unknown parameters with an estimating function G. The detector is a score-type statistic which allows to check whether the initial estimate still describes the current data well enough.
More presicely, we use three different types of detector statistics based on partial sums of a monitoring function H, which can be equal to the function G, namely the modified moving-sum-statistic (mMOSUM), Page's cumulative-sum-statistic (Page-CUSUM) and the standard moving-sum-statistic (MOSUM). The statistics only differ in the number of observations included in the partial sum. The mMOSUM uses a bandwidth parameter $h \in (0, 1)$ which multiplicatively scales the lower bound of the moving sum. The MOSUM uses a constant bandwidth parameter. And the Page-CUSUM chooses the maximum over all possible lower bounds for the partial sums.
We develop the asymptotics under the null hypothesis and alternatives under mild conditions for each test statistic.
While the standard cumulative-sum-detector (CUSUM) has recently been considered in this general setup, the first two schemes have only been studied in a linear model, the MOSUM only for a mean change.
Our general conditions unify the theory for those but also many new examples such as the ones mentioned above.
In a simulation study we compare all four types of test procedures in terms of their size, power and run length.

Modelling electricity prices using an iteratively reweighted lasso approach

Rick Steinert and Florian Ziel

In this talk we present a new model for electricity prices. The considered model is a multivariate time-varying AR process $(\boldsymbol{Y}_t)_{t\in\mathbb{Z}}$ with

$$\boldsymbol{Y}_t = \boldsymbol{\Phi}_0(t) + \sum_k \boldsymbol{\Phi}_k(t)\boldsymbol{Y}_{t-k} + \boldsymbol{\varepsilon}_t.$$

and condional heteroscedastic errors $\boldsymbol{\varepsilon}_t$. The proposed parametrisation of the model and is very close to a periodic AR-TARCH process. We consider the hourly day-ahead electricity prices for Germany and Austria traded at the European Power Exchange, but also take into account time series of the electricity load and renewable energy feed-in. The model is designed in that way that it is able to capture the daily, weekly, and annual seasonal behaviour, such as effects due to public holidays and the daylight saving time. Additionally we provide evidence for leverage effects within the data.
We use an efficient iteratively reweighted lasso approach for the parameter estimation to enjoy model selection properties of the lasso estimator. This procedure takes into account the conditional heteroscedasticity behaviour and improves the estimates and forecast in comparison to common homoscedastic aproaches. The proposed method also provides a wide range of applications in other areas of high-dimensional time series modelling.

Reference:

F. Ziel, R. Steinert (2014): Efficient Modeling and Forecasting of the Electricity Spot Price. arXiv preprint arXiv:1402.7027.

J. Wagener, H. Dette (2012): Bridge estimators and the adaptive Lasso under heteroscedasticity. Mathematical Methods of Statistics, 21, No. 2, 109–126.

17.00 - 18.30

A test for stationarity for irregularly spaced spatial data

Soutir Bandyopadhyay and Suhasini Subba Rao

The analysis of spatial data is based on a set of assumptions, which in practice need to be checked. A commonly used assumption is that the spatial random field is second order stationary. In this paper, a test for spatial stationarity for irregularly sampled data is proposed. The test is based on a transformation of the data (a type of Fourier transform), where the correlations between the transformed data is close to zero if the random field is second order stationary. On the other hand, if the random field were second order nonstationary, this property does not hold. Using this property a test for second order stationarity is constructed. The test statistic is based on measuring the degree of correlation in the transformed data. The asymptotic sampling properties of the test statistic is derived under both stationarity and nonstationarity of the random field. These results motivate a graphical tool which allows a visual representation of the nonstationary features. The method is illustrated with simulations and two real data examples.

Reference:

Bandyopadhyay, S. and Subba Rao, S. (2014): A test for stationarity for irregularly spaced spatial data. Submitted.

Subba Rao, S. (2014): Fourier based statistics for irregular spaced spatial data. Submitted.

Spectral Density Ratio Models for Multivariate Extremes

Miguel de Carvalho and Anthony Davison

The modeling of multivariate extremes has received increasing recent attention because of its importance in risk assessment. In classical statistics of extremes, the joint distribution of two or more extremes has a nonparametric form, subject to moment constraints. This paper develops a semiparametric model for the situation where several multivariate extremal distributions are linked through the action of a covariate on an unspecified baseline distribution, through a so- called density ratio model. Theoretical and numerical aspects of empirical likelihood inference for this model are discussed, and an application is given to pairs of extreme forest temperatures.

