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Studies of stratospheric ozone layer from near-earth orbit utilizing ultraviolet polarimeter

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Abstract

Stratospheric aerosols (at altitudes above 30 km) play an important role in formation of the thermal condition and the ozone layer thickness. Nowadays, there are data on optical thickness of aerosols at these altitudes in the visible wavelength band received by spectrophotometric methods. At the same time, the origin of these aerosols, as well as particle distribution function, has not been completely studied (the real part of refractive exponent). Amongst remote methods, only polarization measurements (data gaining of changing light polarization reflected by the Earth atmosphere from a phase angle) allow to gain these characteristics.

The principal astronomic observatory of the NAS of Ukraine proposes to carry out the polarization measurements of the stratospheric aerosol at a wavelength of approximately 260 nm from near-earth orbit. Currently, NASA is carrying out a similar experiment; however, these measurements are being carried out in the wavelength interval above 412 nm. Their data are formed basically by dispersed light of the troposphere and its reflection from the Earth surface and clouds. Our experiment makes it possible to exclude the influence of troposphere and underlying surface, and explore the light flux dispersed by the Earth atmosphere at altitudes above 30 km.

Keywords: Zone; Aerosols; Polarimeter; Satellite; Ultraviolet

1. Introduction

The ultraviolet (UV) radiation significantly affects the Earth atmosphere; so it is very important to assess the effect of atmospheric factors on variation of this radiation nearby the Earth surface. The gas and aerosol components of the atmosphere play the main role in regulation of the UV ingress. It is well known that ozone degradation occurs only in the stratosphere while in the troposphere the ozone content increases due to its contamination by nitrogen oxides.

Because of this fact, the total content of ozone in the troposphere and stratosphere is usually considered separately. During the recent years, there emerged data about comparatively high concentrations of certain troposphere gases that have the absorption band in the UV spectrum. These gases are present, basically, not far from the sources of anthropogenic pollution or are formed during natural disasters (for example, large-scale forest fires, volcanic eruptions and so forth).

The fine Stratospheric aerosols (at altitudes above 30 km), which may remain in the atmosphere for years, play an important role in formation of thermal behavior and thickness of the ozone layer. The integrated refractive exponent (index of refraction) is one of the most essential amongst the parameters that govern dissipative

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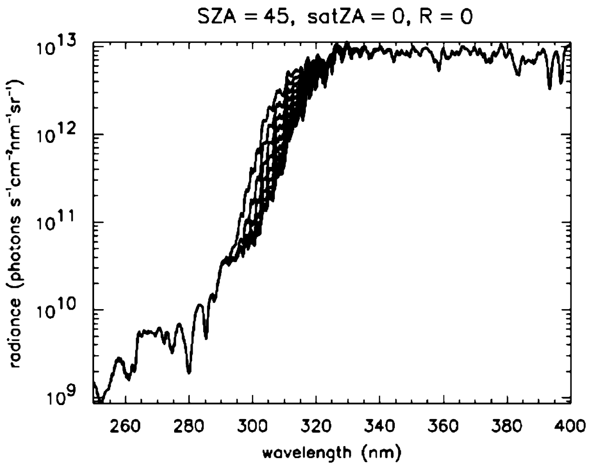

Fig. 1. Backscatter ultraviolet radiance spectrum from 250 to 200 mm.

and absorbing properties of the atmospheric aerosol, and the value of its seasonal variations provides additional information about qualitative transformation of particle properties during the year. However, the efforts of its estimation based upon data of chemical analysis with respect to an aerosol substance lead to practically unpredicted errors in assessment of the optical parameters. A more adequate approach for solution of such tasks is its estimation directly from the data of optical measurements.

Currently, owing to a series of spectrophotometric measurements (Fig. 1) [1], there are data on the optical thickness of aerosols at these altitudes in the visible wavelength band. However, its origin (the real part of refractive exponent) and particle distribution function are not completely explored. Amongst remote methods, only polarization measurements (receipt of data on variation of the polarization degree of light reflected by the Earth atmosphere from a phase angle) allow definition of aerosol characteristics [2]. The information received from the polarization components is actively used during satellite remote sensing.

2. Target setting and idea of space experiment

The Main Astronomic Observatory of the NAS of Ukraine proposed to the National Space Agency of Ukraine to accomplish a space experiment referenced as "Aerosol" associated with the studies of stratospheric aerosol for explanation of the reasons of changes occurring in the ozone layer. The essence of this experiment lies in performance of measurements with respect to the polarization component of solar radiation diffusely reflected by the Earth atmosphere in the wavelength band of 240–270 nm utilizing a UV polarimeter installed onboard the Ukrainian youth satellite (UMS-1). The measurements shall be conducted systematically during its every circuit round the Earth. Dependence in polarization variation received over the time of multiple circuits of the microsatellite versus the phase angle f is the subject of studies (Fig. 2) [3]. The spacial–time relationships of these variations for different parts of the Earth sphere will allow estimation of the reasons contributing to these changes. Currently, NASA is accomplishing a similar experiment; however, these measurements are conducted in the wavelength interval exceeding 412 nm. That is, the data received are formed basically by dispersed light of the troposphere and its reflection from the Earth surface and clouds. In order to exclude the influence of troposphere and underlying surface, we suggest to accomplish polarization measurements in the wavelength of approximately 260 nm on one of the artificial satellites of the Earth, at which length the ozone layer completely cuts off the influence of light scattered by the Earth atmosphere at altitudes lower than 30 km.

3. Implementation of space experiment

The implementation of space experiment consists in development, manufacture and installation on the Earth microsatellite platform an onboard ultraviolet polarimeter (OUVP). The database received during such polarization measurements will allow estimation of physical characteristics of the stratospheric aerosol.

- The structural layout in construction of the experiment is illustrated in Fig. 3.
  - The object of research (OR) is a portion of medium radiation in the volume that forms at intersection of a conditional cone of the instrument viewing (vision) in the stratospheric aerosol thickness.
  - The system of collection and creation of radiation (SCCR) collects and transforms the required amount of radiation and transmits it to a photo detector.
  - The optometrist-mechanical block is composed (OMB) of
    - Diaphragm;
    - Polarizing modulator;
    - Light filter block;
    - Imaging block for photodetector.
  - The registration block of a friendly signal (FS), which is composed of
    - Photo electronic receiver block;
    - Friendly signal amplifier;