METEOROLOGICAL SATELLITE CENTER

THE GMS USER'S GUIDE

Third Edition

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Rev.1

Change of The GMS User's Guide (English version)
(published in March 1997)

We found some errors in some pages of The GMS User's Guide.
We would like you to change with the correct pages.
Thank you.

Meteorological Satellite Center
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Pages should be removed	Numbers	Pages should be inserted	Numbers
		58−1	1
		59−1	1
82	1	82	1
84～89	6	84～89	6
91	1	91	1
93～97	5	93～97	5

CONTENTS

APPENDIX

FOREWORD

This document provides users with background information on the functions of GMS system to help them understand, obtain and use the GMS data. The basic GMS system and its function are outlined, followed by discussions of GMS data productions, formats and archiving.

This Third Edition is an updated version of the Second User's Guide published in 1989. This document includes the recent development of GMS data processing at the Meteorological Satellite Center. In addition, TOVS data processing at the MSC based on TIROS-N/NOAA satellite data is also described in an Appendix.

As regards the GMS and TOVS data, "Monthly Report of Meteorological Satellite Center" has been published on CD-ROM since July 1996.

A. Kurosaki
Director
Meteorological Satellite Center

SECTION 1 OUTLINE OF GMS SYSTEM

1.1 OUTLINE OF GMS SYSTEM

The Geostationary Meteorological Satellite (GMS) series are operated as part of the Global System of Meteorological Satellites (see Fig.1.1.1) by the MSC/JMA. The first GMS was launched in July 1977 and started to provide meteorological products operationally on April 6, 1978. The successors GMS-2,3,4 and 5 were launched in August, 1981, August, 1984, September, 1989 and March, 1995 respectively. The current operational satellite is the GMS-5.

The GMS-5 configuration is shown in Fig.1.1.2. The spacecraft height is 354 cm and its diameter 215 cm. Its weight is approximately 344 kg at the beginning of the life. The designed mission life is 5 years. The spacecraft consists of a despun earth oriented antenna assembly and a spinning section rotating at 100 rpm. The spinning section consists of VISSR and supporting subsystems. It is covered by solar panels.

There are three major missions in the GMS project:

(1) Observation with VISSR
- -Imaging earth surface and cloud distribution, and observation of meteorological phenomena such as typhoons, cyclones, fronts, and detection of volcanic ash clouds.
- -Meteorological parameter extraction such as temperature on both the earth's surface and cloud top and cloud height, cloud amount, cloud motion winds, upper level water vapor amount.

(2) Collection of Meteorological Observation Data
- -Collection of meteorological data from Data Collection Platforms (DCPs) installed in ships, buoys, aircraft and land stations.

(3) Direct Broadcast of Cloud Images
- -Real-time dissemination of digital image data, the Stretched VISSR, to users of the Medium Scale Data Utilization Station (MDUS).
- -Dissemination of processed analog image data, the WEFAX, to users of the Small Scale Data Utilization Station (SDUS)

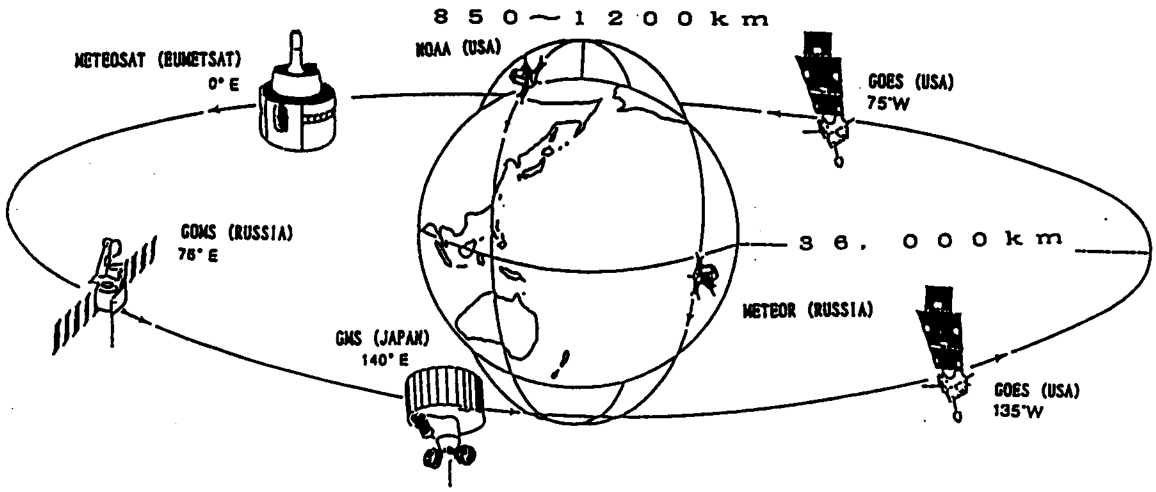

Fig.1.1.1 The Global System of Meteorological Satellites

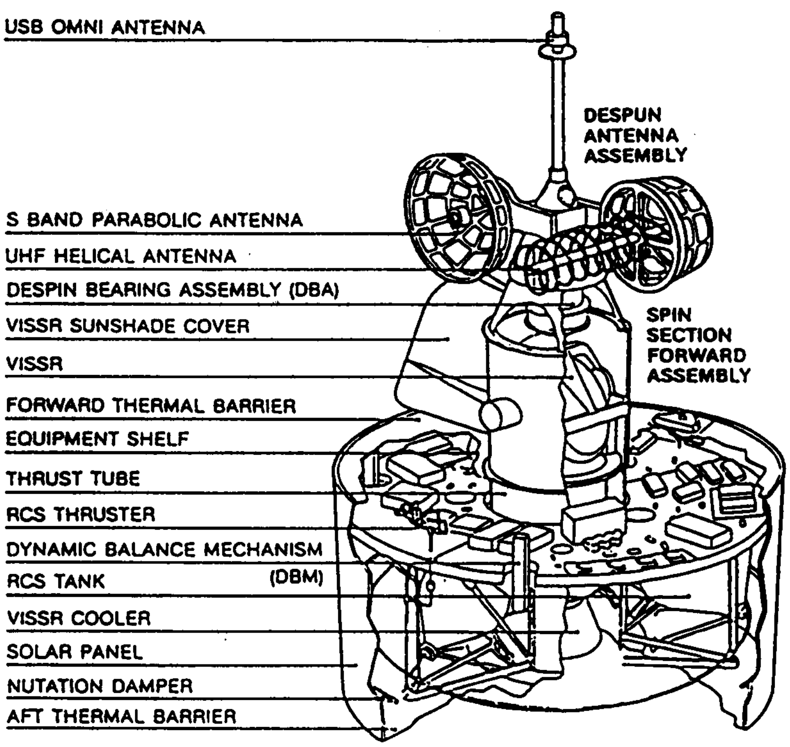

Fig.1.1.2 The GMS-5 Configuration

1.2 Ground Facilities

The GMSS consists of the GMS spacecraft itself and ground facilities; Command and Data Acquisition Station (CDAS), the Data Processing Center (DPC), the Turn Around Ranging Station (TARS), the Data Utilization Stations (DUSs), etc. These facilities and data communication between them are described in this section and illustrated in Fig.1.2.1.

1.2.1 Telecommunication System

The GMS ground telecommunication facilities consist of the CDAS telecommunication system and the DPC telecommunication system. The configuration of the telecommunication system and its data linkage is shown in Fig.1.2.2. The characteristics of the GMS communication system is shown in Table.1.2.1.

1.2.1.1 CDAS Telecommunication System

The primary role of the CDAS is to make a communication between the GMS spacecraft/ other ground facilities and CDAS itself. The CDAS system is controlled mainly automatically by a duplex computer system with hot-standby architecture.

A couple of large Cassegrain antennas with a diameter of 18 meters are installed in CDAS compound to communicate with the GMS spacecraft. The commands to operate the GMS the Stretched VISSR data, and WEFAX image data are transmitted to the GMS through the antenna, and the telemetry data, observed VISSR image data, weather reports of DCP, and observed solar particle data are received by the antenna. The CDAS system is processing these data and interchanging with DPC in Kiyose through the PCM microwave link.

The major functions of CDAS are:

-VISSR signal production and transmission to MDUS
-Processing of telemetry, and transmission of command signal to GMS
-Operation of trilateration ranging by use of TARS stations
-Relay of DCP signal to DPC
-Modulation/transmission of WEFAX signal to SDUS

1.2.1.2 DPC Telecommunication System

The system consists of VISSR interface, monitoring/control unit, and automatic image-recorder. The monitoring/control of the equipments are performed automatically.

The major tasks of the system are:

-Dissemination of the WEFAX signal to mass media, and SDUS user via CDAS/GMS;
-Relay of the VISSR signal to the computer system in DPC, and monitoring the signal, the status of each equipment, and the connection routes.

1.2.2 Turn Around Ranging Station

Turn Around Ranging Station (TARS) is a station for ranging the distance between TARS and the spacecraft. TARSs are operated in Ishigaki Is., Japan and in Australia. The ranging data obtained from three stations, two TARSs and CDAS, are used for the determination and prediction of the spacecraft orbit.

1.2.3 Data Utilization Station

There are two types of Data Utilization Station (DUS): the Medium-scale Data Utilization Station (MDUS) and the Small-scale Data Utilization Station(SDUS). The MDUS receives the S-VISSR image data from the GMS and the SDUS receives the WEFAX image data.

Functions and specifications of DUS are described in Appendices A and B.

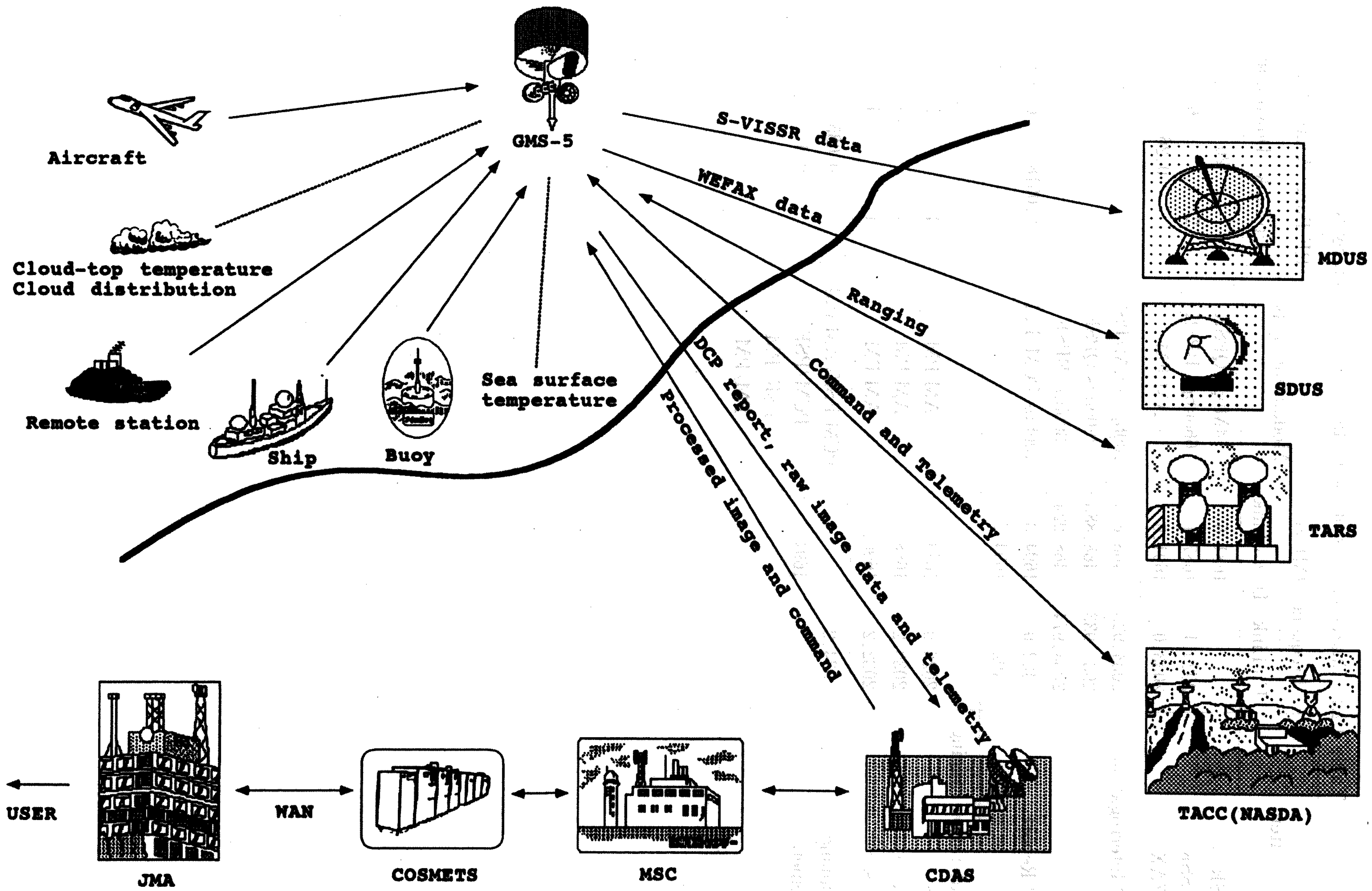

Fig.1.2.1 The facilities and data communication in the GMSS

Table 1.2.1 Characteristics of the GMS Communication System

Item	Frequency (MHz)		Modulation Type	RF Band Width (MHz)	
	Up-Link	Down-Link		Up-Link	Down-Link
VISSR		1681.6	14Mbps QPSK	20	
S-VISSR	2029.1	1687.1	660kbps BPSK	2	6
WEFAX	2033.0	1691.0	AM-FM	0.26	
DCP Interrogation	2034.925	468.875	100bps PCM/PSK	0.005	0.005
	2034.933	468.883	4800bps QPSK		
	2034.974	468.924	300bps BPSK		
DCP Report	402.0	1694.3	100bps PCM/PSK	0.0018	0.002
	−402.4	−1694.7			
Trilateration ranging					
MRS	2026.0	1684.0	AM-PM	1	1
TARS-1	2030.2	1688.2	AM-PM	1	1
TARS-2	2032.2	1690.2	AM-PM	1	1
Command	2034.2		PCM-FSK/AM-PM	0.035	
Telemetry		1694.0	PCM/PSK	0.4	
			FSK/PM		
			FM/PM		

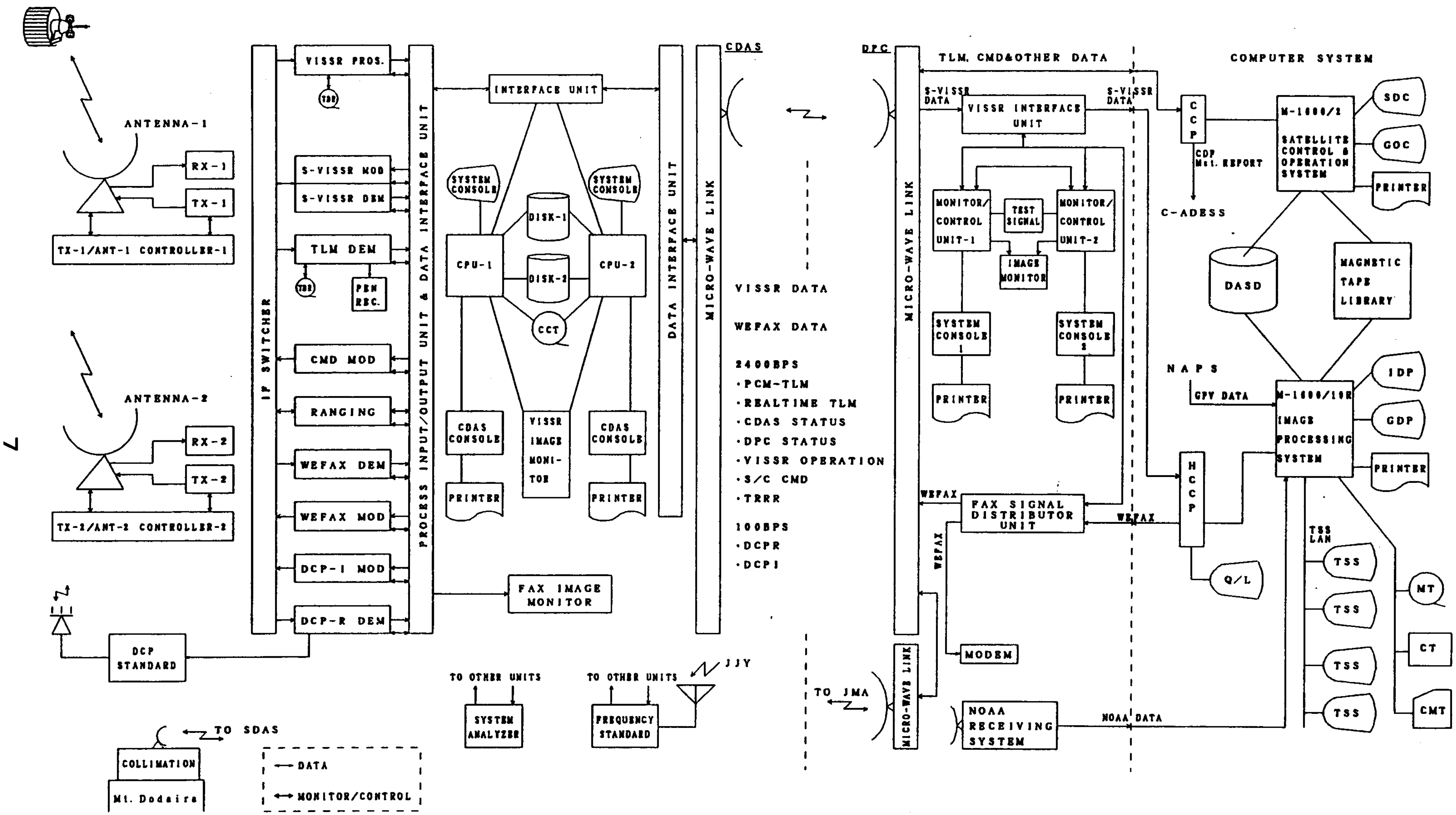

Fig.1.2.2 The configuration of GMS telecommunication system and computer system

1.3 Data Processing Center

A computer system is installed at the DPC to process various observational data derived from the GMS and NOAA spacecrafts. This system consists of two types of mainframe computers, Fujitsu M-1600/2 and M-1600/10R.

The configuration of the computer system is shown in Fig.1.4.2

(1) Satellite Control & Operation System

M-1600/2's are used for control/ operation of the GMS.

(2) Image Processing System

M-1600/10R's are used to process imagery data derive from the GMS. The image processing system performs collection of imagery data, production of WEFAX, extraction of meteorological parameters such as sea surface temperature, cloud top height, cloud motion winds, and archive of meteorological satellite data products.

(3) High-speed Communication Control Processor (HCCP)

The HCCP is connected to the image processing system as the FEP(front-end processor) to receive imagery data from the CDAS and send WEFAX data to the CDAS.

(4) Communication Control Processor (CCP)

The CCP receives meteorological data from the C-ADESS(Central Automated Data Editing and Switching System). The CCP is connected to the control/ operation system as the FEP to the CDAS and the C-ADESS to collect various telemetry and DCP data from the CDAS and send commands to the CDAS.

(5) Image Display Processor (IDP)

The IDP has functions for display, analysis, and animation of cloud images. The IDP is connected to the image processing system.

(6) Graphic Display Processor (GDP)

The GDP has functions to process imagery data. The GDP is connected to the image processing system.

SECTION 2 VISSR

2.1 Visible and Infrared Spin Scan Radiometer

2.1.1 VISSR Scanner Configuration

The Visible and Infrared Spin Scan Radiometer(VISSR) consists of an optical scope made up with a scan mirror, reflectors and lenses and visible(VIS) and infrared(IR) detectors with the radiation cooler as shown in Fig.2.1.1. The detectors convert the incoming radiation energy to electrical currents. In flight calibration methods are provided for both VIS and IR. In the VIS channels, the sun is viewed with a reduced size sidelooking prism system. And in the IR channels, a blackbody radiation is directed to the detectors by a refection mirror intruding the optical axis outside of the earth view.

2.1.2 Characteristics

The characteristics of the VISSR are shown in Table 2.1.1. The VISSR of GMS-5 is improved in spectral bands on its predecessors by the addition of the IR split spectral detectors for the atmospheric window band and a detector for the water vapor absorption band. Also, silicon photodiodes are equipped for VIS detectors instead of photomultiplier tubes. Their features are more stable over temperature variations after solar illumination and throughout life, and have redundant pairs for reliability. The outputs of VIS and IR detectors are quantized into 64 levels(6 bits) and 256 levels(8 bits) respectively, and then transmitted to the earth as the raw VISSR data.

2.1.3 Spin-scan Geometry

The VISSR optical axis is in line with the spacecraft mechanical center axis and its spinning motion orients the line of sight of VISSR to the earth scene west-to-east and the stepping motion of the scan mirror reflection angle (70 micro-radians per spin) provides north-to-south scanning as shown in Fig.2.1.2. Full earth disk imagery are obtainable both in VIS and IR spectral bands at the same time by 2,500 scans at 30 minutes intervals including necessary periods for scan mirror retrace and attitude stabilization of the spacecraft. Fig.2.1.3 indicates the arrangement of the detectors in the image field of view. The pixel resolution is 1.25 km in VIS and 5 km in IR respectively at the subsatellite point. The transmission of the raw data is made within 20 deg. west-to-east and 20 deg. north-to-south area to cover the earth which occupies 17.4 deg. circle observing from the geosynchronous orbit.

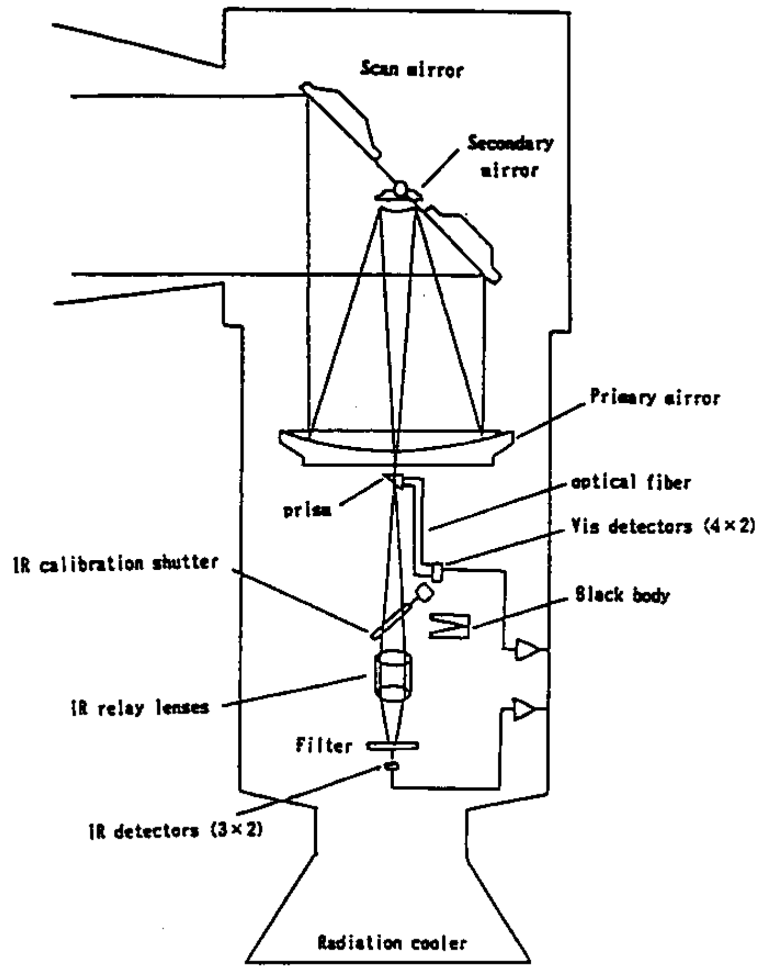

Fig.2.1.1 Meteorological-optical layout of VISSR Scanner

Table 2.1.1 Characteristics of the VISSR

Functions	Provides visible and infrared spectrum mapping of earth, its cloud cover and atmospheric water vapor distribution	
Design	Spin scan radiometer includes scan mirror, 40.64 cm diameter 291.4 cm focal length Ritchey-Chretien optical system, Silicon photo diodes and HgCdTe detectors, ≃90K (−175℃) by radiation cooler with servo temp. control. Beryllium housing.	
	Visible Channels	Infrared Channels
Number	4 (+4 redundant)	3 (+3 redundant)
Instantaneous geometrical field of view (IGFOV)	35×31 μrad	140×140 μrad
Band	0.55 to 0.90μm	10.5 to 11.5 μm (band 1) 11.5 to 12.5 μm (band 2) 6.5 to 7.0 μm (band 3)
Resolution	1.25 km	5.0 km
Scanning lines/frame	2500×4	2500
Scan step repeatability (1σ)	≦1.8 μrad	≦1.8 μrad
Noise periormance	S/N≧84 (albedo=100%) S/N≧6.5 (albedo=2.5%)	NEΔT (300 K) NEΔT (220 K) ≦0.35 K (band 1) ≦1.00 K (band 1) ≦0.35 K (band 2) ≦0.90 K (band 2) ≦0.22 K (band 3) ≦1.50 K (band 3)

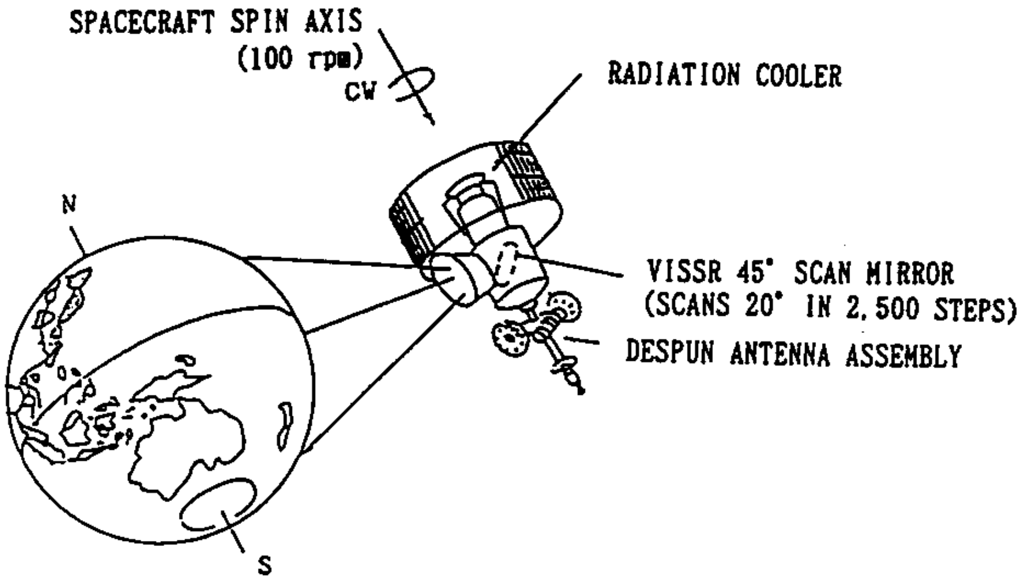

Fig.2.1.2 VISSR Spin-SCAN Geometry

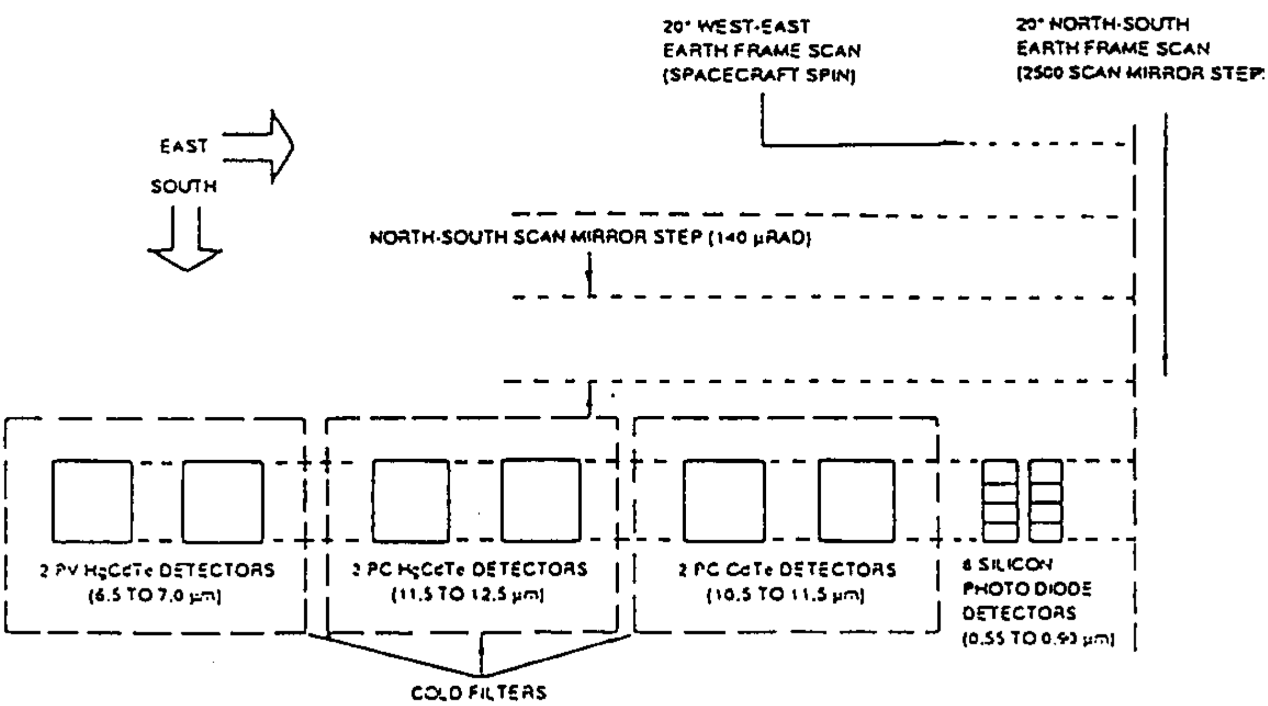

Fig.2.1.3 Image data Format

2.2 Calibration

The sensor output signals (Voltage) correspond to energy of light incident on the VISSR. Infrared channel brightness data and visible brightness data are quantized into 256(8bit) and 64 (6bit) levels by VDM (VISSR Digital Multiplexer), and are transmitted to CDAS. Infrared and visible level data are converted into temperature and albedo. This conversion is called calibration.

2.2.1 Visible data calibration

The visible calibration procedure is obtained through the following process (see Fig.2.2.1). The brightness levels are related to the voltage by the following equation,

$$L=b_0+b_1*\sqrt{V} \qquad (1)$$

where L and V are the brightness level and the sensor output voltage. The coefficients b_0 and b_1 are determined from the prelaunch test data.
Relationship between output voltage and albedo is expressed by Eq(2).

$$V=a*A+V_0 \qquad (2)$$

where A is albedo, and coefficeints a and V_0 are determined from the prelaunch test data. Then albedo is obtained from Eq.(3)

$$A=\{(L-b_0)/b_1\}^2/a-V_0/a \qquad (3)$$

The coefficients b_0, b_1 and V_0 have been utilized up to now. Spectral response of VIS is shown in Fig.2.2.2. The sensitivitiy of each detector is different. Adjustment of sensitivity among four detectors is carried out once after launch and called "Normalization of Visible".

2.2.2 Infrared data calibration

The brightness levels are related to the voltage by the following equation,

$$L=\beta_1*V+\beta_0 \qquad (4)$$

where L and V are brightness level and the sensor output voltage. The coefficients β_1 and β_0 are determined from the prelaunch test data.

The relation between the sensor output voltage and the radiation energy is obtained by the following equation,

$$V=d*R+V_0 \qquad (5)$$

where R is radiation energy. The coefficients d and V_0 are determined from blackbody shutter brightness level, space brightness level, effective shutter temperature (Te) computed by telemetry of GMS-5. The blackbody shutter voltage(Vsh) and space voltage(Vsp) are calculated substituting the blackbody shutter brightness level(Lsh) and space brightness level(Lsp) into Eq.(4).

A radiation energy R(Te) corresponding to effective shutter temperature Te is obtained from

$$R(Te)=\frac{\varepsilon\int\phi(\lambda)B(\lambda,Te)d\lambda}{\int\phi(\lambda)d\lambda} \qquad (6)$$

where λ is wave length, $B(\lambda, Te)$ is Plank's function, $\phi(\lambda)$ is a spectral response and ε is the emissivity of the shutter($\varepsilon=1.0$). Spectral responses of IR are shown in Fig.2.2.3 - 2.2.4.

The radiation energy in space is small and is regarded as 0. The coefficients d and V_0 of Eq.(5) determined from Eq.(7) and Eq.(8),

$$Vsp=d*0+V_0 \qquad (7)$$

$$Vsh=d*R(Te)+V_0 \qquad (8)$$

where Vsh and Vsp are obtained by Eq.(4), R(Te) is obtained by Eq.(6). Since Eq.(5) also can be expressed as

$$V=d*R+V_0=\frac{Vsh-Vsp}{R(Te)}*R+Vsp=G*R+Vsp \qquad (9)$$

Here,

$$G=\frac{Vsh-Vsp}{R(Te)}$$

The relation between brightness level L and radiation R is obtained from Eq.(4) and Eq.(9), as

$$R=\frac{L-\beta_0-Vsp*\beta_1}{\beta_1*G} \qquad (10)$$

The relation between radiation energy and temperature is given by the following equation.

$$R=\frac{\int\phi(\lambda)B(\lambda, Te)d\lambda}{\int\phi(\lambda)d\lambda} \qquad (11)$$

A calibration table between temperature and brightness level is made with Eq.(10) and Eq.(11). The infrared calibration procedure is shown in Fig.2.2.5.

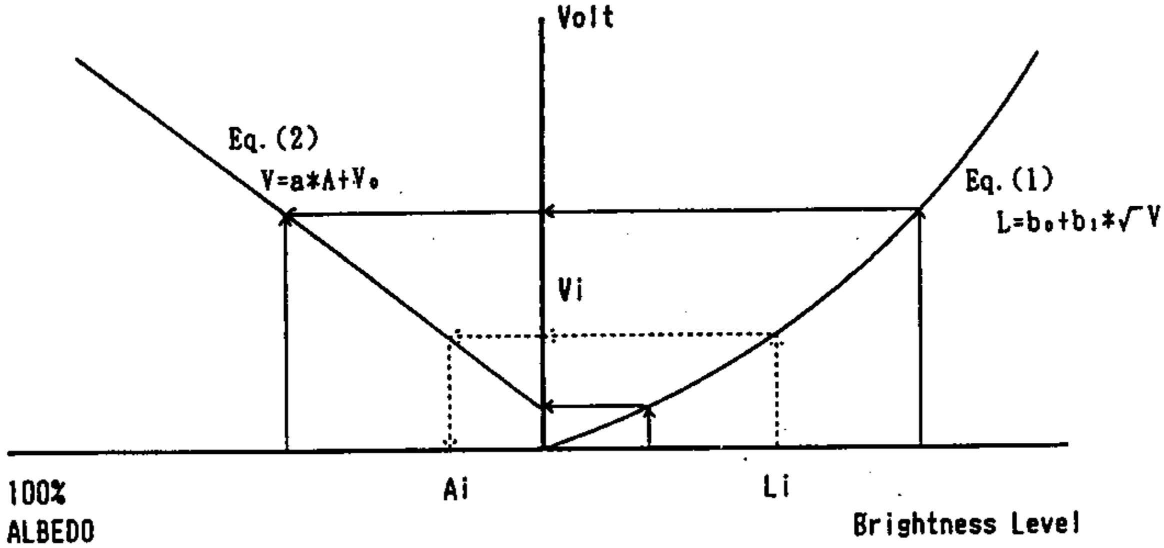

Fig.2.2.1 Visible calibration procedure

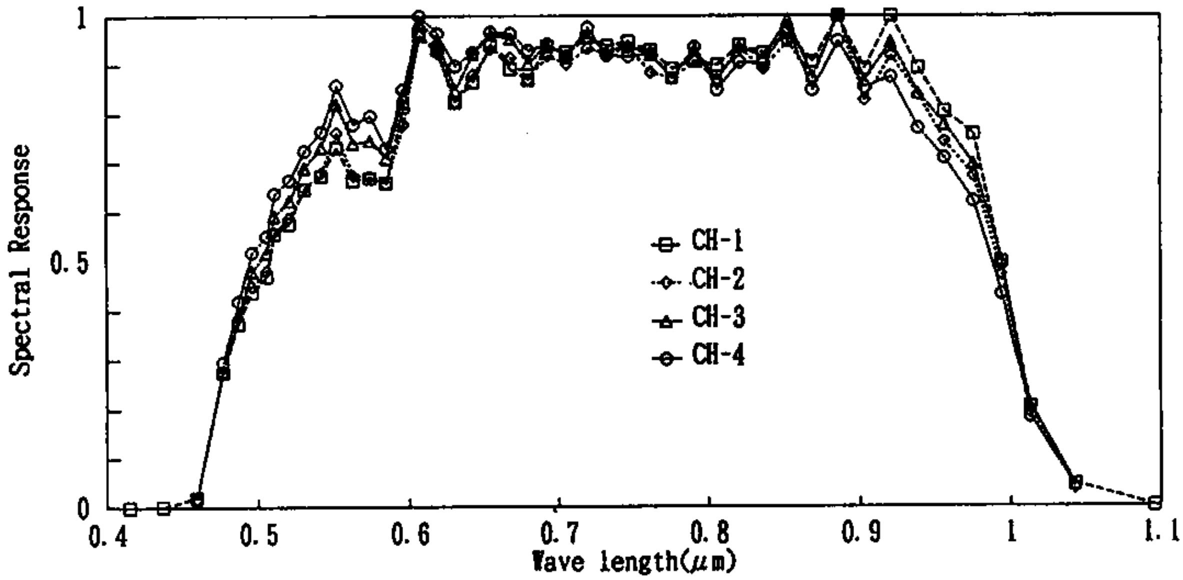

Fig.2.2.2 Spectral response of GMS-5 visible channels

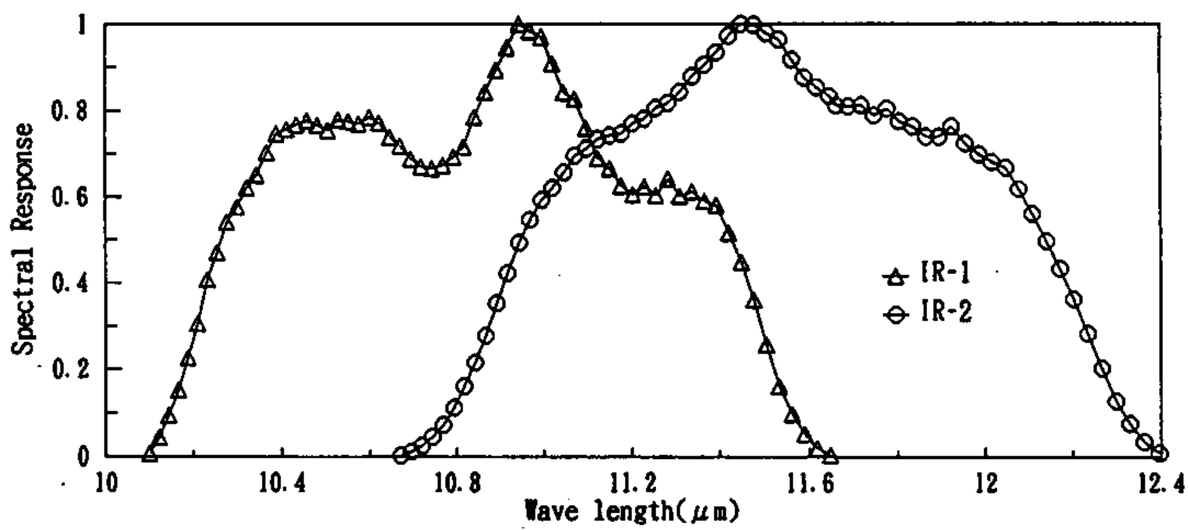

Fig.2.2.3 Spectral response of GMS-5 infrared channels 1 and 2

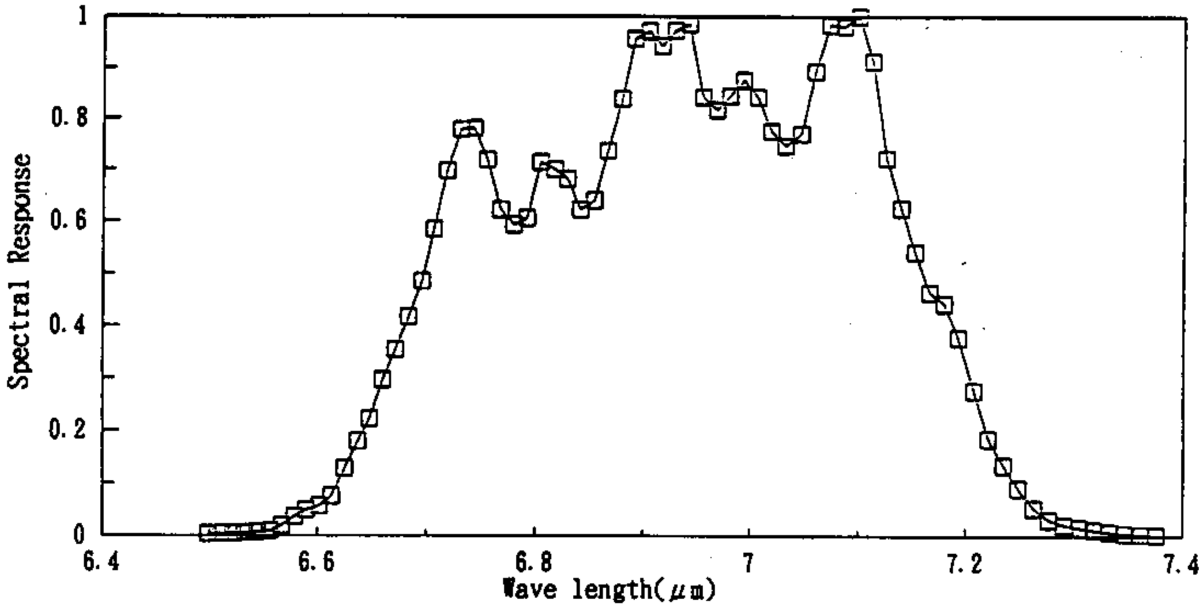

Fig.2.2.4 Spectral response of GMS-5 infrared channel 3

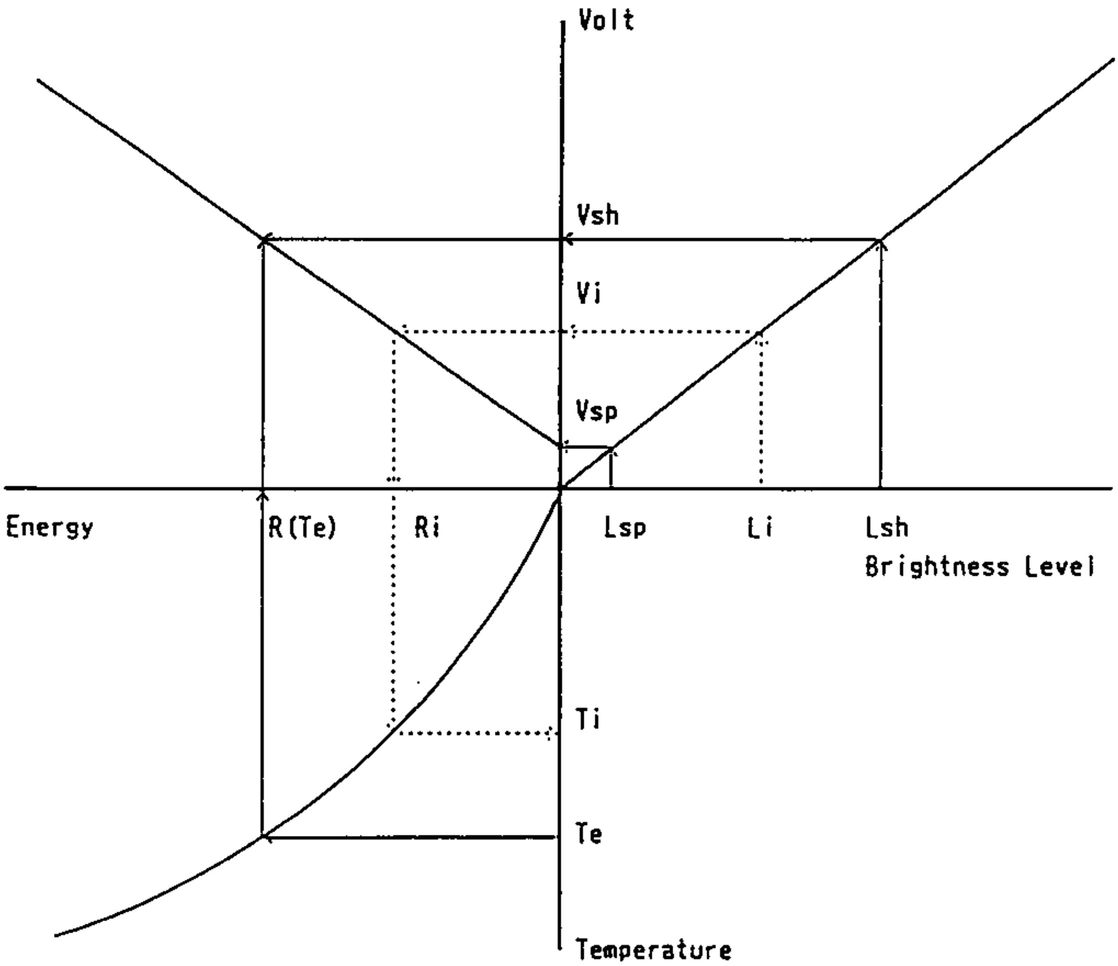

Fig.2.2.5 Infrared calibration procedure

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SECTION 3 VISSR OBSERVATION AND DIRECT DISSEMINATION OF CLOUD IMAGE

3.1 Stretched-VISSR

The Stretched-VISSR(S-VISSR) data are the digital image data for Medium scale Data Utilization Station(MDUS). The S-VISSR data format was revised in June of 1995 to fit the new format to GMS-5 which was additionally equipped with a water vapor channel and infrared split-window channels.

3.1.1 Contents of information sectors

S-VISSR data consists of a documentation sector, an infrared data sector and a visible data sector. The documentation sector is composed of spacecraft and CDAS status block, simplified mapping block 1, simplified mapping block 2, orbit and attitude information block including attitude/orbit prediction data sub blocks, manual amendment block and calibration information block.

The infrared data sector is composed of infrared-1(IR-1), infrared-2(IR-2) and water vapor(IR-3) data. The visible data sector is composed of visible 1, 2, 3 and 4 data. Details of the S-VISSR signal format and S-VISSR data format are given in APPENDIX A.

3.1.2 Infrared data brightness level conversion

There are two methods for conversion from S-VISSR brightness levels to brightness temperatures. One is to use the calibration table, and the other is to use the conversion table.

3.1.2.1 Calibration table

A calibration information block is newly added in the documentation sectors which consists of calibration tables for infrared and visible data and calibration coefficients for infrared data. The calibration tables for infrared data are updated at every observation. In case of visible data, the tables are prepared as fixed conversion tables.

3.1.2.2 Conversion table

The conversion table for infrared data has already been prepared and distributed to the MDUS users by a document. The values in the table were estimated from the result of a GMS-5 prelaunch test. The conversion tables for IR-1, IR-2 and IR-3 data are shown in tables 3.1, 3.2 and 3.3 respectively.

3.1.2.3 Notice to utilize

The conversion table is no consideration of diurnal and annual variations of the relationship between brightness level and brightness temperature. Then users need to understand that use of the conversion table possibly causes same errors in the corresponding brightness temperature due to the diurnal and annual variation.

3.1.3 Visible data brightness level conversion

In the case of visible data, both the calibration and conversion tables are really the same values, which are an assigned relationship between S-VISSR brightness levels and brightness albedo. The table for visible data is shown in table 3.4.

3.1.4 Dissemination schedule

S-VISSR data are disseminated simultaneously every VISSR observation. The dissemination schedule of S-VISSR data is shown in APPENDIX C.

Details of the revision are described in "REVISION OF GMS STRETCHED VISSR DATA FORMAT. (October 1993)

Table 3.1.1 level-temperature conversion table for IR-1 data

LEVEL	TEMPERATURE														
255	130.00	223	201.42	191	237.23	159	259.81	127	277.42	95	292.28	63	305.36	31	317.18
254	130.00	222	203.02	190	238.06	158	260.42	126	277.92	94	292.71	62	305.74	30	317.53
253	130.00	221	204.57	189	238.87	157	261.03	125	278.41	93	293.14	61	306.13	29	317.88
252	130.00	220	206.07	188	239.68	156	261.62	124	278.91	92	293.57	60	306.51	28	318.24
251	130.00	219	207.52	187	240.48	155	262.22	123	279.40	91	293.99	59	306.90	27	318.59
250	130.00	218	208.92	186	241.27	154	262.81	122	279.89	90	294.42	58	307.28	26	318.94
249	130.00	217	210.29	185	242.05	153	263.40	121	280.37	89	294.84	57	307.66	25	319.28
248	130.00	216	211.62	184	242.82	152	263.98	120	280.86	88	295.27	56	308.04	24	319.63
247	130.00	215	212.91	183	243.58	151	264.56	119	281.34	87	295.69	55	308.42	23	319.98
246	130.00	214	214.17	182	244.33	150	265.13	118	281.82	86	296.11	54	308.79	22	320.32
245	130.00	213	215.40	181	245.08	149	265.70	117	282.30	85	296.52	53	309.17	21	320.67
244	130.00	212	216.60	180	245.81	148	266.27	116	282.77	84	296.94	52	309.54	20	321.01
243	130.00	211	217.78	179	246.54	147	266.83	115	283.24	83	297.36	51	309.92	19	321.36
242	130.00	210	218.92	178	247.26	146	267.39	114	283.71	82	297.77	50	310.29	18	321.70
241	134.19	209	220.05	177	247.98	145	267.95	113	284.18	81	298.18	49	310.66	17	322.04
240	147.65	208	221.15	176	248.69	144	268.50	112	284.65	80	298.59	48	311.03	16	322.38
239	155.73	207	222.23	175	249.39	143	269.05	111	285.11	79	299.00	47	311.40	15	322.72
238	161.75	206	223.29	174	250.08	142	269.60	110	285.58	78	299.41	46	311.77	14	323.06
237	166.62	205	224.33	173	250.77	141	270.14	109	286.04	77	299.81	45	312.14	13	323.40
236	170.77	204	225.35	172	251.46	140	270.68	108	286.49	76	300.22	44	312.51	12	323.74
235	174.40	203	226.35	171	252.13	139	271.21	107	286.95	75	300.62	43	312.87	11	324.07
234	177.64	202	227.33	170	252.80	138	271.75	106	287.40	74	301.02	42	313.24	10	324.41
233	180.47	201	228.30	169	253.47	137	272.28	105	287.86	73	301.42	41	313.60	9	324.74
232	183.18	200	229.26	168	254.12	136	272.80	104	288.31	72	301.82	40	313.96	8	325.08
231	185.70	199	230.20	167	254.78	135	273.33	103	288.75	71	302.22	39	314.32	7	325.41
230	188.05	198	231.12	166	255.42	134	273.85	102	289.20	70	302.62	38	314.68	6	325.75
229	190.26	197	232.03	165	256.07	133	274.37	101	289.65	69	303.01	37	315.04	5	326.08
228	192.35	196	232.93	164	256.70	132	274.88	100	290.09	68	303.41	36	315.40	4	326.41
227	194.33	195	233.81	163	257.33	131	275.39	99	290.53	67	303.80	35	315.76	3	326.74
226	196.22	194	234.68	162	257.96	130	275.90	98	290.97	66	304.19	34	316.12	2	327.07
225	198.03	193	235.54	161	258.58	129	276.41	97	291.41	65	304.58	33	316.47	1	327.40
224	199.76	192	236.39	160	259.20	128	276.92	96	291.84	64	304.97	32	316.83	0	327.73

Table 3.1.2 level-temperature conversion table for IR-2 data

LEVEL	TEMPERATURE														
255	130.00	223	196.66	191	234.27	159	258.07	127	276.74	95	292.57	63	306.57	31	319.27
254	130.00	222	198.35	190	235.14	158	258.72	126	277.27	94	293.03	62	306.98	30	319.65
253	130.00	221	199.98	189	236.00	157	259.36	125	277.79	93	293.49	61	307.40	29	320.03
252	130.00	220	201.55	188	236.85	156	259.99	124	278.32	92	293.95	60	307.81	28	320.41
251	130.00	219	203.08	187	237.69	155	260.62	123	278.84	91	294.40	59	308.22	27	320.79
250	130.00	218	204.55	186	238.52	154	261.24	122	279.36	90	294.86	58	308.63	26	321.17
249	130.00	217	205.99	185	239.34	153	261.86	121	279.88	89	295.31	57	309.04	25	321.54
248	130.00	216	207.38	184	240.15	152	262.48	120	280.39	88	295.76	56	309.45	24	321.92
247	130.00	215	208.74	183	240.95	151	263.09	119	280.91	87	296.21	55	309.85	23	322.29
246	130.00	214	210.06	182	241.74	150	263.70	118	281.42	86	296.66	54	310.26	22	322.66
245	130.00	213	211.35	181	242.53	149	264.31	117	281.93	85	297.11	53	310.66	21	323.03
244	130.00	212	212.61	180	243.30	148	264.91	116	282.43	84	297.55	52	311.06	20	323.40
243	130.00	211	213.85	179	244.07	147	265.50	115	282.93	83	298.00	51	311.46	19	323.77
242	130.00	210	215.05	178	244.83	146	266.10	114	283.44	82	298.44	50	311.86	18	324.14
241	130.00	209	216.23	177	245.59	145	266.69	113	283.94	81	298.88	49	312.26	17	324.51
240	135.12	208	217.39	176	246.33	144	267.27	112	284.43	80	299.32	48	312.66	16	324.88
239	146.04	207	218.52	175	247.07	143	267.85	111	284.93	79	299.76	47	313.06	15	325.25
238	153.34	206	219.63	174	247.80	142	268.43	110	285.42	78	300.19	46	313.46	14	325.61
237	158.97	205	220.72	173	248.53	141	269.01	109	285.91	77	300.63	45	313.85	13	325.98
236	163.62	204	221.79	172	249.25	140	269.58	108	286.40	76	301.06	44	314.24	12	326.34
235	167.63	203	222.84	171	249.96	139	270.15	107	286.88	75	301.49	43	314.64	11	326.71
234	171.18	202	223.88	170	250.67	138	270.71	106	287.37	74	301.92	42	315.03	10	327.07
233	174.38	201	224.90	169	251.37	137	271.28	105	287.85	73	302.35	41	315.42	9	327.43
232	177.30	200	225.90	168	252.06	136	271.84	104	288.33	72	302.78	40	315.81	8	327.79
231	180.00	199	226.88	167	252.75	135	272.39	103	288.81	71	303.21	39	316.20	7	328.15
230	182.50	198	227.85	166	253.44	134	272.94	102	289.28	70	303.63	38	316.59	6	328.51
229	184.86	197	228.81	165	254.12	133	273.50	101	289.76	69	304.05	37	316.97	5	328.87
228	187.08	196	229.75	164	254.79	132	274.04	100	290.23	68	304.48	36	317.36	4	329.23
227	189.18	195	230.68	163	255.46	131	274.59	99	290.70	67	304.90	35	317.74	3	329.58
226	191.17	194	231.60	162	256.12	130	275.13	98	291.17	66	305.32	34	318.13	2	329.94
225	193.08	193	232.50	161	256.77	129	275.67	97	291.64	65	305.74	33	318.51	1	330.30
224	194.91	192	233.39	160	257.43	128	276.20	96	292.10	64	306.15	32	318.89	0	330.65

Table 3.1.3 level-temperature conversion table for IR-3 data

LEVEL	TEMPERATURE														
255	170.00	223	235.69	191	264.49	159	281.76	127	294.71	95	305.29	63	314.36	31	322.35
254	170.00	222	237.01	190	265.14	158	282.22	126	295.07	94	305.59	62	314.62	30	322.59
253	170.00	221	238.28	189	265.77	157	282.67	125	295.43	93	305.90	61	314.88	29	322.83
252	170.00	220	239.51	188	266.40	156	283.11	124	295.78	92	306.20	60	315.15	28	323.06
251	170.00	219	240.69	187	267.02	155	283.56	123	296.14	91	306.49	59	315.41	27	323.29
250	170.00	218	241.84	186	267.63	154	284.00	122	296.49	90	306.79	58	315.67	26	323.53
249	170.00	217	242.96	185	268.24	153	284.43	121	296.84	89	307.09	57	315.93	25	323.76
248	170.00	216	244.04	184	268.83	152	284.86	120	297.18	88	307.38	56	316.18	24	323.99
247	170.00	215	245.09	183	269.42	151	285.29	119	297.53	87	307.68	55	316.44	23	324.22
246	170.00	214	246.11	182	270.00	150	285.72	118	297.87	86	307.97	54	316.70	22	324.45
245	170.00	213	247.11	181	270.58	149	286.14	117	298.22	85	308.26	53	316.95	21	324.68
244	170.00	212	248.08	180	271.14	148	286.56	116	298.56	84	308.55	52	317.21	20	324.91
243	170.00	211	249.03	179	271.70	147	286.98	115	298.89	83	308.84	51	317.46	19	325.14
242	175.70	210	249.96	178	272.26	146	287.39	114	299.23	82	309.12	50	317.72	18	325.36
241	186.71	209	250.86	177	272.81	145	287.80	113	299.56	81	309.41	49	317.97	17	325.59
240	193.76	208	251.75	176	273.35	144	288.21	112	299.90	80	309.70	48	318.22	16	325.82
239	199.14	207	252.61	175	273.88	143	288.61	111	300.23	79	309.98	47	318.47	15	326.04
238	203.52	206	253.46	174	274.41	142	289.01	110	300.56	78	310.26	46	318.72	14	326.27
237	207.24	205	254.29	173	274.94	141	289.41	109	300.88	77	310.54	45	318.97	13	326.49
236	210.49	204	255.11	172	275.46	140	289.80	108	301.21	76	310.82	44	319.21	12	326.71
235	213.40	203	255.91	171	275.97	139	290.20	107	301.53	75	311.10	43	319.46	11	326.94
234	216.03	202	256.69	170	276.48	138	290.59	106	301.85	74	311.38	42	319.71	10	327.16
233	218.43	201	257.46	169	276.98	137	290.97	105	302.17	73	311.65	41	319.95	9	327.38
232	220.66	200	258.22	168	277.48	136	291.36	104	302.49	72	311.93	40	320.19	8	327.60
231	222.72	199	258.96	167	277.97	135	291.74	103	302.81	71	312.20	39	320.44	7	327.82
230	224.65	198	259.69	166	278.46	134	292.12	102	303.13	70	312.48	38	320.68	6	328.04
229	226.48	197	260.41	165	278.95	133	292.50	101	303.44	69	312.75	37	320.92	5	328.26
228	228.20	196	261.12	164	279.43	132	292.87	100	303.75	68	313.02	36	321.16	4	328.48
227	229.84	195	261.81	163	279.90	131	293.24	99	304.06	67	313.29	35	321.40	3	328.69
226	231.40	194	262.50	162	280.37	130	293.61	98	304.37	66	313.56	34	321.64	2	328.91
225	232.89	193	263.17	161	280.84	129	293.98	97	304.68	65	313.82	33	321.88	1	329.13
224	234.32	192	263.84	160	281.30	128	294.34	96	304.99	64	314.09	32	322.12	0	329.34

Table 3.1.4 level-albedo calibration/conversion table for visible data

LEVEL	ALBEDO	LEVEL	ALBEDO	LEVEL	ALBEDO	LEVEL	ALBEDO
0	0.000000	16	0.064500	32	0.258000	48	0.580499
1	0.000252	17	0.072814	33	0.274376	49	0.604938
2	0.001008	18	0.081633	34	0.291257	50	0.629882
3	0.002268	19	0.090955	35	0.308642	51	0.655329
4	0.004031	20	0.100781	36	0.326531	52	0.681280
5	0.006299	21	0.111111	37	0.344923	53	0.707735
6	0.009070	22	0.121945	38	0.363820	54	0.734694
7	0.012346	23	0.133283	39	0.383220	55	0.762157
8	0.016125	24	0.145125	40	0.403124	56	0.790123
9	0.020408	25	0.157470	41	0.423532	57	0.818594
10	0.025195	26	0.170320	42	0.444444	58	0.847569
11	0.030486	27	0.183673	43	0.465860	59	0.877047
12	0.036281	28	0.197531	44	0.487780	60	0.907029
13	0.042580	29	0.211892	45	0.510204	61	0.937516
14	0.049383	30	0.226757	46	0.533132	62	0.968506
15	0.056689	31	0.242126	47	0.556563	63	1.000000

3.2 WEFAX

WEFAX is the analog facsimile image data processed from VISSR imagery at the DPC and made available for meteorological analysis in appropriate forms (e.g. addition of grid and coast line or polar-stereographic projection). WEFAX is disseminated via GMS for SDUS users hourly, 3-hourly or 12-hourly.

