A-1.4 MEASUREMENTS OF STRATOSPHERIC OZONE BY THE ROCKET OZONESONDE

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Abstract A small optical ozone instrument has been developed for a rocket-borne dropsonde to measure the altitude profile of stratospheric ozone. The ozone dropsonde is launched aboard a meteorological rocket MT-135, providing the altitude profiles of ozone as well as atmospheric temperature and wind. The rocket launchings have been carried out eight times since September 1990 at Uchinoura (31N, 131E), Japan, to measure ozone concentration from 52 to 20 km altitude during the slow fall of the dropsonde. The ozone profiles measured in summer were very stable above an altitude of 28 km, where as those measured in winter showed considerable variations compared to the summer profiles at the stratospheric altitudes.

Key Words Stratospheric ozone, Rocket measurement, Optical ozonesonde

Introduction

It is increasingly important to monitor the possible changes in amount of ozone in the stratosphere as human activities or natural causes might result the long-term changes in it. The trend analysis have been made, in most cases, in terms of the total ozone amount by using the world-wide Dobson measurements. Also some satellite measurements are believed to be capable to detect vertical structure of trends in the stratosphere. It is not a easy task to detect clear long-term changes in the stratosphere, as very small amount of the changes is expected in total amount of ozone. In the present stage, it is reasonable to collect more information on the long-term ozone trends. Some model calculations indicate clear vertical structure of trends in the stratosphere, and shows maximum ozone depletions around 40 - 45 km. Rocket measurements are suitable to monitor ozone concentration at these altitude region. It is therefore reasonable to establish a monitoring system using rocket-borne instrument.

The revisions of the optical system of the roket-borne sensor, telemetry system, and of instrument calibration, are studied and developed in this study. These works are successfully integrated in the ISAS's rocket ozone measurement program. In this report, the major achievements of the rocket experiments are presented.

Instrumentation

Ozone has been observed by the rocket-borne optical ozone sensor by using relatively large sounding rockets by the Institute of Space and Astronautical Science since 1965. In the early stage of the series of ozone measurements, it was the measurement of the mesospheric ozone between 50 and 80 km at the ascending stage of spin-stablized rocket. In the later stage of ozone observations, a small one-axis sun follower system has been developed.

The development of the optical ozonesonde for the MT-135 rocket has been started in 1987. The MT-135 optical ozonesonde is a miniaturized four band filter photometer designed to measure ozone from observation of the absorption of the sunlight by ozone as a function of altitude. The filter wavelengths are selected in the uv Hartley and Huggins bands to provide measurements between 20 and 60km. The instrument is operated as a dropsonde carried by a parashute after deployment near 60km from MT-135 rocket booster.

The telemeter aboard MT-135 rocket is a 1680MHz digital echosonde. Both the transmittion of the measured data and the positioning the payload are carried out by this compact telemetry system. Data are transmitted 40-bit pulse code modulation system, with a sampling rate of 4 millisecond.

The absorption of the solar uv by ozone is converted to the product of ozone column density along the sunlight path by the ozone absorption cross section. As the ozone cross section is well known, ozone column density is derived as a function of altitude from the absorption data. The number density of ozone is then obtained as the derivative of the ozone column density with respect to altitude.

The sensor receives the sunlight by means of a transmission quartz diffuser plate located at the top of the instrument. The light transmitted through the diffuser plate is then passes through a beam splitter, filter, and a lens and then accepted by the phototube with SbCs photocathode. The use of a diffuser plate eliminates the need for any pointing devices, but results in a signal level depending on the incident angle of the sunlight. To correct for this modulation, the small fraction of light reflected by the beam splitter passes through the filter centered at 420nm is received by the second detector. The ratio of the uv signal to this reference signal removes the angle-of-incidence modulation.

