

## UPPER ATMOSPHERE PHYSICS DATA OBTAINED AT SYOWA STATION IN 2005

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### 1. Introduction

This data book summarizes upper atmosphere physics data acquired by the 46th Japanese Antarctic Research Expedition (JARE-46) with the "Upper Atmosphere Physics Monitoring (UAPM) System" at Syowa Station in 2005. 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 (N<sub>2</sub><sup>+</sup>1NG)
    - Video type : Panchromatic video signal recorded by DVD recorder
  - Scanning photometers :
    - Meridian-scanning record at the following seven wavelengths  
427.8 nm (N<sub>2</sub><sup>+</sup>1NG), 485.2 nm (Hg), 487.4 nm (BG of Hg),  
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, 2005 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](mailto: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; Macgawa *et al.*, 2000; Kato *et al.*, 2001; Taguchi *et al.*, 2003; Yamada *et al.*, 2006; Matsuzawa *et al.*, 2006). This report is the 25th 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  $\mu$ 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  $2 \times 10^{-11}$ /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  $\pm 2500$  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 $\phi$ , 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 2005–January 2006. 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/m<sup>2</sup> 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 2005.

## 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 (N<sub>2</sub><sup>+</sup>)) 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 200 nights from March 1 until October 30 in 2005. 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 196 nights from March 1 until October 23 in 2005. 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 (N<sub>2</sub><sup>+</sup>), 485.2 nm (H<sub>β</sub>), and 487.4 nm (Back-ground of H<sub>β</sub>). The photometers have a field-of-view of 3 degrees except for 6 degrees for the channels of H<sub>β</sub> 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 170 nights from March 1 until October 18 in 2005.

### **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.

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

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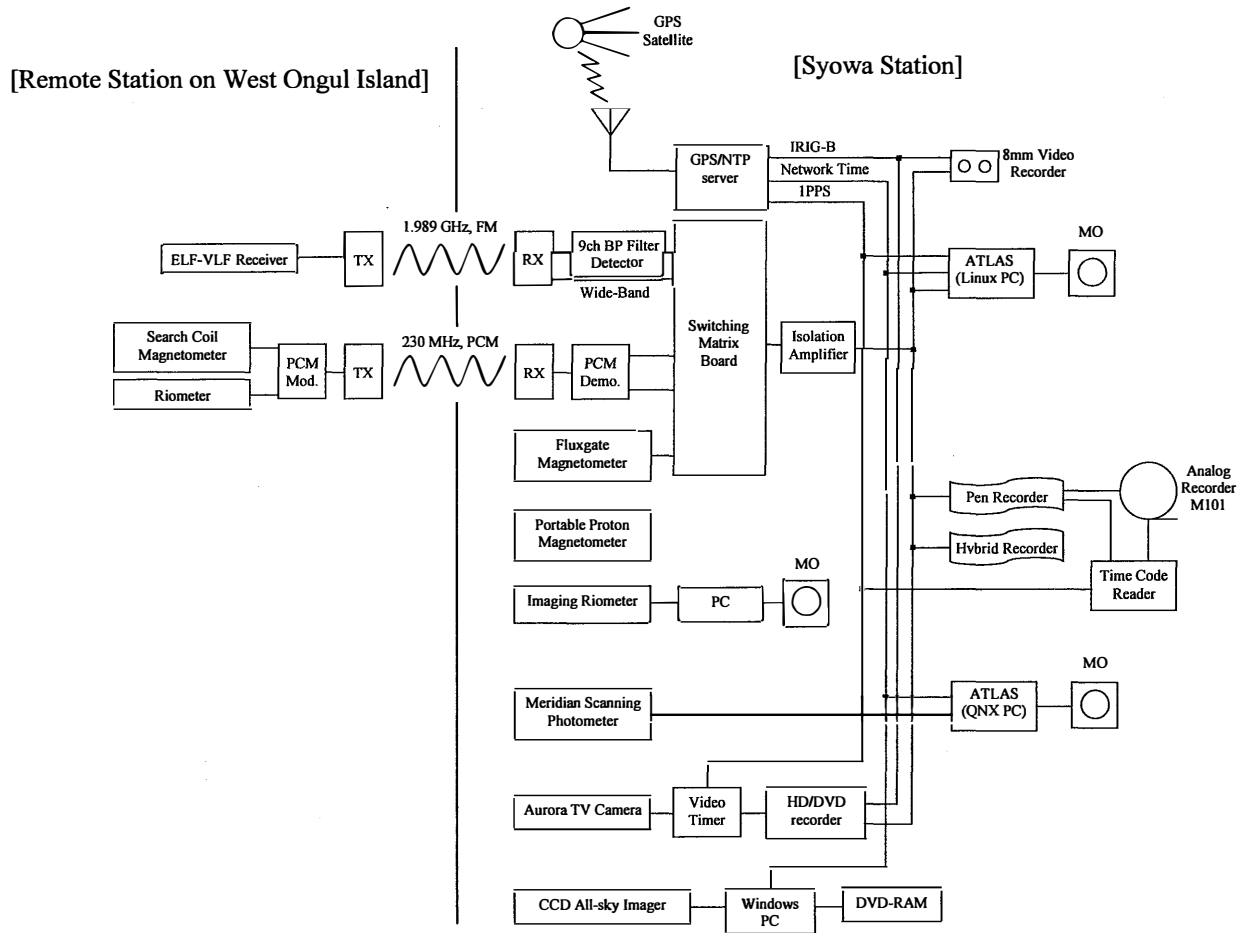


