Evaluation of multi-parameter dependencies in weather and climate simulations

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Weather and climate simulations based on numerical models provide 4-dimensional reconstructions of multiple meteorological parameters describing the atmospheric state. Yet, the vast majority of evaluation studies focus on the evaluation of single parameters in time and space without looking at the statistical multivariate dependence between the parameters. This, however, is necessary especially with respect to specific events where two or more parameters are involved, i.e., so called compound events. Previous studies have investigated the representation of natural hazards such as wildfires, heat stress, droughts by evaluating corresponding indices based on two or more parameters. Thereby the evaluation process stays in a single parameter framework with well established verification methods at hand.

In this work, we present a more sophisticated and generalized approach to investigate physical dependencies between parameters by employing copula theory. With this method, we aim at evaluating the multivariate statistical dependence between two parameters (i.e. the copula) separately from their marginal distributions. This separation enables a more detailed investigation of compound indices (CI) based on the involved parameters. The differences in CI derived from model simulations and observations can now be related to deficiencies of the numerical model due to (i) a misrepresentation of the marginal distributions of the contributing variables, (ii) a misrepresentation of the statistical dependence between the parameters (the copula), (iii) or both. While the method is applicable to all combinations of two parameters, we will present the results of a specific joint copula-based evaluation of temperature and humidity which are the basis for natural hazards mentioned above.