Proc. NIPR Symp. Upper Atmos. Phys., **8**, 60–64, 1995

EXPERIMENTAL RESULTS OF POLAR PATROL BALLOON PROJECT IN ANTARCTICA (EXTENDED ABSTRACT)

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Since 1984, the National Institute of Polar Research and the Institute of Space and Astronautical Science have studied the feasibility of a long-term circumpolar balloon experiment, called the Polar Patrol Balloon (PPB) project. This project aims at establishing a PPB system to bring scientific payloads into the stratosphere over the Antarctic region. Three test flights in 1987 and 1990 at Syowa Station convinced us that the PPB would have a good chance of coming back to the launching area, provided that we utilize the advantage of having no sunset during the summer in Antarctica. Six PPB experiments were planned and carried out in 1990 to 1993 as an Antarctic STEP project. PPB #1 accomplished a complete circumpolar flight over Antarctica. The 2nd flight (#2) was launched on January 5, 1991 to make measurements of auroral X-rays, magnetic and electric fields. The 3rd flight (#3) was carried out on September 23–28, 1991 when the Antarctic ozone hole was well developed, in order to investigate the chemical source and sink of ozone. PPB #4 and #5, with payloads of vector magnetic and electric fields and auroral X-rays, were launched on December 26 and 30, 1992, respectively. PPB #6 aimed at studying the elemental and isotopic composition of galactic cosmic rays, solar energetic particles and cosmic gamma ray bursts, and was launched on January 5, 1993.

The Polar Patrol Balloon (PPB) project is to perform a long duration circum-

polar balloon experiment over Antarctica using a zero pressure balloon with an auto-ballast control (EJIRI *et al.*, 1994). With the advantage of no sunset during the summer in Antarctica, a long duration fight over a few weeks is possible using a zero-pressure balloon (NISHIMURA *et al.*, 1985; NAGATA *et al.*, 1985).

The first PPB (B_{15}: volume of 15000 m^3) test flight (MIYAOKA *et al.*, 1988) was carried out at Syowa Station (69°00′S, 39°35′E), Antarctica on December 18, 1987 to obtain the data of stratospheric radiation environments and to test the PPB systems including an auto-ballast controlling system, a command and telemetry system, etc.

Three test flights were performed to observe stratospheric radiation environments and to check instruments developed for the PPB: two flights in 1987 and one in 1990. All PPBs were equipped with an auto-ballast controlling system and used a zero-pressure balloon. These balloons also had an ARGOS/NOAA positioning/data transfer system, thermometer, barometer, telemetry and command receiver. The first test PPB was launched on December 18, 1987 from Syowa Station (MIYAOKA *et al.*, 1988). The basic functions of the PPB system operated well as expected, though the other was in failure.

The third test PPB (B_{15}) was launched on January 5, 1990 from Syowa Station and drifted westwards (KADOKURA *et al.*, 1991). On January 27 when the PPB reached about seven eighths of the circumpolar circle, the zonal wind almost stopped and then changed direction from easterly to westerly. These experiments convinced us that the PPB could make a complete circumpolar flight. We had completed developing the PPB system with these two test flights.

Two PPB experiments with scientific instruments: a proton magnetometer, a dc electric field double probe and an X-ray detector, were subsequently carried out during the austral summer of 1990 to 1991, as one of the STEP projects in Japanese Antarctic research work. PPB #1, which was launched at 0825 UT on December 25, 1990 reached a height of 30 km and drifted westward as illustrated in Fig. 1. At 2230 UT on June 8, 1991 after about a 14-day flight, the PPB passed longitude 39°35′ about 400 km north of Syowa Station; that is, the PPB accomplished a complete circumpolar flight over Antarctica. This PPB took 38 days for the circumpolar flight.

A proton magnetometer on board PPB #1 measured the total force of the geomagnetic main field with an accuracy of 1 nT. A difference between "measured" and "IGRF-90" is fairly well observed over the geomagnetic south pole area. This is considered to be attributable to the local geomagnetic anomalies originating from the earth's crust (FUJII *et al.*, 1991; TOHYAMA *et al.*, 1993). This kind of geomagnetic field survey by the PPB is particularly useful over Antarctica where field observation is very difficult. Geomagnetic pulsations associated with the magnetospheric disturbance were also observed. The PPB #2 flight was launched on January 5, 1991 with scientific payloads for auroral X-rays, magnetic and electric fields. Though this balloon did not complete a circumpolar trajectory, it also floated for a long period, approximately one month, as illustrated in Fig. 1.

