The University Grenoble Alpes is funding ambitious Cross-Disciplinary Projects. The project Trajectories has been selected in order to favour the rise of an interdisciplinary community working on a better understanding of socio-ecological systems facing global changes. PhDs/Postdocs included in this project are designed to favour interdisciplinary approaches. An abstract (in French and in English) of the proposed project for a scholarship starting **on or before January 1st 2018** is included below.

The scholarship will be funded by Trajectories https://trajectories.univ-grenoble-alpes.fr

Applicants for this project should contact:

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TITLE

NONPARAMETRIC NON STATIONARITY TESTS FOR EXTREMES

Supervisions:

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Institut des Géosciences de l'Environnement http://www.ige-grenoble.fr/

Required skills : we are looking for a student who received a Master's degree in statistics

Doctoral School: Mathématiques, Sciences et Technologies de l'Information, Informatique

http://edmstii.ujf-grenoble.fr/

Main objectives of the work:

The work proposed in this PhD concerns the study of Climate Change in the hydrometeorological series using rigorous statistical methods. By its nature, the project is interdisciplinary

because it requires for its short and long-term success, specialized expertise to both in theoretical statistics and hydrology/climatology. More specifically, the concerns are: (i) multivariate nonparametric statistics and modeling of the dependence using copula; (ii) change point tests; (iii) statistical hydrology and statistical climatology. We aim at proposing new probabilistic and statistical concepts as well as methods for modeling climatic and environmental risks in a non stationary framework. More precisely, the objective is the detection and modeling of temporal non stationarities in extremes. Extremes and maxima of stationary sequences under various mixing conditions have been studied intensively. However still little is known in the framework of non stationarity, induced by climate changes for example.

Deliverables

D1) Around the Lombard's test

The work will first focus on the Lombard's test, which is quite flexible as it is able to detect abrupt changes, linear trends or onset-of-trends. Even in the univariate context, few tests have been dedicated to the detection of changes for extremes. Nonparametric techniques, such as Mann-Kendall test for trend or Pettitt test for change point, have a long tradition of use in geosciences, even if they are inefficient for extremes. The Lombard test is a generalization of the Pettitt test that has been proposed in [3], and which allows to test also a linear trend. It could be adapted for more flexible trend, by nonparametric or semi parametric modeling. However, the main issue is that such tests have not been specifically developed for extremes. Indeed, the Lombard test is based on the rank score which corresponds to the normalization of a square-integrable transformation of the rank. In [1], various Cramér-von Mises and Kolmogorov-Smirnov statistics are compared. The challenge of adapting such tests for our purpose is thus to design new statistics, efficient for detecting extremes.

D2) Tests based on copulas

Copulas model the dependence between several random variables, in our context, for example statistical indices of detecting changes in extremes [5] or output of climate models. This approach has been proved to be successful these last years, where several statistical models of copulas have been developed. However the emergency of copulas to detect breaks is very recent. At short term we will propose improvements to existing methods; in addition we will consider a very general framework where data can be issued from a stochastic process with a temporal link. More specifically we will consider three different parts:

1. Part 1: We will develop tests based on Kendall's tau, a nonparametric measure of dependence, in the continuity of [2]. In this work we will rather consider a model with a

gradual change in the dependence

2. Part 2: In the same vein as in Part 1 we will consider tests based on Spearman's rank coefficient and on other measures of dependence.

3. Part 3: The dependence between two indices or output of dynamic models can be modeled by a nonparametric regression model. It is then possible to study the breaks in adapting the approach proposed by [4] and in generalizing it to multiple break-points.

5 references to support the work

. [1] J.-F. Quessy, A.-C. Favre, M. Saïd, and M. Champagne. Statistical inference in Lombard's smooth-change model. *Environmetrics*, 22(7):882–893, 2011.

. [2] J.-F. Quessy, M. Saïd, and A.-C. Favre. Multivariate Kendall's tau for change-point detection in copulas. *Canadian Journal of Statistics*, 41(1):65–82, 2013.

. [3] F. Lombard. Rank tests for changepoint problems. *Biometrika*, 74(3):615–624, 1987.

. [4] O. Mestre, C. Gruber, C. Prieur, H. Caussinus, and S. Jourdain. SPLID- HOM: A method for homogenization of daily temperature observations. *Journal of Applied Meteorology and Climatology*, 50(11):2343–2358, 2011.

. [5] X. Zhang and F. Zwiers. Statistical indices for the diagnosing and detect- ing changes in extremes. In *Extremes in a changing climate*, volume 65 of Water Sci. Technol. Libr., pages 1–14. Springer, Dordrecht, 2013.

Trajectories Project

The project's main scientific goal is to substantially improve knowledge of interactions between human societies and environment. The project fits into the overarching scheme of co-constructing decision-making support with territorial actors: those from the Arves valley, from the Maurienne valley, from the Romanche and Guisane valleys. Sustainable development urges to create policies enlightened by a better understanding of adaptation and coevolution patterns between social and physical environments.

Drawing from cross-cutting research mixing natural, geoscience, engineering, and human and social sciences, the project aims at promoting an emerging methodology based on:

- Observations of social, economic and environmental evolution of a given territory on a 200-year time-frame (strengthened with older data to better understand observable dynamics);

- Efforts to model coupled society-environment dynamics aiming at providing keys to both understand patterns and predict pattern inter-relations. The study of these interactions is three-fold: physical milieu-climate interactions, physical milieu-social practices interactions, social practices - socio-economic systems interactions.

- Territorial assessment to connect locally structuring human activities with both the way these activities draw on their territory's resources to metabolize them and turn them into sources of wealth, and the way this metabolization depreciates social and physical environment.

- Prospective scenarii built on an iterative mode, and which starting points are local decision-makers' territorial projects, connecting with global institutional constraints (related to sustainable development goals). The overaching goal is to feed a dialogue among researchers and territorial actors with observation, models, and assessment in order to create likely territorial trajectories.