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Reconstruction of principal dynamical modes from climatic variability: nonlinear approach

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Analysis of multivariate time-series produced by complex systems requires efficient tools for reduction of data dimension. We consider this problem in relation to empirical modeling of climate, which implies an analysis of spatial-distributed time-series. The main goal is to establish the number of principal modes which have key contribution to data and actually governs the observed variability. Currently, the number of widely used linear methods based on PCA and factor analysis exists, which yield different data decompositions taking into consideration simultanious/time-lag correlations between spatial grid points. However, the question about possibility of improving the decomposition by taking into account nonlinear couplings between variables often remains untouched.

In the report the method for constructing principal dynamic modes on the basis of low-dimensional nonlinear parametric representation of observed multivariate time-series is suggested. It is aimed to extracting the set of latent modes that both explains an essential part of variability, and obeys the simplest evolution law. Thus, this approach can be used for optimal reconstruction of the phase space for empirical prognostic modeling of observed dynamics. The evidence of nonlinear couplings in SST space-distributed data covering the Globe is investigated by the proposed approach. It is demonstrated that the obtained principal modes capture more part of SST variability than principal components (PCs) constructed by either EOF decomposition or its spatio-temporal extension. Relation of these modes to various climate phenomena is shown and discussed in the report. The application of the approach to data-driven forecast of climate bahavior is also discussed.