SOME EXPERIMENTAL RESULTS OF LIDAR SOUNDING OF THE OZONE AND TEMPERATURE IN THE TROPOSPHERE AND STRATOSPHERE

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We present here some results of lidar sounding of the ozone and temperature in the troposphere and stratosphere. Using the channels of differential absorption, Rayleigh and Raman light scattering in one lidar complex, we have simultaneously obtained ozone profiles in the altitude range from 13 *to* 31 km *and the temperature profiles in the altitude ranges from* 14 *to* 40 *and from* 3 *to* 14 km. *Very high ozone content was observed in the layer from* 13 *to* 24 km. *Considerable increase of temperature, by* 8–10°C *was observed at the same altitudes, that, in our opinion, is caused by warming due to the absorption of solar radiation by ozone. In the lower part of the temperature profile from* 3 *to* 8 km, *we have observed the temperature decrease by* 10 *to* 12°C *what well agrees with the anticyclonic conditions, when temperature at the ground surface decreased down to* −30°C. *The experiment we have carried out confirms the justification of the use of lidar instrumentation for investigation of the relations between geophysical parameters of the atmosphere.*

Modern developments in lidar technology have lead to the possibility of simultaneous measurement of several components and characteristics of the atmosphere. Using the effects of aerosol, molecular and Raman scattering as well as differential absorption of light, one can obtain the vertical profiles of ozone, temperature and aerosol by means of one and the same lidar complex.

Such lidar complexes are operated in the known observatories, such as Table Mountain (USA), Haute Provance (France), Hohenpeissenberg (Germany) and Tsukuba (Japan), and are widely presented in the Network for Detection of Stratospheric Change (NDSC).[2] This paper describes some results of the experiment on simultaneous sounding of ozone and temperature in the troposphere and stratosphere by means of the lidar with the receiving mirror of 1 m diameter, included into the Siberian Lidar Station (Tomsk, 57°N, 85°E).[3] The excimer XeCl laser with the wavelength of 308 nm and an SRS wavelength converter on H_2 with the wavelength of 353 nm were used in the lidar as a transmitter. Total power of laser radiation pulse was 70–100 mJ, pulse repetition rate was 40–60 Hz, divergence of the beam at the level of 0.5 did not exceed 0.2 mrad. The lidar was equipped with the receiving channel of Raman scattering on the first vibrational-rotational transition of nitrogen molecules. Thus, the ozone vertical profiles were reconstructed from the return signals at the wavelengths of 308 and 353 nm, using the differential absorption technique for measuring and data processing; temperature profiles in the stratosphere were reconstructed from the Rayleigh return signals at the wavelength of 353 nm; and, finally, the temperature profiles in the troposphere were reconstructed from the Raman return signals at the wavelength of 384 nm. In addition, the scattering ratio profiles were calculated using the return signals at the wavelength of 353 nm for estimating and taking into account the aerosol scattering.

The ozone profiles in the altitude range from 12 to 31 km and two temperature profiles in the altitude ranges from 3 to 14 and from 14 to 40 km were obtained in the experiment carried out at night. Measurement time in these cases was 50, 25 and 25 min, respectively. Spatial resolution when receiving the return signals was 100 m.

The results of the experiment are shown in Figs. 1 and 2. According to Fig. 1, the unique situation is observed in the ozone distribution. It manifests itself in significant excess of the ozone concentration in the layer from 12 to 24 km in comparison with the model distribution. It reaches the value of $7.8\cdot10^{12}$ mol/cm^3 at the layer maximum at the altitude of 18 km, that is significantly greater than the concentration in the layer maximum by the Kruger model (H = 22 km; $4.9\cdot10^{12}$ mol/cm^3). Daytime measurements of the total ozone content carried out by means of an M-124 network device also showed very high value of 464 D.u. Our calculations of the total ozone content from the measured optical thickness of the layer from 15 to 30 km taking into account the statistically averaged ozone content in the layers for mid-latitudes of the northern hemisphere[4] gave the value of 450 D.u. Taking into account some temporal difference in measurements (4–6 hours) and possible statistical deviations, the results of lidar and ozonometric measurements are in a good agreement.

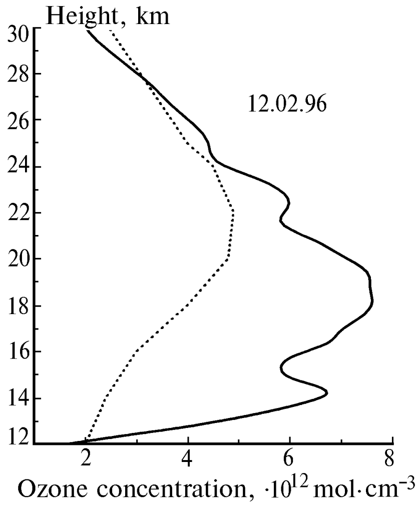

FIG. 1. Vertical profile of ozone. Solid line is for lidar profile; dotted line is the model.

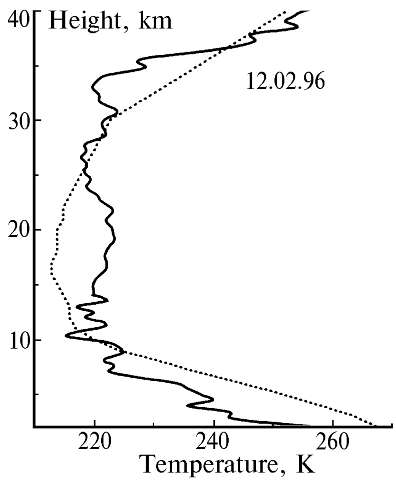

FIG. 2. Vertical profile of temperature. Solid line is for a lidar profile; dotted line is the model

Let us also note that, in order to estimate the errors in lidar profiles of ozone concentration, we carried out the test examinations in July 1996. Two ozone sondes were launched simultaneously with the lidar measurements. The comparison of the lidar and ozone sonde profiles in the altitude range from 15 to 35 km shows that the maximum difference between them is $0.5\cdot10^{12}$ mol/cm^3. If one recalculates it for the ozone profiles obtained on February 12, 1996, and shown in this paper, the error does not exceed 12% for the altitude range mentioned above.

Let us consider the temperature profiles (Fig. 2). It should be noted that the coincidence of the beginning of the «Rayleigh» temperature profile with the top of the «Raman» profile at the altitude of 14 km evidences in a good quality of measurements. The estimate of the maximum rms errors in temperature measurement was 2 K for the upper profile and 3 K for the lower one. The deviation of the lidar temperature profile from the model one (shown by dots) toward lower temperatures by 10–12 K is seen in the troposphere (see the lower part of Fig 2). Such temperature distribution agrees with the general synoptic conditions, when temperature strongly decreased down to −30°C at the ground surface under the anticyclonic conditions. The stable anticyclone leads to conditions when the radiative model of the atmosphere is applicable. One should pay attention to the fact of a noticeable increase in temperature by 10 K in comparison with the model in the altitude range from 13 to 24 km. The geophysical factor of heating of the atmosphere appears here. It is seen from Fig. 1, that it is the altitude range where large amount of ozone is accumulated. So it is most likely that the heating of the stratosphere is related to the heating due to absorption of solar radiation by ozone. On the whole, the experiment confirmed the capabilities of lidar instrumentation to study relations between geophysical parameters of the atmosphere simultaneously in a wide altitude range.

ACKNOWLEDGMENTS

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