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MAP OBSERVATIONS AT SYOWA STATION IN 1985

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Abstract: The coordinated observations of the Antarctic middle atmosphere were conducted by the wintering parties of the 23rd–26th Japanese Antarctic Research Expeditions at Syowa Station (69.0°S, 36.6°E) during 1982–1985 in cooperation with the Middle Atmosphere Program (MAP). The wintering party of JARE-26 carried out the final campaign for the MAP at Syowa Station. The middle atmosphere was observed with a combination of remote-sensing techniques from the ground and spacecraft and *in-situ* measurements on balloons and sounding rockets. The major ground-based remote-sensing facilities were a Dobson spectrophotometer for ozone measurement, a ruby lidar for stratospheric aerosol measurement and a dye lidar for sodium layer measurement, a VHF doppler radar for measuring motions of ionized and neutral atmospheres and a multi-beam riometer for monitoring particle precipitation. The meteorological rockets launched at 2-hour intervals succeeded in detecting internal gravity waves at the 20–70 km altitude range. This paper gives an outline of the MAP campaign in 1985.

1. Introduction

The Middle Atmosphere Program (MAP) is an international cooperative program conducted during 1982–1985. Its major objective is to obtain a comprehensive understanding of the middle atmosphere which is defined from the tropopause to the lower thermosphere (approximately 10–120 km). This altitude region has been the least explored and understood part of the earth's atmosphere due to lack of available techniques for its exploration. Recent remote-sensing and *in-situ* measurement techniques, however, have enabled us to observe the structures of the middle atmosphere and the dynamical and photochemical processes with a high time resolution.

The coordinated observations of the middle atmosphere in Antarctica were planned by the National Institute of Polar Research as one of the major national projects for the MAP. The observations were carried out at Syowa Station over the MAP interval by the wintering parties of the 23rd–26th Japanese Antarctic Research Expeditions (JARE-23–26). The geographic latitude and longitude of Syowa Station are 69.0°S and 39.6°E, respectively, while the magnetic latitude and longitude and L value are $-66.1°$, 70.7° and 6.1, respectively. In January 1982 the party of JARE-23 constructed a VHF doppler radar which had spectrum and meteor modes for measurements of motions of the ionized atmosphere and the neutral atmosphere, respectively (IGARASHI *et al.*, 1985). The Dobson spectrophotometer was improved to measure the total ozone content throughout the year using ozone absorption lines in solar and lunar radiations (CHUBACHI, 1984). The balloon experiments were carried out for measurements of ozone, auroral X-ray and electric field. In January 1983 the party of JARE-24 set up two kinds of ground-based remote-sensing facilities; a ruby lidar for stratospheric aerosol measurement (IWASAKA, 1985) and an infrared spectrometer for measuring trace gases such as N_2O, CH_4, $CFCl_3$, CF_2Cl_2, and HNO_3 (MAKINO *et al.*, 1985). Aerosols were also observed by balloons. The height distribution and total column content of NO_2 were observed by balloon-born and ground-based spectrometers.

In January 1984 the party of JARE-25 constructed a new radar tracking and telemetry system for rocket experiment. Three S-310JA type rockets were launched into auroras for simultaneous observations of auroral particles and related phenomena (NAGATA *et al.*, 1985). The EXOS-C satellite was launched in February 1985 for the MAP. The real-time telemetry data from the satellite have been received on a routine basis at Syowa Station since the launching.

The wintering party of JARE-26 carried out the closing campaign of the Antarctic Middle Atmosphere Program. The ground-based, balloon, rocket, and satellite observations were carried out at Syowa Station on an extensive scale using both new facilities constructed in January 1985 by the party of JARE-26 and those operated over 1982–1984 by the parties of JARE-23–25. This paper gives an outline of the 1985 campaign.

2. Scientific Aim of the 1985 Campaign and Facilities

The scientific aim of the MAP campaign carried out at Syowa Station in 1985 is to study the dynamics of the Antarctic middle atmosphere and the associated variations of aerosols and minor constituents, and to clarify the effect of auroral particles on the middle atmosphere. The major objectives and the facilities are as follows.

2.1. Internal gravity waves in the Antarctic middle atmosphere

It is becoming clear that internal atmospheric gravity waves play an essential role on the formation of the general circulation of the middle atmosphere. It has been suggested theoretically by MATSUNO (1982) that the momentum in the lower stratosphere is transported upward by gravity waves. Traveling ionospheric disturbances (TIDs) are also caused by the passage of internal gravity waves generated by the Joule heating due to the auroral electrojet. Therefore, the measurement of gravity waves is crucial for understanding the dynamics of the polar middle atmosphere. The behavior of gravity waves has been detected by the four different techniques. The meteorological rockets, which were launched successively at 2-hour intervals, detected wave-like variations in wind vector and temperature in the altitude range of 20–70 km. The ruby lidar measured wave-like variations in aerosol content in the 10–30 km altitude range. The dye lidar measured wave-like motions of the sodium layer in the 80–100 km altitude range. TIDs were identified from the total electron density data which were deduced from the phase differences between 136- and 400-MHz telemetry signals transmitted from the NNSS satellites.

