UFR IM²AG

UNIVERSITÉ Grenoble Alpes

SYLLABUS
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Time Series Analysis

WMM9MO19

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Motivation A time series is a sequence of random variables X_t, the index $t \in \mathbb{Z}$ being referred to as "time". Typically the observations are dependent and one aim is to predict the "future" given observations $X_1, \ldots, X_n$ in the "past".
As pinpointed by Shumway and Stoffer (2016): *"The analysis of experimental data ... observed at different points in time leads to new and unique problems in statistical modeling and inference. The obvious correlation introduced by the sampling ... can severely restrict the applicability of the many conventional statistical methods traditionally dependent on the assumption that these adjacent observations are independent and identically distributed."*

Overall objectives This course attempts to provide a comprehensive introduction to time series analysis. It gives an account of linear time series models and their application in modelling and forecasting of data collected sequentially in time.

Specific goals At the end of the course, the student will be able to analyse and model time series, not necessarily stationary, by proposing a model and proceed to the estimation of parameters using specific R packages and validate the proposed model. He will also be able to produce forecasts in terms of prediction intervals.

Approach The course rests on two main axes. To introduce the subject, a few examples are discussed at the beginning of the course.
The first part is mainly concerned with the basic theoretical aspects of time series. The basic concepts are introduced, namely the notion of stochastic processes, stationarity, mean and autocovariance of such processes. Then we dwell on the notion of observed trend in time series. Traditional models are studied and we discussed the notion of invertibility. In a natural way, the non-stationary time series are introduced.
In the second part, more applied, we are concerned mainly with the determination a model and estimation of the parameters with the aim of forecasting the values of the series.

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Prerequisites Shumway and Stoffer (2016) state that *"the prerequisites are an understanding of linear regression and some basic probability"* and statistic *"skills ... It also assumes general math skills at the high school level (trigonometry, complex numbers, polynomials, calculus, and so on).*

Contents **Time Series Characteristics:** Some Time Series Data; Time Series Models; Measures of Dependence; Stationary Time Series; Estimation of Correlation.
Time Series Regression: Classical Regression for Time Series; Exploratory Data Analysis; Smoothing Time Series.
ARIMA Models: Autoregressive Moving Average Models; Autocorrelation and Partial Autocorrelation; Estimation; Least Squares Estimation; Forecasting; Maximum Likelihood Estimation; Integrated Models; Building ARIMA Models Regression with Autocorrelated Errors; Seasonal ARIMA Models.
Some Additional Topics: (Depending on the time left.) GARCH Models; Transfer function models; Intervention analysis; Long Memory and Fractional Differencing; Unit Root Testing.

In parallel with the introduction of statistical concepts, R commonly used procedures are introduced. A special attention will be given to astsa packages developed by David Stoffer, see Shumway and Stoffer (2011) and TSA developed by Kung-Sik Chan and Brian Ripley, see Cryer and Chan (2008) .

Document(s) The lectures are based on elements from several books: see the references below. The student ought to get Shumway and Stoffer (2016). Get it at:
www.stat.pitt.edu/stoffer/tsa4/tsaEZ.pdf

Evaluation There will be a final written exam. **Duration:** 2 hours. **Authorized documents:** handwritten summary on two two-sided single A4 sheets and a copy of the course slides available on the website. **Prohibited materials:** other documents. **Equipment:** *Authorized material:* calculator; *Prohibited materials:* mobile phone / computer; think about spare batteries.

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