

UPPER ATMOSPHERE PHYSICS DATA OBTAINED AT SYOWA STATION IN 2006

Michinari YAMAMOTO¹, Mitsunori OZAKI², Hisao YAMAGISHI³, Makoto TAGUCHI³
and Akira KADOKURA³

¹*Ayabe Astronomical Observatory, Ayabe, Kyoto 623-0005*

²*Kanazawa University, Kanazawa, Ishikawa 920-1192*

³*National Institute of Polar Research,
Research Organization of Information and Systems, Itabashi-ku, Tokyo 173-8515*

1. Introduction

This data book summarizes upper atmosphere physics data acquired by the 47th Japanese Antarctic Research Expedition (JARE-47) with the "Upper Atmosphere Physics Monitoring (UAPM) System" at Syowa Station in 2006. Observation items are as follows:

- 1) Geomagnetism :
 - H-, D- and Z-components of magnetic variations
 - H-, D- and Z-components of magnetic pulsations
 - Absolute observation of geomagnetic field (once per month)
- 2) ELF-VLF wave :
 - Intensities at 0.35, 0.75, 1.2, 2, 4, 8, 30, 60 and 95 kHz
 - Wide-band (0–10 kHz) signal of ELF-VLF emissions
- 3) Ionosphere :
 - Cosmic noise absorption at 30 MHz observed with a broad-beam riometer
- 4) Aurora :
 - All-sky imagers :
 - CCD type : Monochromatic images recorded in a digital format at the following three wavelengths: 557.7 nm (OI), 630.0 nm (OI), 427.8 nm (N₂⁺1NG)
 - Video type : Panchromatic video signal recorded by DVD recorder
 - Scanning photometers :
 - Meridian-scanning record at the following seven wavelengths
 - 427.8 nm (N₂⁺1NG), 485.2 nm (H_β), 487.4 nm (BG of H_β),
 - 557.7 nm (OI), 630.0 nm (OI), 777.4 nm (OI), and 844.6 nm (OI)

An outline of the observation system is given in Section 2. Section 3 describes specifications of the observation instruments and the data acquisition systems. Observation periods are also listed in Section 3. Format of the compiled digital data is shown in Section 4. Magnetograms in the period of January 1–December 31, 2006 are given in the Appendix.

All-sky imager observation data, magnetograms, summary plots and digital data of the monitoring data are available to users on the following Web site, or on request. The request should be addressed to:

Space and Upper Atmospheric Science Group
via World Data Center for Aurora
National Institute of Polar Research
9-10, Kaga 1-chome, Itabashi-ku,
Tokyo 173-8515, Japan.
E-mail: aurora@nipr.ac.jp
<http://polaris.nipr.ac.jp/~aurora/>

2. Upper Atmosphere Physics Monitoring (UAPM) System

A real-time digital data acquisition system for the upper atmosphere physics observation was constructed at Syowa Station in January 1981 (Sato *et al.*, 1984). Data obtained from the system have been collected and published annually in the JARE Data Reports (Upper Atmosphere Physics) (Sato *et al.*, 1984, 1991; Fujii *et al.*, 1985, 1994; Sakurai *et al.*, 1985; Ono *et al.*, 1986, 1993; Yamagishi *et al.*, 1987; Kikuchi *et al.*, 1988; Miyaoka *et al.*, 1990; Kadokura *et al.*, 1992, 2006; Yamazaki *et al.*, 1995; Tonegawa *et al.*, 1996; Obara *et al.*, 1996; Arisawa *et al.*, 1997; Kawana *et al.*, 1998; Takeuchi *et al.*, 1999; Okano *et al.*, 2000; Maegawa *et al.*, 2000; Kato *et al.*, 2001; Taguchi *et al.*, 2003; Yamada *et al.*, 2006; Matsuzawa *et al.*, 2006; Yukimatu *et al.*, 2008). This report is the 26th of this series.