2.2. *Dynamics of the lower thermosphere*

The Joule heating caused by the auroral electrojet and the auroral particle heating are important energy sources for thermospheric winds in the polar region (FULLER-ROWELL and REES, 1981; REES *et al.*, 1985). The thermospheric winds are also driven by the electric field generated by an interaction between the solar wind and the magnetosphere. The motions of the ionized and neutral atmospheres in the 80–120 km altitude range were monitored by the VHF doppler radar with two operation modes; spectrum and meteor modes. The thermospheric winds were also measured by a dye lidar by monitoring the sodium layer in the 80–100 km altitude range.

2.3. *Winter enhancement of the stratospheric aerosol layer*

It is well known that stratospheric aerosols are supplied by volcanic ejection events and then they are transported toward high latitudes by a general circulation of the atmosphere. However, satellite measurements showed that an extremely highly concentrated particle layer is formed in the winter polar stratosphere (MCCORMICK *et al.*, 1985). The ruby lidar measurements of stratospheric aerosols conducted at Syowa Station in 1983 revealed that the aerosol content is enhanced greatly in winter when the stratospheric temperature falls down to $-80°C$ (IWASAKA *et al.*, 1985). Unfortunately the ruby lidar did not work in the period of 2–30 August 1983 due to a system trouble, and the operation was suspended in 1984. Therefore the lidar measurement in 1985 aimed at monitoring the aerosol layer through the winter, and to clarify the relationship between the winter enhancement of the aerosol content and the descent of the stratospheric temperature. The particle size of aerosols was detected by aerosol sondes which were launched during the lidar operation.

2.4. *Ozone depletion*

The total ozone measurement at Halley Bay (77.6°S, 26.7°W) demonstrated that the column density of ozone in the southern polar region has been decreasing greatly since 1977 (FARMAN *et al.*, 1985). This tendency is also clear in the column density of ozone measured at Syowa Station in the recent years (CHUBACHI and KAJIWARA, 1986). The accelerated rate of decline in total ozone content might be due to an enhanced radiation heating from a concurrent increase in stratospheric aerosol loading caused by major volcanic eruptions such as of St. Helens in May 1980 and El Chichon in March and April 1982. Since there was no great eruption after April 1982, the measurement of total ozone content in 1985 is quite important to examine whether or not the observed decrease in ozone content is due to an effect of volcanic eruptions. The column density of ozone was measured by the Dobson spectrophotometer throughout the year using ozone absorption lines under solar radiation in summer and those in lunar radiation in winter (CHUBACHI, 1984).

2.5. *Auroral particle precipitation processes*

In the polar region the Joule heating due to the auroral electrojet and the heating due to precipitating particles are major energy sources of the lower thermosphere. In addition precipitating high energy particles and auroral X-rays cause appreciable changes in composition of minor constituents in the middle atmosphere. Therefore the observations of auroral particle precipitation processes are important to understand the effect of auroral energies on the polar middle atmosphere. The regions of high energy electron precipitation were monitored throughout the year by a multi-beam riometer system constructed at Syowa Station in January 1985. The wave-particle interaction processes for high energy electron precipitation were studied by simultaneous measurements of auroral X-rays and VLF waves on balloons. The wave-particle interaction processes in auroras were studied with two sounding rockets launched into auroral arcs. The activities of auroras were monitored by a meridian-scanning photometer, an all-sky camera and an all-sky TV camera.

3. Summary of the 1985 Campaign

The coordinated observations of the polar middle atmosphere carried out at Syowa Station in 1985 are summarized in Table 1. The principle investigator of each observation is listed in Table 2. The facilities used for these observations and the altitude ranges explored by the remote-sensing techniques and *in-situ* measurements are schematically illustrated in Fig. 1.

Table 1. Facilities used for the coordinated observations of the Antarctic middle atmosphere carried out at Syowa Station in 1985.

Observation items	Ground	Balloon, sonde	Rocket	Spacecraft
Composition				
Total ozone	Dobson spectro-photometer			NOAA-9
Ozone vertical profile				EXOS-C
Aerosol	Lidar (ruby laser)	Aerosol sonde		EXOS-C
Minor constituents				EXOS-C
Electron density	Ionosonde		S-310JA-11, 12	NNSS, EXOS-C
Sodium layer	Lidar (dye laser)			
Motion				
Ionized atmosphere	VHF doppler radar (spectral mode)			
Neutral atmosphere	VHF doppler radar (meteor mode) lidar (ruby laser)	Rawin sonde	MT-135JA-1-11	
Radiation				
Solar radiation	Solar radiometer			
Atmospheric radiation	Sun photometer		NOAA-9	
Auroral energy				
Auroral motion	All-sky camera All-sky CCD camera			
Auroral intensity	Photometer			
Precipitating particle	Multi-beam riometer	Balloon (auroral X-ray)	S-310JA-11, 12	EXOS-C, NOAA-9
Auroral electrojet	Magnetometer		S-310JA-11, 12	
Electric field	VHF doppler radar		S-310JA-11, 12	
Electromagnetic wave	ELF, VLF, HF receivers	Balloon (VLF receiver)	S-310JA-11, 12	EXOS-C ISIS-2

Table 2. Principal investigators of the MAP campaign at Syowa Station in 1985.

