The NOAA-HRPT Data Receiving System in the Center for Atmospheric and Oceanic Studies in the Tohoku University

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The NOAA-HRPT Data Receiving System in the Center for Atmospheric and Oceanic Studies in the Tohoku University

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Abstract: The receiving system of NOAA-HRPT data has been developed for reception and archive of the HRPT data on a routine basis. Using the system, the HRPT data has been received since April 1988. The number of the acquired HRPT data from 1988 to 1992 is 8565, increasing about 1900 in a year. The received HRPT data are processed daily for researches and to monitor the reception condition. In order to store the original HRPT data and the processed image data, we use a optical disk with recording capacity of 5 gigabyte, which ensures the life of these data for several decades. The AVHRR data processing system and TOVS data processing system have been developed for various types of researches using the received HRPT data.

1. Introduction

The NOAA satellites have been observing atmospheric and oceanic phenomena using remote sensing sensors since 1978 when TIROS-N was launched as the first of a series satellites (Schwalb, 1978). This series of satellites continued with NOAA-A (renamed NOAA-6), NOAA-C (NOAA-7), NOAA-E (NOAA-8), NOAA-F (NOAA-9), NOAA-G (NOAA-10), NOAA-H (NOAA-11) and NOAA-D (NOAA-12). The satellites have a sun synchronous polar orbit with an inclination angle of 98.7°. The altitude of the satellites is about 850 km and the orbital periods is 102 minutes. Two NOAA satellites are always operated at the same time to compensate each other and cover the dawn-dark and noon-mid night sectors. At present (June, 1993), the NOAA-11 and NOAA-12 satellites are in operation. The NOAA-12 satellite passes over Japan at around 9 UT (18 Japan Standard Time, JST) and 23 UT (8 JST), while the NOAA-11 satellite passes at around 5 UT (14 JST) and 17 UT (2 JST). The NOAA satellites have two data transmission systems, which are called APT(Automatic Picture Transmission) and HRPT(High resolution Picture Transmission).

The Earth Observing Satellite Center (EOSC) of the Tohoku University was established in 1988 as a receiving station of the HRPT data. The EOSC developed into a new research organization, Center for the Atmospheric and Oceanic Studies (CAOS) in 1990.

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The HRPT data reception has been carried out, and a large number of the HRPT data are archived in the Center. In this paper, the NOAA-HRPT data receiving system is described together with the received HRPT data set and several data sets of the processed images.

2. Sensors on board the NOAA satellites and HRPT data

The instruments on board the satellites are summarized in Table 1. The sensors on board the NOAA satellites are the Advanced Very High Resolution Radiometer

Table 1. Sensors on board the NOAA satellites.

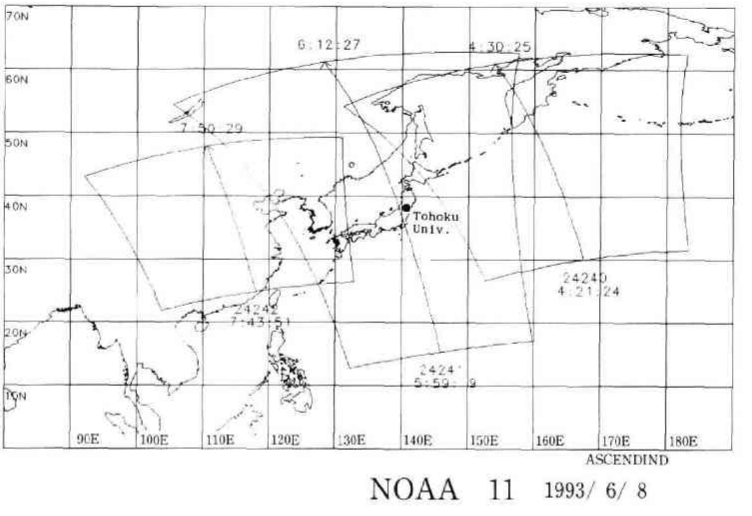
○ : on board.