A block diagram of the system, including other ground observations, is shown in Fig. 1. The sensors for measuring weak natural electromagnetic waves such as ELF-VLF emissions, the three components of ULF magnetic pulsations and cosmic radio noise absorption (CNA) have been placed at a remote station on West Ongul Island, located about 5 km from Syowa Station in order to avoid man-made electromagnetic interference. Data of the magnetic pulsations and CNA are transmitted continuously to Syowa Station by a PCM telemeter in VHF band. Wide-band signals of ELF-VLF emissions are transmitted to Syowa Station through an FM telemeter in UHF band.

At the remote station, the electric power which drives all the instruments has been supplied by a solar battery system with maximum output power of 530 W since February 1985. An additional solar battery system with maximum power of 365 W was installed in January 1987 to reinforce the original battery system. The solar battery system consists of eighteen rechargeable car batteries (200 Ah each), five solar panels and three controllers in total. During winter when no sunlight is available, these batteries are charged manually about once a month by using a 10 kVA diesel-engine dynamo, which was installed in 1992 in place of the previous 16 kVA one. There is also a backup battery system which consists of twenty-four batteries same as the solar battery system to supply the power during the time when the solar battery system is not available.

The fluxgate magnetometer sensor is placed at Syowa Station on East Ongul Island, about 150 m distant from the Data Processing Building. All the auroral photometric instruments are placed on the roof of the building, and the data acquisition facilities are installed inside the building. All the outputs obtained from the observation instruments except the auroral photometric ones are transferred to the matrix terminal board and then recorded with pen recorders, analog data

recorders and a computer system. These data had been recorded simultaneously with two sets of the TEAC DR-200 digital data logger systems since January 1987 and with the Accurate Timing data Logging and Analysis support System (ATLAS) since February 1997. Recording by the TEAC systems was terminated in January 1999, and ATLAS succeeded them since then. An 8 mm video tape recorder is used to record wide-band VLF emissions, and 24-hour data can be stored on one volume of 8 mm video tape.

Universal time (UT) is supplied from a precise time-keeping system. This system consists of a network time (NT) server equipped with the GPS satellite timing receiver. The NT server has the interface for the 10Base-T, IRIG-B, 1PPS and 10MPPS, supplies a time with an accuracy of less than 100 μ s to UTC, and adjusts the time of client machines with an accuracy of less than 2 ms through the NT protocol (NTP). This NT server was introduced in January 2003, succeeding the former system using a quartz frequency standard with a stability of 2×10^{-11} /day, and time code generators.

3. Specifications of Instruments

3.1. Geomagnetism

(1) *Magnetogram*

Magnetic variations were measured by a three-axis fluxgate magnetometer. Full scale ranges were +1250 to -3750 nT for H-component and ± 2500 nT for D- and Z-components, respectively, with the frequency response of DC-5 Hz and noise levels less than 0.1 nT. The magnetometer data were recorded in digital form at the sampling rate of 20 Hz, and also recorded on a chart recorder.

(2) *ULF magnetic pulsations*

The H-, D-, and Z-components of ULF magnetic pulsations are detected by three sets of search coil magnetometers. The search coil sensors have copper wires (0.4 mm ϕ , 40000 turns each) wound around permalloy cores (1 cm in diameter \times 100 cm in length). Measurable intensity range of the magnetometer is 0.001-5 nT/s and the frequency response is 0.001-5 Hz. The search coil magnetometers are installed at the remote station on West Ongul Island. The output signals transmitted by the PCM telemeter are recorded on a chart recorder and a digital data recorder. The sampling frequency of the digital data is 20 Hz for each component.

(3) *Absolute observation of geomagnetic field*

Absolute values of the magnetic field were observed, basically, once per month during a magnetically quiet day with a fluxgate declinometer/inclinometer and a portable proton magnetometer. Based on those observations, baseline values for the magnetic variation observation with a fluxgate magnetometer were calculated. Observed absolute values and baseline values are listed in Table 1 and Table 2, respectively.