	Facilities	Principal investigators
Groun-based observation	Dobson spectrophotometer	S. MESHIDA (Meteorol. Agency)
	Ruby lidar	Y. IWASAKA (Nagoya Univ.)
	Dye lidar	A. NOMURA (Shinshu Univ.)
	VHF doppler radar	T. OGAWA (Radio Res. Lab.)
	Multi-beam riometer	H. YAMAGISHI (NIPR)
Balloon experiment	Aerosol sonde	T. MORITA (Nagoya Univ.)
	X-ray–VLF balloon	H. YAMAGISHI (NIPR)
Rocket experiment	MT-135JA rocket	H. KANZAWA (NIPR)
	S-310JA rocket	H. YAMAGISHI (NIPR)
		H. FUKUNISHI (Tohoku Univ.)
Satellite data acquisition	EXOS-C	T. ITO (ISAS)
	NOAA-9	S. KAWAGUCHI (NIPR)
	ISIS-2	N. MATUURA (Radio Res. Lab.)
	NNSS	T. OGAWA (Radio Res. Lab.)

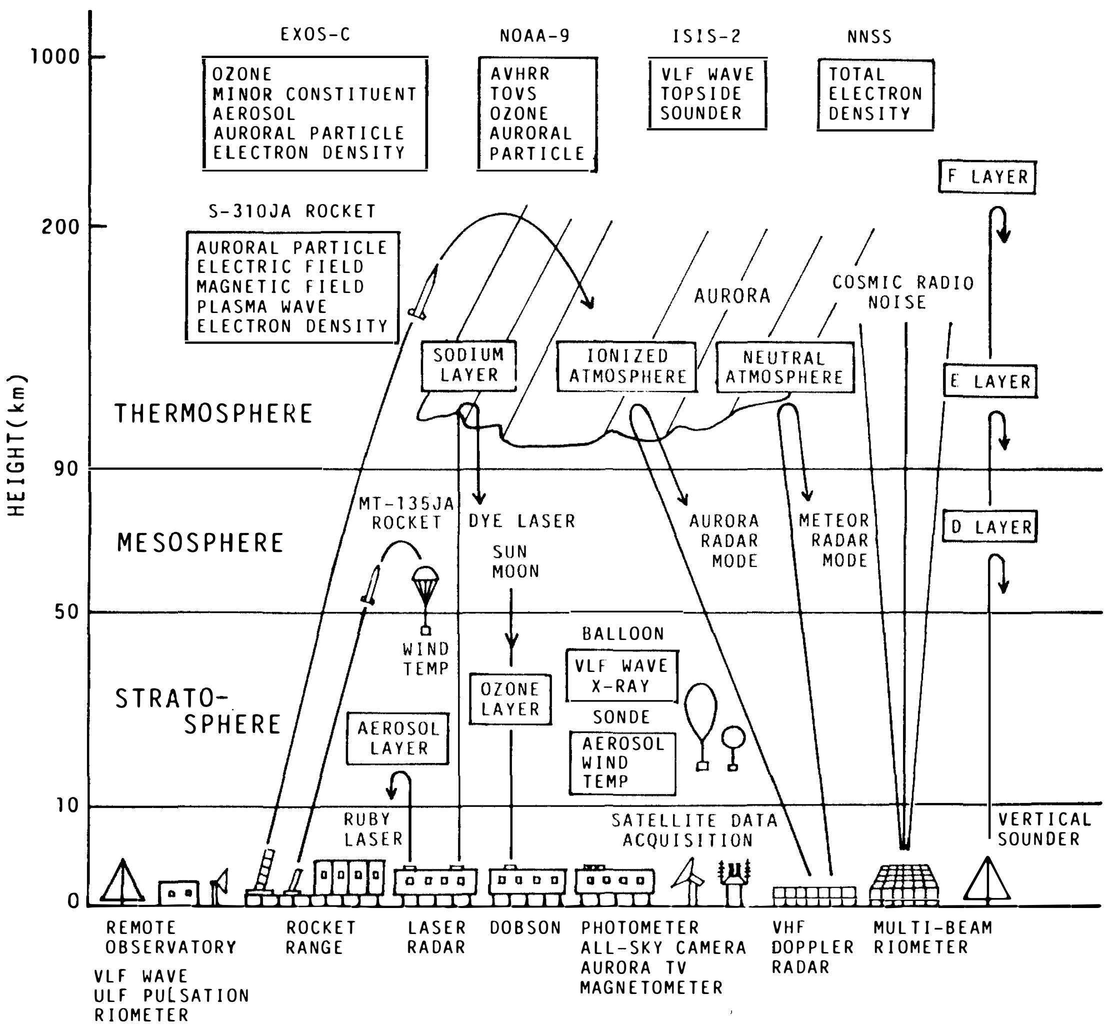

Fig. 1. Schematic diagram illustrating MAP observations at Syowa Station in 1985.