3.2.1 Classification of pictures

WEFAX has two projection types. One is four-sectorized earth disk pictures with overlapping borders. The other is a polar-stereographic projection picture covering the Far East area including Japan. These are:

- Four-sectorized earth disk pictures;
  "A", "B", "C" and "D" pictures are in IR-1 (atmospheric window band: 10.5 - 11.5μm),
  "K", "L", "M" and "N" pictures are WV (water vapor band: 6.5 - 7.0μm).
- Polar-stereographic picture;
  "H" is IRI,
  "I" is VIS (visible band: 0.5 - 0.9 μm),
  "J" is the enhanced infrared (IR-1).

IR-2 (atmospheric window band for split window: 11.5 - 12.5 μm) is not used for WEFAX. Examples of the above pictures are shown in Figure 3.2.1 through 3.2.3.

The schedule of WEFAX dissemination is described in "3.3 Schedule of Observation and Dissemination".

3.2.2 Data Format

SDUS specification are shown in Appendix B. WEFAX picture data consists of annotation code, gray scale, scale mark, annotation lines and image lines. One picture is composed of 800 lines and each line is composed of 1710 pixels, each of which conveys one of 64 levels.

The gray scale represents the 16 references from zero up to 60 in every four levels (0, 4, 8,.., 56, 60). The scale mark is put under the gray scale and indicates the boundaries of the brightness level in the gray scale. The annotation shows the image information. This information contains satellite name, distinction of channels, observation time and picture classification (H/I/J, A-D or K-N). The annotation code is serial bit data which is contained above annotation character into EBCDIC code for users.

3.2.3 Brightness Level Conversion

The brightness level conversion relates the energy of the VISSR and the WEFAX brightness level. VISSR data are converted to WEFAX image data according to the temperature or albedo conversion table shown in Table 3.2.1(1) through (6).

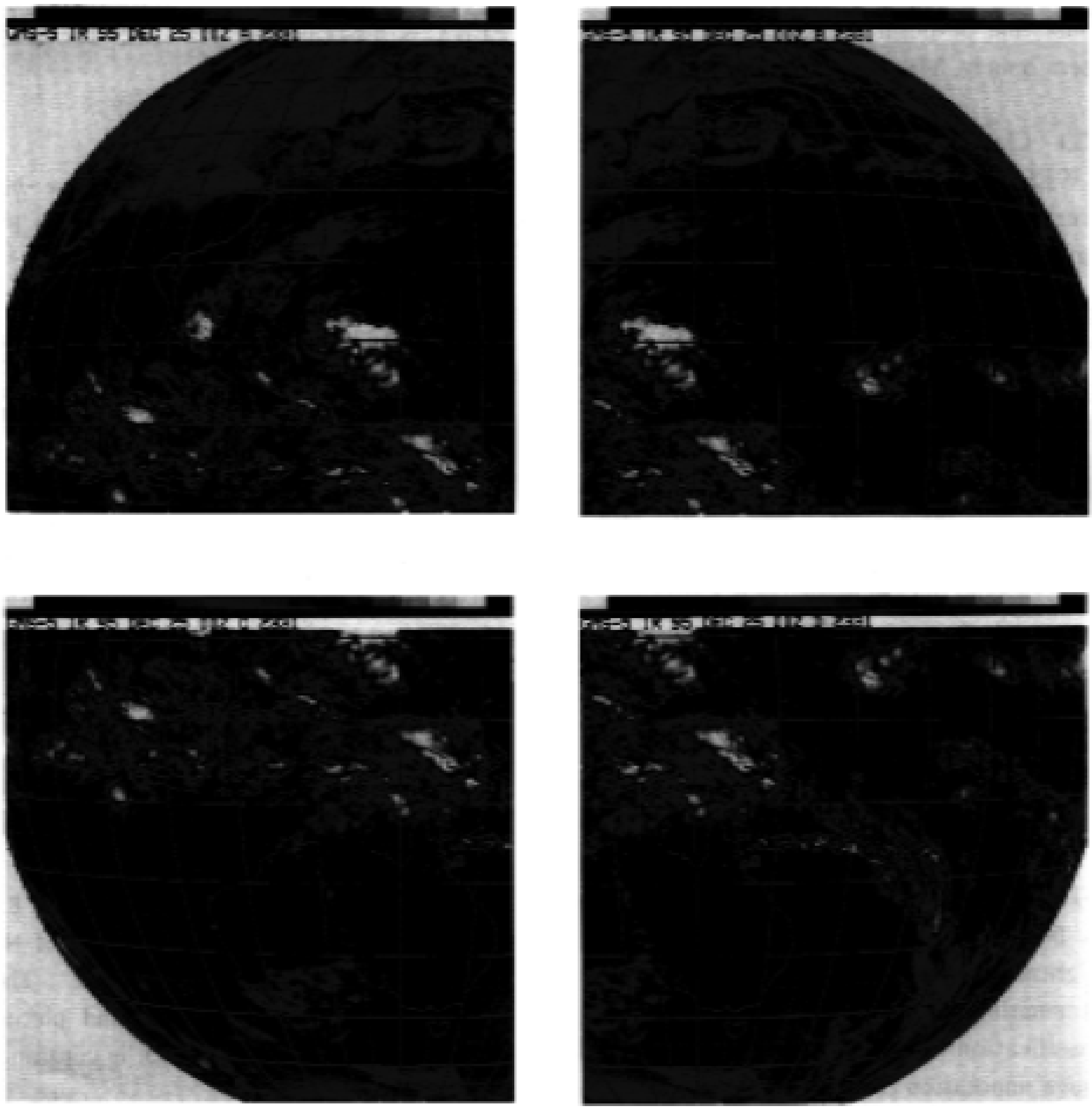

Fig.3.2.1 Infrared four-sectored disk pictures (A,B,C and D)

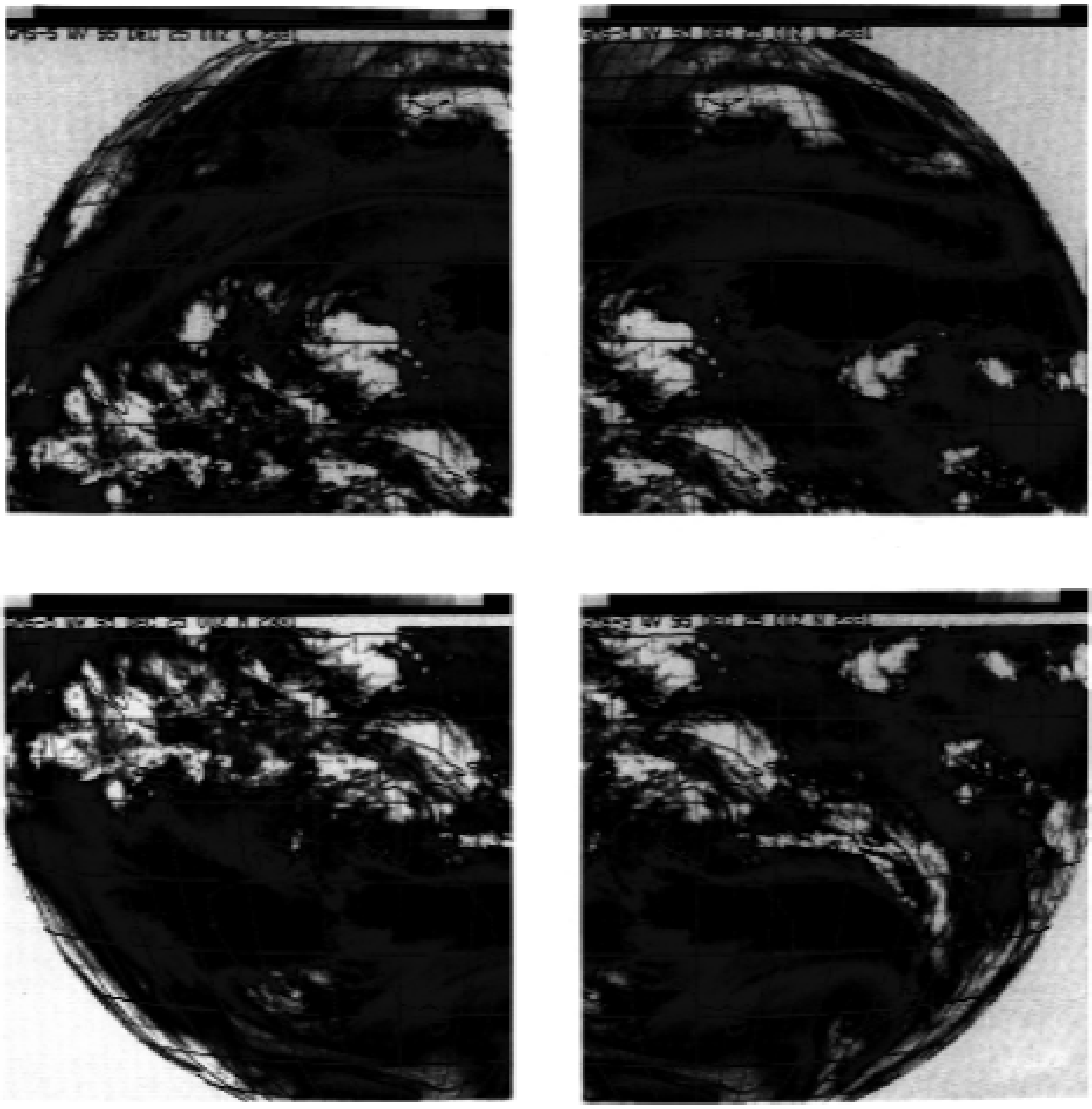

Fig.3.2.2 Water Vapor four-sectored disk pictures (K,L,M and N)

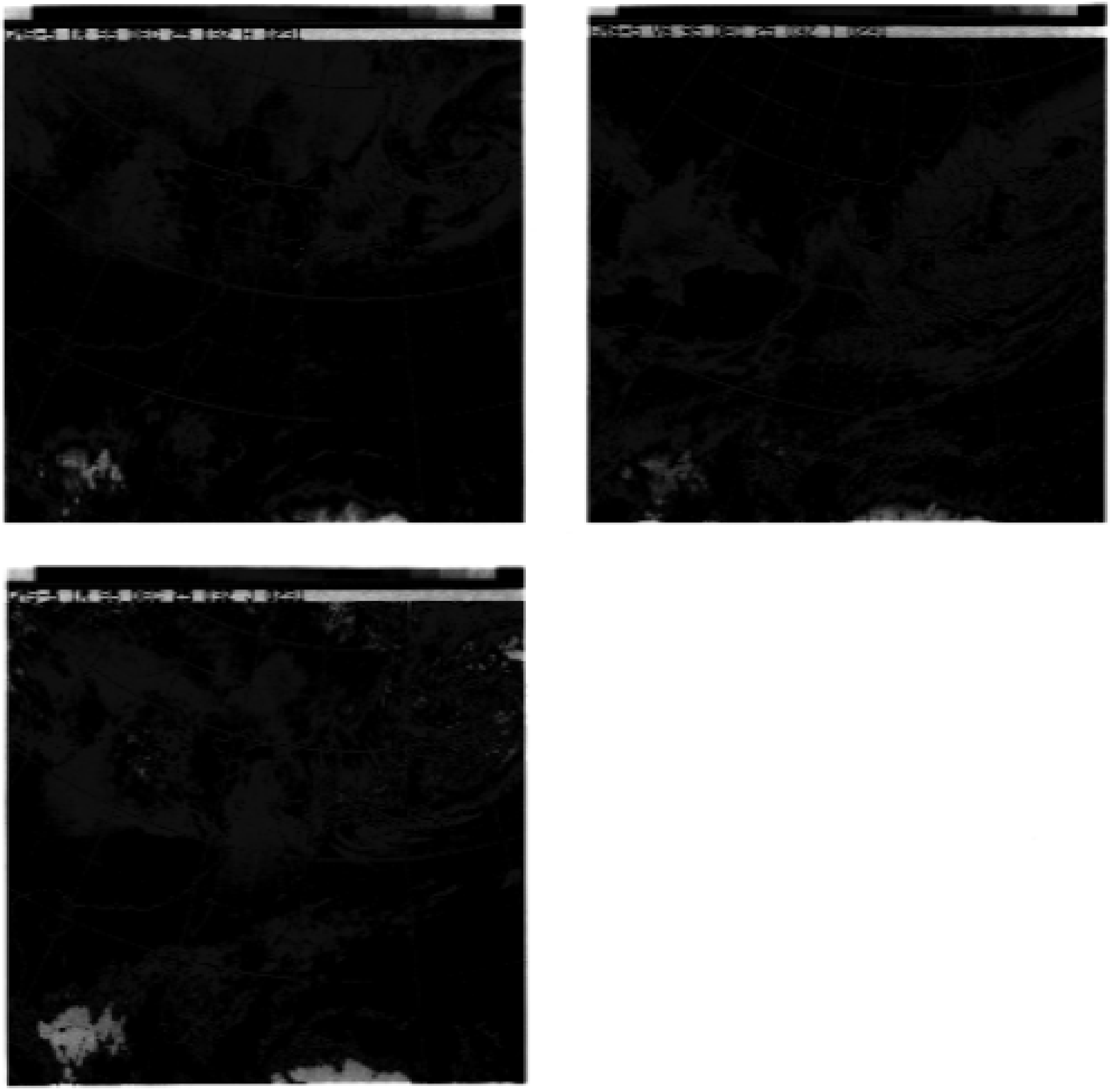

Fig.3.2.3 Infrared Polar - stereographic picture (H) (upper left), visible polar - stereographic picture (I) (upper right) and enhanced infrared polar-stereographic picture (J) (lower left).

Table 3.2.1 WEFAX brightness level conversion table

(1) WEFAX infrared image brightness level / temperature conversion table

level	temperature (K)	level	temperature (K)	level	temperature (K)	level	temperature (K)
61	- 196.78	46	221.24 - 222.97	31	247.43 - 249.16	16	273.62 - 275.35
60	196.79 - 198.53	45	222.98 - 224.72	30	249.17 - 250.91	15	275.36 - 277.10
59	198.54 - 200.27	44	224.73 - 226.46	29	250.92 - 252.66	14	277.11 - 278.85
58	200.28 - 202.02	43	226.47 - 228.21	28	252.67 - 254.40	13	278.86 - 280.59
57	202.03 - 203.77	42	228.22 - 229.96	27	254.41 - 256.15	12	280.60 - 282.34
56	203.78 - 205.51	41	229.97 - 231.70	26	256.16 - 257.89	11	282.35 - 284.08
55	205.52 - 207.26	40	231.71 - 233.45	25	257.90 - 259.64	10	284.09 - 285.83
54	207.27 - 209.00	39	233.46 - 235.19	24	259.65 - 261.39	9	285.84 - 287.58
53	209.01 - 210.75	38	235.20 - 236.94	23	261.40 - 263.13	8	287.59 - 289.32
52	210.76 - 212.50	37	236.95 - 238.69	22	263.14 - 264.88	7	289.33 - 291.07
51	212.51 - 214.24	36	238.70 - 240.43	21	264.89 - 266.62	6	291.08 - 292.81
50	214.25 - 215.99	35	240.44 - 242.18	20	266.63 - 268.37	5	292.82 - 294.56
49	216.00 - 217.73	34	242.19 - 243.92	19	268.38 - 270.12	4	294.57 - 296.31
48	217.74 - 219.48	33	243.93 - 245.67	18	270.13 - 271.86	3	296.32 - 298.05
47	219.49 - 221.23	32	245.68 - 247.42	17	271.87 - 273.61	2	298.06 -

(2) WEFAX visible image brightness level / albedo conversion table

level	albedo (%)	level	albedo (%)	level	albedo (%)	level	albedo (%)
3	0.000 - 0.033	18	0.157 - 0.166	33	0.316 - 0.327	48	0.523 - 0.540
4	0.034 - 0.042	19	0.167 - 0.176	34	0.328 - 0.339	49	0.541 - 0.561
5	0.043 - 0.051	20	0.177 - 0.186	35	0.340 - 0.352	50	0.562 - 0.581
6	0.052 - 0.060	21	0.187 - 0.197	36	0.353 - 0.364	51	0.582 - 0.602
7	0.061 - 0.069	22	0.198 - 0.207	37	0.365 - 0.376	52	0.603 - 0.622
8	0.070 - 0.077	23	0.208 - 0.217	38	0.377 - 0.388	53	0.623 - 0.643
9	0.078 - 0.086	24	0.218 - 0.228	39	0.389 - 0.401	54	0.644 - 0.668
10	0.087 - 0.095	25	0.229 - 0.238	40	0.402 - 0.415	55	0.669 - 0.699
11	0.096 - 0.104	26	0.239 - 0.248	41	0.416 - 0.430	56	0.700 - 0.730
12	0.105 - 0.113	27	0.249 - 0.258	42	0.431 - 0.445	57	0.731 - 0.760
13	0.114 - 0.121	28	0.259 - 0.268	43	0.446 - 0.461	58	0.761 - 0.807
14	0.122 - 0.130	29	0.269 - 0.279	44	0.462 - 0.476	59	0.808 - 0.868
15	0.131 - 0.139	30	0.280 - 0.290	45	0.477 - 0.491	60	0.869 - 1.000
16	0.140 - 0.148	31	0.291 - 0.302	46	0.492 - 0.507		
17	0.149 - 0.156	32	0.303 - 0.315	47	0.508 - 0.522		

(3) WEFAX enhanced infrared image brightness level / temperature conversion table (Summer ; 1 June - 14 October)

level	temperature (K)	level	temperature (K)	level	temperature (K)	level	temperature (K)
60	- 202.14	48	271.82 - 273.40	32	281.31 - 281.82	16	289.73 - 290.25
40	202.15 - 211.14	47	273.41 - 273.93	31	281.83 - 282.35	15	290.26 - 290.77
20	211.15 - 223.14	46	273.94 - 274.46	30	282.36 - 282.88	14	290.78 - 291.30
3	223.15 - 241.14	45	274.47 - 274.98	29	282.89 - 283.40	13	291.31 - 291.82
60	241.15 - 242.47	44	274.99 - 275.51	28	283.41 - 283.93	12	291.83 - 292.35
59	242.48 - 245.14	43	275.52 - 276.04	27	283.94 - 284.46	11	292.36 - 292.88
58	245.15 - 247.81	42	276.05 - 276.56	26	284.47 - 284.98	10	292.89 - 294.64
57	247.82 - 250.47	41	276.57 - 277.09	25	284.99 - 285.51	9	294.65 - 297.64
56	250.48 - 253.14	40	277.10 - 277.61	24	285.52 - 286.04	8	297.65 - 300.64
55	253.15 - 255.81	39	277.62 - 278.14	23	286.05 - 286.56	7	300.65 - 303.64
54	255.82 - 258.47	38	278.15 - 278.67	22	286.57 - 287.09	6	303.65 - 306.64
53	258.48 - 261.14	37	278.68 - 279.19	21	287.10 - 287.61	5	306.65 - 309.64
52	261.15 - 263.81	36	279.20 - 279.72	20	287.62 - 288.14	4	309.65 - 312.64
51	263.82 - 266.47	35	279.73 - 280.25	19	288.15 - 288.67	3	312.65 -
50	266.48 - 269.14	34	280.26 - 280.77	18	288.68 - 289.19		
49	269.15 - 271.81	33	280.78 - 281.30	17	289.20 - 289.72		

(4) WEFAX enhanced infrared image brightness level / temperature conversion table (Winter ; 1 December - 14 March)

level	temperature (K)	level	temperature (K)	level	temperature (K)	level	temperature (K)
60	- 218.19	49	247.68 - 248.53	33	261.48 - 262.33	17	275.27 - 276.12
46	218.20 - 223.19	48	248.54 - 249.40	32	262.34 - 263.19	16	276.13 - 276.98
32	223.20 - 228.19	47	249.41 - 250.26	31	263.20 - 264.05	15	276.99 - 277.84
18	228.20 - 233.19	46	250.27 - 251.12	20	264.06 - 264.91	14	277.85 - 278.71
3	233.20 - 238.19	45	251.13 - 251.98	29	264.92 - 265.78	13	278.72 - 279.57
60	238.20 - 239.05	44	251.99 - 252.85	28	265.79 - 266.64	12	279.58 - 280.43
59	239.06 - 239.91	43	252.86 - 253.71	27	266.65 - 267.50	11	280.44 - 281.29
58	239.92 - 240.78	42	253.72 - 254.57	26	267.51 - 268.36	10	281.30 - 282.16
57	240.79 - 241.64	41	254.58 - 255.43	25	268.37 - 269.22	9	282.17 - 283.02
56	241.65 - 242.50	40	255.44 - 256.29	24	269.23 - 270.09	8	283.03 - 283.88
55	242.51 - 243.36	39	256.30 - 257.16	23	270.10 - 270.95	7	283.89 - 284.74
54	243.37 - 244.22	38	257.17 - 258.02	22	270.96 - 271.81	6	284.75 - 285.60
53	244.23 - 245.09	37	258.03 - 258.88	21	271.82 - 272.67	5	285.61 - 286.46
52	245.10 - 245.95	36	258.89 - 259.74	20	272.68 - 273.53	4	286.47 - 287.33
51	245.96 - 246.81	35	259.75 - 260.60	19	273.54 - 274.40	3	287.34 - 288.19
50	246.82 - 247.67	34	260.61 - 261.47	18	274.41 - 275.26	2	288.20 -

(5) WEFAX enhanced infrared image brightness level/temperature conversion table (Spring/Autumn ; 15 March-31 May/15 October-30 November)

level	temperature (K)	level	temperature (K)	level	temperature (K)	level	temperature (K)
61	- 213.15	49	261.59 - 262.86	32	278.50 - 279.15	15	289.83 - 290.49
47	213.16 - 220.15	48	262.87 - 264.15	31	279.16 - 279.82	14	290.50 - 291.15
32	220.16 - 227.15	47	264.16 - 265.44	30	279.83 - 280.49	13	291.16 - 291.82
17	227.16 - 234.15	46	265.45 - 266.72	29	280.50 - 281.15	12	291.83 - 292.49
2	234.16 - 242.15	45	266.73 - 268.01	28	281.16 - 281.82	11	292.50 - 293.15
61	242.16 - 243.44	44	268.02 - 269.29	27	281.83 - 282.49	10	293.16 - 295.65
60	243.45 - 245.72	43	269.30 - 270.58	26	282.50 - 283.15	9	295.66 - 298.15
59	245.73 - 248.01	42	270.59 - 271.86	25	283.16 - 283.82	8	298.16 - 300.65
58	248.02 - 250.29	41	271.87 - 273.15	24	283.83 - 284.49	7	300.66 - 303.15
57	250.30 - 252.58	40	273.16 - 273.82	23	284.50 - 285.15	6	303.16 - 305.65
56	252.59 - 253.87	39	273.83 - 274.49	22	285.16 - 285.82	5	305.66 - 308.15
55	253.88 - 255.15	38	274.50 - 275.15	21	285.83 - 286.49	4	308.16 - 310.65
54	255.16 - 256.44	37	275.16 - 275.82	20	286.50 - 287.15	3	310.66 - 313.15
53	256.45 - 257.72	36	275.83 - 276.49	19	287.16 - 287.82	2	313.16 -
52	257.73 - 259.01	35	276.50 - 277.15	18	287.83 - 288.49		
51	259.02 - 260.29	34	277.16 - 277.82	17	288.50 - 289.15		
50	260.30 - 261.58	33	277.83 - 278.49	16	289.16 - 289.82		

(6) WEFAX water-vapor image brightness level / temperature conversion table

level	temperature (K)	level	temperature (K)	level	temperature (K)	level	temperature (K)
63	- 223.14	47	237.44 - 238.19	31	248.15 - 248.72	15	256.55 - 257.01
62	223.15 - 224.31	46	238.20 - 238.95	30	248.73 - 249.29	14	257.02 - 257.48
61	224.32 - 225.45	45	238.96 - 239.69	29	249.30 - 249.85	13	257.49 - 257.94
60	225.46 - 226.54	44	239.70 - 240.41	28	249.86 - 250.41	12	257.95 - 258.40
59	226.55 - 227.60	43	240.42 - 241.12	27	250.42 - 250.96	11	258.41 - 258.85
58	227.61 - 228.62	42	241.13 - 241.81	26	250.97 - 251.50	10	258.86 - 259.30
57	228.63 - 229.61	41	241.82 - 242.49	25	251.51 - 252.03	9	259.31 - 259.74
56	229.62 - 230.57	40	242.50 - 243.17	24	252.04 - 252.56	8	259.75 - 260.18
55	230.58 - 231.51	39	243.18 - 243.82	23	252.57 - 253.08	7	260.19 - 260.62
54	231.52 - 232.42	38	243.83 - 244.47	22	253.09 - 253.59	6	260.63 - 261.05
53	232.43 - 233.31	37	244.48 - 245.11	21	253.60 - 254.10	5	261.06 - 261.47
52	233.32 - 234.17	36	245.12 - 245.73	20	254.11 - 254.60	4	261.48 - 261.90
51	234.18 - 235.01	35	245.74 - 246.35	19	254.61 - 255.09	3	261.91 - 262.31
50	235.02 - 235.84	34	246.36 - 246.96	18	255.10 - 255.58	2	262.32 - 262.73
49	235.85 - 236.64	33	246.97 - 247.55	17	255.59 - 256.06	1	262.74 - 263.14
48	236.65 - 237.43	32	247.56 - 248.14	16	256.07 - 256.54	0	263.15 -

3.3 Schedule of VISSR Observation and WEFAX Dissemination

After the observation by VISSR earth images are processed to WEFAX and are disseminated to users. These processes are carried out automatically according to the schedule. The schedule is based on hourly full-disk observation and can be modified according to the situation, i.e., the satellite eclipse and solar-interference, etc. The stretched VISSR data are disseminated simultaneously via GMS.

Schedule of observation and dissemination is shown in Appendix C (Fig.C.1 and Fig.C.2).

3.3.1 Regular Observation Schedule

The VISSR full-disk observation is carried out hourly. Additionally, 6-hourly full-disk observation is carried out 4 times for wind extraction. Pictures of hourly observation are called "Picture of 00UTC or 01UTC" etc. But they are actually observed from 2330 to 0000 UTC, from 0030 to 0100UTC,etc. And these times 00UTC,01UTC are called "Observation time." Hourly full-disk observation take 25 minutes and scanning starts ordinarily 28 minutes before the observation time. Observation at 05,11,17 and 23UTC start 35 minutes before the observation time, and observation for wind extraction starts 2 minutes after the observation time.

As for the WEFAX dissemination, pictures H and I(J at night) are disseminated hourly via GMS. Four-sectorized full-disk picture (picture A, B, C and D) are disseminated 3-hourly after the dissemination of picture H and I(J). In case of the observation for wind extraction (05,11,17 and 23UTC), only picture H is disseminated. Four-sectorized water vapor picture (picture K, L, M, and N) at 00 and 12UTC observation are disseminated at 0110 and 1310UTC.

3.3.2 Observation Schedule for the Satellite Eclipse Period

GMS enters the shade of the earth in the midnight for 45 days around the vernal equinox and the autumnal equinox. The periods of satellite eclipse are from late in February to early in April and from late in August to early in October. During these periods, the observations at 14 and 15UTC are stopped and the observation at 16UTC is delayed for 10 minutes. The WEFAX dissemination of 16UTC via GMS is also delayed for 10 minutes.

3.3.3 Observation Schedule at Solar-interference

When the sun, GMS and the antenna at CDAS are located all in a line, signal reception at CDAS is influenced by noise of the sun(solar-interference). Solar-interference continues about 6 days around the beginning of vernal eclipse period and the end of autumnal eclipse period. During these periods, the observation at 03UTC is stopped, and the dissemination of WEFAX at 03UTC(H,I,A,B,C,D) is carried out by using the image observed at 02UTC.

3.3.4 Typhoon Special Observation Schedule

In case of the typhoon special observation, observation at 04UTC for full-disk coverage is changed to the northern half-disk coverage, and additionally, other two northern half-disk observations are performed from 0345 to 0400UTC and 0400 to 0415UTC. The WEFAX dissemination of 04UTC is delayed for 15 minutes and only the image H is disseminated.

3.3.5 Observation Schedule for System Maintenance

In case of maintenance of the ground subsystem, observation at 02UTC for full-disk coverage is changed to the northern half-disk coverage. WEFAX dissemination at 02UTC may be canceled depending on the kind of system maintenance.

3.3.6 WEFAX MANAM(Manual Amendment) and Test Pattern

MANAM informs users of weekly WEFAX dissemination schedule and is disseminated according to the schedule shown in Appendix C (Fig.C.1). The contents of MANAM is updated at 08UTC on Thursday. An example of MANAM is shown in Appendix D (Fig.D.1).

WEFAX test pattern is disseminated at 02 and 08UTC on Sunday in place of MANAM.

3.3.7 S-VISSR MANAM

MANAM informs users of weekly S-VISSR dissemination schedule and is disseminated according to the schedule shown in Appendix C(Fig.C.1). The contents of S-VISSR MANAM is updated at 16UTC on Thursday. An example of S-VISSR MANAM is shown in Appendix D(Fig.D.2).

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SECTION 4 METEOROLOGICAL PRODUCTS

4.1 The outline of the product processings

The process flow in MSC to make products from VISSR image data observed by GMS-5 is shown in the outline figure of Fig.4.1.1. The derived products are disseminated to the JMA headquarters via ADESS, and some of those products, e.g., the Wind Vector, SAREP(WMO international code) for typhoon analysis are also disseminated to foreign meteorological organizations via GTS.

Products from VISSR image data are classified into following four categories by the kind of the used Basic Data (Basic Histogram Data, Cloud Grid Data, Image Data for display and Pre-processed Image Data), etc..

(1) The product processings from the Basic Histogram Data or 2-Dimensional Histogram Data

The Basic Histogram Data are the frequency distribution of pixels for brightness levels in each 0.25° latitude/longitude grid segment on each data of VIS, IR1 and WV channels and the data of the difference between IR1 and IR2 channels. The 2-Dimensional Histogram Data are made from the data of two channels, IR1 and WV, or of IR1 and IR2, in each 0.25° latitude/longitude grid segment.

Products by using these data are the Longwave Radiation (mean brightness temperature), the Cloud Amount (for climatology), the OLR(Outgoing Longwave Radiation), the GPCP(Global Precipitation Climatology Project), the Precipitable Water Amount and the Upper Toroposphere Humidity. As regarding the Precipitable Water Amount and the Upper Toroposphere Humidity, the Cloud Grid Data are also used to identify the grid segments for the product processings. And the processed data for the Precipitable Water Amount, the Upper Toroposphere Humidity and the OLR are fed back to the Cloud Grid Data in addition to being saved in each accumulation file.

(2) The product processings from the Cloud Grid Data

The Cloud Grid Data are the grid data with 0.25° latitude/longitude resolution processed from the Basic Histogram Data or the 2-Dimensional Histogram Data. The Cloud Grid Data are the data base including not only the statistical data (the mean data, standard deviation, etc.) for the brightness temperatures and albedo about total pixels in each segment, the statistical data for those about the pixels considered as clouds in each segment, the cloud amount for each layer, etc., but also the data of the Precipitable Water Amount, the Upper Toroposphere Humidity, the OLR, the Sea Surface Temperature and the Convective Cloud Amount.

(3) The product processings by the use of the Pre-processed Image Data or the Image Data for display

The Pre-processed Image Data and the Image Data for display are made by being navigated and cut out from VISSR Image data in order to usefully image the data on man-machine interactive processings etc.. As regarding the Image Data for display, its file format is transformed to the one for the workstation.

SAREP (typhoon analysis), the Wind Vector and the Cloud Information Chart (Vicinity of

Japan) are made by the use of these data through man-machine processes in workstations. Besides, as regarding Cloud Information Chart (Vicinity of Japan), the data except these image data, which have been already processed in the host computer are also used.

(4) Product processings from VISSR Image Data

The ISCCP(International Satellite Cloud Climatology Project), the satellite-derived Index of Precipitation Intensity, the Solar irradiation, the Sea Surface Temperature and the Cloud Information Chart (Far East) are directly made from VISSR Image Data.

The Cloud Information Chart (Far East) is made in its exclusive workstations. The required VISSR Image Data for this product processing are automatically transported from the host computer.

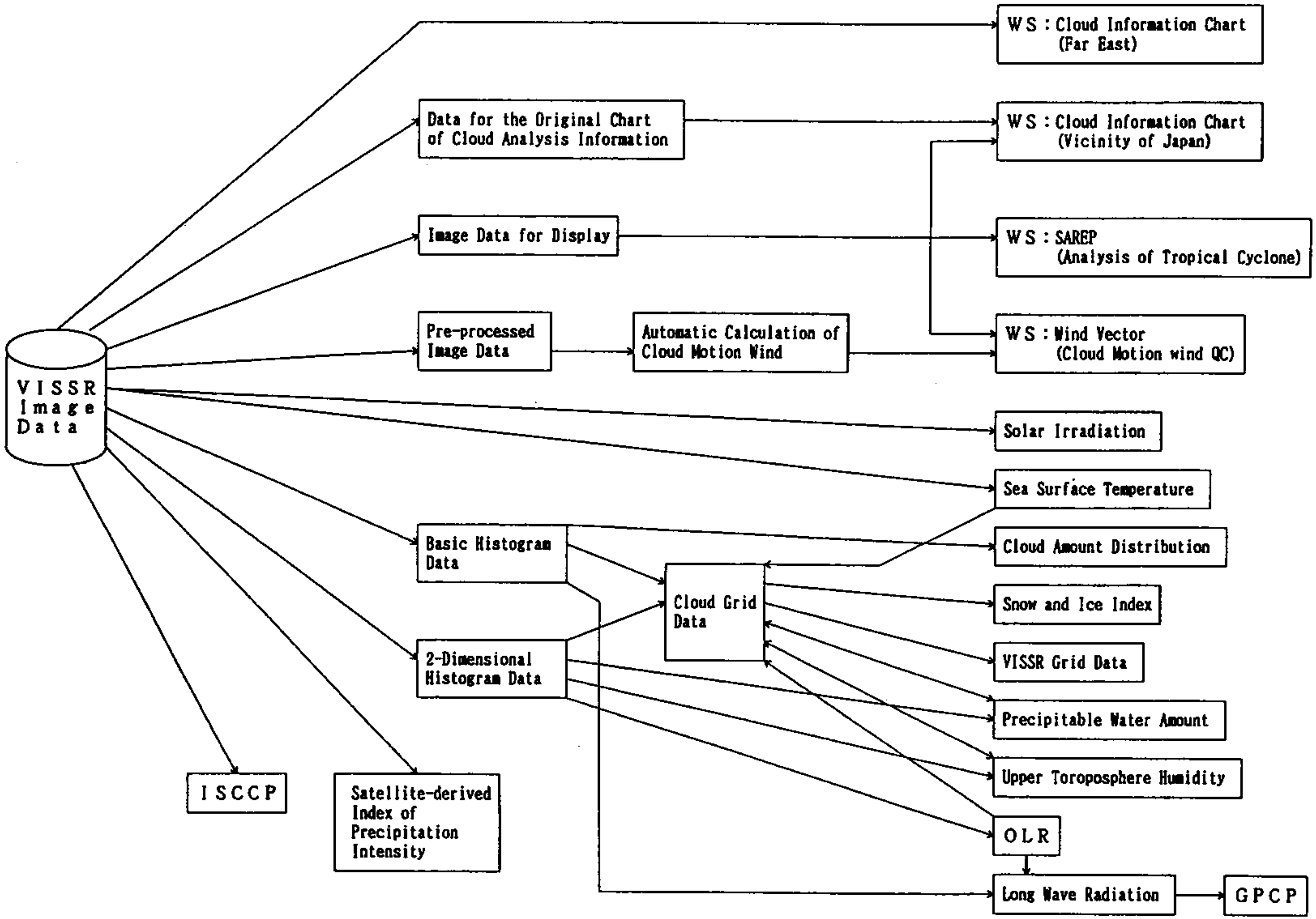

Fig.4.1.1 General flow of the product processing from VISSR Image Data

4.2 Cloud Motion Winds

4.2.1 An outline

Cloud Motion Winds (CMWs) are the derived from displacement of cirrus and cumulus by using infrared (IR) and visible (VIS) images at 30- minute intervals.

VIS images are used to derive low- level winds in the daytime and IR images are used to derive high- level winds and low- level winds at night.

Derivation of CMWs is either automatic or manual (man- machine interactive) process.(see Fig.4.2.1) In the automatic process, clouds, which represent a flow of winds, are automatically selected and tracked by computers. In the manual process, CMWs are selected and tracked by an operator on Graphic Display (GDP) and Image Display (IDP).

After quality control for CMWs is performed automatically by computers, quality control by an operator on GDP and IDP is performed and unreliable CMWs are deleted.

Resultant CMWs which pass quality control are stored on magnetic tapes and disseminated.

4.2.2 Description

4.2.2.1 Routine operations

CMWs are derived four times a day, 00UT, 06UT, 12UT and 18UT by using three successive images at 30- minute intervals. The schedule of IR / VIS images taken at 06UT is shown in Fig.4.2.2. The three images in use are called image A, B and C, respectively.

In the automatic process, CMWs derivation procedures begin after image B is obtained. First, clouds are selected automatically on image B. Wind vectors are extracted between image A and B, and then between image B and C. A direction and a speed of CMW are extracted from the initial and the end positions of a wind vector. A height of CMW is assigned to a certain level, after Cloud Top Height (CTH) is extracted by using IR and water vapor (WV) images. Next, automatic (objective) quality control for CMWs is performed and CMWs of low quality are flagged.

Following the automatic process, a manual process is performed by an operator on GDP and IDP. Extraction of CMWs in the manual process is the same method as in the automatic process except for selecting clouds / selecting and tracking clouds. At the same time, an operator checks not only the flagged CMWs from the automatic process but also the others. Low quality CMWs are deleted.

CMWs which pass quality control are transmitted to the JMA Headquarters through ADESS and to worldwide users through GTS.

4.2.2.2 Automatic cloud selection procedure

Cirrus are selected in the high-level CMWs derivation procedure and cumulus in the low-level CMWs derivation procedure by a histogram analysis on IR image data. Moreover, cumulonimbus are checked and rejected as unsuitable clouds at each point except those points which are rejected by a histogram analysis.

(1) Points for cloud selection

The number of points provided at grid points with 1° intervals of latitude and longitude is 10000 to select clouds suitable to track between 50N to 49S in lat. and 90E to 171W in lon.

Each point is checked for whether the zenith angle of the satellite is lower than a preset value, whether points are in a land area, or the zenith angle of the sun is lower than a preset value when VIS images are used in the daytime, and so on. Considering sufficient time for manual process, the number of points which are finally sent to the CMWs derivation procedure is 500 for high- level and 800 for low- level, respectively. Each point is checked in random order to uniformly select clouds in the observation area.

(2) Histogram analysis

Histogram analysis of IR data is made in an area centered at the point for cloud selection. IR data are analyzed on all kinds of parameters, for example, cloud top temperature, cloud amount, a range of temperatures which clouds can exist between, and so on. Then the points are decided whether they are suitable for tracking. Unsuitable points are not selected as points for cloud selection.

(3) Cumulonimbus

Cirrus are selected when high- level CMWs are derived. However it is impossible to reject cumulonimbus, which do not represent high-level CMWs, by the procedure based on histogram analysis of IR data only. This problem is solved in following way. The top of a well developed cumulonimbus reaches the tropopause. As there is very little water vapor between the cloud top and the satellite, IR brightness level is almost the same as WV brightness level. Therefore, when the difference between IR and WV brightness levels of a cloud is less than a preset value, the cloud is rejected as being cumulonimbus.

4.2.2.3 Wind derivation procedure

(1) Tracking (Matching)

Displacement of selected clouds is calculated by pattern matching by using cross- correlation techniques. Image B, on which clouds are selected, overlaps with image A and C. Then, a template area and a search area centered on the selected cloud are decided on image B and image A / C, respectively. The template area moves pixel by pixel on the lag area within a search area. At each position of lag area, a cross- correlation coefficient between the template area and the same size area in the search area is calculated. (see Fig.4.2.3) The position which has the largest cross- correlation coefficient is decided as the position to which the cloud displaces. An example of coefficient values calculated by the cross- coefficient technique is shown in Fig.4.2.4.

The positions of the selected and tracked cloud are transformed into latitude and longitude coordinates, based on information from the satellite orbit and attitude. Then, wind directions and wind speeds of CMWs are calculated.

(2) Height assignment

(a) Low- level CMWs

Heights of all low- level CMWs derived by tracking cumulus are assigned to 850 hPa as a represent height, because derived CMWs are best fitted to rawinsonde winds at this level, compared with rawinsonde winds.

(b) High- level CMWs

Heights of high- level CMWs derived by tracking cirrus are assigned to CTHs as a represent height. Moreover, in the case of semi- transparent cirrus, CTHs can be extracted accurately by using both the IR and WV channel data.

(3) Quality control in CMWs derivation process

In CMWs derivation process of routine operation, three successive images A, B and C are used. At image B, clouds are selected, and then wind vector Vab between image A and B and wind vector Vbc between image B and C are derived. A difference between Vab and Vbc is checked. Further, a change between CTHs for derived wind vectors is checked, because a wind vector derived from a developing or decaying cloud is of low quality.

4.2.2.4 Automatic quality control procedure

High / low- level CMWs are compared with the neighboring same / different- level CMWs and NWP winds obtained from 12- or 18- hour forecasts of NWP. When a difference between them does not satisfy preset threshold values, they are flagged and then an operator checks, the quality control of CMWs in the manual quality control procedure described below.

4.2.2.5 CMWs derivation and quality control in manual process

(1) CMWs derivation procedure

In an area where CMWs of high quality can not be derived in the automatic process, CMWs are derived on GDP and IDP. There are two methods, that is to say, MM- 1 method and MM- 2 method. In MM- 1 method, an operator selects clouds manually, and then CMWs are tracked and assigned to heights automatically. In MM- 2 method, an operator decides the initial and the end position of cloud displacement, and then directions and speeds of CMWs are calculated automatically.

(2) Quality control procedure

An animation of three successive images is displayed on IDP and wind vectors are overlapped on the animation. An operator examines CMWs on their displacement, and then checks their height assignment, referring to rawinsonde winds and NWP winds which are displayed on GDP. CMWs of low quality are deleted, but CMWs of high quality are sent to output procedure.

4.2.2.6 Output procedure

CMWs considered reliable through automatic and manual quality control are coded into WMO format (SATOB) for transmission to worldwide users through ADESS and through GTS.

The derived winds are listed on NLP, are plotted in a map of mercator projection and are stored on archival data tape.

4.2.3 Remarks

For exchange of data decided at FGGE, wind data are also stored on archival data tape in the format. Wind data are also listed in "Monthly Report" (CD- ROM edition) issued by MSC.

To check the accuracy of CMWs, CMWs compared with rawinsonde winds are stored at every observation and are assessed for accuracy every month.

Results of comparison in 1996 are shown in Fig.4.2.5.

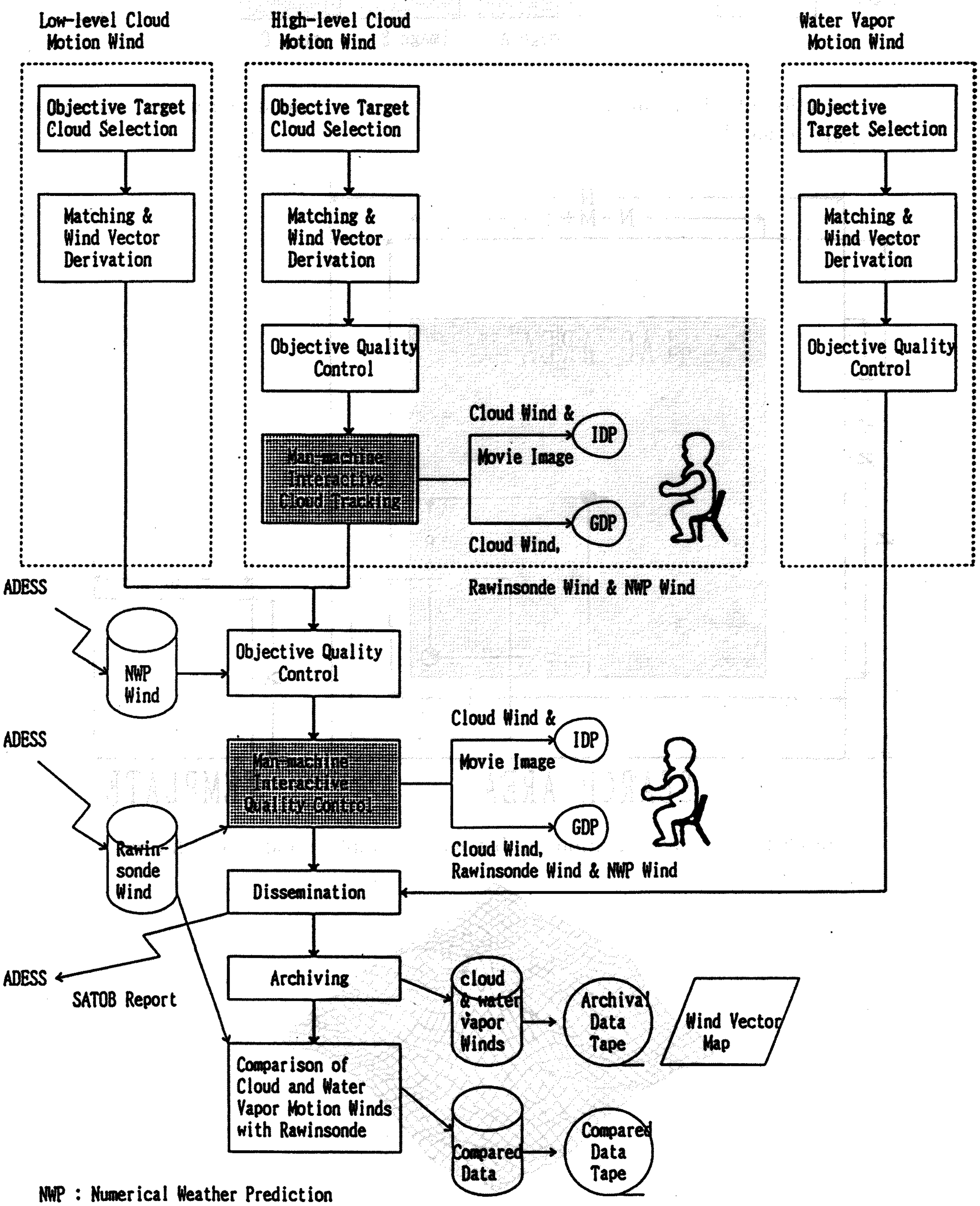

Fig.4.2.1 A flowchart of cloud and water vapor motion winds derivation system in MSC.

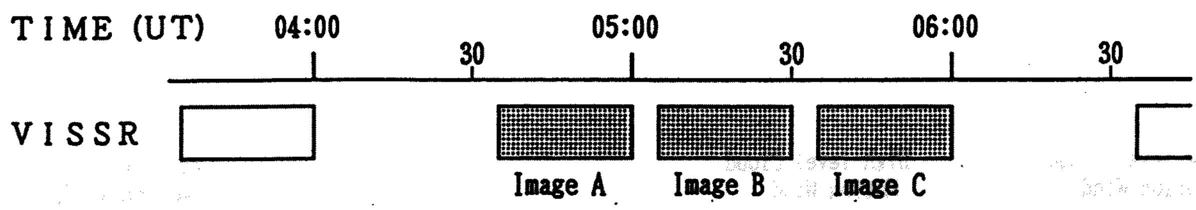

Fig.4.2.2 Selection of VISSR images which are used to derive cloud and water vapor motion winds at 06UT.

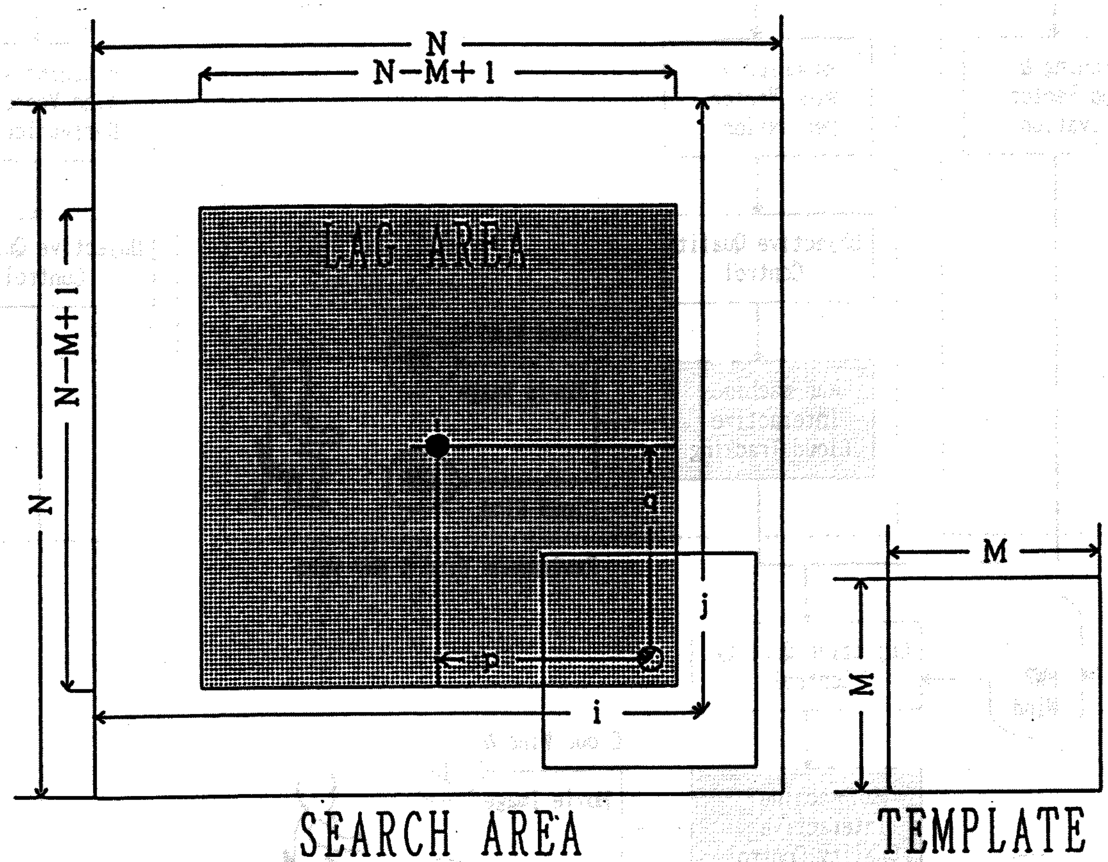

Fig.4.2.3 Schematic relationship between a template and a search area.

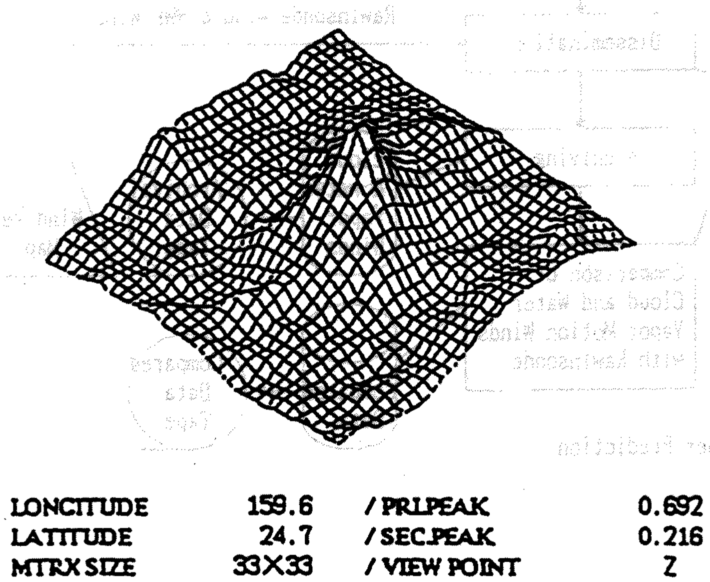

Fig.4.2.4 A3-dimensional display of a cross-correlation matrix.

