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Constructing the reduced dynamical models of interannual climate variability from spatial-distributed time series

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We suggest a method for empirical forecast of climate dynamics basing on the reconstruction of reduced dynamical models in a form of random dynamical systems [1,2] derived from observational time series. The construction of proper embedding – the set of variables determining the phase space the model works in – is no doubt the most important step in such a modeling, but this task is non-trivial due to huge dimension of time series of typical climatic fields. Actually, an appropriate expansion of observational time series is needed yielding the number of principal components considered as phase variables, which are to be efficient for the construction of low-dimensional evolution operator. We emphasize two main features the reduced models should have for capturing the main dynamical properties of the system: (i) taking into account time-lagged teleconnections in the atmosphere-ocean system and (ii) reflecting the nonlinear nature of these teleconnections. In accordance to these principles, in this report we present the methodology which includes the combination of a new way for the construction of an embedding by the spatio-temporal data expansion and nonlinear model construction on the basis of artificial neural networks. The methodology is aplied to NCEP/NCAR reanalysis data including fields of sea level pressure, geopotential height, and wind speed, covering Northern Hemisphere. Its efficiency for the interannual forecast of various climate phenomena including ENSO, PDO, NAO and strong blocking event condition over the mid latitudes, is demonstrated. Also, we investigate the ability of the models to reproduce and predict the evolution of qualitative features of the dynamics, such as spectral peaks, critical transitions and statistics of extremes.

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