3.1. Ground-based observation

3.1.1. Ozone measurement

Total ozone was observed throughout the year by a Dobson spectrophotometer on a routine basis. The observations in winter were conducted using an extinction of lunar radiation. The column density of ozone, which has been decreasing greatly since 1977 at Syowa Station, showed a further decrease in 1985. A particularly large decrease occurred in October and November months. SEKIGUCHI (1986) demonstrated a clear relationship between monthly mean values of ozone and stratospheric temperature over the 1966–1985 interval. This relationship suggests that the ozone depletion in the spring season is governed by dynamical processes rather than chemical processes.

Table 3. Operation of the ruby lidar for observation of stratospheric aerosols at Syowa Station in 1985.

Month	Number of operation day	Number of shot
2	3 days	400
3	12	2500
4	10	1600
5	9	2800
6	16	6500
7	9	3600
8	16	6800
9	9	2800
10	8	3300
Total	92	30300

Table 4. Characteristics of the lidar system installed at Syowa Station.

Items	Ruby lidar	Dye lidar
Transmitter system		
Wavelength	694.3 nm	589.0 nm
	347.1 nm	
Energy	0.8 J/pulse	0.2 J/pulse
	0.3 〃	
Linewidth		0.003 nm
Pulse width	36 ns	500 ns
Repetition rate	0.5 Hz	0.5 Hz
Divergence	1.0 mrad	1.0 mrad
Receiver system		
Telescope diameter	0.5 m	
Telescope area	0.17 m^2	
Field of view	0.5–1.5 mrad	
Bandwidth	1.0 nm (694.3 nm)	
	2.5 nm (347.1 nm)	
	1.0 nm (589.0 nm)	
Photon counter	2 channel	
Analog output	1 channel	
Height resolution	0.1–10 km (P.C. mode)	
	7.5–750 m (A-mode)	

3.1.2. Lidar measurement

A ruby lidar for stratospheric aerosol measurement was operated on 92 days from February to October in 1985, as shown in Table 3. The characteristics of the system are given in Table 4 (NOMURA *et al.*, 1985). The winter enhancements of stratospheric aerosols discovered by IWASAKA *et al.* (1985) were observed again in 1985. As is shown in Fig. 2, the enhancements started in June when the stratospheric tem perature fell down to about −80°C.