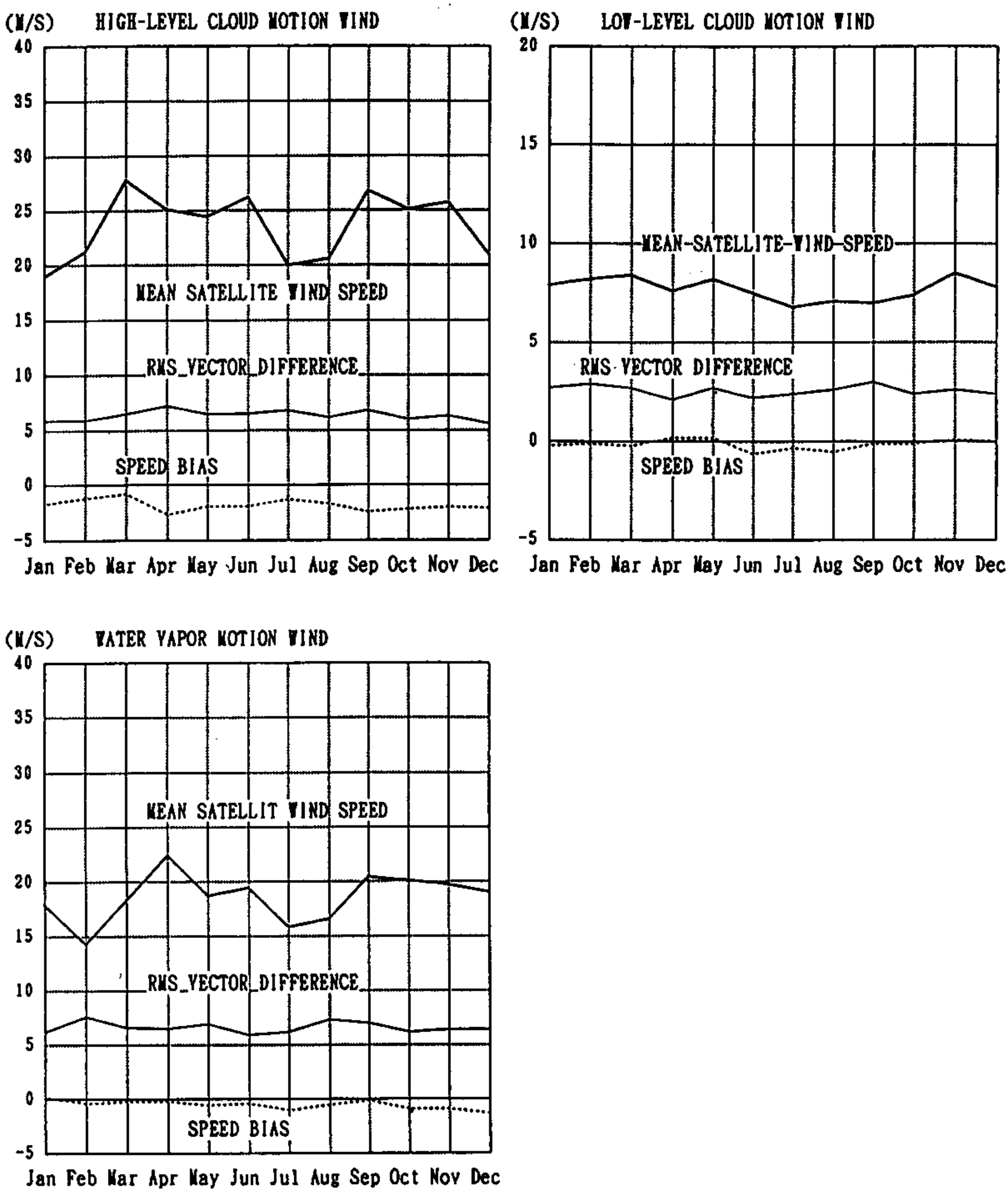

Fig.4.2.5 Comparison results of the CMWs and the WVMWs with rawinsonde winds in 1996.

Bold solid line : Mean CMWs/WVMWs wind speed

Solid line : RMS vector differences

Dashed line : Speed bias (CMWs/WVMWs wind speed - rawinsonde wind speed)

4.3 Water Vapor Motion Winds

4.3.1 An outline

MSC has operated GMS- 5 from June 1995 and, at the same time, derived Water Vapor Motion Winds (WVMWs). WVMWs are derived from displacement of water vapor (WV) distribution or cirrus in water vapor images in the WVMWs derivation process.

4.3.2 Description

All the procedures in this derivation process are performed automatically by computer.

The same algorithm of WVMWs as CMWs from selection of WV distribution or cirrus to automatic quality control is performed except using WV image data. The number of points which are sent to the WVMWs derivation procedure is 1000, after selection of WV distribution and cirrus.

Quality control for the WVMWs is only performed automatically. To automatically reject low- quality WVMWs, the homogeneity of the WVMWs is checked by comparison of the WVMWs with neighboring the WVMWs and NWP winds. If the WVMWs do not satisfy preset threshold values, they are decided to be WVMWs of low quality and rejected in this procedure.

Together with CMWs that pass quality control, the WVMWs that pass quality control are transmitted to the JMA Headquarters through ADESS and to worldwide users through GTS.

4.3.3 Remarks

The accuracy of the WVMWs is shown in Fig.4.2.3. There are the same problems in WVMWs derivation process as in CMWs.

4.4 Upper Troposphere Humidity

4.4.1 Outline

An Upper Tropospheric air Humidity (UTH), which is defined the relative humidity for a layer between 600 and 300 hPa (Poc et al., 1980), is retrieved from GMS-5 VISSR "water vapor" channel at 6.7 μm band, designated WV, and "split window" channel at 11 μm band, designated IR. This estimation scheme was developed by Schmetz et al. at the European Space Operations Center (ESOC) of the European Space Agency (ESA) as an operational algorithm from radiance measurements in the 6.3 μm channel of the geostationary satellite METEOSAT (Schmetz and Turpeinen, 1988).

The physical retrieval method is based on an efficient radiative transfer scheme which uses the temperature forecast profiles from the Numerical Weather Prediction (NWP) of the Japan Meteorological Agency (JMA) as an ancillary data. Theoretical radiances for the given temperature profile and a set of fixed upper tropospheric humidity are employed to relate the observed radiance to mean humidity for a layer between 600 and 300 hPa. The retrieval is confined to areas with neither medium- nor high-level clouds.

4.4.2 Description

The UTH is estimated on 0.25×0.25 grid boxes covering 60 N - 60 S and 80 E - 160 W region. A schematic figure of the algorithm for the UTH is shown in Fig.4.4.1.

(1) Extraction of grid boxes with neither medium- nor high-level clouds (STEP1 in Fig.4.4.1)

-To eliminate contamination by medium- or high-level clouds, information on cloud amount from "Cloud Grid Data" file (see Appendix H) is used as a discriminator. An effective grid box of which cloud amount above 600 hPa is zero is extracted as a grid box with neither medium- nor high-level clouds.

-A two-dimensional (2-D) histogram whose axes are TB_{IR} and TB_{WV} is prepared using all pixels in each grid box with neither medium- nor high-level clouds.

-Using the 2-D histogram, the warmer pixels whose TB_{IR}s are warmer than a threshold temperature T_c are extracted as "clear" pixels suitable for the UTH derivation.

(2) Calculation of a Looking-up Table (LT) of UTH (STEP2 in Fig.4.4.1)

For each grid box, radiative transfer calculations are performed to estimate theoretical radiances, which should be observed in the WV channel of GMS-5 as follows;

-A temperature profile is obtained from a NWP model of the JMA.

-A calculation is performed for a set of fixed upper tropospheric humidities of 1 %, 10 %, 20 %, 30 %, 50 %, 70 % and 100 % (seven cases) at levels from 600 to 300 hPa.

-Theoretical radiances are converted to theoretical brightness temperature in the WV channel of GMS-5, designated TB_{WV}, so that the LT relating TB_{WV}s to UTHs for each grid area is prepared.

(3) Derivation of the UTH (STEP3 in Fig.4.4.1)

The UTH for each grid area is derived from the LT by an interpolation of the theoretical TB_{IR}-TB_{WV} planes with an observed TB_{IR} and TB_{WV} from GMS-5.

The UTH is derived every 3-hours (00, 03, 06, 09, 12, 15, 18, 21 UTC) and disseminated to the JMA headquarters every 6-hours (00, 06, 12, 18 UTC).

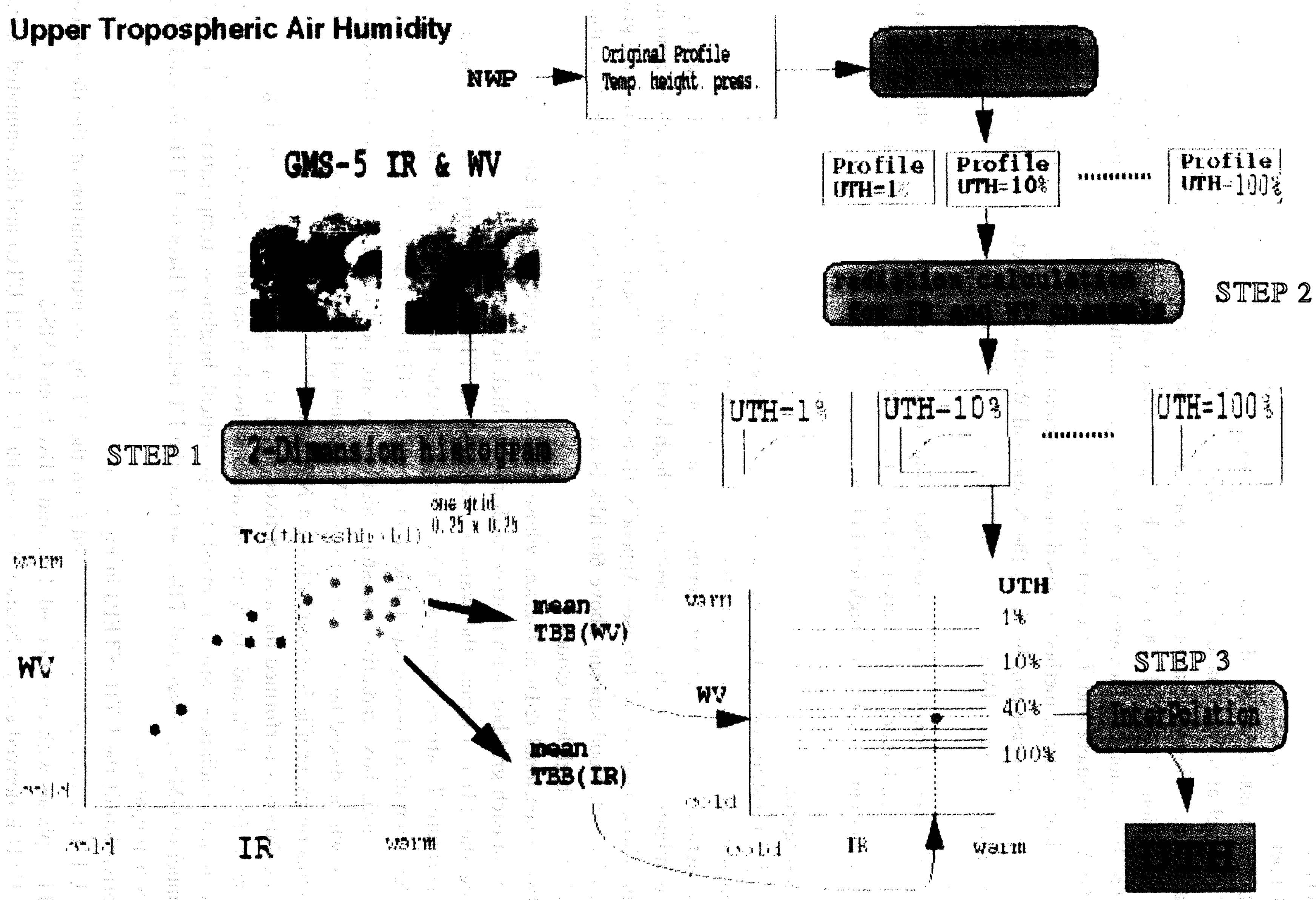

Fig.4.4.1 Schematic figure of the algorithm for Upper Tropospheric Air Humidity (UTH).

4.4.3 Remarks

The GMS-5 IR-derived UTH is compared with radiosonde-derived "ground truth" data in the area of 80°E - 160°W and 60°N - 60°S. An annual variation of the UTH evaluation in 1996 is shown in Fig.4.4.2. When using this data set, its bias should be taken into account, as much as 5 %, and RMS error, as much as 15 %, though there is no pronounced annual trend of difference between satellite estimation and radiosonde truth data.

Reference

Poc M.M., M. Roulleau, N.A. Scott and A. Chedin, 1980: Quantitative Studies of Meteosat Water- Vapor Channel Data, J. Appl. Meteor., 19, 868-876

Schmetz, J., and O.M. Turpeinen, 1988: Estimation of the upper tropospheric relative humidity field from METEOSAT water vapor image data. J. Appl. Meteor., 27, 889-899

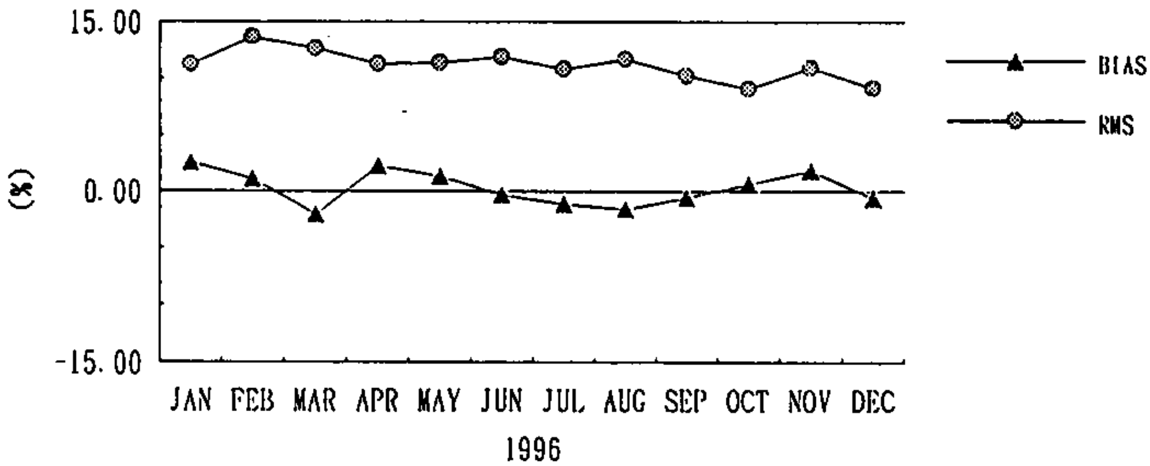

Fig.4.4.2 Annual variation of the Upper Tropospheric Air Humidity (UTH) evaluation with BIAS and RMS error in comparison with radiosonde-derived "ground truth" data in 1996.

4.5 Precipitable Water Amount

4.5.1 Outline

A Precipitable Water Amount (PWA) is defined as a mean column value of water vapor content of the lower troposphere. It is well correlated with the air temperature between 700 hPa and 920 hPa (Chesters, 1983) It is retrieved from a difference of radiance observed through GMS-5 VISSR "split window" channels at 11 and 12 μm band, designated SP1 and SP2 respectively. This estimation scheme was developed by Chester et al. (1987) at the NASA Goddard Space Flight Center from radiance measurements in 11 and 12 μm "split window" channels of the VISSR Atmospheric Sounder (VAS) on board the Geosynchronous Operational Environmental Satellite (GOES) of the U.S.A.

The PWA is calculated using a regression equation of brightness temperature (TB) observed in SP1 and SP2, and a temperature at 700 hPa from the Numerical Weather Prediction (NWP) of the Japan Meteorological Agency (JMA) as ancillary data. Coefficiencies of the equation were

empirically decided from collocated observations of GMS-5 and radiosonde. The retrieval is confined to areas under clear sky condition.

4.5.2 Description

The PWA is estimated on 0.25°×0.25° grid boxes covering the 60°N - 60°S and 80°E - 160°W region.

(1) Extraction of pixels in a grid area under clear sky condition

To eliminate contamination by clouds, information on cloud amount from "Cloud Grid Data" file (see Appendix H) is used as a discriminator. An effective pixel, of which cloud amount is zero is extracted as a grid area under clear sky conditions.

(2) Derivation of the PWA

For each grid area under clear sky conditions, PWA is calculated by using the following regression equation:

$$\begin{aligned} PWA = {} & a_0 + a_1 * \cos\theta + a * (TB_{11} - TB_{12}) + a_3 * (TB_{11} - TB_{12}) * \cos\theta \\ & + a_4 * \ln(TB_{11} - T_{700}) + a_5 * \ln(TB_{11} - T_{700}) * \cos\theta \\ & + a_6 * \ln(TB_{12} - T_{700}) + a_7 * \ln(TB_{12} - T_{700}) * \cos\theta \end{aligned}$$

where:

PWA: precipitable water amount (mm)

TB_{11} and TB_{12}: TBs observed in SP1 and SP2, derived from A two-dimensional histogram, respectively (K)

T_{700}: Temperature at 700 hPa derived from the NWP of the JMA (K)

θ: Satellite zenith angle (rad)

Coefficiencies of a_0, a_1, a_2, ..., a_7 were empirically decided from collocated observations of GMS-5 and radiosonde in October 1995 as follows:

$a_0 = -8.6077$ $a_1 = 53.561$ $a_2 = -19.078$ $a_3 = 47.651$ $a_4 = 149.24$ $a_5 = -202.27$
$a_6 = -151.38$ $a_7 = 193.16$

This equation was derived from the study of Chester et al. (1987) with some additional terms experimentally decided for improving the precision.

The PWA is derived every 3-hours (00, 03, 06, 09, 12, 15, 18, 21UTC) and disseminated to the JMA headquarters every 6-hours (00, 06, 12, 18UTC).

4.5.3 Remarks

The GMS-5 IR-derived PWA is compared with radiosonde-derived "ground truth" data in the area 80°E - 160°W and 60°N - 60°S. An annual variation of the PWA evaluation in 1996 is shown in Fig.4.5.1. When using this data set, its bias should be taken into account of its bias, as much as 5 mm, and RMS error, as much as 15 mm, though there is no pronounced annual trend of difference between satellite estimation and radiosonde truth data.

Reference

Chesters, D., L.W. Uccellini and W.D. Robinson, 1983: Low-level water vapor fields from the VISSR atmospheric sounder (VAS) "Split Window" channels. J. Climate and Appl. Meteor., 22, 725-743

Chesters, D., W.D. Robinson and L.W. Uccellini, 1987: Optimized Retrievals of Precipitable Water from the VAS "Split Window", J. Climate and Appl. Meteor., 26, 1059-1066

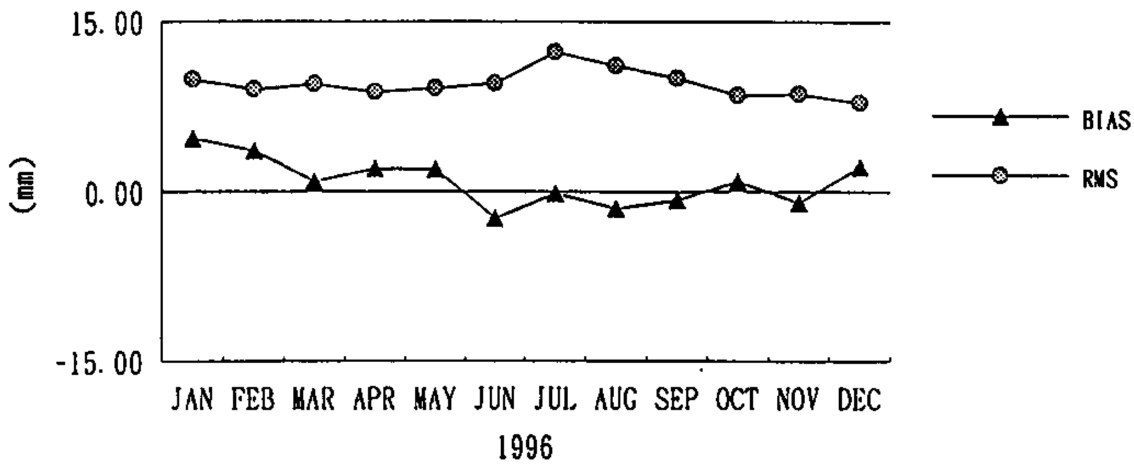

Fig.4.5.1 Annual variation of the Precipitable Water Amount (PWA) evaluation with BIAS and RMS in comparison with radiosonde-derived "ground truth" data in 1996.

4.6 Sea surface temperature

4.6.1 Outline

Sea surface temperatures(SSTs) are extracted from measurements of Visible Infrared Spin Scan Radiometer(VISSR) on Geostationary Meteorological Satellite(GMS). The SSTs are estimated every three hours. The area of SSTs estimation is from 50 degree North to 50 degree South and from 90 degree East to 170 degree West.

The SSTs estimation uses brightness temperature in the spectral band of 10.5-12.5 μm that is practically transparent and is called the atmospheric window. However, satellite measured brightness temperatures of sea surface are slightly attenuated by the constituents of atmosphere. Therefore, correction to the atmospheric attenuation is necessary to extract SSTs from the satellite measurements.

4.6.2 Description

(1) Basic concept

Until 1995 the SST was calculated from a brightness temperature of atmospheric window-channel, 10.5-12.5 μm, with a correction for atmospheric attenuation. The atmospheric correction was based on an empirical formula with climatological precipitable water amount or a radiative transfer model with the results of objective analysis.

Since GMS-5 is equipped with thermal infrared split-window channels: atmospheric window channel is divided into two, the SST has been calculated from two simultaneous brightness temperatures of split-window channels by using a linear regression equation. Recently using two or more simultaneous brightness temperatures in different spectral bands is a major means to correct for atmospheric attenuation. The brightness temperature differs for each window channel because of different absorption efficiencies for each spectral band, and an amount of attenuation of brightness temperature in one channel is a linear function of the brightness temperature difference of the two or more different window channels.

(2) Processing method

The SSTs estimation consists of three processes: cloud filtering, SST retrival and statistics.

Pixels (image-elements) of VISSR full-resolution data are discriminated into cloud free pixels or cloud contaminated pixels by a cloud filtering algorithm. The algorithm is based on threshold tests of reflectance, brightness temperature and brightness temperature difference of split-window channels.

The SST is calculated from two simultaneous brightness temperatures of split-window channels of cloud free pixel by using Multi-Channel SST(MCSST) retrieval algorithm. The algorithm is based on a linear regression equation and uses two or more simultaneous brightness temperatures in different spectral bands, because an amount of atmospheric attenuation of brightness temperature in one channel is a linear function of the brightness temperature difference of split-window channels. The equation is as follows:

$$SST = aT_{11} + b(T_{11} - T_{12}) + c(T_{11} - T_{12})(\sec\theta - 1) + d$$

where T_{11} is brightness temperature in IR1, 10.5-11.5 μm, T_{12} is brightness temperature in IR2, 11.5-12.5 μm, θ is satellite zenith angle, a, b, c, and d are coefficients of the linear regression.

Coefficients are calculated by the linear regression method from a set of matches of satellite observations and measurements of drifting buoys and moored buoys located in GMS coverage. The calculated SSTs are compared to climatological values and unreasonable values are eliminated.

The mean is calculated from the reasonable values in the area with regular intervals of 0.25 degree latitude by 0.25 degree longitude, and is employed as the representative SST in the area. Daily mean SSTs with 0.5 degree latitude and longitude resolution are produced from a set of the mean SSTs with 0.25 degree latitude and longitude every three hours. Five-day mean, ten-day mean or monthly mean SSTs with one degree latitude and longitude resolution are produced from a set of the daily mean SSTs for five days, ten days or a month respectively.

Grid point values of daily mean SSTs are sent to Headquarters of JMA in GRIB code. Contour chart of five-day mean, ten-day mean and monthly mean SSTs are sent to the JMA Headquarters in G-III FAX. Grid point values of five-day mean SSTs are distributed to worldwide users in SATOB code through Global Telecommunication System(GTS).

4.6.3 Remarks

As a result of comparison between satellite SSTs and measurements of buoys located in GMS coverage, Root Mean Square difference of them is from 1.2 to 1.5 degree Kelvin.

4.7 Cloud Amount Distribution

4.7.1 Outline

The VISSR image data derived from observations by GMS(Geostationary Meteorological Satellite) are divided into small segments of 0.25° latitude/longitude grid. Cloud pixels are distinguished from clear sky pixels by some kinds of judgement tests in the histogram of the frequency distribution of pixels on brightness levels in a segment. Furthermore, each cloud pixel is assigned to one of five layers in height by its brightness temperature, using the vertical temperature profile.

After transferring 0.25° latitude/longitude grid to 1.0° one, the ratio of the number of cloud pixels to the number of total pixels is calculated as the total cloud amount, and the ratio of the number of cloud pixels in each layer to the number of total pixels is calculated as an each layer cloud amount. The upper cloud amount and the lower cloud amount are calculated with the boundary of 400 hPa.

The upper, lower and total cloud amount are made 3-hourly and furthermore processed statistically by units of 5-days, one month and 3-months, and disseminated to JMA headquarters in the forms of the contour maps or telegrams.

4.7.2 Description

(1) Data processing method

The VISSR image data derived from observations by GMS are divided into segments of 0.25° latitude/longitude grid in the area between 60.0°N and 60.0°S, 80.0°E and 160.0°W. For the histogram of pixels on the brightness level in a segment, the histogram shape tests and threshold tests about both visible and infrared data are performed, and the segments are classified into one of the groups of CLEAR(clear sky area existing), CLOUDY, FOG/STRATUS and UNDECIDED, based on combinations of results of those tests.

If a segment is classified into CLEAR(sky area existing) group, the clear sky brightness temperature (or the clear sky albedo) on the day is calculated by averaging a constant part of infrared histogram from high temperature side (or visible histogram from low albedo side). If not, the clear sky brightness temperature (or the clear sky albedo) is calculated by correcting the previous day's one. The derived clear sky radiance which is the clear sky brightness temperature and the clear sky albedo is used for the next day's clear sky area judgement.

The histogram shape test is performed, assuming that the histogram shape in clear sky area is characteristic for each place and time. The threshold test is to distinguish the clear sky area by an established threshold value, assuming that the cloud temperature is lower than the surface temperature and the cloud albedo is larger than the surface albedo. In the infrared threshold test, the threshold temperature is established at the proper temperature which is lower than the clear sky brightness temperature on the previous day, considering surface status feature at each place and each observation time, and the pixels with lower temperature than the threshold temperature are recognized as clouds.

By the threshold temperature used in the calculation of clear sky brightness radiance, which is described above, cloud pixels and clear sky pixels are distinguished. In the infrared histogram, the pixels with lower temperature than the threshold temperature are considered as clouds, and furthermore the cloud pixels are classified into five layers (surface - 700hPa, 700 - 600hPa, 600 - 500hPa, 500 - 400hPa and 400hPa -) by observed temperatures of pixels, based on the vertical temperature profile data which are modified in response to the atmospheric temperature attenuation above the cloud top. Here, the pre-modified vertical temperature profile data is the 12-hour or 18-hour predicted the 2.5° grid point values by JMA's numerical prediction.

The 1.0° grid data consist of sixteen the 0.25° grid data. Total cloud amount is calculated as the ratio of the number of cloud pixels to that of total pixels. Furthermore, the cloud pixels are distinguished with the boundary of 400hPa and the ratio of the number of cloud pixels in each layer to that of total pixels is calculated as the upper cloud amount and the lower cloud amount.

This processing is performed 3-hourly, 8 times per a day and 3-hourly data are made. From 3-hourly data, one day mean cloud amount is derived. Furthermore, from one day mean cloud amount, 5-day and monthly mean cloud amount are derived. From monthly mean high cloud amount, 3-month mean high cloud amount is derived. As for high cloud amounts of the term not shorter than 5-day, the anomaly from the value of a normal year (for 13 years until 1990) derived from the observations by GMS is calculated. The statistics of mean or anomaly of the term not shorter than 5 day are disseminated for Climate Prediction Division in the headquarters of JMA in the forms of the contour maps or telegrams.

4.7.3 Remarks

The value of a normal year had been derived according to five-day mean cloud amount for 9 years (Feb. 1978-Feb. 1987) from Mar. 1987 to May 1995, and according to the data for 13 years (Feb.1978-1990) since Jun. 1995, and the anomalies for these data have been calculated.

The cloud amount had been derived only over the oceans in the area between 50.0°N and 49.5°S, 90.5°E and 170.5°W from Apr. 1978 to Feb.1987, whereas it has been derived in the area between 59.5°N and 59.5°S, 80.5°E and 160.5°W since Mar. 1987. Monthly statistics had been derived by averaging six 5-day mean data (seven 5-day mean data only in August) until August 1993, but has been derived by averaging one-day mean data through the period of the almanac month since Sep. 1993.

The above cloud amount data are for climatology, and only infrared 1 and visible channels are used to make the data by the previous method in order to keep quality continuity of cloud amount data until GMS-5.

As the actual cloud emissivity varies from 0 to 1 by cloud kinds or status of the atmosphere, the brightness temperature sensed by the satellite represents the sum of the radiance from the high cloud, that from the low cloud and that from the underlying surface. Therefore, if it is assumed that the radiance comes from only one layer thick cloud, the guess errors of the cloud height may be caused and the errors of cloud amount of each layer classified by the height may be also caused, because the cloud altitude correction can not be performed with only infrared 1 and visible channels. Especially for high thin cirrus cloud this effect is larger, and cloud amount data (for climatology) should be used carefully. Besides, clouds smaller than one pixel covered area lead errors.

And as the variation of land surface status is larger than that of sea surface status, the error of clear sky temperature in land surface is larger. Furthermore, the error of cloud amount is larger than that in sea surface, and the data should be used carefully.

As a result of comparing the two total cloud amounts of the satellite observation and the surface observation in every month, satellite-derived one tends to be smaller than surface-observation-derived one and to have smaller differences in larger cloud amounts.

Besides, as other data concerned with the cloud amount, the cloud amount (for numerical prediction) and convective cloud amount are produced 3-hourly as 0.25° latitude/longitude grid data and furthermore 6-hourly, the VISSR grid data are produced by transferring the grid interval from 0.25° to 0.5° latitude/longitude and disseminated for Numerical Prediction Division in the headquarters of JMA in a form of telegram.

On the cloud amount(for numerical prediction), the altitude correction of semi-transparency high cloud is performed, using water vapor channel data which came to be able to use from the operational start of GMS-5 in June 1995 in addition to visible and infrared 1 data processing until then, and the cloud amount is calculated more than that of GMS-4 and the previous ones.

And the convective cloud amount is the amount of cloud which is considered as convective cloud (cumulonimbus and cumulus) and is calculated, using the combination of infrared 1 and water vapor channels and the combination of infrared 1 and infrared 2 channels.

4.8 Outgoing longwave radiation and brightness temperature

4.8.1 Outline

The total amount of the radiation emitted from the earth-atmosphere system with a wavelength 3-100μm is called outgoing longwave radiation (OLR). The OLR flux is calculated from infrared 1 and water vapor channels data at the Meteorological Satellite Center. The OLR is an important variable, not only as a component of the radiation budget but also as an index representing variations of meteorological parameters. The brightness temperature can be meaningful since energy of the longwave radiation has a peak in the infrared 1 window of GMS-5. Although approximation of the OLR is now possible, the brightness temperature is also derived because of its continuity as a long-term environmental observation.

4.8.2 Description

(1) Processing method for the OLR

The OLR, which is the total amount of the longwave radiation, is calculated 3-hourly over the GMS-5 coverage (60°N - 60°S, 80°E - 160°W) for every 0.25×0.25 degree latitude-longitude box. First of all, the two-dimensional histogram in each box, whose axes are the brightness temperature of infrared 1 and water vapor channels, is converted to radiance by looking up a calibration table. Then, these radiances are converted to the OLR by a multiple regression formula based on a radiative transfer model (LOWTRAN7). The LOWTRAN7 calculates atmospheric transmittance and background radiance for a given atmospheric path. The satellite zenith angle is also considered in the calculation. Subsequently, the OLR for every 0.5×0.5 degree box and every 2.5×2.5 degree box is calculated for dissemination.

(2) Processing method for the brightness temperature

The brightness temperature is produced 3-hourly over the GMS-5 coverage (60°N - 60°S, 80°E - 160°W). First of all, every 0.25×0.25 degree latitude-longitude box data of the IR1 VISSR histogram is transformed into 2.5×2.5 degree box histogram data. Every brightness level is transformed into a brightness temperature by referring to the calibration information, which shows the relation between brightness level (0-255) and brightness temperature. Then, the brightness temperature histogram data is produced, using a temperature table.

(3) Data sequence

For each five day period, both three-hourly data of the OLR and the brightness temperature are averaged to take away the influence of the difference in observation times in five days(e.g. missing observations). In addition to that, five-day, monthly and past three-months average data are derived based on the five-day average. The results and three contour maps of these periods are produced and disseminated to JMA headquarters.

4.8.3 Remarks

The brightness temperature has been produced since March 1987. The OLR has been produced since GMS-5 become operational in June, 1995.

4.9 solar irradiation

4.9.1 Outline

The visible channel equipped on GMS-5 observes solar energy that is reflected from the earth's and clouds' surface or diffused by mixed gas and aerosol in the atmosphere. Taking advantage of this property, it is possible to estimate solar irradiation observed on the earth's surface from the visible channel data indirectly.

JMSC estimates solar irradiation from visible channel VISSR data for the GMS-5 coverage area (from 60 degrees N to 60 degrees S, from 80 degrees E to 160 degrees W) at every 0.25 degrees latitude/longitude grid.

4.9.2 Description

(1) Basic concept

Solar irradiation is estimated hourly from visible channel VISSR data for the time period 21 to 09 UTC, for each 0.25 degrees by 0.25 degrees grid. The region for the estimation is below:

latitude direction : from 60 degrees N to 60 degrees S
longitude direction: from 80 degrees E to 160 degrees W

In estimation, the following radiative transfer model is adopted. First, under clear sky conditions, solar irradiation is modeled as follows:

$$E = E_0 d^{-2} \cos(q) T(q) \qquad (1)$$

where E: hourly solar irradiation (hourly solar net flux) (MJ/m^2), E_0: solar constant (hourly solar net flux) (4.923 MJ/m^2), d: the ratio of actual to mean sun-earth distance, q: sun zenith angle, T(q): transmittance of the atmosphere.

Secondly, we consider a cloudy scattering atmosphere with no absorption and molecular scattering and we assume isotropy of the radiance reflected by the cloud layer and the earth's surface. Then the planetary albedo A is given by

$$A = A_c + (1 - A_c)^2 A_s / (1 - A_c A_s) \qquad (2)$$

where A_c is the cloud albedo, A_s the earth's albedo. In this model, solar irradiation at the earth's surface expressed without A_c is given by

$$E = E_0 d^{-2} \cos(q)(1 - A)/(1 - A_s) \qquad (3)$$

Thirdly, the atmospheric transmission effect in eq.(1) and cloud effects in eq.(3) are combined to give the equation for estimating solar irradiation at the earth's surface is derived.

$$E = E_0 d^{-2} \cos(q) T(q)(1 - A)/(1 - A_s) \qquad (4)$$

(2) Data processing method

In the operational estimation process, d is estimated from the satellite observation time, and T(q) is estimated taking account of absorption due to absorbing gases, Rayleigh and Mie scattering, scattering due to mixed gas, and multiple scattering in the atmosphere. For A_s, the

3 hourly minimum albedo from 1987 to 1991 for each grid is prepared in advance. It is interpolated to hourly data, and regarded as hourly surface albedo for each grid. For A, the average albedo observed by GMS-5 for each grid (this value is expressed as 'L' below) is corrected for sun zenith angle, and obtained. In a short enough sun zenith angle interval, A is assumed to be proportional to L and expressed as follows:

$$A = aL/\cos(q) + b \tag{5}$$

where a is the correlation coefficient computed with weight least regression of satellite estimates against pyranometer measurements obtained from the JMA observation network, and b is bias. The sets of a and b are calculated every 0.5 degrees sun zenith angle interval. Using eq.(5), eq.(4) is reformed as follows:

$$E = E_0 d^{-2} \cos(q) T(q)(1 - aL/\cos(q) + b)/(1 - A_s) \tag{6}$$

Using eq.(6), JMSC estimates solar irradiation hourly from 21 to 09 UTC for each grid, and accumulates it with the average albedo and cosine of the sun zenith angle that are used in the estimation. The solar irradiation is disseminated to JMA headquarters.

4.9.3 Remarks

The rms of errors obtained from comparison of satellite estimates with pyranometer measurements is about 0.4(MJ/m^2)(Jun.-Dec. 1996). This error is mainly due to the assumption of isotropy in the theory. Therefore, the error becomes greater when sun zenith angle is large and scattered cloud exists in the object grid. As the earth's surface albedo (A_s) takes larger value in some cases(for example, snow/ice cover), the error of estimation becomes greater, too. User should pay attention to these points in using these data.

4.10 Snow-ice index

4.10.1 Outline

The visible channel on GMS-5 observes the short-wave radiation reflected by the earth's surface. Snow/ice has a large reflecting property in this wavelength region. Taking advantage of it, JMSC estimates an index about the earth's surface status of snow/ice cover (snow-ice index) from visible channel VISSR data for GMS-5 coverage area (from 60 degrees N to 20 degrees N, from 80 degrees E to 160 degrees W) at every 0.25 degrees latitude/longitude box once a day.

4.10.2 Description

(1) Basic concept

The visible channel observes short-wave radiance reflected by the earth's surface. It becomes greater if the earth's surface is covered with snow/ice. Taking advantage of it, it is possible to monitor snow/ice cover by using the snow/ice index (SI) defined in eq.(1).

$$SI = A_s - A_{min} \qquad (1)$$

where A_s : the earth's surface albedo of the day of estimation, A_{min} : the minimum albedo of the earth's surface in a time series long enough. A_s is the albedo that indicates the earth's surface status of the day of estimation, on the other hand, A_{min} is the albedo under the least snow/ice cover condition. A_s becomes greater as snow/ice covers the earth's surface while A_{min} remains a constant. Then SI becomes greater as the snow/ice covers the earth's surface.

Using eq.(1), JMSC estimates snow/ice index(SI) once a day at every 0.25 degrees latitude/longitude box for GMS-5 coverage area (from 60 degrees N to 20 degrees N, from 80 degrees E to 160 degrees W).

(2) Data processing method

The operational estimating process is as follows.

At first, A_{min} is prepared in advance. It is obtained from the visible channel data for five years (from 1987 to 1991).

Next, A_s is extracted. Albedo becomes larger when cloud exists in the object grid because cloud reflects short-wave radiance strongly. To avoid this cloud's influence, the minimum value among albedo data for the last fifteen days is extracted. Moreover, albedo is very sensitive for the angle of incident energy, generally. In this estimation, albedo for the small solar zenith angle (two data per day) is selected. After all, A_s is the smallest value among thirty data.

Then SI is the difference between A_s and A_{min}. SI is estimated once a day, and it is accumulated with A_s and the cosine of the solar zenith angle which are used in the estimation. The snow/ice index is disseminated to JMA headquarters.

4.10.3 Remarks

This index is used to distinguish snow/ice cover. The probability of snow/ice cover becomes larger when this index takes large value. But it varies with each grid's surface property, matter, and season. So the user must judge snow/ice cover from this index for each grid. And when cloud has existed in the same grid for more than fifteen days, this index becomes larger than that under cloudless conditions. Users should pay attention to these points in using this index.

4.11 Cloud Information Chart

4.11.1 Outline

The purpose of the Cloud Information Chart is to provide local weather services the information extracted from the data observed by GMS-5 so that they can make use of it for weather watch and forecasting. It contains information about vertical/horizontal cloud distribution in the atmosphere obtained from observed data, and also contains information which is added by the analyst about synoptic and meso scale atmospheric conditions and disturbances.

4.11.2 Description

The Cloud Information Chart is a polar-stereo graphic projection chart centered on Japan with a scale of 1 :21,300,000. Standard longitude is 140E, the south-west end is at (15N, 117E) and the north-east end is at (54.9N, 173.4E). The Cloud Information Chart is produced every 3 hours and distributed within 30 minutes after observation time. An example of a Cloud Information Chart is shown in Fig.1.

Contents of the cloud information chart are as follows:

(1) Cloud types

Cloud types are shown by hatched patterns corresponding to each cloud type. Cloud types are automatically classified by using an algorithm that makes use of the multi-spectral data of GMS-5 together with NWP data. The following seven cloud types are classified, i.e. Cumulonimbus, Cumulus congestus, cumulus, upper level cloud, middle level cloud, fog, and dense cloud. Multi layered cloud is indicated by the overlap of patterns.

Automatically classified cloud types are quality controlled by an analyst through man machine interaction.

(2) Isotherms of TBB and the dark area of water vapor image

The water vapor field in the upper and middle troposphere is observed by the water vapor channel of GMS. Low TBB areas in a water vapor image correspond to moist areas and high TBB areas correspond to dry areas. When upper dry air (high TBB) covers lower warm moist air, it is known that potential instability is intensified and Cb development may be prompted. It is useful to recognize these upper dry areas for short range forecasting. Isothermal lines of TBB are drawn on the chart every 10℃, and the dry areas where TBBs are warmer than −20℃ are shown as dark area.

(3) Analytic information

Some kinds of cloud patterns are closely related to significant meteorological phenomena such as cloud vortices, convective cloud line, cirrus streaks etc. These cloud patterns are recognized by the man-machine interactive procedure and displayed on the chart by symbolic marks. Upper level jet streams and troughs, which are recognized in water vapor image, are also added. Symbols are shown in Table 4.11.1.

If significant trends and features about these cloud patterns are recognized, alphabetical marks are attached to the cloud patterns, and the corresponding information is tabulated in the description columns on the left side of the chart. The column consists of the location,

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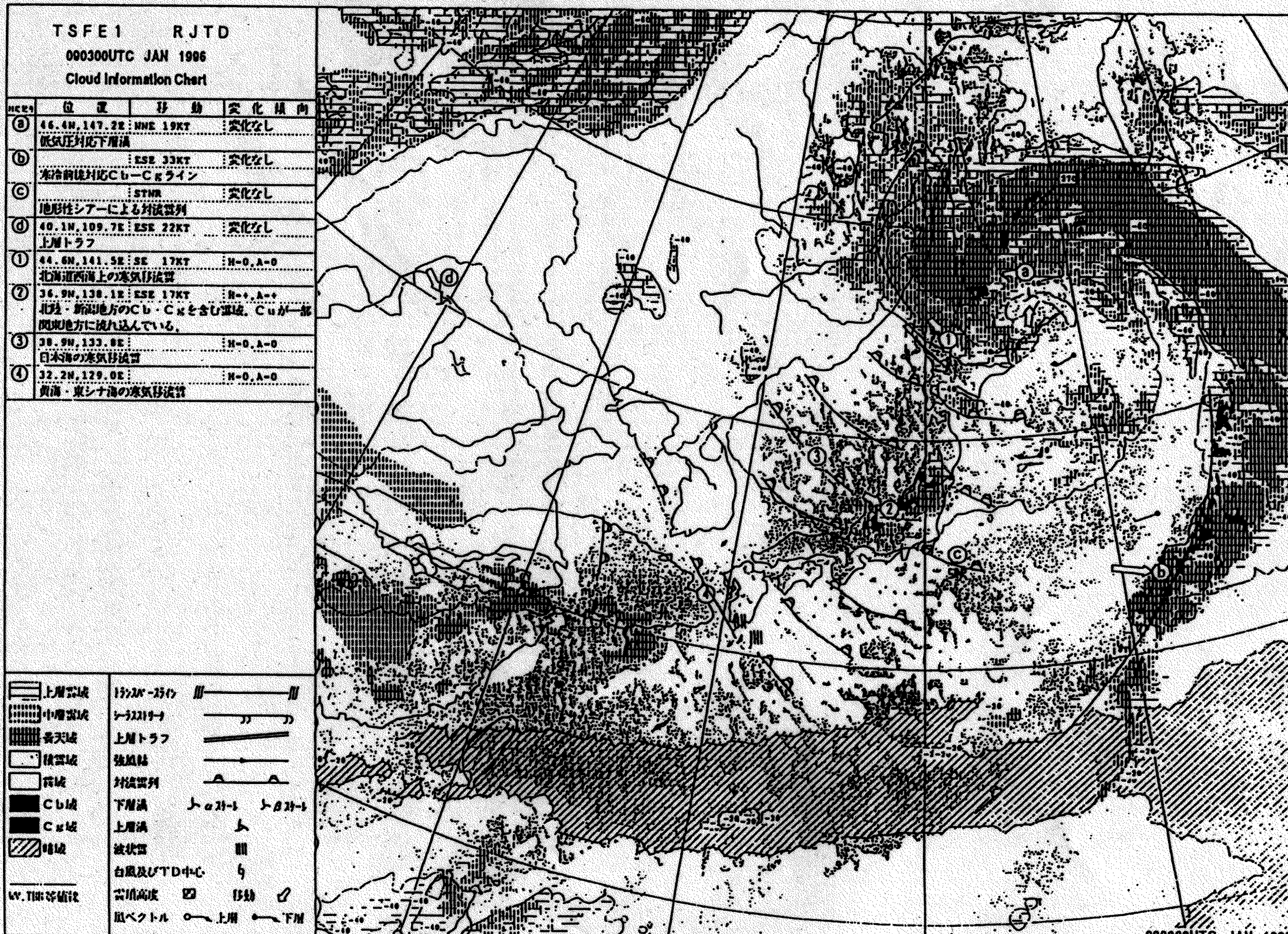

Fig. 1. Cloud Information Chart

propagation speed, developing/weakening trend, and comment.

Significant cloud areas are marked in the chart, and also interpreted in the columns. Significant cloud areas include active convective region, cloud areas which suggests fronts or centers of disturbances, rapid darkening areas in water vapor image etc.

(4) Satellite cloud drifting wind vector and cloud height

Two kinds of values are measured and put on the chart, satellite cloud drifting vector which is derived from the motion of upper level cirrus and low level cumulus, and cloud top height calculated from TBB. They are shown by each mark (Table 4.11.1). For semi-transparent cirrus, cloud top height is estimated by infra-red and water vapor data.

Satellite Cloud Information Chart (Far East)

The Satellite Cloud Information Chart (Far East) is the meteorological product which shows distribution of clouds classified by altitude and active convective cloud areas. It is based on GMS Image data displayed on Mercator chart for aviation weather forecasting. A cloud top height in this chart is expressed in feet unit. Its spatial resolution and area covering are 0.25 degree in latitude and longitude and a box of 60.0N- 0.0N and 90.0E- 170.0W respectively. This product is disseminated hourly to JMA headquarter.

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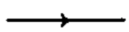
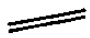
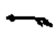
Table 4.11.1 Additional information and symbols

(Symbol)	(Article)
	(Low Level Cloud Vortex)
	(Upper Level Cloud Vortex)
	(Center of Typhoon)
	(Cirrus Streak)
	(Transverse Line)
	(Convective Cloud Line)
	(Meso- β Scale Cloud Vortex)
	(Wave Cloud)
	(Jet Streak)
	(Upper Level Trough)
	(Upper Level Cloud Motion Wind)
	(Lower Level Cloud Motion Wind)
	(Cloud Top Level)
	(System Propagation)

4.12 Typhoon Information

4.12.1 Outline

MSC analyzes the location, movement, intensity and size of tropical cyclones using GMS images throughout the cyclone's life cycle. All analyses are carried out by man-machine interactive operation on the work stations. Enhanced images and time lapse movie loops are used to determine the location, movement and cloud system size of the tropical cyclone. Intensity (CI number) of the tropical cyclone is estimated by Dvorak's method based on the enhanced infrared images. The results of the analyses are disseminated as SAREP to the Typhoon Committee Members' countries and the domestic forecast centers. The summary of SAREP for the users is as follows.

4.12.2 Description

(1) SAREP contents

SAREP (WMO international code FM 85-IX) is the name of the code for reporting synoptic interpretation of cloud data obtained by a meteorological satellite. Part A of the SAREP, which deals with information on tropical cyclones, is disseminated from MSC on the Global Telecommunication System (GTS) when a tropical cyclone is located in the region between 100° E and 180° E in the northern hemisphere. Information on the location, movement, and cloud system size of the tropical cyclone is disseminated 3-hourly (00, 03, 06, 09, 12, 15, 18, 21 UTC) under the heading TCNA20 RJTD and information on the tropical cyclone's intensity in addition to the above mentioned data is disseminated 6-hourly (00, 06, 12, 18 UTC) under the heading TCNA21 RJTD.

CODE FORM

TCNAjj RJTD YYGGgg (BBB) CCAA YYGGg IIiii [Name of cyclone]
[Common No.] $n_t n_t L_a L_a L_a$ $1 L_o L_o L_o L_o$ $1 A_t W_f a_t t_m$ $2 S_t S_t$ // $9 d_s d_s f_s f_s$=

TCNAjj = TCNA20 : Location, accuracy, movement, and cloud system size are transmitted.
TCNA21 : Information of intensity are added to TCNA20

RJTD : Identification code of JMA

YYGGgg : Observed time, i.e. day, hour, minute by UTC (gg is '00' always)

BBB : Correction code. Only in case of correction, first CCA, next CCB, CCC, ...CCZ

CCAA : This indicates a report from a land station and part A of the SAREP

YYGGg : Observed time, i.e. day, hour, minute by UTC (g is '0' always)

IIiii : Station code number (47644)

[Name of cyclone] : Name of the tropical cyclone whenever it is known

[Common No.] : Number assigned to the typhoon whenever it is known

$n_t n_t$: Number assigned to the tropical cyclone

$L_a L_a L_a$: Latitude of geographical cyclone center in 0.1 degree

$L_o L_o L_o L_o$: Longitude of geographical cyclone center in 0.1 degree

A_t : Accuracy of the estimated cyclone position (shown in Table 4.12.1)

W_f : Size of the cyclone cloud system (shown in Table 4.12.2)

a_t : Previous 24-hour trend of cyclone intensity (shown in Table 4.12.3)
t_m : Time interval of movement (shown in Table 4.12.4)
S_tS_t : Intensity of the cyclone (CI-number) (shown in Table 4.12.5)
d_sd_s : Direction of movement of the tropical cyclone center in 10 degrees
f_sf_s : Movement speed of the tropical cyclone center in knots

*Note 1. If speed is less than 3kt, $d_sd_s=00$, $f_sf_s=00$.
If speed is undetermined, $t_m=/$, and $9d_sd_sf_sf_s$ group is omitted.
2. When two or more cyclones exist, the groups '$n_tn_tL_aL_aL_a$ $1L_oL_oL_oL_o$ $1A_tW_fa_tt_m$ $2S_tS_t$ // $9d_sd_sf_sf_s$' shall be repeated for each cyclone, preceded by the name whenever it is known.

(2) Accuracy of the estimated cyclone position (A_t)

Accuracy is classified into 5 levels in the code (shown in Table 4.12.1). There are some error factors such as that the systematic error of location determination of GMS images is about 0.1 degree and that there is parallax of tall clouds being seen farther than actual from the direction of the satellite. It is necessary to pay attention to those errors.

(3) Size of the cyclone cloud system (W_f)

Size of the cyclone cloud system is defined as the average diameter of the dense and almost circular cloud area which surrounds the cyclone's center. In the case of no Cbs near the center, like in the shear type, the system size will be undetermined (i.e. $W_f=/$. shown in Table 4.12.2).

(4) Intensity of the cyclone and the trend of intensity (S_tS_t, a_t)

Dvorak's methods are used to estimate the intensity of tropical cyclones from satellite images. This method estimates the intensity by the cloud pattern of the tropical cyclone. MSC adopts and uses this method and disseminates the result by SAREP. In this method, the most important index is the Current Intensity number (CI number). The CI number is the index representing the cyclone's cloud system, considering the intensity trend. It is determined by 0.5. The previous 24-hour trend of the cyclone intensity is coded according to Table 4.12.3. The relations between the CI number and the central pressure are shown in Table 4.12.5. (valid only for the cyclones in western North Pacific Ocean)

(5) Time interval for determination of movement (t_m)

Movement speed is calculated by comparing the present observation with the observation 6 hours before. However, if the movement speed is very slow or very quick, the time intervals are set to longer or shorter than 6 hours respectively (shown in Table 4.12.4).

Table 4.12.1 A_t: Accuracy of the estimated cyclone position

code figure	meanings
0	cyclone center within 10 km of the transmitted position
1	cyclone center within 20 km of the transmitted position
2	cyclone center within 50 km of the transmitted position
3	cyclone center within 100 km of the transmitted position
4	cyclone center within 200 km of the transmitted position
5	cyclone center within 300 km of the transmitted position
/	cyclone center undetermined

Table 4.12.2 W_f: Size of the cyclone cloud system

code figure	size (latitude/longitude)
0	less than 1°
1	1° — 2°
2	2° — 3°
3	3° — 4°
4	4° — 5°
5	5° — 6°
6	6° — 7°
7	7° — 8°
8	8° — 9°
9	over 9°
/	undetermined

Table 4.12.3 a_t: Previous 24-hour trend of cyclone intensity

code figure	meaning	CI-number change in previous 24 hours
0	rapidly weakening	−1.5 or less
1	weakening	−1.0 to −0.5
2	no change	0.0
3	developing	0.5 to 1.0
4	rapidly developing	1.5 or more
9	no previous observation	
/	undetermined	

Table 4.12.4 t_m: Time interval of movement

code figure	time interval
0	less than 1 hour
1	1≦ 2 hour
2	2≦ 3 hour
3	3≦ 6 hour
4	6≦ 9 hour
5	9≦ 12 hour
6	12≦ 15 hour
7	15≦ 18 hour
8	18≦ 21 hour
9	21≦ 30 hour
/	movement is not contained

Table 4.12.5 S_tS_t : Intensity of the cyclone (CI-number)

Code figure	Current intensity (CI number)	Maximum sustained wind speed (knots)	Central pressure (hPa)
00	Decaying		
15	1.5	25	
20	2.0	30	1000
25	2.5	35	997
30	3.0	45	991
35	3.5	55	984
40	4.0	65	976
45	4.5	77	966
50	5.0	90	954
55	5.5	102	941
60	6.0	115	927
65	6.5	127	914
70	7.0	140	898
75	7.5	155	879
80	8.0	170	858
99	Becoming extratropical cyclone		
//	Undetermined		

Note: The procedures for determining the Current Intensity (CI) Number from satellite imagery are in publication WMO. NO. 305 —Guide on the Global Data-processing System.

4.13 ISCCP DATA

4.13.1 Outline

The operational data collection phase of the International Satellite Cloud Climatology Project (ISCCP) began on 1 July 1983 as the first element of the World Climate Research Program (WCRP). Since then, visible and infrared images from the international network of operational geostationary and polar orbiting meteorological satellites (GOES-E, GOES-W, METEOSAT, GMS and NOAA/TIROS-N) have been routinely processed to develop a global data set of calibrated radiances and to derive cloud parameters for climatological research.

4.13.2 Description

In the ISCCP, the MSC provides the observation and distributes the image data. Three types (AC, B1 and B2) of image data set are produced from the observation data of GMS and sent to a few processing centers.

The general flow of data processing is shown in Fig.4.13.1

4.13.2.1 AC data

AC data are sector image data of full resolution covering an area that is around sub-satellite point (SSP) and is coincident with the orbital swath of the polar orbiting satellite. The data are produced five times a month and are sent to the Satellite Calibration Center (SCC) at Lannion, France, for determination of inter-satellite normalization parameters.

4.13.2.2 B1 data

B1 data are image data of reduced resolution (around 10km) over the full GMS coverage area. The data are produced every three hours and are sent to ISCCP Central Archive (ICA) at Washington, U.S.A.

4.13.2.3 B2 data

B2 data are image data of reduced resolution (around 30km) over full GMS coverage area. The data are produced every three hours and are sent to the Global Processing Center (GPC) at New York, U.S.A.

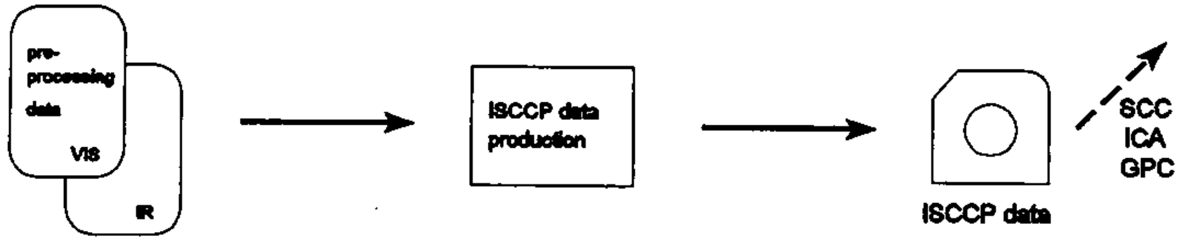


Fig.4.13.1 The general flow of data processing

4.14 Global Precipitation Climatology Project (GPCP) Data Set

4.14.1 Outline

It has been recognized that latent heat with condensation of water vapor plays an important role in large scale atmospheric circulations. The Global Precipitation Climatology Project (GPCP) has been planned as a part of the World Climate Research Program (WCRP) of World Meteorological Organization (WMO) / International Council of Scientific Union (ICSU) in 1984. It aims to estimate the spatial and temporal average of global precipitation.

MSC has been producing histogram data sets of infrared (IR) brightness temperature (TB) derived from GMS IR window channel and their statistics on an operational basis since March 1984 and has been providing those data to the GPCP on a routine basis since March 1987. The data are sent to the Geostationary Satellite Precipitation Data Center (GSPDC) of the GPCP to calculate the monthly global precipitation.

4.14.2 Description

The function of MSC at the GPCP data processing center for GMS is as follows;

(1) Acquire IR TB data in the area between 40° N and 40° S, and 90° E and 170° W, 3-hourly (nominally at 00, 03, 06, 12, 15, 18 and 21 UTC).

(2) For each data, assign picture elements (pixels) to 2.5°×2.5° (latitude/longitude) "boxes" and compute the following statistics for each "box": sixteen class histogram (class limits are shown in Table 4.14.1), mean value and variance.

(3) For each five day period (pentad), aggregate the statistical information to produce the following quantities for each 3-hourly time: sums of the histogram class, averages of the mean values and averages of the variances.

(4) For every three months, the data set for the past three months (18 pentads) is accumulated on a magnetic tape and sent to GSPDC.

