OBSERVATION OF OZONE AND AEROSOLS IN THE ANTARCTIC OZONE HOLE
OF 1991 UNDER THE POLAR PATROL BALLOON (PPB) PROJECT
-PRELIMINARY RESULT-

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ABSTRACT

We present preliminary results for the PPB
(Polar Patrol Balloon) experiment. The balloon
was launched at 07:55 UT on 23 September and
dropped at 21 UT on 28 September 1991. During
the period Ozone and aerosol concentrations were
measured correspondingly along the track.

During the Lagrangian type observation,
drastic change of ozone concentration in 'same
air mass' and positive correlation between ozone
concentration and sulfate aerosol amount were
obtained at the level within 80-78 hPa.

During the descent motion at 80°S active
PSCs (type-I and -II) were observed from 200 hPa
to 80 hPa.

1. INTRODUCTION

Among Polar Patrol Balloon (PPB) experiments, one balloon was launched from Syowa
Station (69°S, 40°E) at 07:55 UT on 23 September
1991. The balloon directed eastward around the
80 hPa level in the lower stratosphere inside of
the polar vortex, i.e., inside of the Antarctic
ozone hole. The balloon flew for about 5 days to
reach around 80°S, 250°E (110°W) around 02 UT on
28 September after about three-fourth round
flight in the stratosphere. The balloon dropped
to the ice shelf at the earth's surface around
84°S, 196°E (164°W) around 21 UT on 28 September.

In situ measurements were made of ozone,
size distribution of aerosol, and temperature
along the track of the balloon. The PPB observation is a Lagrangian type observation, i.e. the
observation following the motion of an air
parcel: the ozone instrument measures the chemical source/sink more directly than any other
type of observation. The instruments used in the
observation are briefly described as follows.
The ozone instrument is essentially a modified
version of Dasibi ozone monitor. That is an
ultraviolet photometer to determine ozone concentration by measuring the absorption at the

253.65 nm mercury line near the ultraviolet
ozone peak, i.e., in the Hartley absorption
band. The aerosol instrument determines size
distribution of aerosol by measuring Mie scattering using a Tungsten lamp emitting 2850K
blackbody radiation as the light source. Size
distribution of aerosols for 6 classes is measured by using the fact that pulse intensity of
the scattered light depend on the size of aerosol. In the present paper, aerosol data for
three size ranges with diameters larger than
about 0.8 μm, 2.0 μm, and 5.0 μm are used.
However, the threshold for these size ranges are
poorly determined at the moment. More accurate
determination is to be made. Ambient temperature
is measured by thermistor thermometer. Data
acquisition and balloon positioning utilize
ARGOS system.

Ozone, aerosol, and temperature analyses
are presented in this paper, and a trajectory
analysis is presented by Kanzawa et. al. in the
present issue.

2. RESULT AND DISCUSSION

Ozone concentrations, aerosol concentrations whose diameter is larger than 0.8μm,
temperature, and pressure observed through this
experiment are shown in Figure 1. The horizontal
axis indicates the passing time from the starting time (05:05 UT on 23 September) of the CPU
system, 170 minutes before the balloon launch.
The data were obtained every 4 minutes. The main
reason for existence of "no-data periods" seen
in Fig. 1 is that the radio waves emitted by the
ARGOS transmitter boarded on the PPB can not
encounter the ARGOS system of NOAA satellites in
those period.

Pressure variation shows vertical motion
of the balloon. During night time, the altitude
was maintained near 80 hPa. During day time, the
balloon ascents and its altitude was at higher
levels than 80 hPa, because buoyancy of the
balloon increases by solar radiation heating.
We divide the experiment period into period-A,
-H1-5, -L1-5, and D as shown in Fig.1. A, H, L,

and D means Ascent, High level, Low level, and Descent, respectively. Each L corresponds to one night, when the balloon maintained its position approximately in the same air masses. But each point of observations during period-Ls is considered to be far from each other, from several 10s km to several 100s km, because vertical wind shear of several m/s per kilometer existed as inferred from rawin sonde wind data at Syowa Station.

Temperature was ranged from -56°C to -81°C. Temperature during period-A and -Hs is too high in comparison with results of observations at Syowa Station, and is very fluctuating. Perhaps, the heating of thermistor is caused by solar radiation. Then we use only night time temperature in the following discussion. Temperature during period-Ls is ranged from -67°C to -81°C at 80 hPa. It is warmer than the temperature observed in winter at Syowa Station by about 6°C.

Ozone concentration is shown as number density. Error of ozone number density is estimated to be nearly 10×10^{16} molecules/m^3. The value in the vertical axis, 100×10^{16} molecules/m^3, is nearly equal to 350 ppbv under the condition of -70°C at 80 hPa. The ozone concentration data were obtained till 5700 minutes.

Ozone concentration is ranged from a few 10s ppbv to several 100s ppbv. It is consistent with the values having been measured so far in the ozone hole.

Vertical axis of aerosol is aerosol count number per about 6 litter volume air. 10^0 count indicate 1 count and zero count together. Then 10^0 count means less than 1 particle per 6 litter.

