*Visualization and assessment of spatio-temporal covariance properties*

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Spatio-temporal covariances are important for describing thespatio-temporal variability of underlying random fields in geostatistical data. For second-order stationary random fields, there exist subclasses of covariance functions that assume a simpler spatio-temporal dependence structure with separability and full symmetry. However, it is challenging to visualize and assess separability and full symmetry from spatio-temporal observations. In this work, we propose a functional data analysis approach that constructs test functions using the cross-covariances from time series observed at each pair of spatial locations. These test functions of temporal lags summarize the properties of separability or symmetry for the given spatial pairs. We use functional boxplots to visualize the functional median and the variability of the test functions, where the extent of departure from zero at all temporal lags indicates the degree of non-separability or asymmetry. We also develop a rank-based nonparametric testing procedure for assessing the significance of the non-separability or asymmetry. Essentially, the proposed methods only require the analysis of temporal covariance functions. The performances of the proposed methods are examined by simulations with various commonly used spatio-temporal covariance models. To illustrate our methods in practical applications, we apply it to real datasets, including weather station data and climate model outputs.