Fig. 1. Block diagram of the "Upper Atmosphere Physics" monitoring system at Syowa Station in 2005.

Table 1. Absolute values of geomagnetic field at Syowa Station in February 2005–January 2006.

YEAR	DATE	TIME (hh:mm)	TOTAL (nT)	HORIZONTAL (nT)	VERTICAL (nT)	DECLINATION (deg:min)	DIP ANGLE (deg:min)
2005	02/24	11:13	43193.5	19190.1	-38696.4	-49:07.92	-63:37.35
2005	03/14	10:52	43228.8	19212.3	-38724.1	-49:08.58	-63:36.75
2005	04/11	10:58	43201.3	19195.4	-38702.3	-49:09.92	-63:37.18
2005	05/23	11:11	43214.2	19205.4	-38711.9	-49:11.00	-63:36.81
2005	06/16	10:59	43191.0	19174.9	-38707.6	-49:07.29	-63:38.83
2005	07/15	10:53	43197.4	19199.6	-38696.2	-49:08.90	-63:36.67
2005	08/12	11:06	43189.4	19196.9	-38688.2	-49:10.29	-63:36.58
2005	09/19	11:04	43189.6	19184.5	-38694.5	-49:13.38	-63:37.69
2005	10/12	10:57	43182.0	19187.5	-38685.0	-49:12.80	-63:37.14
2005	11/08	10:52	43187.4	19194.2	-38687.3	-49:12.38	-63:36.74
2005	12/06	10:45	43168.4	19192.6	-38668.2	-49:12.48	-63:36.18
2006	01/08	12:49	43192.0	19203.0	-38687.3	-49:12.25	-63:36.11

Table 2. Baseline values of fluxgate magnetometer at Syowa Station in February 2005–January 2006.

DATE			TIME(UT)		H (nT)	D (nT)	Z (nT)
year	month	day	hour	min			
2005	2	24	11	13	18061.89	18666.929	-38802.01
2005	3	14	10	52	18057.43	18666.323	-38804.05
2005	4	11	10	58	18071.34	18665.273	-38798.05
2005	5	23	11	11	18078.63	18662.35	-38785.8
2005	6	16	10	59	18077.52	18662.833	-38787.55
2005	7	15	10	53	18074.89	18662.242	-38789.23
2005	8	12	11	6	18076.59	18662.542	-38791.11
2005	9	19	11	4	18077.08	18662.731	-38790.34
2005	10	12	10	57	18076.02	18662.417	-38788.54
2005	11	8	10	52	18074.29	18662.427	-38785.25
2005	12	6	10	45	18072.29	18662.446	-38782.16
2006	1	8	12	49	18065.85	18663.017	-38782.57

Table 3. K-indices at Syowa Station in February 2005 –January 2006.

