Studying the variations in background aerosol loading of the stratosphere in 2014

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ABSTRACT

The report analyzes the experimental data on the variability of vertical-temporal structure of the aerosol produced in the complex lidar station altitude atmospheric sounding IAO SB RAS in 2014. The primary data used for the analysis of an array of data from 67 combined signals accumulated in individual nights, probed range in height from 15 to 50-60km, the spatial resolution was 192m.

INTRODUCTION

In our previous works [1,2], we presented the results of lidar observations of variations in the vertical structure of aerosol in different months during the period of 2011-2013. Work in this direction was also continued in 2014. All this period was characterized by almost complete absence of volcanic eruptions, which could influence the disturbance of the aerosol component of the stratosphere of the Northern Hemisphere, including the Western Siberian region. Therefore, there had been an opportunity to trace the specific features of time variations in background aerosol loading of the stratosphere in the Western Siberia for quite a long time interval.

As initial information for analysis of 2014 data, we used dataset of 67 total signals, accumulated on separate nights. As in above-mentioned works, the sensed altitude interval extended from 15 to 50-60 km, and the spatial resolution was 192 m. Lidar signals were received in photocurrent pulse counting mode with accumulation according to 12×10^4 laser shots (accumulation time is about two hours for a night). As an example, describing the vertical aerosol stratification, we present the optical characteristic R(H), i.e., the aerosol scattering ratio (H is the current height), defined as the ratio of the sum of coefficients of aerosol and molecular backscattering coefficients to the latter. In particular, fulfillment of condition R(H)=1 means that no aerosol is present at the given heights; conversely, aerosol appears where R(H)>1.

OBSERVATION RESULTS

In January and February 2014, weather conditions over Tomsk were often cloudy, which permitted us to perform only five separate nighttime measurements: on January 28 and February 2, 4, 7, and 12. Therefore, the dynamics of variations in vertical structure of aerosol could not be traced. We can only indicate insignificant aerosol loading of the lower stratosphere up to 30 km, with maximal value R=1.3 at height of 15 km in observations on February 4.

Five successful observations were performed in third decade of March (Fig. 1).

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21st International Symposium on Atmospheric and Ocean Optics: Atmospheric Physics,
edited by G. G. Matvienko, O. A. Romanovskii, Proc. of SPIE Vol. 9680, 96806U
 · doi: 10.1117/12.2205781

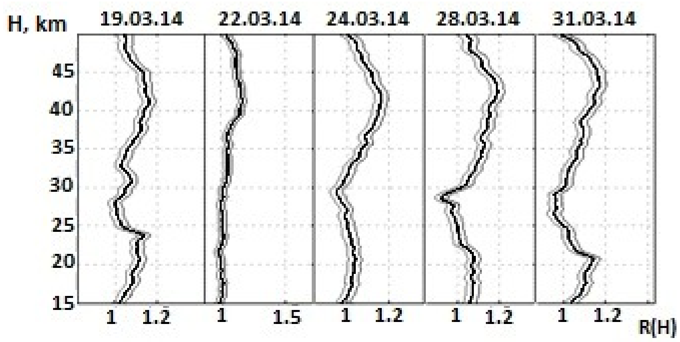

Figure 1. Dynamics of stratospheric aerosol loading in March 2014. Thick line shows average value of R(H), thin lines show standard deviations.

Detailed analysis of the figure reveals a kind of two-humped structure of vertical distribution of aerosol component, with the lower-hump maximum at height of about 20 km, upper-hump maximum at heights of 40-43 km, and with (aerosol-free) minimum at heights of 25-30 km. An exception occurs for data obtained on March 22, from which insignificant aerosol loading in the height interval of 37-50 km can be apparent. These observations are in striking contrast to those in the second half of March 2013, which recorded no aerosol component throughout the altitude interval of 15-50 km [2].

Aerosol loading of the stratosphere varied stronger in April (Fig. 2, seven separate nighttime measurements). There were large fluctuations in the lower stratosphere, from absolutely no aerosol on April 6 to appearance of stratified aerosol structure with maxima R=1.3 – 1.8, recorded at heights of 23-28 km on April 3 and 15.

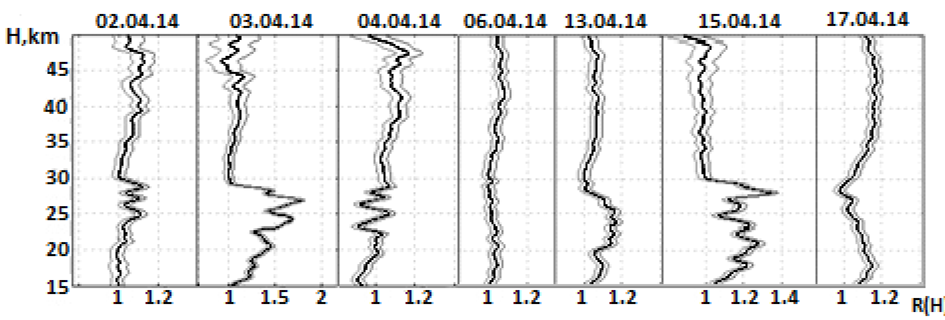

Figure 2. Dynamics of stratospheric aerosol loading in April 2014

For May (Fig. 3), there was a more stable aerosol structure, with almost no aerosol in the lower stratosphere and with minor aerosol content up to R=1.2-1.3 in the upper stratosphere.

