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Empirical diagnosis and forecasting of extremes in a changing climate: a case study of Russia

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Extreme events have a strong impact on economic and ecological systems, causing dramatic effects on agriculture, health and other socio-economic activities. Predicting these impacts is of great importance, that is why climate studies over the last decades have focused on weather and climate change extremes both in the future and in the past.

Statistical analysis of observational data is still considered as the basic one in climatology. It allows one to study regional manifestations of the global processes in the climate system of different temporal scales of variability. The results of such a retrospective analysis are usually used for validation of global or regional climate models, for statistical forecasting of expected changes as well as for implementation of methods for dynamical and empirical-statistical downscaling of global climate model output to the regional scales. This issue becomes particularly relevant when studying extreme meteorological events in a changing climate.

The goal of the present study is to develop an algorithm of empirical diagnosis and forecasting of extremes in a changing climate. The algorithm suggested here is based on (a) technique of nonlinear time series decomposition into empirical modes from noise to trend - EMD method (Huang et al., 1998), (b) modeling of extreme values distribution by GEV, (c) reproduction of correlation structure of climatic series with long "memory" using fractional-integrated autoregressive models - moving average (FARIMA), (d) generation of ensemble of "artificial" surrogate time series using stochastic iterative amplitude adjusted Fourier transform algorithm (Venema V. et al., 2006).

Such an approach allows one not only to make a thorough statistical diagnosis of regional meteorological extremes in a non-stationary climate but also to make an empirical forecasting of the weather and climate anomalies into the near future. The algorithm was implemented and tested using daily data on air temperature and precipitation at meteorological stations of different climate regions: the upper Volga region, the territory of the Northern Caucasus and the Azov-Black sea coast region.

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