# Rocket Measurement of Mesospheric Ozone at High Latitude

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高緯度における中間圏オゾンの観測

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**要旨**：冬期高緯度において，中間圏オゾンのロケット観測を太陽吸光法を用いて行った．得られた高度分布は，典型的な中緯度の値にくらべて著しく小さい．

***Abstract***: A rocket measurement of the vertical distribution of ozone in the mesosphere has been made under a high latitude winter condition, with the solar ultraviolet absorption method. The measured ozone concentration at 60 km was $1.7\times10^{9}$ cm$^{-3}$, which was much lower than the typical value of that measured at the mid-latitude.

## 1. Introduction

As most measurements of ozone distribution in the upper atmosphere have been carried out at the mid-latitude, there is very little information of ozone distribution at high latitude where atmospheric density, temperature and radiation are very different from those in mid-latitude.

For measuring the ozone at high latitude we launched five S-210 rockets during the period from March 1977 to February 1978 at Syowa Station, Antarctica, but unfortunately four of the experiments failed mainly because of the inadequate attitude of the rocket. Therefore, presented in this paper is the result of the one successful experiment.

The ultraviolet solar radiometers were mounted on the S-210 rocket for measuring the ozone. The observation was carried out at sunset, to take advantage of the increased sensitivity by using the long solar absorption path in the atmosphere, which enabled us to measure ozone up to 75 km.

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## 2. Instrumentation

The attenuation of the solar ultraviolet radiation due to ozone photo-absorption was measured with a pair of solar radiometers, which consisted of an interference filter and a solar blind phototube. The optical characteristics of the radiometers were basically similar to those described by TOHMATSU (1969). For this experiment, the interference filters having the maximum transmission at 2575 Å and 3310 Å with band width of approximately 150 Å were used in conjunction with HTV R765 CsTe phototubes. A radiometer centered at 4500 Å with FWHM of 35 Å was also mounted to monitor the spurious variation of the output of the radiometers due to the change of the rocket attitude.

The radiometers were mounted on a single staged spin-stabilized rocket S-210JA-27. The rocket was launched from Syowa Station, Antarctica (69°S, 39°E) at 12 : 47 : 03UT on August 10, 1977 with the azimuth of 135° and the elevation 82°. The rocket reached a maximum altitude of 119 km 167 s after launch. Solar zenith angle was 91°.

The radiometers were looking outward and the solar radiation was introduced through quartz windows attached to the rocket skin and was detected by radiometers intermittently as the rocket spun.

A small mono-axial sun follower was used to control the 2575 Å radiometer. The pointing control system provided the motor-driven rotation of the radiometer to cancel the rocket's coning motion, so that the axis of the radiometer passed through the center of the solar disc once a spin cycle. The sun follower is described in detail by WATANABE and TOHMATSU (1977). The transmission of the filters was obtained using Cary 17 spectrophotometer. Special attention was paid at longer wavelength leak of the MUV filters, because the intense stray light from the sun would be expected in the visible region. The spectral response of the phototubes was measured by using a Leiss double monochromator with a deuterium lamp. Overall sensitivity of the radiometers was checked by UV-40 irradiance standard deuterium lamp.

## 3. Data Reduction

The determination of the ozone concentration from the twilight measurement is basically similar to the midday experiment described earlier by OGAWA and TOHMATSU (1970). Finite wavelength sensitivity of the radiometers complicates the analysis. That is, the strong wavelength dependence of the solar radiation flux, absorption coefficient of ozone and the radiometers' sensitivity prevent the observed current ratio $I/I_0$ from being interpreted as a single absorption coefficient. In order to overcome this problem, we employed the following method:

(a) First, the attenuation of the solar radiation flux $I(N)/I(N=0)$ is calculated numerically as a function of the integrated path-ozone $N(O_3)$ for the individual wavelength response of the radiometer.

(b) Secondly, according to the observed attenuation $I(z)/I(z=\infty)$ at the altitude of $z$, the integrated path ozone $N(O_3, z)$ is determined as a function of $z$ by using the conversion table which was prepared in (a).

(c) Thirdly, the inversion from $N(O_3, z)$ to ozone concentration $n(O_3, z)$ is carried out by working shell to shell downward from the top of the atmosphere.

In the computation, the absorption coefficient of ozone has been taken from INN and TANAKA (1953), and solar radiation flux between 2100–3200 Å from BROADFOOT (1972) and that beyond 3200 Å from DUNKELMAN and SCOLNIK (1959). Air density data for estimating the small amount of attenuation by Rayleigh scattering, were obtained from the table in CIRA 1972.

## 4. Results

The observed attenuation by the S-210JA-27 experiment is shown in Fig. 1 and the derived profile of ozone is shown in Figs. 2 and 3. Our results show a wavy profile which has an average scale height of 5.1 km from about 50 to 74 km. The concentrations are significantly less than the typical midlatitude values by WATANABE and TOHMATSU (1976).

