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FIRST OZONE PROFILES MEASURED WITH ELECTROCHEMICAL AND CHEMILUMINESCENT SONDES, DEVELOPED IN RUSSIA

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ABSTRACT

Results obtained with experimental balloon electrochemical and chemiluminescent ozonesondes are summarized and estimated as quite satisfactory. The average normalization factor for the electrochemical ozonesonde obtained in 1991 at four Soviet balloon routine network stations is 1.069+0.073 (in 17 flights). Some ozone profiles obtained in summer 1991 at Volgograd are discussed together with corresponding meteorological data.

1. INTRODUCTION

Among several types of balloon ozonesondes the Komhyr electrochemical concentration cell (ECC) ozonesonde is the most prevalent. Its advantages are: 1) yielding absolute ozone concentration that causes high accuracy in the 10-25 km region and 2) possibility for unskilled operator to achieve good results after short training. The most important characteristic of ozonesonde is total ozone normalization factor - the ratio of spectrophotometer (usually Dobson) total ozone to ozonesonde total ozone. In the recent balloon ozone intercomparison campaign (Hilsenrath et al., 1986) the average normalization factors and their standard deviation obtained by various operators were from 0.93 to 1.02 and about 0.07, respectively. Shortcomings of ECC sondes are: 1) relatively high cost (compared to component's costs) owing to complexity of manufacturing and 2) total shortcomings that are inherent for electrochemical ozonesondes, namely, a) the relatively high time-response (about 30 s near the surface and more during ascent); b) sharp and non-controlled lowering of precision higher than 25 km (results of measuring are doubtful for heights more than 32 km); c) inconveniences due to using of "wet chemistry" during pre-flight preparation. Attempting to eliminate some of these shortcomings, we tried to develop our own ozonesonde.

2. INSTRUMENTS

Experimental electrochemical (ECC-CAO) and chemiluminescent (CL-CAO) ozonesondes were developed and manufactured in CAO using our own materials and technology. The ECC-CAO sonde is simular to the ECC-5a sonde. Using CAO sondes with modified industrial MARZ type radiosonde (Russia) we obtain information about temperature, humidity and ozone concentration during ascent in the manner described by Roennebeck and Sonntag (1976). The composition of chemiluminescent sensor is simular to that described by Sahand et al. (1991). CL-CAO sonde has some advantages over ECC-CAO (a time-response, a possibility of measuring at all heights, simple pre-flight preparation) but ECC-CAO sonde has the most important advantage in precision owing to simplicity of its calibration and stability of its sensor during a flight.

3. PRELIMINARY RESULTS

First testing of CAO ozonesondes was carried out in Rylsk (51°N, 34°E) in autumn 1989. We noticed that CL-CAO sonde showed more fine ozone structure than ECC-CAO; in particulary, sometimes (in rainy days) CL-CAO sonde discovered some about 50 m height distinct regions in low troposphere (below 4 km) where ozone concentration abruptly rose about twice (e.g., on September 12, 1989, increasing was from 31 up 63 nbar at 2.6 km height). We suppose that this phenomenon was caused by sonde passing through the upper boundary of rainclouds.

More comprehensive investigations of our ozonesondes were carried out in Rylsk in summer 1990 with participation of the specialists from German Lindenberg Aerological Observatory (Albrecht et al., 1991). Three different electrochemical

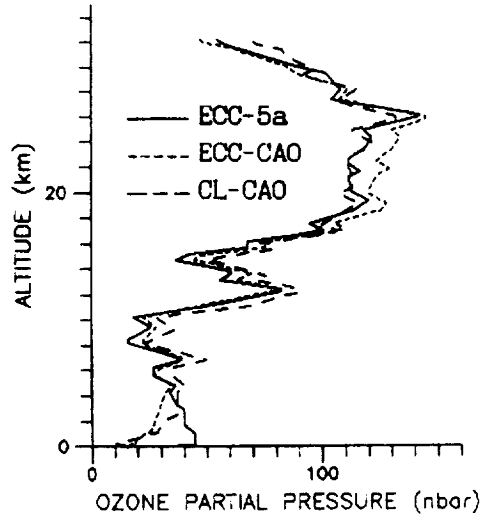

Fig.1. Ozone vertical distribution measured at Rylsk on August 1, 1990, by three ozonesondes flown in one gondola.

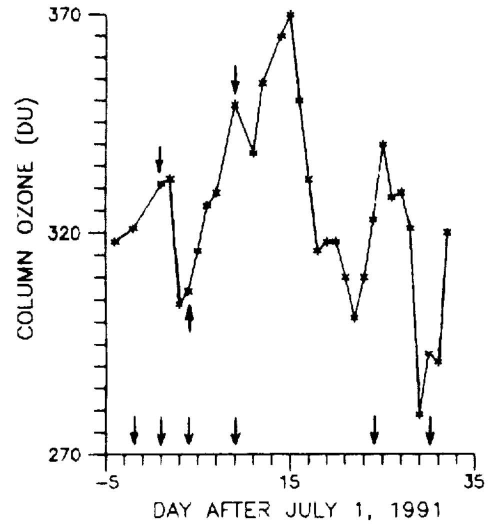

Fig.2. Temporal variations of total ozone at Volgograd in 1991 (double arrows indicate days of ozonesonde flights whose profiles are shown at Fig.3).

ozonesondes (ECC-5, OSE-4 and ECC-CAO) and chemiluminescent one (CL-CAO) were compared. Experiments included 2 launches of multiple-instruments gondola and 6 balloon flights (3 triplets, 2 doublets and 1 singlet). In case of gondola's flights all results were obtained at once from a micro-computer; in case of balloon flights the results were calculated using information from diagram tapes of C-band radar "Meteorite-R". Some performance characteristics of our ozonesondes are illustrated by Figure 1. Absolute differences between ECC-5a and ECC-CAO data (being corrected by factor K) were as high as 10 nbars at all heights below 30 km. The relatively high normalization factor (1.237) and its standard deviation (0.212) for ECC-CAO sonde were obtained; apparently it was caused mainly by shortcomings in manufacturing or/and pre-flight preparation of a pump and partly by the error in measuring total ozone by the filter ozonometer M-124 which equals about 8 %. These shortcomings were taken into account in successive experiments.

