

TEACHING PLAN

STATISTICAL MODELING OF MULTIVARIATE EXTREMES, HT-19
FMSN15/MASM23 (Updated: Sun May 12, 2019)

Home page

Home page of course is in <http://www.maths.lth.se/matstat/kurser/fmsn15masm23/index.html> and will be updated regularly.

Teacher

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Course expedition

The secretary's office is on the second floor at the Centre for Mathematical Sciences building, south part. Office is open Mon-Fri 8³⁰–12, 13⁰⁰–16⁰⁰, tel 046-22 245 77.

Lectures and Exercises

See the last page for the schedule.

Computer assignments

Three computer assignments are included in the course. The main goal of the computer sessions is to provide the basic knowledge on how to use the statistical programming language R along with some specialized libraries for using copulas and analyzing multivariate extreme value data. They also provide some supplementary topics on applications of copulas and extreme value theory which are not covered in the course books. All the programs which are used in the computer sessions are free software so students who have access to a personal computer are encouraged to download and install them from <http://www.r-project.org> themselves.

In addition, there is a "Complementary Computer Assignment" for those students who have not taken the course "FMS155/MASM15: Statistical Modeling of Extreme Values".

It is mandatory to attend the first computer session but it is strongly recommended that all students participate even in the other two computer sessions in the scheduled time. In addition the students need to write and send a report (preferably as a PDF file) by e-mail to fmsn15@matstat.lth.se by the deadline which is specified for each computer assignment. See the home page of the course for more information on how to submit your report.

Credits and bonus points for computer assignments

This part of the course gives 1.5 credits. All computer assignments will be assessed as "passed" or "failed" and one needs to pass all three assignments in order to get credits for this part.

In addition, the last two computer assignments give a total bonus score 20 (maximum 10 points each) which will be counted in the final exam. The bonus points can only be used in the corresponding exams for that year. Note also that the bonus points will only be given to those reports which get "passed" after the first submission of the reports. Those reports which do not pass, can be resubmitted once again the next time the course runs. However, these reports will not get any bonus points.

Computer laboratory sessions

Three laboratory sessions are scheduled in the course to provide help for computer assignments. Computer lab MH:230 has been booked for students in this course on Thursdays, study weeks 1, 3 and 6 at 13¹⁵–16⁰⁰.

However, please note that **we always start the computer sessions in the class room** at the scheduled times as above. In these sessions the relevant commands and packages in R are demonstrated first. It is recommended that, if possible, the students bring their own laptop to these sessions.

Literature

- An Introduction to Copulas, Roger B. Nelsen, (2006). This book is available as e-book at Lund University library.
- Statistics of Extremes: Theory and Applications. (2004) Jan Beirlant, Yuri Goegebeur, Johan Segers, Jozef Teugels, with contributions from Daniel De Waal, Chris Ferro. This book is available as a reference book at Mathematics library. We will use only two chapters of this book and copies of those chapters will be handed out during the course. The book is available as e-book at Lund University library.

Other literature references

The following books are recommended to those students who are more interested in rather mathematical presentation of extreme value theory.

- Leadbetter, M.R., Lindgren, G. and Rootzén, H. (1983) Extremes and Related Properties of Random Sequences and Processes, Berlin: Springer-Verlag.
- Resnick, S.I. (1987) Extreme values, Regular Variation and Point Processes, Berlin: Springer-Verlag.
- Embrechts P. , Kluppelberg C., Mikosch T. (1997) Modelling Extremal Events , Berlin: Springer-Verlag.

Handouts

The handouts will also be available in the course shelf outside the Mathematical Statistic's expedition in the second floor.

Exams

Please check "upcoming exams in the Centre for Mathematical Sciences" or Lund University's exam schedule "TimeEdit" for the scheduled exams at LTH.

Allowed aids in the exams

1. Collection of formulas: *Table of Formulæ* and Appendix 2 on "Some distributions and their characteristics".
2. Calculator.
3. Dictionaries for translation.

