STAT 547M – Topics in Statistics
STATISTICAL MODELLING OF EXTREMES
2023/2024 – Term 1

Lecturer: Natalia Nolde (office: ESB 3156, email: natalia@stat.ubc.ca)
Lecture times: Tue/Thu 1:00-2:30pm in ESB 4192 (Sep 7 – Oct 19, 2023)

Course description: The statistical analysis of extreme values is of great importance in diverse fields of application, including finance and insurance, civil and reliability engineering, hydrology and environmental sciences. The largest insurance claims may lead to the insurer's insolvency; high waves together with strong wind may lead to a dike failure. These examples illustrate situations in which it is of interest and concern not just the typical behaviour of the underlying physical process but rather the behaviour of its extremes. Since, by definition, extreme observations are rare, there is too little data for adequate statistical modeling and inference in the context of extremes. To address this challenge, one can rely on asymptotic theory, known as Extreme Value Theory (EVT). The aim of the course is to motivate and demonstrate the use of EVT and its extensions as a basis for extreme value data modeling, with a greater emphasis on data analysis and associated inference techniques.

Learning outcomes: On completion of the course, students will be familiar with probabilistic foundations of extreme value theory, including univariate theory for the marginals and multivariate approaches for the extremal dependence structure. Students will acquire a basic toolkit to perform extreme value analyses in one dimension (the block maxima approach, peaks-over-threshold method and their extensions to non-stationary settings) and in higher dimensions via extremal dependence measures and parametric modeling of tail dependence structures.

Prerequisites: Sufficient background in basic probability theory and statistics (STAT 547C and STAT 560 as co-requisites are recommended). Some experience with statistical software R will be helpful.

Assessment: assignments (75%) and a course project[1] (25%).

References:

- Coles, S. G., *An Introduction to Statistical Modeling of Extreme Values*, Springer Series in Statistics, Springer-Verlag, London, 2001.
- Beirlant, J., Goegebeur, Y., Segers, J., and Teugels, J., *Statistics of Extremes: Theory and Applications*, Wiley Series in Probability and Statistics, Wiley, Chichester, UK, 2004.
- de Haan, L. and Ferreira, A., *Extreme Value Theory*: *An Introduction*, Springer, 2006.
- Resnick, S.I., *Extreme Values, Regular Variation and Point Processes*, Springer, 1987.

[1] This is a group project, which involves reading a paper on extreme value analysis and making a class presentation.

Tentative course outline:

1. Univariate extreme value analysis
   1.1 Univariate extreme value theory
   1.2 Inference: block maxima approach
   1.3 Threshold exceedances
   1.4 Peaks-over-threshold method
   1.5 Extension to non-stationary processes

2. Multivariate extreme value theory
   2.1 Ordering of multivariate data
   2.2 Multivariate limit distributions
   2.3 Tail dependence (summary) measures
   2.4 Asymptotic independence

3. Statistics of multivariate extremes
   3.1 Parametric models for coordinate-wise maxima
   3.2 Bivariate threshold models
   3.3 Inference in asymptotic independence case