(4) *K-index*

K-indices are calculated for every 3-hour interval measuring the amplitudes of the H- and D-component magnetic fields from the quiet-day variations. The definition of the K-indices at Syowa Station is as follows:

<u>K-index</u>		<u>Deviation</u>	<u>K-index</u>		<u>Deviation</u>
0	:	0 – 25 nT	5	:	350 – 600 nT
1	:	25 – 50	6	:	600 – 1000
2	:	50 – 100	7	:	1000 – 1650
3	:	100 – 200	8	:	1650 – 2500
4	:	200 – 350	9	:	2500 and more

The ordinary magnetogram is also available on chart papers with a recording speed of 5 cm/hr. The sensitivity of each component on the chart papers is about 100 nT/cm. Table 3 gives the K-indices at Syowa Station in February 2006–January 2007. Inquiries or requests for the data copies of the magnetic field measurements should be addressed to World Data Center for Aurora in NIPR.

3.2. ELF-VLF waves

The natural ELF-VLF wave receiving system at the remote station has consisted of a triangle-shaped three turn loop antenna (10 m in height, 20 m in the bottom side), a pre-amplifier and a main amplifier with gains of 60 and 40 dB, respectively. The ELF-VLF wave intensities at the frequency bands of 0.35, 0.75, 1.2, 2, 4, 8, 30, 60, 95 kHz were obtained from wide band waveforms using a 9-channel filter bank and detectors. The ELF-VLF emissions within the intensity range of 10^{-17} to 10^{-13} W/m² Hz were detectable with this system. These data were recorded continuously in digital form at the sampling rate of 20 Hz. Some of the wide-band ELF-VLF signals up to 10 kHz can be recorded on 8 mm video tape recorders. The wide-band recording is executed in the case of special requests. There were no requests for the wide-band recording in 2006.

3.3. Ionosphere

Cosmic noise absorption at 30 MHz was observed with a broad-beam riometer, which has been installed at the remote station on West Ongul Island since 1981. Its beam half-width is 60°. A receiver used is made by La Jolla Science, and bandwidth and time constant are 150 kHz and 0.25 s, respectively. The riometer data were recorded in digital form at the sampling rate of 20 Hz in the UAPM system.

3.4. Aurora

(1) *CCD all-sky imager*

All-sky observation of aurora is carried out with a CCD all-sky imager which was installed at Syowa Station by

JARE-39 in 1998. Monochromatic auroral images at three wavelengths (557.7 nm (OI), 630.0 nm (OI), and 427.8 (N₂⁺)) are taken sequentially every twenty seconds with an exposure time of two seconds. Image data are saved in a DVD-RAM disk. Observations were carried out during 177 nights from February 22 until October 15 in 2006. An observation list for the all-sky imager is given in Table 4. This observation has been considered as an item of the UAPM observation since 2004, because the former panchromatic CCD all-sky imager had some troubles in 2003. Inquiries or requests for the all-sky data in past years should be addressed to World Data Center for Aurora in NIPR. Observation by the film-type all-sky camera was terminated on April 8, 1998.

(2) *Aurora TV camera*

All-sky observation of aurora was also carried out with an all-sky TV camera, which was installed at Syowa Station by JARE-40 in 1999. The TV camera consists of an image intensifier and an interline CCD camera. Video signal from the CCD camera is recorded with HD/DVD recorders. Observations were carried out during 179 nights from February 22 until October 19 in 2006. Inquiries or requests for the all-sky data should be addressed to World Data Center for Aurora in NIPR.

