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Non-random correlation structures and dimensionality reduction in multivariate climate data

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It is well established that the global climate is a complex phenomenon with dynamics driven by the interaction of a multitude of identifiable but intertwined subsystems. The identification, at some level, of these subsystems is an important step towards understanding climate dynamics. We present a method to determine the number of principal components representing non-random correlation structures in climate data, or components that cannot be generated by a surrogate model of independent stochastic processes replicating the auto-correlation structure of each time series. The purpose of the method is to automatically reduce the dimensionality of large climate datasets into spatially localised components suitable for further interpretation or, for example, for use as nodes in a complex network analysis of large-scale climate dynamics. We apply the method to two 2.5° resolution NCEP/NCAR reanalysis global datasets of monthly means: the sea level pressure (SLP) and the surface air temperature (SAT), and extract 60 components explaining 87 % variance and 68 components explaining 72 % variance, respectively. The obtained components are in agreement with previous results in that they recover many well-known climate modes previously identified using other approaches including regionally constrained principal component analysis. Selected SLP components are discussed in more detail with respect to their correlation with important climate indices and their relationship to other SLP and SAT components. Finally, we consider a subset of the obtained components that have not yet been explicitly identified by other authors but seem plausible in the context of regional climate observations discussed in literature.

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