Results and Discussion

The ozone profiles measured in summer (August - September) exhibit stable altitude profile. Indeed the variance of ozone density of summer profile is only 3% above 25 km (Figure 1). This is close to or less than the estimated measurement error, and this may indicate the possibility to detect the long term ozone trend in the upper stratosphere by the dropsonde observations extending in summertime. Also the summer ozone profiles are in good agreement with the CIRA (Cospar International Reference Atmosphere) 1986 within ±10%.

On the contrary, winter (February) ozone profiles show considerable variations mainly in the lower stratospheric altitudes. The wind component simultaneously measured shows intense westery wind which may be the cause of the disturbed stratosphere. On the contrary, the eastery wind is dominant in summer stratosphere, which may maintain the stable stratosphere in summertime. The February / September ratio of the ozone concentration is in good agreement with the seasonal variation derived by CIRA (Figure 2).

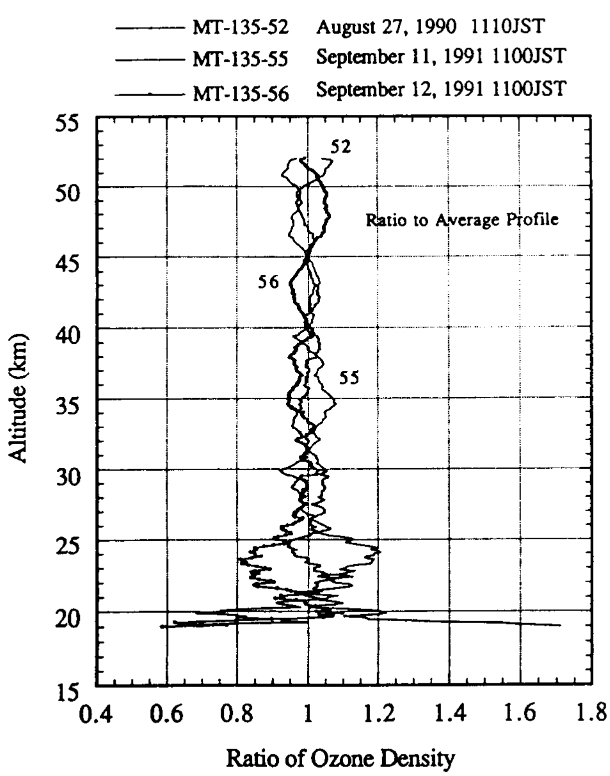

Figure 1. Ozone number densities measured on August and September 1991 at Uchinoura (31N, 131E), Japan. Ratios of the three profiles to their mean profile.

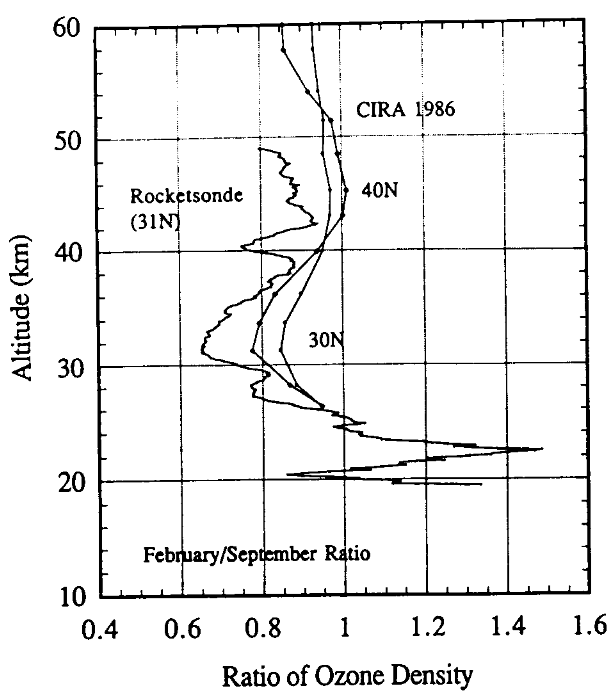

Figure 2. Ratio of the mean February profile to the mean September profile. Thin curve shows ozone number density ratios of February to September CIRA average ozone for 30N and 40N, respectively.