(3) *Meridian-scanning photometer*

A meridian-scanning photometer (SPM) measures intensities of auroral emissions along a geomagnetic meridian at the seven wavelengths of 557.7 nm (OI), 630.0 nm (OI), 777.4 nm (OI), 844.6 nm (OI), 427.8 (N₂⁺), 485.2 nm (H_β), and 487.4 nm (Back-ground of H_β). The photometers have a field-of-view of 3 degrees except for 6 degrees for the channels of H_β and its background. A scan along a meridian is triggered every 20 s starting from the equatorward horizon to the poleward horizon, and requires approximately 18 s. Shutters of the photometers are closed during every first scan of hour to obtain dark correction signals. Each photometer has two outputs, of which signal gains differ exactly by ten times to expand its dynamic range. The output and scanning angle data are recorded with a PC at a sampling frequency of 10 Hz with a depth of 16 bits for each channel. The photometers are removable from a scanner for yearly calibration of sensitivity. We have two identical sets of photometers. While one is in operation at Syowa Station, the other is calibrated at NIPR. Observations were carried out during 162 nights from February 22 until October 21 in 2006.

4. Compiled Digital Data Format

In the ATLAS system, a QNX PC had been used for the data recording until May, 2004, and a Linux PC has been used since that time. System clock is adjusted by the NTP server. Observed data are digitized by the 16bit straight binary A/D converter (from -10 V to 10 V), and recorded on a MO disk. Data in the MO are written in Common Data Format (CDF). As for the details of the CDF, please refer to the NASA Web page (<http://cdf.gsfc.nasa.gov/>). Each record consists of one time stamp and 16 kinds of data. The names of the CDF variables in each record are as follows:

EPOCH:	Time stamp (unit: CDF Epoch)
MGFH:	H component of fluxgate magnetometer
MGFD:	D component of fluxgate magnetometer
MGFZ:	Z component of fluxgate magnetometer
CNA:	Output of the broad-beam riometer
ULFH:	H component of induction magnetometer
ULFD:	D component of induction magnetometer
ULFZ:	Z component of induction magnetometer
VLF350:	Intensity of natural VLF wave at 350 Hz
VLF750:	Intensity of natural VLF wave at 750 Hz
VLF1.2k:	Intensity of natural VLF wave at 1.2 kHz
VLF2.0k:	Intensity of natural VLF wave at 2.0 kHz
VLF4.0k:	Intensity of natural VLF wave at 4.0 kHz
VLF8.0k:	Intensity of natural VLF wave at 8.0 kHz
VLF30k:	Intensity of natural VLF wave at 30 kHz
VLF60k:	Intensity of natural VLF wave at 60 kHz
VLF95k:	Intensity of natural VLF wave at 95 kHz.

Each CDF variable has 5 attributes. The names of attributes (CDF standard attribute name) and characteristics are as follows:

<u>Attribute name</u>	<u>Contents</u>
VALIDMIN:	Minimum valid value of raw AD data (usually, -32768).
VALIDMAX:	Maximum valid value of raw AD data (usually, 32767)
SCALEMIN:	Minimum value in the UNIT for VALIDMIN (usually, -10.0)
SCALEMAX:	Maximum value in the UNIT for VALIDMAX (usually, 9.9997)
UNIT:	Unit of the scale (usually, "volt")

One can convert from A/D value to physical value with the following equation.

$$\begin{aligned}
 (\text{Physical value}) = & \text{SCALEMIN} + \\
 & (\text{SCALEMAX}-\text{SCALEMIN})/(\text{VALIDMAX}-\text{VALIDMIN}) * \\
 & ((\text{Variable data})-\text{VALIDMIN})
 \end{aligned}$$