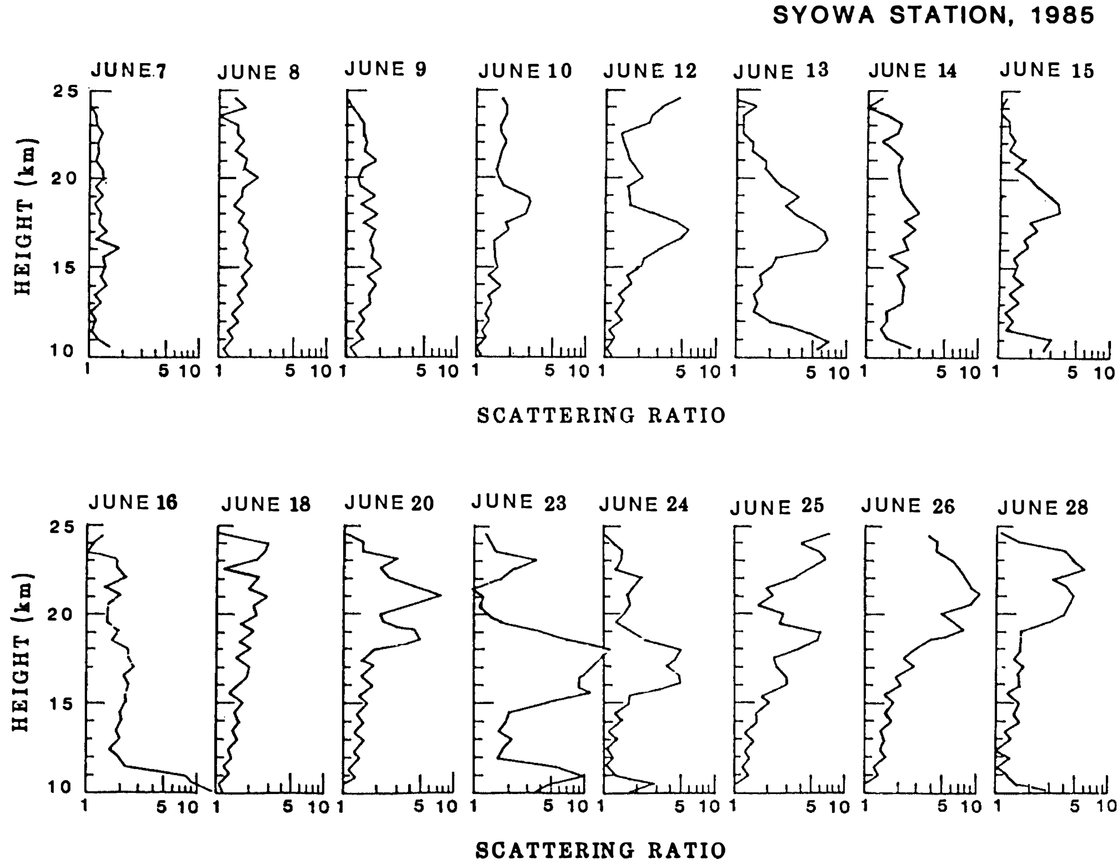

Fig. 2. Example of winter enhancements of stratospheric aerosols observed by the ruby lidar at Syowa Station in June 1985.

Table 5. Operation of the dye lidar for observation of the sodium layer at Syowa Station in 1985.

Month	Number of operation day	Total time	Number of shot
3	5 days	21 h 36 min	6900
4	8	66 43	21400
5	8	71 17	24400
6	3	27 13	8700
7	7	73 43	25300
8	9	90 12	33000
9	4	20 53	8000
10	4	11 10	4000
Total	48 days	382 h 53 min	131900

The dye lidar was installed at Syowa Station in January 1985 for monitoring the sodium layer. The characteristics of the system are given in Table 4. The dye lidar was operated on 48 days from March to October in 1985, as shown in Table 5. The wave-like density variations with periods of several hours and downward phase shifts were often observed in the sodium layer (NOMURA *et al.*, 1986). The observations suggest that these density variations are caused by upward propagating internal gravity waves. It is also observed that the height profiles of the sodium density change in a close relation with auroral activity (NOMURA *et al.*, 1987). It is likely that these changes are due to enhanced thermospheric winds during magnetospheric substorms.

3.1.3. VHF doppler radar measurement

The VHF doppler radar system installed at Syowa Station in 1982 transmits 50- and 112-MHz pulsed radio waves with peak power of 15 kW. The system has two beams directed towards magnetic south (GMS beam) and 32.8° west from the magnetic south (GGS beam) (IGARASHI *et al.*, 1985). The wind vector can be estimated by combining the doppler shifts measured by the two beams. The VHF doppler radar has the spectrum and meteor modes which give information on the doppler motions of the ionized and neutral atmospheres, respectively. As shown in Fig. 3, the spectrum-mode operation was conducted mainly in April, July and September in coordination with the auroral conjugate campaigns in Iceland. The meteor-mode operation was conducted over the remaining period.

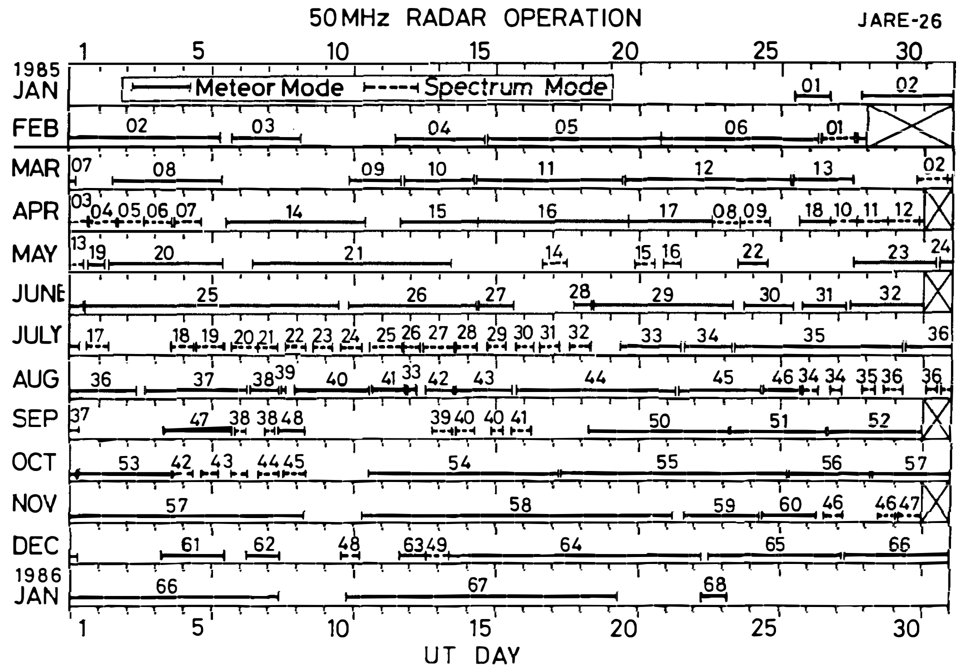

Fig. 3. Operation diagram of the VHF doppler radar at Syowa Station in the period from January 1985 to January 1986 (after OGAWA, 1986a).

