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Detecting anomalous spatial patterns with the cumulant function

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In climate studies, detecting spatial patterns that largely deviate from the sample mean still remains a statistical challenge. Although Principal Component Analysis (PCA) is often applied on this purpose, it can only provide meaningful results if the underlying multivariate distribution is Gaussian. Indeed, PCA is based on optimizing second order moments quantities, and the covariance matrix can only capture the full dependence structure for a multivariate Gaussian vector. Whenever the application at hand can not satisfy this normality hypothesis (e.g. precipitation data), alternatives and/or improvements to PCA have to be developed and studied. To go beyond the second order statistics constraint we take advantage of the cumulant function. As well-known from statistical literature, the cumulant function can produce higher order moments information, and allows us to propose a new, simple and fast procedure to identify spatial patterns for non-Gaussian data. Our algorithm consists in maximizing the cumulant function over growing hyperspheres, which correspond to the extraction of the most relevant cumulants. This methodology is tested on two non-Gaussian multivariate random variables (Gamma and Skewed-Normal).