This procedure will be continued until 2000.

4.14.3 Remarks

Produced global merged data sets of 5-day infrared statistics and accumulated 5-day and pseudo-monthly rainfall estimates from GMS, GOES-USA and METEOSAT-EUMETSAT are recorded and archived on magnetic tapes.

Table 4.14.1 GPCP IR histogram class boundaries.

Class	Temperature Limits (K)
1	270.5<T
2	265.5<T≤270.5
3	260.5<T≤265.5
4	255.5<T≤260.5
5	250.5<T≤255.5
6	245.5<T≤250.5
7	240.5<T≤245.5
8	235.5<T≤240.5
9	230.5<T≤235.5
10	225.5<T≤230.5
11	220.5<T≤225.5
12	215.5<T≤220.5
13	210.5<T≤215.5
14	200.5<T≤210.5
15	190.5<T≤200.5
16	T≤190.5

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5 GMS DATA COLLECTION SYSTEM

5.1 General Description

The Data Collection System(DCS) is the system that collects environmental data from Data Collection Platforms(DCPs) and distributes them for users.

DCPs are automatic environmental data observation systems. They may be installed isolated islands, mountains, ships, buoys or aircrafts. In all cases, observed data are transmitted from them to the Meteorological Satellite Center (MSC) via GMS. Then, the data are reformatted and distributed to users over the Global Telecommunications System (GTS).

5.1.1 Data Collection Platforms

There are two types of DCPs as follows;

a) International DCPs (IDCPs) are mobile platforms that move from the telecommunications field of view of one geostationary satellite to another.

b) Regional DCPs (RDCPs) are fixed platforms that have telecommunications with a particular geostationary satellite only.

All RDCPs in the GMS coverage area currently are the self-timed type one. They transmit messages to GMS at fixed times.

5.1.2 Radio Frequency Specification

The radio frequency specifications are as follows;

Up-Link		
Frequency bands allocated	402.0 - 402.1 MHz	(IDCP)
	402.1 - 402.4 MHz	(RDCP)
Number of channels	33	(IDCP)
	100	(RDCP)
Bit rate	100 bit/sec.	
Power (EIRP)	43 - 46 dBm	
Type of modulation	PCM - PSK (±60°)	
Down-Link		
Frequency bands allocated	1694.3 - 1694.4 MHz	(IDCP)
	1694.4 - 1694.7 MHz	(RDCP)
Bit rate	100 bit/sec.	
Power (EIRP)	34 dBm	
Type of modulation	PCM - PSK (±60°)	

5.2 DCPs Data Processing

The main functions of the DCPs data processing system are as follows;

a) DCPs reports collection,

b) collected data verification,

-whether the data received have errors such as parity error or not

-the data are formatted in a standard WMO code

-DCP address is registered in data base of the DCPs data processing system

-the observation time in the data agrees with the preset slot time

-the number of words that constitute the data is 649 or under

If the results of verification as above are not acceptable, the data are not distributed.

c) an exclusive header appendix to the reports,

d) the reports distribution to users through GTS on a real - time basis.

The DCPs reports are primarily formatted in a standard WMO code by each DCP. However, if the data is raw, it is formatted at the DCPs Data processing system.

Users are able to discriminate the DCP report that is needed by referring to the to refer a header appended to the report.

5.2.1 Report Format

The DCPs report consists of the following elements. (See Figure 5.1)

-an unmodulated carrier for 5 seconds,

-a 250 bit alternate "0","1" preamble,

-a 15 bit Maximal Linear Sequence (MLS) code synchronization word,

-the DCP address that is 31 bit Bose-Chaudhuri-Hocquenghem (BCH) coded word,

-the environmental data that is a maximum of 649 words, each word being 8 bits longs,

-the 31 bit End of Transmission (EOT) sequence.

Refer to "Technical Requirement of Data Collection Platform (DCP)" for further details.

unmodulated carrier	preamble	sync	address	environmental data	E.O.T.
5 second	250 bits	15 bits	31 bits	649 (max) words of 8 bits	31 bits

Fig.5.1 : DCP Report Format

6 Data Archives

6.1 Type and Period of Data Archives

The type and Period of meteorological Satellite data archives at the MSC are shown in Table 6.1.1

Manegement of these data for users is carried out at the System Engineering Division, Data processing Department, MSC (tel : 0424-93-1111).

6.2 Monthly Report of the Meteorological Satellite Center

The Monthly Report of the Meteorological Satellite Center has been published on a CD-ROM since January 1996. Previously it was published as a printed report. Image data have been changed to CD-ROM since July 1996.

Contents and forms of observational monthly report are described in appendix I.

Table 6.1.1 Data archives

a. Geostationary Meteorological Satellite

Type of Data	media	retention period	Data period (*1)
Picture data			
Original negative film	Film	10yr.	Apr.1978
Printed positive picture	Picture	5yr.	ditto
Microfilm	Film	Permanent	ditto
16mm animation film	Film	10yr.	Apr.1978-Mar.1990
VTR tape	Video Tape(VHS)	30yr.	Nov.1978
Digital image data(VISSR archive data) (*2)			
IR data	MT	10yr.	Mar.1981-Feb.1987
	CT	ditto	Mar.1987-May.1995
	CMT	ditto	Jun.1995.
WV data	CMT	ditto	Jun.1995-
VIS data	MT	ditto	Mar.1981-Feb.1987
	CT	ditto	Mar.1987-May.1995
	CMT	ditto	Jun.1995-
Extracted data			
VISSR histogram data(IR)	MT	30yr.	Jun.1982-Oct.1982 Jan.1984-Feb.1987
	CT	ditto	Mar.1987-May.1995
	CMT	ditto	Jun.1995-
VISSR histogram data(VIS)	CMT	ditto	ditto
Cloud grid point data	ditto	ditto	ditto
Cloud amount	MT	ditto	Feb.1978-May.1995
	CMT	ditto	Jun.1995-
Sea surface temperature (SST)	MT	10yr.	Feb.1978-May.1995
	CMT	ditto	Jun.1995-
Brightness temperature distribution	MT	ditto	Mar.1987-May.1995
	CMT	ditto	Jun.1995-
Cloud motion wind	MT	ditto	Apr.1978-May.1995
	CMT	ditto	Jun.1995-
ISCCP data (B1)	MT	ditto	Jun.1983-May.1995
	CMT	ditto	Jun.1995-
ISCCP data (B2)	MT	30yr.	Apr.1988-May.1995
	CMT	ditto	Jun.1995-
GPCP data	MT	ditto	Jan.1986-May.1995
	CMT	ditto	Jun.1995-
SEM data	MT	ditto	Apr.1978-May.1995

Table 6.1.1 Data archives

Type of Data	media	retention period	Data period (*1)
Contour chart, etc.			
Cloud amount	chart	5yr.	Jan.1991-
Sea surface temperature (SST)	ditto	ditto	ditto
Brightness temperature distribution	ditto	ditto	ditto
Cloud motion wind	ditto	ditto	ditto
SCIC (Vicinity of Japan) (*3)	ditto	3yr.	ditto
SCIC (Far East area) (*3)	ditto	ditto	ditto

b. Polar Orbiting Satellite (NOAA)

Type of Data	media	retention period	Data period (*1)
Digital data			
HRPT data	CT	5yr.	Mar.1987-May.1995
	CMT	5yr.	Jun.1995-
Extracted data			
TOVS data	MT	10yr.	Nov.1980-May.1995
	CMT	ditto	Jun.1995-
NOAA surface temperature data	MT	ditto	Jan.1981-May.1995
	CMT	ditto	Jun.1995-
Ozone data	CMT	ditto	Jun.1995-

c. Publication

Title	retention
Monthly Report of Meteorological Satellite Center	Permanent
Technical Report of Meteorological Satellite Center	ditto
All publications published by MSC	ditto

(*1) Data archiving period. The archive data out of retention period might be discarded without announcement.

(*2) Format of these data is described in Appendix F.

(*3) Style is modified since Jun.1995.

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MDUS SPECIFICATIONS

MDUS receives the Stretched VISSR (S-VISSR) signal which is transmitted via GMS.

1. Stretched VISSR Transmission

The S-VISSR are transmitted by each scan at 14 Mbps within approximately 50 mS and processed to reduce at 660 Kbps and edited into the S-VISSR data format at the CDAS. It is accompanied by dummy data to modulate the up-link carrier continuously white raw data are transmitted within this time slot.(see Fig.A.1) S-VISSR data are relay during the remainder time of the on board S-band transponder and coincidentally with the VISSR operational mode of the GMS-5.

2. Stretched VISSR Data Format

The S-VISSR of each satellite spin-scan (line) are edited into sectors of the S-VISSR data of the line. A sync code is leading each S-VISSR data for acquisition and decoding at MDUSs. Transmission sequence of the sectors are shown in Fig.A.2.

2.1 SYNC Code

SYNC code is transmitted to allow bit and frame SYNC by demodulators and decommutators at user sites. This code consists of 20,000 bits of a Pseudo-Noise (PN) code of Maximal Length Sequence (MLS) generated by means of a 15 digits serial shift register. The PN sequence begins with the fixed pattern (010001001100001) at a timing of every satellite spin.

A 15 digits local serial shift register is necessary for SYNC with the incoming S-VISSR data stream at the user site and SYNC is established as follows.

Any 15 consecutive bits in the detected bit stream are loaded into the local shift register and then the shift register starts to generate a bit stream of MLS PN pattern. This PN pattern is locally generated and the incoming bit pattern is continuously compared with this locally generated pattern. When a bit stream of SYNC code comes in, both bit patterns will be satisfactory coincident indicating SYNC. SYNC will be maintained unless any error occurs in the input bit stream. Otherwise, this procedure has to be repeated until satisfactory matching can be obtained. In this way, the user station can acquire the start point of the information sectors.

This bit stream is also necessary in order to descramble the information sector's bit stream.

2.2 Information Sectors

There eight information sectors , which consist of :

-the documentation (DOC) sector
-three infrared image (IR) data sectors

-four visible image (VIS) data sectors

The DOC sector and each IR sector contain 2,293 eight bit words and each VIS sector contains 9,166 six bit words. Besides every sector has also 16 bits of the Cyclic Redundancy Check (CRC) code and 2,048 bits filled with logic zeros (Filler). The filler provides approximately 3 msec of buffer time for data acquisition by a computer system of a user station.

2.2.1 Documentation Sector

This sector is divided into nine information blocks:

-sector ID block
-spacecraft (S/C) and CDAS status block
-simplified mapping block 1
-sub-commutation ID block
-simplified mapping block 2
-orbit and attitude information block
-MANAM block
-Calibration data block
-spare block

The block format is shown in Fig.A.3.

The parameters block for simplified mapping, orbit and attitude data block and the MANAM block are sub-commutated into 25 groups due to the data volume. Each group is repeatedly transmitted on 8 consecutive scan lines to reduce the errors. Thus the complete documentation text is received every 200 scan lines with redundancy of 7 lines.

(1) Sector ID block

This block contains 2 words (16 bits), all logic zeros, and is used to identify the documentation sector.

(2) S/C and CDAS Status block

This block contains 126 words (1,008 bits). This information is provided to process S-VISSR image data. Details are shown in Table.A.1.

(3) Simplified Mapping block 1(constants)

This block consists of 64 words (512 bits). The data in this block is used for simplified mapping together with the data in the parameters block. Details are shown in Table.A.2. This block is inserted into each line.

(4) Sub-Commutation ID block

This block consists of 4 words (32 bits). The first counter (194th word from top of the DOC) is the repeat counter indicating the sub-commutation ID and increments from 0 to 24 for the 25 documentation text groups. The second counter (196th) is also the repeat counter and increments from 0 to 7 for each repeated line of a group. The most significant words of each counter (193th and 195th) are always zero. Recovery of a whole information block containing the parameters block for simplified mapping, orbit and attitude data and MANAM, requires 200 lines.

(5) Simplified Mapping block 2 (parameter table)

This block consists of 2,500 words. 100 words are contained in each line. The same data (100 words) are repeated for 8 lines to avoid missing (so there are 25 sub-commutations in the block). Thus 200 lines are needed to acquire all the information of this block. Details are shown in Table.A.3.

(6) Orbit and Attitude Data block

This block consists of 3,200 words and is used for mapping on the received image data by means of a large scale computer system. 128 words (1,024 bits) are contained in each line. The same data (128 words) are repeated for 8 lines to avoid missing. Thus 200 lines are needed to acquire all the information in this block. Details are shown in Table.A.4,A.5 and A.6.

(7) MANAM block

This information is provided to notify users of the GMS operational schedule. The block is made of 10,250 words. 410 words (3,280 bits) are continued in each line. The same data (410 words) are repeated for 8 lines to avoid missing. Thus 200 lines are needed to acquire all the information of this block.

Data in the MANAM block is coded as ASCII characters. One set of characters consist of 80 alpha-numeric characters, CR and LF (82 bytes in total), so 5 sets of character based information are included in a line. Thus a complete MANAM block would consist of 125 sets of characters (5 sets/line by 25).

Users are able to directly obtain up to 125 lines of MANAM information on a line printer.

(8) Calibration data block

Information to convert the level value of S-VISSR into a reflection quantity black body brightness temperature of emission. Details are shown in Table.A.7.

(9) Spare block

This block contains 1,203 words (9,624 bits) and is filled with zeros. The block is provided for future expansion.

2.2.2 Infrared Image Data Sectors

Each IR data sector consists of 2 words (16 bits) of sector ID code, 2,291 words of IR image data, 16 bits of CRC code and 2,048 bits of Filler.

The first IR sector contains the observed image data. The rest are reserved for future use and are filled with logic zeros. IR sector 1 contains 2,291 pixels of image data derived from one VISSR scan. Each pixel of data is thermally calibrated and represented in an eight bit word. It corresponds to the VISSR Instantaneous Field of View (IFOV) for 140 μrad sampling with a resolution of 5 km around the SSP.

IR sector code

Each IR data sector consists of 2 words (16 bits) and is used to identify the IR sectors. The following list shows the code assignments.(refer to Fig.A.4)

2.2.3 Visible Image Data Sectors

Each visible (VIS) image data sector consists of 2 words (12 bits) of sector ID code, 9,164 words of VIS image data, 16 bits of CRC code and 2,048 bits of filler.

The four VIS sectors contain the observed image data of the four visible detectors from one VISSR scan. Each sector contains 9,164 pixels of data and represented in a six bit words. It corresponds to the visible IFOV for 35 μrad sampling with the resolution of 1.25 km at the SSP.

VIS sector ID code

This code consists of 2 words (12 bits) and is used to identify the VIS sectors. The following list shows the code assignments. (refer to Fig.A.5)

2.3 Dummy Data

S-VISSR data is transmitted sharing time with the raw VISSR transmission during one satellite spin.

Time available for relaying the S-VISSR signal and raw VISSR signal varies around 600 msec in proportion to the satellite spin rate which will be maintained within 100 ± 1 RPM. Accordingly, transmission time of S-VISSR data (SYNC code and Information sectors) is fixed as 500 msec (329,872 bits/660 Kbps). Otherwise, dummy data is transmitted during the rest period of one satellite spin (approximately 100 msec). Dummy data will be interrupted by transmission of raw VISSR signal for approx. 42 msec. This data is filled with all logic O bits.

3. Coding Scheme

The transmitted S-VISSR data is modulated by two stages of coding in order to distribute more equally the RF signal spectrum and to maintain sync-lock of users demodulator. As the original data could contain some length of logic zeros or logic ones, it would cause false synchronization of the demodulator.

3.1 Byte Complementing

The first stage of coding is started at the beginning of the information sectors. The contents of the every other eight bits (even bytes) are complemented and this process continues up to just before the commencement of SYNC code. Note the SYNC code is not complemented.

3.2 PN Scrambling

The second stage of coding involves the output bit stream from the SYNC code generator described in 2.1.

The bit stream from the byte complementing process and the output of the PN code generator enter an exclusive OR gate. Resulting output is transmitted through the S-VISSR PSK modulator at the CDA station for transmission by GMS.

For descrambling the incoming bit stream at user stations, the incoming bit stream and the output of the local PN code generator shall be passed through an exclusive OR gate.

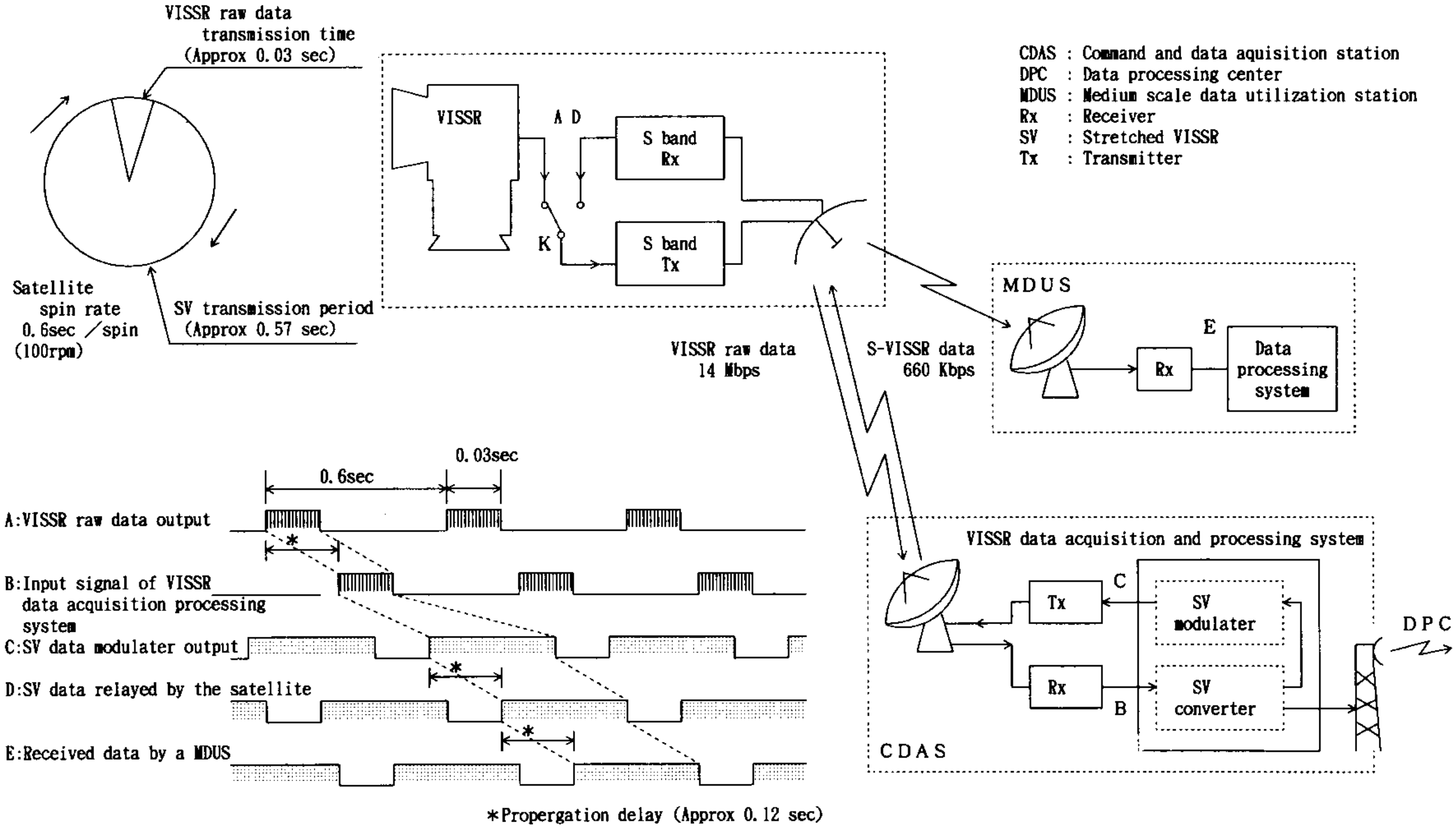

Fig.A.1 Stretched VISSR signal transmission timing chart

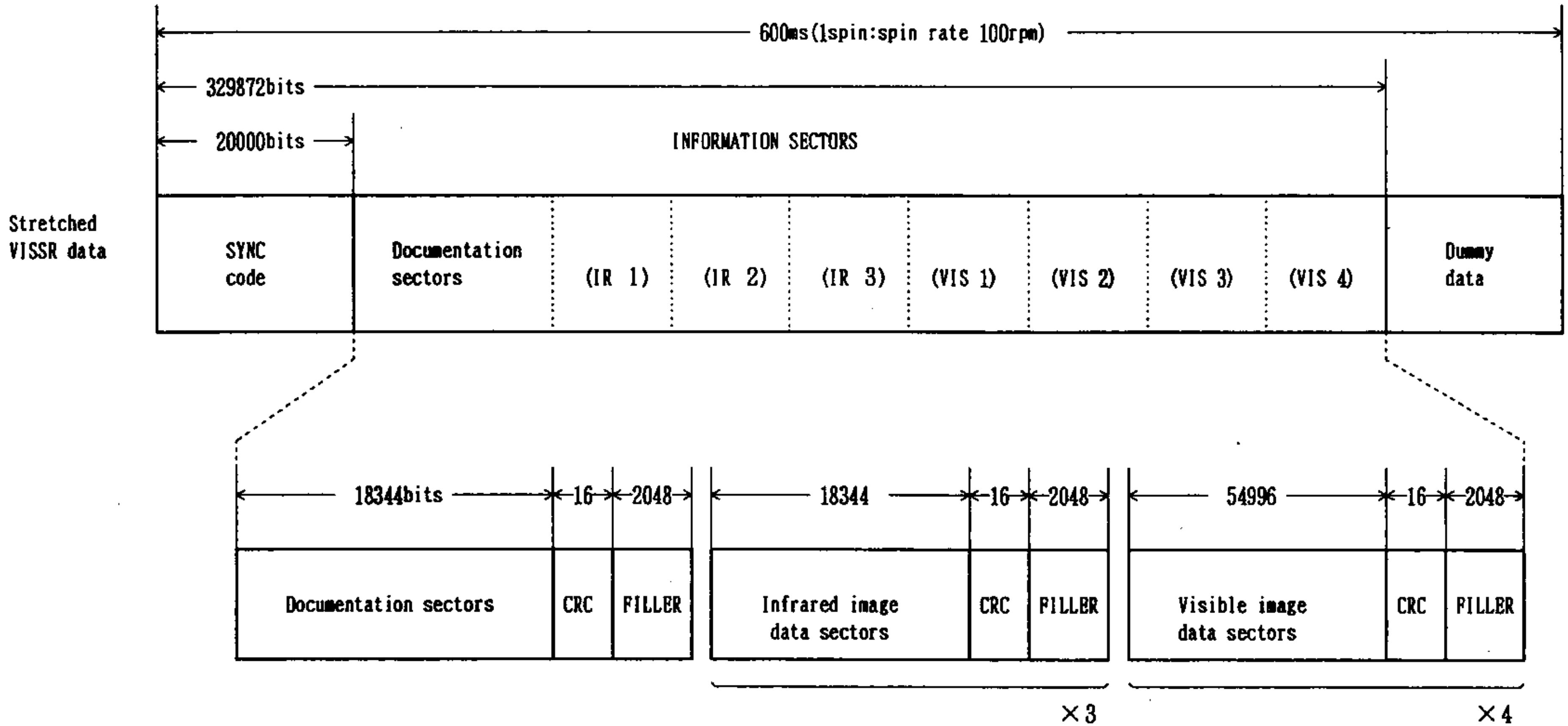

Fig.A.2 Stretched VISSR data format

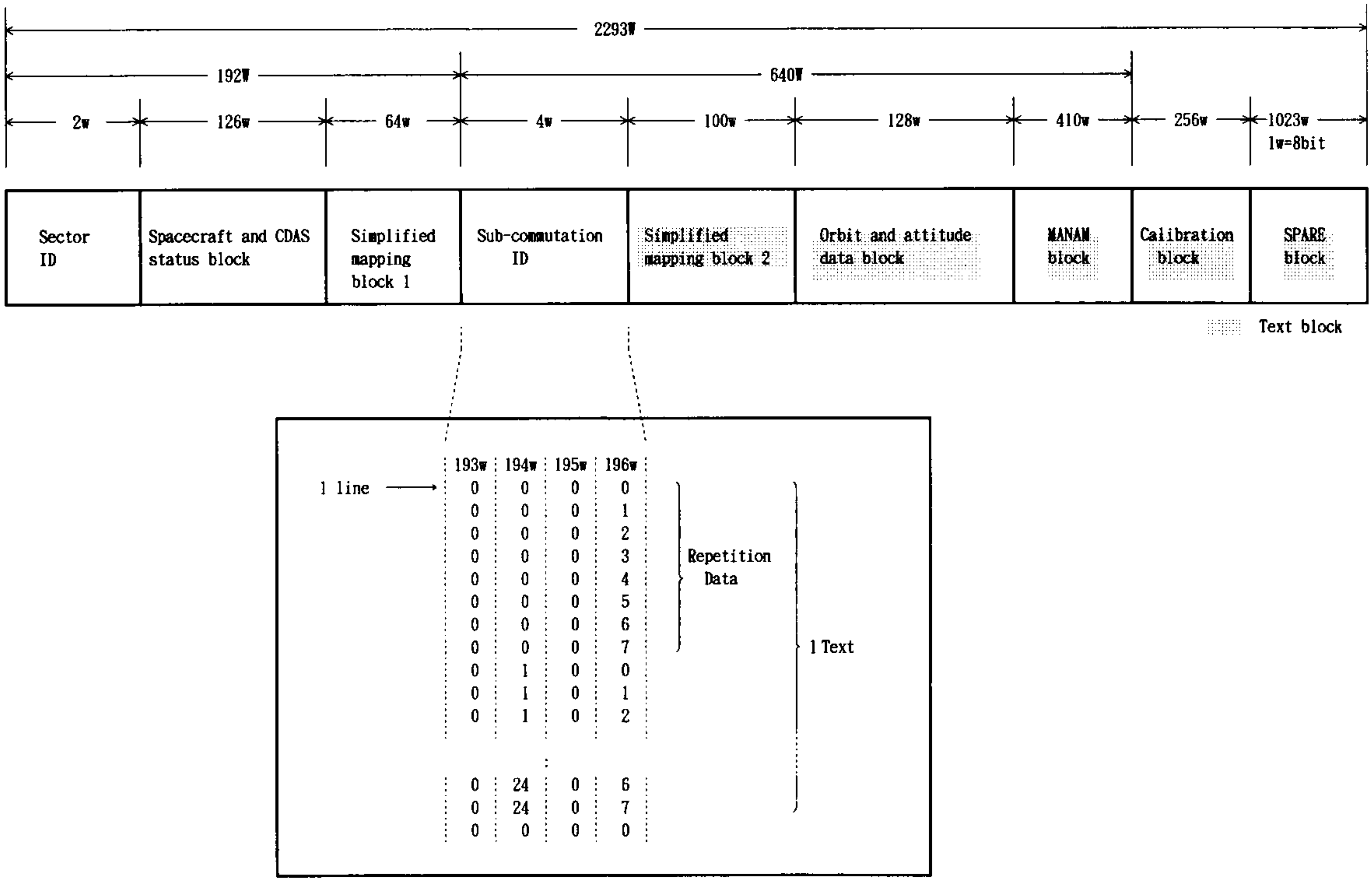

Fig.A.3 Block format of Documentation sector

Rev. 1

Table. A. 1 S/C & CDAS documentation block (126 words)

Word NO.	Item	Contents	(Type)
1	Scan Mode Normal Scan Limited Scan Single Scan	Scan Mode $00_{(16)}$: Full frame observation $0F_{(16)}$: Observation of the preset scan lines $FF_{(16)}$: VISSR Observation without mirror stepping	I * 1
2	Scan Status	MSB LSB b_8 | b_7 | b_6 | b_5 | b_4 | b_3 | b_2 | b_1 b_1, b_2 = 1, 1 : Forward (Scan Mirror driven from North to South) b_3, b_4 = 1, 1 : Reverse (Scan Mirror driven from South to North) b_5, b_6 = 1, 1 : Step Normal (Scan Mirror stepping 1 step per spin) b_7, b_8 = 1, 1 : Step Rapid (Scan Mirror stepping 10 2/3 steps per spin) all bits = "0" : Step Scan Off	I * 1
3	Frame Flag	$FF_{(16)}$: Signification Data $00_{(16)}$: Insignification Data	I * 1
4	Picture Flag	$FF_{(16)}$: Signification Image $00_{(16)}$: Insignification Image	I * 1
5 ~ 6	Picture Flag Set Line Number	Line Number of that Picture Flag on In Normal Scan : Equator Scan Count-1145 In Limited Scan : LSS In Single Scan : 0000 (BCD)	BCD * 2
7 ~ 8	Picture Flag Reset Line Number	Line Number of that Picture Flag off In Normal Scan : Equator Scan Count+1145 In Limited Scan : LES In Single Scan : 0000 (BCD)	BCD * 2
9 ~ 10	Scan Count (1)	Scan Count	BCD * 2
11 ~ 12	West Horizon Point	Pixel count of IR1 data at the Earth edge (12 bit binary) In no detection or Q/D error : $FFFF_{(16)}$ MSB: 11ward b_4 LSB: 12ward b_1	I * 2
13 ~ 14	East Horizon Point	Pixel count of IR1 data at the Earth edge (12 bit binary) In no detection or Q/D error : $FFFF_{(16)}$ MSB: 13ward b_4 LSB: 14ward b_1	I * 2
15	Sync lock Q/D	Error information of Tracking $00_{(16)}$: Normal operation $FF_{(16)}$: Some defective detected	I * 1
16 ~ 17	Bit Error Count	Bit Error Count in SYNC code of the VISSR minor frame In Q/D error : $FFFF_{(16)}$ 13 bit binary MSB: 16word b_5 LSB: 17word b_4	I * 2

@ Continue

Word NO.	Item	Contents	(Type)
18 ~ 19	Year	Year	BCD*2
20	Month	Month (01~12)	Each BCD*1
21	Day	Day (01~31)	
22	Hour	Hour (00~23)	
23	Minute	Minute (00~59)	Each BCD*1
24	Second	Second (00~59)	
25	1/100 second	1/100 second (00~99)	
26 ~ 27	Calibration Table ID	Calibration Table ID (16 bit binary) | MSB: 26word b_8 | LSB: 27word b_1 |	I*2
28 ~ 29	MANAM Revision Number	MANAM Revision Number (16 bit binary) | MSB: 28word b_8 | LSB: 29word b_1 |	I*2
30	Data Source	$FF_{(16)}$: Operation Data $00_{(16)}$: Test Data	I*1
31 ~ 64	Spare		
65	Scanner Select	$FF_{(16)}$: Primary Scan Mirror Drive-1 $F0_{(16)}$: Primary Scan Mirror Drive-2 $00_{(16)}$: Redundant Scan Mirror Drive-1 $0F_{(16)}$: Redundant Scan Mirror Drive-2	I*1
66 ~ 67	Scan Count (2)	Raw Binary Scan Count from S/C In Q/D Error : $FFFF_{(16)}$ (12 bit binary) | MSB: 66word b_4 | LSB: 67word b_1 |	I*2
68	Sensor Select	MSB [b_8 | b_7 | b_6 | b_5 | b_4 | b_3 | b_2 | b_1] LSB b_8: VIS4 b_4: IR3 b_7: VIS3 b_3: IR2 b_6: VIS2 b_2: IR1 b_5: VIS1 b_1: All 1 (1 :Primary 0 :Redundant)	I*1

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Word NO.	Item	Contents	(Type)
69	Sensor Patch	Indicates which VIS sensor's data inserted in each VIS sector MSB [b_8 | b_7 | b_6 | b_5 | b_4 | b_3 | b_2 | b_1] LSB $b_8 b_7$: V4, $b_6 b_5$: V3, $b_4 b_3$: V2, $b_2 b_1$: V1 V1: 00 V2: 01 V3: 10 V4: 11	I * 1
70 ~ 72	Beta Count	Sun-Earth angle counted by reference 20 MHz clock (ref. clock) (μrad) 24 bit binary MSB: 70word b_8 LSB: 72word b_1	I * 3
73 ~ 75	Spin Period Count	Spacecraft spin period counted by ref. clock 24 bit binary MSB: 73word b_8 LSB: 75word b_1	I * 3
76 ~ 78	Scan SYNC Detect Angle	Deference between predicted and detected line SYNC code, counted by ref. clock 24 bit binary In Q/D Error : $FFFFFF_{(16)}$ MSB: 76word b_8 LSB: 78word b_1	I * 3
79 ~ 81	S/C Clock	Raw VISSR data bit rate counted by ref. clock 24 bit binary In Q/D Error : $FFFFFF_{(16)}$ MSB: 79word b_8 LSB: 81word b_1	I * 3
82 ~ 84	Earth Pulse Angle (1)	Deference between predicted Sun Pulse and detected Leading Edge of Earth pulse, counted by Ref. clock (only Earth Pulse Tracking) 24 bit binary In Q/D Error : $FFFFFF_{(16)}$ MSB: 82word b_8 LSB: 84wprd b_1	I * 3
85 ~ 87	Earth Pulse Angle (2)	Deference between predicted Sun Pulse and detected Trailing Edge of Earth pulse, counted by Ref. clock (only Earth Pulse Tracking) 24 bit binary In Q/D Error : $FFFFFF_{(16)}$ MSB: 85word b_8 LSB: 87word b_1	I * 3
88	Resampling Mode	Interpolation mode taken when resampling Raw VISSR Data MSB [b_8 | b_7 | b_6 | 0 | 0 | 0 | 0 | 0] LSB b_8: In Nearest Neighbor : 1 b_7: In Linear Divided 8 : 1 b_6: In Cubic Combolution : 1 b_1-b_5: all"0"	I * 1

Word NO.	Item	Contents	(Type)
89	PLL Status	PLL mode and bandwidth for tracking S/C spin rate (each 4 bit binary) Lower 4 bit : Tracking Mode 1 : SSD Tracking(auto) 2 : Analog Sun Pulse Tracking(auto) 3 : Earth Pulse Tracking(auto) 4 : SSD Tracking(Manual) 5 : Analog Sun Pulse Tracking(Manual) 6 : Earth Pulse Tracking(Manual) Upper 4 bit : Time Constant	I＊1
90	S/C ID	S/C ID (8 bit binary) 4 : GMS−4 5 : GMS−5	I＊1
91 ～ 93	Analog Sun Pulse Angle	Deference between predicted Analog Sun Pulse and detected Precision Sun Pulse, counted by Ref. clock (20MHz) 24 bit binary In Q/D error : FFFFFF(16) MSB: 91word b_8 LSB: 93word b_1	I＊3
94 ～ 96	PLL Error	Tracking error of Spin Tracking Loop, counted by Ref. clock (20MHz) 24 bit binary MSB: 94word b_8 LSB: 96word b_1	I＊3
97	Scanner Expanded Mode	Scanner Expanded Mode 00 : Normal Mode F0 : North Expanded Mode 0F : South Expanded Mode FF : North and South Expanded Mode	I＊1
98	Bit and Frame SYNC ID	Bit and Frame SYNC ID MSB [0 | 0 | 0 | 0 | 0 | 0 | b_2 | b_1] LSB b_1 : VISSR Acquisition is completed (0 : LOCK ON) b_2 : Scan SYNC or minor frame SYNC are locked (0 : LOCK ON)	I＊1
99 ～126	Spare		

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Table. A. 2 Simplified mapping block 1 (constants) (64 words)

Word No.	Item	Contents	Type
1 ~ 4	Earth Radius	Equatorial Radius of the Earth (m)	I*4
5 ~ 8	Satellite Elevation	Satellite Elevation (m)	I*4
9 ~ 12	Stepping Angle	Stepping Angle for IR Sensor (nrad)	I*4
13 ~ 16	Sampling Angle	Sampling Angle for IR Sensor (nrad)	I*4
17 ~ 20	Latitude of Sub Satellite Point	Latitude of Sub Satellite Point (mdeg)	I*4
21 ~ 24	Longitude of Sub Satellite Point	Longitude of Sub Satellite Point (mdeg)	I*4
25 ~ 28	Line Number of Sub Satellite Point	Line number of IR 1 Sensor of Sub Satellite Point	I*4
29 ~ 32	Pixel Number of Sub Satellite Point	Pixel number of IR 1 Sensor of Sub Satellite Point	I*4
33 ~ 36	Ratio of Circumference	Ratio of Circumference (π)	R*4.7
37 ~ 40	Concealment Quantity of VIS Line	The concealment quantity that converts line number of IR 1 sensor into line number of VIS sensor (X_1) $L_{VIS} = (L_{IR1}-1)\times 4+2.5+X_1$ L_{VIS} : line number of VIS sensor L_{IR1} : line number of IR1 sensor In case of minus number = First bit of MSB "ON"('1'B)	R*4.2
41 ~ 44	Concealment Quantity of VIS Pixel	The concealment quantity that converts pixel number of IR 1 sensor into pixel number of VIS sensor (Y_1) $P_{VIS} = (P_{IR1}-1)\times 4+2.5+Y_1$ P_{VIS} : pixel number of VIS Sensor P_{IR1} : pixel number of IR1 Sensor A quantity of minus number = First bit of MSB "ON"('1'B)	R*4.2
45 ~ 48	Concealment Quantity of IR 2 Line	The concealment quantity that converts line number of IR 1 sensor into line number of IR 2 sensor (X_2) $L_{IR2} = L_{IR1}+X_2$ L_{IR2} : line number of IR2 sensor	R*4.2
49 ~ 52	Concealment Quantity of IR 2 Pixel	The concealment quantity that converts pixel number of IR 1 sensor into pixel number of IR 2 sensor (Y_2) $P_{IR2} = P_{IR1}+Y_2$ P_{IR2} : pixel number of IR2 sensor	R*4.2

Word No.	Item	Contents	Type
53 ～ 56	Concealment Quantity of IR 3 Line	The concealment quantity that converts line number of IR 1 sensor into line number of IR 3 sensor (X_3) $L_{IR3} = L_{IR1}+X_3$ L_{IR3} : line number of IR3 sensor	R*4.2
57 ～ 60	Concealment Quantity of IR 3 Pixel	The concealment quantity that converts pixel number of IR 1 sensor into pixel number of IR 3 sensor (Y_3) $P_{IR3} = L_{IR1}+Y_3$ P_{IR3} : pixel number of IR3 sensor	R*4.2
61 ～ 64	Spare		

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Table. A. 3　Simplified mapping block 2 (parameters) (2500 words)

Word No.	Item	Contents	Type
1 , 2	Line number of 60° N , 80° E	Line number in IR1 sensor of 60 ° N , 80° E .	I＊2
3 , 4	Pixel number of 60° N , 80° E	Pixel number in IR1 sensor of 60 ° N , 80° E .	I＊2
5 , 6	Line number of 60° N , 85° E	Line number in IR1 sensor of 60 ° N , 85° E .	I＊2
7 , 8	Pixel number of 60° N , 85° E	Pixel number in IR1 sensor of 60 ° N , 85° E .	I＊2
9 , 10	Line number of 60° N , 90° E	Line number in IR1 sensor of 60 ° N , 90° E .	I＊2
11 , 12	Pixel number of 60° N , 90° E	Pixel number in IR1 sensor of 60 ° N , 90° E .	I＊2
	↓	↓	
101 , 102	Line number of 55° N , 80° E	Line number in IR1 sensor of 55 ° N , 80° E .	I＊2
103 , 104	Pixel number of 55° N , 80° E	Pixel number in IR1 sensor of 55 ° N , 80° E .	I＊2
105 , 106	Line number of 55° N , 85° E	Line number in IR1 sensor of 55 ° N , 85° E .	I＊2
107 , 108	Pixel number of 55° N , 85° E	Pixel number in IR1 sensor of 55 ° N , 85° E .	I＊2
	↓	↓	
2493 , 2494	Line number of 60 ° S, 165° W	Line number in IR1 sensor of 60 ° S , 165° W .	I＊2
2495 , 2496	Pixel number of 60 ° S, 165° W	Pixel number in IR1 sensor of 60 ° S , 165° W .	I＊2
2497 , 2498	Line number of 60 ° S, 160° W	Line number in IR1 sensor of 60 ° S , 160° W .	I＊2
2499 , 2500	Pixel number of 60 ° S, 160° W	Pixel number in IR1 sensor of 60° S , 160° W .	I＊2

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Table . A. 4 Orbit and attitude data block 3200 Words

Word No.	Item	Contents	Type
1 ~ 6	Observation Start Time	Scheduled start time imaging (MJD)	R*6.8
7 ~ 10	Stepping Angle	VIS channel stepping angle along line (rad)	R*4.8
11 ~ 14	Stepping Angle	IR channel stepping angle along line (rad)	R*4.8
15 ~ 18	Sampling Angle	VIS channel sampling angle along pixel (rad)	R*4.10
19 ~ 22	Sampling Angle	IR channel sampling angle along pixel (rad)	R*4.10
23 ~ 26	VIS channel Center Line Number	VIS channel center line number of VISSR frame	R*4.4
27 ~ 30	IR1 channel Center Line Number	IR1 channel center line number of VISSR frame	R*4.4
31 ~ 34	VIS channel Center pixel Number	VIS channel center pixel number of VISSR frame	R*4.4
35 ~ 38	IR1 channel Center pixel Number	IR1 channel center pixel number of VISSR frame	R*4.4
39 ~ 42	Number of Sensors of VIS channel	Number of sensors of VIS channel	R*4.0
43 ~ 46	Number of Sensors of IR channel	Number of sensors of IR channel	R*4.0
47 ~ 50	Total Line Number	VIS channel total line number of VISSR frame	R*4.0
51 ~ 54	Total Line Number	IR channel total line number of VISSR frame	R*4.0
55 ~ 58	Total Pixel Number	VIS channel total pixel number of VISSR frame	R*4.0
59 ~ 62	Total Pixel Number	IR channel total pixel number of VISSR frame	R*4.0
63 ~ 66	VISSR Misalignment X-axis	VISSR misalignment angle around X-axis in the VISSR coordinate system (rad)	R*4.10
67 ~ 70	VISSR Misalignment Y-axis	-around Y-axis	R*4.10
71 ~ 74	VISSR Misalignment Z-axis	-around Z-axis	R*4.10

● Continue

Word No.	Item	Contents	
75 ~ 78	VISSR Misalignment Matrix	Element of VISSR Misalignment Matrix on row 1 and column 1	R*4.7
79 ~ 82		- row 2 and column 1	R*4.10
83 ~ 86		- row 3 and column 1	R*4.10
87 ~ 90		- row 1 and column 2	R*4.10
91 ~ 94		- row 2 and column 2	R*4.7
95 ~ 98		- row 3 and column 2	R*4.10
99 ~ 102		- row 1 and column 3	R*4.10
103 ~ 106		- row 2 and column 3	R*4.10
107 ~ 110		- row 3 and column 3	R*4.7
111 ~ 114	Center line number	VISSR flame center line number of IR 2 channel	R*4.4
115 ~ 118		VISSR flame center line number of IR 3 channel	R*4.4
119 ~ 122		VISSR flame center pixel number of IR 2 channel	R*4.4
123 ~ 126		VISSR flame center pixel number of IR 3 channel	R*4.4
127 ~ 128	Spare		
129 ~ 132	Constants	Ratio of Circumference : π	R*4.7
133 ~ 136		Ratio of Circumference / 180	R*4.9
137 ~ 140		180 / Ratio of Circumference	R*4.6
141 ~ 144		Equatorial Radius of The Earth (m)	R*4.1
145 ~ 148		Oblateness of The Earth	R*4.10
149 ~ 152		Eccentricity of The Earth	R*4.9
153 ~ 156		Angle between the VISSR and the view direction of the Sun Sensor : βbias	R*4.8
157 ~ 162	Orbital Parameters	Epoch Time of Orbital Parameters (MJD)	R*6.8
163 ~ 168		Semi-major axis (km)	R*6.8
169 ~ 174		Eccentricity	R*6.10
175 ~ 180		Orbital Inclination (deg)	R*6.8
181 ~ 186		Longitude of Ascending Node (deg)	R*6.8
187 ~ 192		Argument of Perigee (deg)	R*6.8
193 ~ 198		Mean Anomaly (deg)	R*6.8
199 ~ 204		Sub-Satellite East Longitude (deg)	R*6.6
205 ~ 210		Sub-Satellite North Latitude (deg)	R*6.6

Word No.	Item	Contents	
211 ~ 216	Attitude Parameters	Epoch time of attitude parameters (MJD)	R*6.8
217 ~ 222	$\alpha r 0$	Angle between Z-axis and Satellite spin axis projected on YZ-plane in inertia coordinate system αr (rad)	R*6.8
223 ~ 228	$\alpha r 1$	Change-rate of αr (rad/sec)	R*6.15
229 ~ 234	$\delta r 0$	Angle between Satellite spin axis and YZ-plane in inertia coordinate system δr (rad)	R*6.11
235 ~ 240	$\delta r 1$	Change-rate of δr (rad/sec)	R*6.15
241 ~ 246	Spin Rate	Daily mean of Satellite spin rate (rpm)	R*6.8
247 ~ 256	Spare		
257 ~ 896	Attitude Prediction Data Sub-Blocks	Attitude prediction data sub-blocks 1 through 10 (10 similar attitude prediction data sub-blocks are repeated - for details see Table.A.5)	
897 ~2944	Orbit Prediction Data Sub-Blocks	Orbit prediction data blocks 1 through 8 (8 similar orbit prediction data sub-blocks are repeated - for details, see Table.A.6)	
2945 ~2950	Attitude Prediction Parameters	Time of the first attitude prediction data (MJD)	R*6.8
2951 ~2956		Time of the last attitude prediction data (MJD)	R*6.8
2957 ~2962		Interval time of attitude prediction data (MJD)	R*6.8
2963 ~2964		Number of attitude prediction data	I*2
2965 ~2970	Orbit Prediction Parameters	Time of the first orbit prediction data (MJD)	R*6.8
2971 ~2976		Time of the last orbit prediction data (MJD)	R*6.8
2977 ~2982		Interval time of orbit prediction (MJD)	R*6.8
2983 ~2984		Number of orbit prediction data	I*2
2985 ~3200	Spare		

Table.A.5 Contents of attitude prediction data sub-block (64 words)
(Position means a relative address in the block.)

Word NO.	Item		Contents		(Type)
1 ～ 6	Prediction Time	UTC	UTC represented in MJD		R＊6.8
7 ～ 12		AD	Anno Domini represented by BCD (YYMMDDHHmmSS;Year, Month, Day, Hour, Minute, Second)		BCD ＊6
13 ～ 18	α r 0		Same as that of Attitude Parameters	(rad)	R＊6.8
19 ～ 24	δ r 0		Ditto		R＊6.11
25 ～ 30	β Angle		Dihedral Angle between the sun and the earth measured clockwise seeing from north	(rad)	R＊6.8
31 ～ 36	Spin Rate		Spin speed of the satellite	(rpm)	R＊6.8
37 ～ 42	Right Ascension		Right ascension on the satellite orbit plane coordinate system at the attitude epoch	(rad)	R＊6.8
43 ～ 48	Declination		Declination and otherwise same as above	(rad)	R＊6.8
49 ～ 64	Spare				

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Table. A. 6 Contents of orbit prediction data sub-block (256 Words)
(Position means a relative address in the block.)

Word NO.	Item		Contents	(Type)
1 ～ 6	Prediction Time	UTC	UTC represented in MJD	R*6.8
7 ～ 12		AD	Anno Domini represented by BCD (YYMMDDHHmmSS;Year, Month, Day, Hour, Minute, Second)	BCD*6
13 ～ 18	Satellite Position and Speed	X1	X component of satellite position in the 1950.0 mean coordinate system (m)	R*6.6
19 ～ 24		Y1	Y component of satellite position in the 1950.0 mean coordinate system (m)	R*6.6
25 ～ 30		Z1	Z component of satellite position in the 1950.0 mean coordinate system (m)	R*6.6
31 ～ 36		Vx1	X component of satellite velocity in the 1950.0 mean coordinate system (m/sec)	R*6.8
37 ～ 42		Vy1	Y component of satellite velocity in the 1950.0 mean coordinate system (m/sec)	R*6.8
43 ～ 48		Vz1	Z component of satellite velocity in the 1950.0 mean coordinate system (m/sec)	R*6.8
49 ～ 54	Satellite Position and Speed	X2	X component of satellite position in the earth-fixed coordinate system (m)	R*6.6
55 ～ 60		Y2	Y component of satellite position in the earth-fixed coordinate system (m)	R*6.6
61 ～ 66		Z2	Z component of satellite position in the earth-fixed coordinate system (m)	R*6.6
67 ～ 72		Vx2	X component of satellite velocity in the earth-fixed coordinate system (m/sec)	R*6.10
73 ～ 78		Vy2	Y component of satellite velocity in the earth-fixed coordinate system (m/sec)	R*6.10
79 ～ 84		Vz2	Z component of satellite velocity in the earth-fixed coordinate system (m/sec)	R*6.10
85 ～ 90	Greenwich Sidereal Time		Greenwich sidereal time in true of date system (deg)	R*6.8
91 ～ 96	Sun Direction		Right ascension from the satellite to the sun in the 1950.0 mean coordinate system (deg)	R*6.8
97 ～102			Declination and otherwise same as above	R*6.8
103 ～108			Right ascension from the satellite to the sun in the earth-fixed coordinate system (deg)	R*6.8
109 ～114			Declination and otherwise same as above	R*6.8

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Word NO.	Item	Contents	(Type)
115 ~128	Spare		
129 ~134	Precession and Nutation Matrix	Element of nutation and precession matrix -row 1 and column 1	R*6.12
135 ~140		-row 2 and column 1	R*6.14
141 ~146		-row 3 and column 1	R*6.14
147 ~152		-row 1 and column 2	R*6.14
153 ~158		-row 2 and column 2	R*6.12
159 ~164		-row 3 and column 2	R*6.16
165 ~170		-row 1 and column 3	R*6.12
171 ~176		-row 2 and column 3	R*6.16
177 ~182		-row 3 and column 3	R*6.12
183 ~188	Sub-Satellite Point	North Latitude (deg)	R*6.8
189 ~194	Sub-Satellite Point	East Longitude (deg)	R*6.8
195 ~200	Satellite Height	Height of the satellite above the earth surface (m)	R*6.6
201 ~256	Spare		

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Table. A. 7 Calibration data block (6400 words)

Word NO.	Item	Contents	(Type)
1 ~ 4	Calibration Table ID	Calibration Table ID	I＊4
5 ~ 10	Data Generated Time	Data generated time (YYYYMMDDHHmm;Year, Month, Day, Hour, Minute)	BCD＊6
11	Sensor Selection	Sensor selection : 1-Primary, 2-Redundant	I＊1
12 ~ 56	Coefficient Table for IR1 Radiance Estimates	Coefficient table for IR1 radiance estimates	
	n : Number of Valid β_i	$C = 255 - C' + C_0$	I＊1
	β_0 : Factor 1	$C = \sum_{i=0}^{n} \beta_i V^i = \beta_0 + \beta_1 V + \cdots + \beta_6 V^6$	R＊4.6
	β_1 : Factor 2	$R = (V - V_0)/G$	R＊4.6
	β_2 : Factor 3	C' : S-VISSR Level	R＊4.6
	β_3 : Factor 4	C : Level	R＊4.6
	β_4 : Factor 5	V : Voltage (V)	R＊4.6
	β_5 : Factor 6	R : Radiant Quantity (W/cm^2 sr · μm)	R＊4.6
	β_6 : Factor 7		R＊4.6
	G : Gradient		R＊4.6
	V_0 : Intercept		R＊4.6
	C_0 : level Bias		R＊4.6
	Spare		
57 ~101	Same Above but IR 2	Same above but IR 2	
102 ~146	Same Above but IR 3	Same above but IR 3	
147 ~256	Spare		

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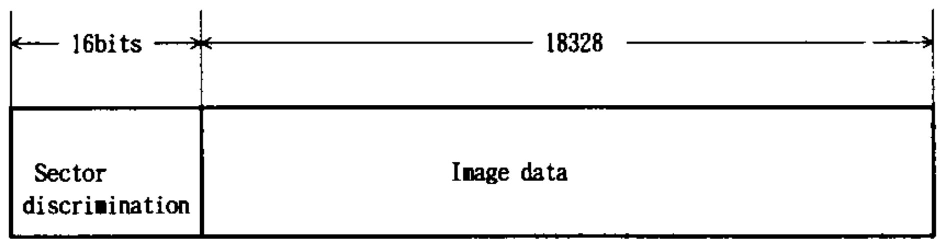
Word NO.	Item	Contents	(Type)
257 ~512	VIS1 Level Albedo Conversion Table	VIS1 Level Albedo Conversion Table albedo of 0 level . . albedo of 63 level	R*4.6 ×64
513 ~768	Same Above but VIS 2	Same as above but position	R*4.6 ×64
769 ~1024	Same Above but VIS 3	Same as above but position	R*4.6 ×64
1025~1280	Same Above but VIS 4	Same as above but position	R*4.6 ×64
1281~2304	IR1 Level Temperature Conversion Table	IR1 level temperature conversion table temperature of 0 level . . temperature of 255 level	R*4.3 ×256
2305~3328	Same Above but IR 2	Same as above but position	R*4.3 ×256
3329~4352	Same Above but IR 2	Same as above but position	R*4.3 ×256
4353~6400	Spare		

<u>Explanation about type</u>

```
1.   R*n.m          n : word number (8 bit/word)
                    m : Decimal point following digit number

          most significant bit  0 : +
                                1 : -

                       MSB                                LSB
 Example  R*4.2          00000000 00000000 00000111 10110101     =    19.73
                       MSB                                LSB
          R*4.7          00000000 00000000 00000111 10110101     =    0.0001973
                       MSB                                LSB
          R*4.5          10000000 11001000 00010000 01000010     =  -131.11362
```

```
2.   I*n            n : word number (8 bit/word)

                       MSB              LSB
 Example  I*2            00101101 10011100      =    11676
```

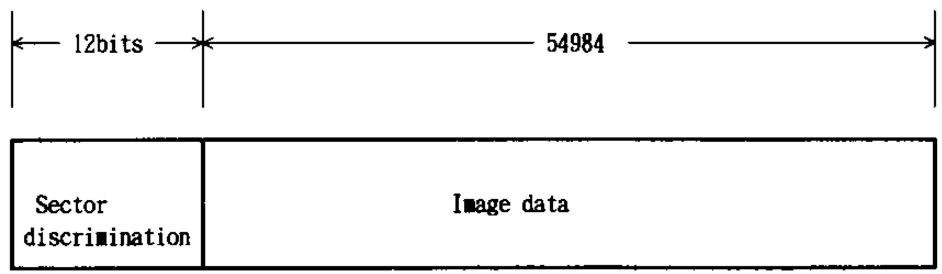
```
3.   BCD*n          n : word number              4 bit binary

                       MSB                LSB
 Example  BCD*2          1001 0111 0110 0101     =    9765
```



[Contents of sector discrimination]

IR 1	0001 0001 0001 0001
IR 2	0010 0010 0010 0010
IR 3	0100 0100 0100 0100

Fig. A. 4. Image Data Sector



[Contents of sector discrimination]

VIS 1	011 011 011 011
VIS 2	101 101 101 101
VIS 3	110 110 110 110
VIS 4	111 111 111 111

Fig. A. 5 Visible Image Data Sector

3. MDUS Specifications

S-VISSR image format and line budget example are shown in Fig.A.6*[1)] and Table.A.8.

3.1 Construction of MDUS

The construction of MDUS is shown in Fig.A.7.

3.2 Receiving System

3.2.1 Antenna

(1) Function

a. Gain and C/N : Sufficient gain and C/N are required to receive the S-VISSR signal from GMS.

b. Polarization Adjustment : The rotation of the primary radiator is available to adjust the plane of beam polarization.

c. Antenna support structure : The direction of the antenna can be adjustable.

(2) Characteristics

a. Receive frequency	1687.1 MHz
b. Polarizations	Linear
c. Antenna diameter	4.0 m ϕ
d. Gain	34.8 dB or more
e. Beam width	Approx.3°
f. Mounting system	AZ,EL semi-fixed
g. Adjustable range of direction	±5°
h. Adjustable range of polarization	92°or more
i. Receptacle	N-R

3.2.2 RF unit

(1) Function

a. The RF unit performs the low noise amplification by using a parametric amplifier.

b. The down converter included in RF units changes the radio frequency signal to the intermediate frequency signal.

(2) Characteristics

a. Input frequency	1687.1 MHz
b. Noise figure	1.7 dB or less
c. Gain	35 dB or more
d. Band width	10 MHz or more (-3 dB)

e. Output frequency	60 MHz band, IF
f. Local frequency	1657.1 MHz±20 KHz
g. Input-output receptacle	N-R

3.2.3 Main Receiver

(1) Function

a. Main receiver consists of an IF amplifier, a PSK demodulator and a Bit Synchronizer.
b. It amplifies the intermediate frequency signal from RF unit and detects the NRZ-M signal by making a PSK detection. Then the NRZ-M signal converts to the NRZ-L signal by Bit Synchronizer. Thus the Bit Synchronizer generates the bit clocks at 660 kbps. The NRZ-L and the bit clocks signal are supplied to the processing system after amplification.
c. AGC functions are incorporated.
d. Receiving level is indicated to control the necessary receiving operation.

