PRELIMINARY STATISTICAL ANALYSIS OF THE LIDAR SENSING OF STRATOSPHERIC OZONE

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In this paper we describe some results of preliminary analysis of the ozone vertical distribution during the period of background stratospheric aerosol content (1995–1997). The maximum ozone concentration in the mean profile is observed at 18 km *altitude. The ensemble variability has no distinct maximum in a given altitude range. Its monotonic decrease is observed from* 15–16 km *altitude to about* 22.5 km *altitude, and at higher altitudes the variability remains practically unchanged.*

The interest in lidar investigations of the stratospheric ozone is caused by both the problem of atmospheric ozone as whole and the absence of systematic data on its vertical distribution and dynamics over a vast territory of Siberia and Far East. Lidar sounding of the stratospheric ozone over Western Siberia has been started in 1989.[1] However, most powerful volcanic eruption in this century (Mt. Pinatubo, 1991) significantly affected the stratosphere as a whole and ozonosphere in particular. The effect of volcanic aerosol was observed in the dynamics and behavior of the stratospheric ozone, so the correctness of the analysis of all the ozone profiles obtained with lidars available is doubtful.

In this paper we present some results of the preliminary analysis of vertical distribution of the stratospheric ozone after the Mt. Pinatubo eruption, when the aerosol overburden of the stratosphere came back to the background level. The analysis was based on the data of lidar sounding carried out at the Siberian Lidar Station in Tomsk since summer 1995 and until the summer 1997. Ninety four profiles were used in the analysis, each being an average ozone profile obtained during a night in the altitude range 15 to 30 km. The error in measuring each profile at the altitudes 25–30 km did not exceed 7%. Sometimes, in order to decrease the measurement error we increased the measurement time and made the spatial resolution 0.7 km. The initial spatial resolution was 0.1 km. The ozone vertical distribution was reconstructed from lidar returns using spline approximation methods.

The mean profile of the ozone vertical distribution and its variability are shown in Fig. 1 (variability means the square root of the variance of the bulk of the profiles analyzed). The maximum of the ozone concentration at the mean profile ($N(H) = 4.5{\cdot}10^{+12}\,\text{cm}^{-3}$) is at the altitude of 18 km. The variability of the ensemble available has no any well pronounced maximum in the altitude range considered. Starting from the altitude of 15–16 km, the variability monotonically decreases up to the altitude of ≈ 22.5 km, and then remains constant.

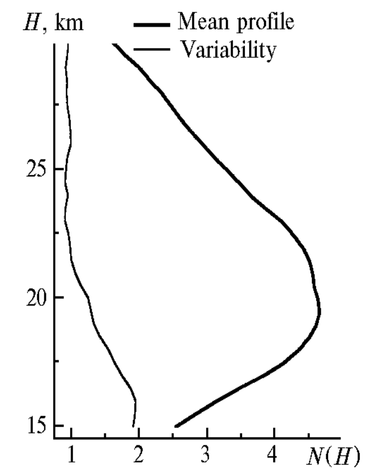

FIG. 1. Mean profile of the ozone vertical distribution and its variability in the stratosphere over Tomsk. $N(H) = n \cdot 10^{12}/\text{cm}^3$.

The results of statistical analysis of the vertical ozone profiles are shown in Fig. 2 in the form of the first three eigenvectors of its correlation matrix.[3] The eigenvectors of the ensemble of the vertical profiles of the scattering ratio (the ratio of the sum of molecular and aerosol scattering coefficients to the molecular one) obtained at Tomsk since 1987 till 1991 are shown in this same figure for a comparison. The contribution of three first eigenvectors of the ensemble of ozone profiles under investigation (S_i, i is the vector number) is 82% of the total variability (S_1 = 45.4%, S_2 = 27.6%, S_3=9.0%), and for aerosol this value is 82.5% (S_1 = 49.5%, S_2 = 20.5%, S_3 = 12.5%). The values S_1 are positive in the whole altitude range for both ozone and aerosol, hence, the increase of the ozone concentration in the lower part of the vertical profile (15 km) means that practically the same increase is observed in the whole profile $N(H)$. Vertical variations of the second and third vectors are not so unambiguous. For example, for S_2 the increase in $N(H)$ at the altitude of 17.5 km means practically equivalent decrease in $N(H)$ at the altitude of 27.5 km. The vertical relations of the third vector are more complicated.

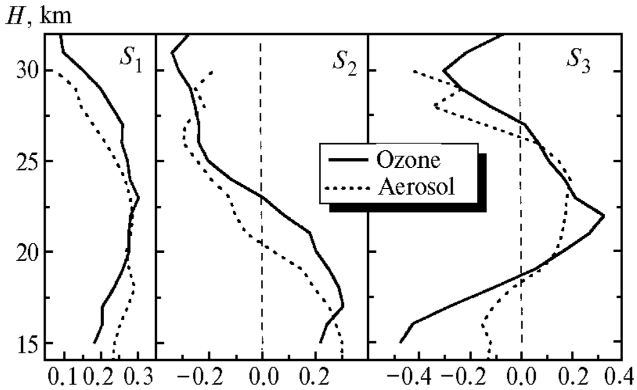

FIG. 2. Eigenvectors of the correlation matrices of the ozone and aerosol vertical profiles in the stratosphere.

In general the vectors presented have similar vertical behavior. The greatest similarity is observed for two first vectors with a 2.5 km displacement of the aerosol vectors higher. This displacement corresponds to the difference in the altitudes of the ozone and aerosol localization.

The similarity of the eigenvectors of independent ensembles reflecting the behavior of non-interacting stratospheric components of ozone and aerosol evidences that the mechanism of their variability is the same. Such a mechanism can be caused by the stratospheric circulation.

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