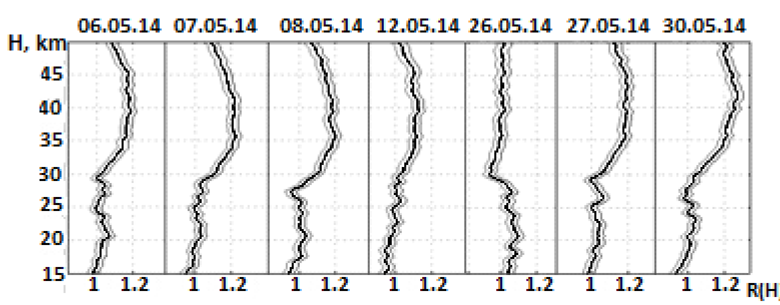

Figure 3. Dynamics of stratospheric aerosol loading in May 2014

The vertical aerosol distribution was quite stable in warm period of the year (Figs. 4-6). For all summer months, as well as for September and October, the aerosol component was episodically recorded only at heights from 25 to 30 km in the form of weak layers. Some exceptions occurred in observations on July 22 and August 9, when aerosol content in the layers increased to R=1.2.

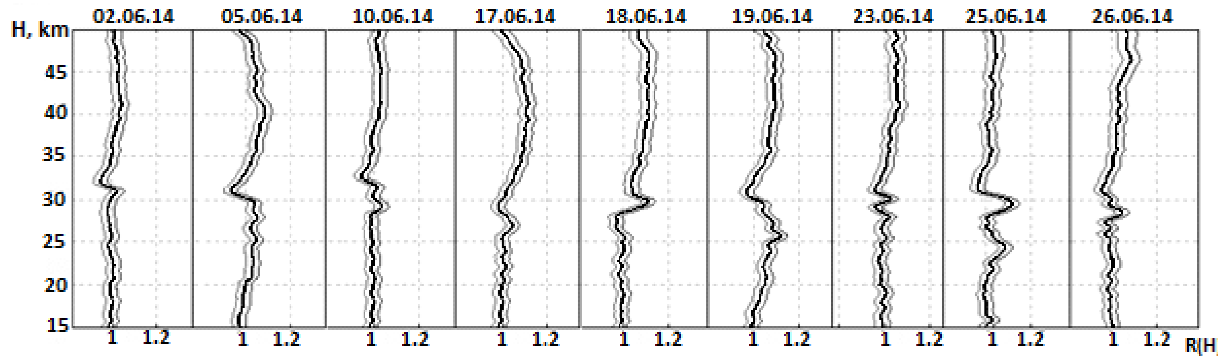

Figure 4. Dynamics of stratospheric aerosol loading in June 2014

Permanent cloudy weather in October permitted only two separate nighttime measurements, according to results of which no aerosol component was revealed throughout the stratospheric layer where observations were performed.

Disturbances of the vertical structure of aerosol became apparent in November (Fig. 8). From the figure it can be seen that the largest changes in the form of ragged profiles of the scattering ratio were characteristic for the lower stratosphere. In the upper stratosphere, the profiles of the scattering ratio remain smooth, indicating that the state of the upper stratosphere is more stable to disturbance of the aerosol component.