(2) Characteristics

a. Input frequency	60 MHz band, IF
b. Input signal	BPSK,NRZ-M
c. PCM signal bit rate	660 Kbps
d. Output signal	S-VISSR PCM serial data and clock
e. Input receptacle	N-R
f. Output receptacle	BNC-R

3.2.4 Decoder and Processor

The decoder performs PN decoding and word complement decoding. The PN pattern generator circuitry is shown in Fig.A.8.

3.2.5 Processor

Users apply the processor to carry out the effective meteorological analysis and processing, using documentation information data.

Remarks: *1)

The picture flag of S-VISSR image is turned off when the scanning line number reaches at the Picture Flag Reset Line Number. However, it is sometimes observed that the Picture Flag is not turned off even after the scanning is completed. The phenomenon is explained as follows.

1. Solid lubricant is applied to the driving part of the scanning mirror of GMS. In order to avoid building-up of the lubricant at the ends of the scanning range in the long run, scanning operations are made in several scanning ranges.

2. On the other hand, the lines where the Picture Flag is turned on or off are determined from the center position of the Earth that is calculated from the position and the attitude of the

spacecraft so that the whole Earth and some marginal lines are contained in the range between these lines (image frame). The determination is made independently of the scanning range as mentioned in the previous paragraph.

3. When the imagery of the Earth shifts towards the southern boundary of the scanning range, the southern end of the image frame may exceed the southern end of the scanning range of the mirror. In that case, the mirror begins rapid reversing when it reaches the end of the scanning range while the Picture Flag is still on.

4. In case of these situations, when four consecutive rapid reverse lines are detected, the Frame Flag and the Picture Flag are automatically turned off. In such circumstances, as many as four lines in the rapid reverse operation may be transmitted.

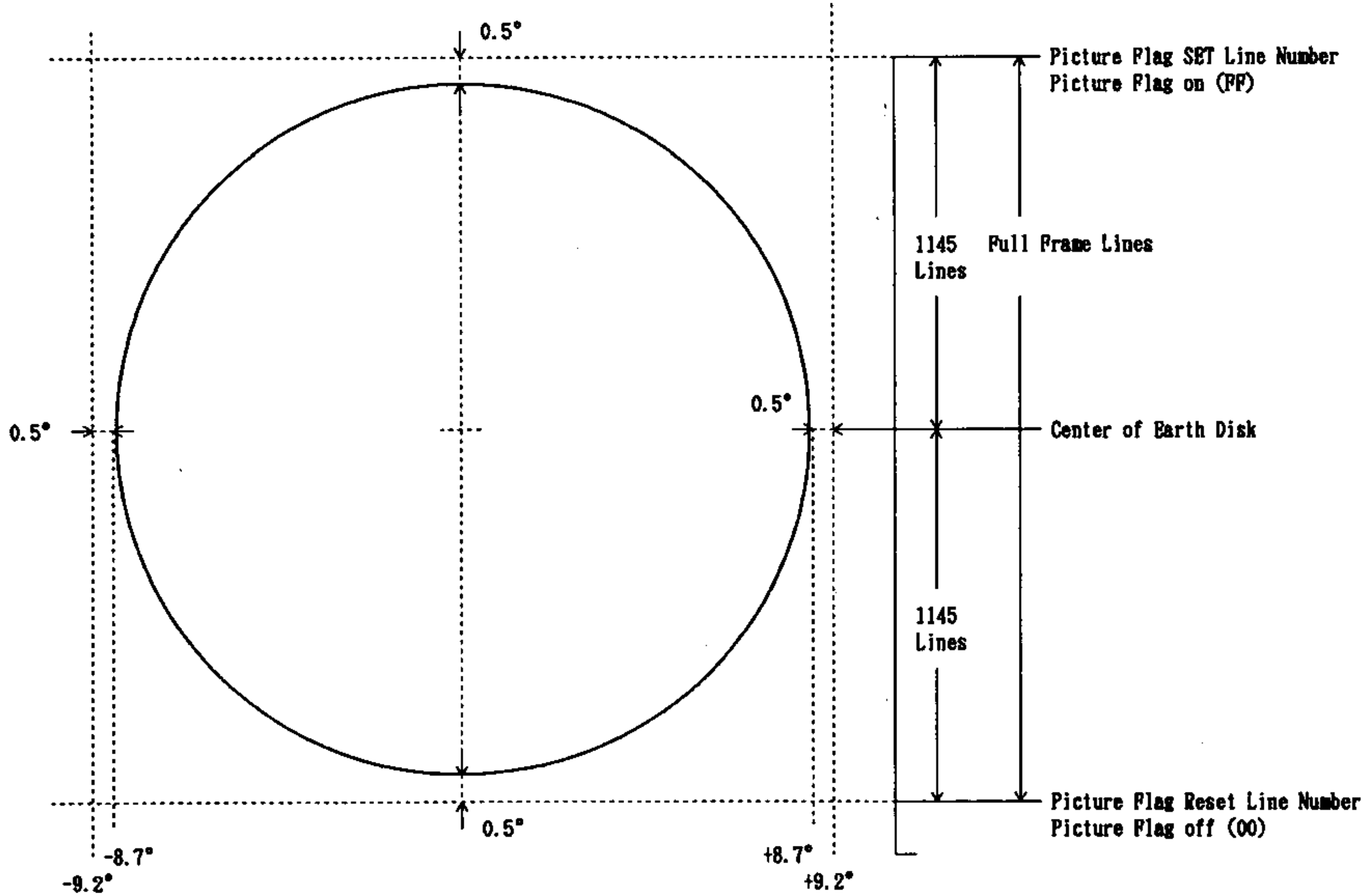


Fig.A.6 Frame format of S-VISSR image data

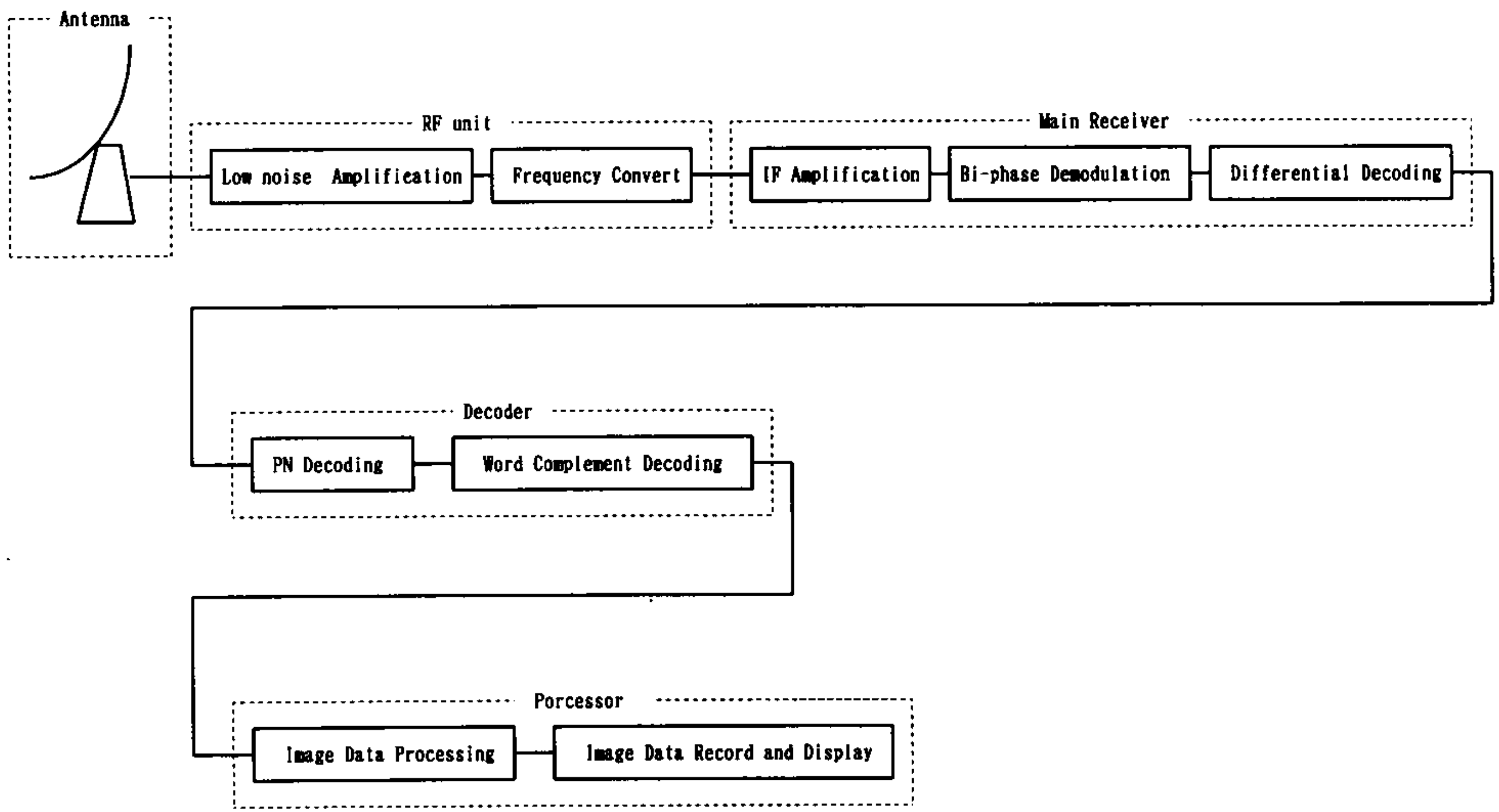


Fig.A.7 MDUS Configuration Diagram

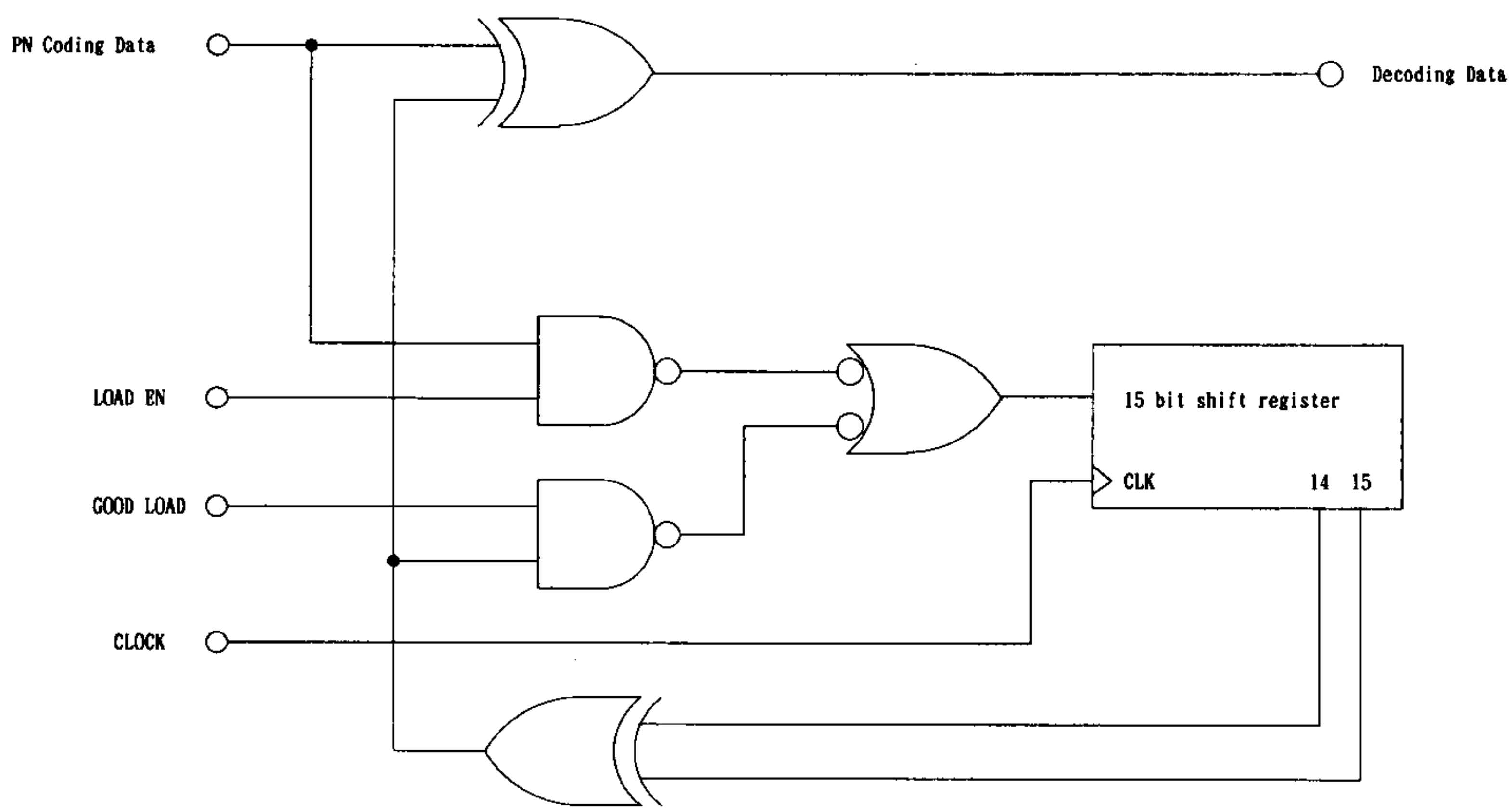


Fig.A.8 PN Decoding Circuit Example

Parameters

(1) S/C EIRP 54.5 dBm (Worst value at elevation angle 20°)

(2) G/T 10.4 dB/K (Ground station)

: Antenna gain (4mϕ)	34.7	dB
Low noise amplifier noise temperature	130	K
Antenna noise temperature	80	K
Feeder loss	0.5	dB

(3) Required C/N_0 71.6 dB·Hz

: Bit rate (660 Kbps)	58.2	dB
E_b/N_0 (2PSK) for 10^{-6}	10.6	dB/Hz
Demodulater loss	2	dB
Deferential loss	0.3	dB
S/C loss	0.5	dB

Parameters expected above are estimated as the worst case.

Link budget

PARAMETERS		GMS→MDUS
FREQUENCY	(MHz)	1687.1
EIRP	(dBm)	54.5
T-ANTENNA TRACKING LOSS(dB)		−0.7
FREE SPACE LOSS	(dB)	−189.5 (39500 km)
R-ANTENNA TRACKING LOSS(dB)		−1.5
G/T	(dB/K)	10.4
BOLTZMANN CONSTANT	(dB/K)	−198.6
C/N_0	(dB/Hz)	73.1
TOTAL C/N_0	(dB/Hz)	73.0
REQUIRED C/N_0	(dB/Hz)	71.6
MARGIN	(dB)	1.4

Table.A.8 MDUS Link Budget example

SDUS SPECIFICATIONS

The SDUS is the ground station to receive the GMS weather facsimile (WEFAX) signal and to produce the photographic imagery and/or computer-processed data from it for the use of meteorological analysis and forecasting.

B.1 WEFAX SIGNAL

B.1.1 Signal format

The signal and frame format of WEFAX are shown in Fig.B.1 and B.2 respectively. Its characteristics are summarized as follows:

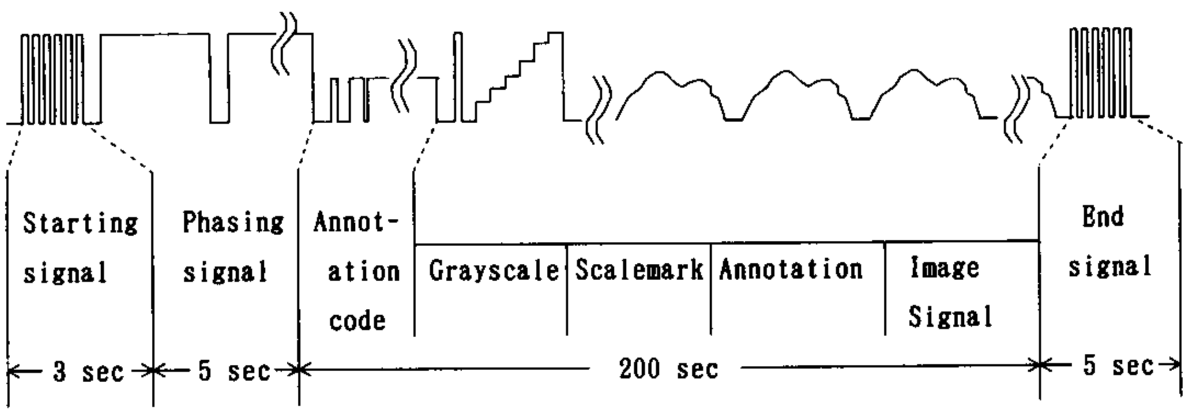


Fig.B.1 WEFAX signal format

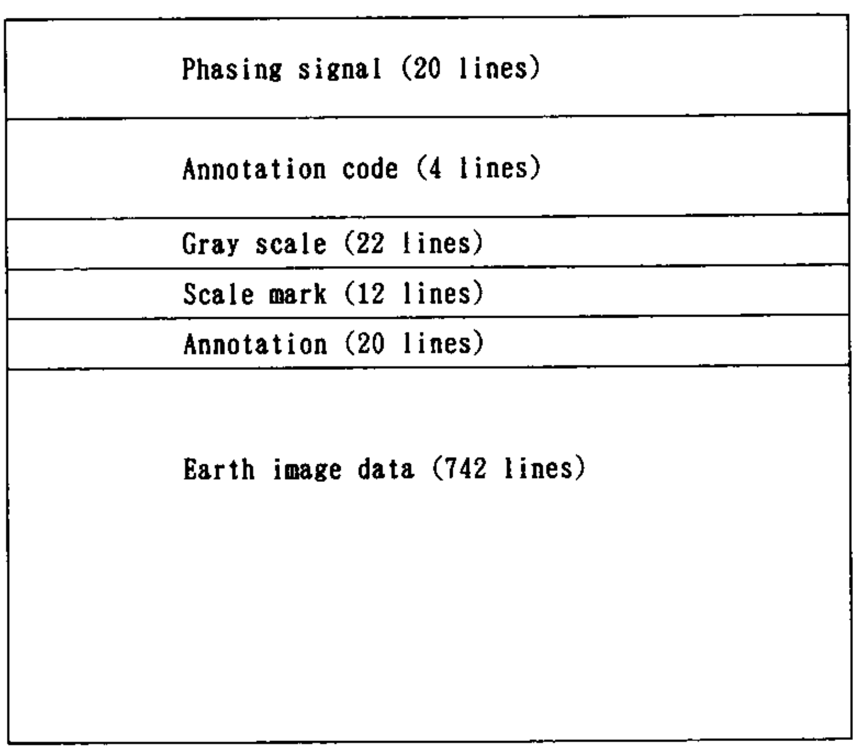


Fig.B.2 WEFAX frame format

(1) The signal modulated by the black level (0 volt DC) is transmitted for 60 seconds at the every beginning of the series of frames.

(2) The start signal modulated by 300 Hz wave is transmitted for 3 seconds and then the phasing signal which is the pulse modulated signal with the duty cycle of 0.95 in a line is transmitted for 5 seconds (20 lines). These signals are transmitted at the beginning of every frame and may be used to start the recorder automatically and to achieve the horizontal synchronization.

(3) Annotation code, gray scale, scale mark, annotation and the earth image are transmitted for 1 second (4 lines), 6 seconds (24 lines), 3 seconds (12 lines) ,5 seconds (20 lines) and approx. 3 minutes (800 lines) respectively in sequence.

(4) The end signal composed of the signal modulated by 450 Hz wave and the signal modulated by the black level (0 volt DC) are transmitted for 5 seconds and 10 seconds respectively. This signal is transmitted at the end of every frame and may be used to stop the recorder automatically.

(5) Number of frame transmitted changes according to the dissemination schedule.

B.1.2 Annotation Code

Annotation code is inserted at the head of scanning lines of the gray scale by the EBCDIC type bits sequence. It is repeated four times to recover some missing lines.

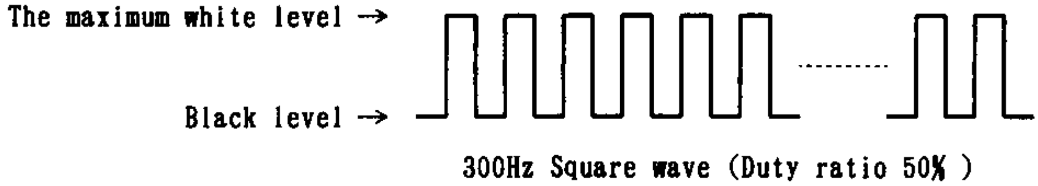
Annotation code includes the following information.

-satellite name	(GMS-5)
-kind of image data	(IR or VIS)
-picture time	(UTC)
-picture name	(A/B/C/D, H/I/J or K/L/M/N)
-started time of VISSR observation	(UTC)

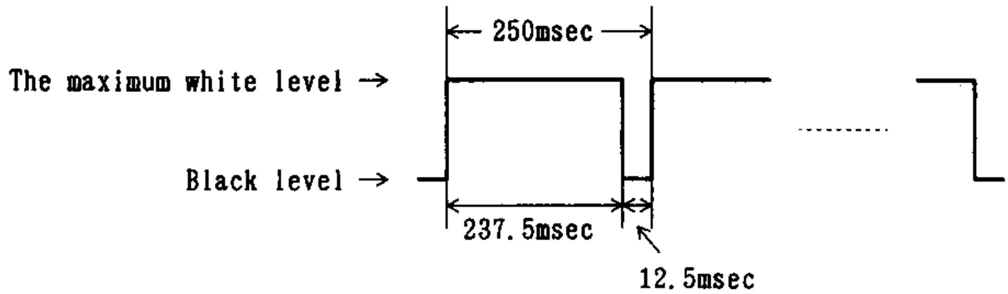
By the use of annotation code, WEFAX users can recognize the image information easily.

The signal details are shown in Fig.B.3.

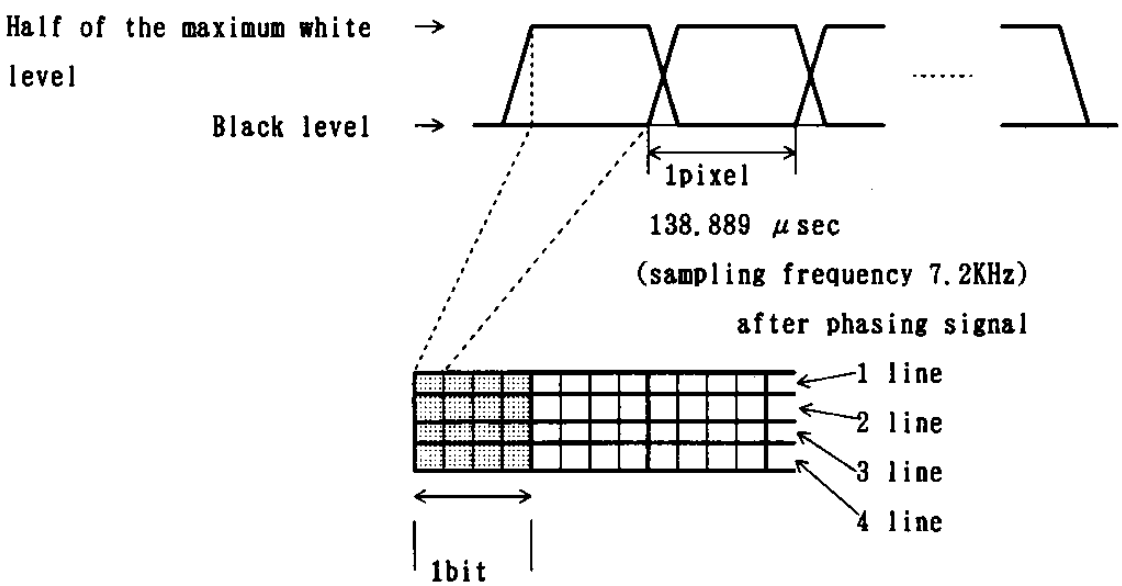
a. Start signal (3 sec)



b. Phasing signal (20 lines, 5 sec)



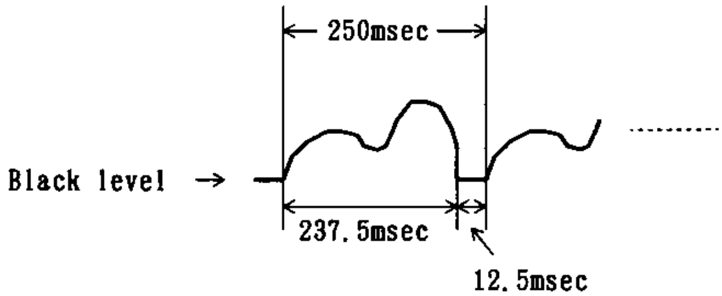
c. Annotation code



1 bit consists of 4 lines ×4 pixel (4 lines repetition)

Fig.B.3 Annotation code (1/2)

d. Image Signal (796 lines)



e. End signal (5 sec)

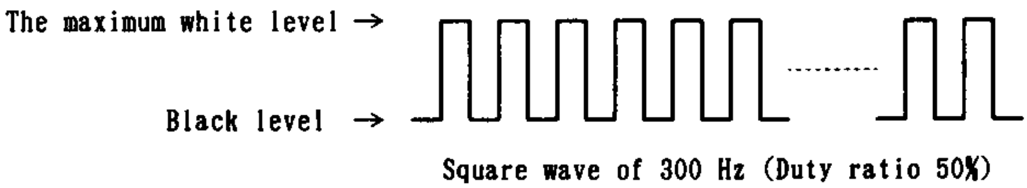


Fig.B.3 Annotation code (2/2)

B.2 Configuration

System block diagram an example of functional block diagram of SDUS.

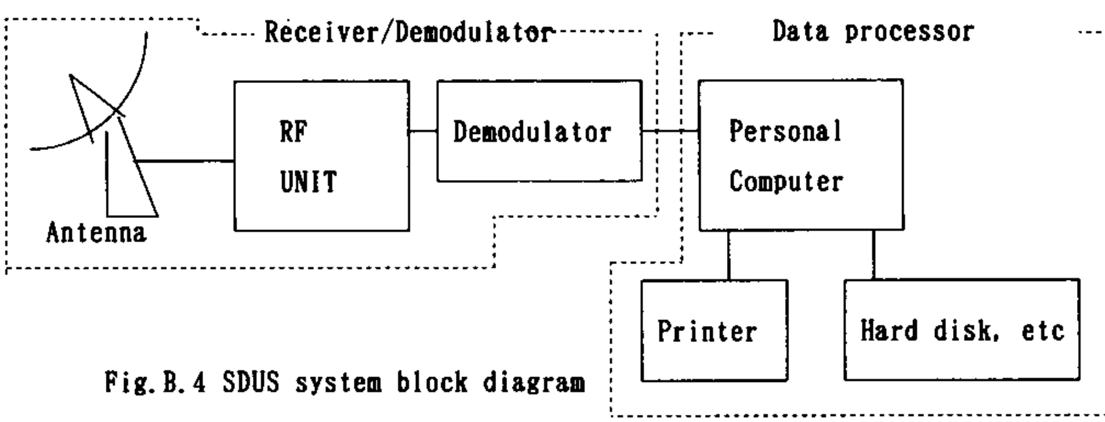


Fig.B.4 SDUS system block diagram

B.3 Receiving System

B.3.1 Antenna

(1) Function

a. Gain & C/N: A sufficient gain and C/N are required to receive the WEFAX signal from GMS. The link budget is calculated with 2.5 mφ parabolic antenna. However this specification is required G/T greater than 3 dB, and it is able to estimate to use about 1.3 mφ antenna with advanced lownoise amplifire.

b. Polarization Adjustment: The rotation of the primary radiator is available to adjust the plane of beam polarization.

c. Antenna support structure: The direction of the antenna can be adjustable.

(2) Characteristics

a. Receiving frequency	1691.0 MHz
b. Polarization	Linear
c. Antenna diameter	2.5 m φ
d. Gain	30 dB or more
e. Mounting system	AZ, EL semi-fixed
f. Adjustable range for antenna direction	±5 °
g. Adjustable range for polarization	92° or more
h. Interconnecting cable	1 m or more (Loss: 0.5 dB)
i. Receptacle	N-R

B.3.2 RF Unit

(1) Function

a. RF unit consists of a preamplifier and a down converter. Preamplifier performs the low noise amplification by using a transistor amplifier.

b. Down converter changes the radio frequency signal to an intermediate signal.

(2) Characteristics

a. Input frequency	1691.0 MHz
b. Noise figure	3.4 dB or less
c. Gain	34 dB or more
d. Band width	20 MHz(-3 dB)
e. Local frequency	1553.5 MHz±20 KHz
f. Output frequency	137.5 MHz
g. Input-output receptacle	N-R

B.3.3 Main Receiver

(1) Function

a. Main Receiver amplifies the intermediate frequency signal from RF unit and detects the sub-carrier signal by making an FM detection. The sub-carrier signal (AM modulated signal) is supplied to the processing system.

(2) Characteristics

a. Input frequency	137.5 MHz, AM-FM
b. Noise figure	13 dB or less
c. Band width	260 KHz
d. Output signal	2.4 KHz AM
e. Output level	0 dBm(75 ohm)
f. Input receptacle	N-R
g. Output receptacle	BNC-R

B.4 Link Budget

SDUS link budget is as shown in Table.B.1.

Table.B.1 WEFAX Link budget (down link)

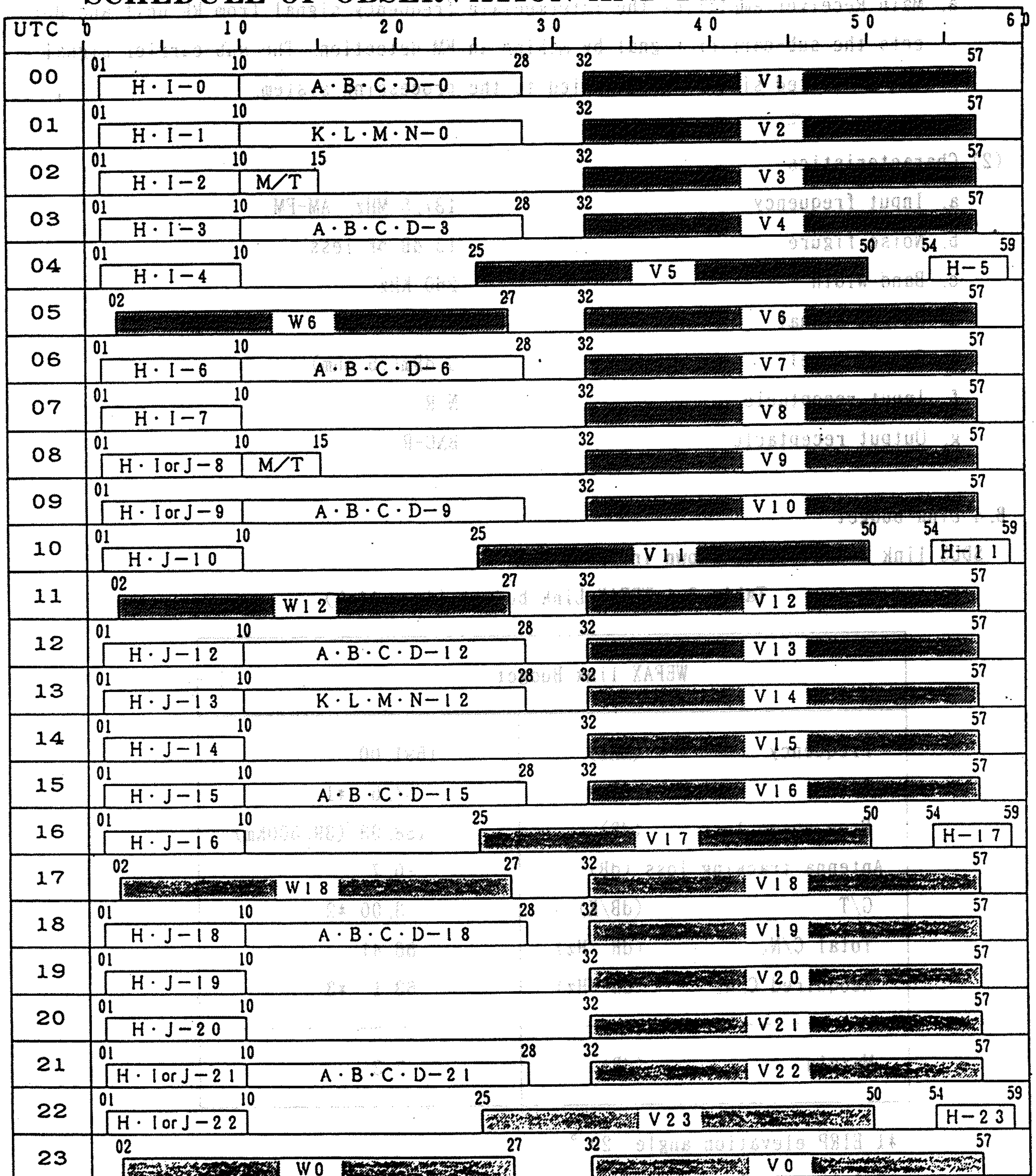
WEFAX link Budget		
Frequency	(MHz)	1691.00
EIRP	(dBm)	54.5 *1
Free space loss	(dB)	188.93 (39,500Km)
Antenna tracking loss	(dB)	-0.7
G/T	(dB/K)	3.00 *2
Total C/N_0	(dB /Hz)	66.41
Reoquired C/N_0	(dB /Hz)	63.1 *3
Margin	(dB)	3.3

*1 EIRP elevation angle 20 °

*2 Antenna gain	30dB
System noise temperature	500k
*3 Frequency bandwith (260KHz)	54.1dB
Threshold level	9.0dB

These parameters are estimated as the worst case.

SCHEDULE OF OBSERVATION AND DISSEMINATION



ABBREVIATIONS

VISSR OBSERVATION

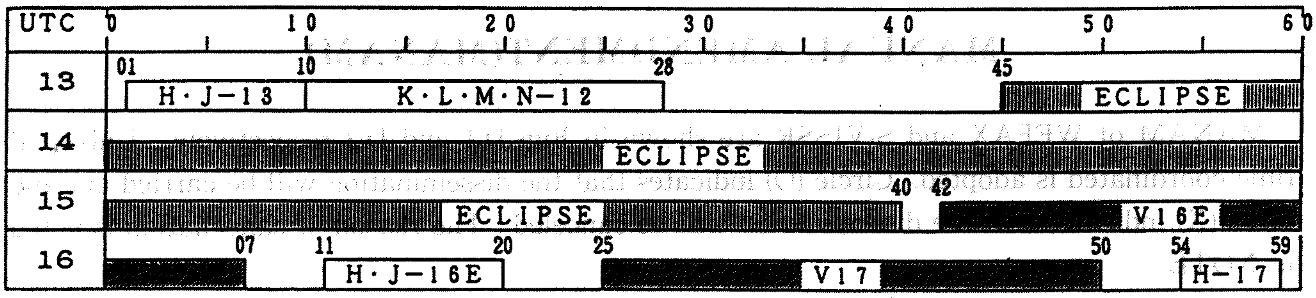
- Vn : VISSR observation (hourly)
- Wn : VISSR observation for wind extraction

WEFAX DISSEMINATION

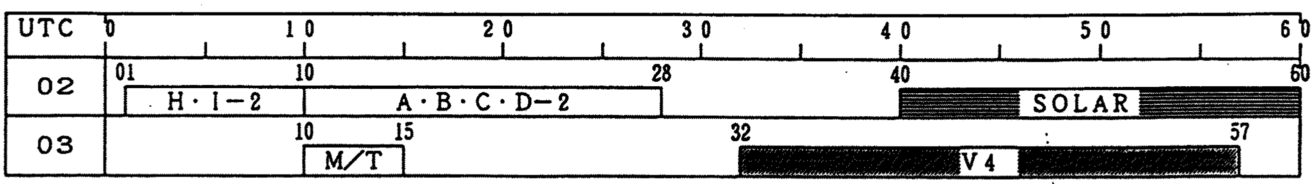
- A～D : IR 4-sectorized picture of full-disk image
- H～J : IR, VIS and enhanced IR polar-stereographic picture covering the far east area
- K～N : Water vapor 4-sectorized picture of full-disk image
- M : Manual amendment (MANAM)
- T : Test pattern

Fig.C.1 Normal operation schedule

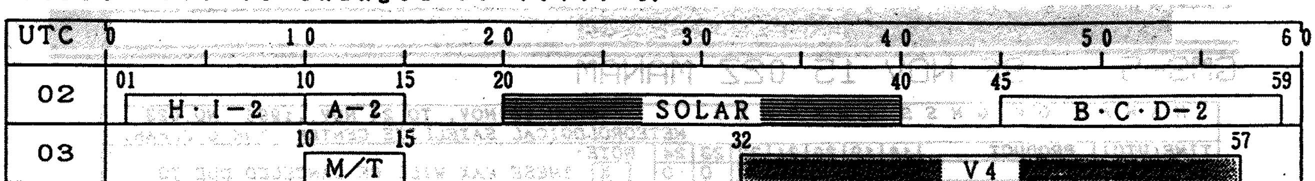
In case of eclipse operation, schedule of 13~17UTC will be changed as follows.



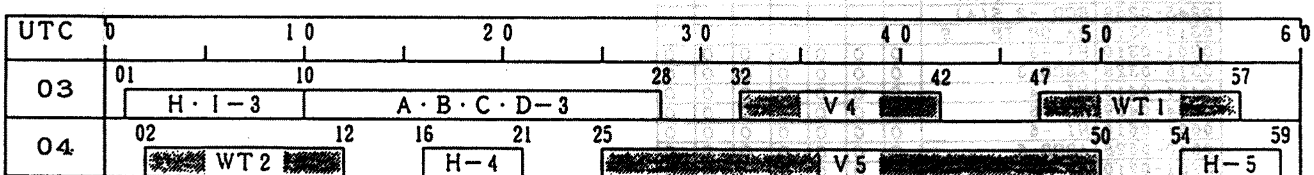
In case of solar-interference (spring) operation, schedule of 02~04UTC will be changed as follows.



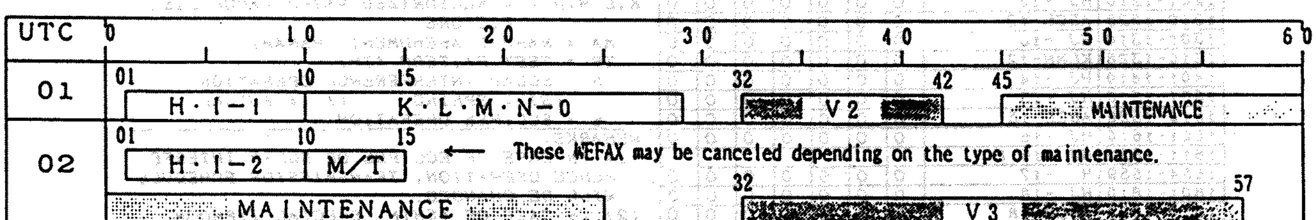
In case of solar-interference (autumn) operation, schedule of 02~04UTC will be changed as follows.



In case of TYPHOON special observation, schedule of 03~05UTC will be changed as follows.



In case of system maintenance, schedule of 01~03UTC will be changed as follows.



ABBREVIATIONS

ECLIPSE : Eclips operation
SOLAR : Solar-interference operation
WTn : VISSR observation for wind estimation in typhoon area
MAINTENANCE : System maintenance

Fig.C.2 Special operation schedules

MANUAL AMENDMENT(MANAM)

MANAM of WEFAX and S-VISSR are shown in Figs.D.1 and D.2 respectively. Universal time coordinated is adopted. Circle (O) indicates that the dissemination will be carried out and cross (X) indicates that the dissemination will be canceled. The reason of cancellation is noted in NOTE.

GMS-5 96 NOV 15 02Z MANAM

M A N A M O F G M S S (W E F A X) FROM 18 NOV. TO 24 NOV.,1996 NO.023
METEOROLOGICAL SATELLITE CENTER (TOKYO,JAPAN)

TIME(UTC)	PRODUCT	18	19	20	21	22	23	24
0001-0010	HI -0	O	O	O	O	O	O	O
0010-0028	ABCD-0	O	O	O	O	O	O	O
0101-0110	HI -1	O	O	O	O	O	O	O
0110-0128	KLMN-0	O	O	O	O	O	O	O
0201-0210	HI -2	O	X	X	O	O	O	O
0210-0215	MA OR TP	MA	X	X	MA	MA	MA	TP
0210-0228	ABCD-2 S(S)							
0210-0215	A -2 S(A)							
0245-0259	BCD -2 S(A)							
0310-0315	MA OR TP S							
0301-0310	HI -3	O	O	O	O	O	O	O
0310-0328	ABCD-3	O	O	O	O	O	O	O
0401-0410	HI -4	O	O	O	O	O	O	O
0454-0459	H -5	O	O	O	O	O	O	O
0601-0610	HI -6	O	O	O	O	O	O	O
0610-0628	ABCD-6	O	O	O	O	O	O	O
0701-0710	HI -7	O	O	O	O	O	O	O
0801-0810	HJ -8	O	O	O	O	O	O	O
0810-0815	MA OR TP	MA	MA	MA	MA	MA	MA	TP
0901-0910	HJ -9	O	O	O	O	O	O	O
0910-0928	ABCD-9	O	O	O	O	O	O	O
1001-1010	HJ -10	O	O	O	O	O	O	O
1054-1059	H -11	O	O	O	O	O	O	O
1201-1210	HJ -12	O	O	O	O	O	O	O
1210-1228	ABCD-12	O	O	O	O	O	O	O
1301-1310	HJ -13	O	O	O	O	O	O	O
1310-1328	KLMN-12	O	O	O	O	O	O	O
1401-1410	HJ -14	O	O	O	O	O	O	O
1501-1510	HJ -15	O	O	O	O	O	O	O
1510-1528	ABCD-15	O	O	O	O	O	O	O
1601-1610	HJ -16	O	O	O	O	O	O	O
1611-1620	HJ -16 E							
1654-1659	H -17	O	O	O	O	O	O	O
1801-1810	HJ -18	O	O	O	O	O	O	O
1810-1828	ABCD-18	O	O	O	O	O	O	O
1901-1910	HJ -19	O	O	O	O	O	O	O
2001-2010	HJ -20	O	O	O	O	O	O	O
2101-2110	HJ -21	O	O	O	O	O	O	O
2110-2128	ABCD-21	O	O	O	O	O	O	O
2201-2210	HI -22	O	O	O	O	O	O	O
2254-2259	H -23	O	O	O	O	O	O	O

NOTE:
[X] THESE FAX WILL BE CANCELED DUE TO THE MAINTENANCE OF GROUND SUBSYSTEM.

ABBREVIATIONS:
H,I,J = POLAR-STEREO PICTURE
H = IR (INFRARED)
I = VS (VISIBLE)
J = ENHANCED IR
A,B,C,D = 4 SECTORIZED IR DISK PICTURE
K,L,M,N = 4 SECTORIZED WATER VAPOR DISK PICTURE
MA = MANUAL AMENDMENT (MANAM)
TP = TEST PATTERN (TP)
S = SOLAR INTERFERENCE OPERATION
(S) = SPRING (A) = AUTUMN
E = ECLIPSE OPERATION

REMARKS:
(1) IN CASE OF ECLIPSE OR SOLAR INTERFERENCE OPERATION, TRANSMISSION SCHEDULE WILL BE CHANGED.
(2) IN CASE OF 15MIN. SPECIAL TYPHOON OBSERVATION(SYMBOL '#T'), THE WEFAX(I-4) WILL BE CANCELED AND THE TRANSMISSION TIME OF THE WEFAX(H-4) WILL CHANGE FROM 0401 TO 0416 UTC.
(3) THE SCHEDULE IS SUBJECT TO CANCEL OR CHANGE WITHOUT NOTICE.

Fig.D.1 MANAM of WEFAX

MANAM OF GMS-5 (DISSEMINATION SCHEDULE OF STRETCHED VISSR DATA)

FROM 18 NOV. TO 24 NOV.,1996

METEOROLOGICAL SATELLITE CENTER
JAPAN METEOROLOGICAL AGENCY (TOKYO,JAPAN)

TIME(UTC)	VISSR	18	19	20	21	22	23	24	COMMENTS
2302 - 2327	V-0 FULL	O	O	O	O	O	O	O	
2332 - 2357	V-0 FULL	O	O	O	O	O	O	O	
0032 - 0057	V-1 FULL	O	O	O	O	O	O	O	
0132 - 0157	V-2 FULL				O	O	O	O	
0132 - 0142	V-2N NORTH	ON	ON	ON					SYSTEM MAINTENANCE
0232 - 0257	V-3 FULL	O	O	O	O	O	O	O	
0332 - 0357	V-4 FULL	O	O	O	O	O	O	O	
0425 - 0450	V-5 FULL	O	O	O	O	O	O	O	
0502 - 0527	V-6 FULL	O	O	O	O	O	O	O	
0532 - 0557	V-6 FULL	O	O	O	O	O	O	O	
0632 - 0657	V-7 FULL	O	O	O	O	O	O	O	
0732 - 0757	V-8 FULL	O	O	O	O	O	O	O	
0832 - 0857	V-9 FULL	O	O	O	O	O	O	O	
0932 - 0957	V-10 FULL	O	O	O	O	O	O	O	
1025 - 1050	V-11 FULL	O	O	O	O	O	O	O	
1102 - 1127	V-12 FULL	O	O	O	O	O	O	O	
1132 - 1157	V-12 FULL	O	O	O	O	O	O	O	
1232 - 1257	V-13 FULL	O	O	O	O	O	O	O	
1332 - 1357	V-14 FULL	O	O	O	O	O	O	O	
1432 - 1457	V-15 FULL	O	O	O	O	O	O	O	
1532 - 1557	V-16 FULL	O	O	O	O	O	O	O	
1542 - 1607	V-16E FULL								ECLIPSE OPERATION
1625 - 1650	V-17 FULL	O	O	O	O	O	O	O	
1702 - 1727	V-18 FULL	O	O	O	O	O	O	O	
1732 - 1757	V-18 FULL	O	O	O	O	O	O	O	
1832 - 1857	V-19 FULL	O	O	O	O	O	O	O	
1932 - 1957	V-20 FULL	O	O	O	O	O	O	O	
2032 - 2057	V-21 FULL	O	O	O	O	O	O	O	
2132 - 2157	V-22 FULL	O	O	O	O	O	O	O	
2225 - 2250	V-23 FULL	O	O	O	O	O	O	O	

IN CASE OF 15 MIN. SPECIAL TYPHOON OBSERVATION

TIME(UTC)	VISSR	COMMENTS
0332 - 0342	V-4 NORTH	
0347 - 0357	VT-1 NORTH	
0402 - 0412	VT-2 NORTH	

ABBREVIATIONS:

FULL = FULL DISK OBSERVATION　　M = MAINTENANCE OPERATION
NORTH = NORTHERN HEMISPHERE OBSERVATION　　E = ECLIPSE OPERATION

REMARKS:
1) IN CASE OF ECLIPSE OPERATION OR SYSTEM MAINTENANCE, THE SCHEDULE WILL BE CHANGED.
2) IN CASE OF 15 MIN. SPECIAL TYPHOON OBSERVATIONS, THE SCHEDULE WILL BE CHANGED, DESCRIBED ABOVE.
3) IN CASE OF SOLAR-INTERFERENCE OPERATION, THE OBSERVATION (V-3) WILL BE CANCELED.
4) THE SCHEDULE IS SUBJECT TO CANCEL OR CHANGE WITHOUT NOTICE.

NOTE:

ON: THIS OBSERVATION WILL BE CHANGED FOR NORTHRN HEMISPHERE OBSERVATION(V2N) DUE TO THE MAINTENANCE OF GROUND SUBSYSTEM.

TE: THE 15MIN. SPECIAL TYPHOON OBSERVATION SCHEDULE CEASED ON 14TH NOV. (REMARK 2)

Fig.D.2 MANAM of S-VISSR

S-VISSR Mapping

1. Introduction

Image mapping is used to process Visible and Infrared Spin Scan Radiometer (VISSR) image data, i.e., each pixel of the VISSR image data must correspond to its respective position on earth, thus making it necessary to transform between geodetic and VISSR frame coordinates. Coordinate transformation allows converting the geodetic coordinates (latitude, longitude, height) to VISSR frame coordinates (line, pixel) and vice versa. This report describes a coordinate transformation method that uses orbit and attitude prediction data to determine the position on the earth which corresponds to a VISSR image pixel. On the other hand, it can also be conversely used to determine the VISSR image pixel which corresponds to a position on earth.

Another significant feature of the presented transformation method is that it calculates important information which can be utilized in other digital processing techniques, e. g., infrared (IR) digital image processing requires the satellite zenith distance, and visible (VIS) digital image processing uses the sun zenith distance, distance to the sun, and sun glint imformation. This information can easily be supplied because the positions of the sun, satellite, and earth reference point are all calculated with this coordinate transformation process.

The applicable theory and sample coordinate transformation programs are presented. These programs were designed for a small-scale computer system which can utilize VISSR archive data that is stored at the Meteorological Satellite Center (MSC), and also Stretched-VISSR (and HiRID: High Resolution Imager Data) data that is broadcasted via satellite. This appendix is the latest version of "A Mapping Method for VISSR Data" (Kigawa: 1991, Meteorological Satellite Center Technical Note, No. 23).

2. Coordinate Transformation Theory

All parameters used for the VISSR image coordinate transformation are defined in Table E. 1 whereas Fig. E.1-1 to E.1-4 show applicable transformation flow charts.

The transformation consists of three stages: (1) The transformation from geodetic to VISSR coordinates, (2) The transformation from VISSR to the geodetic coordinates, and (3) The subsequent computation of information required for digital image processing. The information necessary for digital image processing is the sun and satellite zenith distances, sun and satellite azimuth angles, distances to the sun and satellite, satellite-sun digression, and sun glint data. The transformation from the geodetic to the VISSR coordinates (Fig. E. 1-2) necessitates a calculation reiteration because the scanning time corresponding to a point on the earth is unknown.

2.1 Geodetic to Earth-fixed Transformation

The transformation from geodetic (ϕ, λ, h) to earth-fixed coordinates (X_e, Y_e, Z_e) is given by

$$
\left.\begin{aligned}
X_e &= (R_N + h)\cos\phi\cos\lambda \\
Y_e &= (R_N + h)\cos\phi\sin\lambda \\
Z_e &= \{R_N(1-e^2) + h\}\sin\phi
\end{aligned}\right\} \tag{1}
$$

where

$$R_N = \frac{R_e}{(1 - e^2\sin^2\phi)^{0.5}} \tag{2}$$

ϕ : geodetic latitude, with north (+) and south (−)
λ : longitude, with east (+) and west (−)
h : height

with flattening of the earth f being related to eccentricity e by the below relation.

$$e^2 = 2f - f^2 \tag{3}$$

2.2 Scanning Time

Scanning time of a picture element (I, J) is given by

$$t_{IJ} = \frac{[(I-1)/n] + QJ/2\pi}{1440\omega} + t_S \tag{4}$$

where t_{IJ} is the scanning time represented in Modified Julian Date (MJD), I and J are line and pixel number of the point of interest, and [ ] denotes Gauss' notation.

2.3 Satellite Position and Attitude at Scanning Time

The orbit and attitude prediction data (α_r, δ_r, β, X, Y, Z, θ_g, α_S, δ_S) is interpolated to obtain values which correctly correspond to the scanning time. Interpolation is not necessary to determine the nutation and precession matrix $[N_P]$, thus prediction times occurring just prior to the scanning time can be employed.

Any parameter W of the orbit and attitude prediction data at time t_{IJ} is interpolated as follows,

$$W = W_0 + \frac{W_1 - W_0}{t_1 - t_0}(t_{IJ} - t_0) \tag{5}$$

where W_0, W_1 are 5-min data prediction intervals, and t_1, t_0 are the prediction times represented in MJD.

2.4 Mean of 1950.0 to True of Date Transformation

The transformation from the mean of 1950.0 coordinates $\mathbf{X}_M$ to the true of data coordinates $\mathbf{X}_T$ is given by

$$\mathbf{X}_T = [N_P]\cdot\mathbf{X}_M \tag{6}$$

where $[N_P]$ is the nutation and precession matrix.

2.5 True of Data to Earth-fixed Transformation

The true of data coordinates $\mathbf{X}_T$ are transformed into the earth-fixed coordinates $\mathbf{X}_E$ as

$$\mathbf{X}_E=[B]\cdot\mathbf{X}_T \tag{7}$$

where

$$[B]=\begin{bmatrix} \cos\theta_g & \sin\theta_g & 0 \\ -\sin\theta_g & \cos\theta_g & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{8}$$

with θ_g being the true Greenwich sidereal time.

2.6 Axis Direction Unit Vectors of Satellite Angular Momentum Coordinates

Figure E.2 shows the satellite's angular momentum coordinates, with the origin representing the satellite's center of gravity, the x-axis the direction of the vector which is rotated $\mathbf{S}_S'$ around the z-axis to obtain the β angle ($\mathbf{S}_S'$ is the sun direction vector projected onto the z-axis vertical plane), the y-axis which is used to form a right-handed coordinate system, and the z-axis which indicates the direction of the angular momentum vector.

The x, y, and z direction unit vectors of the satellite angular momentum coordinates which are transformed into the earth-fixed coordinates are defined as

z-axis, $\mathbf{S}_P$:

$$\mathbf{S}_P=[B]\cdot[N_P]\cdot\begin{bmatrix} \sin\delta_r \\ -\cos\delta_r\cdot\sin\alpha_r \\ \cos\delta_r\cdot\cos\alpha_r \end{bmatrix} \tag{9}$$

x-axis, $\mathbf{S}_X$:

$$\mathbf{S}_X=\frac{\mathbf{S}_P\times\mathbf{S}_S}{|\mathbf{S}_P\times\mathbf{S}_S|}\sin\beta+\frac{\mathbf{S}_P\times\mathbf{S}_S}{|\mathbf{S}_P\times\mathbf{S}_S|}\times\mathbf{S}_P\cos\beta \tag{10}$$

y-axis, $\mathbf{S}_y$:

$$\mathbf{S}_y=\mathbf{S}_P\times\mathbf{S}_X \tag{11}$$

where $\mathbf{S}_S$ is the vector from the satellite to the sun.

$$\mathbf{S}_S=\begin{bmatrix} \cos\delta_S\cdot\cos\alpha_S \\ \cos\delta_S\cdot\sin\alpha_S \\ \sin\delta_S \end{bmatrix} \tag{12}$$

2.7 View Vector

The view vector $\mathbf{X}_E$ is directed from the satellite (X, Y, Z) to the point of interest (X_e, Y_e, Z_e) in the earth-fixed coordinates, and is expessed as

$$\mathbf{X}_E=\begin{bmatrix} X_e-X \\ Y_e-Y \\ Z_e-Z \end{bmatrix} \tag{13}$$

2.8 Earth-fixed to VISSR Frame Transformation

Line number I and pixel number J of the point of interest in the VISSR frame coordinates are given by

$$\theta_L=\cos^{-1}\frac{\mathbf{X}_E\cdot\mathbf{S}_P}{|\mathbf{X}_E||\mathbf{S}_P|} \tag{14}$$

$$I=\frac{(\pi/2-\theta_L)-M_Y}{P}+I_C \tag{15}$$

$$\mathbf{V}_A=\mathbf{S}_P\times\mathbf{X}_E \tag{16}$$

$$\mathbf{V}_B=\mathbf{S}_y\times\mathbf{V}_A \tag{17}$$

$$\theta_P=\cos^{-1}\frac{\mathbf{S}_y\cdot\mathbf{V}_A}{|\mathbf{S}_y||\mathbf{V}_A|} \tag{18}$$

$$T_F=\mathbf{S}_P\cdot\mathbf{V}_B \tag{19}$$

if $T_F<0$ then $\theta_P=-\theta_P$

$$J=\frac{\theta_P+M_Z-(\pi/2-\theta_L)\tan M_X}{Q}+J_C \tag{20}$$

2.9 VISSR Frame to Satellite Angular Momentum Transformation

The vector $\mathbf{X}_S$ is directed from the satellite to the point of interest in the satellite angular momentum coordinates, and is expressed as

$$\mathbf{X}_S=\begin{bmatrix} \cos Q(J-J_C) & -\sin Q(J-J_C) & 0 \\ \sin Q(J-J_C) & \cos Q(J-J_C) & 0 \\ 0 & 0 & 1 \end{bmatrix}\cdot[M]\cdot\begin{bmatrix} \cos P(I-I_C) \\ 0 \\ \sin P(I-I_C) \end{bmatrix} \tag{21}$$

where I and J are line and pixel number of the point of interest in the VISSR frame coordinates.

2.10 Satellite Angular Momentum to Earth-fixed Transformation

The sattellite angular momentum coordinates $\mathbf{X}_S$ are transformed into the earth-fixed coordinates $\mathbf{X}_E$ as follows

$$\mathbf{X}_E=\begin{bmatrix} u_x \\ u_y \\ u_z \end{bmatrix}=[S]\cdot\mathbf{X}_S \tag{22}$$

where

$$[S]=[S_x,\ S_y,\ S_P] \quad (23)$$

2.11 View Vector to Point on the Earth

The point interest on the earth is computed by the unit view vector $\mathbf{X}_E$ and satellite position (X, Y, Z) in the earth-fixed coordinates.

