Non-linear prediction method in short-range forecast of atmospheric pollutants:
Low-dimensional chaos

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Abstract: A chaotic behaviour in the nitrogen dioxide and sulphurous anhydride concentration time series at 2 sites in Gdansk region is investigated. To reconstruct an 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.

Keywords: Low-dimensional chaos, Non-linear prediction method, Lyapunov exponents, Kaplan-Yorke dimension, Kolmogorov entropy, Atmospheric pollutants.

1. Introduction
It’s known that a chaos is alternative of randomness and occurs in very simple deterministic systems. Although chaos theory places fundamental limitations for long-range prediction (c.f.[1-9]), 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. In [5] it’s investigated time series of NO₂, CO, O₃ in Bristol and New Castle (Pennsylvania), and is not received an evidence of chaos. In refs.[3,6], it was shown that O₃ concentrations in Cincinnati (Ohio) and Istanbul are evidently chaotic, and non-linear prediction method provides satisfactory results. The above-mentioned studies allow concluding that methodology from chaos theory can be applied and the short-range forecast by the non-linear prediction method can be satisfactory. Time series of concentrations are however not always chaotic, and chaotic behaviour must be examined for each time series. So, we shall (i) study the concentration of atmospheric constituents in Gdansk region to select only those measurements, which are defined as chaotic, and (ii) build non-linear
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prediction model for selected time series.

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