3.1.4. Monitoring of auroral energies

The precipitation of high energy particles was monitored by a multi-beam riometer system which was constructed at Syowa Station in January 1985. As shown in Fig. 4, the system has four beams directed to zenith, 30° southward, 30° northward, and

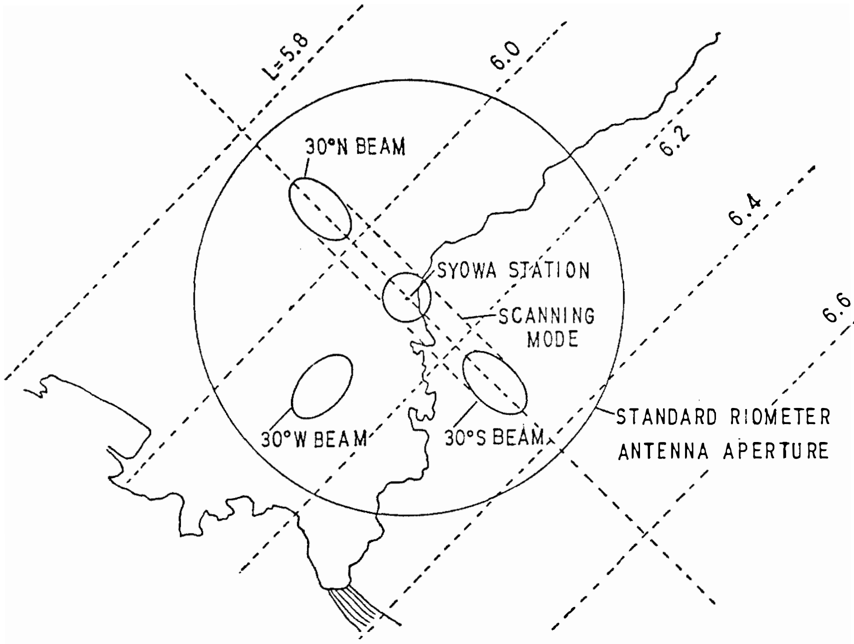

Fig. 4. Schematic diagram showing field of view of the four beams and a scanning mode of the multi-beam riometer system.

30° eastward in the magnetic coordinates (YAMAGISHI *et al.*, 1987). The field of view of each beam is 15°. The system also has a scanning mode between 30°S and 30°N along the magnetic meridian. The system has been operated continuously since February 1985. The data give useful information on the location and motion of the precipitation regions.

The auroral activities were monitored by a standard all-sky camera, meridian-scanning photometers (Hβ, 557.7 nm), three-direction photometers (427.8 nm), and all-sky monochromatic CCD cameras (630.0 nm, 557.7 nm).

3.2. *Balloon experiment*

3.2.1. Aerosol sonde experiment

Four aerosol sondes were launched from Syowa Station to measure the height profiles of both Aitken-size (<0.1 μm) aerosols and large-size (>0.3 μm) aerosols. The time and date of the launch are given in Table 6. The ruby lidar was operated during the aerosol sonde experiment for comparing the remote-sensing data with *in-situ* measurement data.

Table 6. Summary of the aerosol sonde experiment at Syowa Station in 1985.

Sonde name	Launching time(UT), date	Observation time	Ceiling height	Total weight	Particle size
Aerosol-1	1954 July 21	114 min	9 km	8.0 kg	Aitken size (r<0.1 μm)
〃 -2	1939 Oct. 3	121	25	8.0	〃
〃 -3	1709 July 21	117	23	11.5	large size (r>0.3 μm)
〃 -4	0057 Oct. 8	83	25	11.5	〃

3.2.2. Balloon experiment for auroral X-ray and VLF wave

Five balloons were launched from Syowa Station to study wave-particle interaction processes between high energy electrons and whistler mode waves in the VLF range. The time and date of the launch are given in Table 7. The volumes of B-5 and B-15 type balloons are 5000 and 14000 m^3, respectively. Each of the B15-1, -2 and -3 balloons has a VLF wide-band receiver and three X-ray detectors for reproducing auroral X-ray imaging. Each of the B5-27 and B5-28 balloons has a VLF wide-band receiver and a X-ray detector. It is found that there is a good correspondence between the precipitation regions of high energy electrons deduced from the balloon-borne X-ray detectors and those obtained from the multi-beam riometer data (SUZUKI *et al.*, 1987).