Data for 'Same' Air Mass

The data for the low levels (L) between 80 hPa and 78 hPa are selected and shown in Figure 2 in order to investigate their variations in the same air mass as far as possible. Ozone concentration changes slowly by several 10s percents in the period. However, drastic change of ozone concentration was observed sometimes. Most drastic change was observed in period-L1, decreasing from 170×10^{16}/m^3 to 100×10^{16}/m^3 in 8 minutes. We are now checking data quality for this kind of rapid changes.

Aerosol concentration was generally small. It shows 0 or 1 particle per 6 litters for most of the time.

In addition, Figure 2 suggests that there is positive correlation between ozone concentration and aerosol amounts. This is well expressed in Figure 3 which shows ozone concentrations plotted against aerosol concentration whose diameter is larger than 0.8 μm. The data are classified into two groups. One is period-L3 and the other is period-L1, -L2, and -L4. Period-L3 is characteristic in low concentrations for both ozone and aerosol.

The aerosol count is plotted against temperature in Figure 4 in order to see types of aerosols. Most of aerosol concentrations are
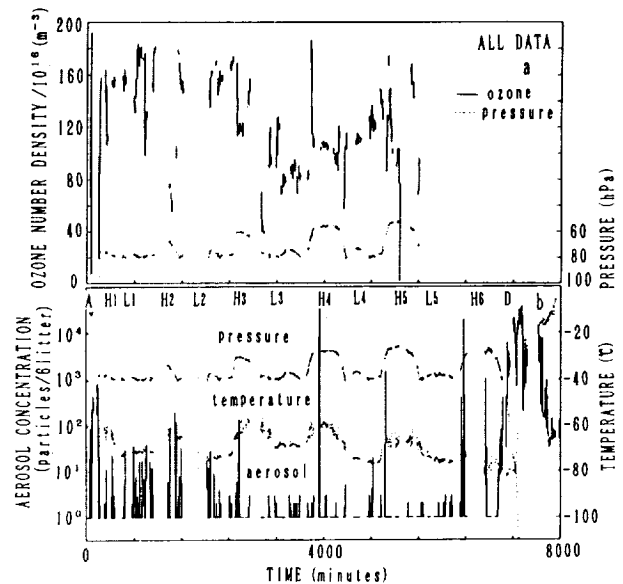

Figure 1. Ozone, pressure, aerosol concentrations (diameter > 0.8 μm), and temperature observed along the track of the balloon.
a: ozone and pressure.
b: aerosol concentration, temperature, and pressure.
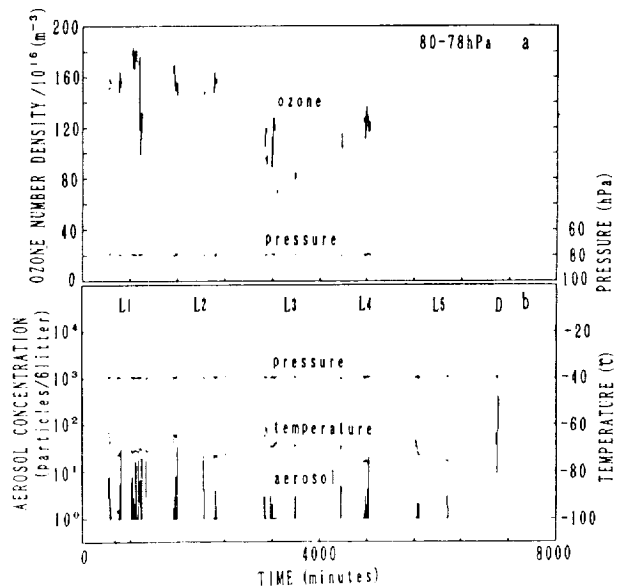Note that the data are preliminary and will be updated.

Figure 2. Same as Fig.1 but for the pressure level from 80 to 78 hPa.

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less than 100 particles/6 litters in period-Ls, and temperature is higher than -78°C. Correlation between aerosol concentration and temperature is not clear. At 80 hPa level, condensation temperature for nitric-acid trihydrate (NAT) and ice is less than -78°C and -85°C, respectively, under the condition of 5 ppbv HNO_3 and 3 ppmv H_2O. Perhaps, during the period-Ls, PSCs did not exist, and the observed aerosols are considered to be sulfate aerosols.

Why low ozone concentrations and low aerosol concentrations were observed simultaneously in period-L3? There are two candidates. One is that the result reflects a presumed vertical profile of aerosol and ozone distributions, i.e., lower ozone and aerosol for the higher altitude of the L3 period. Temperature in period-L3 is about 8 degrees higher than that in other periods. Then the parcel observed during period-L3 is a little higher in potential temperature height by about 15 K, corresponding to 800 m in geopotential height. The other is that low concentrations of ozone and aerosols reflect the history of the air mass, i.e., PSCs activities in the past. PSCs not only release ClOx species which act for ozone destruction in the air mass but also remove preexistent sulfate aerosols from the air mass downward by sedimentation. If the air mass in period-L3 had experienced more active PSCs event in winter than other air masses had, simultaneous low values of both ozone and aerosol concentrations are reasonable results. It is not clear which reason is true.