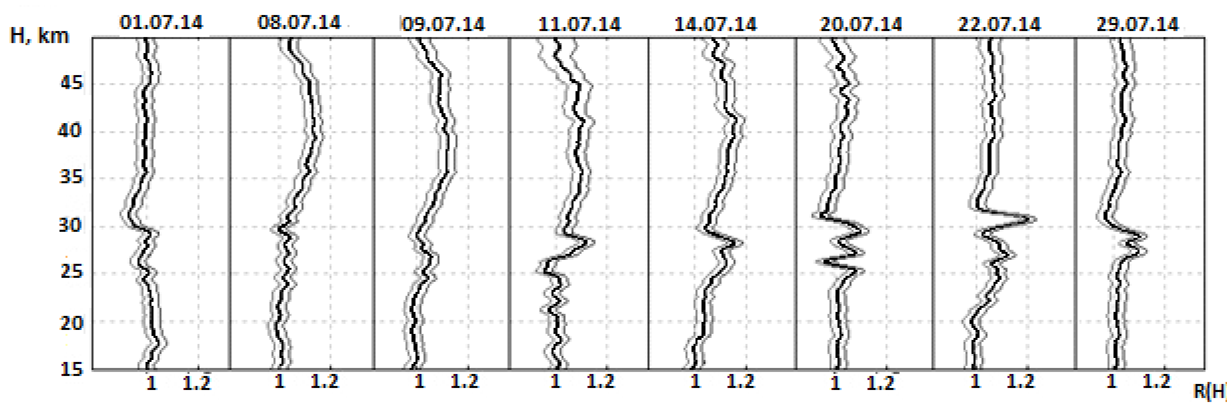

Figure 5. Dynamics of stratospheric aerosol loading in July 2014

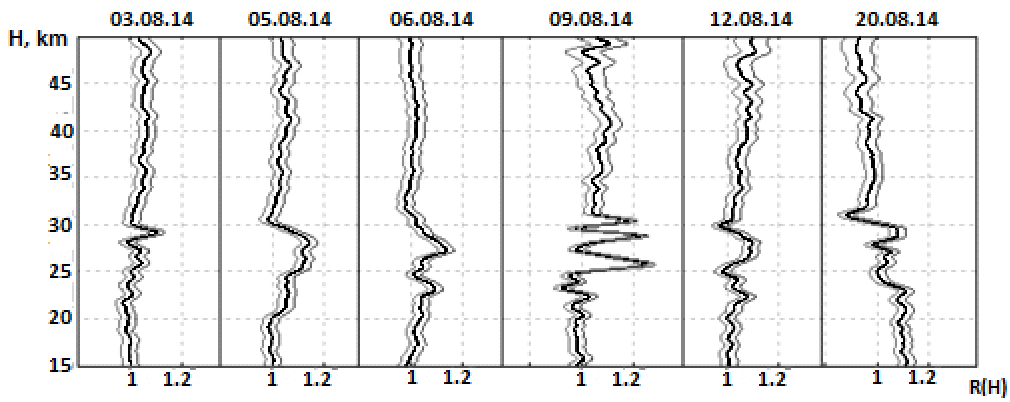

Figure 6. Dynamics of stratospheric aerosol loading in August 2014

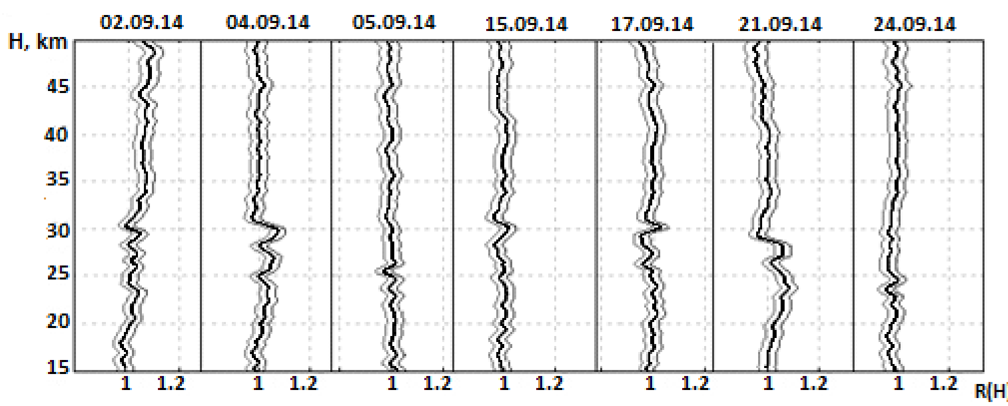

Figure 7. Dynamics of stratospheric aerosol loading in September 2014

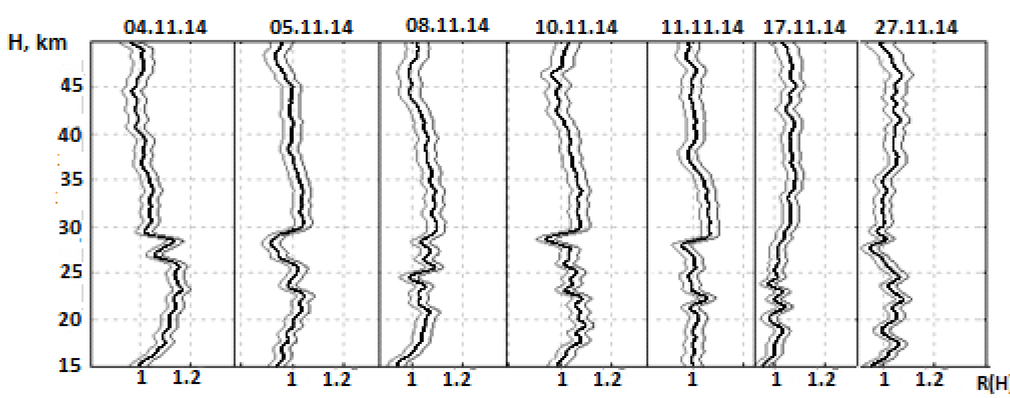

Figure 8. Dynamics of stratospheric aerosol loading in November 2014

In December, the cloudy conditions also permitted only two measurements. Appearance of weak aerosol loading at heights of 15-30 km was recorded.

This article uses the results obtained during of the project 8.1.12.2015, within the Program "Scientific Foundation. D. I. Mendeleev Tomsk State University" in 2015.

This work was supported by Siberian Branch of Russian Academy of Sciences (through integration project no. 106), Russian Fund for Basic Research (through grant no. 13-05-01036a), President of the Russian Federation (through grant no. NSh4714.2014.5), and Russian Scientific Fund (through grant no. 14-27-00022).

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