Table 7. Summary of the B5 and B15 balloon experiment at Syowa Station in 1985.

Balloon name	Launching time(UT), date	Observation time	Ceiling height	Total weight	Payload weight
B15-1	2017 Feb. 27	10 h 13 m	34 km	93.0 kg	28.0 kg
B5-27	0557 Nov. 29	09 04	24	59.5	19.5
B5-28	0550 Nov. 30	36 04	31	62.5	19.5
B15-2	0651 Dec. 3	14 11	34	98.2	30.2
B15-3	2109 Dec. 13	14 07	34	95.4	29.4

3.3. Rocket experiment

3.3.1. Meteorological rocket experiment

The MT-135JA type meteorological rocket was developed for the Antarctic middle atmosphere study in 1984 by the staff of the Institute of Space and Astronautical Science. When the rocket reaches the apogee altitude of 70 km, a rocketsonde is detached. Then it measures the height profiles of temperature. The wind vectors are obtained from the radar tracking of the rocketsonde. Height resolution of temperature and wind vector measurements is less than 0.5 km. After the test flights of the MT-135JA-1 and -2 on January 30 and March 26, 1985, five meteorological rockets were launched successively at 2-hour intervals on June 28, 1985 to detect gravity

Table 8. Summary of the MT-135JA rocket experiment at Syowa Station in 1985.

Rocket name	Launching time(UT), date	Apogee height	Observation time
MT-135JA-1	1400 Jan. 30	—	118 min
〃 -2	1335 Mar. 26	60.9 km	59
〃 -3	1335 June 28	69.9	39
〃 -5	1616 〃	71.2	40
〃 -6	1810 〃	73.4	36
〃 -7	2002 〃	68.8	37
〃 -4	2158 〃	68.7	40
〃 -9	1400 Sep. 25	71.2	43
〃 -8	1600 〃	71.4	37
〃 -11	1800 〃	71.2	47
〃 -10	2000 〃	73.0	42

waves with periods of several hours in the winter season (Table 8). Four rockets were launched again successively at 2-hour intervals on September 25, 1985 to study the gravity waves in the spring season (Table 8). The summary of the meteorological rocket experiment is presented by KANZAWA *et al.* (1986). The rocketsonde data obtained from both experiments showed clearly the existence of gravity waves with increasing amplitude with altitude (KANZAWA and KAWAGUCHI, 1986).

Table 9. Summary of the S-310JA rocket experiment at Syowa Station in 1985.

Rocket name	Launching time(UT), date	Apogee height	Condition
S-310JA-11	005953 May 29	211.7 km	Quiet arcs
S-310JA-12	193539 July 12	222.6	Active arcs

Table 10. Characteristics of scientific payloads on board the S-310JA-11 and -12 rockets.

Instrument	Ranges covered by the instrument
Auroral electron	
Quadraspherical energy spectrum analyzer	32 step spectrum: 50 eV–15 keV/0.64 s
	Slow fluctuations: 0.5, 2, 8 keV
	1–100 Hz
	Fast fluctuations: 320 Hz–10 kHz
	100 kHz–4 MHz
Faraday cup	Integrated flux: <90 eV
Plasma wave	
VLF receiver	E: 200 Hz–10 kHz (wide band)
	E, B: 500 Hz–13.5 kHz/0.32 s
Faraday cup	Ne: 5–300 Hz
	200 Hz–10 kHz (wide band)
HF receiver	E: 100 kHz–16 MHz/0.5 s
Plasma	
Impedance probe	Ne: $2\times10^3-5\times10^6$/cc/0.5 s
Faraday cup	Ne: $<10^6$/cc
E, B fields	
Fluxgate magnetometer	B: 100 vector samples/s
	resolution 2 nT
Double probes	E: 1 sample/2 s
	DC–200 Hz

3.3.2. Aurora rocket experiment

The S-310JA-11 and -12 rockets were launched on May 29 and July 12, 1985, respectively (Table 9). The S-310JA-11 rocket traversed across two quiet stable arcs (4 and 2.5 kR for 557.7 nm), while the S-310JA-12 rocket penetrated into bright active arcs (14 kR for 557.7 nm) during the breakup phase. The scientific aim of these experiments was to study wave-particle interaction processes on auroral field lines (YAMAGISHI and FUKUNISHI, 1985). As shown in Table 10, the rocket-borne instruments enable us to compare plasma waves in the frequency range of 5 Hz–16 MHz with fluctuations of particle flux in the corresponding frequency ranges. The wave-particle interaction processes obtained from these rocket observations are being analyzed. The results will be published in the near future.

3.4. Satellite data acquisition

The Ohzora (EXOS-C) satellite data were received at Syowa Station on a routine basis. The data of 369 orbits were received at Syowa Station in the period from February 1985 to January 1986 (Table 11). The major objectives of EXOS-C satellite are, 1) remote sensing of aerosol, ozone and other minor constituents in the middle atmosphere, and 2) *in-situ* measurements of plasmas and waves. The inclination of the orbit is 74.6° and the apogee and perigee heights are 875 and 350 km, respectively.

