PRELIMINARY RESULTS OF TROPOSPHERIC TEMPERATURE SOUNDING USING A RAMAN LIDAR ON THE FIRST VIBRATIONAL-ROTATIONAL TRANSITION OF NITROGEN MOLECULES

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*The paper describes the first results of the tropospheric temperature sounding using a Raman lidar. The temperature is reconstructed from signals on the first vibrational-rotational transition of nitrogen molecules (*384 nm*) excited by the* 353-nm *radiation. The latter, in its turn, is the SRS-conversion of the* XeCl-*laser radiation in a cell filled with hydrogen. The lidar temperature profiles, obtained during the experiment, cover the altitude range from* 3 *to* 14 km *and are close to the model temperature distribution. The rms error varies from* 5 K *at low altitudes to* 20 K *at* 14 km *altitude. The accuracy of temperature reconstruction can be easily improved by the increase of the signal accumulation time from* 20 min *to an hour and more.*

The lidar with a receiving mirror 1 m in diameter and a transmitter based on an excimer XeCl-laser is a part of the Siberian Lidar Station (Tomsk, Western Siberia) and is intended for sounding of ozone and temperature in the stratosphere.[1] This lidar was supplemented with a receiving channel for Raman signals. The first vibrational transition of N_2 molecules (384 nm) was excited, in its turn, by SRS conversion of the 308-nm laser radiation in a cell filled with hydrogen.

The temperature profiles derived from Raman signals, as differentiated from a traditionally used technique based on an analysis of the characteristics of the Raman vibrational spectrum,[2] were reconstructed from the N_2 molecular concentration, i.e., from the atmospheric density.[3] To calculate the temperature T using Raman signals, we have obtained the expression similar to that for calculating the temperature from Rayleigh signals[4]:

$$T(H) = \frac{P_1(H)\, P_2(H)}{N(H)\, H^2} \times$$
$$\times \left[\frac{N(H_m)\, H_m^2}{P_1(H_m)\, P_2(H_m)}\, T(H_m) + \frac{1}{R^*} \int\limits_{H_m}^{H} \frac{N(h) h^2 g(h) \mathrm{d}h}{P_1(h)\, P_2(h)} \right],$$

where H and H_m are the running and maximum altitudes, respectively, from which the signal processing started; $N(H)$ is the lidar signal; $P_1(H)$ and $P_2(H)$ are the values of molecular atmospheric transmittance from the altitude of lidar location to the altitude H at wavelengths of 353 nm and 384 nm; R^* is the specific gas constant; g is the acceleration of free fall.

The lidar returns were detected in the photon counting regime with spatial resolution of 100 m and accumulation time of 20–30 min for obtaining individual temperature profile.

The results of temperature sounding from the latter part of January to the beginning of March 1996 are shown in Fig. 1, where the lidar temperature profiles are denoted by solid curves, the rms errors of temperature reconstruction are denoted by horizontal bars, and the model temperature profiles are denoted by dashed curves. Also shown in the first four plots are curves the radiosonde data of the Novosibirsk meteorological station (the distance from the lidar station is 210 km), obtained at the same time. As seen from the figure, the 3–14 km altitude range was mastered. The vertical temperature distribution, calculated from the lidar data, is close to a model one. The error of temperature reconstruction varied from 5 K at low altitudes up to 20 K at 14 km altitude. This fact indicates the need for the increase of signal accumulation time at least up to an hour. Good agreement of the temperature profiles was obtained in spite of the large distance between the sites of lidar and meteorological sounding.

As a whole, the tests of the Raman lidar channel on the first vibrational-rotational transition of N_2 molecules show the lidar promise for sounding the temperature in the troposphere and above including the tropopause. In case of simultaneous operation of the Raman and Rayleigh light scattering channels provided in this lidar, the temperature profile can be obtained in the 3–35 km altitude range. This is undoubtably important for investigation of exchange processes between the troposphere and stratosphere.

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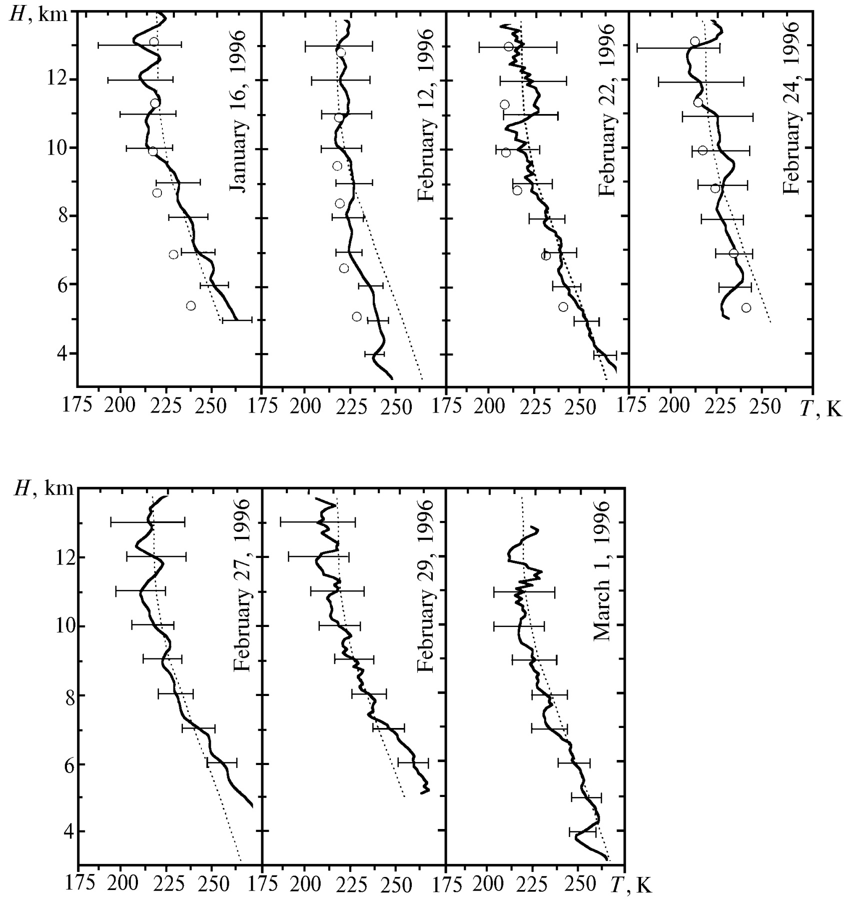

FIG. 1. Results of temperature sounding in the troposphere using the Raman lidar.

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