COMPARISON OF TEMPERATURE MEASUREMENT DATA ACQUIRED WITH A LIDAR AND A RADIOSONDE AT ALTITUDES FROM 13 TO 30 km

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In this paper we present a comparison of temperature measurement data acquired with a lidar and a radiosonde at altitudes from 13 *to* 30 km. *For the comparison we have selected a period (January–February), for which a maximal temperature variability exceeding* 30 K *is characteristic at altitudes of* 25 km. *Our lidar was about* 210 km *far from the meteorological station, but since the processes of air mass transport in the stratosphere are of a large scale (*~1000 km*), this comparison is well justified. The temperature profiles measured with the lidar and radiosondes proved to match very closely both qualitatively and quantitatively. The rms deviation between the profiles, calculated using 73 pairs of records, was* 2.4 K. *For a comparison, the estimate of the standard error of temperature reconstruction from lidar data was about* ±5 K *at an altitude of* 25 km. *The validation of the lidar measurements performed has confirmed their reliability.*

Hauchecorne and Chanin[1] were the first who succeeded in lidar measurements of temperature by Rayleigh light scattering in 1982. During the period from 1980 to 1996 Rayleigh lidars have been significantly improved and now they are widely for temperature sounding of the stratosphere. One can find information about research groups, parameters of lidars and their geography in the handbook.[2]

In Tomsk (57°N, 85°E) routine lidar measurements of temperature in the lower stratosphere have been started in 1995 with a lidar comprising a receiving mirror 1 m in diameter and XeCl excimer laser with a hydrogen SRS frequency converter giving output at the wavelength of 353 nm. For lidar parameters and the technique of signal processing see Ref. 3. In the time period since 1995, a number of vertical temperature profiles were obtained. For further use of these data in the problems of climatology and weather formation it is necessary to assess their reliability. To this end, we have derived the equations for estimating standard errors in temperature profiles and conducted two comparative measurements of temperature with a lidar and a radiosonde. They showed that the discrepancy between the lidar and balloon data does not exceed 5°C at altitudes from 15 to 25 km, i.e. it is within the experimental error. However, because of a limited number of independent comparisons and some subjectivity in estimating the standard error, the above measures are insufficient for a complete validation of the lidar data. That is why we undertook a comparison of temperature measurements using a lidar and a radiosonde in January-February 1996. For that time, eight night lidar temperature profiles were obtained. It should be noted that this period was selected to enhance the requirements to validation of the data. As follows from lidar observations, just in this period the greatest deviations of temperature profiles from the model ones, both negative up to 15 K (January 26 and 27, February 1 and 5) and positive up to 25 K (February 12, 22 and 24), were observed, as well as the behavior close to the model one (February 20). As an independent data, we took the temperature profiles obtained with radiosondes at the Novosibirsk meteorological station being 210 km far from Tomsk.

Unfortunately, it was impossible to organize the launching of radiosonde from the point of lidar installation. However, since the distribution of meteorological parameters in the stratosphere is governed by large-scale (~1000 km) processes of air mass circulation, such a comparison of stratospheric temperature profiles can be considered as justified. In addition, the measurements were conducted under stable weather, rather than in a frontal zone. The comparison of temperature profiles at altitudes from 13 to 30 km is shown in Fig. 1. Here the solid line is for the lidar profile, circles are for the radiosonde data, dots show the model profile for midlatitudes, also set out in the figure are the standard errors of temperature reconstruction from lidar data. The first four figures corresponding to January 26 and 27 and February 1 and 5 show the negative deviation of the lidar temperature profile from the model one at altitudes of 15–28 km. The radiosonde data closely coincide with the lidar ones. The temperature rise was observed on February 12 at altitudes 13 to 25 km. The temperature change in this case is about 20 K at an altitude of 20 km as

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compared to the previous profiles. The radiosonde measurements demonstrate similar temperature behavior with altitude. On February 20 the lidar temperature profile was close to the model one. Balloon measurements gave identical vertical temperature distribution. Finally, the two last figures (February 22 and 24) demonstrate a strong temperature change toward its rise exceeding 235 K at an altitude of 25 km as follows from both lidar and radiosonde data. Discrete temperature measurements with radiosonde well agree with the lidar temperature profiles.

