

Statistical assessment of influence of changing meteorological conditions and anthropogenic air pollution level on surface ozone

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The study is based on the assumption that the field of surface ozone concentration is substantially uniform within the air mass. Only regional fluctuations of weather conditions and specific sources of natural and anthropogenic ozone precursors, to some extent, "modulate" this field, and cause local fluctuations in ozone concentration with regard to its natural diurnal variation. In particular, one may definitely expect concentrations measured in different regions of such a small (in terms of its area) country as Belarus to be rather close if the impact of different weather conditions and air pollution level is excluded. To state the hypothesis, a statistical analysis of the surface ozone and precursors in different areas of Minsk city has been made.

If one assumes that chemical equilibrium is reached quickly enough in the surface atmosphere, dependence of the surface ozone on the precursors and weather conditions can be described by a nonlinear function of these variables. The function is approximated by a limited Taylor series. The smaller is the "distance" in the multidimensional space of variables between a considered point and a point near which the expansion is realized (a reference point), the smaller is the number of terms in the expansion that can be used to satisfactory approximate the function. It seems reasonable to choose a set of variables equal to the normals of meteorological parameters at the time of measurement and zero concentrations of precursors as the "reference point".

Since the dependence of ozone on the variables is not linear, the Taylor series must include terms at least of the second order. The study has evaluated the deviation of the observed ozone concentration from its climatic normal earlier obtained. Therefore, the values of the derivatives in the decomposition are assumed independent of time (one considers the main seasonal and diurnal variability of the ozone concentration to be well described by the daily course of its normal).

Expansion coefficients (estimates of the first and second derivatives present in the Taylor series) are determined by solving a regression equation based on observations in Minsk made for 3 years time period. Observation points are located in four districts of the city differing in the air pollution level.

A list of key variables includes temperature, humidity, wind speed, the photochemical activity of solar radiation near the ground, vertical stability of the atmosphere, concentrations of CO, NO₂, NO, and volatile organic compounds (benzene, toluene, and xylene). Additional variables in the form of squares and products of the key ones are accounted for as well.

The calculated deviations of the surface ozone concentration from its normal demonstrate a good agreement with the measurements. It is also shown that in the clear atmosphere (i. e. pollutants free one) under the same weather conditions the values of ozone concentrations measured in different regions of the country turn out to be close thus confirming the basic assumption of the study.