Friday:

9.30 - 10.30

Predicting temporal trajectories of regional wind and solar power production

Egil Ferkingstad, Anders Løland and Thordis L. Thorarinsdottir

Renewable energy sources provide a constantly increasing contribution to the total energy production worldwide. However, the power generation from these sources is highly variable due to their dependence on meteorological conditions. Accurate forecasts for the production at various temporal and spatial scales are thus needed for an effective electricity market. We propose fully probabilistic prediction models for spatially aggregated wind and solar power production at an hourly time scale with lead times up to several days using weather forecasts from numerical weather prediction systems as covariates. After an appropriate transformation of the power production, we build up a multivariate Gaussian prediction model under a Bayesian inference framework which incorporates both the temporal error correlation for each energy source as well as the correlation between the two sources. Recently proposed simulation methods for G-Wishart variates allow us to efficiently compare several alternative formulations of the correlation structure. We furthermore compare the predictive performance of a full single-stage model versus a two-stage copula model.

Variogram-based proper scoring rules for probabilistic forecasts of multivariate quantities

Michael Scheuerer

Many statistical methods in disciplines such as economics, atmospheric sciences, epidemiology, and environmental modelling are concerned with forecasting and interpolating uncertain, unknown, or partially known quantities. To communicate the associated prediction uncertainty, probabilistic forecasts taking the form of probability distributions should be provided rather than just a single "best" prediction. Alternatively, a sample – in some applications referred to as an "ensemble" – that represents the range of possible outcomes could be generated. The latter has become common practice e.g. in numerical weather prediction.

To assess the quality of probabilistic forecasts, both diagnostic, qualitative tools and quantitative performance measures have been proposed. A theoretically principled framework for the latter has been established under the heading "proper scoring rules" and permits quantitative comparisons of the forecast skill of different forecasters including statistical testing.

While a wide selection of such scoring rules for univariate quantities exists, there are only few scoring rules for multivariate quantities, and many of them require that forecasts are given in the form of a probability density function. In this talk we present an class of proper scoring rules for multivariate quantities that is based on the geostatistical concept of variograms and is applicable also in the case of ensemble forecasts. We study the sensitivity of those scoring rules to incorrectly predicted means, variances, and correlations in a number of examples with simulated observations and forecasts, and we show that the variogram-based scoring rules are distinctly more discriminative with respect to the correlation structure. The importance of this property is emphasized in a case study with probabilistic 80m wind speed forecasts at five wind park locations in Colorado, U.S.A.

11.15 - 12.45

Statistically and Computationally Efficient Estimating Equations for Large Spatial Datasets

Michael Stein and Ying Sun

For Gaussian process models, likelihood based methods are often difficult to use with large irregularly spaced spatial datasets, because exact calculations of the likelihood for n observations require $O(n^3)$ operations and $O(n^2)$ memory. Various approximation methods have been developed to address the computational difficulties. In this work, we propose new unbiased estimating equations based on score equation approximations that are both computationally and statistically efficient. We replace the inverse covariance matrix that appears in the score equations by a sparse matrix to approximate the quadratic forms, then set the resulting quadratic forms equal to their expected values to obtain unbiased estimating equations. The sparse matrix is constructed by a sparse inverse Cholesky approach to approximate the inverse covariance matrix. The statistical efficiency of the resulting unbiased estimating equations are evaluated both in theory and by numerical studies. Our methods are applied to nearly 90,000 satellite-based measurements of water vapor levels over a region in the Southeast Pacific Ocean.

Parallel inference for massive spatial data

Dorit Hammerling and Matthias Katzfuss

Automated sensing instruments on satellites and aircraft have enabled the collection of massive amounts of data indexed in space and time. While the field of spatial statistics provides a rich toolkit for the analysis of such data, traditional techniques such as kriging are not computationally feasible for big datasets. We introduce parallel algorithms for the analysis of massive, high-resolution spatial datasets that can (approximately) fit spatial statistical models exhibiting arbitrary dependence structure. Our methodology uses a hierarchical setup that employs basis-function representations at different levels of spatial resolution, capturing inhomogenous spatial behavior at all scales. Parallelization results in algorithms that are highly scalable for massive datasets, as long as enough computing nodes are available. After discussing an extension to spatio-temporal data, we apply our methodology to fusing millions of data points from three different satellite sensor systems, in order to predict hourly Total Precipitable Water fields, which are critical in severe weather forecasting.