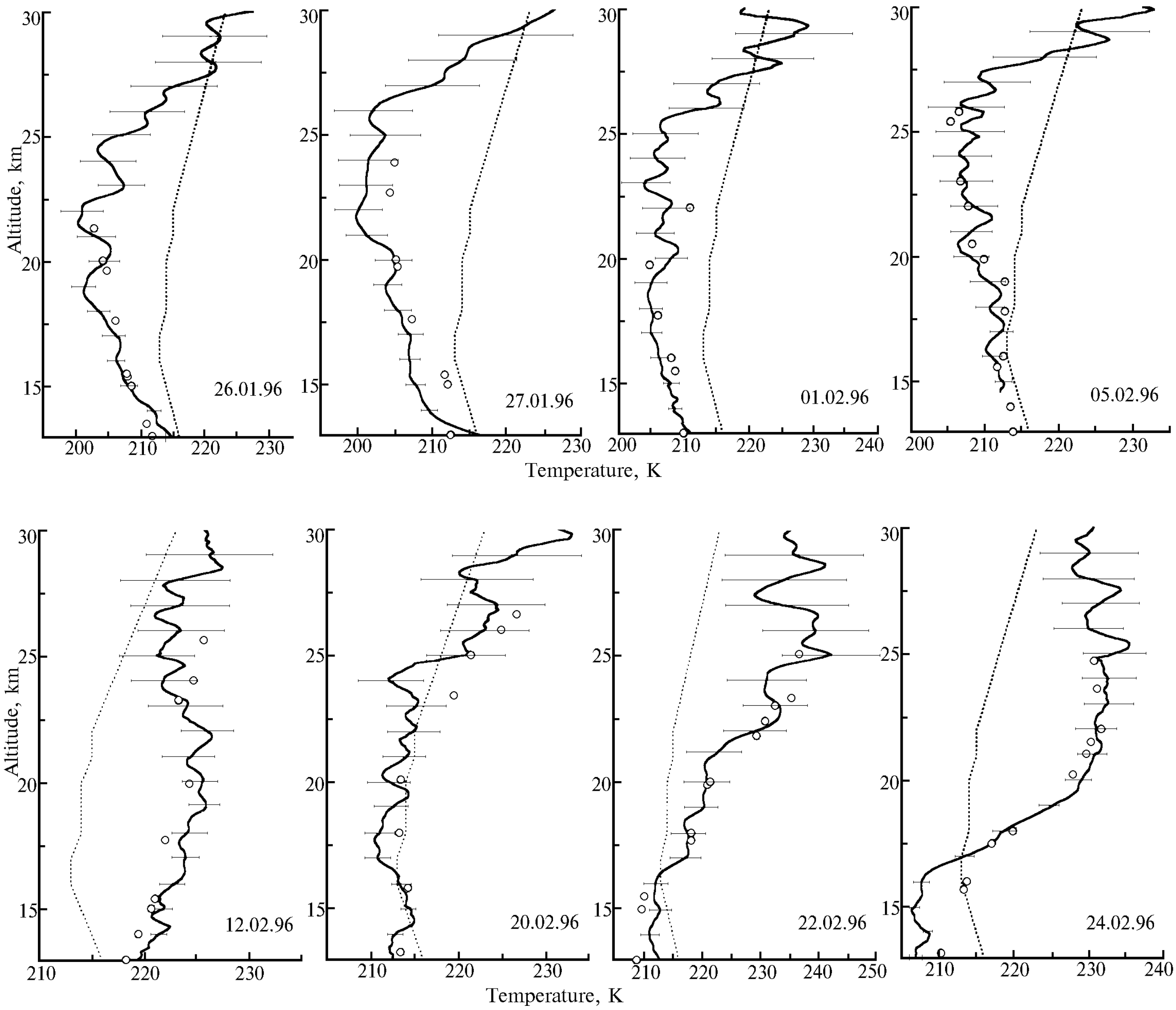

FIG. 1. Comparison of the results of temperature measurements with a lidar (solid curve), radiosondes (circles) for January-February of 1996, as well as the model profile (dotted curve).

As was mentioned above, the plots show the vertical behavior of the estimated standard error of temperature reconstruction from lidar data. The error is about ±1 K at an altitude of 15 km and ±5 K at a 25-km altitude. The rms deviation between the lidar and balloon data, calculated using 73 pairs of points, was 2.4 K. Thus it is within the interval of variation of theoretical estimate of standard error even regardless of the balloon measurement error.

Thus, the comparison of results of lidar and balloon temperature measurements in the lower stratosphere (13–27 km) has shown their very close qualitative and quantitative agreement. It should be noted that for comparison we specially selected the period characterized by the highest variability of temperature in the altitude range, studied when both negative and positive temperature deviations from the model profile ranging up to 30 K were observed. The rms deviation of 2.4 K is within the estimated standard error of the lidar temperature measurements.

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