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Modelling air pollution field structure in the industrial city's atmosphere: Correlation integral method and fractal dimension

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This paper is devoted to studying temporal and spatial structure of the air pollution fields in the industrial city's atmosphere within such theoretical approaches as the correlation integral (function) method and multi-fractal approach. The first task is to carry out studying the key features of the air pollution fields in the industrial city's atmosphere. The next problem is connected with searching optimal laser emission spectrum analysis methodises. Here we present new theoretical approach to sensing temporal and spatial structure of the air pollution fields in the industrial city's atmosphere and applied to an analysis of the Odessa and Szchezyn (Poland) 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. 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. daily, 1-week, 0,5-month, and 1-month, over a period of about 20 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 Svalues for some embedding dimensions are presented.

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

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. This, in turn, may imply the applicability (or suitability) of a chaotic approach for transformation of the air pollution dusty component data from one scale to another.

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