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Spectral methods for non-linear co-regionalization

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It is frequently the case that direct and indirect measurements have to be combined to deliver meaningful estimates of the variable of interest. Linear co-regionalization, which assumes that all variables share common spatial structures, has widely been used in geostatistics to model the correlated spatial random fields. The underlying linearity assumption, however, is restrictive with respect to the choice of the direct and cross variograms, as it assumes very similar spatial structure for the direct and indirect variables. In this contribution, a new method of non-linear co-regionalization based on Fourier transformation is presented. First, the coherence of the corresponding fields based on their power spectra is introduced. The coherence gives a variogram-dependent upper and lower limit for the correlation of the random fields. The direct variograms of the two fields depend on their phase spectrum. The phase differences of these phase spectra determine the cross-variogram. A simulation method for generating correlated random fields with given direct and cross variograms is presented. The method allows the use of different models for the direct variograms as well as for the cross variogram. Further, the method enables the consideration of non-Gaussian copula-based spatial features, such as different types of spatial asymmetries. This enables the simulation of correlated fields with value-dependent correlations. A real world and various theoretical examples with different Gaussian and non-Gaussian copula-based dependence structures will be used to illustrate the methodology and its flexibility.