
**EMPIRICAL RECONSTRUCTION OF COMPLEX SYSTEMS:
PROGNOSTIC MODELS OF EVOLUTION OPERATOR, OPTIMAL PRE-PROCESSING OF HIGH-
DIMENSIONAL DATA, APPLICATIONS TO CLIMATE**

A. Feigin¹, A. Gavrilov¹, E. Loskutov¹ & D. Mukhin¹

¹*Institute of Applied Physics of the Russian Academy of Sciences, Nizhny Novgorod, Russia*

Key words empirical reconstruction, complex systems, critical transition prediction, data processing, principal dynamical modes

The report presents new empirical approach to predicting evolution of complex system including bifurcations (critical transitions) of their behavior. By complex system we mean high-dimensional, spatially distributed system possessing broad spectrum of temporal scales.

This approach relies on nonlinear stochastic modeling of the system's time-dependent evolution operator by the analysis of observed behavior. Empirical models that take the form of a discrete random dynamical system are constructed using artificial neural networks; these models include state-dependent stochastic components.

A key difficulty in applying this methodology to construct a model that helps simulate and predict the real climate system's behavior is the mismatch between the large number of variables by which one wishes to describe the system versus the shortness of the time series of available experimental data.

Efficient reduction of the system's dimensionality is thus essential in order to infer an evolution operator for a low-dimensional subsystem that determines the key properties of the observed dynamics. To solve this problem the suggested approach combines two procedures:

- i. Optimal decomposition of the high-dimensional data produced by the system into (weakly) coupled space-time patterns ("modes"), which make the basic contribution to the observed variability;
- ii. Construction of models of the separate modes in a form of low dimensional random dynamical systems.

The methods of solutions of these tasks are described in the report. The abilities of these methods are illustrated by dint of both really measured and generated numerically vector time series of climatic observables. Please upload the generated pdf on the abstract submission field in the New submission link, and provide a zipped version of the source text and figures as supplementary data.