REMOTE ACOUSTIC MONITORING OF THE FIELDS OF METEOROLOGICAL PARAMETERS IN THE ATMOSPHERIC BOUNDARY LAYER

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Results of experimental studies of the atmospheric boundary layer with a sodar performed as part of the SATOR program are presented. Regimes of atmospheric stability during summer and fall seasons are classified. The interrelationship is found between the thickness of the mixing layer and the concentration of ozone and carbon dioxide in the atmospheric boundary layer.

In the course of experiments with the help of the ZVUK–1 sodar performed as part of the SATOR program the following problems were solved: continuous routine monitoring of such meteorological parameters as the structure constant of the temperature field, the depth of the layer of mixing the impurities, and the classes of the temperature stratification in the atmospheric boundary layer. The principle of measuring these parameters using the directed acoustic radiation was repeatedly discussed in the literature including the publications in this journal, therefore it is meaningless to dwell on this question. The instrumental peculiarity of this experiment is the application of the sodar of new generation which has been developed in recent years at the Institute of Atmospheric Optics, Siberian Branch of the Russian Academy of Sciences. The ZVUK–1 sodar is the small–dimensioned automatic device mounted on a table (with the exception of the antenna arranged outdoors) and controlled by the IBM PC/AT. The computer provides processing of the signal received by the sodar, signal recording in the form of a file on the information medium for the subsequent use, and calculating the required parameters of the atmospheric boundary layer.

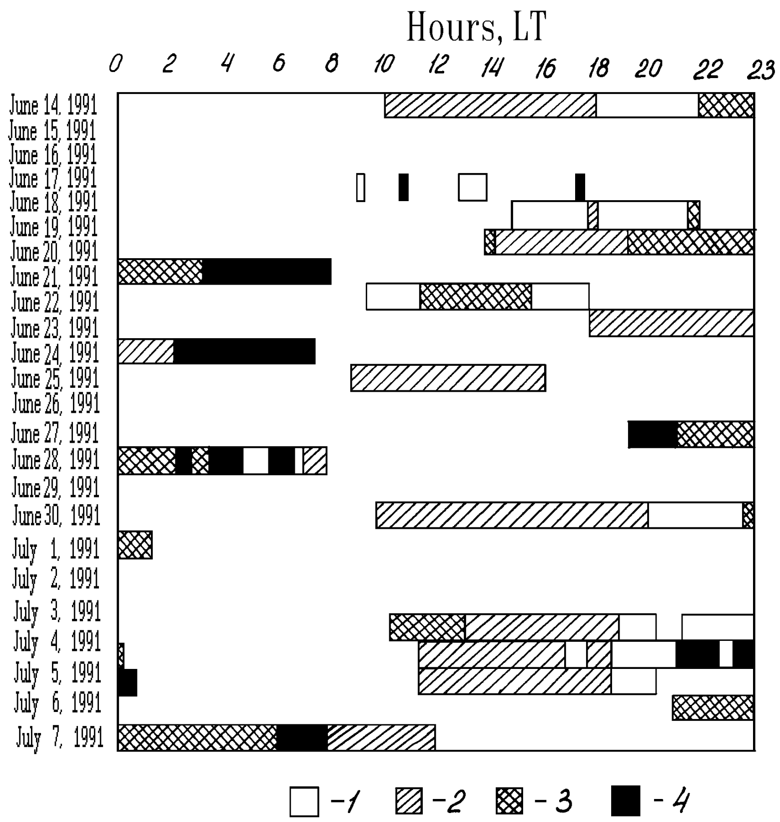

FIG. 1. Diagram of sodar performance from June 14 to July 7, 1991 along with the type of atmospheric stratification: 1) neutral stratification of the atmosphere, 2) convective regime, 3) surface temperature inversion, and 4) elevated temperature inversion .