		TIROS N	NOAA 6	NOAA 7	NOAA 8	NOAA 9	NOAA 10	NOAA 11	NOAA 12
Lanuch Date		Oct. 13 1978	Jun. 23 1981	Mar. 28 1983		Dec. 12 1984	Sep. 17 1986	Sep. 24 1988	May. 14 1991
Operational Dates		Oct. 19 1978 – Jan. 30 1980	Jun. 27 1979 – Nov. 16 1986	Aug. 19 1981 – Jun. 7 1986	Jun. 20 1983 – Oct. 31 1985	Feb. 25 1985 – Nov. 7 1988	Nov. 17 1986	Nov. 8 1988	May 14 1991
AVHRR		/1	/1	/2	/1	/2	/1	/2	/2
TOVS	HIRS/2	○	○	○	○	/	○	○	○
	SSU	○	○	○	○	○	/	○	/
	MSU	○	○	○	○	○	○	○	○
SEM		○	○	○	○	○	○	○	○
DCS		○	○	○	○	○	○	○	○
SAR		/	/	/	○	○	○	○	/
SBUV/2		/	/	/	/	○	/	○	/
ERVE	scan	/	/	/	/	○	○	/	/
	n-snan	/	/	/	/	○	○	/	/

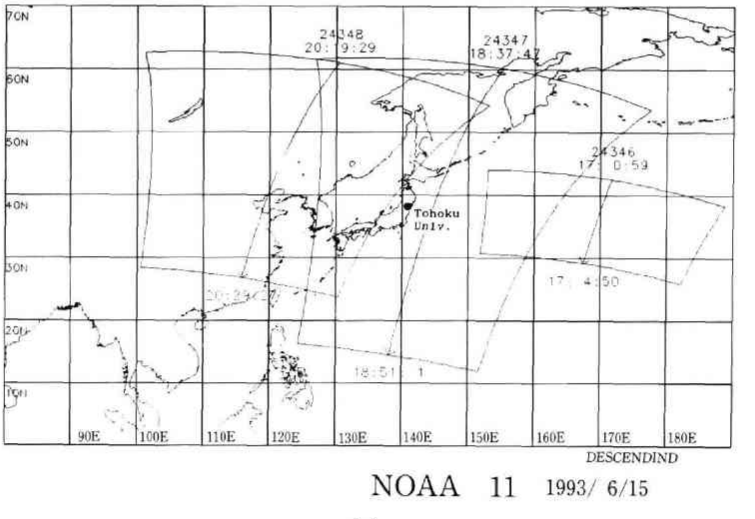
AVHRR : Advanced Very High Resolution Radiometer
/1 : The 4-channel version of the AVHRR
/2 : The 5-channel version of the AVHRR
TOVS : TIROS Operational Vertical Sounder
HIRS/2 : High Resolution Infrared Radiation Sounder
SSU : Stratospheric Sounding Unit
MSU : Microwave Sounding Unit
SEM : Space Environment Monitor
DCS : Data Collection System
SAR : Search and Rescue or Search and Rescue Satellite Aided Tracking (SARSAT)
SBUV/2 : Solar Backscatter Ultra Violet Radiometer
ERBE : Earth Radiation Budget Experiment
scan : a scanning instrument of the ERBE
n-scn : a fixed field-of-view instrument of the ERBE

(AVHRR), the TIROS Operational Vertical Sounder (TOVS), the Space Environment Monitor (SEM), the Data Collecting System (DCS), the Solar Backscatter Ultraviolet Radiometer (SBUV/2), and so on.

The Advanced Very High Resolution Radiometer (AVHRR) represents an improvement over the VHRR sensor flown on board the ITOS series of operational satellites (the



(a)



(b)

Fig. 1. Examples of the coverage of the AVHRR data in the HRPT received at the present station (38°15′26″072 N, 140°50′33″394 E). a) Ascending passes of the NOAA11 on 8 June, 1993, and b) descending passes of the NOAA11 on 15 June, 1993. The orbit number and the start and end times of reception are shown for each of the passes. The location of the receiving station is also shown by a black circle in the figures.

last of which was NOAA-5). The AVHRR is a cross-track scanning system similar to the VHRR, but features four or five spectral channels, compared to just two for the VHRR. The AVHRR sensors on board TIROS-N, NOAA-6, NOAA-8, and NOAA-10 has four channels, and the AVHRR aboard NOAA-7, NOAA-9, NOAA-11 and NOAA-12 have five channels (Kidwell, 1991).

