The 6th European Conference on Ecological Modelling ECEM '07

Trieste

November 27-30, 2007

Conference proceedings

Challenges for ecological modelling in a changing world: Global Changes, Sustainability and Ecosystem Based Management

MULTI-FRACTAL APPROACH AND CORRELATON INTEGRAL METHOD TO MODELING AIR POLLUTIION FIELD STRUCTURE FOR INDUSTRIAL CITY'S ATMOSPHERE (ODESSA REGION)

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Key words: atmospheric pollutants, chaos, fractals, correlation integral method

Here we present effective approach to studying temporal and spatial structure of the air pollution fields in the industrial city's atmosphere, based on the correlation integral method and multifractal and wave-let formalism. The approach is applied to an analysis of the Odessa atmosphere aerosol component data. On the basis of the correlation dimension approach to empirical data we have discovered the effects of stochasticity and fractal features in the dusty air pollution field structure. We evaluate Lyapunov exponents as the dynamic invariants of chaotic system. All used methods are in detail described in the review of Abarbanel et al. (1993) and are widely used. As a first step, the present study investigates the dusty air pollution variability series of different (temporal) scales. Data of four different temporal scales, i.e. 0,5-daily, 1-daily, 1-week, 0,5-month, and 1-month, over a period of about last 40 years observed at the studied cities are analyzed (independently) to investigate the existence of stochasticity (chaos). The underlying assumption is that the individual behavior of the dynamics of the processes at these scales provides important information about the dynamics of the overall dusty air pollution transformation between these scales. More specifically, if the dusty air pollution variability processes at different scales exhibit chaotic behavior, then the dynamics of the transformation between them may also be chaotic. The correlation functions and the exponents are computed for the four series. The delay time, t, for the phase-space reconstruction is computed using the auto correlation function method and is taken as the lag time at which the auto correlation function first crosses the zero line. Data about the relationship between the correlation exponent values and the embedding dimension values for different data sets are given. For all the series, the correlation exponent value increases with the embedding dimension up to a certain dimension, beyond which it is saturated; this is an indication of the existence of deterministic dynamics. Saturation of the correlation exponents is observed for all data sets and amounts to the 2.72, 3.42, 4.15, and 5.92. Also, we will show that relationship for the 30 realization of surrogate datasets, and no saturations are observed in this case. The S values for some embedding dimensions are presented (table 1). The finite correlation dimensions obtained for the four series indicate that they all exhibit chaotic behaviour. The presence of chaos at each of these four scales suggests that the dynamics of transformation of the air pollution dusty component between these scales may also exhibit chaotic behaviour.

Table 1. Significance values, S, for datasets with different time resolution (sample period: January 1, 1976—December 31, 2002) and some embedding dimensions, m. (Odessa city)

	m=2	m=4	m=6	m=8	m=9	m=10	m=11	m=12
Daily	12.3	25.7	41.4	50.6	48.1	47.0	45.6	42.1
Weekly	11.8	20.3	28.4	39.6	45.2	48.3	47.6	44.2
Semi-monthly	12.6	15.6	20.3	28.4	33.7	39.0	44.5	41.9
Monthly	12.1	16.2	22.7	26.1	30.0	32.1	35.2	38.9

Using the results of previous analysis, we apply the non-linear prediction method and compare the predicted values with both last one hundred data and nine hundred random data in the series. Our results can be considered as an example of quite satisfactory short-range forecast for the air pollutants in the Odessa city. Let us note that the 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.

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