Observations of ozone and nitrogen dioxide profiles in TROICA experiments

O.V. Postylyakov, A.S. Elokhov, I.B. Belikov, A.I. Igaev, N.F. Elansky
A.M. Obuhov Institute of Atmopsheric Physics, RAS, Pyzhevsky per.3, Moscow, 119017,

Abstract. Opportunity to modify the spectrometers used at the stationer observatory and to employ it at a mobile train-carriage laboratory for determination of the ozone and nitrogen dioxide contents has been shown. The retrieved gas contents are compared with data of TOMS and stationer ground-based stations.

Introduction

Several experiments TROICA (Transcontinental Observations Into the Chemistry of the Atmosphere) has been carried out using a mobile train-carriage laboratory in the zonal (between Moscow and Khabarovsk) and meridional (between Murmansk and Kislovodsk) directions over Russian railways [Elansky et al. 2004]. Mobile instruments for optical remote sensing of gases in the atmosphere was tested during 4th (1998), 5th (1999) and 8th (2004) expeditions.

The main goals of remote sensing from a mobile train-based laboratory are:

- measurements of the vertical distribution and the total content of atmospheric compositions in spacious regions of Russia and Asia, where stationer ground-based network stations are absent;
- validation of measurements of satellite instruments TOMS, GOME, OMI, SAGE III, SCIAMACHI et al. at extended areas;
- regular calibration of scattered over Russia ground-based network instruments using one standard mobile instrument.

The paper presents preliminary results of retrieval of gas contents in the atmosphere obtained during TROICA expeditions.

Instruments and retrieval methods

The first measurements of the gas profiles aboard a train-carriage laboratory were performed in the scientific expeditions TROICA-4 (February 18 -March 5 1998) along way Moscow-Khabarovsk-Moscow. A carriage coupled just behind an electric locomotive of a passenger train was equipped with the LOMO MDR-23 monochromator. It is a grating spectrometer with focal distance 0.6 m and asymmetric optical Fastie's scheme. A system of mirrors illuminated the entrance slit of the monochromator using carriage window. It formed field of viewer about 10^O in the zenith direction. The slits provided a resolution of 1 nm. The detector was a photomultiplier. Rotation the grating, using a sine bar mechanism driven by stepper motor, scanned wavelength. The measurement wavelengths were from 305 to 335 nm in UV and from 434 to 451 nm in visual region. Forward and reverse scans together take about 40 s.

Measurements were carried out aboard the moving and standing train. For the solar zenith angles (SZA) less than 75^O, the measurements were performed each first 15 minutes of an hour only in UV region. The UV measurements became continues for 75^O<SZA<=84^O. The UV and visual measurements were alternated for 84^O<SZA<=90^O. Only visual measurements were performed for 90^O<SZA<=96^O.

A new carriage-laboratory [*Elansky et al. 2004*] has been equipped by image spectrometer Oriel MS257. Optical input for the instrument was mounted using fiber optics. It bacame capable to measure simultaneously radiance incoming from several directions to determine the slant columns of ozone, nitrogen dioxide and other small gases. Instrument measure UV and visual spectrum. Using observations at a few wavelengths and in several directions spatial distribution of gases will be retrieved. The first expedition of a new carriage-laboratory (TROICA-8) with the new optical remote sensing system was performed from March 19 to April 1 2004.

To determine the ozone distribution, the express Umkehr method [*Elansky et al. 1999*] and modification of the DOAS method for the UV wavelengths were used. Weighting functions and air mass factors were calculated taking into account multiple scattering using the MCC++ radiative model [*Postylyakov 2004a*]. To determine the nitrogen dioxide profiles, the DOAS twilight method was used [*Elokhov and Gruzdev1995*].

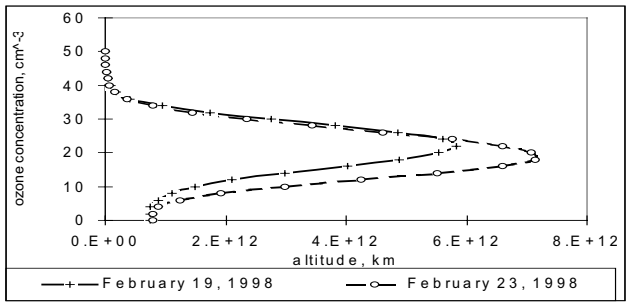

Figure 1. The vertical ozone distribution measured at evening of 19.02.1998 and of 23.02.1998.

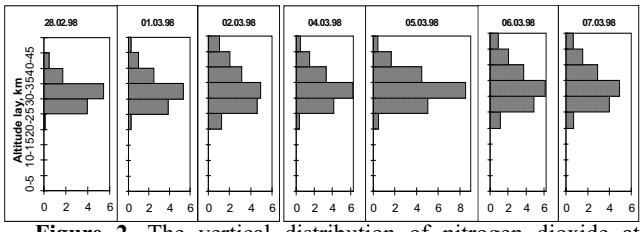

Figure 2. The vertical distribution of nitrogen dioxide at evening. Integral content in 5-km layers is shown in 10^{14} cm^2.

First results

All morning or evening UV specter measured at 80^O<SZA<=90^O were used for retrieving one vertical ozone profile. Examples of retrieved profiles are shown in Figure 1. Twilight visual measurements gave vertical profiles of NO_2, shown in Figure 2.

