PhD position in Mathematical Statistics

Institut 3IA Côte d'Azur, Laboratoire J.A. Dieudonné, Université Côte d'Azur, Nice.

This PhD scholarship aims to investigate open problems in spatio-temporal extreme-value modeling by adapting stochastic geometry tools and by developing applications to environmental risk assessment.

Duration. 3 years starting from September 2021. Monthly gross salary : around 2650 €.

Required qualification. Master 2 or equivalent level in Mathematical Statistics.

Teaching obligation. The selected PhD student is subject to a teaching obligation of 64 hours per year.

Required training and skills. The following skills are required:

- A solid background in multivariate probability and multivariate statistical theory,
- Possible knowledge in extreme value theory and spatial statistics,
- Good knowledge in programming languages (as R, Python, C++ or Matlab).

Goals. The theoretical developments of this P.h.D. project will focus on the following directions.

Geometric characterization of extremal space-time dependence in high-resolution gridded data. In spatial extreme-value analysis, threshold-based approaches have been extensively studied recently, but extensions to the space-time setting are still in their infancy, and summary statistics used in environmental risk assessment practice are most often defined from bivariate observations. The advent of satellite-based remote sensing techniques and of data assimilation into physical models has led to an increasing availability of data on highly resolved spatio-temporal grids. In this context of spatio-temporal extreme-value analysis of gridded datasets, we propose to develop threshold-based geometric summary statistics of higher order, related to excursion sets. They convey a more complete picture of the extremal behavior, e.g. with respect to "hot spots" and the interface between extreme and non-extreme regions. We aim to systematically study these *geometric summaries* for *Gaussian mixture constructions* and their limit processes. Statistical inference for such summaries will be developed and utilized for gridded datasets. Special attention is paid to the distinction of *asymptotically dependent* and *asymptotically independent* regimes.

Anomaly Detection for spatio-temporal data. In environmental risk management, an application of extreme-value theory is the *Anomaly Detection* problem. In the machine learning community, it is viewed as a special case of classification problems where the class representing anomalies has very few instances. Detecting anomalies usually consists in first learning a "normal profile" from training data, and then to label as abnormal any new data point located far from this profile. Extreme values play a crucial role because very often anomalies belong to *extremal regions*. The aim of this task is to propose novel methods for detecting anomalies in space-time indexed data. It will draw from results of the first task by taking into account probabilistic representations of *geometrical features* of high-dimensional data, where the temporal dimension is included to improve anomaly detection for dynamic processes. Due to spatio-temporal coherence of environmental phenomena, the developed approaches must appropriately address the space-time variability of geometrical features using functional extreme-value theory.

Applications. The methods developed in the above tasks will be applied to gridded datasets of temperatures, agro-meteorological indicators and weather-based wildfire danger indices, with a focus on hotspot characterization and detection and attribution of climate change effects. Data are available from the COPERNICUS Climate Data Store and from Météo France.

Contacts for candidates. Contacts to apply via mail:

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Required documents for candidates.

- Detailed Curriculum vitae;
- Motivation letter;
- Academic transcripts of a master's degree(s) or equivalent;
- Two reference contacts willing to provide a letter of recommendation;
- Internship report.