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Short-Range Forecast Of Pollutants in the Water Basins of Rivers Using Non-Linear Prediction Method

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During the last two decades, many studies treated chaos theory with respect to various dynamical systems. The studies of chaos that was applied to time series of atmospheric (environmental, water mediums) pollutants are few in number, and their outcomes are ambiguous [1-3]. Using chaos theory and non-linear short-range forecast of atmospheric and water environment pollutants are in principle possible, but time series of air constituents are by no means always chaotic. The present study is two-aimed: (1) to identify the chaos in the hourly time series of nitrates, sulphates and others substances at water basin's of the Small Carpathians during the 1969-1996, and (2) to forecast the concentrations of these pollutants using the non-linear prediction method. To identify the chaos in the time series, the following methods are applied. (1) To determine time delays, the concept of mutual information is used; (2) To determine attractor dimensions, we apply both the correlation integral method and the false nearest neighbours algorithm; (3) To refine the obtained results, we use surrogate data sets; (4) We evaluate Lyapunov exponents as the dynamic invariants of chaotic system. The detailed data on the time delays (τ) and attractor (d_A), embedding (d_E), Kaplan-York (d_L) dimensions and limits of predictability (Pr_{max},hours) for nitrates at water basins of Small Carpathians are presented. As example, let us indicate these data for Ondava (Stropkov) river.

River (Station)	τ	d_A	d_E	d_L	Pr_{max}	K
Ondava (Stropkov)	9	5,31	6	4,11	8	0,68

In spite of the fact that the correlation integral method provides the relatively small attractor dimensions, both the surrogate data method and the false nearest neighbours algorithm assert that the more reliable d_E for all datasets is 6. Such a value for the embedding dimension is comparatively large, but still indicates the presence of low-dimensional chaos in the studied time series. Also, two positive Lyapunov exponents validate the previous outcome. Using the results of previous analysis, we apply the non-linear prediction method and compare the predicted values with observed ones during 1969-1996 years term. Our results can be considered as an example of quite satisfactory short-range forecast for the pollutants (substances) at water basins of rivers. It should be noted that predicted values using the non-linear method are close to the real data in the case of abrupt changes of concentrations; at least, all tendencies to the increase or decrease are uncovered.

References

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