Teaching plan

In the following **L**, **T**, **C** stand for “Lectures”, “Theoretical exercises” and “Computer assignments”, respectively. As for the literature we use “AITC” and “SOE” to refer to the books “An Introduction to Copulas” and “Statistics of Extremes: Theory and Applications”, respectively.

week 1

- L** Introduction to the course. Examples of applications of the course in insurance, finance and climate change studies. Stochastic vectors and multivariate models. Multivariate normal distribution.
Handout: Teaching plan, Collection of formulas: *Table of Formulæ*, *Computer assignment 1*.
- L** Pearson’s correlation and its limitations. Multivariate normal and multivariate t-distribution. Introduction to elliptical distributions. Parameter mixture distributions. Stieltjes integrals.
Handout: Stieltjes integrals.
- L** Necessary and sufficient conditions for multivariate distribution functions. Definitions and basic properties of copulas and Sklar’s theorem (Chapter 1 in AITC). Fréchet-Hoeffding bounds for joint distributions (Chapter 2 in AITC).
- C** Introduction to R, plots in R, programming in R (Bring your own laptop if possible). If you plan to use your own laptop make sure that you have installed the software package R before you attend the class.

week 2

- L** Properties of copulas for strictly monotone transformations of random variables, survival copulas, comonotonic and countermonotonic copulas, simulation of copulas (Chapter 2 in AITC).
Handout: Exercises 1.
- L** Methods for Constructing Copulas (Chapter 3 in AITC except Section 3.2). Introduction to archimedean copulas (Chapter 4 in AITC).
Handout: Article “Enjoy the joy of copulas”.
- T** Exercises1: 1-4.

week 3

- L** Archimedean copulas (Chapter 4 in AITC). Laplace transforms and Archimedean copulas. Dependence concepts, concordance function (Chapter 5 in AITC).
- L** Kendalls tau, Spearmans rho, other measures of association. Upper and lower tail dependence, examples of tail dependence for spherical and elliptical copulas and some parametric families of copulas (Chapter 5 in AITC)
- L** Statistical inference for copulas. (lecture notes)
Handout: Two handouts about statistical inference.

- T Exercises1: 5-9.
- C Introduction to using `copula` package in R. If you plan to use your own laptop make sure that you have installed the package `copula` in R before you attend the class. **Handout:** Computer assignment 2.

week 4

- L Some theoretical background for univariate extreme value theory, convergence to types theorem, max-stable distributions, extremal types theorem (lecture notes). (Chapter 8.1-8.2 in SOE).
- L Introduction to bivariate extreme value distributions, dependence function. Some parametric models for dependence functions. Statistical inference for bivariate extreme values. (Chapter 8.2 in SOE).
- T Exercises1: 10-14. Discussion of computer assignment 2.

week 5

- L Extreme value theory with copulas. Max-stable and extreme-value copulas. Pickand's non-parametric estimator of dependence structure. More on nonparametric estimation of dependence functions. (Chapter 9.1-9.2 in SOE). Introduction to package `evd` in R. If you plan to use your own laptop make sure that you have installed the package `evd` before you attend the class.
Handout: Exercises 2.
- L Generalisation of peaks over threshold model to multivariate case (Chapter 9.4 in SOE). Bivariate generalised Pareto distributions, type I (Chapter 9.4 in SOE, lecture notes, additional papers). Introduction to package `evd` in R for estimation of BGPD Type I.
Handout: Bivariate generalised Pareto distributions type I, computer assignment 3.
- T Exercises2: 1-3. Discussion of computer assignment 2.
- T Exercises2: 4-5. Discussion of computer assignment 2.

week 6

- L Parametric inference for bivariate generalised Pareto distributions, type II. Maximum likelihood estimation (lecture notes, additional papers). Introduction to package `mgpd` for estimation of BGPD Type II.
- L Review of the course.
Handout: Two old exams with solutions.
- T Exercises2: 6-10. Discussion of computer assignment 3.
- C Discussion of computer assignment 3.