The view vector directed from the satellite to the point of interest is

$$\mathbf{X}_E=\begin{bmatrix} u_x \\ u_y \\ u_z \end{bmatrix} \quad (24)$$

$$k=\frac{-b\pm(b^2-ac)^{0.5}}{a} \quad (25)$$

where

$$\left.\begin{aligned} a&=(1-f)^2(u_x^2+u_y^2)+u_z^2 \\ b&=(1-f)^2(Xu_x+Yu_y)+Zu_z \\ c&=(1-f)^2(X^2+Y^2-R_e^2)+Z^2 \end{aligned}\right\} \quad (26)$$

Among the two solutions for k , the smaller absolute value is employed.

If the value of b^2-ac is negative, the view vector does not cross the earth surface, thus the point of interest in the earth-fixed coordinates is given by

$$\left.\begin{aligned} X_e&=X+ku_x \\ Y_e&=Y+ku_y \\ Z_e&=Z+ku_z \end{aligned}\right\} \quad (27)$$

2.12 Earth-fixed to Geodetic Transformation

The transformation from the earth-fixed (X_e, Y_e, Z_e) to the geodetic coordinates (ϕ, λ) is gjven by

$$\phi=\tan^{-1}\left[\frac{Z_e}{(1-f)^2(X_e^2+Y_e^2)^{0.5}}\right] \quad (28)$$

$$\lambda=\tan^{-1}\left[\frac{Y_e}{X_e}\right] \quad (29)$$

2.13 Zenith Pointing Vector

The unit vector pointing to the zenith at subject **H** is given by

$$\mathbf{H}=\begin{bmatrix} \cos\phi\cos\lambda \\ \cos\phi\sin\lambda \\ \sin\phi \end{bmatrix} \quad (30)$$

where the subject is defined by the point of interest on the earth (Fig. E.3).

2.14 Satellite Zenith Distance

The satellite zenith distance at the subject, Z_{SAT}, is computed by the vector **H** and the vector from the subject to the satellite $\mathbf{V}_{SAT}$.

$$Z_{SAT}=\cos^{-1}\frac{\mathbf{H}\cdot\mathbf{V}_{SAT}}{|\mathbf{H}||\mathbf{V}_{SAT}|} \tag{31}$$

2.15 Distance to the Sun

The distance from the earth to the sun is given by

$$\left.\begin{array}{l} A_M=315.253^\circ+0.98560027^\circ t_{IJ} \\ R_{SUN}=1.00014-0.01672\cos A_M-0.00014\cos^2 A_M \end{array}\right\} \tag{32}$$

where t_{IJ} is the scanning time represented in MJD, and R_{SUN} is expressed in astronomical units.

2.16 North Pointing Vector

The vector in the horizontal plane that points north at the subject **N** is given by following equations (Fig. E.4).

$$\left.\begin{array}{l} \phi_N=90^\circ-\phi \\ \lambda_N=\lambda-180^\circ \end{array}\right\}\phi\geqq 0 \tag{33}$$

$$\left.\begin{array}{l} \phi_N=90^\circ+\phi \\ \lambda_N=\lambda \end{array}\right\}\phi< 0 \tag{34}$$

if $\lambda_N\leqq -180^\circ$ then $\lambda_N=\lambda_N+360^\circ$

$$\mathbf{N}=\begin{bmatrix}\cos\phi_N\cos\lambda_N \\ \cos\phi_N\sin\lambda_N \\ \sin\phi_N\end{bmatrix} \tag{35}$$

2.17 Sun Zenith Distance

The sun zenith distance at the subject, Z_{SUN}, is computed by the vector **H** and the vector from the subject to the sun, $\mathbf{V}_{SUN}$.

$$Z_{SUN}=\cos^{-1}\frac{\mathbf{H}\cdot\mathbf{V}_{SUN}}{|\mathbf{H}||\mathbf{V}_{SUN}|} \tag{36}$$

2.18 Sun/Satellite Azimuth Angle

Azimuth angle A of a vector **A** at the subject is computed by the vector pointed to zenith **H** and the vector pointed north **N** at the subject (Fig. E.5(a)-(c)). The vector **A** is either $\mathbf{V}_{SUN}$ or $\mathbf{V}_{SAT}$.

$$\mathbf{B}=\mathbf{N}\times\mathbf{H} \tag{37}$$

$$\mathbf{C}=\mathbf{A}\times\mathbf{H} \tag{38}$$

$$\theta_1=\cos^{-1}\frac{\mathbf{B}\cdot\mathbf{C}}{|\mathbf{B}||\mathbf{C}|} \tag{39}$$

$$\mathbf{D}=\mathbf{B}\times\mathbf{C} \tag{40}$$

$$\theta_2=\cos^{-1}\frac{\mathbf{H}\cdot\mathbf{D}}{|\mathbf{H}||\mathbf{D}|} \tag{41}$$

and

if $\theta_2=0^\circ$ then $A=360^\circ-\theta_1$
if $\theta_2=180^\circ$ then $A=\theta_1$

2.19 Sun Glint Angle

The sun glint angle, G (Fig. E.6) is defined as the angle between the vector of the sun's rays reflected at the subject and the vector from the subject to the satellite, being given by

$$\theta_S=\cos^{-1}\frac{\mathbf{H}\cdot\mathbf{V}_{SUN}}{|\mathbf{H}||\mathbf{V}_{SUN}|} \tag{42}$$

$$\mathbf{S}_G=\mathbf{H}\cos\theta_S-\frac{\mathbf{H}\times\mathbf{V}_{SUN}}{|\mathbf{H}\times\mathbf{V}_{SUN}|}\times\mathbf{H}\sin\theta_S \tag{43}$$

$$G=\cos^{-1}\frac{\mathbf{S}_G\cdot\mathbf{V}_{SAT}}{|\mathbf{S}_G||\mathbf{V}_{SAT}|} \tag{44}$$

3. Sample Programs

Sample programs are presented which are represented in FORTRAN (FORTRAN 77), and are applicable for both VISSR archive data that is stored at the MSC and S-VSSR (and HiRID) data that is broadcasted via satellite.

Table E.1. Parameters Used for Coordinate Transformation

a. Coordinate Transformation Parameters	
t_s	: Observation start time (UTC represented in MJD)
P	: Stepping angle along line (rad)
Q	: Sampling angle along pixel (rad)
I_c	: Center line number of VISSR frame
J_c	: Center pixel number of VISSR frame
n	: Number of sensors
M_X	: VISSR misalignment angle around x-axis (rad)
M_Y	: VISSR misalignment angle around y-axis (rad)
M_Z	: VISSR misalignment angle around z-axis (rad)
[M]	: VISSR misalignment matrix (3×3)
R_e	: Equatorial radius of the earth (m)
f	: Flattening of the earth
b. Attitude Parameters (33 sets at 5-minute intervals)	
t_n	: Prediction time (UTC represented in MJD)
α_r	: Angle between z-axis and satellite spin axis projected on yz-plane in mean of 1950.0 coordinates (rad)
δ_r	: Angle between satellite spin axis and yz-plane (rad)
β	: β -angle (rad), i.e., angle between the sun and earth center on the z-axis vertical plane
ω	: Spin rate of satellite (rpm)
c. Orbital Parameters (9 sets at 5-minute intervals)	
t_n	: Prediction time (UTC represented in MJD)
X	: X component of satellite position in the earth-fixed coordinates (m)
Y	: Y component of satellite position in the earth-fixed coordinates (m)
Z	: Z component of satellite position in the earth-fixed coordinates (m)
θ_g	: True Greenwich sidereal time (rad)
α_s	: Right ascension from satellite to the sun in the earth-fixed coordinates (rad)
δ_s	: Declination from satellite to the sun in the earth-fixed coordinates (rad)
$[N_P]$	: Nutation and precession matrix (3×3)

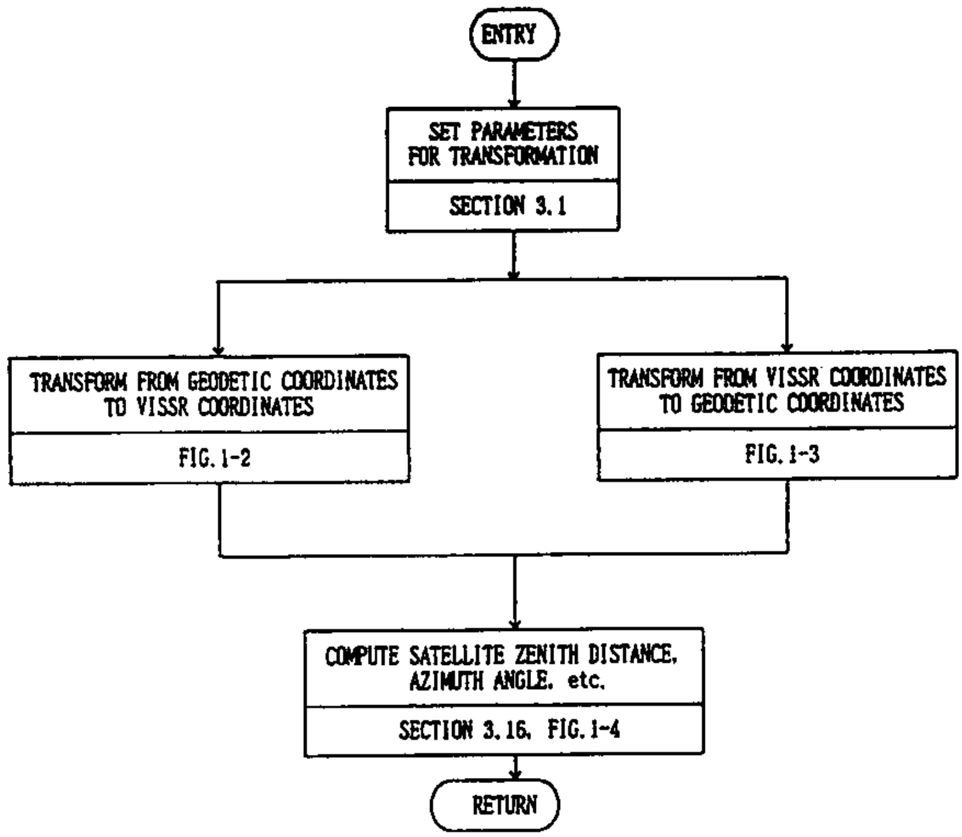


Fig.E.1-1 Flow chart of coordinate transformation

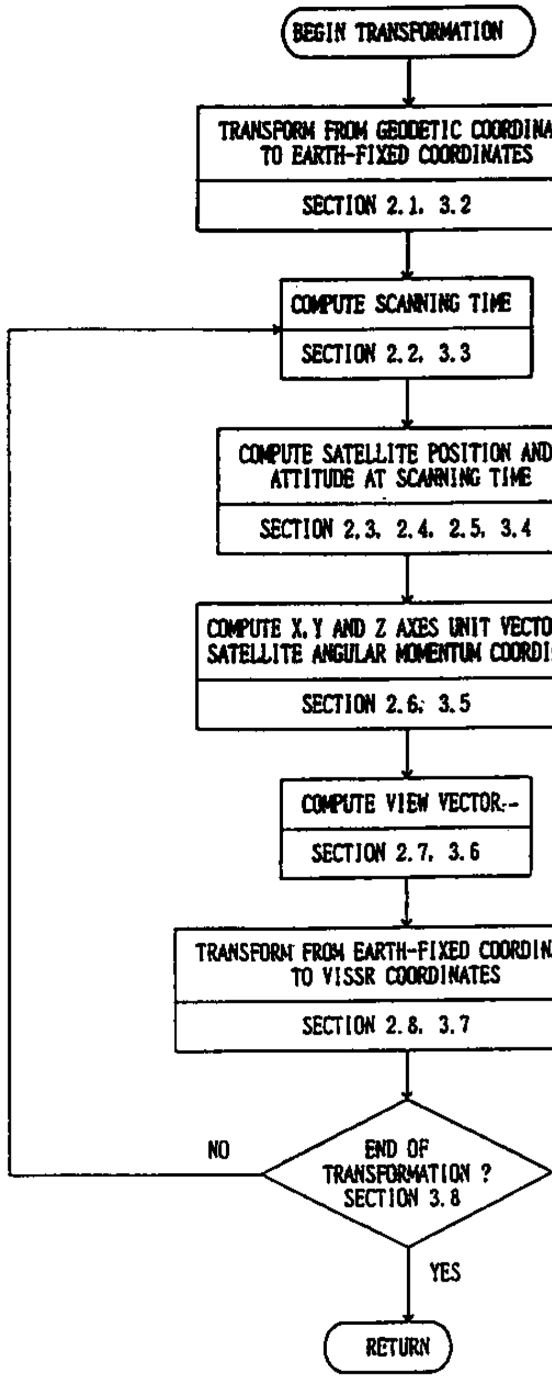


Fig.E.1-2 Flow chart of transformation from geodetic to VISSR coordinates

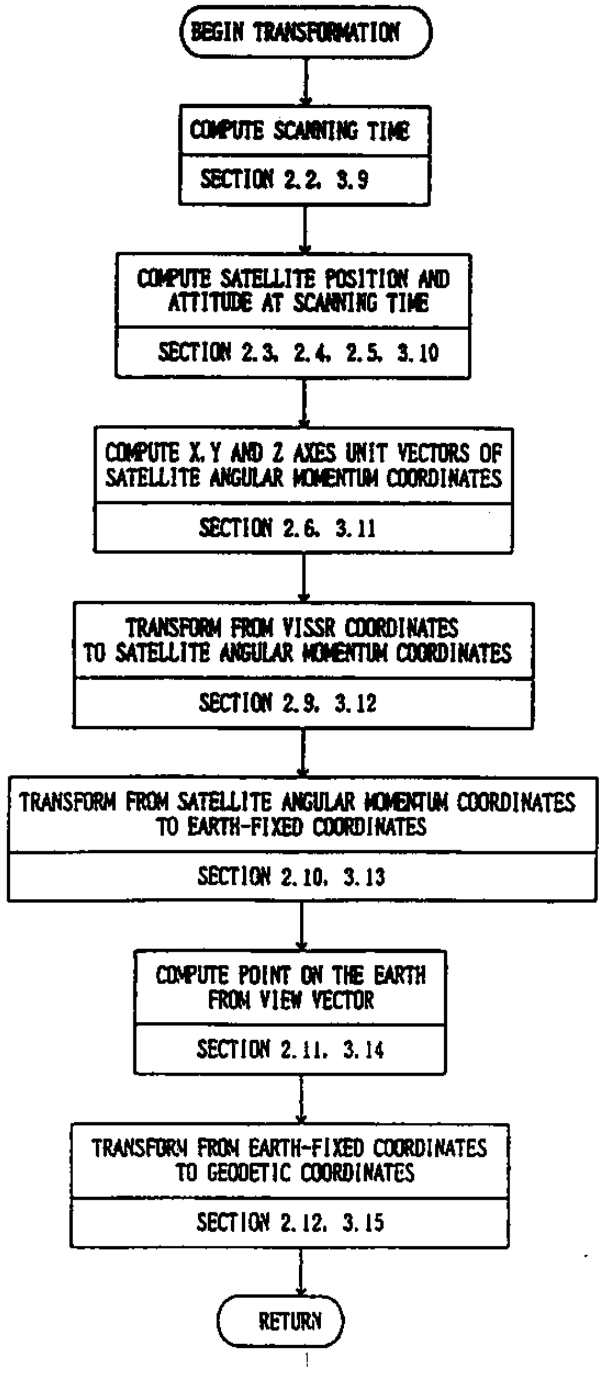


Fig.E.1-3 Flow chart of transformation from VISSR to geodetic coordinates

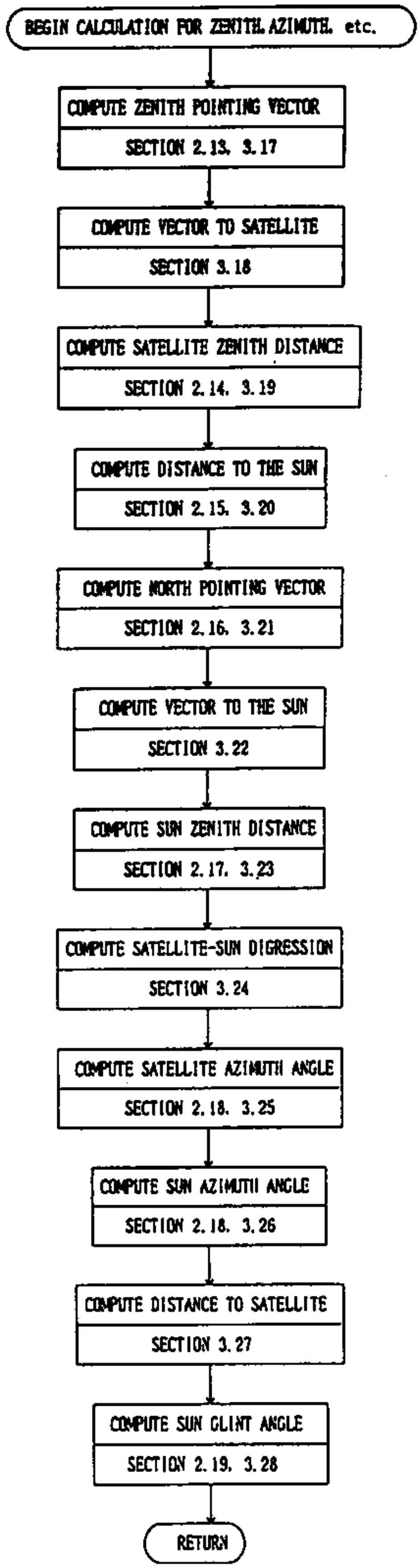


Fig.E.1-4 Flow chart to calculate various transformation parameters

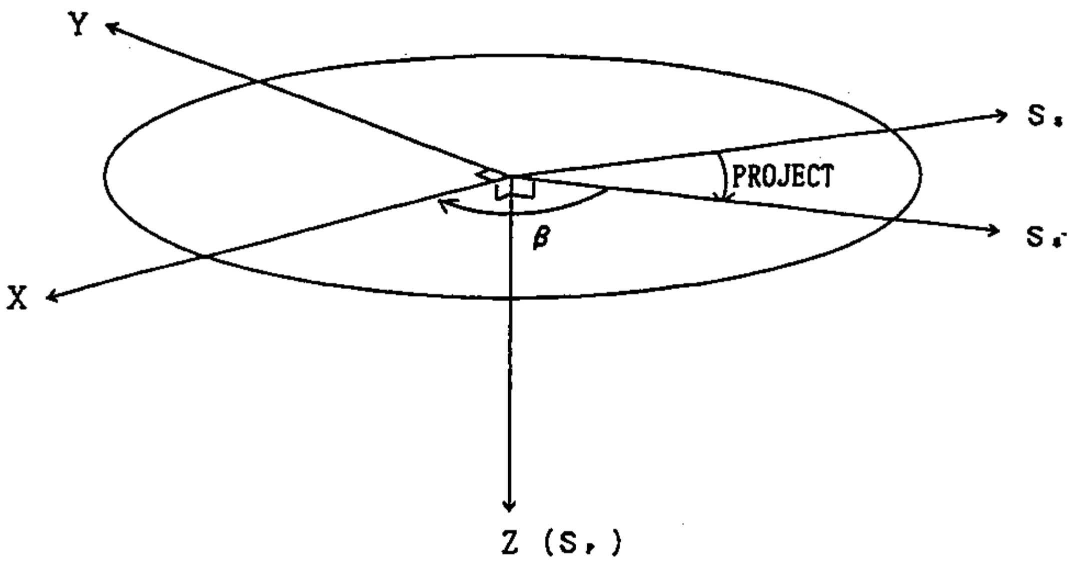


Fig.E.2 Satellite angular momentum coordinates

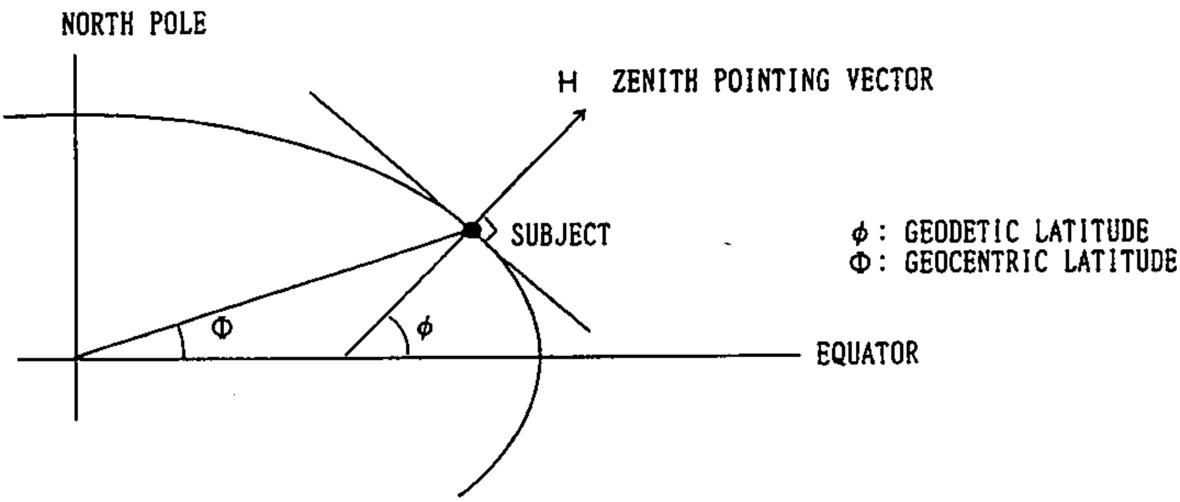


Fig.E.3 Subject zenith pointing vector along the geodetic vertical

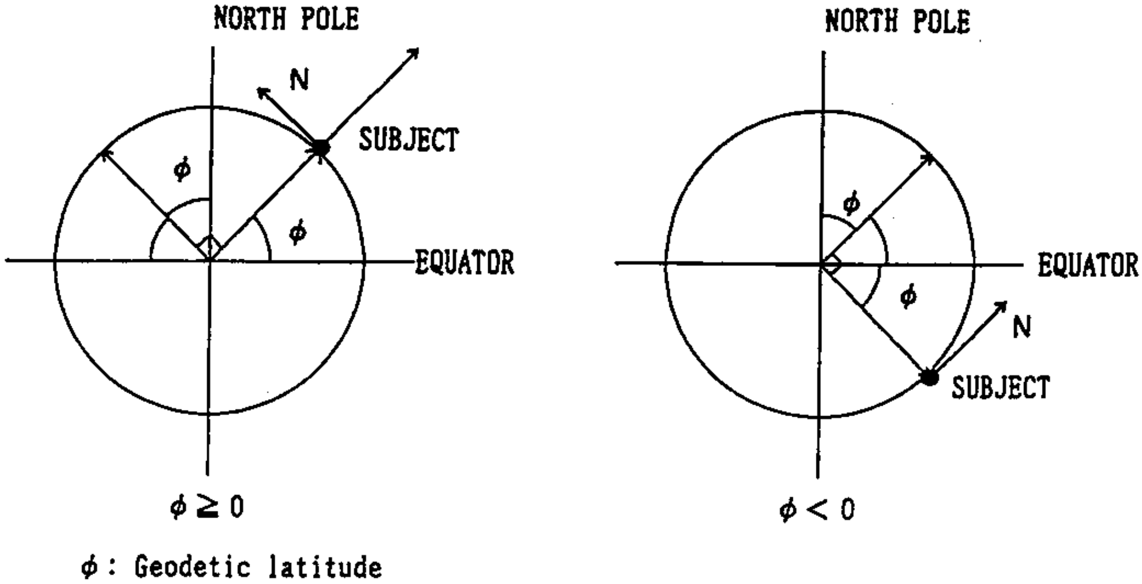


Fig.E.4 Horizontal plane of vector that points north

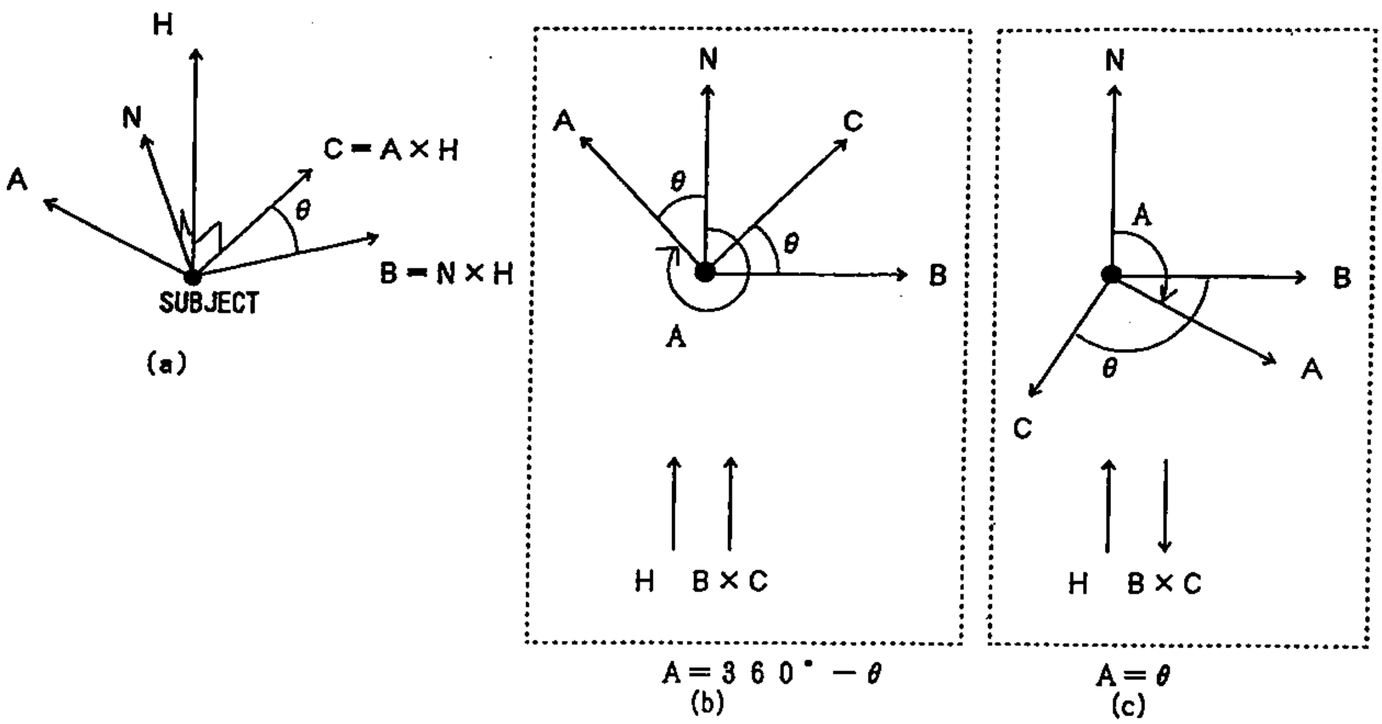


Fig.E.5 Azimuth angle calculation.

(a) **A** : vector to the sun or satellite

H : zenith pointing vector

N : north pointing vector

(b) Azimuth angle A of the vector **A** is $360° - \theta$ in the case where **H** and **B**×**C** are in the same direction.

(c) Azimuth angle A of the vector **A** is θ in the case where **H** and **B**×**C** are in opposite directions.

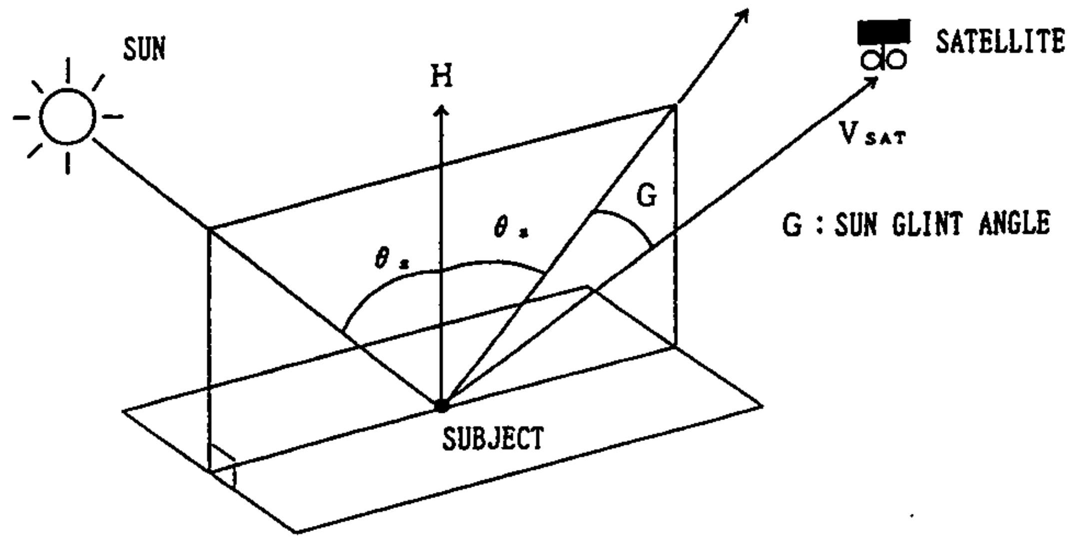


Fig.E.6 Sun glint angle, i.e., the angle between the vector of the sun's rays reflected at the subject and the vector from the subject to the satellite.

```
C*****************************************************************************
C                                                                           C
C                   +=========+   +--------------+ BLOCK LENGTH :           C
C                   ! S-VISSR !<----! S-VISSR DATA !  9174 BYTES            C
C                   ! NAV.    !   +--------------+ (FIXED LENGTH)           C
C                   ! DATA    !   UNIT=10  (DISK)                           C
C                   ! CHECK   !          !                                  C
C +---------+       ! PROGRAM !          !                                  C
C ! LISTING !<----! <SV0000>!            !                                  C
C +---------+       +=========+          !                                  C
C UNIT=6                                 !                                  C
C                        +--    +------------------------------+            C
C                        !    1 ! DOCUMENTATION SECTOR DATA /  !            C
C                        !      ! IR1, IR2, IR3 DATA           !            C
C                        !      +------------------------------+            C
C                        !    2 ! VIS 1 DATA                   !            C
C                        !      +------------------------------+            C
C               1 SCAN LINE   3 ! VIS 2 DATA                   !            C
C               ==> 5 BLOCKS    +------------------------------+            C
C                        !    4 ! VIS 3 DATA                   !            C
C                        !      +------------------------------+            C
C                        !    5 ! VIS 4 DATA                   !            C
C                        +--    +------------------------------+            C
C                               <----------9174 BYTES---------->            C
C                                                                           C
C                                                                           C
C*****************************************************************************
      PROGRAM  SV0000
C-----------------------------------------------------------------------------
C     GMS-5 S-VISSR AND MTSAT HiRID NAVIGATION
C-----------------------------------------------------------------------------
      INTEGER*4   ISMT(25,25,4),JSMT(25,25,4),IX(25)/25*0/
      INTEGER*4   JWEL1/0/,JWEL2/0/,ITC/0/,LAEDG(2),LEEDG(2)
      REAL*4      WEL1(100)/100*0/,WEL2(100)/100*0/,
     .            WEL3(100)/100*0/,WEL4(100)/100*0/
      REAL*4      RINF(8)
      REAL*8      DSCT
      CHARACTER   CSMT(2500)*1,COBAT(3200)*1
      CHARACTER   CBUF(9174)*1,DATID*2,SCTID*2,COND*128,MAPC*64,
     .            TEXTID*4,MAPTBL*100,OBAT*128,MANAM*410,SPARE*1459,
     .            SCTCD1*2,SCTCD2*2,SCTCD3*2,CMAPC*64
      EQUIVALENCE ( CBUF(   1)(1:1), DATID(1:1)  )
      EQUIVALENCE ( CBUF(   3)(1:1), SCTID(1:1)  )
      EQUIVALENCE ( CBUF(   5)(1:1), COND(1:1)   )
      EQUIVALENCE ( CBUF( 131)(1:1), MAPC(1:1)   )
      EQUIVALENCE ( CBUF( 195)(1:1), TEXTID(1:1) )
      EQUIVALENCE ( CBUF( 199)(1:1), MAPTBL(1:1) )
      EQUIVALENCE ( CBUF( 299)(1:1), OBAT(1:1)   )
      EQUIVALENCE ( CBUF( 427)(1:1), MANAM(1:1)  )
      EQUIVALENCE ( CBUF( 837)(1:1), SPARE(1:1)  )
      EQUIVALENCE ( CBUF(2296)(1:1), SCTCD1(1:1) )
      EQUIVALENCE ( CBUF(4589)(1:1), SCTCD2(1:1) )
      EQUIVALENCE ( CBUF(6882)(1:1), SCTCD3(1:1) )
C                                          *OPEN FILE
      OPEN(UNIT=10,ACCESS='DIRECT',RECL=9174,IOSTAT=IOS)
      IF( IOS.NE.0 )                                        GO TO  9000
C                                          *GET MAPPING DATA
      DO 1000 IBLK=801*5,2500*5,5
C                                          +READ S-VISSR DATA
        READ(UNIT=10,REC=IBLK,FMT='(91(100A1),74A1)',IOSTAT=IOS)  CBUF
        IF( IOS.NE.0 )                                      GO TO  8000
C                                          +DOCUMENTAION SECTOR ?
        IF( ICHAR(SCTID(1:1)).NE.0 .OR. ICHAR(SCTID(2:2)).NE.0 )
     .                                                      GO TO  1000
C                                          +SET TEXT ID
        ITLN1 = ICHAR( TEXTID(2:2) )
C                                          +ALREADY SET ?
        IF( IX(ITLN1+1).NE.0 )                              GO TO  1000
C                                          +SET SIMPLIFIED MAPPING DATA
        CMAPC(1:64) = MAPC(1:64)
        DO 1100 I1=1,100
          CSMT(ITLN1*100+I1)(1:1) = MAPTBL(I1:I1)
 1100   CONTINUE
C                                          +SET ORBIT/ATTITUDE DATA
        DO 1200 I2=1,128
          COBAT(ITLN1*128+I2)(1:1) = OBAT(I2:I2)
 1200   CONTINUE
C                                          +SET TEXT ID FLAG
        IX(ITLN1+1) = 1
C                                          +ALL DATA ?
        KTLN = IX( 1)+IX( 2)+IX( 3)+IX( 4)+IX( 5)+IX( 6)+IX( 7)+IX( 8)
     .         +IX( 9)+IX(10)+IX(11)+IX(12)+IX(13)+IX(14)+IX(15)+IX(16)
     .         +IX(17)+IX(18)+IX(19)+IX(20)+IX(21)+IX(22)+IX(23)+IX(24)
     .         +IX(25)
        IF( KTLN.EQ.25 )                                    GO TO  2000
 1000 CONTINUE
C
 2000 CONTINUE
C                                          *GET SIMPLIFIED MAPPING TABLE
      CALL  SV0200( CSMT, ISMT )
C                                          *GET ORBIT/ATTITUDE TABLE
      CALL  SV0300( COBAT, JSMT )
C                                          *EXAMPLE POSITION
      RLAT = 35.00
      RLON = 140.00
C                                          *GET LINE & PIXEL
      CALL  MGIVSR(1,RPVIS,RLVIS,RLON, RLAT, 0.0,RINF,DSCT,JR)
      CALL  MGIVSR(2,RPIR1,RLIR1,RLON, RLAT, 0.0,RINF,DSCT,JR)
      CALL  MGIVSR(3,RPIR2,RLIR2,RLON, RLAT, 0.0,RINF,DSCT,JR)
      CALL  MGIVSR(4,RPWV ,RLWV ,RLON, RLAT, 0.0,RINF,DSCT,JR)
C                                          *OUTPUT LINE & PIXEL
      WRITE(6,*)  'VISIBLE  LINE & PIXEL : ', RLVIS, RPVIS
      WRITE(6,*)  'IR1(IR4) LINE & PIXEL : ', RLIR1, RPIR1
      WRITE(6,*)  'IR2      LINE & PIXEL : ', RLIR2, RPIR2
      WRITE(6,*)  'WV(IR3)  LINE & PIXEL : ', RLWV , RPWV
C                                          *CLOSE FILE
 8000 CONTINUE
      CLOSE(UNIT=10)
 9000 CONTINUE
      STOP
      END
      SUBROUTINE  SV0100( IWORD, IPOS, C, R4DAT, R8DAT )
C---- -------------------------------------------------------------------
C     TYPE CONVERT ROUTINE ( R-TYPE )
C---- -------------------------------------------------------------------
      INTEGER*4   IWORD,IPOS,IDATA1
      CHARACTER   C(*)*1
      REAL*4      R4DAT
      REAL*8      R8DAT
      R4DAT = 0.0
      R8DAT = 0.D0
      IF( IWORD.EQ.4 )  THEN
        IDATA1 = ICHAR( C(1)(1:1) )/128
        R8DAT  = DFLOAT( MOD(ICHAR(C(1)(1:1)),128) )*2.D0**(8*3)+
     .           DFLOAT(     ICHAR(C(2)(1:1))      )*2.D0**(8*2)+
     .           DFLOAT(     ICHAR(C(3)(1:1))      )*2.D0**(8*1)+
     .           DFLOAT(     ICHAR(C(4)(1:1))      )
        R8DAT  = R8DAT/10.D0**IPOS
        IF( IDATA1.EQ.1 )  R8DAT = -R8DAT
        R4DAT  = SNGL( R8DAT )
      ELSEIF( IWORD.EQ.6 )  THEN
        IDATA1 = ICHAR( C(1)(1:1) )/128
        R8DAT  = DFLOAT( MOD(ICHAR(C(1)(1:1)),128) )*2.D0**(8*5)+
     .           DFLOAT(     ICHAR(C(2)(1:1))      )*2.D0**(8*4)+
     .           DFLOAT(     ICHAR(C(3)(1:1))      )*2.D0**(8*3)+
     .           DFLOAT(     ICHAR(C(4)(1:1))      )*2.D0**(8*2)+
     .           DFLOAT(     ICHAR(C(5)(1:1))      )*2.D0**(8*1)+
     .           DFLOAT(     ICHAR(C(6)(1:1))      )
        R8DAT  = R8DAT/10.D0**IPOS
        IF( IDATA1.EQ.1 )  R8DAT = -R8DAT
        R4DAT  = SNGL( R8DAT )
      ENDIF
      RETURN
      END
      SUBROUTINE  SV0110( IWORD, C, I4DAT )
C---- -------------------------------------------------------------------
C     TYPE CONVERT ROUTINE ( I-TYPE )
C---- -------------------------------------------------------------------
      INTEGER*4   IWORD,I4DAT
      CHARACTER   C(*)*1
      I4DAT = 0
      IF( IWORD.EQ.2 )  THEN
        I4DAT =      ICHAR( C(1)(1:1) )*2**(8*1)+
     .               ICHAR( C(2)(1:1) )
      ELSEIF( IWORD.EQ.4 )  THEN
        I4DAT =      ICHAR( C(1)(1:1) )*2**(8*3)+
     .               ICHAR( C(2)(1:1) )*2**(8*2)+
     .               ICHAR( C(3)(1:1) )*2**(8*1)+
     .               ICHAR( C(4)(1:1) )
      ENDIF
      RETURN
      END
      SUBROUTINE  SV0200( CSMT, ISMT )
C-----------------------------------------------------------------------
C     SIMPLIFIED MAPPING DATA PROCESSING ROUTINE                        C
C-----------------------------------------------------------------------
      CHARACTER   CSMT(2500)*1
      INTEGER*4   ISMT(25,25,4)
      DO 2100 IL1=1,25
        DO 2200 IL2=1,25
          ILAT   = 60-(IL1-1)*5
          ILON   = 80+(IL2-1)*5
```

```
          IL3    = (IL1-1)*100+(IL2-1)*4+1
          ILINE1 = ICHAR(CSMT(IL3  )(1:1))*256+ICHAR(CSMT(IL3+1)(1:1))
          IPIXE1 = ICHAR(CSMT(IL3+2)(1:1))*256+ICHAR(CSMT(IL3+3)(1:1))
          ISMT(IL2,IL1,1) = ILAT
          ISMT(IL2,IL1,2) = ILON
          ISMT(IL2,IL1,3) = ILINE1
          ISMT(IL2,IL1,4) = IPIXE1
 2200   CONTINUE
 2100 CONTINUE
      RETURN
      END
      SUBROUTINE  SV0300( COBAT ,JSMT )
C-----------------------------------------------------------------------
C     ORBIT AND ATTITUDE DATA PROCESSING ROUTINE                       C
C-----------------------------------------------------------------------
      COMMON /MMAP1/MAP
      INTEGER*4  MAP(672,4)
      CHARACTER  COBAT*3200
      INTEGER*4  JSMT(25,25,4)
      REAL*4     R4DMY,RESLIN(4),RESELM(4),RLIC(4),RELMFC(4),SENSSU(4),
     &           VMIS(3),ELMIS(3,3),RLINE(4),RELMNT(4),RINF(8)
      REAL*8     R8DMY,DSPIN,DTIMS,ATIT(10,33),ORBT1(35,8),DSCT
C
      EQUIVALENCE (MAP( 5,1),DTIMS),     (MAP( 7,1),RESLIN(1))
      EQUIVALENCE (MAP(11,1),RESELM(1)), (MAP(15,1),RLIC(1))
      EQUIVALENCE (MAP(19,1),RELMFC(1)), (MAP(27,1),SENSSU(1))
      EQUIVALENCE (MAP(31,1),RLINE(1)),  (MAP(35,1),RELMNT(1))
      EQUIVALENCE (MAP(39,1),VMIS(1)),   (MAP(42,1),ELMIS)
      EQUIVALENCE (MAP(131,1),DSPIN)
      EQUIVALENCE (MAP(13,3),ORBT1(1,1)), (MAP(13,2),ATIT(1,1))
C
      DO 1000 I=1,4
        DO 1100 J=1,672
          MAP(J,I) = 0
 1100   CONTINUE
 1000 CONTINUE
C
      CALL  SV0100( 6, 8, COBAT(  1:  6), R4DMY    ,  DTIMS )
      CALL  SV0100( 4, 8, COBAT(  7: 10), RESLIN(1),  R8DMY )
      CALL  SV0100( 4, 8, COBAT( 11: 14), RESLIN(2),  R8DMY )
      CALL  SV0100( 4, 8, COBAT( 11: 14), RESLIN(3),  R8DMY )
      CALL  SV0100( 4, 8, COBAT( 11: 14), RESLIN(4),  R8DMY )
      CALL  SV0100( 4,10, COBAT( 15: 18), RESELM(1),  R8DMY )
      CALL  SV0100( 4,10, COBAT( 19: 22), RESELM(2),  R8DMY )
      CALL  SV0100( 4,10, COBAT( 19: 22), RESELM(3),  R8DMY )
      CALL  SV0100( 4,10, COBAT( 19: 22), RESELM(4),  R8DMY )
      CALL  SV0100( 4, 4, COBAT( 23: 26), RLIC(1)  ,  R8DMY )
      CALL  SV0100( 4, 4, COBAT( 27: 30), RLIC(2)  ,  R8DMY )
      CALL  SV0100( 4, 4, COBAT(111:114), RLIC(3)  ,  R8DMY )
      CALL  SV0100( 4, 4, COBAT(115:118), RLIC(4)  ,  R8DMY )
      CALL  SV0100( 4, 4, COBAT( 31: 34), RELMFC(1),  R8DMY )
      CALL  SV0100( 4, 4, COBAT( 35: 38), RELMFC(2),  R8DMY )
      CALL  SV0100( 4, 4, COBAT(119:122), RELMFC(3),  R8DMY )
      CALL  SV0100( 4, 4, COBAT(123:126), RELMFC(4),  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 39: 42), SENSSU(1),  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 43: 46), SENSSU(2),  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 43: 46), SENSSU(3),  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 43: 46), SENSSU(4),  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 47: 50), RLINE(1) ,  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 51: 54), RLINE(2) ,  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 51: 54), RLINE(3) ,  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 51: 54), RLINE(4) ,  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 55: 58), RELMNT(1),  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 59: 62), RELMNT(2),  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 59: 62), RELMNT(3),  R8DMY )
      CALL  SV0100( 4, 0, COBAT( 59: 62), RELMNT(4),  R8DMY )
      CALL  SV0100( 4,10, COBAT( 63: 66), VMIS(1)  ,  R8DMY )
      CALL  SV0100( 4,10, COBAT( 67: 70), VMIS(2)  ,  R8DMY )
      CALL  SV0100( 4,10, COBAT( 71: 74), VMIS(3)  ,  R8DMY )
      CALL  SV0100( 4, 7, COBAT( 75: 78), ELMIS(1,1), R8DMY )
      CALL  SV0100( 4,10, COBAT( 79: 82), ELMIS(2,1), R8DMY )
      CALL  SV0100( 4,10, COBAT( 83: 86), ELMIS(3,1), R8DMY )
      CALL  SV0100( 4,10, COBAT( 87: 90), ELMIS(1,2), R8DMY )
      CALL  SV0100( 4, 7, COBAT( 91: 94), ELMIS(2,2), R8DMY )
      CALL  SV0100( 4,10, COBAT( 95: 98), ELMIS(3,2), R8DMY )
      CALL  SV0100( 4,10, COBAT( 99:102), ELMIS(1,3), R8DMY )
      CALL  SV0100( 4,10, COBAT(103:106), ELMIS(2,3), R8DMY )
      CALL  SV0100( 4, 7, COBAT(107:110), ELMIS(3,3), R8DMY )
      CALL  SV0100( 6, 8, COBAT(241:246), R4DMY     , DSPIN )
C
      DO 2000 I=1,10
        J = (I-1)*64+257-1
        CALL  SV0100(6, 8,COBAT( 1+J: 6+J),R4DMY,ATIT(1,I))
        CALL  SV0100(6, 8,COBAT(13+J:18+J),R4DMY,ATIT(3,I))
        CALL  SV0100(6,11,COBAT(19+J:24+J),R4DMY,ATIT(4,I))
        CALL  SV0100(6, 8,COBAT(25+J:30+J),R4DMY,ATIT(5,I))
        CALL  SV0100(6, 8,COBAT(31+J:36+J),R4DMY,ATIT(6,I))
 2000 CONTINUE
C
      DO 3000 I=1,8
        J = (I-1)*256+897-1
        CALL  SV0100(6, 8,COBAT(  1+J:  6+J),R4DMY,ORBT1( 1,I))
        CALL  SV0100(6, 6,COBAT( 49+J: 54+J),R4DMY,ORBT1( 9,I))
        CALL  SV0100(6, 6,COBAT( 55+J: 60+J),R4DMY,ORBT1(10,I))
        CALL  SV0100(6, 6,COBAT( 61+J: 66+J),R4DMY,ORBT1(11,I))
        CALL  SV0100(6, 8,COBAT( 85+J: 90+J),R4DMY,ORBT1(15,I))
        CALL  SV0100(6, 8,COBAT(103+J:108+J),R4DMY,ORBT1(18,I))
        CALL  SV0100(6, 8,COBAT(109+J:114+J),R4DMY,ORBT1(19,I))
        CALL  SV0100(6,12,COBAT(129+J:134+J),R4DMY,ORBT1(20,I))
        CALL  SV0100(6,14,COBAT(135+J:140+J),R4DMY,ORBT1(21,I))
        CALL  SV0100(6,14,COBAT(141+J:146+J),R4DMY,ORBT1(22,I))
        CALL  SV0100(6,14,COBAT(147+J:152+J),R4DMY,ORBT1(23,I))
        CALL  SV0100(6,12,COBAT(153+J:158+J),R4DMY,ORBT1(24,I))
        CALL  SV0100(6,16,COBAT(159+J:164+J),R4DMY,ORBT1(25,I))
        CALL  SV0100(6,12,COBAT(165+J:170+J),R4DMY,ORBT1(26,I))
        CALL  SV0100(6,16,COBAT(171+J:176+J),R4DMY,ORBT1(27,I))
        CALL  SV0100(6,12,COBAT(177+J:182+J),R4DMY,ORBT1(28,I))
 3000 CONTINUE
C
      DO 4100 IL1=1,25
        DO 4200 IL2=1,25
          RLAT   = FLOAT( 60-(IL1-1)*5 )
          RLON   = FLOAT( 80+(IL2-1)*5 )
          CALL  MGIVSR(2,RPIX,RLIN,RLON,RLAT,0.0,RINF,DSCT,IRTN)
          JSMT(IL2,IL1,1) = NINT( RLAT )
          JSMT(IL2,IL1,2) = NINT( RLON )
          JSMT(IL2,IL1,3) = NINT( RLIN )
          JSMT(IL2,IL1,4) = NINT( RPIX )
 4200   CONTINUE
 4100 CONTINUE
C
      RETURN
      END
      SUBROUTINE  MGIVSR( IMODE,RPIX,RLIN,RLON,RLAT,RHGT,
     &                    RINF,DSCT,IRTN)
C
C***********************************************************************
C***********************************************************************
C***********************************************************************
C***********************************************************************
C
C  THIS PROGRAM CONVERTS GEOGRAPHICAL CO-ORDINATES (LATITUDE,LONGITUDE,
C  HEIGHT) TO VISSR IMAGE CO-ORDINATES (LINE,PIXEL) AND VICE VERSA.
C
C  THIS PROGRAM IS PROVIDED BY THE METEOROLOGICAL SATELLITE CENTER OF
C  THE JAPAN METEOROLOGICAL AGENCY TO USERS OF GMS DATA.
C
C                                            MSC TECH. NOTE NO.23
C                                                        JMA/MSC 1991
C
C***********************************************************************
C***********************************************************************
C***********************************************************************
C***********************************************************************
C
C***********************************************************************
C              I/O  TYPE
C   IMODE       I   I*4   CONVERSION MODE & IMAGE KIND
C                           IMAGE KIND
C                                 GMS-4 GMS-5  MTSAT
C                            1,-1  VIS   VIS    VIS
C                            2,-2  IR    IR1  IR1,IR4
C                            3,-3  --    IR2    IR2
C                            4,-4  --    WV     WV
C                           CONVERSION MODE
C                             1 TO 4    (LAT,LON,HGT)=>(LINE,PIXEL)
C                            -1 TO -4   (LAT,LON    )<=(LINE,PIXEL)
C   RPIX       I/O  R*4   PIXEL OF POINT
C   RLIN       I/O  R*4   LINE OF POINT
C   RLON       I/O  R*4   LONGITUDE OF POINT (DEGREES,EAST:+,WEST:-)
C   RLAT       I/O  R*4   LATITUDE OF POINT (DEGREES,NORTH:+,SOUTH:-)
C   RHGT        I   R*4   HEIGHT OF POINT (METER)
C   RINF(8)     O   R*4   (1) SATELLITE ZENITH DISTANCE (DEGREES)
C                         (2) SATELLITE AZIMUTH ANGLE (DEGREES)
C                         (3) SUN ZENITH DISTANCE (DEGREES)
C                         (4) SUN AZIMUTH ANGLE (DEGREES)
C                         (5) SATELLTE-SUN DIPARTURE ANGLE (DEGREES)
C                         (6) SATELLTE DISTANCE (METER)
C                         (7) SUN DISTANCE (KIRO-METER)
C                         (8) SUN GRINT ANGLE (DEGREES)
C   DSCT        O   R*8   SCAN TIME (MJD)
C   IRTN        O   I*4   RETURN CODE (0=O.K.)
```

```
C
C!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C
C   COMMON /MMAP1/MAP(672,4)
C
C     1. COORDINATE TRANSFORMATION PARAMETERS SEGMENT
C                                               MAP(1,1)-MAP(672,1)
C     2. ATTITUDE PREDICTION DATA SEGMENT       MAP(1,2)-MAP(672,2)
C     3. ORBIT PREDICTION DATA 1 SEGMENT        MAP(1,3)-MAP(672,3)
C     4. ORBIT PREDICTION DATA 2 SEGMENT        MAP(1,4)-MAP(672,4)
C***********************************************************************
C
C!!!!!!!!!!!!!!!!!! DEFINITION !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      COMMON /MMAP1/MAP
C
      REAL*4     RPIX,RLIN,RLON,RLAT,RHGT,RINF(8)
      INTEGER*4  MAP(672,4),IRTN
C
      REAL*4     EPS,RI0,RI,RJ,RSTEP,RSAMP,RFCL,RFCP,SENS,RFTL,RFTP
      REAL*4     RESLIN(4),RESELM(4),RLIC(4),RELMFC(4),SENSSU(4),
     .           VMIS(3),ELMIS(3,3),RLINE(4),RELMNT(4)
      REAL*8     BC,BETA,BS,CDR,CRD,DD,DDA,DDB,DDC,DEF,DK,DK1,DK2,
     .           DLAT,DLON,DPAI,DSPIN,DTIMS,EA,EE,EF,EN,HPAI,PC,PI,PS,
     .           QC,QS,RTIM,TF,TL,TP,
     .           SAT(3),SL(3),SLV(3),SP(3),SS(3),STN1(3),STN2(3),
     .           SX(3),SY(3),SW1(3),SW2(3),SW3(3)
      REAL*8     DSCT,DSATZ,DSATA,DSUNZ,DSUNA,DSSDA,DSATD,SUNM,SDIS,
     .           DLATN,DLONN,STN3(3),DSUNG
C
C!!!!!!!!!!!!!!!!!! EQUIVALENCE !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      EQUIVALENCE (MAP( 5,1),DTIMS),     (MAP( 7,1),RESLIN(1))
      EQUIVALENCE (MAP(11,1),RESELM(1)), (MAP(15,1),RLIC(1))
      EQUIVALENCE (MAP(19,1),RELMFC(1)), (MAP(27,1),SENSSU(1))
      EQUIVALENCE (MAP(31,1),RLINE(1)),  (MAP(35,1),RELMNT(1))
      EQUIVALENCE (MAP(39,1),VMIS(1)),   (MAP(42,1),ELMIS)
      EQUIVALENCE (MAP(131,1),DSPIN)
C
C***********************************************************************
C
      PI   =  3.141592653D0
      CDR  =  PI/180.D0
      CRD  =  180.D0/PI
      HPAI =  PI/2.D0
      DPAI =  PI*2.D0
      EA   =  6378136.D0
      EF   =  1.D0/298.257D0
      EPS  =  1.0
C!!!!!!!!!!!!!!!!!! PARAMETER CHECK !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      IRTN  =  0
      IF(ABS(IMODE).GT.4)  IRTN=1
      IF(ABS(RLAT).GT.90. .AND. IMODE.GT.0)  IRTN=2
      IF(IRTN.NE.0)  RETURN
C!!!!!!!!!!!!!!!!!! VISSR FRAME INFORMATION SET !!!!!!!!!!!!!!!!!!!!!!!!!
      LMODE   = ABS(IMODE)                                        [3.1]
      RSTEP   = RESLIN(LMODE)
      RSAMP   = RESELM(LMODE)
      RFCL    = RLIC(LMODE)
      RFCP    = RELMFC(LMODE)
      SENS    = SENSSU(LMODE)
      RFTL    = RLINE(LMODE)+0.5
      RFTP    = RELMNT(LMODE)+0.5
C!!!!!!!!!!!!!!!!!! TRANSFORMATION (GEOGRAPHICAL->VISSR) !!!!!!!!!!!!!!!!
      IF( IMODE.GT.0 .AND. IMODE.LT.5 )  THEN
        DLAT    = DBLE(RLAT)*CDR                                  [3.2]
        DLON    = DBLE(RLON)*CDR
        EE      = 2.D0*EF-EF*EF
        EN      = EA/DSQRT(1.D0-EE*DSIN(DLAT)*DSIN(DLAT))
        STN1(1) = (EN+DBLE(RHGT))*DCOS(DLAT)*DCOS(DLON)
        STN1(2) = (EN+DBLE(RHGT))*DCOS(DLAT)*DSIN(DLON)
        STN1(3) = (EN*(1.D0-EE)+DBLE(RHGT))*DSIN(DLAT)
C
        RI0     = RFCL-ATAN(SIN(SNGL(DLAT))/(6.610689-COS(SNGL(DLAT))))
     .            /RSTEP
        RTIM    = DTIMS+DBLE(RI0/SENS/1440.)/DSPIN                [3.3]
C
  100   CONTINUE
        CALL  MG1100(RTIM,CDR,SAT,SP,SS,BETA)                     [3.4]
C-----------------------------------------------------------------------
        CALL  MG1220(SP,SS,SW1)                                   [3.5]
        CALL  MG1220(SW1,SP,SW2)
        BC      = DCOS(BETA)
        BS      = DSIN(BETA)
        SW3(1)  = SW1(1)*BS+SW2(1)*BC
        SW3(2)  = SW1(2)*BS+SW2(2)*BC
        SW3(3)  = SW1(3)*BS+SW2(3)*BC
        CALL  MG1200(SW3,SX)
        CALL  MG1220(SP,SX,SY)
        SLV(1)  = STN1(1)-SAT(1)                                  [3.6]
        SLV(2)  = STN1(2)-SAT(2)
        SLV(3)  = STN1(3)-SAT(3)
        CALL  MG1200(SLV,SL)                                      [3.7]
        CALL  MG1210(SP,SL,SW2)
        CALL  MG1210(SY,SW2,SW3)
        CALL  MG1230(SY,SW2,TP)
        TF      = SP(1)*SW3(1)+SP(2)*SW3(2)+SP(3)*SW3(3)
        IF(TF.LT.0.D0)  TP=-TP
        CALL  MG1230(SP,SL,TL)
C
        RI      = SNGL(HPAI-TL)/RSTEP+RFCL-VMIS(2)/RSTEP
        RJ      = SNGL(TP)/RSAMP+RFCP
     .            +VMIS(3)/RSAMP-SNGL(HPAI-TL)*TAN(VMIS(1))/RSAMP
C
        IF(ABS(RI-RI0).GE.EPS)  THEN                              [3.8]
          RTIM  = DBLE(AINT((RI-1.)/SENS)+RJ*RSAMP/SNGL(DPAI))/
     .            (DSPIN*1440.D0)+DTIMS
          RI0   = RI
          GO TO  100
        ENDIF
        RLIN    = RI
        RPIX    = RJ
        DSCT    = RTIM
        IF(RLIN.LT.0 .OR. RLIN.GT.RFTL)  IRTN=4
        IF(RPIX.LT.0 .OR. RPIX.GT.RFTP)  IRTN=5
C
C!!!!!!!!!!!!!!!!!! TRANSFORMATION (VISSR=>GEOGRAPHICAL) !!!!!!!!!!!!!!!!
      ELSEIF(IMODE.LT.0 .AND. IMODE.GT.-5)  THEN
C
        RTIM    = DBLE(AINT((RLIN-1.)/SENS)+RPIX*RSAMP/SNGL(DPAI))/
     .            (DSPIN*1440.D0)+DTIMS                           [3.9]
        CALL  MG1100(RTIM,CDR,SAT,SP,SS,BETA)                     [3.10]
        CALL  MG1220(SP,SS,SW1)                                   [3.11]
        CALL  MG1220(SW1,SP,SW2)
        BC      = DCOS(BETA)
        BS      = DSIN(BETA)
        SW3(1)  = SW1(1)*BS+SW2(1)*BC
        SW3(2)  = SW1(2)*BS+SW2(2)*BC
        SW3(3)  = SW1(3)*BS+SW2(3)*BC
        CALL  MG1200(SW3,SX)
        CALL  MG1220(SP,SX,SY)
        PC      = DCOS(DBLE(RSTEP*(RLIN-RFCL)))                   [3.12]
        PS      = DSIN(DBLE(RSTEP*(RLIN-RFCL)))
        QC      = DCOS(DBLE(RSAMP*(RPIX-RFCP)))
        QS      = DSIN(DBLE(RSAMP*(RPIX-RFCP)))
        SW1(1)  = DBLE(ELMIS(1,1))*PC+DBLE(ELMIS(1,3))*PS
        SW1(2)  = DBLE(ELMIS(2,1))*PC+DBLE(ELMIS(2,3))*PS
        SW1(3)  = DBLE(ELMIS(3,1))*PC+DBLE(ELMIS(3,3))*PS
        SW2(1)  = QC*SW1(1)-QS*SW1(2)
        SW2(2)  = QS*SW1(1)+QC*SW1(2)
        SW2(3)  = SW1(3)
        SW3(1)  = SX(1)*SW2(1)+SY(1)*SW2(2)+SP(1)*SW2(3)          [3.13]
        SW3(2)  = SX(2)*SW2(1)+SY(2)*SW2(2)+SP(2)*SW2(3)
        SW3(3)  = SX(3)*SW2(1)+SY(3)*SW2(2)+SP(3)*SW2(3)
        CALL  MG1200(SW3,SL)                                      [3.14]
        DEF     = (1.D0-EF)*(1.D0-EF)
        DDA     = DEF*(SL(1)*SL(1)+SL(2)*SL(2))+SL(3)*SL(3)
        DDB     = DEF*(SAT(1)*SL(1)+SAT(2)*SL(2))+SAT(3)*SL(3)
        DDC     = DEF*(SAT(1)*SAT(1)+SAT(2)*SAT(2)-EA*EA)+SAT(3)*SAT(3)
        DD      = DDB*DDB-DDA*DDC
        IF(DD.GE.0.D0 .AND. DDA.NE.0.D0)  THEN
          DK1     = (-DDB+DSQRT(DD))/DDA
          DK2     = (-DDB-DSQRT(DD))/DDA
        ELSE
          IRTN    = 6
          GO TO  9000
        ENDIF
        IF(DABS(DK1).LE.DABS(DK2))  THEN
          DK      = DK1
        ELSE
          DK      = DK2
        ENDIF
        STN1(1) = SAT(1)+DK*SL(1)
        STN1(2) = SAT(2)+DK*SL(2)
        STN1(3) = SAT(3)+DK*SL(3)
        DLAT    = DATAN(STN1(3)/(DEF*DSQRT(STN1(1)*STN1(1)+
     .            STN1(2)*STN1(2))))                              [3.15]
        IF(STN1(1).NE.0.D0)  THEN
          DLON  = DATAN(STN1(2)/STN1(1))
          IF(STN1(1).LT.0.D0 .AND. STN1(2).GE.0.D0)  DLON=DLON+PI
          IF(STN1(1).LT.0.D0 .AND. STN1(2).LT.0.D0)  DLON=DLON-PI
        ELSE
          IF(STN1(2).GT.0.D0)  THEN
            DLON=HPAI
```

```
          ELSE
            DLON=-HPAI
          ENDIF
        ENDIF
        RLAT    = SNGL(DLAT*CRD)
        RLON    = SNGL(DLON*CRD)
        DSCT    = RTIM
      ENDIF
C
C!!!!!!!!!!!!!!!!!! TRANSFORMATION (ZENITH/AZIMUTH) !!!!!!!!!!!!!!!![3.16]
      STN2(1)   = DCOS(DLAT)*DCOS(DLON)                             [3.17]
      STN2(2)   = DCOS(DLAT)*DSIN(DLON)
      STN2(3)   = DSIN(DLAT)
      SLV(1)    = SAT(1)-STN1(1)                                    [3.18]
      SLV(2)    = SAT(2)-STN1(2)
      SLV(3)    = SAT(3)-STN1(3)
      CALL  MGI200(SLV,SL)
C
      CALL  MGI230(STN2,SL,DSATZ)                                   [3.19]
      IF(DSATZ.GT.HPAI)  IRTN = 7
C
      SUNM    = 315.25300+0.98560000*RTIM                           [3.20]
      SUNM    = DMOD(SUNM,360.D0)*CDR
      SDIS    = (1.00014D0-0.01672D0*DCOS(SUNM)-0.00014*DCOS(2.D0*
     .          SUNM))*1.49597870D8
C
      IF(DLAT.GE.0.D0) THEN                                         [3.21]
        DLATN   = HPAI-DLAT
        DLONN = DLON-PI
        IF(DLONN.LE.-PI)  DLONN=DLONN+DPAI
      ELSE
        DLATN   = HPAI+DLAT
        DLONN   = DLON
      ENDIF
      STN3(1) = DCOS(DLATN)*DCOS(DLONN)
      STN3(2) = DCOS(DLATN)*DSIN(DLONN)
      STN3(3) = DSIN(DLATN)
      SW1(1)  = SLV(1)+SS(1)*SDIS*1.D3                              [3.22]
      SW1(2)  = SLV(2)+SS(2)*SDIS*1.D3
      SW1(3)  = SLV(3)+SS(3)*SDIS*1.D3
      CALL  MGI200(SW1,SW2)                                         [3.23]
      CALL  MGI230(STN2,SW2,DSUNZ)
      CALL  MGI230(SL,SW2,DSSDA)                                    [3.24]
      CALL  MGI240(SL,STN2,STN3,DPAI,DSATA)                         [3.25]
      CALL  MGI240(SW2,STN2,STN3,DPAI,DSUNA)                        [3.26]
      DSATD   = DSQRT(SLV(1)*SLV(1)+SLV(2)*SLV(2)+SLV(3)*SLV(3))    [3.27]
C
C
      CALL  MGI200(STN1,SL)                                         [3.28]
      CALL  MGI230(SW2,SL,DSUNG)
      CALL  MGI220(SL, SW2,SW3)
      CALL  MGI220(SW3,SL, SW1)
      WKCOS=DCOS(DSUNG)
      WKSIN=DSIN(DSUNG)
      SW2(1)=WKCOS*SL(1)-WKSIN*SW1(1)
      SW2(2)=WKCOS*SL(2)-WKSIN*SW1(2)
      SW2(3)=WKCOS*SL(3)-WKSIN*SW1(3)
      CALL  MGI230(SW2,SLV,DSUNG)
C
      RINF(6) = SNGL(DSATD)
      RINF(7) = SNGL(SDIS)
      RINF(1) = SNGL(DSATZ*CRD)
      RINF(2) = SNGL(DSATA*CRD)
      RINF(3) = SNGL(DSUNZ*CRD)
      RINF(4) = SNGL(DSUNA*CRD)
      RINF(5) = SNGL(DSSDA*CRD)
      RINF(8) = SNGL(DSUNG*CRD)
C!!!!!!!!!!!!!!!!!! STOP/END !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 9000 CONTINUE
      RETURN
      END
      SUBROUTINE  MGI100(RTIM,CDR,SAT,SP,SS,BETA)
      COMMON /MMAP1/MAP
      REAL*8    ATTALP,ATTDEL,BETA,CDR,DELT,RTIM,SITAGT,SUNALP,SUNDEL,
     .          WKCOS,WKSIN
      REAL*8    ATIT(10,10),ATT1(3),ATT2(3),ATT3(3),NPA(3,3),
     .          ORBT1(35,8),SAT(3),SP(3),SS(3)
      INTEGER*4 MAP(672,4)
C
      EQUIVALENCE (MAP(13,3),ORBT1(1,1))
      EQUIVALENCE (MAP(13,2),ATIT(1,1))
C
      DO 1000 I=1,7
        IF(RTIM.GE.ORBT1(1,I).AND.RTIM.LT.ORBT1(1,I+1))  THEN
          CALL  MGI110
     .         (I,RTIM,CDR,ORBT1,ORBT2,SAT,SITAGT,SUNALP,SUNDEL,NPA)
          GO TO  1200
        ENDIF
 1000 CONTINUE
 1200 CONTINUE
C
      DO 3000 I=1,33-1
        IF(RTIM.GE.ATIT(1,I) .AND. RTIM.LT.ATIT(1,I+1))  THEN
          DELT = (RTIM-ATIT(1,I))/(ATIT(1,I+1)-ATIT(1,I))
          ATTALP = ATIT(3,I)+(ATIT(3,I+1)-ATIT(3,I))*DELT
          ATTDEL = ATIT(4,I)+(ATIT(4,I+1)-ATIT(4,I))*DELT
          BETA   = ATIT(5,I)+(ATIT(5,I+1)-ATIT(5,I))*DELT
          IF( (ATIT(5,I+1)-ATIT(5,I)).GT.0.D0 )
     .      BETA   = ATIT(5,I)+(ATIT(5,I+1)-ATIT(5,I)-360.D0*CDR)*DELT
          GO TO  3001
        ENDIF
 3000 CONTINUE
 3001 CONTINUE
C
      WKCOS     = DCOS(ATTDEL)
      ATT1(1)   = DSIN(ATTDEL)
      ATT1(2)   = WKCOS         *(-DSIN(ATTALP))
      ATT1(3)   = WKCOS         *DCOS(ATTALP)
      ATT2(1)   = NPA(1,1)*ATT1(1)+NPA(1,2)*ATT1(2)+NPA(1,3)*ATT1(3)
      ATT2(2)   = NPA(2,1)*ATT1(1)+NPA(2,2)*ATT1(2)+NPA(2,3)*ATT1(3)
      ATT2(3)   = NPA(3,1)*ATT1(1)+NPA(3,2)*ATT1(2)+NPA(3,3)*ATT1(3)
      WKSIN     = DSIN(SITAGT)
      WKCOS     = DCOS(SITAGT)
      ATT3(1)   = WKCOS*ATT2(1)+WKSIN*ATT2(2)
      ATT3(2)   =-WKSIN*ATT2(1)+WKCOS*ATT2(2)
      ATT3(3)   = ATT2(3)
      CALL  MGI200(ATT3,SP)
C
      WKCOS     = DCOS(SUNDEL)
      SS(1)     = WKCOS         *DCOS(SUNALP)
      SS(2)     = WKCOS         *DSIN(SUNALP)
      SS(3)     = DSIN(SUNDEL)
C
      RETURN
      END
      SUBROUTINE  MGI110
     .            (I,RTIM,CDR,ORBTA,ORBTB,SAT,SITAGT,SUNALP,SUNDEL,NPA)
      REAL*8    CDR,SAT(3),RTIM,ORBTA(35,8),ORBTB(35,8)
      REAL*8    SITAGT,SUNDEL,SUNALP,NPA(3,3),DELT
      INTEGER*4 I
      IF(I.NE.8)  THEN
        DELT=(RTIM-ORBTA(1,I))/(ORBTA(1,I+1)-ORBTA(1,I))
        SAT(1)    = ORBTA( 9,I)+(ORBTA( 9,I+1)-ORBTA( 9,I))*DELT
        SAT(2)    = ORBTA(10,I)+(ORBTA(10,I+1)-ORBTA(10,I))*DELT
        SAT(3)    = ORBTA(11,I)+(ORBTA(11,I+1)-ORBTA(11,I))*DELT
        SITAGT    =(ORBTA(15,I)+(ORBTA(15,I+1)-ORBTA(15,I))*DELT)*CDR
        IF( (ORBTA(15,I+1)-ORBTA(15,I)).LT.0.D0 )
     .    SITAGT    =(ORBTA(15,I)+(ORBTA(15,I+1)-ORBTA(15,I)+360.D0)
     .               *DELT)*CDR
        SUNALP    =(ORBTA(18,I)+(ORBTA(18,I+1)-ORBTA(18,I))*DELT)*CDR
        IF( (ORBTA(18,I+1)-ORBTA(18,I)).GT.0.D0 )
     .    SUNALP    =(ORBTA(18,I)+(ORBTA(18,I+1)-ORBTA(18,I)-360.D0)
     .               *DELT)*CDR
        SUNDEL    =(ORBTA(19,I)+(ORBTA(19,I+1)-ORBTA(19,I))*DELT)*CDR
        NPA(1,1) = ORBTA(20,I)
        NPA(2,1) = ORBTA(21,I)
        NPA(3,1) = ORBTA(22,I)
        NPA(1,2) = ORBTA(23,I)
        NPA(2,2) = ORBTA(24,I)
        NPA(3,2) = ORBTA(25,I)
        NPA(1,3) = ORBTA(26,I)
        NPA(2,3) = ORBTA(27,I)
        NPA(3,3) = ORBTA(28,I)
      ENDIF
      RETURN
      END
      SUBROUTINE  MGI200(VECT,VECTU)
      REAL*8  VECT(3),VECTU(3),RV1,RV2
      RV1=VECT(1)*VECT(1)+VECT(2)*VECT(2)+VECT(3)*VECT(3)
      IF(RV1.EQ.0.D0)  RETURN
      RV2=DSQRT(RV1)
      VECTU(1)=VECT(1)/RV2
      VECTU(2)=VECT(2)/RV2
      VECTU(3)=VECT(3)/RV2
      RETURN
      END
      SUBROUTINE  MGI210(VA,VB,VC)
      REAL*8  VA(3),VB(3),VC(3)
      VC(1)= VA(2)*VB(3)-VA(3)*VB(2)
      VC(2)= VA(3)*VB(1)-VA(1)*VB(3)
      VC(3)= VA(1)*VB(2)-VA(2)*VB(1)
      RETURN
```

```
END
SUBROUTINE  MGI220(VA,VB,VD)
REAL*8  VA(3),VB(3),VC(3),VD(3)
VC(1)= VA(2)*VB(3)-VA(3)*VB(2)
VC(2)= VA(3)*VB(1)-VA(1)*VB(3)
VC(3)= VA(1)*VB(2)-VA(2)*VB(1)
CALL  MGI200(VC,VD)
RETURN
END
SUBROUTINE  MGI230(VA,VB,ASITA)
REAL*8  VA(3),VB(3),ASITA,AS1,AS2
AS1= VA(1)*VB(1)+VA(2)*VB(2)+VA(3)*VB(3)
AS2=(VA(1)*VA(1)+VA(2)*VA(2)+VA(3)*VA(3))*
    (VB(1)*VB(1)+VB(2)*VB(2)+VB(3)*VB(3))
IF(AS2.EQ.0.D0)  RETURN
ASITA=DACOS(AS1/DSQRT(AS2))
RETURN
END
SUBROUTINE  MGI240(VA,VH,VN,DPAI,AZI)
REAL*8  VA(3),VH(3),VN(3),VB(3),VC(3),VD(3),DPAI,AZI,DNAI
CALL  MGI220(VN,VH,VB)
CALL  MGI220(VA,VH,VC)
CALL  MGI230(VB,VC,AZI)
CALL  MGI220(VB,VC,VD)
DNAI = VD(1)*VH(1)+VD(2)*VH(2)+VD(3)*VH(3)
IF(DNAI.GT.0.D0)  AZI=DPAI-AZI
RETURN
END
```