4. RESULTS AND DISCUSSION

In 1991 we used ECC-CAO sondes in 17 balloon flights for measuring of ozone profiles at Volgograd (49°N, 44°E), Tashkent (41°N, 69°E), Dushanbe (38°N, 68°E) and Khorog (37°N, 71°E). Five different operators had launched ozonesondes; results were calculated in CAO using the information being read from radar tapes. Total ozone was measured in Volgograd by ozonemeter M-124; TOMS-METEOR's data were used for Middle-Asian sites. The average normalization factor and its standard deviation were 1.069+0.073 in these measurements; these results are quite satisfactory and consistent with the results for ECC sondes from the Palestine 1983-84 intercomparison campaign (Hilsenrath et al., 1986).

In order to demonstrate the possibility of applying ECC-CAO sondes for routine soundings six launches were carried out between June 28 and July 30, 1991, at Volgograd (corresponding days are marked by arrows on X-axis at Fig.2). The replacement of polar air in June by subtropical air in July is typical for that region. This replacement becomes apparent in the stratification, namely in the transition of the tropopause from 11 km (which is typical for polar air) to 16 km (which is typical for subtropical air). Figures 2-3 show temporal variations of total ozone and also some ozone and temperature profiles. In period of observations the stratosphere temperature field was typical for summer. Temperature vertical distribution with the clear polar tropopause at 11 km and the weak second subtropical tropopause at about 16 km was observed on June 28, July 1,9, and 24; two such profiles are shown at Fig.3, right (curves 1 and 3). The weak first tropopause at 11 km (or its trace) and the second tropopause at 16 km were observed on July 4 and 30 (curve 2 at Fig.3, right). The temporal variations of total ozone also indicate that the replacement of air masses took place: total ozone is less in subtropical air

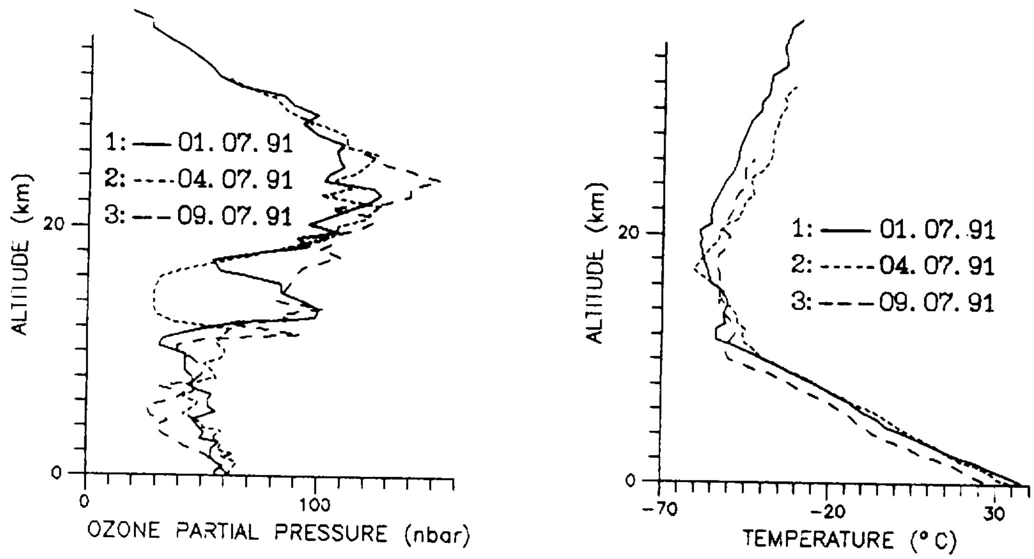

Fig.3. Ozone (left) and temperature (right) vertical distribution measured on July 1, 4, and 9, 1991 at Volgograd.

than in polar air here. The air replacement produced the disappearance of the secondary maximum in ozone vertical distribution in the 12–16 km region – between the polar and subtropical tropopause levels (curve 2 at Fig.3, left).

5. CONCLUDING REMARKS

1. Our developments of two types of the ozonesondes described above have indicated the possibility of their use in field experiments and routine network to investigate the problems of ecologie, ozone layer, physics of atmosphere etc.

2. One standard payload (its weight is less than 1.3 kg) equipped with both ozone sensors will give the advantage allowing to carry out the most accurate *in situ* ozone concentration measurements with its high spatio-temporal resolution.

3. Laboratory and field experiments showed practical possibility of ozone measurements using fast response chemiluminescent sensor installed in fast flying vehicles (rocket, aircraft).

4. The ozone measuring instruments for monitoring of ozone concentration in the near-ground layer of the atmosphere may be developed on the basis of balloon and rocket ozone sondes; our first experiments and observations with such apparatus were successful.

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