جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Statistics of Extremes - AMCS 315

Division	Computer, Electrical and Mathematical Sciences & Engineering
Course Number	AMCS 315
Course Title	Statistics of Extremes
Academic Semester	Spring
Academic Year	2016/2017
Semester Start Date	01/22/2017
Semester End Date	05/18/2017
Class Schedule (Days & Time)	10:30 AM - 12:00 PM | Sun Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Raphael Georges Huser	raphael.huser@kaust.edu.sa	+966128080682	4117, 1, Al-Khawarizmi (bldg. 1)	

Teaching Assistant(s)

Name	Email

Course Information

Comprehensive Course Description	***Description:*** This advanced statistics course aims at providing a rather deep understanding of Extreme-Value Theory results, models, and methods, as well as some experience in the practical application of these tools to real data using the statistical software R. Theoretical and practical aspects will be covered. ***Tentative week-by-week outline:*** -W1: **Introduction:** Motivation; Examples; Brief history of the field developments; -W1-2: **Fluctuations of Sums:** Convergence; Laws of large numbers; Glivenko-Cantelli Theorem; Law of the iterated logarithm; Stable laws; Central Limit Theorem; Domains of attraction; -W2: **Fluctuations of Maxima:** Max-stability; Extremal Types Theorem (ETT); Generalized Extreme-Value (GEV) distribution; Max-domains of attraction; Von Mises conditions; -W3-4: **Statistical Analysis of Maxima:** Application of the ETT; Return levels; Moment and likelihood estimation; Bayesian extremes; MCMC; Metropolis-Hastings algorithm; -W5-6: **Threshold Approaches:** Point processes; Limiting results; Peaks Over Threshold (POT) analysis; Generalized Pareto Distribution (GPD); r-largest statistics method; -W7: **Modeling of Non-stationarity:** Non-stationarity; Inference and diagnostics; Semi-parametric regression; Quantile regression; -W8-9: **Temporal Dependence:** Time series; Stationarity; D(un) and D(un) conditions; Clustering and cluster size distribution; Extremal index; Return levels; Declustering; -W10-12: **Multivariate Extremes:** Componentwise maxima; Standardization; Limit distribution; Exponent measure; Pickands' dependence function; Parametric models; Multivariate point process; Multivariate GPD; Extrapolation; Asymptotic dependence and independence; Dependence measures; Likelihood inference; Composite likelihood Ledford-Tawn model and extensions; Heffernan-Tawn approach; -W13-15: **Spatial Extremes:** Gaussian processes; Stationarity and isotropy; Correlation functions; Max-stable processes; Limiting results for pointwise maxima; de Haan's representation; Parametric models; Current challenges.
Course Description from Program Guide	The advanced statistics course aims at providing a rather deep understanding of Extreme-Value Theory results, models, and methods, as well as some experience in the practical application of these tools to real data using the statistical software R. Theoretical and practical aspects will be covered.
Goals and Objectives	***Objectives:*** At the end of this course, the students should be able to: -Understand, state, prove all results seen in class and in the weekly assignments. -Apply extreme-value statistics tools in real data applications, fit extreme-value models using various techniques, interpret the results and diagnostic plots, know how to use the statistical software R in this context, and understand and interpret R outputs. -Master Extreme-Value Theory and Statistics in the univariate, multivariate, and spatio-temporal case, when extreme events are defined as block maxima or threshold exceedances.
Required Knowledge	**Prerequisites**: AMCS 241, 243, 245 (Mandatory); AMCS 307, 313 (Recommended)
Reference Texts	1. Coles (2001) An Introduction to Statistical Modeling of Extreme Values, Springer; 2. Embrechts, Klu ppelberg and Mikosch (1997) Modelling Extreme Events for Insurance and Finance, Springer; 3. Beirlant, Goegebeur, Teugels and Segers (2004) Statistics of Extremes: Theory and Applications, Wiley; 4. de Haan and Ferreira (2006) Extreme Value Theory: An Introduction, Springer; 5. Resnick (1987) Extreme Values, Regular Variation, and Point Processes, Springer; 6. Leadbetter, Lindgren and Rootz en (1983) Extremes and Related Properties of Random Sequences and Processes, Springer; 7. Other books: › – Galambos (1987) The Asymptotic Theory of Extreme Order Statistics, Krieger › – Gumbel (1958) Statistics of Extremes, Columbia University Press › – Kotz and Nadarajah (2000) Extreme Value Distributions, Imperial College Press › – Finkensta dt and Rootz en (2004) Extreme Values in Finance, Telecommunications and the Environment, CRC › – Reiss and Thomas (2007) Statistical Analysis of Extreme Values, Birkhauser