Geometrical correction of Cloud location

F.1 Outline

Cloud location of the VISSR images are apparent because the earth is spherical and the differences with their true geometrical positions are more increased at higher the latitude and the line of sight of the VISSR is the more oblique. Assuming a cloud of 15 km high, the difference becomes about 10 km in a middle latitude region. In this paper, typical corrections to determine the true geometrical location are introduced.

F.2 Description

As shown in Fig.F.1, a cloud top P in the VISSR line of sight is projected to the apparent location Q on the earth surface ABCD. Pixel data of GMS-5 / VISSR are composed of Qs (that are assembled instantaneous field of views strictly) and there is a distance Δ to be compensated to determine the true cloud position between the sub-cloud point P' that is the true geometrical position of P and Q. In Fig.F.1, the relationship between geometric latitude Ψ_0 and longitude λ_0 and apparent geometric latitude Ψ_Q and longitude λ_Q are expressed as follows.

$$\Psi_0 = \Psi_Q + \Delta\Psi$$
$$\lambda_0 = \lambda_Q + \Delta\lambda$$

Examples of correction curves of $\Delta\Psi$, $\Delta\lambda$ are shown in Fig.F.2 and Fig.F.3.

F.3 Reference

Meteorological Satellite Center Technical Note No.1, March 1979

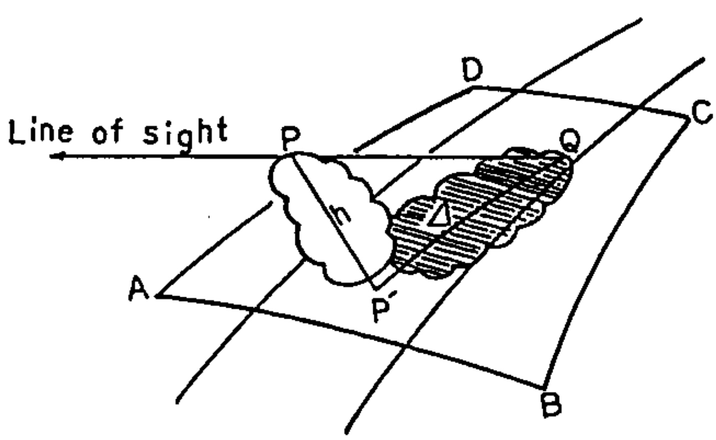


Fig.F.1 The illustration of the cloud projected on the earth surface.
Q ; apparent position of cloud.

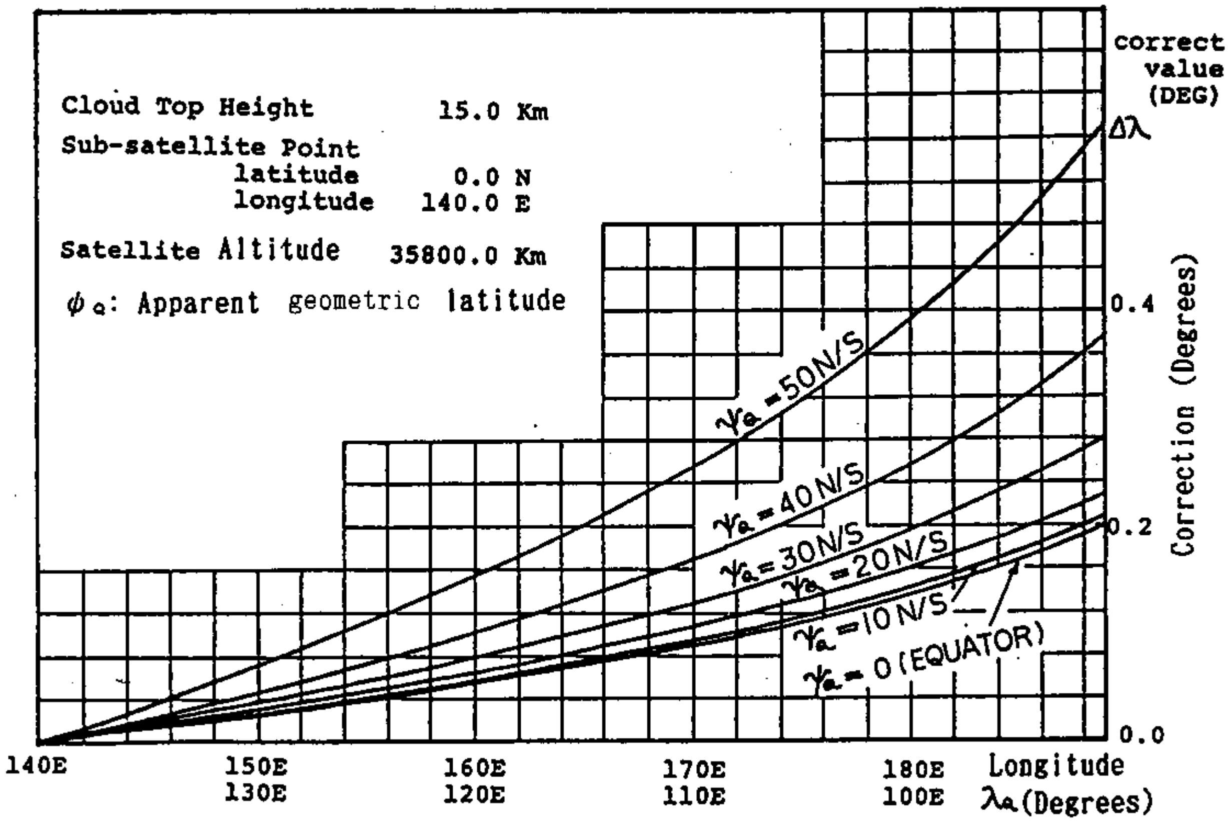


Fig.F.2 The correction curve for longitude-ways

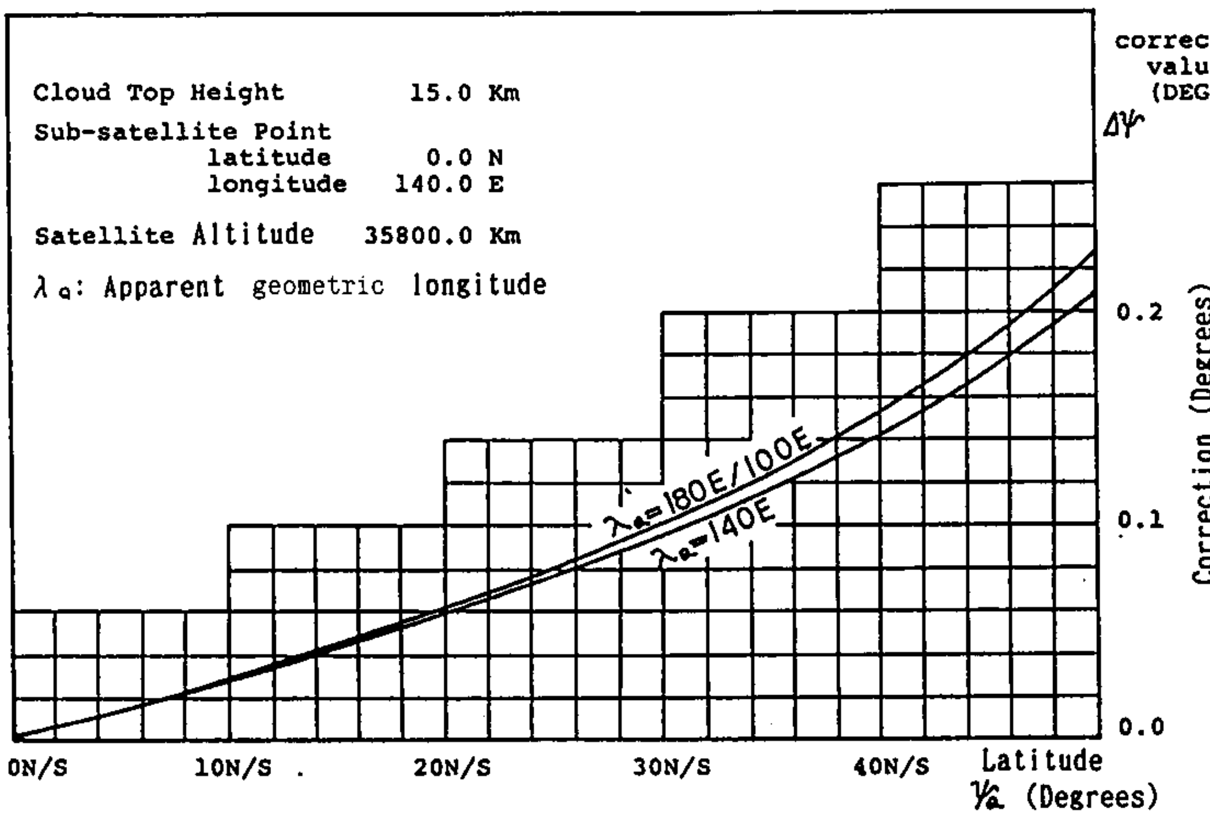


Fig.F.3 The correction curve for latitude-ways

FORMAT OF VISSR ARCHIVE DATA

VISSR raw data are archived at MSC in digital form.

1. VISSR IR Data

Global VISSR IR image data file is composed of northern hemisphere and southern hemisphere data. It consists of IR1, IR2 and WV. A half inch CMT (Cartridge Magnetic Tape) contains four day's data.

Start times of VISSR data (28 observations per day) are as follows.
00 : 32, 01 : 32, 02 : 32, 03 : 32, 04 : 25, 05 : 02, 05 : 32, 06 : 32, 07 : 32, 08 : 32, 09 : 32
10 : 25, 11 : 02, 11 : 32, 12 : 32, 13 : 32, 14 : 32, 15 : 32, 16 : 25, 17 : 02, 17 : 32, 18 : 32
19 : 32, 20 : 32, 21 : 32, 22 : 25, 23 : 02, 23 : 32 UTC

(1) File specifications

Items	Specifications	Comments
Density	76,000 BPI	36 Tracks
File label	Standard label	
File type	Multi-file	
Block length	3,664 Bytes	Fixed length
Transfer mode	8 bits	

(2) File composition

BLK#	2688 bytes	976 bytes
1 ~ 2	CONTROL BLOCK	
3	Mode record	not used
4	Information of S/DB operation	not used
5	Coordinate transformation parameters	not used
6	Attitude prediction data	not used
7	Orbit prediction data (1)	not used
8	Orbit prediction data (2)	not used
9	DCD Communication	not used
10	VIS calibration	not used
11	IR1 calibration	not used
12	IR2 calibration	not used
13	WV calibration	not used
14	Split window calibration	not used
15	Reserved	not used
16	Reserved	not used

(continued)

17	Simple coordinate transformation + Return code			not used
18	β-angle sampling			not used
19~final	LCW	DOC	Image data	

(3) File contents

BLK# 1~2 Control block

Position (bytes)	ITEMS	CONTENTS	Type
1 ~ 2	Control block size	Block size of IR image data file=2	I*2
3 ~ 4	Head block number of parameter block	Parameter block number of IR image data file= 3	I*2
5 ~ 6	Parameter block size	Parameter block size of IR image data file=16	I*2
7 ~ 8	Head block number of image data	Parameter block number of IR image data file= 19	I*2
9 ~10	Total block size of image data	Total block size of image data	I*2
11~12	Available block size of image data	Normal line number of image data	I*2
13~14	Head valid line number	Head line number of image data	I*2
15~16	Final valid line number	Line number of final input valid data	I*2
17~18	Final data block number	Block number of final input data	I*2
19~32	Reserved		
33~	Address table	Block number of available data. (−1=not available)	I*2

BLK# 3~18 Image parameter block same as File composition.

BLK# 19~final Image data block. From the first to the 64th bytes are line control words (LCW).

Image data block

LCW (Line Control Word) section

Position (bytes)	ITEMS	CONTENTS	Type
1 ~ 4	Data ID	Higher 16 bits=Image segment, Lower 16 bits=Data segment Image segment 0000=standard (part) observation 0008=test observation Data segment 0001=IR 1ch 0002=IR 2ch 0004=IR 3ch 0008=VIS 1ch 0010=VIS 2ch 0020=VIS 3ch 0040=VIS 4ch 0000=others	
5 ~ 8	Line number	Added by VISSR collection signal	I
9 ~ 12	Line name	Contents of VISSR data 01=VISSR image data 08=test 10=annotation data 20=gray scale data	I
13~16	Error line flag	Normal/Error line 0000=normal line	I
17~20	Error message	Massage number of S/DB mode error. 0=normal	I
21~24	Mode error flag	Bit data of S/DB mode error. 0=normal	I
25~32	Scan time	MJD (Modified Julian Day) of VISSR scan time	R*8
33~36	Beta angle	Sun-Earth angle in radian	R*8
37~40	West side earth edge	Pixel position of west side earth edge	I
41~44	East side earth edge	Pixel position of east side earth edge	I
45~52	Received time (1)	Received time of host side (2I6 type)	I
53~56	Received time (2)	Received time of host side in milli-seconds	I
57~64	Reserved		

DOC (Document) Section

Position (bytes)	ITEMS	CONTENTS	Type
65~320	DOC	Omitted	

Image data section

Position (bytes)	ITEMS	CONTENTS	Type
321~	Image data	Brightness value of each pixel (one byte/pixel)	Binary

2. VISSR VIS data

Global VISSR visible image data file is composed of northern hemisphere and southern hemisphere data. A half inch CMT (Cartridge Magnetic Tape) contains one day's data.

Start times of VISSR data (16 observations per day) are as follows.

00 : 32, 01 : 32, 02 : 32, 03 : 32, 04 : 25, 05 : 02, 05 : 32, 06 : 32, 07 : 32, 08 : 32, 15 : 32, 20 : 32, 21 : 32, 22 : 25, 23 : 02, 23 : 32 UTC

(1) File specification

Items	Specification	Comments
Density	76,000BPI	36 Track
File label	Standard label	
File type	Multi-file	
Block length	13,504 bytes	Fixed length
Transfer mode	8 bits	

(2) File composition

BLK#

BLK#					
1 ~ 2	CONTROL BLOCK				

BLK#					
3	Mode record (2688 bytes)	Information of S/DB operation (2688 bytes)	Coordinate transformation parameters (2688 bytes)	Attitude prediction data (2688 bytes)	Not used (2752 bytes)
4	Orbit prediction data (1) (2688 bytes)	Orbit prediction data (2) (2688 bytes)	Information of DCD communication (2688 bytes)	VIS calibration (2688 bytes)	Not used (2752 bytes)
5	IR1 calibration (2688 bytes)	IR2 calibration (2688 bytes)	WV calibration (2688 bytes)	Split window calibration (2688 bytes)	Not used (2752 bytes)
6	Reserved (2688 bytes)	Reserved (2688 bytes)	Simple coordinate transformation table (2688 bytes)	β-angle sampling (2688 bytes)	Not used (2752 bytes)

The return codes of VZ4000 and VACTBL are written in the last.

BLK#			
7 ~ final	LCW	DOC	Image data

(3) File contents

BLK#

1 ~ 2 CONTROL BLOCK

Position (bytes)	ITEMS	CONTENTS	Type
1 ~ 2	Control block size	Block size of VIS image data file=2	I*2
3 ~ 4	Head block number of parameter block	Parameter block number of VIS image data file=3	I*2
5 ~ 6	Parameter block size	Parameter block number of VIS image data file=4	I*2
7 ~ 8	Head block number of image data	Parameter block number of VIS image data file=7	I*2
9 ~10	Total block line of image data	Total block size of image data	I*2
11~12	Available block size of image data	Normal line number of image data	I*2
13~14	Head valid line number	Head line number of image data	I*2
15~16	Final valid line number	Line number of final input available data	I*2
17~18	Final data block number	Block number of final input data	I*2
19~32	Reserved		
33~	Address table	Block number of available data (−1=not available)	I*2

BLK# 3~18 Image parameter block same as File composition of VISSR IR data.

BLK# 19~final Image data block. From the first to the 64th bytes are line control words (LCW).

LCW (Line Control Word)

Position (bytes)	ITEMS	CONTENTS	Type
1 ~ 4	Data ID	Higher 16 bits=Image segment, Lower 16 bits=Data segment Image segment 0000=standard (part) observation 0008=test observation Data segment 0001=IR 1ch 0002=IR 2ch 0004=IR 3ch 0008=VIS 1ch 0010=VIS 2ch 0020=VIS 3ch 0040=VIS 4ch 0000=others	
5 ~ 8	Line number	Added by VISSR collection signal	I
9 ~ 12	Line name	Contents of VISSR data 01=VISSR image data 08=test 10=annotation data 20=gray scale data	I
13~16	Error line flag	Normal/Error line 0000=normal line	I
17~20	Error message	Massage number of S/DB mode error. 0=normal	I
21~24	Mode error flag	Bit data of S/DB mode error. 0=normal	I
25~32	Scan time	MJD (Modified Julian Day) of VISSR scan time	R*8
33~36	Beta angle	Sun-Earth angle in radian	R*8
37~40	West side earth edge	Pixel position of west side earth edge	I
41~44	East side earth edge	Pixel position of east side earth edge	I
45~52	Received time (1)	Received time of host side (2I6 type)	I
53~56	Received time (2)	Received time of host side in milli-seconds	I
57~64	Reserved		

DOC (Document) Section

Position (bytes)	ITEMS	CONTENTS	Type
65~128	DOC	Omitted	

Image data section

Position (bytes)	ITEMS	CONTENTS	Type
129~	Image data	Brightness value of each pixel (one byte/pixel)	Binary

3. VISSR typhoon short time observation data.

Six days image data (VIS,IR1,IR2,WV) of VISSR typhoon short time observation are archived in a half inch CMT.

Start times of data (3 observations per day) are 03:32, 03:47, 04:02 UTC.

Table-1 Image parameter block

① Mode record

Position (word)	ITEMS	CONTENTS	Type
1	Satellite number	Serial number of satellite	I
2 ~ 4	Satellite name	Satellite name (≦8 letters)	EBCDIC
5 ~ 8	Observation time	AD (UTC)	EBCDIC
9 ~ 10	Observation time	MJD	R*8
11	GMS operation mode	1=S1 6=S6 7=S7 0=not specified	I
12	DPC operation mode	1=automatic 2=manual	I
13	VISSR observation mode	1=scheduled 2=wind vectors 3=unscheduled 4=special	I
14	Scanner selection	1=primary-1 11=primary-2 2=redundant-1 12=redundant-2 0=not specified	
15	Sensor selection	Used sensor (70digit decimal) 10^6: IR1, 10^5: IR2, 10^4: WV1, 10^3: VIS1, 10^2: VIS2, 10^1: VIS3, 10^0: VIS4 0=not specified 1=primary 2=redundant	I
16	Sensor mode	Selection of VIS/IR (IR1,IR2,WV) MSB 31 ... LSB 0: [... | IR | VIS] 0=not used 1=used (control parameter)	I
17	Scan frame mode	1=normal frame (2500 steps) 2=expanded frame (2756 steps) 0=not specified	I
18	Scan mode	1=normal scan 2=partial scan 3=single scan 0=not specified	I
19	Upper limit of scan line	Scan line number of upper limit	I
20	Lower limit of scan line	Scan line number of lower limit	I
21	Equatorial scan line number	Line number of equatorial scan	I
22	Spin rate	Rotational rate (spins/minute)	R

(continued)

23	VIS frame parameters	Bit length	I
24		Number of lines	I
25		Number of pixels	I
26		Stepping angle	R
27		Sampling angle	R
28		LCW-pixel size	I
29		DOC-pixel size	I
30		reserved	
31~38	IR frame parameters	Same as above	I,R
39	Satellite height	Nominal height of satellite (3.59×10^{7} m)	R
40	Earth radius	Earth radius (6.3702895×10^{6}m)	R
41	SSP-longitude	Nominal SSP-longitude	R
42~50	Reserved		
51	Table of sensor trouble	VIS primary 1ch	I
52	(1=VISSR sensor is	VIS primary 2ch	I
53	available)	VIS primary 3ch	I
54		VIS primary 4ch	I
55		VIS redundant 1ch	I
56		VIS redundant 2ch	I
57		VIS redundant 3ch	I
58		VIS redundant 4ch	I
59		IR 1 primary	I
60		IR 1 redundant	I
61		IR 2 primary	I
62		IR 2 redundant	I
63		WV primary	I
64		WV redundant	I
65~100	Reserved		

(continued)

101～160	Status tables of data segment	Relative address 0 Data segment 1 Data presence 2 Generated 3 day & time 【Data segment】 1=Information of S/DB operation 2=Parameters for coordinate transformation 3=Attitude prediction data 5=Orbit prediction data (1),(2) 6=DCD communication data 7=VIS calibration 8=IR1 calibration 9=IR2 calibration 10=WV calibration 11=Split window calibration (reserved) 12～14=Reserved 15=β-angle sampling (reserved) 【Data presence】 1=Exist 2=Not exist 【Data generation time】 YYMMDD date hhmmss time	I
161 - 672	Reserved		

① Coordinate conversion parameters segment

Position (word)	ITEMS	CONTENTS	Type
1	Data segment	2=Coordinate transformation parameters	I
2	Reserved		
3 ～ 4	Data generation time	Generation time of this block's parameters 3 YYMMDD date 4 hhmmss time	I
5 ～ 6	Scheduled observation time	Scheduled observation time (MJD)	R*8
7	Stepping angle along line	VIS channel	R
8		IR1 channel	R
9		IR2 channel	R
10		WV channel	R

(continued)

11 12 13 14	Sampling angle along pixel	VIS channel IR1 channel IR2 channel WV channel	R R R R
15 16 17 18	Central line number of VISSR frame	VIS channel IR1 channel IR2 channel WV channel	R R R R
19 20 21 22	Center pixel number of VISSR frame	VIS channel IR1 channel IR2 channel WV channel	R R R R
23 24 25 26	Pixel difference of VISSR center from the normal position	VIS channel IR1 channel IR2 channel WV channel	R R R R
27 28 29 30	Number of sensor elements	VIS channel IR1 channel IR2 channel WV channel	R R R R
31 32 33 34	Total number of VISSR frame lines	VIS channel IR1 channel IR2 channel WV channel	R R R R
35 36 37 38	Total number of VISSR frame pixels	VIS channel IR1 channel IR2 channel WV channel	R R R R
39~41	VISSR misalignment	39 x-component : δ a 40 y-component : δ b 41 z-component : δ c	R

(continued)

42～50	Matrix of misalignment	$ELMIS=\begin{bmatrix} \cos\delta\,c & \sin\delta\,c & 0 \\ -\sin\delta\,c & \cos\delta\,c & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\delta\,b & 0 & -\sin\delta\,b \\ 0 & 1 & 0 \\ \sin\delta\,b & 0 & \cos\delta\,b \end{bmatrix} \times \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\delta\,a & \sin\delta\,a \\ 0 & -\sin\delta\,a & \cos\delta\,a \end{bmatrix}$ ELMIS(1,1)=CC×CB ELMIS(2,1)=−SC×CB ELMIS(3,1)=SB ELMIS(1,2)=CC×SB×SA+SC×CA ELMIS(2,2)=−SC×SB×SA+CC×CA ELMIS(3,2)=−CB×SA ELMIS(1,3)=−CC×SB×CA+SC×SA ELMIS(2,3)=SC×SB×CA+CC×SA ELMIS(3,3)=CB×CA where, SA=sinδ a CA=cosδ a SB=sinδ b CB=cosδ b SC=sinδ c CC=cosδ c	R
51	Parameters	Judgement of observation convergence time	R
52		Judgement of line convergence	R
53		E-W angle of Sun-light condense prism	R
54		N-S angle of Sun-light condense prism	R
55		$\pi=3.141592$	R
56		$\pi/180=0.017453292$	R
57		$180/\pi=57.295780$	R
58		Equatorial radius=6377397.2	R
59		Oblateness of the earth=0.0033427731	R
60		Eccentricity of the earth orbit=0.081696829	R
61		First angle of VISSR observation in S/DB	R
62		Upper limited line of the 2nd prism for VIS solar observation	R
63		Lower limited line of the 1st prism for VIS solar observation	R
64		Upper limited line of the 3rd prism for VIS solar observation	R
65		Lower limited line of the 2nd prism for VIS solar observation	R
66	Stepping angle along line	VIS solar observation	R
67		IR solar observation	R
68	Sampling angle along pixel	VIS solar observation	R
69		IR solar observation	R
70	Center line of VISSR frame	VIS solar observation	R
71		IR solar observation	R
72	Center pixel of VISSR frame	VIS solar observation	R
73		IR solar observation	R

(continued)

74 75	Pixel difference of VISSR center from the normal position	VIS solar observation IR solar observation	R R
76 77	Sensor elements number	VIS solar observation IR solar observation	R R
78 79	Total number of VISSR frame lines	VIS solar observation IR solar observation	R R
80 81	Total number of pixels / lines of VISSR frame	VIS solar observation IR solar observation	R R
82～100	Reserved		
101 - 102	Orbital parameters	Epoch time	R*8
103 - 104		Semi-major axis (km)	R*8
105 - 106		Eccentricity	R*8
107 - 108		Orbital inclination (deg)	R*8
109 - 110		Longitude of the ascending node (deg)	R*8
111 - 112		Argument of perigee (deg)	R*8
113 - 114		Mean anomaly (deg)	R*8
115 - 116		Longitude of SSP (deg)	R*8
117 - 118		Latitude of SSP (deg)	R*8
119 - 120	Reserved		
121 - 122	Attitude parameters	Epoch time (MJD)	R*8
123 - 124		Angle between Z-axis and satellite spin axis at the epoch time	R*8
125 - 126		Angle change rate between spin axis and Z-axis	R*8
127 - 128		Angle between spin axis and ZY-axis	R*8
129 - 130		Angle change rate between spin axis and ZY-axis	R*8
131 - 132		Daily mean of spin rate (RPM)	R*8
133 - 661	Reserved		
662	Correction of image distortion	Stepping angle along line of IR1 (rad)	R
663		Stepping angle along line of IR2 (rad)	R
664		Stepping angle along line of WV (rad)	R
665		Stepping angle along line of VIS (rad)	R
666		Sampling angle along pixel of IR1 (rad)	R
667		Sampling angle along pixel of IR2 (rad)	R
668		Sampling angle along pixel of WV (rad)	R
669		Sampling angle along pixel of VIS (rad)	R
670		X component of VISSR misalignment (rad)	R
671		Y component of VISSR misalignment (rad)	R
672		Z component of VISSR misalignment (rad)	R

Attitude prediction

Position (word)	ITEMS	CONTENTS	Type
1	Data segment	3=Attitude prediction data	I
2	Reserved		
3 ~ 4	Data generation time	3 YYMMDD date 4 hhmmss time	I
5 ~ 6	Start time	Start time of attitude prediction (MJD)	R*8
7 ~ 8	End time	End time of attitude prediction (MJD)	R*8
9 ~10	Prediction interval time	Interval time of attitude prediction (MJD)	R*8
11	Number of prediction	Number of attitude prediction	I
12	Data size	Number of attitude prediction data set	I
13~672	Attitude prediction data	Attitude prediction data 1~33 (See table ③-1)	

Table ③-1 Contents of attitude prediction data

Position (word)	ITEMS	CONTENTS	Type
0 ~ 1	Prediction time	Prediction time (MJD)	R*8
2 ~ 3	Prediction time	Prediction time (UTC) 2 YYMMDD date 3 hhmmss time	I
4 ~ 5	Right ascension of attitude	Predicted right ascension of attitude (rad)	R*8
6 ~ 7	Declination of attitude	Predicted declination of attitude (rad)	R*8
8 ~ 9	Sun-earth angle	Sun-earth angle at prediction time	R*8
10~11	Spin rate	Satellite spin rate at prediction time	R*8
12~13	Right ascension of orbital plane	Right ascension of orbital plane at prediction time	R*8
14~15	Declination of orbital plane	Declination of orbital plane at prediction time	R*8
16~17	Reserved		
18	Eclipse flag	0=Out of eclipse period, 1=In eclipse period	I
19	Spin axis flag	0=within 0.5 degree, 1=beyond 0.5 degree	I

④ Orbit prediction

Position (word)	ITEMS	CONTENTS	Type
1	Data segment	5=Orbit prediction data	I
2	Reserved		
3 ~ 4	Data generation time	3: YYMMDD date 4: hhmmss time	I
5 ~ 6 7 ~ 8 9 ~ 10	Start time End time Prediction interval time	Start time of orbit prediction (MJD) End time of orbit prediction (MJD) Interval time of orbit prediction (MJD)	R*8 R*8 R*8
11 12	Number of prediction Data size	Number of orbit prediction Number of orbit prediction data set	I I
13~642	Attitude prediction data	Orbit prediction data 1~9 (See table ④-1)	
643 - 672	Reserved		

Table ④-1 Contents of orbit prediction data

Position (word)	ITEMS	CONTENTS	Type
0 ~ 1	Prediction time	Prediction time (MJD)	R*8
2 ~ 3	Prediction time	Prediction time (UTC) 2: YYMMDD date 3: hhmmss time	I
4 ~ 5 6 ~ 7 8 ~ 9 10~11 12~13 14~15	Satellite position and velocity in the 1950.0 yearly mean inertial coordinate system	X-component of position Y-component of position Z-component of position X-component of velocity Y-component of velocity Z-component of velocity	R*8 R*8 R*8 R*8 R*8 R*8
16~17 18~19 20~21 22~23 24~25 26~27	Satellite position and velocity in the earth-fixed coordinate system	X-component of position Y-component of position Z-component of position X-component of speed Y-component of speed Z-component of speed	R*8 R*8 R*8 R*8 R*8 R*8

(continued)

28～29	Greenwich sidereal time		R*8
30～33	Sun-directional vector	Vector from Satellite to Sun in 1950.0 yearly mean inertial coordinate system 30～31 Azimuth 32～33 Elevation	 R*8 R*8
34～37	Sun-directional vector	Vector from Satellite to Sun in the earth-fixed coordinate system 34～35 Azimuth 36～37 Elevation	 R*8 R*8
38～55	Conversion matrix A1～A9	Matrix to convert from 1950.0 yearly mean inertial coordinate system(X,Y,Z) to the earth-fixed coordinate system(x,y,z) $\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} A1 & A4 & A7 \\ A2 & A5 & A8 \\ A3 & A6 & A9 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}$	R*8
56～61	Moon directional vector	Vector from Satellite to Moon in 1950.0 yearly mean inertial coordinate system 56～57 X-component of vector 58～59 Y-component of vector 60～61 Z-component of vector	 R*8 R*8 R*8
62～63 64～65 66～67	Satellite position	Latitude of SSP Longitude of SSP Satellite height	R*8 R*8 R*8
68	Eclipse period flag	0=out of eclipse period, 1=In eclipse period	I
69	Reserved		

⑤ VIS Calibration data

Position (word)	ITEMS	CONTENTS	Type
1	Data segment	7=VIS calibration	I
2	Data validity	1=available (At least one channel is available) 2=not available (4 channels are not available)	I
3 ～ 4	Data generation time (UTC)	3 [YYMMDD] date 4 [hhmmss] time	I
5	Sensor group	Sensor group calibration table of primary or redundant Bit position 3 2 1 0(LSB) [VIS ch.1 | VIS ch.2 | VIS ch.3 | VIS ch.4] 1=primary 2=redundant	I

(continued)

6～405	VIS 1～4 ch calibration table	See Table ⑤-1
406 - 672	Reserved	

Table ⑤-1 Contents of VIS channel calibration table

Position (bytes)	ITEMS	CONTENTS	Type
0	Channel number	channel number = 1～4	I
1	Data validity	1 = utilization possible 2 = utilization impossible	I
2 ～ 3	Updated time	YYMMDD date hhmmss time	I
4	Table ID	Increment when the table is updated.	I
5 ～68	Brightness-albedo conversion table	Brightness = 0 Albedo 1 Albedo ⋮ 63 Albedo Albedo = 0～1	R
69～74	VIS channel staircase brightness data	Brightness and voltage used to calculate the electric calibration regression curve	R
75～84	Coefficients table of VIS staircase regression curve	Coefficients of VIS staircase regression curve	R
85～86	Brightness table for Calibration	85 Universal space brightness 86 Solar brightness	R
87～88	Calibration uses brightness correspondence voltage chart	87 Universal space voltage 88 Solar voltage	R
89～90	Calibration coefficients of radiation observation	Equation of calibration of radiation observation is $V = G \cdot E + V_0$ 89 G 90 V_0	R
91～99	Reserved		

Table ⑥ VIS 1 · VIS 2 · WV calibration record

Position (bytes)	ITEMS	CONTENTS	Type
1	Data segment	8=VIS 1 calibration record 9=VIS 2 calibration record 10=WV calibration record	I
2	Data validity	1=available 2=not available	I
3 ~ 4	Updated time	3 [YYMMDD] date 4 [hhmmss] time	I
5	Sensor group	1=primary 2=redundant	I
6	Table ID	Calibration table ID. Increment when the table is updated.	I
7 ~ 8	Reserved		
9 ~264	Conversion table of equivalent black body radiation	Radiation (W/cm^2 sr·μm) to brightness Brightness=0 [Radiation] 1 [Radiation] ⋮ 255 [Radiation]	R
265~520	Conversion table of equivalent black body temperature	Temperature (K) to brightness Brightness=0 [Temperature] 1 [Temperature] ⋮ 255 [Temperature]	R
521~526	Staircase brightness data	Brightness and voltage used to calculate regression curve for electric correction	R
527~536	Coefficients table of Staircase regression curve	Coefficients table of staircase regression curve	R
537 538 539	Brightness data for calibration	Brightness of space Brightness of black body shutter Reserved	R R R
540 541 542	Voltage table for brightness of calibration	Voltage of space Voltage of black body shutter Reserved	R R R

(continued)

<table>
<tr><td>543~544</td><td>Calibration coefficients of radiation observation</td><td>Equation of calibration of radiation observation is
$V = G \cdot E + V_0$
89 G
90 V_0</td><td>R</td></tr>
<tr><td>545</td><td>Valid shutter temperature</td><td>Valid shutter temperature (K)</td><td>R</td></tr>
<tr><td>546</td><td>Valid shutter radiation</td><td>Valid shutter radiation (W/cm^2 sr·μm)</td><td>R</td></tr>
<tr><td>547~562</td><td>Telemetry data table</td><td>Telemetry data of calibration and VISSR temperature.
Telemetry data are defined by flags of valid shutter temperature calculation method of picture coefficients file.</td><td>R</td></tr>
<tr><td></td><td colspan="3">
<table>
<tr><th>relative word</th><th>mark</th><th>flag=0
GMS-3</th><th>flag=1
GMS-4</th><th>flag=2
GMS-5</th></tr>
<tr><td>0</td><td>T_1</td><td>shutter temp.1 (℃)</td><td>shutter temp. (℃)</td><td>shutter temp.1 (℃)</td></tr>
<tr><td>1</td><td>T_2</td><td>shutter temp.2 (℃)</td><td colspan="2">redundant mirror temp. (℃)</td></tr>
<tr><td>2</td><td>T_3</td><td>scanner temp.1 (℃)</td><td colspan="2">primary mirror temp. (℃)</td></tr>
<tr><td>3</td><td>T_4</td><td>scanner temp.2 (℃)</td><td colspan="2">baffle FW temp. (℃)</td></tr>
<tr><td>4</td><td>T_5</td><td>scanner temp.2 (℃)</td><td colspan="2">baffle AF temp. (℃)</td></tr>
<tr><td>5</td><td>—</td><td colspan="3">+15 volt auxiliary power supply (V)</td></tr>
<tr><td>6</td><td>—</td><td colspan="3">radiative cooler temp.1 (K)</td></tr>
<tr><td>7</td><td>—</td><td colspan="3">radiative cooler temp.2 (K)</td></tr>
<tr><td>8</td><td>—</td><td colspan="3">electronics module temp (℃)</td></tr>
<tr><td>9</td><td>T_{10}</td><td colspan="2">reserved</td><td>scan mirror temp. (℃)</td></tr>
<tr><td>10</td><td>T_{11}</td><td colspan="2">reserved</td><td>shutter cavity temp. (℃)</td></tr>
<tr><td>11</td><td>T_{12}</td><td colspan="2">reserved</td><td>Primary mirror aperture stop temp. (℃)</td></tr>
<tr><td>12</td><td>T_{13}</td><td colspan="2">reserved</td><td>Redundant mirror sealed temp. (℃)</td></tr>
<tr><td>13</td><td>T_{14}</td><td colspan="2">reserved</td><td>shutter temp.2 (℃)</td></tr>
<tr><td>14</td><td></td><td colspan="3">reserved</td></tr>
<tr><td>15</td><td></td><td colspan="3">reserved</td></tr>
</table>
</td></tr>
<tr><td>563</td><td>Flag of valid shutter temperature calculation</td><td>0=GMS-3 method
1=GMS-4 method
2=GMS-5 method</td><td>I</td></tr>
<tr><td>564~672</td><td colspan="3">Reserved</td></tr>
</table>

⑦ Split window calibration record is wholly set by 0.

Table ⑧ Simple coordinate conversion table

Position half word	ITEMS	CONTENTS	Type
1	60°N, 80°E IR1 line number	Calculated by coordinate conversion (ZGCG00)	I
2	60°N, 80°E IR1 pixel number		
3	60°N, 85°E IR1 line number		
4	60°N, 85°E IR1 pixel number		
⋮			
51	55°N, 80°E IR1 line number		
52	55°N, 80°E IR1 pixel number		
53	55°N, 85°E IR1 line number		
54	55°N, 85°E IR1 pixel number		
⋮			
1249	60°S, 160°W IR1 line number		
1250	60°S, 160°W IR1 pixel number		

Position word	ITEMS	CONTENTS	Type
626	Earth equator radius (m)	Retrieved from coordinate conversion block (58 th word) of image data file	R
627	Satellite height (m)	Retrieved from orbit prediction block (78th word) of image data file	R
628	Stepping angle (rad)	Retrieved from coordinate conversion block (8th word) of image data data file	R
629	Sampling angle (rad)	Retrieved from coordinate conversion block (12 nd word) of image data file	R
630	SSP-latitude (deg)	Calculated by coordinate conversion (ZGCG00)	R
631	SSP-longitude (deg)		R
632	SSP-line number		
633	SSP-pixel number		

(continued)

634	π	Retrieved from coordinate conversion block (12 nd word) of image data file	R
635	line correction (X) IR1-VIS	Calculated by conversion of coordinates of SSP (lat/lon) X=Lvis-(Lir1-1)*4-2.5 Lvis: VIS sensor line number Lir1 : IR1 sensor line number	R
636	Pixel correction (Y) IR1-VIS	Y=Pvis-(Pir1-1)*4-2.5 Pvis: VIS sensor pixel number Pir1 : IR1 sensor pixel number	R
637	Line correction (X) IR1-IR2	X=Lir2-Lir1 Lir2 : IR2 sensor line number Lir1 : IR1 sensor line number	R
638	Pixel correction (Y) IR1-IR2	Y=Pir2-Pir1 Pir2 : IR2 sensor pixel number Pir1 : IR1 sensor pixel number	R
639	Line correction (X) IR1-WV	X=Lwv-Lir1 Lwv : WV sensor line number Lir1 : IR1 sensor line number	R
640	Pixel correction (Y) IR1-WV	Y=Pwv-Pir1 Pwv : WV sensor pixel number Pir1 : IR1 sensor pixel number	R
641~669	Reserved		
670 (*1)	Flag of VZ4000	Flag set by the return code of the subroutine VZ4000 1=return code is 0 or 6 2=except above	R
671 (*1)	Return code of VZ4000	Return code of the sudroutine VZ4000	R
672 (*1)	Return code of simple coordinate conversion	Return code of the subroutine VACTBL	R

(*1) VIS imagery data are located on 670~672 word of β-angle sampling record until 16 October 1995.

⑨ β angle sampling - Omitted.

FORMAT OF VISSR HISTOGRAM DATA

VISSR histogram data are the frequency distribution of pixels for brightness levels. They are calculated in every 0.25 ° x 0.25° grid in the area from 60° N to 60 ° S and from 80° E to 160° W of VISSR image data for visible, infrared 1, infrared 2, water vapor and split (the difference of brightness level between two channels) channel. The data are produced 5 times a day (00, 03, 06, 09, 21 UT) for visible image data, 8 times a day (00, 03, 06, 09, 12, 15, 18, 21 UT) for the other image data. One VISSR histogram data file is made at each observation time and from each kind of image data. These histogram data are saved once a day to a CMT(Cartridge Magnetic Tape), being accumulated.

File characteristics on CMT(Cartridge Magnetic Tape)

Items	Specifications	Comments
Recording density	76000 BPI	36 tracks
File label	standard label	
File format	Multi-file	
Block length	23136 bytes	Fixed length

Construction of the file

This file is constituted of the following three parts.