The TOVS consists of three instruments: 1)the second version of the High resolution Infrared Radiation Sounder(HIRS/2), 2) the Microwave Sounding Unit (MSU), and 3) the Stratospheric Sounding Unit (SSU). The TOVS is a vertical sounding instrument capable of providing complete global coverage of vertical temperature profiles between the surface and the stratopause, and the total column moisture content of the stratosphere(Smith et al., 1979).

The HRPT contains almost all the data obtained by the sensors on board the NOAA satellites. The full resolution data in the HRPT are quite useful for scientific researchers in various fields. As a result of the design of the AVHRR scanning system,

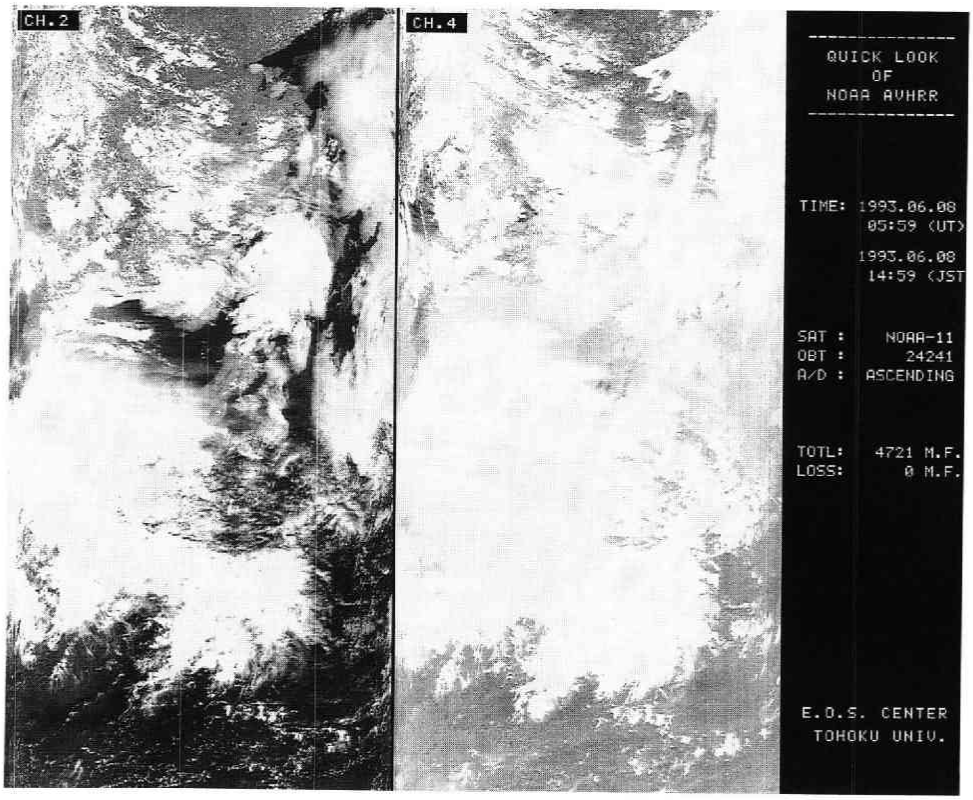


Fig. 2. A quick look image of the AVHRR in the HRPT received at the station on 8 June, 1993 (Orbit Number 24241, shown in Fig. 1a)). The left is the channel 2 image, and the right the channel 4 image. Almost the whole area of the AVHRR coverage are imaged. The Tohoku district of Japan, where the present station is situated, is seen between the clouds at the center of the images.

