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Stochastic modeling of ENSO phenomena: low-dimensional prognostic model from time series

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The majority of natural systems (climate system including) are known to be both high-dimension and open, i.e. subject to numerous external forcings. Hence in many cases they produce complex multi-scale behavior which cannot be modeled in deterministic way by direct analysis of observed processes. A basic idea underlying the suggested stochastic approach is that the key ("robust") dynamic properties of the system evolution can be described by a few variables, while other features may be considered as a stochastic disturbance [1]. Stochastic models of this sort are of the form of random dynamical systems; they present a necessary and important step towards reconstructing the observed systems when their adequate first-principle mathematical models are either unknown or subjected to further verification.

In this report we present new attempt of application of this approach to prognostic analysis of El-Niño/Southern-Oscillation (ENSO) system behavior. We construct low dimensional stochastic model of evolution operator of unknown system by virtue of scalar time series generated by the system. The model operator includes deterministic as well as stochastic terms; both of them supposed to be inhomogeneous in the model state space and are parameterized by artificial neuron networks. We use as a data source one of the simplified ENSO models [2], complimented by both dynamical noise reflecting influences of external forcing, and slow trend of control parameter making this system weakly non-autonomous. Applicability of reconstructed model for prognosis of qualitative changes (critical transitions) of system behavior is demonstrated for time interval greater than "observation" period. We compare suggested technique of reconstruction with the procedure described in [3] and discuss a workability of the approach for analysis and prognosis of real-measured ENSO dynamics.

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