	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
1	4112 2111	4432 2225	1231 1022	5653 3345	4322 1112	4321 1345	4444 3324	4442 3224	4322 3235	4421 2333	5423 3237	4221 2222
2	1222 2342	4423 2313	3011 0101	4321 2214	2211 1103	6442 2325	4532 2213	5542 4553	5522 2325	3311 1155	5343 3334	2222 2223
3	3532 1211	3211 1121	3111 0113	5422 3253	3221 1121	4423 2314	3431 0235	6654 3115	3321 1123	5533 4366	5422 3435	3211 1211
4	1111 2111	2011 0010	3221 1577	3321 0032	4311 2366	3311 1104	6532 3124	6664 4335	4111 1111	4533 3345	3221 3233	1221 1110
5	2121 1010	3431 1365	7663 3346	2211 0110	5554 2236	2111 1002	3121 0234	6322 2134	3211 1124	4442 2235	2212 1110	1111 2223
6	4432 1244	6543 3556	5422 3236	1000 1123	5631 0125	2010 0004	5533 3365	5512 2234	3111 1112	5523 3435	0121 2212	3431 3323
7	4532 3367	6663 3466	4522 1102	3110 1146	6553 3214	0011 2114	5554 3225	5532 2000	3122 1335	5222 2213	1111 1110	4221 2221
8	4554 3446	6663 2366	4211 1020	6565 6645	4311 1003	3210 0003	4321 2114	4410 1133	5454 3256	2211 0103	0110 0123	2122 1211
9	5664 3345	5562 2456	3301 0001	6522 1236	2000 0102	3333 4355	4322 2245	2312 4534	5422 2145	4111 1112	3211 1134	1111 0000
10	5544 3345	5543 2223	2210 0001	5542 2213	2000 0012	4654 4557	4344 4213	4343 4567	4342 2215	1010 1133	4541 2235	0111 2121
11	5533 2235	4422 1112	2311 1246	1022 2346	3200 0024	4353 2365	3111 1101	7775 6476	4311 1223	2221 1223	4433 3643	2211 2111
12	4321 2111	3211 0104	5643 4444	4532 2247	4233 2586	6855 4311	3200 1114	6664 4477	0110 0003	4322 3333	4422 2355	4221 0123
13	3211 1131	3111 1126	4553 4466	6543 3323	7554 3333	2244 4435	5432 2057	7745 4255	2111 1123	5523 4444	2222 2133	2211 1212
14	3422 1234	6642 3325	5433 3335	3222 1232	3231 2244	3432 2202	6522 1113	5553 4344	2311 1001	5522 2133	1221 1111	3111 1121
15	2211 1122	4121 1113	4532 2236	8687 2357	4543 3311	2111 2133	2211 0014	5434 5665	1111 0000	3212 1122	2211 1011	4321 1331
16	5322 4454	2111 2125	5422 1134	6775 3445	0233 3235	5531 1224	3632 3336	5534 3243	1221 2334	2211 1114	3312 2221	2333 3345
17	3311 1226	4652 1323	3410 0013	4642 2356	7632 3233	4124 3336	5543 2236	2313 2345	5542 4321	2121 1000	2112 1101	4432 3222
18	7463 3525	3--- ---5	3431 2114	5433 3211	3322 2222	6663 3145	5443 2333	3422 3222	3421 2221	1111 2331	4222 2111	4423 2233
19	4234 3334	5542 1002	4422 1102	1342 2112	3311 1111	5421 1125	4111 2122	4221 1222	4422 2223	3111 3443	3322 2444	3122 2324
20	5551 1334	-211 1123	3643 3334	4664 4225	1200 1100	4333 3336	2100 0010	2232 1123	3111 1001	2322 2324	5522 3343	3211 2332
21	4431 1113	2122 3113	311- -000	5764 2355	0000 0000	5653 2335	1111 1234	1111 1100	0011 0005	3421 1224	2222 3324	3421 2110
22	2211 1223	0110 0012	4311 1223	5332 3113	1000 0015	5432 2355	4522 2114	3321 1341	5411 1022	3121 3334	4222 1111	1212 2212
23	3111 0011	0011 1124	2111 0222	4211 0212	6675 3344	4221 1113	3332 3233	3421 1134	2111 1111	3332 3223	1111 1100	3543 3335
24	1122 2114	3112 1033	5522 2213	2000 0004	5422 3113	1011 1011	5357 6565	3211 1000	2211 1132	3222 2336	1112 2224	3332 2101
25	3222 2342	2543 2435	4332 2114	2121 0000	6622 2345	3310 0004	6453 4434	0111 2111	5633 2355	5532 2233	3322 2212	1212 1245
26	5422 2343	3443 3334	1001 0011	0010 0000	5623 2114	3111 1001	5542 0213	6521 3244	3332 2334	4212 1222	1111 2234	4632 3556
27	1331 2222	4333 2353	0011 0000	0000 0000	2100 1132	3222 1135	5422 1003	5422 1115	5112 2323	1121 1112	5111 2464	5322 3334
28	4332 2214	3311 1022	0000 0011	0111 0345	0111 0012	5743 3244	3411 0024	4331 2322	1122 2224	2122 3235	5533 3345	3322 2133
29		1110 0115	0222 1345	5444 1245	3121 1001	4432 3545	6531 0001	5311 1310	1111 1022	4121 1225	5343 2344	2111 0001
30		4332 2212	6543 3446	5663 4865	2211 1113	6432 1114	1000 0013	1212 3225	4311 1133	3223 3235	4322 1224	2111 1100
31		2320 1333		5633 2225		4331 2105	2321 3577		2221 4455		5221 3344	1111 1201

Table 4. Observation periods of the CCD all-sky imager at Syowa Station in 2005.

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

## Appendix

### Magnetograms at Syowa Station in 2005

- 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