Total ozone contents (TOCs) were retrieved for each measured UV specter. Figures 2 and 3 show TOCs averaged over 19 spectral scans. Obtained TOC data reflect mainly the large-scale gas species distribution influenced by planetary waves. Significant variations in the total content and vertical distribution of ozone and NO_2 were observed between 19 and 23 February 1998. It was the cross-section of a deep low representing a part of a circumpolar vortex. A comparison with the TOC maps obtained by the Earth Probe/TOMS confirms observation of such an event.

The TROICA TOC measurements are compared with the data obtained by TOMS in Figures 3 and 4. Difference of two methods usually not exceeds 25-30 DU. Retrieved TROICA TOCs correspond to the different local time for different locations, while TOMS data correspond to near midday at each shown point. Disagreement of midday TROICA data and TOMS data is typically within 10 DU.

Preliminary analysis of the TROICA-4 experiment allows conclusion on validity of obtained data and on potential effectiveness of using a moving laboratory for remote sensing of gases.

First results of TROICA-8 expedition will also be presented at Symposium.

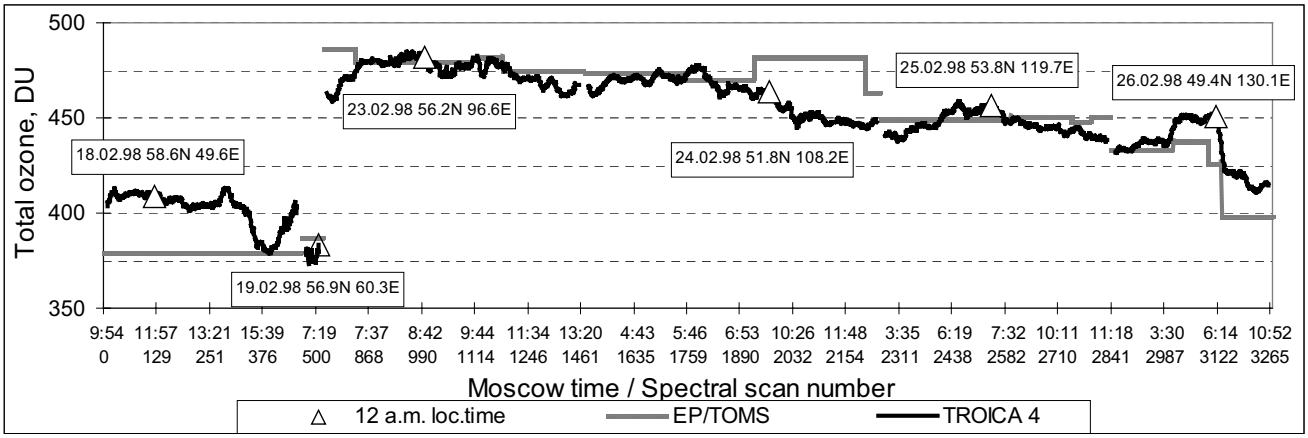

Figure 3. The total ozone content measured from train during way Moscow-Khabarovsk from February 18 to 26, and data of TOMS. Points of crossing of the local midday is shown for each day.

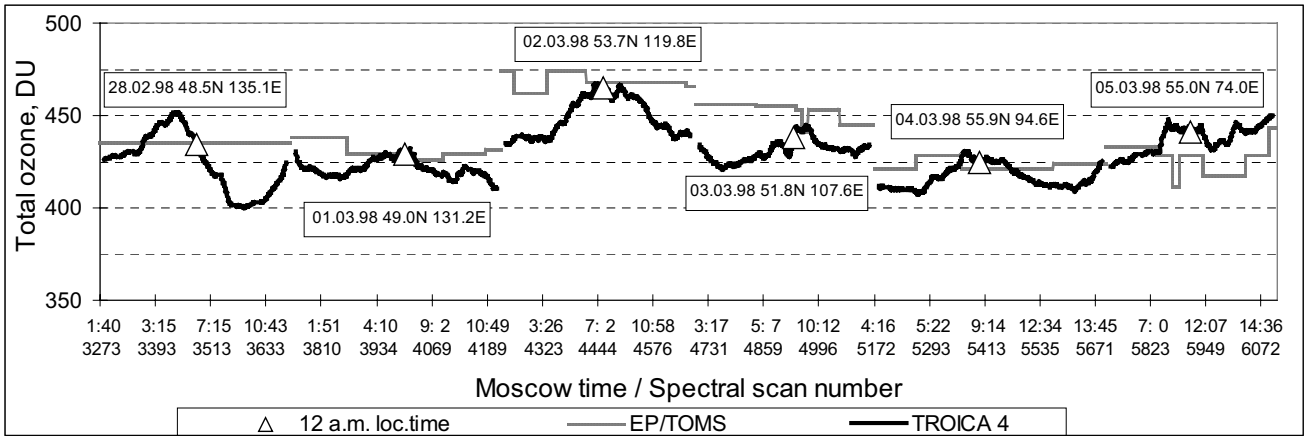

Figure 4. The same what at Figure 2, but for the back way Khabarovsk-Moscow from February 28 to March 5.

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