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# Modelling Spatial Phenomena and Joint Return Periods with Copulas using R: the spcopula Package

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The freely available and open R-package spcopula implements applications of copulas in the spatial and hydrological domain. Copulas allow us to flexibly build multivariate distributions with mixed margins where the copula describes the multivariate dependence structure coupling the margins. Many bivariate copula families are well known and quite a few of them have been provided in other R-packages. As multivariate copulas often lack flexibility, the spcopula package uses the concept of vine copulas where a multivariate copula is approximated through decomposition into bivariate building blocks. These blocks are modelled by bivariate copulas that can be flexibly combined and rely on well-known theory.
The spcopula package provides methods to estimate spatial multivariate distributions with changing parameters over space as similarly done in kriging but with distributions beyond the Gaussian one. Furthermore, copula families may change over space allowing not only for a varying strength of dependence but for changing dependence structures. These distributions can for instance be used to predict values at unobserved locations, do risk assessment or run simulations. The spatial multivariate copulas describing the varying dependence structure for local neighbourhoods are approximated using vine copulas where the first tree consists of spatially varying bivariate copulas.
Additional functions based on multivariate copulas (not necessarily vine copulas) are provided to calculate multivariate joint return periods for a set of variables. These include the joint return period of the or-case where either one of the margins may be larger than the design event and the joint Kendall return period being consistent with the univariate concept of classifying all possible events through their cumulative distribution function. Some copula families allow for joint tail dependence and are powerful tools in the multivariate extreme value analysis.
Being based on vine copulas, the spcopula package incorporates an extensive set of multivariate distributions. This makes it especially helpful for modelling skewed or heavy tailed data stemming from complex dependence structures.