ON INVESTIGATION INTO RELATION BETWEEN METEOROLOGICAL PARAMETERS OF THE ATMOSPHERIC BOUNDARY LAYER AND OZONE CONCENTRATION

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The investigation results of the correlation between the ozone concentration and wind speed, height of the pollutant mixing layer, structural constant of temperature field, and the parameter of atmospheric stability are described. The investigations were based on the data obtained in the experiments under the SATOR program in 1992. During the period under study, the correlation coefficients of the aforementioned values varied from positive to negative within a wide range. The 10–day periodicity in behavior of correlation coefficients was found.

The effect of the atmospheric stratification on distribution of pollutant concentration is beyond question. In the models used in forecasting the air pollution, one of the defining parameters is the height of the pollutant mixing layer H_{td} which, in turn, is determined by the height of temperature inversion boundaries in the atmosphere. Examinations carried out during several years using meteorological sodars MAL–1, MAL–2, and ZVUK–1 and a LOZA–3 lidar for studying the atmospheric aerosol revealed an important role of temperature inversion in aerosol distribution in the boundary layer of the atmosphere. Further investigation within the framework of the SATOR program enabled us to find the specific correlation between the parameters of atmospheric stratification and concentration of some gases, in particular ozone and carbon dioxide.[1] At the same time, such a correlation was substantially weak for carbon monoxide and was lacking for ammonia. The gas concentration was measured using the TRAL–4 base laser gas analyzer. The similar investigations were also made the subsequent stages of the SATOR program. The same instrumentation was used, while ozone concentration was determined by the contact method. As in the previous stages, the specific correlation between the ozone concentration and the pollutant mixing layer height was observed. The time delay between temporal behavior of these values was not observed in contrast to the previous experiment. However, the mean value of the coefficient of correlation between these values from May 26 till June 15, 1992 was substantially smaller than that in the previous series and was -0.21. The coefficient of correlation between the ozone concentration and the environmental temperature was much larger (0.47).

In the subsequent experiments (from the 3rd till 23rd of December, 1992) in the framework of this program, we carried out investigation efforts on the relation between the ozone concentration and a number of parameters characterizing the situation in the atmospheric boundary layer. In addition to the mixing layer height, the wind speed V, the parameter of atmospheric stability B, and the mean, over the mixing layer thickness, value of structural constant of temperature field C_T^2 were chosen as such parameters. The value B is an analog of the Richardson number and defined as[2]

$$B = \frac{g}{T_1} \frac{z_2 \Delta T}{V_2^2},$$

where $\Delta T = T_3 - T_1$, T_1 is the temperature at the altitude of z_1, T_3 is the temperature at the altitude of z_3, V_2 is the wind speed at the altitude of z_2, $z_1 = 2$ m, $z_2 = 4$ m, $z_3 = 8$ m, and g is the acceleration due to gravity.

The coefficients of correlation between the aforementioned values and the ozone concentration in the ground layer for each day of the experiments are listed in Table I. If we compare obtained results with those obtained at the previous stages of the SATOR program, we find strong variation in the mean correlation

TABLE I.

Date	H_{td}	C_T^2	V	B
03.12	–0.64	–0.45	0.50	–0.28
04.12	–0.27	–0.48	0.02	0.22
05.12	–0.28	–0.39	0.38	0.39
06.12	–0.37	–0.72	–0.55	0.13
07.12	0.68	0.30	0.16	0.36
08.12	0.01	0.44	–0.24	–0.41
09.12	0.11	–0.40	0.35	–0.21
10.12	0.65	0.01	0.75	–0.78
11.12	0.16	0.39	0.36	–0.37
12.12	0.58	–0.11	–0.11	0.03
13.12	0.16	–0.64	0.71	–0.78
14.12	–0.25	–0.03	0.63	–0.50
15.12	–0.28	–0.68	0.70	–0.69
17.12	0.51	0.61	0.06	0.45
18.12	0.48	–0.52	–0.50	0.67
19.12	0.60	–0.24	0.55	–0.41
20.12	0.20	–0.61	0.87	–0.96
21.12	–0.64	–0.29	–0.03	0.10
22.12	–0.32	–0.43	0.58	0.35
23.12	–0.64	–0.32	0.07	–0.60

coefficient of the ozone concentration with H_{td} from negative values to $+0.225$. The absolute values of the correlation coefficients are not large and their behavior day

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after day is chaotic, without apparent regularity. Depicted in Fig. 1*a* is the day–after–day variations in correlation coefficients. Some regularity in behavior of the correlation coefficients can be found in the figure. A wavy variation in all of the plots with equal specific period of about 10 days is observed. It becomes especially pronounced after smoothing of the obtained experimental plots (Fig. 1*b*). The correlation between the ozone concentration and the parameters of the atmospheric boundary layer changes with this period from positive to negative. This suggests that there is some other neglected parameter, which also affects the ozone concentration. Such parameters can be vertical distribution of ozone concentration, some anthropogenic parameter, which influences the increase or decrease in ozone content in the ground layer as well as other meteorological, chemical, or any different parameters.

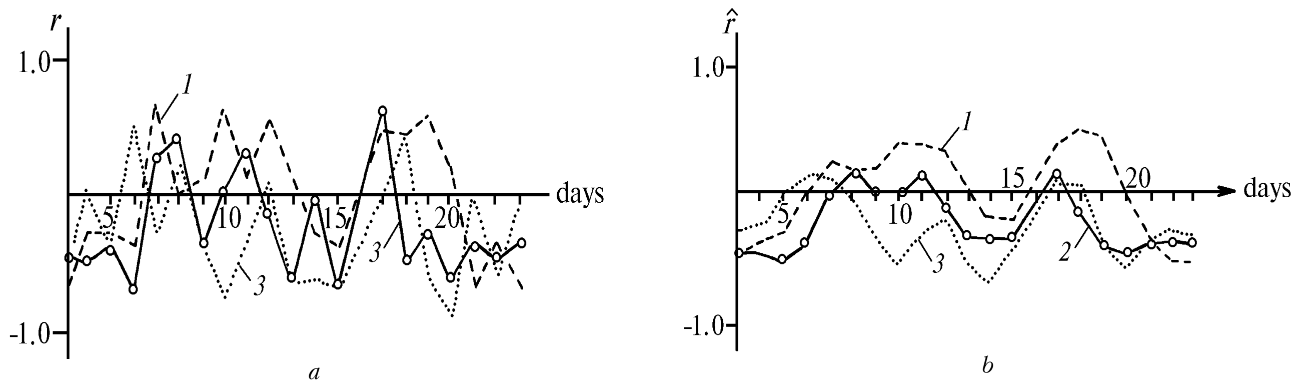

FIG. 1. Day–after–day variations in correlation coefficients before smoothing (a) and after smoothing (b). Here r is the correlation coefficient and $\hat{r}$ is the smoothed one; curve 1 corresponds to $r(O_3\ H_{td})$, curve 2 represents $r(O_3\ C_T^2)$, and curve 3 – $r(O_3\ V)$.

The measurements carried out revealed that the use of the same models for both aerosol and gaseous pollutants in predicting the pollution in the ground atmospheric layer can produce an erroneous result since, as was shown by the example of ozone, the locking inversion layers in the atmosphere, wind, and stability of the boundary layer are not of crucial importance in accumulating these pollutants.

REFERENCES

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