Politecnico di Torino

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CIVIL AND ENVIRONMENTAL ENGINEERING

Space-time estimation of flood quantiles

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Context of the research activity	The research aims at better estimating design river flood peak discharges, i.e., flood quantiles, in the context of climate and environmental change. The idea is to develop and test new regionalization techniques that, as the existing ones, make use of past observation to quantify the probability of extreme river flood events in the future but, in addition, account for non-stationarity, i.e., the possible change in time of this probability due to changes of climate, land use, and river works.

As our climate system climbs through its current warming path, temperature and precipitation are greatly affected also in their extremes. There is a general concern that climate change may affect also the magnitude and frequency of river floods and, as a consequence, that existing and planned hydraulic structures and flood defences may become inadequate to provide the required protection level in the future. At the same time, land-use changes and river training also have affected, are affecting, and will affect river floods in the future. The standard engineering paradigm of estimating flood probabilities from what has been observed in the past should therefore be revised by acknowledging all these changes. For this reason, the recipient PhD student will aim at identifying functional relationships for predicting current and future flood intensities from climate indices and (combinations of different) topographic and river network indices, depending on catchment scales and hydrological features and context. She/he will develop and test new regionalization techniques that, as the existing ones, make use of past observation to quantify the probability of extreme river flood events in the future but, in addition, account for non-stationarity, i.e., the possible change in time of this probability due to changes of climate, land use, and river works. She/he will focus on the European Alps, which are an ideal laboratory for analysing complex effects of climate on floods, because change in heavy precipitation is only one of the drivers of flood change, being snow-rain partitioning and snowmelt other key processes in the formation of river floods of different types. Also, the European Alps are of great interest because they divide the Mediterranean and Continental Europe, with opposite projected changes in precipitation and different responses to climate oscillations.

The research questions are:

(i) Considering all existing uncertainties, are current regionalization procedures still adequate for flood quantile prediction in a changing environment?

Objectives	(ii) What are the necessary assumptions required by non-stationary regionalization models (e.g., space-time symmetry, space-time separability, …)? (iii) What are the climate/landscape predictors that are relevant to river flood changes? The recipient PhD student will tackle these questions using both statistical techniques and conceptual rainfall-runoff modelling. It is also expected that the recipient PhD student will develop diagnostic tools for describing where and how alterations of climate and flood extremeness are more likely to result in significant alterations of fluvial flood hazard, accounting for uncertainty. Understanding how floods and their probabilities will change is important, both from practical and theoretical perspectives. From a practical perspective, adaptation measures to floods are needed that consider realistic representation of climate related changes (as required by the EU Flood directive), which need the scientific and technical advancement of operational tools such as flood design regionalization techniques. From a scientific perspective, understanding extremes and their changes are a challenge as processes may change and the data base of extremes is by definition sparse. It is expected that our research will contribute to the understanding of the dominant climate mechanisms leading to flood changes and to improve our confidence in their future projections. The topic addressed in this research is expected to significantly improve our knowledge on the causes, magnitude and change of hydrometerological hazard, in line with one of the activities of Mission 2 of the Recovery and Resilience Plan (PNRR): Green Revolution and Ecological Transition. The recipient PhD is expected to spend at least 6 months abroad, at the Vienna University of Technology, in order to strengthen her/his international network and collaborate with one of the strongest international groups in the field of mountain hydrology. The products of the research will be made available following the FAIR data principles and Horizon 2020 guidelines on open access, i.e., making generated data, analysis software and tools open source (e.g. on platforms such as GitHub) as much as possible.

Skills and competencies for the development of the activity	It is expected that the recipient PhD will spend part of her/his research time (at least 6 months) abroad, at the Vienna University of Technology. Good knowledge of English is therefore mandatory. Programming skills are required, and the knowledge of the software R is to be considered preferable. Experience on issues related to Hydrology and Climatology is required. The ability to manage and analyze weather-climatic data is an advantage.