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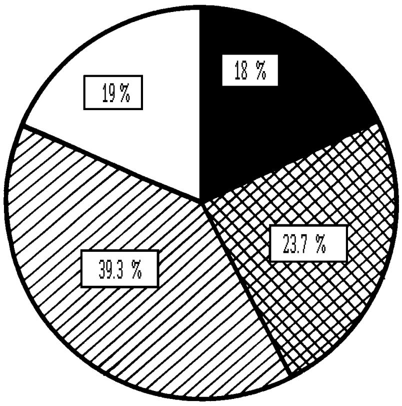

FIG. 2. Classification of atmospheric stability from June 14 to July 7, 1991 (designations are the same as in Fig. 1).

Figure 1 shows the diagram of sodar performance at the first stage of investigations performed as part of the SATOR program from June 14 to July 7, 1991. The atmospheric stratification monitored with the sodar at the given moment is plotted in this figure. The occurrence of the temperature inversion in the diagram does not exclude the existence of subinversion convection, and the occurrence of the elevated inversion does not exclude the existence of the surface inversion at the same time. Figure 2 shows the classes of atmospheric stability over Tomsk at that period. As can be seen from the figure the temperature inversions existed in 41.7% of the observation time while the surface inversions were found in 56.8% of all the cases.

The second stage of the experiments performed as part of the SATOR program was also analyzed in detail. The diagram of the sodar performance at that time is shown in Fig. 3, while the classes of atmospheric stability are shown in Fig. 4. The temperature inversion existed in about 70% of the entire observation time and in more than 77% of all the cases it was the surface inversion. The tendency to the increase of the number of cases of temperature inversions during the winter–fall seasons compared to the summer season, as the experiments have shown, is stable for Tomsk.

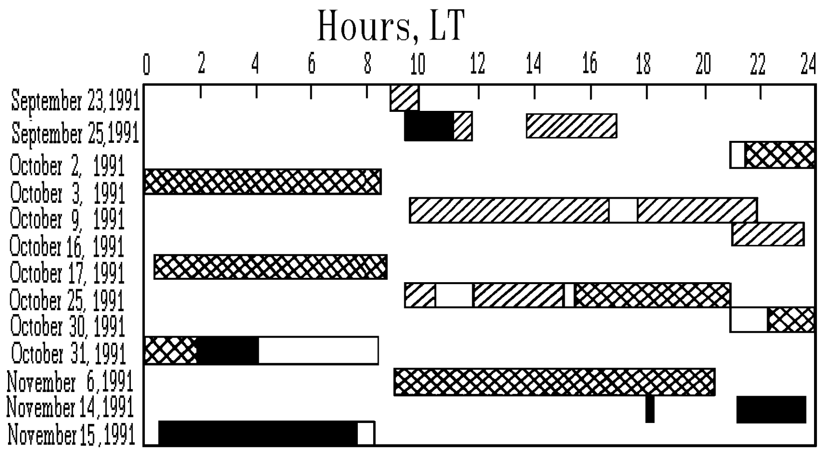

FIG. 3. Diagram of the sodar performance from September 23 to November 15, 1991 (designations are the same as in Fig. 1).

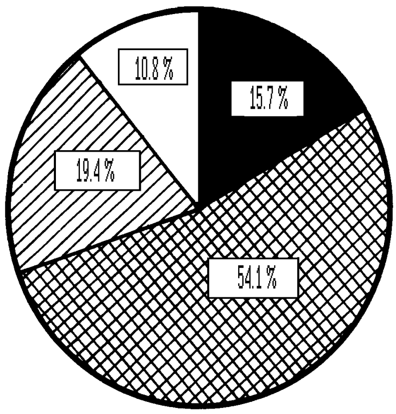

FIG. 4. Classification of atmospheric stability from September 23 to November 15, 1991 (designations are the same as in Fig. 1).