Table 11. Summary of the satellite data acquisition at Syowa Station in the period from February 1985 to January 1986. Each column gives orbit numbers received at Syowa Station.

	EXOS-C	ISIS-2	NOAA-9
February 1985	27	14	28
March	33	10	33
April	44	9	32
May	31	8	35
June	4	7	29
July	—	7	27
August	—	—	29
September	55	—	27
October	51	—	56
November	—	—	27
December	39	—	30
January 1986	85	—	30
Total	369	55	383

The telemetry signals from the NNSS satellites were received at Syowa Station on a routine basis for monitoring total electron density over the southern polar region. The NNSS satellite system consists of six polar orbiting satellites with the altitude of 1000–1200 km (NNSS satellite number; 11, 13, 20, 30, 48, 50). The total electron densities were deduced from the phase difference between 149.988 and 399.968 MHz signals transmitted from the satellites. The data received at Syowa Station in the period from March 1985 to January 1986 cover about 12000 orbits. About 36 orbits' data were received everyday. These orbits almost cover the entire polar region, as shown in Fig. 5. Therefore the electron density distributions in the auroral oval and polar cap regions were well monitored. TIDs were also detected frequently from these data (OGAWA *et al.*, 1987).

The AVHRR, TOVS and SEM data of the NOAA-9 satellite and the VLF and topside sounder of the ISIS-2 satellite were also received at Syowa Station. The data received at Syowa Station cover 383 orbits of NOAA-9 and 55 orbits of ISIS-2, respectively (Table 11).

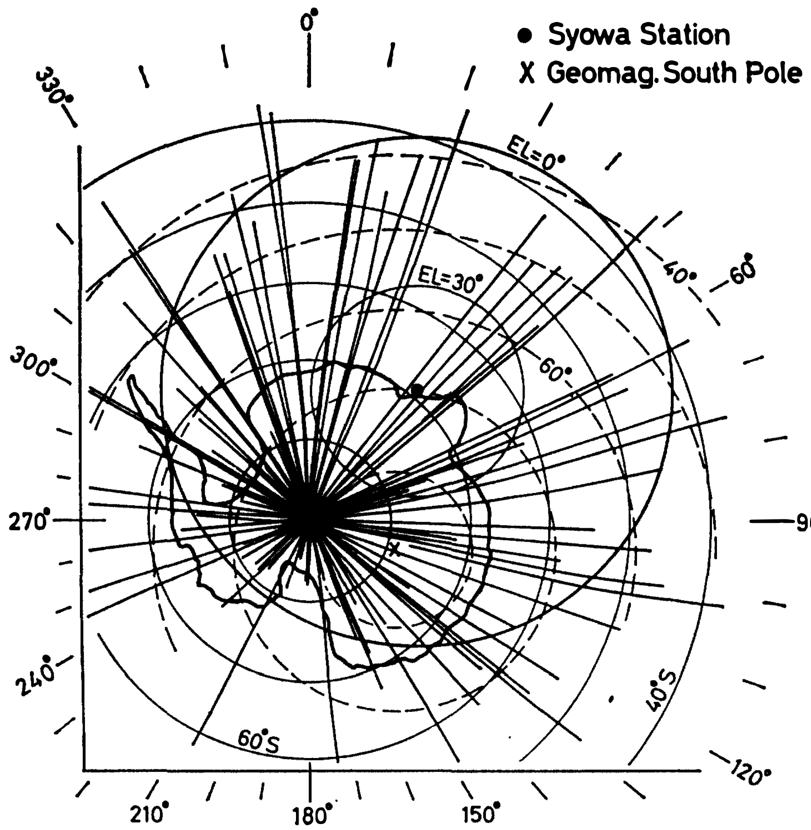

Fig. 5. Coverage of 49 orbits of the NNSS satellites received at Syowa Station on September 9, 1985 (after OGAWA, 1986b).

4. Conclusion

The ground-based remote-sensing facilities were successfully operated by the wintering party of JARE-26 at Syowa Station in 1985 composed of a Dobson spectrophotometer, ruby and dye lidars, a VHF doppler radar, a multi-beam riometer, and an aurora monitoring system. Balloon and rocket experiments and satellite data acquisition were also carried out successfully according to an original plan. This is the first time that we have obtained comprehensive information on the Antarctic middle atmosphere. At present large quantity of data taken at Syowa Station in 1985 are being analyzed by many collaborators. Several preliminary results have been reported and published. However, results of detailed analyses will be published in the near future. Major objectives of these studies are internal gravity waves, stratospheric aerosols, ozone depletion, density variations in the sodium layer, neutral winds in the lower thermosphere, high energy particle precipitation, and wave-particle interaction processes in auroras.

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