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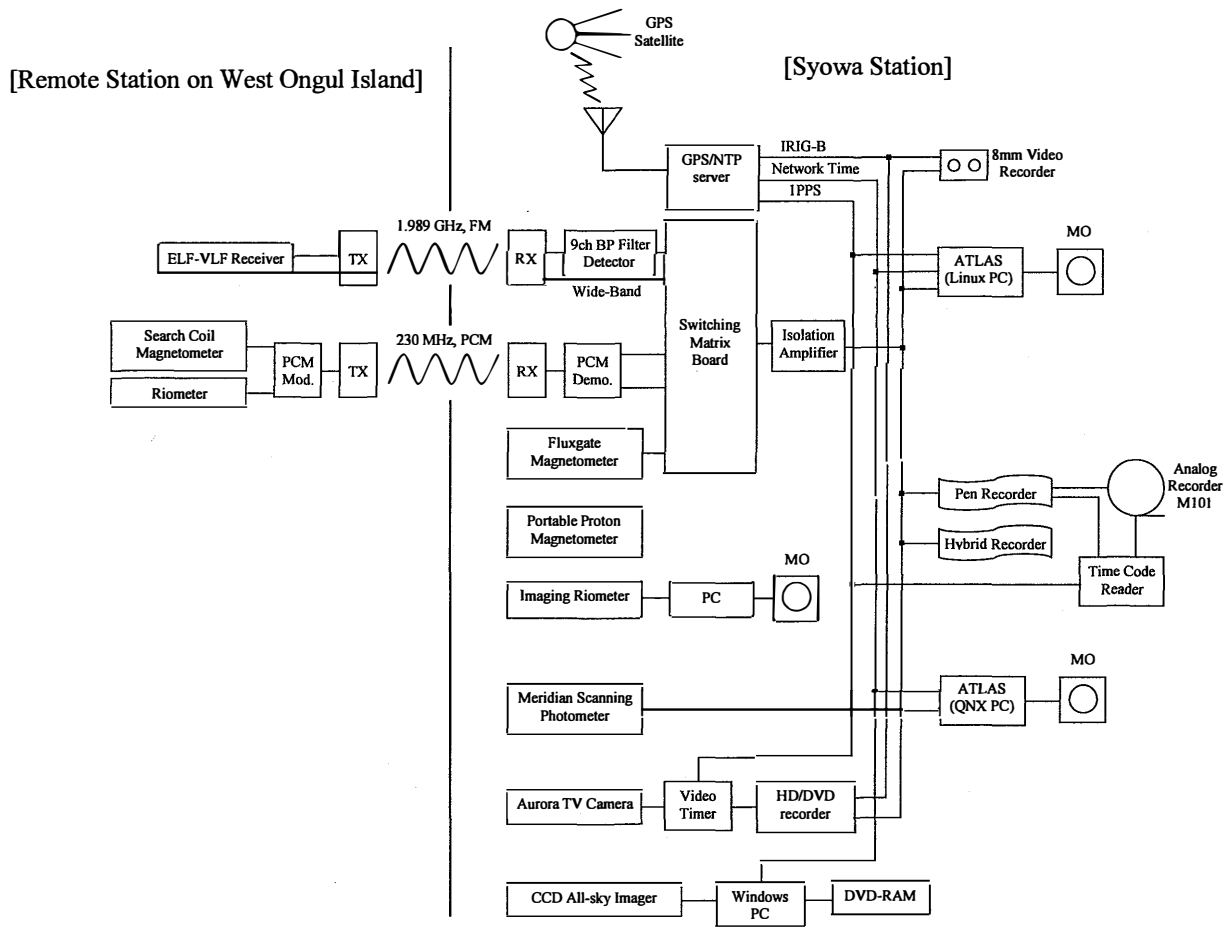


Fig. 1. Block diagram of the "Upper Atmosphere Physics" monitoring system at Syowa Station in 2006.

Table 1. Absolute values of geomagnetic field at Syowa Station in February 2006–January 2007.