Method of evaluation	**30.00**% - Course Project(s) **30.00**% - Scientific review article presentation **40.00**% - Final exam
Nature of the assignments	There are three types of assignments: -**Weekly homework**: This consists of written theoretical exercises, but will NOT count for the final grade. -**Paper presentation**: Around the middle of the semester, the students will have to present one scientific paper in class (only once); this will count for 30% of the final grade. -**Project**: Each student will have to do a project, where the extreme-value concepts and methods will be applied in practice using the statistical software R. This project, done individually, will be due near the end of the semester. More details will be given as the semester progresses; this will count for 30% of the final grade.
Course Policies	-Class notices and course related information will be posted periodically on the AMCS 315 website on Blackboard. Please check regularly for important information. Also, there may be important email communications (like homework hints or a change in the exams date), so it is important to monitor your email account regularly. -Homeworks will be given throughout the semester. Although homeworks will not count for the final mark, students are strongly encouraged to do them regularly, and submit them to get corrections and feedback. For this, staple the pages together, submit the problems in order and write clearly. Solutions will be regularly posted on the course website. -The required computer software is R (see http://www.r-project.org). All examples and datasets will be provided in R code, and posted on the class webpage (on Blackboard). Recommended R packages for extreme-value analysis include evd, evdbayes, ismev, POT, evir, extRemes, fExtremes, HimDimMaxStable, SpatialExtremes, RandomFields, etc. Students are allowed to use other softwares (such as Matlab), although it might be more time-consuming than using R and is at their own risk. -Project: A project, done individually, will be due near the end of the semester. More details will be given as the semester progresses. Late projects will not be accepted. -Final exam: The final exam is closed books and closed notes. However, students are allowed to bring two A4 sheets (2 sides each) of notes, formulae or any other information (no photocopy is allowed).
Additional Information	

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Sun 01/22/2017 Wed 01/25/2017	Introduction: Motivation; Examples; Brief history of the field developments;
2	Sun 01/29/2017 Wed 02/01/2017	Fluctuations of Sums: Convergence; Laws of large numbers; Glivenko-Cantelli Theorem; Law of the iterated logarithm; Stable laws; Central Limit Theorem; Domains of attraction; Fluctuations of Maxima: Max-stability; Extremal Types Theorem (ETT); Generalized Extreme-Value (GEV) distribution; Max-domains of attraction; Von Mises conditions;
3	Sun 02/05/2017 Wed 02/08/2017	Statistical Analysis of Maxima: Application of the ETT; Return levels; Moment and likelihood estimation; Bayesian extremes; MCMC; Metropolis-Hastings algorithm;
4	Sun 02/12/2017 Wed 02/15/2017	Statistical Analysis of Maxima: Application of the ETT; Return levels; Moment and likelihood estimation; Bayesian extremes; MCMC; Metropolis-Hastings algorithm;
5	Sun 02/19/2017 Wed 02/22/2017	Threshold Approaches: Point processes; Limiting results; Peaks Over Threshold (POT) analysis; Generalized Pareto Distribution (GPD); r-largest statistics method;
6	Sun 02/26/2017 Wed 03/01/2017	Threshold Approaches: Point processes; Limiting results; Peaks Over Threshold (POT) analysis; Generalized Pareto Distribution (GPD); r-largest statistics method;
7	Sun 03/05/2017 Wed 03/08/2017	Modeling of Non-stationarity: Non-stationarity; Inference and diagnostics; Semi-parametric regression; Quantile regression;
8	Sun 03/12/2017 Wed 03/15/2017	Temporal Dependence: Time series; Stationarity; D(un) and D(un) conditions; Clustering and cluster size distribution; Extremal index; Return levels; Declustering;
9	Sun 03/19/2017 Wed 03/22/2017	Temporal Dependence: Time series; Stationarity; D(un) and D(un) conditions; Clustering and cluster size distribution; Extremal index; Return levels; Declustering;
10	Sun 03/26/2017 Wed 03/29/2017	Multivariate Extremes: Componentwise maxima; Standardization; Limit distribution; Exponent measure; Pickands' dependence function; Parametric models; Multivariate point process; Multivariate GPD; Extrapolation; Asymptotic dependence and independence; Dependence measures; Likelihood inference; Composite likelihood Ledford-Tawn model and extensions; Heffernan-Tawn approach;
11	Sun 04/02/2017 Wed 04/05/2017	Multivariate Extremes: Componentwise maxima; Standardization; Limit distribution; Exponent measure; Pickands' dependence function; Parametric models; Multivariate point process; Multivariate GPD; Extrapolation; Asymptotic dependence and independence; Dependence measures; Likelihood inference; Composite likelihood Ledford-Tawn model and extensions; Heffernan-Tawn approach;
12	Sun 04/09/2017 Wed 04/12/2017	Multivariate Extremes: Componentwise maxima; Standardization; Limit distribution; Exponent measure; Pickands' dependence function; Parametric models; Multivariate point process; Multivariate GPD; Extrapolation; Asymptotic dependence and independence; Dependence measures; Likelihood inference; Composite likelihood Ledford-Tawn model and extensions; Heffernan-Tawn approach;
13	Sun 04/16/2017 Wed 04/19/2017	Spatial Extremes: Gaussian processes; Stationarity and isotropy; Correlation functions; Max-stable processes; Limiting results for pointwise maxima; de Haan's representation; Parametric models; Current challenges.
14	Sun 04/23/2017 Wed 04/26/2017	Spatial Extremes: Gaussian processes; Stationarity and isotropy; Correlation functions; Max-stable processes; Limiting results for pointwise maxima; de Haan's representation; Parametric models; Current challenges.
15	Sun 04/30/2017 Wed 05/03/2017	Spatial Extremes: Gaussian processes; Stationarity and isotropy; Correlation functions; Max-stable processes; Limiting results for pointwise maxima; de Haan's representation; Parametric models; Current challenges.
16	Sun 05/07/2017 Wed 05/10/2017	
17	Sun 05/14/2017 Wed 05/17/2017	
18		

Note

The instructor reserves the right to make changes to this syllabus as necessary.