The PPB #3 experiment with B_5 (5000 m^3) to study the Antarctic ozone hole

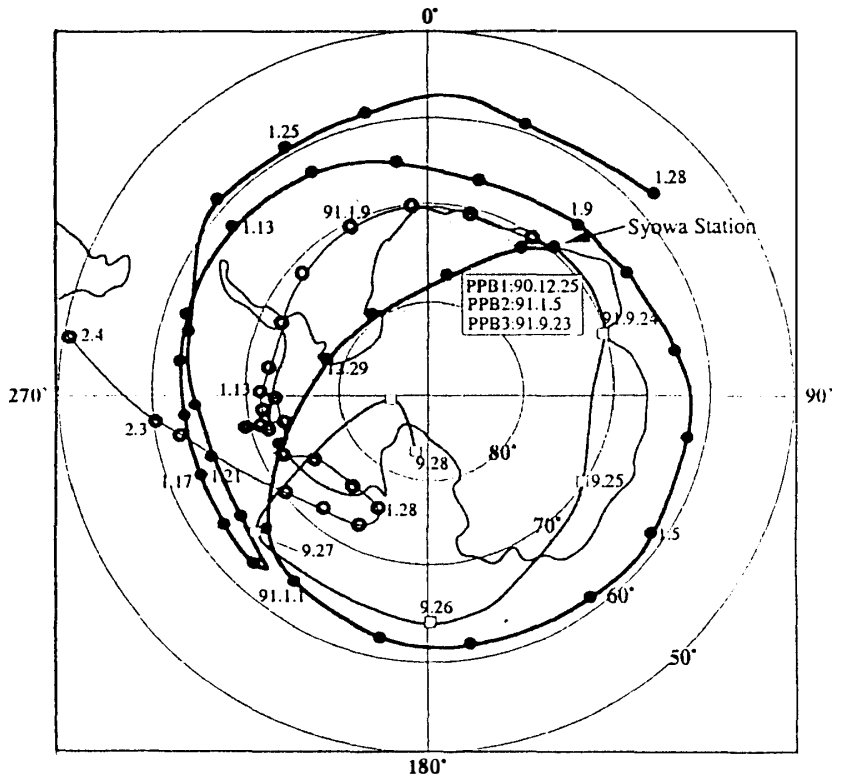

Fig. 1. PPB #1, #2 and #3 trajectories.

which is well developed in the Antarctic late winter and spring seasons was launched at 0755 UT on September 23, 1991 (Fig. 1). The balloon reached the 80 mb level in the lower stratosphere and moved eastward inside the polar vortex for about 5 days, where Nimbus 7/TOMS confirmed the Antarctic ozone hole. Ozone concentration, size distribution of aerosols which include particles of polar stratospheric clouds (PSCs), and temperature were measured along the PPB track. During observations in the same air mass, drastic change of ozone concentration was observed. The other interesting feature is the positive correlation between ozone concentration and sulfate aerosol amount (KANZAWA *et al.*, 1994; HAYASHI *et al.*, 1994).

In the second series of STEP PPB experiments, three flights (PPB #4, #5 and #6) were carried out in 1992 to 1993. PPB #4 and #5 (both B_{40}: 40000 m^3) were launched a few days apart (1324 UT on December 26 and 1433 UT on December 30, 1992), with a tri-axial flux-gate magnetometer, proton magnetometer, 3-axis double probes and X-rays in the region of the auroral zone, the polar cap, the polar cleft/cusp and the geomagnetic south pole. The main data collection system is a multi-ID ARGOS with 41 ID channels and a normal ARGOS with one ID channel. We obtained different patterns of ionospheric convection velocity vectors deduced by the electric field detectors aboard PPB #4, #5 and also #2, over the entire magnetic local time in high latitude. The data are being used to study the dependence on the interplanetary condition and/or location of the balloon.

PPB #6 (B_{60}: 60000 m^3) was launched at 0855 UT on January 5, 1993 to study

cosmic ray protons ($E>100$ MeV), helium and CNO components ($E=100$–500 MeV/n) together with energetic X-rays ($E=30$–120 keV) of auroral, solar and/or cosmic origins. The balloon was drifted westward by 1.5 circumpolar rounds (for 27 days) covering 6–13 g/cm^2 atmospheric depth and 63°S–70°S geographic latitude. From the overall time profile of total counting rates throughout the flight, it is seen that three of the four burst groups occurred in the invariant latitude region from 60°S to 70°S; the last one occurred at lower latitude below 60°S. Examining the spatial distribution of X-ray enhancements in MLT-invariant latitude coordinates, we found that the majority of dots are concentrated between 60°S and 70°S invariant latitude. It is concluded from these data that pronounced auroral X-ray enhancements have been widely observed over the south polar region with several characteristics: (1) eighty-three percent of auroral X-ray enhancements appeared in 60°–70° invariant latitude and 78 percent in 06–18 MLT, and (2) distinct enhancements are predominant in the magnetic local dayside.

Acknowledgments

We would like to express our special thanks to the late Emeritus Prof. T. NAGATA for his great contribution to promoting and supporting this PPB project. The project has been planned and conducted under the PPB Working Group as collaborative research of the NIPR and ISAS, whose members are gratefully acknowledged. Thanks are also due to the Japanese Antarctic Research Expedition (JARE) members who carried out the laborious field operations of the balloon launchings at Syowa Station.

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(Received December 9, 1994; Revised manuscript received December 12, 1994)