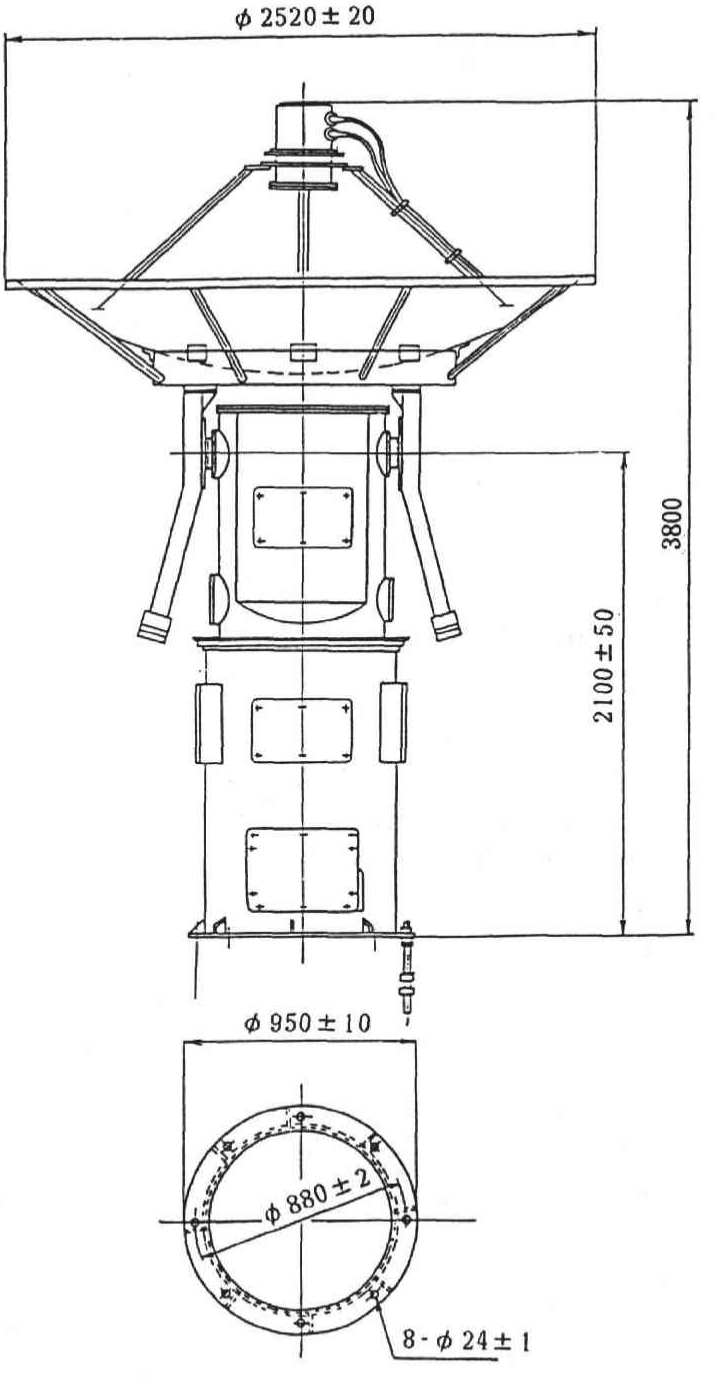


Fig. 3. A sketch of the antenna for the HRPT date reception. The unit is in mm.

the normal operating mode of the satellite requires direct transmission of the AVHRR data to the ground station continuously in real-time. This direct transmission is called HRPT, for High Resolution Picture Transmission (Kidwell, 1991). The HRPT data can be received at the ground station being equipped with an appropriate receiving system. The amount of HRPT data received during one pass of the satellite over the station is limited to the acquisition range of the station. A satellite pass directly over the present receiving station provides a view of about 5,000 km in the moving direction of the satellite and about 3,000 km in the scanning direction of the AVHRR. Fig. 1 shows examples of the coverage of the AVHRR data in the HRPT data received at the present station (38°15′26″072N, 140°50′33″394E). An example of the AVHRR data for the pass (Orbit Number 24241) in Fig. 1 is shown in Fig. 2

3. HRPT data receiving system

Fig. 3 shows an antenna for the HRPT data reception. The antenna was installed on the top of a 3-story building near the EOSC building. The antenna and the instruments in the station are connected by electric lines to transfer the received data and the signals for control of the antenna movement.

