rithm applied to the express measurements taken at 23 wavelengths and one angle z (see section II.5). The discrepancies between these results depend on the actual profile and measurement noise. The mean errors in these two sets of numerical experiments are nearly the same if the express measurements are taken at $z > 82°$. Thus, the numerical experiments confirm the theoretical estimates obtained for the accuracy of retrieval.

Preliminary results of processing on-site experimental data are given in [22]. The main peculiarities of the VOPs obtained correlate well with the previously known VOP peculiarities typical for aerological conditions under which the observations were performed.

CONCLUSIONS

We have studied theoretically the limiting possibilities of increasing the accuracy of ozone determination from Umkehr observations, i.e., from ground-based skylight observations in the UV region at low sun elevations. The possibilities to improve the algorithm of VOP retrieval and to optimize the measurements of UV radiation intensity used for calculations were analyzed.

On the basis of the theoretical investigations, a new method of VOP retrieval from results of Umkehr observations with Brewer spectrophotometers is proposed. The new method is characterized by a better accuracy as compared to the standard method initially designed for Dobson spectrophotometers and currently used at the network of stations equipped with Brewer spectrophotometers. The new method decreases the error of VOP retrieval in the lower stratosphere by a factor of about 2. It serves to restrict the Umkehr observation time to 12 min in cases when atmospheric phenomena, such as discontinuous cloudiness, hamper continuous observations with the standard method requiring 1.5–2 or even 2–3 h in polar regions.

The problem of usefulness of an isolated measurement is considered. The maps of the usefulness against the solar zenith angle and the wavelength are constructed. These maps provide a means for a choice of the solar zenith angles and wavelengths, at which the measurements are of the least usefulness from the viewpoint of achieving the maximum accuracy of VOP retrieval. Measurements at these solar zenith angles and wavelengths can be rejected from the program of Umkehr measurements with the least losses in accuracy of VOP retrieval. Such rejection can be necessary in the cases when it is required to use any universal Brewer spectrophotometer for observations of several types over a common period of time.

On the basis of the optimum design of measurements and optimum distribution of the operating time between measurements at individual wavelengths, a method for optimization of the procedure of Umkehr measurements is proposed. It is shown that optimization of the procedure of measurements can result in an additional increase in the accuracy of VOP retrieval by

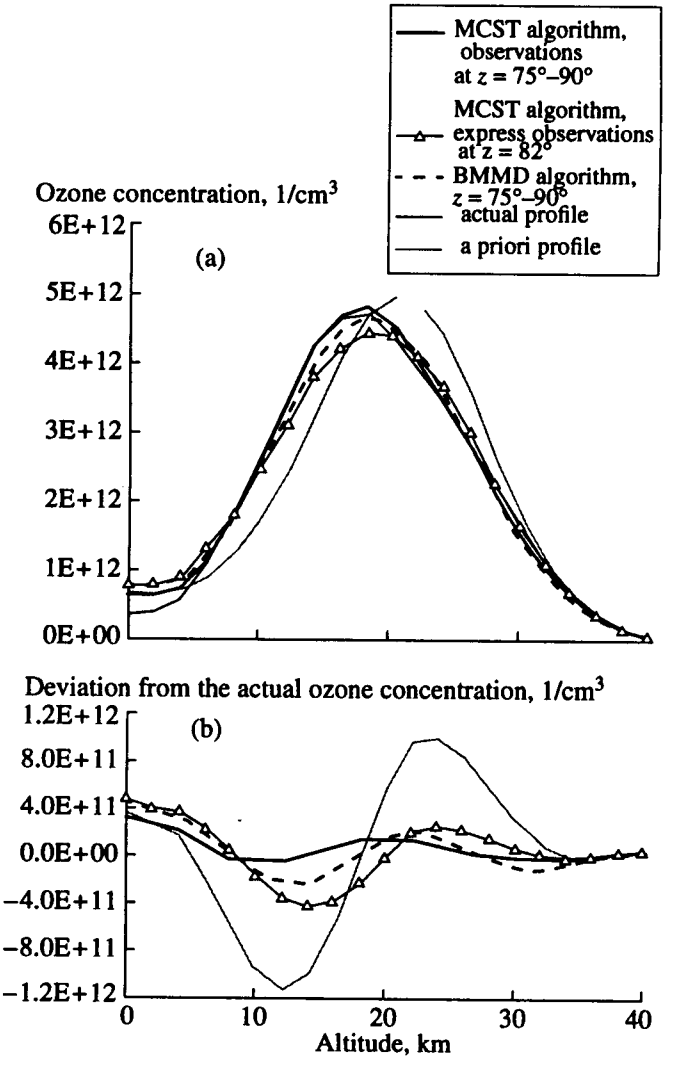

Fig. 7. (a) Results of VOP retrieval with the MCST and BMMD algorithms in the numerical experiment of observations at z from 75° to 90° and of express observations at $z = 75°$ and $z = 90°$. The actual and a priori profiles are also shown. (b) Deviations of the a priori and retrieved profiles shown in Fig. 7a from the actual profile.

values up to 10–25% of the rms error of measurements. Therewith, the shorter is the total time allotted for observations, the larger is a relative decrease in the retrieval error. It is significant that waves shorter than 302 nm are never optimum for the Umkehr method due to a low signal-to-noise ratio. This remark relates even to the Brewer MK III instrument, designed as a double monochromator.

The proposed improvement of the Umkehr method for VOP retrieval can be used at ozonometric stations equipped with Brewer spectrophotometers. At present, there are about a hundred such stations. The possibility of measuring in discontinuities of cloudiness and under unstable aerosol conditions is of fundamental importance, since this significantly increases the volume of

data being obtained. An increase in the accuracy of VOP retrieval can make the Umkehr measurements appropriate for the analysis of trends in the lower stratosphere. The new method will also provide a possibility for more frequent Umkehr observations at polar stations, where the standard method is impractical for much of the year due to small daily variations in the solar zenith angle. All these facts make the new method very promising for employment at the world ozonometric network.

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