Numerical modeling and forecasting the geophysical (atmospheric and hydroecological) systems dynamics by using the non-linear prediction and chaos theory methods

A.V. Glushkov, O.N. Grushevsky, V.N. Vaschenko and T. Gerasimenko

Odessa State University – OSENU, Odessa, SE-65009, Ukraine
Kiev State Environmental Academy, Kiev, Ukraine

It is known that a chaos is alternative of randomness and occurs in very simple deterministic systems. Although chaos theory places fundamental limitations for long-rage prediction, it can be used for short-range prediction since ex facte random data can contain simple deterministic relationships with only a few degrees of freedom. Many studies in various fields of science have appeared, where chaos theory was applied to a great number of dynamical systems. The studies concerning non-linear behaviour in the time series of atmospheric constituent concentrations are sparse, and their outcomes are ambiguous. Our paper concerns results of the research into dynamics of variations atmospheric (atmospheric pollutants concentrations) and hydroecological (nitrates and sulphates concentrations in the river's water reservoirs) systems in the definite region by using the non-linear prediction approaches and a chaos theory methods (in versions [1-3]). A chaotic behaviour in the nitrogen dioxide and sulphurous anhydride concentration time series at a group of the sites in Odessa, Kiev, Donetsk, Alchevsk regions numerically investigated. To analyze measured time histories of the considered system responses with the use of the Recurrence Plots, the phase space of these systems was reconstructed by delay embedding. To reconstruct the corresponding attractor, the time delay and embedding dimension are needed. The former is determined by the methods of autocorrelation function and average mutual information, and the latter is calculated by means of correlation dimension method and algorithm of false nearest neighbours. It's shown that low-dimensional chaos exists in the time series under investigation. The spectrum of Lyapunov exponents (LE) is reconstructed as well as both Kaplan-Yorke dimension and Kolmogorov entropy that inversely proportional to the predictability limit are calculated.

References

1. A. Glushkov A.V., , A chaos theory: Application in Geophysics, Odessa-Astroprint (2013);
2. Rusov V.D., Glushkov A.V., et al, 2008 Adv. Space Res. 42, 1614 (2008); J. of Atm. and Solar-Terr. Phys. 72, 498 (2010)
3. Glushkov A., et al, in: Dynamical Systems: Theory and Application, Lodz, 2011; Quart.J.Royal Met..Soc. 132, 447 (2006); Journ. Hydr.322, 14 (2006); Atmospheric Environment 42, 7284 (2008).