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Several investigations have been carried out in 2016, involving different fields, as outlined below.

Catchment compatibility via copulas (see [2]).
The similarity of catchment responses is a fundamental issue for regionalization studies, and hydrograph attributes (i.e., Discharge Peak, Volume, and Duration) can reveal the signature and the synthesis of local scale processes. Here, we focus the attention on the "compatibility" between catchments, viz. on the possibility to transfer, from one catchment to another, the information about the dependence structures at play. In particular, we statistically investigate the possible relationships between the features of different Basin Scenarios (characterized via the Concentration Time T_c and the Curve Number CN) and the corresponding dependence structures ruling the joint statistics of Discharge, Volume, and Duration. Given a large set of synthetic runoff time series, generated via a rainfall-runoff model, recent non-parametric tests, based on empirical copulas, are used to compare the dependence structures associated with different soil uses and concentration times. The results indicate how the hydrological properties may affect the dependence structure. The outcomes of the investigation could be particularly effective in two practical applications: (1) for determining the degree of compatibility of the dependence structures associated with different basin scenarios, and (2) for enriching scanty data bases, in order to improve the estimation of multivariate copulas.

Hazard Scenarios and Failure Probabilities (see [1]).
This work is of methodological nature, and deals with the foundations of Risk Assessment. Several international guidelines have recently recommended to select appropriate/relevant Hazard Scenarios in order to tame the consequences of (extreme) natural phenomena. In particular, the scenarios should be multivariate, i.e. they should take into account the fact that several variables, generally not independent, may be of interest. In this work, it is shown how a Hazard Scenario can be identified in terms of (i) a specific geometry and (ii) a suitable probability level. Several scenarios, as well as a Structural approach, are presented, and due comparisons are carried out. In addition, it is shown how the Hazard Scenario approach illustrated here is well suited to cope with the notion of Failure Probability, a tool traditionally used for design and risk assessment in engineering practice. All the results outlined throughout the work are based on the Copula Theory, which turns out to be a fundamental theoretical apparatus for doing multivariate risk assessment: formulas for the calculation of the probability of Hazard Scenarios in the general multidimensional case ($d \geq 2$) are derived, and worthy analytical relationships among the probabilities of occurrence of Hazard Scenarios are presented. In addition, the Extreme Value and Archimedean special cases are dealt with, relationships between dependence ordering and scenario levels are studied, and a counter-example concerning Tail Dependence is shown. Suitable indications for the practical application of the techniques outlined in the work are given, and two case studies illustrate the procedures discussed in the paper.

Ties and randomization (see [3]).
Many recent works show that copulas turn out to be useful in a variety of different applications, especially in environmental sciences. Here the variables of interest are usually continuous, being times, lengths, weights, and so on. Unfortunately, the corresponding observations may suffer from (instrumental) adjustments and truncations, and eventually may show several repeated values (i.e., ties). In turn, on the one hand, a tricky issue of identifiability of the model arises, and, on the other hand, the assessment of the risk may be adversely affected. A possible remedy is to adopt suitable randomization procedures: here three different strategies are outlined. The goal of the work is to carry out a simulation study in order to evaluate the effects of the randomization of multivariate observations when ties are present. In particular, it will be investigated whether, how, and to what extent, the randomization may change the estimation of the structural risk: for this purpose, a coastal engineering example will be used, as archetypical of a broad

class of models and problems in engineering applications. Practical advices and warnings about the use of randomization techniques are hence given.

Spin-off copulas and structural risk (see [4]).

In environmental applications, the estimation of the structural risk is fundamental. Beside the knowledge of the physical response of the structure to the loads of interest, a statistical model for the behavior of the input variables is generally required, possibly accounting for the fact that these variables are usually non-independent. For this purpose, a multivariate approach based on copulas is adopted in this paper. In particular, the following classes of dependence structures are often used in practice: the Extreme Value copulas, and the Archimedean copulas. However, how to properly select a suitable Extreme Value or Archimedean copula is a problem open to many solutions. As a viable one, this work shows how two semi-parametric approximations to, respectively, Extreme Value and Archimedean copulas, can be used in order to circumvent the troublesome selection issue in the estimation of the structural risk. Suitable simulation studies are performed, in order to check and evaluate the performance of the approximating techniques introduced in this work.

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