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Data-driven stochastic model for cross-interacting processes with different time scales

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The problem of modeling interaction between processes with different time scales is very important in geoscience. In this report, we propose a new form of empirical evolution operator model based on the analysis of multiple time series representing processes with different time scales. We assume that the time series are given on the same time interval.

To construct the model, we extend the previously developed general form of nonlinear stochastic model based on artificial neural networks and designed for the case of time series with constant sampling interval [1]. This sampling interval is related to the main time scale of the process under consideration, which is described by the deterministic component of the model, while the faster time scales are modeled by its stochastic component, possibly depending on the system's state. This model also includes slower processes in the form of weak time-dependence, as well as external forcing. The structure of the model is optimized using Bayesian approach [1]. The model has proven its efficiency in a number of applications [2-4].

The idea of modeling time series with different time scales is to formulate the above-described model individually for each time scale, and then to include the parameterized influence of the other time scales in it. Particularly, the influence of "slower" time series is included in the form of parameter trends, and the influence of "faster" time series is included by time-averaging their statistics. The algorithm and first results of comparison between the new model and the model without cross-interactions will be discussed.

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