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Analysis of inter-variable relations in regional climate model output

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The topic of physical consistency and inter-variable relations of climate model output, in particular when applying statistical downscaling and bias correction to single variables, is widely discussed in the climate impact modelling and climate impact communities. Many situations require the consideration of several climate variables simultaneously, as a result of which it is also necessary to check that the inter-variable dependence structure is simulated realistically by the RCMs.
Given that it is common practice to bias-adjust RCM outputs so as to improve their properties with respect to the distribution of variables taken individually, it is also of interest to determine whether inter-variable relationships are affected by empirical bias adjustment procedures such as quantile mapping, that are applied separately to each variable. A pragmatic reason to look at this is, if bias-adjusted outputs are to be used in impacts studies, it is necessary to check that the inter-variable relationships are realistic. A more fundamental reason is, that RCMs are physically based and, before bias correction, their outputs should therefore ideally be physically consistent. However, an empirical bias adjustment procedure has the potential to break the physical consistency, thereby removing one of the strongest justifications for using RCMs in the first place.
Based on these considerations, the study aims to answer two questions. The first is to assess the inter-variable relationships in a suite of RCM outputs in more detail than has previously been attempted, by examining conditional probability densities instead of correlations. The second is to quantify the extent to which these conditional densities are distorted by an empirical bias adjustment procedure.
The results can be used both to evaluate the ability of current RCMs (bias-adjusted or not) to provide useful information for climate change impact assessments; and also to determine the viability of quantile mapping as a bias adjustment procedure in situations where multiple variables must be considered.