ISARD-2025-remote010

Reconstruction of atmospheric aerosol parameters using the Optical Depth Sensor (ODS)

Vladimir S. Khorkin[1] , Anna A. Fedorova[1] , Yury S. Dobrolenskij[1] , Ilya A. Dzyuban[1] , Nikita A. Vyazovetskij[1] , Andrey Y. Titov[1] , Oleg I. Korablev[1]

[1] Space Research Institute of the Russian Academy of Sciences

vs_khorkin@mail.ru

The ODS (Optical Depth Sensor) instrument was developed at the Space Research Institute of the Russian Academy of Sciences for the ExoMars-2022 mission. This instrument was part of the lander's meteorological suite and was designed for long-term observation of the state of the Martian atmosphere and the aerosol suspended in it. The ODS instrument is determined the average daily value of the aerosol optical depth and the parameters of the distribution of aerosol particles by size. In the case of the Martian atmosphere, the aerosol is important for the planet's climate - it alters the radiation balance by scattering solar radiation, and atmospheric aerosol particles are condensation nuclei that affect the water and CO_2 ice cycles in the atmosphere. When aerosols settle on the planet's surface, they change its albedo, with the greatest effect in the polar regions of Mars [Haberle R., et al, 2017]. Long-term monitoring of the state of the Martian atmosphere and its dynamics is therefore a relevant and important task.

Currently, after the cancellation of the ExoMars 2022 mission, the ODS instrument is being used to carry out measurements in the Earth's atmosphere. The main operating principle of the instrument is to measure the amount of direct solar radiation and that scattered by the atmosphere during the day [Khorkin V.S., et al., 2023]. The paper discusses the design and main characteristics of the instrument, which allow it to measure both the radiation scattered by the atmosphere and the sum of scattered and direct solar radiation at different times of the day. The daily average of the aerosol optical depth τ of the atmosphere is determined in two spectral channels - blue (λ = 320-500 nm) and red (λ = 700-1050 nm). The data processing technique is analyzed in detail using the developed model, which describes the properties of the atmosphere in the approximation of pseudospheric geometry. Calculations of the amount of scattered radiation were performed using the spherical harmonics and discrete ordinates method, taking into account multiple scattering using the Shdom program [Evans, 2007]. The calculations took into account aerosol attenuation, Rayleigh scattering and atmospheric gas absorption. Using the listed mechanisms of radiation attenuation in the planetary atmosphere, the output signal from the ODS instrument was calculated for different atmospheric states. The calculated values were used to process the results of ground-based field measurements carried out at IKI RAS in 2022-2024, to remotely determine the position of the instrument during the measurements, and to reconstruct the aerosol optical depth and aerosol size distribution parameters. At this stage, a good agreement between theoretical and experimental dependencies has been obtained and the aerosol optical thickness of the atmosphere τ is reconstructed with an accuracy of 0.05.

***Keywords*:** aerosol optical depth, aerosol, attenuation, scattering, SHDOM.

***Литература*:**

1. Haberle R., Clancy R., Forget F., Smith M., Zurek R., The Atmosphere and Climate of Mars. Cambridge: Cambridge Univ. Press, 2017. 588 p.
2. Khorkin, V.S., Fedorova, A.A., Dobrolenskiy, Y.S., Korablev O.I., et. al., ExoMars-2022 Mission ODS Instrument: Modeling and Ground Field Measurements. *Sol Syst Res,* V. 57, pp. 324–335, 2023. doi: 10.1134/S0038094623040056
3. K.F. Evans, Journal of the Atmospheric sciences–special section, p.3854-3864, 2007, doi: 10.1175/2006JAS2047.1