YEAR	DATE	TIME (hh:mm)	TOTAL (nT)	HORIZONTAL (nT)	VERTICAL (nT)	DECLINATION (deg:min)	DIP ANGLE (deg:min)
2006	02/17	12:06	43168.1	19183.4	-38671.1	-49:16.61	-63:36.94
2006	03/13	10:40	43166.9	19194.2	-38666.1	-49:17.06	-63:35.99
2006	04/12	11:12	43164.8	19189.3	-38665.0	-49:18.84	-63:36.30
2006	05/16	10:59	43165.8	19199.2	-38661.1	-49:18.83	-63:35.45
2006	06/20	08:14	43161.6	19207.0	-38652.5	-49:19.38	-63:34.59
2006	07/17	11:25	43159.8	19205.5	-38651.6	-49:19.01	-63:34.67
2006	08/14	10:27	43152.3	19201.2	-38645.4	-49:19.80	-63:34.75
2006	09/12	13:01	43151.2	19196.2	-38646.2	-49:20.10	-63:35.14
2006	10/10	10:36	43137.2	19185.6	-38635.8	-49:21.48	-63:35.53
2006	11/17	12:22	43175.8	19212.9	-38665.1	-49:20.60	-63:34.62
2006	12/04	10:60	43136.6	19183.4	-38636.8	-49:20.92	-63:35.72
2007	01/06	11:60	43136.0	19180.0	-38636.5	-49:21.36	-63:35.95

Table 2. Baseline values of fluxgate magnetometer at Syowa Station in February 2006–January 2007.

DATE			TIME(UT)		H (nT)	D (nT)	Z (nT)
year	month	day	hour	min			
2006	2	17	12	6	18069.45	18663.36	-38783.76
2006	3	13	10	40	18072.92	18663.10	-38783.25
2006	4	12	11	12	18073.71	18663.24	-38783.89
2006	5	16	10	59	18075.39	18662.87	-38788.46
2006	6	20	8	14	18078.61	18663.17	-38792.72
2006	7	17	11	25	18078.87	18663.03	-38795.77
2006	8	14	10	27	18076.50	18662.81	-38791.57
2006	9	12	13	1	18077.89	18663.47	-38795.38
2006	10	10	10	36	18072.15	18663.32	-38788.69
2006	11	17	12	22	18069.52	18662.82	-38783.32
2006	12	4	10	60	18067.98	18662.12	-38778.82
2007	1	6	11	60	18066.31	18663.15	-38778.18

Table 3. K-indices at Syowa Station in February 2006 –January 2007.