Data for Descent Period
- PSCs observed at 80°S-

During period-D, aerosol concentration is large and temperature is less than -78°C, and former correlates negatively with latter as shown in Fig. 4. Figure 5 shows three vertical profiles of aerosol concentrations whose diameters are larger than 0.8 μm, 2.0 μm, and 5.0 μm, and temperature for period-D, as shown in JMA objective analyses data and Nimbus 7/TOMS data

(not shown here). The balloon descended around 80°S well inside of the polar vortex in the period. It is shown that active PSCs (type-I and type-II) were observed from 200 hPa to 80 hPa. It is clear that size distributions change with altitude in the stratosphere. In addition, PSCs are seemed to be related with tropospheric clouds. These results are of interest from a view point of the mechanism of stratospheric material transport by PSCs particles, for example, how long PSCs particles live in the troposphere and how far they transport stratospheric materials into the troposphere.

From these preliminary results, it is expected that we can obtain much information about the ozone hole mechanism, stratospheric materials transport, and dynamics of the stratosphere through more detailed analyses. Observational data obtained in the experiment as well as other data such as ozone data at Syowa Station, Nimbus 7/TOMS data, and meteorological
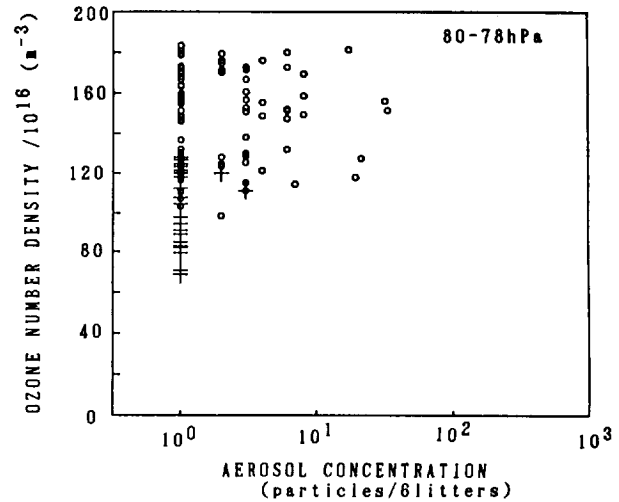
Figure 3. Ozone concentration displayed as a function of aerosol concentrations (diameter > 0.8 μm) for the pressure level from 80 to 78 hPa.
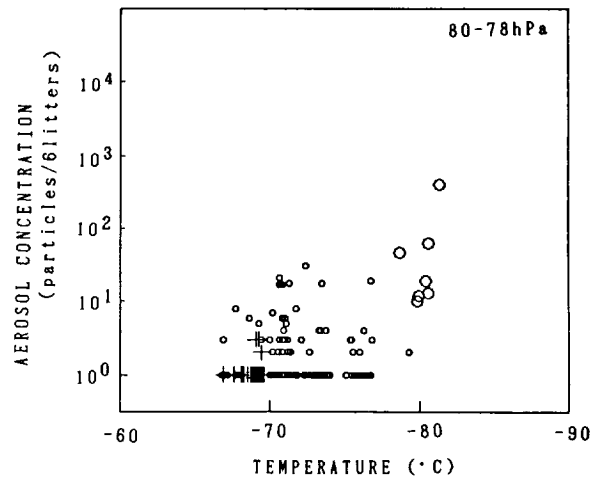+:value for period-L3.
o:value for period-L1,2,4

Figure 4. Aerosol concentrations (diameter > 0.8 μm) displayed as a function of temperature for the pressure level from 80 to 78 hPa. Data whose temperature is affected by solar radiation are omitted.
+:value for period-L3.
o:value for period-L1,2,4,5.
O:value for period-D

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data of JMA objective analysis are now being processed and analyzed.

References

Kanzawa, H. and Kondo, Y.(1991): A plan for observation of the Antarctic ozone hole in 1991 under the Polar Patrol Balloon (PPB) project. Antarctic Record, **35**, No.2, 227-237.
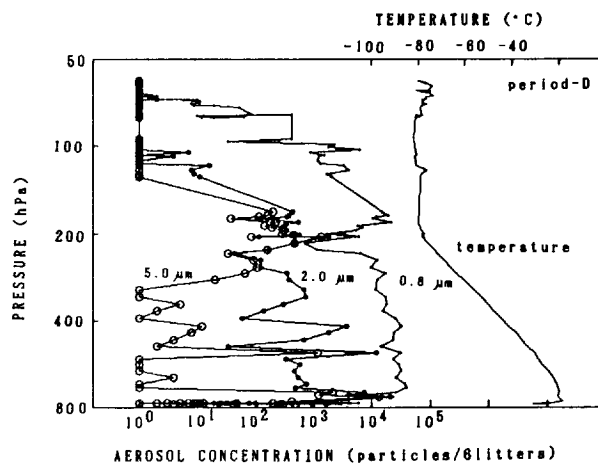
Figure 5. Aerosol concentrations (diameter > 0.8 μm, 2.0 μm, and 5.0 μm) and temperature displayed as a function of pressure during descending of the balloon around 80°S (period-D).