Name of each part	Number of blocks
(1) File control block	1 block
(2) Data address block	1 block
(3) Histogram data block	varying with the amount of the data

(1) File Control Block

Data construction in this file and image data parameter are saved.

In the type column in the following tables, I, R and C stand for Integer, Real and Character(EBCDIC) respectively.

Position (word)	Items	Contents	Type
1-2	Data generated date	1st: 'YY-M' YY=(year)-1900 MM=(month) 2nd: 'M-DD' DD=(day)UTC	C C
3	Data identification	Kind of image data 1 = visible, 2 = IR1, 3 = IR2, 4 = water vapor, 5 = split	I
	Area of information of histogram data	The information of latitude, longitude and grid of the area of the histogram data are saved. The grid point has the coordinate in the center of each grid area.	
4		Starting latitude, ϕ (deg) ϕ is from 90° N to 90 ° S.	R

Position (word)	Items	Contents	Type
5		Starting longitude, λ (deg) λ is from 0 ° to 360° . Western longitude occupies over 180° .	R
6		Grid interval for latitudinal direction (deg)	R
7		Grid interval for longitudinal direction (deg)	R
8		Number of grid for latitudinal direction	I
9		Number of grid for longitudinal direction	I
10		Total number of grids with making histogram	I
11		Northern limit latitude used for histogram making	R
12		Southern limit latitude used for histogram making	R
13	Total block number	Total block number of this file	I
14	Record length	Record length (byte) (=23136)	I
15	Position of address block	Starting block address	I
16		Number of blocks	I
17	Position of histogram data block	Starting block address	I
18		Number of blocks	I
19	VIS channel ID	VIS channel number used for making histogram data	I
20-83	VIS calibration table	Calibration table in response to the channel number in 19th word	R
84-755	Mode block	Mode block in image parameter part in VISSR image data file	
756-1427	IR calibration block	Calibration block in image parameter part in VISSR image data file	
1428 -2099	Transformation parameters block	Coordinate transformation parameter block in image parameter part in VISSR image data file	
2100 -2771	Orbital prediction data block 1	Orbital prediction data block 1 in image parameter part in VISSR image data file	

Position (word)	Items	Contents	Type
2772 -3443	Orbital prediction data block 2	Orbital prediction data block 2 in image parameter part in VISSR image data file	
3444 -5784	(reserved)		

(2) Data address block

The relative block address in the file and the starting byte address in that block are shown, where the histogram data in the head longitudinal grid area (western edge grid area) at each latitude are recorded.

Position (word)	Items	Contents	Type
1	Block address	Block number including the grid data at the western edge of nothernmost latitude	I
2	Starting address(bytes)	Position of the western edge of the grid data at nothernmost latitude	I
....	....	....	..
2(n-1)+1	Block address	Block number including the grid data at the western edge of the nth latitude	I
2(n-1)+2	Starting address(bytes)	Position of the western edge of the grid data at the nth latitude	I
....	....	....	..
2(N-1)+1	Block address	Block number including the grid data at the western edge of the Nth latitude	I
2(N-1)+2	Starting address(bytes)	Position of the western edge of the grid data at the Nth latitude	I
....	....	....	..
2N+1 -5784	(reserved)		

note: N is the number of grid for latitudinal direction (8th word in File Control Block).

(3) Histogram Data Block

Histogram data calculated from all pixels existing in each grid area are sequentially saved.

The saving order is
(1,1)(2,1)(3,1)(1,2)(2,2)(3,2)····(M,N),
when 'M' is grid number for latitudinal direction and 'N' for longitudinal direction respectively.

When each histogram data are saved sequentially, if the remaining area in the block is too small against the length of the histogram data for one grid data, which should be saved, zero data are written in the remaining area, and the histogram data are saved from the head of the next block so as not to be written over the two continuous data blocks.

Relative Position (byte)	Items	Contents	Type
1	Grid number for longitudinal direction	Grid number for longitudinal direction	I
3	Grid number for latitudinal direction	Grid number for latitudinal direction	I
5	Minimum brightness level	The value of minimum brightness level of the pixel which has minimum brightness level in the area of each grid	I
7	Maximum brightness level	The value of maximum brightness level of the pixel which has maximum brightness level in the area of each grid	I
9	Number of pixels in the area of the grid	Total number of pixels in the area of the grid	I
11 -	Histogram data	Numbers of pixels of each level from minimum brightness level to maximum brightness level in the area of the grid are saved sequentially.	I VIS: 2 byte IR : 1 byte

If the length of the IR histogram data is odd, the length is adjusted to be an even number by adding dummy data of 1 byte at the end.

FORMAT OF CLOUD GRID DATA

Cloud grid data are produced as a database by collecting image data processing results. Those are 0.25° x 0.25° grid data in the area from 60° N to 60° S and from 80° E to 160° W. Cloud grid data are made 8 times a day (00, 03, 06, 09, 12, 15, 18, 21 UT). The data are saved once a day to a CMT(Cartridge Magnetic Tape), being accumulated.

File characteristics on CMT(Cartridge Magnetic Tape)

Items	Specifications	Comments
Recording density	76000 BPI	36 tracks
File label	standard label	
File format	Multi-file	
Block length	30720 bytes	Fixed length

Construction of the file

This file is constituted of the following two parts, and data are saved sequentially.

Name of each part	Number of blocks
(1) File control block	1 block
(2) Cloud grid data block	1440 blocks

(1) File Control Block

Information for data construction in this file are saved.

In the type column in the following tables, I, R, DR and C stand for Interger, Real, Real-double precision and Character(EBCDIC) respectively.

Position (word)	Items	Contents	Type
1-2	File generated date	1st: 'YY-M' YY=(year)-1900 MM=(month) 2nd: 'M-DD' DD=(day)UTC	C C
3	Data generated date	Newest data generated date (YYMMDD)	I
4		Newest data generated time (HHmmss)	I
5		Newest data generated day and time (MJD)	I
6-7	Data Identification	Kind of data saved "CLUDGRID"	C
8	Grid position parameters (The center position of each grid area is expressed as follows. As for latitude(ϕ), a north lat. is shown as a positive	Starting latitude, ϕ (deg)	R
9		Starting longitude, λ (deg)	R
10		Grid interval for latitudinal direction (deg)	R

Position (word)	Items	Contents	Type
11	number, while a south lat. as a negative number. As for longitude(λ), an eastern longitude is shown as a number from 0.0 to 360.0, while a western longitude as a number from 180.0 to 360.0) .	Grid interval for longitudinal direction (deg)	R
12		Number of grid for latitudinal direction	I
13		Number of grid for longitudinal direct-ion	I
14	Position of the data block	Address of the data block	I
15		Number of blocks in the data block	I
16	Grid point information	Record length in each grid data (word)= 48 (nominal)	I
17		Number of grids in each block =160 (nominal)	I
18		Number of blocks composing one latitudi-nal line =3 (nominal)	I
19	Grid data saving information	Total block number of this file	I
20	Record length	Record length of this file (byte)	I
21	Number of cloud layer	Number of cloud layer, which is used to calculate cloud amount of each layer	I
22-26	Threshhold level of cloud layer	Atmospheric pressure at boundary level, which is used to calculate cloud amount of each layer (hPa)	I
27	Grid number along the equater	Grid number for latitudinal direction correspond to the equater	I
28-30	(reserved)		
31-32	Starting time of VISSR obser-vation	Starting time of VISSR observation (MJD)	DR
33-34	SSP information	VISSR scan time at sub-satellite point (MJD)	DR
35		Latitude of SSP (deg)	R
36		Longitude of SSP (deg)	R
37		Satellite altitude (m)	R
38		Right ascension of the sun at the scan time of SSP (deg)	R
39		Declination of the sun at the scan time of SSP (deg)	R

Position (word)	Items	Contents	Type
40-41	Sun-glint information (location and expanse of sun-glint are shown) ζ : solar zenith angle θ : satellite zenith angle ϕ : solar direction angle	Extent of ζ (upper limit, lower limit) (deg)	I
42		Extent of $\mid \zeta - \theta \mid$ (deg)	I
43		Extent of ϕ (deg)	I
44-45		Extent of ζ (upper limit, lower limit) (deg)	I
46		Extent of $\mid \zeta - \theta \mid$ (deg)	I
47		Extent of ϕ (deg)	I
48-49		Extent of ζ (upper limit, lower limit) (deg)	I
50		Extent of $\mid \zeta - \theta \mid$ (deg)	I
51		Extent of ϕ (deg)	I
52	VISSR histogram file information (maximum 4 kinds of files can be used)	Data identification of VISSR histogram file I (1:visible 2:infrared 1 3:infrared 2 4:water vapor)	I
53		Generation date of the same file above	I
54		Generation time of the same file above	I
55		Data identification of VISSR histogram file II	I
56		Generation date of the same file above	I
57		Generation time of the same file above	I
58		Data identification of VISSR histogram file III	I
59		Generation date of the same file above	I
60		Generation time of the same file above	I
61		Data identification of VISSR histogram file IV	I
62		Generation date of the same file above	I
63		Generation time of the same file above	I
64	(reserved)		
65	Vertical temperature file information	Generation date of vertical temperature file	I

Position (word)	Items	Contents	Type
66		Generation time of vertical temperature	I
67		Generation date of altitude data	I
68		Generation time of altitude data	I
69		Generation date of temperature data	I
70		Generation time of temperature data	I
71		Generation date of volume mixing ratio data	I
72		Generation time of volume mixing ratio data	I
73		Generation date of atmospheric correction data	I
74		Generation time of atmospheric correction data	I
75	Data file information for justifying clear sky area	Generation date of data file for justify-ing clear sky area	I
76		Generation time of data file for justify-ing clear sky area	I
77	Clear sky radiance file information (brightness temperature)	Generation date of clear sky radiance file (brightness temperature)	I
78		Generation time of clear sky radiance file (brightness temperature)	I
79	Clear sky radiance file information (albedo)	Generation date of clear sky radiance file (albedo)	I
80		Generation time of clear sky radiance file (albedo)	I
81-82	Cloud grid data file information (use for justification of fog and stratus in the night time)	Starting time of VISSR observation (MJD)	DR
83		Generation date of cloud grid data file	I
84		Generation time of cloud grid data file	I
85	2 dimensional histogram file	Data identification of 2 dimensional histogram file I	I
86		Generation date of the same file above	I
87		Generation time of the same file above	I

Position (word)	Items	Contents	Type
88		Data identification of 2 dimensional histogram file Ⅱ	I
89		Generation date of the same file above	I
90		Generation time of the same file above	I
91	Cloud cluster file information	Data identification of cloud cluster file information	I
92		Generation date of the same file above	I
93		Generation time of the same file above	I
94	Infrared and water vapor data file information	Data identification of infrared and water vapor data file	I
95		Generation date of the same file above	I
96		Generation time of the same file above	I
97		Generation date of numerical prediction data used here	I
98		Generation time of the same file above	I
99-5440	(reserved)		

(2) Cloud grid data block

The data calculated for each grid are sequentially saved.

The saving order is
(1, 1)(2, 1)(3, 1)(1, 2)(2, 2)(3, 2)・・・・(M, N),
when 'M' is grid number for latitudinal direction and 'N' for longitudinal direction respectively.

The saving method is subject to the grid data saving information in the file control block. The grid data for the specified number are sequentially saved from the head in a block. The format in one grid data is as follows.

Position (half word)	Items	Contents	Type
1	Statistics of TBB in infrared 1 CH	Total pixel number	I
2		Number of available pixels	I
3		Averaged TBB value (Unit: 0.1K)	I
4		Standard deviation of TBB (Unit: 0.01K)	I
5		Maximum value of TBB (Unit: 0.1K)	I
6		Minimum value of TBB (Unit: 0.1K)	I

Position (half word)	Items	Contents	Type
7		Mode value of TBB (Unit: 0.1K)	I
8		Number of cloudy pixels	I
9		Averaged TBB in cloud area (Unit: 0.1K)	I
10		Standard deviation of TBB in cloud area (Unit: 0.01K)	I
11	Statistics of observation value (converted to albedo) in visible CH (Solar zenith angle is not corrected yet)	Total pixel number	I
12		Number of available pixels	I
13		Averaged albed value (Unit: 0.001)	I
14		Standard deviation of albedo	I
15		Maximum value of albedo (Unit: 0.001)	I
16		Minimum value of albedo (Unit: 0.001)	I
17		Mode value of albedo (Unit: 0.001)	I
18		Number of cloudy pixels	I
19		Averaged albedo in cloud area (Unit: 0.001)	I
20		Standard deviation of albedo in cloud area	I
21	Angle information	Cosine of satellite zenith angle (Unit: 0.0001)	I
22		Cosine of solar zenith angle (Unit: 0.0001)	I
23		Solar direction angle (Unit: deg)	I
24	Cloud top altitude (before correction)	Cloud top altitude calculated from IR1 CH (Unit: 100gpm)	I
25	Justification information	Clear, cloudy and land/sea identification	I

area	clear	cloudy	fog/ stratus	undecided
sea	0	1	2	9
land	10	11	12	19
boundary	20	21	22	29
sun-glint	30	31	32	39

Position (half word)	Items	Contents	Type
26		Justification results (4 figures)	I
27		Extracted TBB (IR1 CH) (Unit: 0.1K)	I
28		Extracted albedo (Unit: 0.001)	I
29		Extracted TBB (temperature remainder for split window) (Unit: 0.1K)	I
30		Extracted TBB (water vapor CH) (Unit: 0.1K)	I
31	Cloud amount in 6 layers	Pixel number in 1st layer	I
32		Average TBB in 1st layer (IR1) (Unit: 0.1K)	I
33-34		Sum of (TBB)*(TBB) in 1st layer (IR1) (Unit: K)	R
35		Pixel number in 2nd layer	I
36		Average TBB in 2nd layer (IR1) (Unit: 0.1K)	I
37-38		Sum of (TBB)*(TBB) in 2nd layer (IR1) (Unit: K)	R
39		Pixel number in 3rd layer	I
40		Average TBB in 3rd layer (IR1) (Unit: 0.1K)	I
41-42		Sum of (TBB)*(TBB) in 3rd layer (IR1) (Unit: K)	R
43		Pixel number in 4th layer	I
44		Average TBB in 4th layer (IR1) (Unit: 0.1K)	I
45-46		Sum of (TBB)*(TBB) in 4th layer (IR1) (Unit: K)	R
47		Pixel number in 5th layer	I
48		Average TBB in 5th layer (IR1) (Unit: 0.1K)	I
49-50		Sum of (TBB)*(TBB) in 5th layer (IR1) (Unit: K)	R
51		Pixel number in 6th layer	I

Position (half word)	Items	Contents	Type
52		Average TBB in 6th layer (IR1) (Unit: 0.1K)	I
53-54		Sum of (TBB)*(TBB) in 6th layer (IR1) (Unit: K)	R
55	Statistics of TBB remainder in split window	Total pixel number	I
56		Number of available pixels	I
57		Averaged TBB value (Unit: 0.1K)	I
58		Standard deviation of TBB (Unit: 0.01K)	I
59		Maximum value of TBB (Unit: 0.1K)	I
60		Minimum value of TBB (Unit: 0.1K)	I
61		Mode value of TBB (Unit: 0.1K)	I
62		Number of cloudy pixels	I
63		Averaged TBB in cloud area (Unit: 0.1K)	I
64		Standard deviation of TBB in cloud area (Unit: 0.01K)	I
65	Statistics of TBB in water vapor CH	Total pixel number	I
66		Number of available pixels	I
67		Averaged TBB value (Unit: 0.1K)	I
68		Standard deviation of TBB (Unit: 0.01K)	I
69		Maximum value of TBB (Unit: 0.1K)	I
70		Minimum value of TBB (Unit: 0.1K)	I
71		Mode value of TBB (Unit: 0.1K)	I
72		Number of cloudy pixels	I
73		Averaged TBB in cloud area (Unit: 0.1K)	I
74		Standard deviation of TBB in cloud area (Unit: 0.01K)	I
75	Semi-transparency cloud information 1	Number of pixels	I
76		Valid emissivity	I
77		Method of altitude correction	I

Position (half word)	Items	Contents	Type
78		Altitude (Unit: 100gpm)	I
79	Semi-transparency cloud information 2	Number of pixels	I
80		Valid emissivity	I
81		Method of altitude correction	I
82		Altitude (Unit: 100gpm)	I
83	Cloud top altitude (after correction)	Corrected altitude of semi-transparency upper cloud by the use of IR1 CH and water vapor CH (Unit: 100gpm)	I
84	Sea surface temperature	(Unit: 0.1K)	I
85	Upper tropospheric air humidity	Upper tropospheric air humidity (relative humidity) (Unit: 0.1%)	I
86		Peak air pressure in weighted function (Unit: hPa)	I
87	Precipitable water amount	(Unit: 0.1g/cm2)	I
88	Outgoing longwave radiation	(Unit: W/m2)	I
89-91	Convective cloud information	Following information is saved in each byte. 1st byte: num. of pixels in clear sky (no cloud) area 2nd byte: num. of pixels of non-convective cloud lower than 400hPa 3rd byte: num. of pixels of non-convective cloud higher than 400hPa 4th byte: num. of pixels of convective cloud lower than 400hPa 5th byte: num. of pixels of convective cloud higher than 400hPa 6th byte: (reserved)	I
92-96	(reserved)		

FORMAT ON CD-ROM OF THE MONTHLY REPORT OF MSC

J.1 Introduction

The CD-ROM of the Monthly Report of the Meteorological Satellite Center (MSC) contains the observation data derived from the Geostationary Meteorological Satellite (GMS) of Japan and the polar orbital meteorological satellites operated by NOAA.

The CD-ROM contains the following observation data.

J.1.1 GMS Full Disk Earth's Cloud Images

The images are from three sensors, i.e. IR1 : infrared (10.5-11.5 μm), VS : visible and WV : water vapor.

Three VS images are made in a day (nominal time : 00,03 and 06UTC) and for other sensors five images are made (00,03,06,12 and 18UTC).

The images are recorded in Bitmap format available in the Microsoft(R) Windows(R) operating system.

The size of the image is 512 pixels by 512 lines and 256 colors.

J.1.2 GMS Cloud Images of Japan and its Vicinity

The images are from three sensors, i.e. IR1 : infrared (10.5-11.5 μm), VS : visible and WV : water vapor.

Thirteen VS images are made in a day (nominal time : from 21UTC to 09UTC) and for the other sensors twenty-four images are made (hourly).

The images are the digital data extracted from VISSR data covering the area from 20N to 50N and 120E to 150E at every 0.06 degrees latitude by 0.06 degrees longitude box.

The images are recorded in an original format which is shown in Fig.J.1 to J.5.

The size of the image is 501 pixels by 501 lines.

The images can be viewed by the Viewer contained in the CD-ROM.

J.1.3 Cloud Amount

Five-days mean data of cloud amounts, total cloud amount (T) and upper cloud amount (U : higher than 400hPa level), are shown in tabular form at every 2 degrees latitude by 2 degrees longitude box covering the area from 50N to 49S and 90E to 171W.

These data are derived from the histogram data of IR-1 channel of GMS-5 and expressed in the number of tenths.

The mark '*' in the columns shows that the cloud amount exceeds 9.5, and the mark '-' shows 'no data'.

J.1.4 Sea Surface Temperature

Ten-days mean data of sea surface temperatures (SST) are shown in tabular form at grid points arrayed every 1 degree latitude and longitude covering the area from 50N to 50S and 90 E to 170W.

SST is derived from brightness temperatures of infrared split-window channels (IR1 and IR2) of GMS-5 using a multi-channel SST retrieval algorithm.

In the table, SSTs are expressed in 0.1 degrees Celsius by integer form (multiplied by 10) of three digits.

The marks '/' and '.' show 'land' and 'no valid data' respectively.

J.1.5 Cloud and Water Vapor Motion Wind

Cloud and water vapor motion wind data (wind direction (unit : degree), wind speed (0.1m/s), target cloud top height (10hPa) and brightness temperature of the target cloud (degree Celsius)) are calculated using time-sequential images of GMS and are shown in tabular form.

These data are derived four times in a day (00,06,12 and 18UTC) and are processed in the area from 50N to 49S and 90E to 171E.

J.1.6 Orbit Data

Six orbital elements (Semi-major axis (SMA : km), Eccentricity (ECC), Inclination (INC : deg.), Right ascension of the ascending node (ASCN : deg.), Argument of perigee (PERG : deg.) and Mean anomaly (MA : deg.)) of the GMS at the epoch of 00UTC are determined by the statistical determination procedure shown in tabular form.

The location of GMS (latitude and longitude of sub-satellite point (SSP : deg.) and height of the GMS above the surface of the earth (H : km)) at the epoch of 00UTC are shown in tabular form.

J.1.7 Attitude Data

The GMS attitude data at the epoch of 00UTC are estimated from specific landmark locations in the latest several VISSR visible images by means of a statistical method and are shown in tabular form.

X and Y direction cosines of the spin axis in the mean of 1950.0 coordinate system
Torque of solar radiation pressure (kg.m)
Spin rate (RPM)
Right ascension of the spin axis in the true of date coordinate system (ALPHA : deg.)
Declination of the spin axis in the true of date coordinate system (DELTA : deg.)
VISSR misalignment angle around X and Y-axis in VISSR coordinates (X,Y MISAL : deg.)
Bias of the Beta angle (B-ANG BI : deg.)

J.1.8 VISSR Image Data Catalog

Data archiving conditions of VISSR images on CMT (cartridge magnetic tape) and microfilm are shown in tabular form.

There are four VISSR datasets on CMT ; VIS (visible), IR (infrared), WV (water vapor) and Typhoon Special Observation Data.

There are three kinds of pictures on the microfilm ; IR, VIS and WV Images.

The VIS, IR and WV data on CMT are retained for ten years, and the Typhoon Special Observation Data are for thirty years.

The data on microfilms are retained permanently.

J.1.9 Equivalent Blackbody Temperature

Five-days mean data of equivalent blackbody temperature derived from IR-1 channel data of GMS-5 are shown in tabular form at every 2.5 degrees latitude by 2.5 degrees longitude box covering the area from 50N to 50S and 90E to 170W.

These data are expressed in Kelvin.

J.1.10 Out-going Longwave Radiation (OLR)

Five-days mean data of brightness temperature corresponding to OLR derived from the IR-1 channel and the water vapor channel data of GMS-5 are shown in tabular form at every 2.5 degrees latitude by 2.5 degrees longitude box covering the area from 50N to 50S and 90E to 170 W.

These data are expressed in W/m**2.

J.1.11 Solar Irradiation

Daily data of day-time (from 20UTC to 09UTC) total downward solar irradiance at the surface of the Earth (solar irradiation) are shown in tabular form at every 1 degree latitude by 1 degree longitude box covering the area from 60N to 60S and 80E to 160W.

Solar Irradiation is derived from the reflectance of the visible channel data of GMS-5 using a simple radiative transfer model.

These data are expressed in MJ/m**2.

J.1.12 Snow and Ice Index

Daily data of index for the information on the Earth's surface about the area covered by snow and ice are shown in tabular form at every 1 degree latitude by 1 degree longitude box for the area from 60N to 20N and 80E to 160W. This index is derived from the reflectance of the visible channel data of GMS-5.

These data are expressed in percent.

J.1.13 TOVS Vertical Profile of Temperature and Precipitable Water

Vertical sounding data are obtained by processing the data observed by TIROS Operational Vertical Sounder (TOVS) and Advanced Very High Resolution Radiometer (AVHRR) on the NOAA/TIROS-N polar orbital meteorological satellite of the USA.

Direct broadcast NOAA data received by the MSC is processed to retrieve the vertical profiles of temperature and precipitable water.

Temperature at surface and 15 pressure levels are expressed in 0.1 degrees Celsius and precipitable water contained in layers from 300hPa to 5 pressure levels are in 0.01 g/cm**2.

Product coverage is around Japan (the area from 10N to 60N and 110E to 170E).

The retrieval is made in the clear ocean region. Resolution of this product is about 20km.

J.1.14 TOVS Total Ozone Amount

A day-mean Total Ozone Amount derived from TOVS-HIRS/2 data of NOAA are shown in tabular form at every 1 degree latitude by 1 degree longitude box covering the area from 60N to 10N and 100E to 180E.

The mark '---' in the columns shows 'no data'.

These data are expressed in m atm-cm.

J.2 Recording format

ISO9660 standard is applied for a volume and file structure. The CD-ROM is recorded as a Single-Session.

The satellite observation data (contained in the directory TEXT) except the Image data are recorded in ASCII code.

The files contained in the directory DOCUMENT are recorded either in ASCII code (*.ENG) or shift JIS code (*.JPN).

Full Disk Earth's Cloud Images are recorded in Bitmap (BMP) format available in the Microsoft(R) Windows(R) Operating System.

Cloud Images of Japan and its Vicinity are recorded in an original format and can be viewed and analyzed by the Viewer (GMSLP*.EXE) contained in the directory VIEWER.

J.3 Directory Structure

The directory structure of the CD-ROM of the Monthly Report is shown in Fig.J.6.

There are five major directories on the disk :

(1) The directory 'DOCUMENT' contains the documents of the satellite observation data, the Viewer and the CD-ROM. Each document is written both in English (*.ENG) and in Japanese (*.JPN).

(2) The directories 'IMAGEDK' and 'IMAGEJP' contain sub-directories 'DKdd' and 'JPdd' respectively.

The sub-directories 'DKdd' contain the Full Disk Earth's Cloud Images of the day 'dd' of a month.

The sub-directories 'JPdd' contain the Cloud Images of Japan and its Vicinity of the day 'dd' of a month.

'IMAGEDK' and 'IMAGEJP' also contain sub-directories 'DKINF' and 'JPINF' respectively.

The sub-directory 'DKINF' contains quality information of the Full Disk Earth's Cloud Images and the sub-directory 'JPINF' contains that of the Cloud Images of Japan and its Vicinity.

The quality information is a list of file-names about missing images, and images which are not available in part and so on.

The quality information is written both in English (DINFyymm.ENG/ JINFyymm.ENG) and in Japanese (DINFyymm.JPN/ JINFyymm.JPN) where 'yy' and 'mm' denote year and month respectively.

(3) The directory 'TEXT' contains the satellite observation data in tabular form except for image data.

Each data set is contained in a sub-directory which is named after the respective data name.

(4) The directory 'VIEWER' contains the Viewer of the Cloud Images of Japan and its Vicinity and additional files.

The Viewer can be used on NEC PC-9800 Series, Microsoft Windows and UNIX operating system.

Each version of the Viewer is contained in a sub-directory which is named after the respective operating system.

The Viewer for Microsoft Windows is prepared both in English and in Japanese, and contained in respective sub-directories 'ENG' and 'JPN'.

PC9800 Series are trademarks of NEC Corporation.
Windows is a registered trademark of Microsoft Corporation in the United States and other countries.
UNIX is a registered trademark in the United States and other countries, licensed exclusively through X/Open Company Limited.

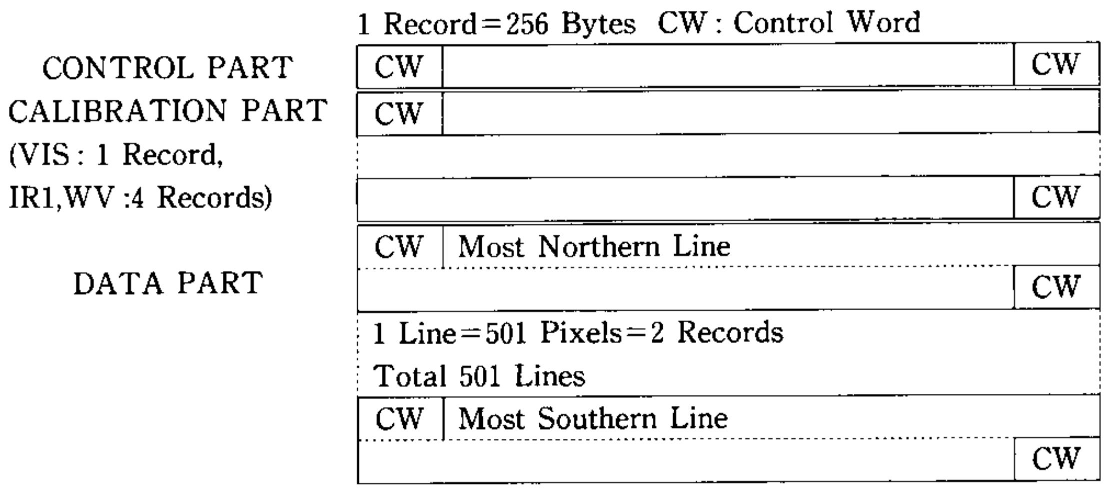


Fig.J.1 Data format about Cloud Images of Japan and its Vicinity

CONTROL PART

(position is relative in the part)

I : integer, R : real, C : character

Byte pos.	Items	Contents	Type
1 - 4	control word	fixed : 256	I * 4
5 - 12	sensor name	"GMS-VIS","GMS-IR1" or "GMS-WV"	C * 8
13 - 20	satellite name	"GMS-5"	ditto
21 - 24	unused		
25 - 56	start time	see Fig.I-5	I * 32
57 - 88	end time	same as above	I * 32
89 - 92	coordinate	rectilinear coordinates=1	I * 4
93 - 96	number of pixels on VISSR data	number of pixels for longitudinal direction	ditto
97 - 100	same as above	number of pixels for latitudinal direction	ditto
101 - 104	resolution on CD-ROM data	longitudinal length of a pixel=0.06 deg.	R * 4
105 - 108	same as above	latitudinal length of a pixel=0.06 deg.	ditto
109 - 112	number of pixels on CD-ROM data	number of pixels for longitudinal direction=501	I * 4
113 - 116	number of pixels on CD-ROM data	number of pixels for latitudinal direction=501	ditto
117 - 120	record length	record length per 1 line=2	ditto
121 - 124	byte length	byte length of a pixel=1(8bits)	ditto
125 - 156	the region of the image on CD-ROM data	lat. and lon. at NW corner lat. and lon. at NE corner lat. and lon. at SW corner lat. and lon. at SE corner	(R * 4) * 8
157 - 160	number of Calibration values	VIS=62 IR1 and WV=254	I * 4
161 - 164	first level	level corresponding to the least value of calibration table=2	ditto
165 - 168	last level	level corresponding to the most value of calibration table VIS=63, IR1 and WV=255	ditto
169 - 252	(reserved)	all "0"	
253 - 256	control word	same as 1 - 4 position	I * 4

Fig.J.2 The contents of CONTROL PART
(Cloud Images of Japan and its Vicinity)

CALIBRATION PART I: integer, R: real, C: character

(position is relative in the part)

byte pos.	Items	Contents	Type
1 - 4	control word	VIS: 256, IR1,WV: 1024	I * 4
5 -	calibration table	VIS: values that show albedos (0.0-1.0) corresponding to levels from 2 to 63 are recorded in 1 record (256 bytes) IR1,WV: values that show TBB(K) corresponding to levels from 2 to 255 are recorded in 4 records (1024 bytes)	R * 4
Last 4 bytes	control word	same as 1-4 position	I * 4

Fig.J.3 The contents of CALIBRATION PART
(Cloud Images of Japan and its Vicinity)

DATA PART I: integer, R: real, C: character

(position is relative in the part)

byte pos.	Items	Contents	Type
1 - 4	control word	Number of bytes per 1 line=512	I * 4
5 -	image data	level of each pixel is recorded in binary form using 1 byte per 1 pixel	
Last 4	control word	same as 1-4 position	I * 4

Fig.J.4 The contents of DATA PART
(Cloud Images of Japan and its Vicinity)

Relative byte pos.	Contents	Type
1 - 4	YY: year 19,20	I * 4
5 - 8	YY: year 00-99	I * 4
9 - 12	MM: month	I * 4
13 - 16	DD: day	I * 4
17 - 20	hh: hour	I * 4
21 - 24	mm: minute	I * 4
25 - 28	ss: second	I * 4
29 - 32	ms: (m sec)	I * 4

Fig.J.5 The contents of start and end time of CONTROL PART

```
ROOT──DOCUMENT
  │      ├──CLOUD.ENG/JPN (Documents of Cloud Amount)
  │      ├──EBT.ENG/JPN (Documents of Equivalent Blackbody Temperature)
  │      ├──GMSLP98.ENG/JPN (Documents of Viewer for PC-9800 series)
  │      ├──GMSLPU.ENG/JPN (Documents of Viewer for UNIX)
  │      ├──GMSLPW.ENG/JPN (Documents of Viewer for Windows)
  │      ├──IMAGEDK.ENG/JPN (Documents of Full Disk Earth's Cloud Image)
  │      ├──IMAGEJP.ENG/JPN (Documents of Cloud Image of Japan and its Vicinity)
  │      ├──OLR.ENG/JPN (Documents of OLR)
  │      ├──README.ENG/JPN (Documents of the CD-ROM)
  │      ├──SNOW.ENG/JPN (Documents of Snow and Ice Index)
  │      ├──SOA.ENG/JPN (Documents of Satellite Orbit and Attitude Data)
  │      ├──SST.ENG/JPN (Documents of Sea Surface Temperature)
  │      ├──SUN.ENG/JPN (Documents of Solar Irradiation)
  │      ├──TOVS.ENG/JPN (Documents of TOVS Data)
  │      ├──VSRINF.ENG/JPN (Documents of VISSR Image Data Catalog)
  │      └──WIND.ENG/JPN (Documents of Cloud and Water Vapor Motion Wind)
  │
  ├────IMAGEDK (contains Full Disk Earth's Cloud Images)
  │      ├──DKdd──ssmmddhh.BMP (Image Data of the day 'dd')
  │      └──DKINF──DINFyymm.ENG/JPN (Quality Information)
  │
  ├────IMAGEJP (contains Cloud Images of Japan and its Vicinity)
  │      ├──JPdd──ssyymmdd.Zhh (Image Data of the day 'dd')
  │      └──JPINF──JINFyymm.ENG/JPN (Quality Information)
  │
  ├────TEXT (contains satellite observation data in tabular form)
  │      ├──CLOUD──CLDmmddH.TXT (Cloud Amount: the day 'dd' of the month 'mm' is the start
  │      │                 date of 5-days that the data are averaged over)
  │      ├──EBT────EBTmmddH.TXT (EBT: the day 'dd' of the month 'mm' is the start date of
  │      │                 5-days that the data are averaged over)
  │      ├──OLR────OLRmmddH.TXT (OLR: the day 'dd' of the month 'mm' is the start date of
  │      │                 5-days that the data are averaged over)
  │      ├──SNOW───SNWmmdd.TXT (Snow and Ice Index)
  │      ├──SOA────ATTyymm.TXT (Attitude Data)
  │      │    └────ORByymm.TXT (Orbit Data)
  │      ├──SST────SSTyymmF.TXT (Sea Surface Temperature: First 10 days of the month 'mm'
  │      │    │            [10-day mean data])
  │      │    ├────SSTyymmS.TXT (ditto: Second 10 days of the month 'mm')
  │      │    └────SSTyymmT.TXT (ditto: Remained days of the month 'mm')
  │      ├──SUN────SUNmmdd.TXT (Solar Irradiation)
  │      ├──TOVS───OZNmmdd.TXT (TOVS Total Ozone Amount)
  │      │    ├────TVSyymmF.TXT (TOVS Vertical Profile of Temperature and Precipitable
  │      │    │            Water: First 10 days of the month 'mm')
  │      │    ├────TVSyymmS.TXT (ditto: Second 10 days of the month'mm')
  │      │    └────TVSyymmT.TXT (ditto: Remained days of the month 'mm')
  │      ├──VSRINF─VCMTyymm.TXT (VISSR Image Data Catalog: CMT)
  │      │    └────VPICyymm.TXT (VISSR Image Data Catalog: Micro Film)
  │      └──WIND───WINCmmdd.TXT (Cloud Motion Wind)
  │           └────WINWmmdd.TXT (Water Vapor Motion Wind)
  │
  └────VIEWER (contains the Viewer)
         ├──98UTL (the Viewer for NEC PC-9800 series)
         ├──UNIXUTL (the Viewer for UNIX)
         └──WINUTL (the Viewer for Microsoft Windows)
              ├────ENG (English edition)
              └────JPN (Japanese edition)
```

In this directory structure, 'yy', 'mm', 'dd' and 'hh' denote year, month, day and hour(UTC), respectively.

The combination of these numbers represents the observed date of data in the file.

The index 'ss' in the cloud image file name identifies the spectral channel; IR denotes infrared, VS: visible, WV: water vapor.

Fig.J.6 Directory Structure of the CD-ROM of the MONTHLY REPORT of MSC

Specification of GMS Image Microfilm

form 35mm, perforation
recorded image and frequency is as follows

projection	channel	frequency
Full Disk(DK)	infrared(IR) visible(VIS) water vapor(WV)	3-hourly 00,03,06 UTC hourly
Polar-Stereographic(PS) (northern hemisphere)	infrared(IR) visible(VIS)	hourly 00,01,02,03,04,05, 06,07,08,22,23 UTC

volume density : 7 days/1 volume
format : see Fig.K.1

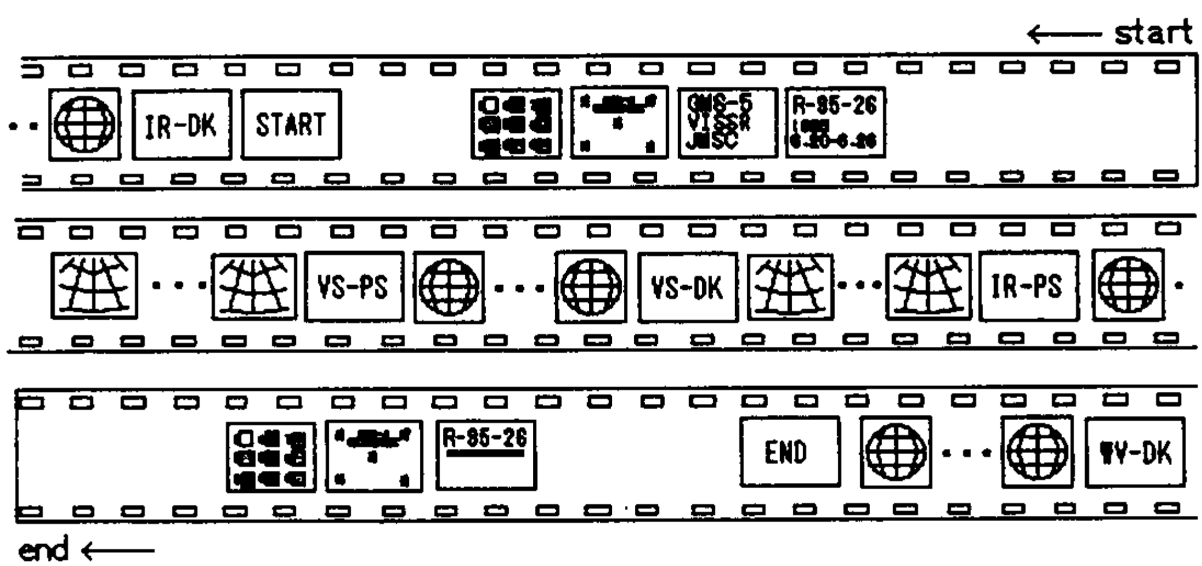


Fig.K.1 Format of GMS image microfilm

Processing of NOAA Satellite Data

L.1 Data Reception and Archive

L.1.1 Introduction

MSC has received High Resolution Picture Transmission (HRPT) data broadcast directly by NOAA operational polar orbiting satellites and made some products from Advanced Very High Resolution Radiometer (AVHRR) data and TIROS Operational Vertical Sounder (TOVS) data. TOVS includes the following instruments:

(1) High Resolution Infrared Radiation Sounder/2 (HIRS/2),
(2) Stratospheric Sounding Unit (SSU),
(3) Microwave Sounding Unit (MSU).

A detailed description of the NOAA Polar Orbiter instrumentation can be found in NOAA Technical Memorandum NESS 116.

The data of morning descending satellite and afternoon ascending satellite have been received two or three times a half day. Before June 13, 1995, the data from one of two operational satellites were received. The HRPT coverage from MSC is shown in Fig. L.1. The coverage area is 5200 km in diameter centered at MSC.

L.1.2 HRPT Archive Data

HRPT data received at MSC has been archived on Cartridge Magnetic Tapes (CMTs). One CMT includes daily HRPT data from one satellite. Before June 13, 1995, the data were archived on Cartridge Tapes (CTs).

L.1.3 APT Predict (TBUS) Bulletin

The source of information concerning a satellite's position in time and space is the APT Predict (TBUS) bulletin prepared by NESDIS. The code form of the TBUS bulletin are given in the TIROS-N Series Direct Readout Services Users Guide. It is transmitted daily, at about 1908 UTC, by KWBC Washington, DC, on the Global Telecommunications Services network. MSC has archived the TBUS bulletin since March 3, 1987.

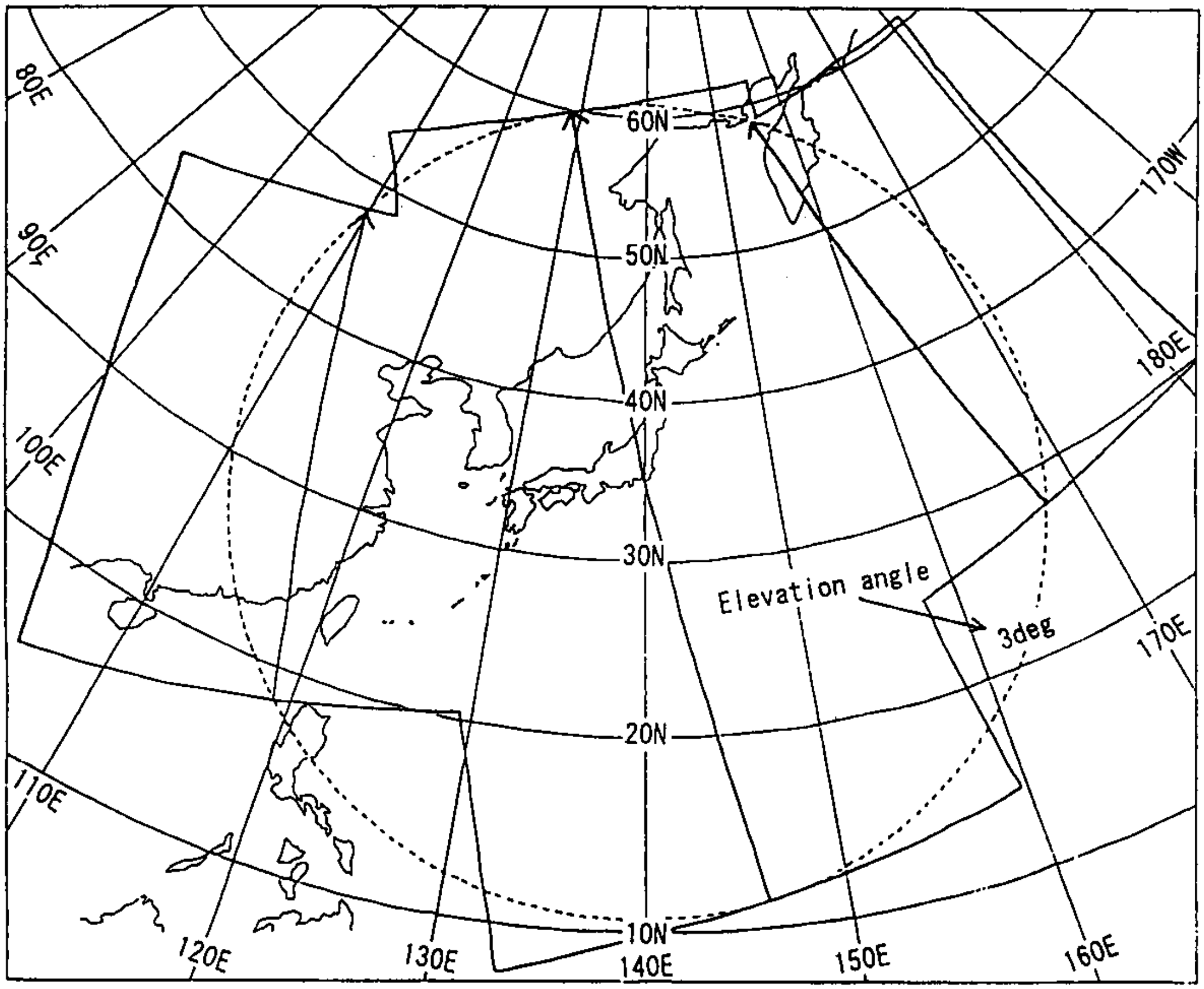


Fig.L.1 HRPT coverage from MSC

L.2 Products

L.2.1 Sea surface temperature

L.2.1.1 Outline

Sea surface temperatures(SSTs) are extracted from measurements of Advanced Very High Resolution Radiometer(AVHRR) on NOAA polar orbit satellites. The SST is calculated from two simultaneous brightness temperatures of split-window channels by using a linear regression equation.

L.2.1.2 Description

The SSTs are estimated every day. The area of SST estimation is from 50 degree North to 20 degree North and from 120 degree East to 160 degree East.

Pixels(image-elements) of AVHRR full-resolution data are discriminated into cloud free pixels or cloud contaminated pixels by a cloud filtering algorithm. The algorithm consists of threshold tests of reflectance, brightness temperature and brightness temperature difference of split-window channels.

SST is calculated from two simultaneous brightness temperatures of split-window channels of cloud free pixels by using a linear regression equation, the so-called Multi-Channel SST (MCSST) retrieval algorithm. The equation is as follows:

$$SST = aT_{11} + b(T_{11} - T_{12}) + c(T_{11} - T_{12})(\sec\theta - 1) + d$$

where T_{11} is brightness temperature in IR1, 10.5-11.5μm, T12 is brightness temperature in IR2, 11.5-12.5μm, θ is satellite zenith angle, a, b, c, and d are coefficients of the linear regression.

The calculated SSTs are compared to climatological values and unreasonable values are eliminated.

The mean is calculated from the reasonable values in the area with regular intervals of 0.25 degree latitude by 0.25 degree longitude, and is employed as the representative SST in the area.

Grid point values of the SSTs with 0.25 degree latitude and longitude resolution are sent to the Headquarters of JMA in GRIB code.

L.2.1.3 Remarks

As a result of comparison between satellite SSTs and measurements of buoys, the Root Mean Square difference of them is from 1.2 to 1.5 degree Kelvin.

Coefficients for the retrieval equation are published by National Oceanic and Atmospheric Administration/ National Environmental Satellite, Data and Information Service (NOAA/ NESDIS).

L2.2 Vertical Profile of Temperature and Water Vapor

L2.2.1 Outline

Vertical sounding data are extracted from TOVS and AVHRR data. The data of the morning descending satellite are processed to retrieve the vertical profiles of temperature and water. The data coverage is around Japan (10-60N, 110-170E) and the retrieval is carried out in the clear ocean region. Resolution of this product is about 20km.

L2.2.2 Description

Prior to the retrieval of vertical profile, TOVS data and AVHRR data are calibrated. Partial cloudiness in a HIRS field of view (FOV) are calculated. 300 to 450 AVHRR FOVs are included in one HIRS FOV so we can derive the partial cloudiness as the ratio of cloudy AVHRR FOVs to total AVHRR FOVs. The cloudy AVHRR FOV is determined from eight parameters deduced from five AVHRR channel data by using a given algorithm and thresholds.

At the same time we calculate some statistical parameters of AVHRR data in the HIRS FOV e.g. minimum, maximum and mean brightness temperature. Latitude and longitude at the center of HIRS FOVs are also calculated by satellite position, HIRS scan time and HIRS scan angle.

To retrieve the vertical profile of temperature and water vapor, an initial guess is generated from forecast grid data of the Global Spectral Model and the Regional Spectral Model, which is provided by Numerical Forecast Division of JMA, through temporal and spatial interpolation. Then we interactively retrieve the optimum profile consistent to observed HIRS brightness temperatures considering the initial guess error, observation error, and bias of the radiative transfer model. The radiation bias and observation error are updated once a month from a match-up dataset of HIRS data and radiosonde data.

Retrieved temperatures at 15 levels and dew point depressions at 5 levels are converted to thickness and precipitable water, coded by SATEM format, and transmitted to the Forecast Department of JMA H.Q. Data amounts are about 200 a day. Sounding data are archived as formatted files on CMT (one volume a month). The archive data include TOVS data, cloud information and location data and vertical profile data. The contents of the sounding archive data are shown in Table L.1.

L.2.2.3 Remarks

Validation with radio sonde data shows the RMS error of retrieved temperature is 1-1.4K in the lower troposphere and is 0.8-1.2K in the mid-troposphere and upper layers. RMS error of retrieved precipitable water is around 30%. Note that the error characteristics of this product depend on that of the numerical forecast as the first guess.

Table L.1 Contents of the sounding archive data.

Product Description
TOVS data
Calibrated HIRS/2, SSU, and MSU brightness temperature at each spot (in K)
Cloud Information and Location data (at each HIRS/2 spot)
Latitude/Longitude at the center of HIRS/2 spot
Partial cloudiness
Maximum, minimum, and mean brightness temperature (in K) and reflectance (in %)
Mean brightness temperature (in K) and reflectance (in %) in cloudy area
Vertical Profile data (at each HIRS/2 spot)
Latitude/Longitude at the center of HIRS/2 spot
Land/Ocean flag, Surface pressure, Surface temperature
Temperature (in K) of the atmosphere at the 15 pressure levels (in hPa) listed below: 1000, 850, 700, 500, 400, 300, 250, 200, 150, 100, 70, 50, 30, 20, 10
Dew point (in K) of the atmosphere at the 9 pressure levels (in hPa) listed below: 1000, 850, 700, 500, 400, 300, 250, 200, 150

L.2.3 Total Ozone Amount (TOA)

L.2.3.1 Outline

The estimation of TOA from TOVS HIRS/2 data is based on a regression method. The area of TOA is from 60N to 10N and from 100E to 180E with 1 degree latitude and longitude resolution.

L.2.3.2 Description

The technique for estimation of TOA is based on a regression method using HIRS/2 channel 9,i.e., the spectral band of ozone absorption. Input data are radiance of five channels, i.e.,ch.1,2, 3,8 and 9 of HIRS/2. The regression coefficients are determined by collocated data of satellite observations and Dobson measurements of direct sun observation at four JMA's surface observation stations; Sapporo, Tateno, Kagoshima, and Naha. The co-located data have been accumulated on the basis of distance within 50km and timelag within one hour since 1991. The regression coefficients were established for every month and renewed once a year, taking into account the seasonal variation of the TOA.

Prior to TOA calculation, HIRS/2 data with high level cloud or overcast cloud are excluded by using the partial cloud data (described L.2.2) and JMA forecast data.

The daily mean values at every 1 degree latitude and longitude area are sent monthly to the Ozone Layer Monitoring Office.

L.2.3.3 Remarks

The RMS error between the TOA grid data and the Dobson measurements is about 5%. The accuracy trends to deteriorate in winter when the regression coefficients could not accurately express the ozone situation. The cause are given as under. In winter, the co-location data are not enough because few Dobson data of the direct sun observations are obtained at Sapporo for broken clouds, and the co-location data are low because TOA is fluctuating sharply.

L.3 References

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List of Acronyms

AD	-Anno Domino
ADESS	-Automated Data Editing and Switching System
AGC	-Automatic Gain Control
AIREP	-AIRcraft REPort
AM	-Amplitude Modulation
APT	-Automatic Picture Transmission
AS	-Automatic target cloud Selection
ASCII	-American Standard Code for Information Interchange
ASDAR	-Aircraft to Satellite DAta Relay
AVHRR	-Advanced Very High Resolution Radiometer
AZ	-AZimuth
BCD	-Binary Coded Decimal
BCH code	-Bose-Chaudhuri-Hocquenghem code
BFL	-Best Fit Level
BPI	-Bits Per Inch
BPS	-Bits Per Second
BPSK	-Bi-Phase Shift Keying
C-ADESS	-Central ADESS
CCP	-Communication Control Processor
CCT	-Computer Compatible Tape
CD	-Character Display
CDA(S)	-Command and Data Acquisition (Station)
CDD	-Command Demodulated/Decoder
CDF	-Coded Digital Facsimile
CGMS	-Coordination of Geostationary Meteorological Satellites
CMT	-Cartridge Magnetic Tape
CMW	-Cloud Motion Wind
CPI	-Character Per Inch
CPU	-Central Processing Unit
CRC	-Cyclic Redundancy Check
CRT	-Cathode Ray Tube
CT	-Cartridge Tape
CTH	-Cloud Top Height
CWES	-Cloud Wind Estimation System
DASD	-Direct Access Storage Device
DBA	-Despin Bearing Assembly
DCD	-Data Collection and Dissemination
DCP	-Data Collection Platform
DCS	-Data Collection System
DEM	-Demodulator

DEV	-Device
DOC	-Documentation
DPC	-Data Processing Center
DUS	-Data Utilization Station
EBCDIC	-Extend Binary Coded Decimal Interchange Code
EL	-ELevation
EOT	-End Of Transmission
ES	-Earth and Sun
ESA	-European Space Agency
FAX	-FAcsimile
FM	-Frequency Modulation
FSK	-Frequency Shift Keying
GDP	-Graphic DisPlay Processor
GMS(S)	-Geostationary Meteorological Satellite (System)
GOC	-GMS Operating Console
GOES	-Geostationary Operational Environmental Satellite
GPC	-Global Processing Center
GPCP	-Global Precipitation Climatology Project
GPV	-Grid Point Value
GSPDC	-Geostationary Satellite Precipitation Data Center
GTS	-Global Telecommunication System
HCCP	-High speed Communication Control Processor
HIRS /2	-High resolution Infrared Radiation Sounder/2
HK	-House Keeping
HR	-High Resolution
HRPT	-High Resolution Picture Transmission
ICA	-ISCCP Central Archive
ICSU	-International Council of Scientific Union
IDCP	-International DCP
IDP	-Image Display Processor
IF	-Intermediate Frequency
IFOV	-Instantaneous Field of View
IGFOV	-Instantaneous Geometric Field Of View
IPC	-Image Processing Console
IR	-InfraRed
ISCCP	-International Satellite Cloud Climatology Project
JJY	-(call-sign of Japan standard frequency and time signal)
JMA	-Japan Meteorological Agency

LBF	-Level of Best Fit
LCW	-Line Control Word
LSB	-Least Significant Bit
LSD	-Least Significant Digit
MANAM	-MANual AMendment
MCSST	-Multi- Channel SST
MDUS	-Medium Scale Data Utilization Station
METEOSAT	-European Geostationary Meteorological Satellite
MJD	-Modified Julian Day
MLS	-Maximum Linear Sequence
MOD	-MODulator
MODEM	-MOdulator-DEModulator
MRS	-Master Ranging Station
MSB	-Most Significant Bit
MSC	-Meteorological Satellite Center
MSD	-Most Significant Digit
MSU	-Microwave Sounding Unit
MT	-Magnetic Tape
NAPS	-Numerical Analysis and Prediction System
NASDA	-NAtional Space Development Agency of Japan
NESDIS	-National Environmental Satellite, Data, and Information Service
NOAA	-National Oceanic and Atmospheric Administration
NRZ	-Non Return to Zero
NWP	-Numerical Weather Prediction
OLR	-Outgoing Longwave Radiation
OQ	-Objective Quality control
PCM	-Pulse Code Modulation
PLL	-Phase Lock Loop
PM	-Phase Modulation
PMT	-PhotoMultiplier Tube
PN	-Pseudo-Noise
PSK	-Phase Shift Keying
Q/D	-Quality of Data
QPSK	-Quadri-Phase Shift Keying
RDCP	-Regional DCP
RF	-Radio Frequency
RMS	-Root Mean Square
RPM	-Revolutions Per Minute
RX	-Receiver

SAREP	-(WMO code name for synoptic interpretation of satellite cloud data)
SATOB	-(WMO code name for satellite observations of surface temperature, winds, clouds and radiation)
S/C	-Space Craft
SCC	-Satellite Calibration Center
SCIC	-Satellite Cloud Information Chart
SDC	-ScheDule Console
SDUS	-Small-scale Data Utilization Station
SEM	-Space Environment Monitor
SI	-Satellite-derived Index of precipitation intensity
S/N	-Signal to Noise ratio
SSP	-Sub-Satellite Point
SST	-Sea Surface Temperature
SSU	-Stratospheric Sounding Unit
S-VISSR	-Stretched VISSR
SYNC	-SYNChronized or SYNChronous
TARS	-Turn-Around Ranging Station
TC,Tc	-temperature of Cloud Top
TBB	-Temperature, equivalent Black-Body
TDR	-Tape Data Recorder
TIROS	-Television and InfraRed Observation Satellite
TLM	-TeLeMetry
TOVS	-TIROS-N Operational Vertical Sounder
TP	-Test Pattern
TRRR	-Trilateration Range and Range Rate
TX	-Transmitter
UHF	-Ultra-High Frequency
UT(C)	-Universal Time (Coordinated)
VDM	-VISSR Digital Multiplexer
VDP	-VISSR Demodulated Processor
VIS	-VISible
VISSR	-Visible and Infrared Spin Scan Radiometer
WCRP	-World Climate Research Program
WEFAX	-WEather FAcsimile
WMO	-World Meteorological Organization
WVMV	-Water Vapor Motion Wind
WWW	-World Weather Watch