Equivalent Kriging

William Kleiber and Douglas Nychka

Most modern spatially indexed datasets are very large, with sizes commonly ranging from tens of thousands to millions of locations. Spatial analysis often focuses on spatial smoothing using the geostatistical technique known as kriging. Kriging requires covariance matrix computations whose complexity scales with the cube of the number of spatial locations, making analysis infeasible or impossible with large datasets. We introduce an approach to kriging in the presence of large datasets called equivalent kriging, which relies on approximating the kriging weight function using an equivalent kernel. Resulting kriging calculations are extremely fast and feasible in the presence of massive spatial datasets. We derive closed form kriging approximations for multiresolution classes of spatial processes, as well as under any stationary model, including popular choices such as the Matérn. Estimation can proceed by either cross-validation or generalized cross-validation. Equivalent kriging is illustrated on simulated datasets, and a monthly average precipitation dataset whose size prohibits traditional geostatistical approaches.

Literature:

Kleiber, W. and Nychka, D. (2014). Equivalent Kriging. Submitted.

14.00 - 15.30

Statistical Models for the Evolving Dynamics of Brain Signals

Mark Fiecas and Hernando Ombao

Our goal here is to rigorously study changes in neuronal activity over the course of an *entire* experiment. The prevailing conjecture is that as the experiment unfolds the brain's response to the repeated presentations of an external stimulus also evolves. Our preliminary analyses support the prevailing conjecture. In an associative learning experiment, we observe that the interaction between the neuronal activity at the nucleus accumbens and the hippocampus regions change both within one trial (or one presentation of a stimulus) and across trials during the course of the experiment. While many statistical models take into account non-stationarity within a single trial, the evolution of brain dynamics across replicated trials in an experiment is often ignored. In fact, the current statistical models often assume that brain signals observed from several trials are realizations of the same underlying brain process. Our analysis demonstrates that these approaches will incorrectly characterize the dynamics of the data over the course of the experiment.

In this talk, we build on the model of local stationarity (Dahlhaus, 1997) to develop a novel time series model that captures both the non-stationarity within a trial and the evolution of the underlying brain process across trials for the duration of the experiment. Our model uses the Fourier waveforms to represent the brain signals. Under the proposed model we rigorously define the spectrum and coherence to vary across time within one trial and also across trials during the experiment. To estimate the evolving evolutionary spectra and coherence, we employ a two-stage procedure. In the first stage, we compute the within-trial time-localized periodogram matrix estimates using a method that automatically selects the optimal smoothing span. In the second stage, we develop a data-driven approach for combining information from local periodogram matrices computed across trials during the experiment. We evaluate the performance of our proposed method and illustrate its advantage over models that ignore between-trials variation. Finally, we used the proposed method to study how the coherence between the nucleus accumbens and hippocampus regions evolves over the course of an associative learning experiment.

Literature:

Dahlhaus, R. (1997): Fitting time series models to non-stationary processes. *Annals of Statistics*, 25, 1–37.

Separable Covariances and their use in Functional Data Analysis

John Aston, Claudia Kirch and Davide Pigoli

In many applications concerning functional data, there is significant spatial or spatio-temporal structure. In cases where a full covariance analysis is required, it can often be very computationally advantageous to assume separable structures. However, such assumptions are often seen as overly restrictive. In this work, we will examine both the cases for and against using separability. It will be shown that if techniques such as PCA are to be formulated from the estimated covariance, using separability will at worst lead to a loss of efficiency (in terms of the basis functions chosen), which is often significantly outweighed by the resulting computational improvements. However, it is also of interest to test separability assumptions, and tests will also be given for examining the validity of separability in functional data. This work will be illustrated with applications from brain imaging and linguistics.

Shape-constrained Semiparametric Additive Stochastic Volatility Models

Peter F. Craigmile, Xinyi Xu and Jiangyong Yin

Nonparametric stochastic volatility models, although providing great flexibility for modeling the volatility equation, often fail to account for useful shape information. For example, a model may not use the knowledge that the autoregressive component of the volatility equation is monotonically increasing as the lagged volatility increases. We propose a class of additive stochastic volatility models that allow for different shape constraints and can incorporate a leverage effect, the asymmetric impact of positive and negative return shocks on volatilities. We develop a Bayesian fitting algorithm and demonstrate model performance on simulated and empirical datasets. Unlike general nonparametric models, our model sacrifices little when the true volatility equation is linear. In nonlinear situations we improve the model fit and the ability to estimate volatilities over general, unconstrained, nonparametric models.

This research is funded in part by the US National Science Foundation.

Literature:

J. Yin, P. F. Craigmile, and X. Xu: Shape-Constrained semiparametric additive stochastic volatility models. Submitted.