The results of simultaneous processing of meteorological data obtained on November 6, 1991 using the sodar and of gas concentrations (carbon dioxide shown in Fig. 4 *a* of Ref. 1 and ozone shown in Fig. 8 *b* of Ref. 1) measured using the TRAL–4 base laser gas analyzer are interesting. The depth of the layer of mixing the impurities in the atmosphere was chosen as the reference parameter for the data obtained using either system. This quantity must directly affect the impurity concentration in air since it determines the volume in which their rarefication occurs. In its turn the depth of the mixing layer can be defined as the distance from the ground to the first capping layer in the atmosphere formed by the temperature inversion boundaries and other thermal structures. The correlation is found between the depth of the mixing layer and the concentration of ozone and carbon dioxide in the surface layer of the atmosphere. The concentration of the above–indicated gases is found to be increased when the depth of the mixing layer is decreased and *vice versa*. In principle, this result is fully logical and can be plausibly explained. The absence of the analogous relationship with such gases as ammonia and water vapor is much less understandable. Figure 5 shows the plots of the temporal behavior of the concentration N of ozone and carbon dioxide and the depth of the mixing layer H_m. The correlation coefficient calculated for H_m and carbon dioxide is equal to –0.67 when the gas concentration is delayed by 12.4 minutes. The correlation coefficient for ozone is equal to –0.47.

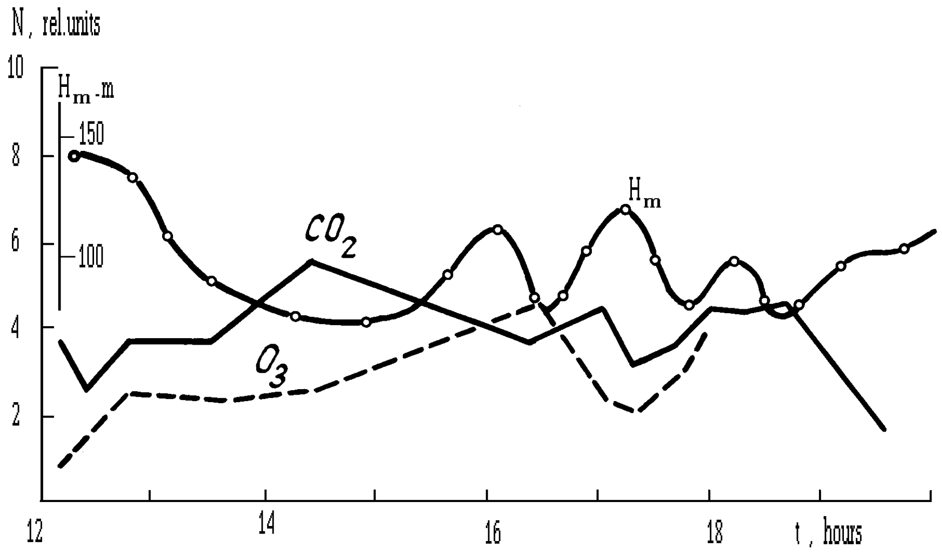

FIG. 5. The temporal behavior of the gas concentration N and of the depth of the mixing layer H_m measured on November 6, 1991.

The correlation is found between the concentration N of ozone and carbon dioxide and the structure constant of the temperature field at a fixed altitude of 100 m above the sodar antenna. The correlation coefficient for carbon dioxide is equal to –0.4 and for ozone it is equal to –0.47. There is a reason to suppose that such a relationship is not regular and is dependent on the type of atmospheric stratification and on the altitude and configuration of capping layers. We can obtain any value of the correlation coefficient varying from positive to negative under the same synoptic conditions by way of choosing the appropriate altitude of measuring the structure constant of the temperature field C_T^2. The correlation will be negative if C_T^2 is measured above the existing capping layers and positive if C_T^2 is measured under these layers. This follows from the dependence of the impurity concentration on the depth of the mixing layer. The further investigations, which will be performed as part of the SATOR program, will make it possible to investigate the processes studied here in ample detail by means of the comprehensive study of the atmosphere using various instruments.

REFERENCES

1. S.L. Bondarenko, S.I. Dolgii, V.V. Zuev, et al., Atm. Opt. **5**, No. 6, 386–399 (1992).