	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
1	2222 1114	5322 2211	1111 1001	0011 0000	3223 2234	2320 1010	4653 3313	6222 2465	6653 3324	3321 2223	2312 2234	3212 3333
2	3322 1223	2111 1103	0111 1000	2011 0020	4432 1101	0000 0111	5532 2116	5311 1235	2221 2235	4121 2355	2221 1122	4433 4334
3	1211 1242	2111 1112	0011 1002	2210 0002	3111 2112	1010 0000	4321 0014	4321 1113	3312 1113	3322 3122	3221 1122	3634 4355
4	4422 1101	2111 1102	1122 2345	0132 4424	1000 0000	0111 2246	2201 0001	5633 2334	3211 0221	2332 1233	1111 1111	5532 3433
5	3112 1121	2111 1001	4653 4334	6442 1103	1000 0001	4653 3235	3200 0011	5332 2234	2111 1122	2222 2223	1112 2222	3322 3322
6	3422 4345	1111 2345	3552 2223	3312 3545	4333 3555	5433 2224	1010 1000	4222 3233	0111 1101	1111 1112	4634 3355	3311 2222
7	3321 1224	5522 2123	3111 0001	3454 3244	6543 3337	4232 2212	5474 4534	3222 2321	1111 1436	1111 1010	6543 4344	0111 1111
8	4311 1100	3211 1134	3101 1122	5422 1111	5544 4454	2010 0003	5533 3232	3221 0113	4322 2223	1111 1101	5643 3343	3221 1221
9	1121 1111	2211 1132	6554 4356	1112 0102	5542 2234	1100 0014	5513 2224	3110 0000	3221 1021	2011 1334	4321 2446	1121 1231
10	2112 1123	2322 3316	5543 3433	0000 0024	5421 3335	4301 2333	2100 1114	1211 1122	3111 1001	5554 3335	3532 3435	3423 2322
11	4321 2222	5433 2212	3411 2212	4544 3236	4321 1113	0101 1134	4211 2211	6521 1103	2111 1011	5553 3355	4542 2236	3332 3221
12	4411 1100	1122 2110	1111 0000	6553 3225	2011 1103	4342 4213	3321 1211	3132 0111	4111 1113	5322 2112	3653 4454	5122 0111
13	0111 1212	0111 0022	1132 3214	5523 3234	3100 0002	3322 1000	1000 0002	2442 1100	3333 2365	2111 1100	5421 1223	1121 0110
14	1111 1001	1002 1104	6664 4555	5332 2223	3211 1115	0212 3354	1010 0000	2221 2101	5633 2355	1211 1345	4422 5657	1121 2123
15	1223 2144	3222 1230	6534 3466	2211 1113	3444 4335	2332 2112	1201 0003	1011 0000	3422 2244	4421 1134	7866 5455	3343 ----
16	4332 2234	2321 1112	5433 2225	1000 0002	4522 2234	1310 0000	2000 0000	1011 1021	4221 2235	5421 1211	4422 2344	--22 3336
17	3421 1112	1011 1001	4321 0125	3411 1112	3443 3222	2211 0110	0021 0035	2223 3254	3111 1124	5521 2211	3221 1221	6543 3454
18	1111 2101	1233 3377	7411 1124	3223 2343	2333 2211	1200 0110	5533 2313	7443 3356	3211 0121	2221 1111	2321 3334	4532 3335
19	4322 2243	6653 3356	3111 0101	3331 1114	4110 0000	2300 0001	1111 5556	5433 1123	1111 1001	2322 0101	3334 3324	4522 3345
20	4434 4455	5654 2365	0111 1111	3323 1122	3100 1000	0100 0002	5631 1234	4411 0000	2122 2434	1111 1101	5333 4365	4222 2223
21	5533 4435	5522 3455	2111 1223	5111 1143	0000 0002	1000 0000	4433 2346	0110 1111	6442 2455	1111 1100	5434 3334	5442 3221
22	5433 3324	5532 1235	6644 3221	5311 1125	1320 0031	1220 0001	5344 3434	1111 1012	5432 3345	0021 2143	4444 3345	1121 1121
23	4322 1102	3411 0102	2332 1114	5331 1101	0000 0000	2211 0000	3331 0102	1111 0246	2112 1124	3233 3356	3332 3445	2322 1101
24	5412 1100	4111 1135	4432 1003	0121 1100	0000 0002	0111 1202	4110 1334	6444 3125	1221 1123	4552 2235	5232 3335	1111 1111
25	4211 1001	3421 1131	5111 1101	1110 1004	3100 0002	5421 1113	4010 0001	4224 3224	2222 1111	3422 3345	5522 3212	1111 1112
26	3321 1325	2211 1334	4411 0000	3101 0010	2000 0001	5111 1200	2111 1023	4421 1235	2111 1110	4522 3355	2221 2211	1122 2112
27	3321 1012	4510 1115	3421 0123	2000 0001	1100 1113	2010 1133	3212 4434	4211 1101	3121 1143	4322 2332	1111 1111	3327 7114
28	1113 1224	3421 1112	4462 2111	0311 1025	4233 3234	7754 3223	6542 2324	1111 1014	3223 3345	3212 2233	1111 1222	53-- -233
29		2211 1125	1110 0002	3100 0013	3323 1334	3121 1021	4423 2211	4011 1121	5543 3346	3321 1133	3111 1222	5332 4545
30		3211 0034	0000 0000	2201 3133	4433 2213	1221 0112	1233 2232	2543 2234	4322 2113	4664 4432	2111 1212	55-3 4345
31		2111 2222		5221 1010		2332 3235	1131 1456		3111 1235		3111 1122	5333 3356

Table 4. Observation periods of the CCD all-sky imager at Syowa Station in 2006.

	Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct	
	start	end	start	end	start	end	start	End	start	end	start	End	start	end	start	end	start	end
1			20:16	23:10	17:05	02:06	15:21	03:03	18:35	23:08	00:10	04:55	14:54	03:48	16:42	02:04	18:48	23:49
2					16:40	01:39			18:56	03:27	13:56	04:45	14:53	03:45			18:50	23:47
3					20:10	01:31	15:21	03:38	14:11	04:25	14:07	04:48	14:43	03:40			18:50	23:28
4							15:12	03:52	14:11	03:31	13:58	05:40	15:01	03:50				
5					17:20	23:58	15:16	03:39			14:04	04:56	14:55	03:40	18:50	02:08	18:50	23:27
6							14:58	04:29	14:01	04:59	14:03	04:52	14:56	04:15	16:55	02:10	18:53	23:28
7			19:05	23:30	22:56	01:28	14:50	03:12	14:10	04:53	14:12	04:43			17:02	01:58		
8			21:02	23:38	17:06	02:57					14:01	04:36			17:08	01:38		
9			19:17	23:36	20:04	01:50					17:02	04:31			17:07	01:59		
10			19:11	23:46					13:55	04:46			01:45	03:28	17:12	01:42	19:49	22:42
11			19:05	23:55	16:33	02:03	15:50	02:26	13:50	04:40	23:23	03:34	17:34	01:57	17:19	01:27		
12			18:40	0:02	16:24	02:00	23:35	03:21	13:56	04:48	18:07	04:48			17:21	01:28	20:00	23:15
13			19:01	23:53	16:20	02:12			13:56	04:20	14:20	20:20	16:05	02:47	17:23	01:26	19:14	23:15
14			20:23	0:01	16:15	02:11			14:05	04:52	16:46	04:48			17:26	01:22	20:10	22:17
15			18:44	0:22	16:12	02:09			13:52	04:59	14:15	04:28			17:23	01:20	20:14	22:02
16					15:57	02:30			13:47	04:50	14:09	04:32			17:30	01:24		
17					16:02	02:28	17:54	02:54	13:54	04:29	14:20	04:29			17:49	01:32		
18					16:24	02:24	14:33	03:55	13:51	05:07	17:39	06:12			17:44	01:59		
19			18:23	0:35	15:56	02:57	14:27	03:54	13:54	05:06			16:30	03:38	17:48	00:48		
20			18:06	0:36	15:50	02:24			13:36	05:01			15:53	02:53	17:50	00:56		
21			18:05	0:41	15:58	01:14			13:53	04:37					18:00	00:40		
22	20:44	22:04	17:59	0:47	15:53	02:24			13:46	04:50					18:00	00:23		
23	20:44	21:58	18:00	0:14			16:28	04:20	13:54	04:47	14:31	04:09	16:08	02:46	18:15	01:27		
24	20:31	22:06	17:35	0:54	16:11	02:48	16:22	03:03	19:32	03:54	14:53	04:17	15:59	02:35	18:15	00:38		
25	20:25	22:11			15:43	03:03	14:18	04:12			14:41	04:31	16:13	02:35	18:23	00:48		
26					15:25	02:57	19:14	04:27	19:08	04:37					18:20	00:37		
27	20:27	23:14			15:25	02:57	14:27	04:51			14:27	04:57			18:27	00:25		
28	20:31	23:05	17:34	1:16	15:22	03:11	14:19	03:30	00:51	04:59	14:41	04:04	16:37	02:11	18:30	23:32		
29			17:31	0:59	14:54	03:00	14:11	03:52	13:58	04:58	14:42	03:57	19:03	02:02	18:35	00:35		
30			18:22	1:24	15:26	02:36	14:09	04:15	13:59	04:52	14:52	03:52			18:40	00:40		
31			16:56	2:04			14:09	04:16			14:54	03:56	16:32	01:51				

Appendix

Magnetograms at Syowa Station in 2006

- Plotted data from top in each panel:

H : Local magnetic northward component of the magnetic variation

D : Local magnetic eastward component of the magnetic variation

Z : downward component of the magnetic variation

- Plotting vertical scale:

H, D, Z : 100 nT/div