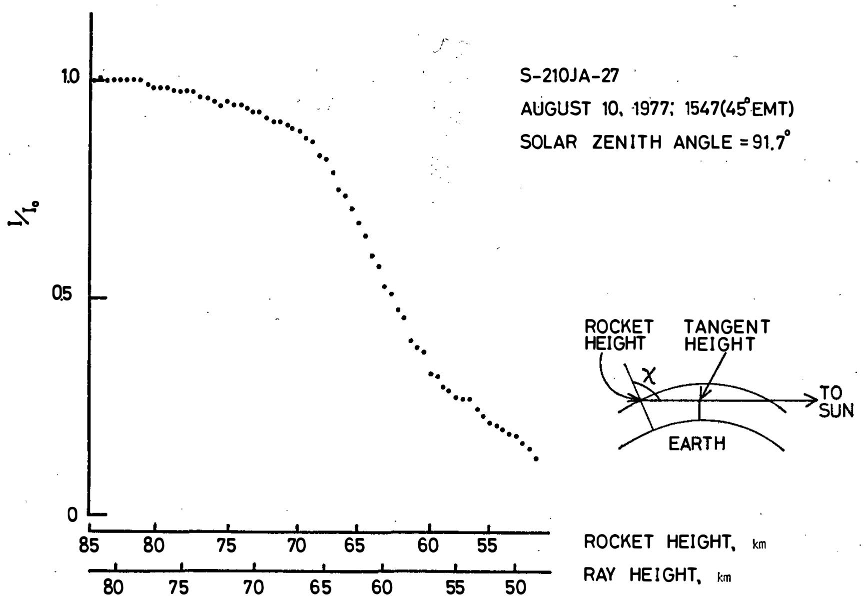


*Fig. 1. Altitude profile of the relative attenuation.*

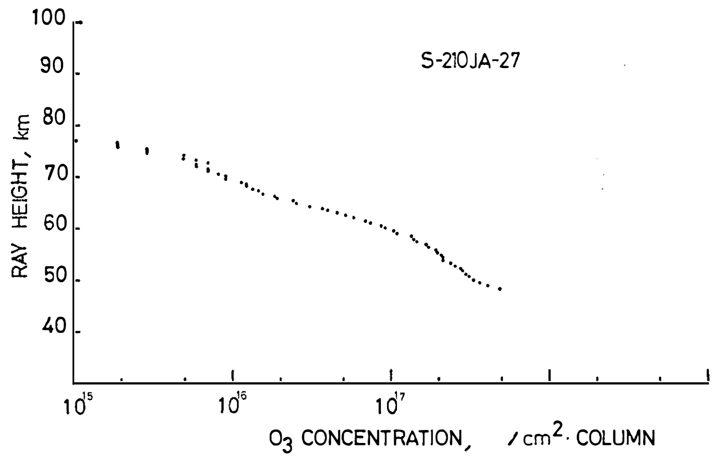


*Fig. 2. Observed ozone column density along the slant ray path.*

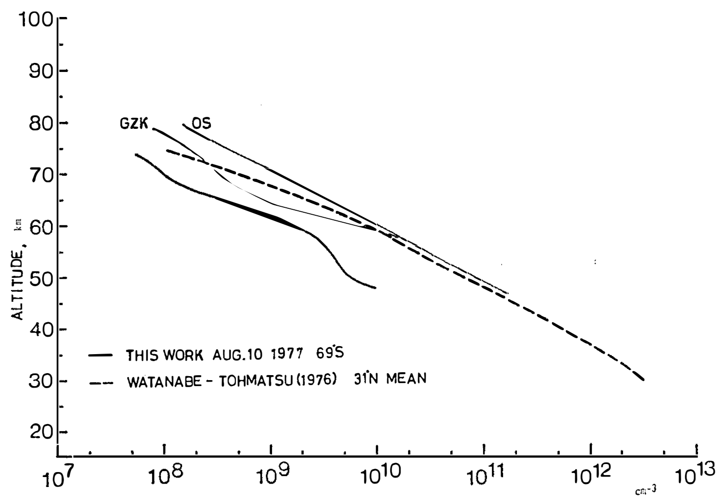


*Fig. 3. Ozone concentration profile of August 10, 1977 compared with mid-latitude observed profile and theoretical profiles.*

As ozone is produced by the reaction $O+O_2+M \rightarrow O_3+M$, it is affected by the total air density profile. In general the upper atmosphere at high latitude is thinner than that in mid-latitude, which provides less ozone at high latitude. WEEKS *et al.* (1972) indicate that the total air density at 60°N can provide about two-thirds of the difference of ozone concentration from the neutral air change between 60°N and 30°N.

There are two theoretical models, one by OGAWA and SHIMAZAKI (1975) (designated OS) and the other by GEORGE *et al.* (1972) (designated GZK). GZK model is based on a mean winter 60°N from US standard atmosphere supplements 1966, while OS model is based on larger neutral densities. To compare these two models further, it is required to consider the differences in air densities, temperature, eddy diffusion coefficients and water vapor mixing ratio, which is not done in this paper.

Even if GZK model is greater than the measurement, additional loss process is required. Loss by the reaction NO may improve this discrepancy because the simultaneous NO measurement shows very high NO concentration in the mesosphere. Further, there may exist loss by O and $HO_X$, although the uncertainties of these species are very large. As auroral activity was low during this experiment, our ozone profile seems not to be affected by the particles, while the particles in such a solar proton event cause a decrease in mesospheric ozone through ion-neutral reactions (SEKIHARA, 1969; WEEKS *et al.*, 1972).

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