Fig. 4 shows a diagram of the instruments for the HRPT data reception and preprocessing system (NESDUS-410 SYSTEM produced by NEC Corporation) and the flows of the control signals and HRPT data. The personal computer for the reception control takes in the TBUS data from the JMG radio wave receiver and prepares the HRPT data reception schedule. The control signal is sent to the antenna according to the preset schedule. An example of the schedule is shown in Fig. 5. The received

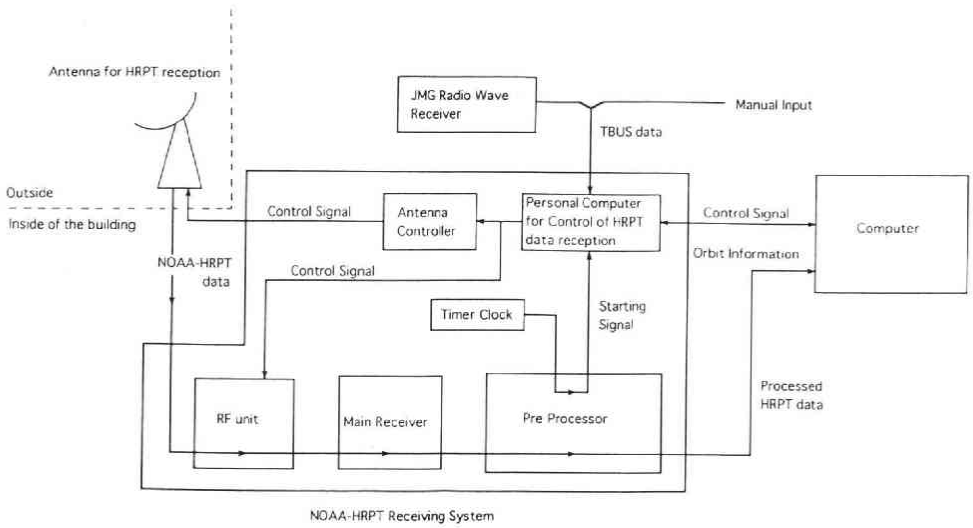


Fig. 4. A diagram of the HRPT data receiving system and the flows of control signals and HRPT data.

telemetry signals including the HRPT data are decoded by the main receiver and the preprocessor and then sent to the computer (MS-4120/NEC) for data storage and analyses. The computer is connected to the local area network of the glass fiber, called TAINS (Tohoku University Academic All-round Advanced Information Network System), to exchange information including the processed images.

In order to calculate the satellite orbit for the HRPT data reception, we need the TBUS information which is renewed by NOAA/NESDIS every day. The present system gets the information through the JMG radio transmission from the Japan Meteorological Agency (Kawamura *et al.*, 1988). Since the reception level of the JMG transmission signal is influenced by weather conditions, manual input of the TBUS data is also possible as an alternative way (Fig. 4).

For analyses of the processed images, an image processor (N7835/NEC) compatible with the computer is used. The image processor enables us to create and display various types of the satellite images through image processing techniques installed in the hardware.

93/06/07 11:31:19 << NESDUS-410 RECEPTION SCHEDULE >>

NO	SATELLITE	RECEPTION	START TIME		DURATION	AZUMUTH	RECEPTI
001	NOAA-11	93/06/07	13:32:51	MON	09:54	111.5	NO
002	NOAA-11	93/06/07	15:11:22	MON	13:02	174.9	YES
003	NOAA-12	93/06/07	16:48:46	MON	06:36	088.8	NO
004	NOAA-11	93/06/07	16:58:30	MON	01:49	265.4	NO
005	NOAA-12	93/06/07	18:24:43	MON	12:52	159.2	YES
006	NOAA-12	93/06/07	20:07:26	MON	08:30	228.1	NO
007	NOAA-11	93/06/08	01:58:46	TUE	01:40	078.9	NO
008	NOAA-11	93/06/08	03:34:38	TUE	12:59	018.7	YES
009	NOAA-11	93/06/08	05:16:17	TUE	09:51	347.7	NO
010	NOAA-12	93/06/08	06:43:30	TUE	11:57	027.7	YES
011	NOAA-12	93/06/08	08:23:39	TUE	11:29	356.6	YES
012	NOAA-11	93/06/08	13:21:26	TUE	08:44	102.1	NO
013	NOAA-11	93/06/08	14:59:08	TUE	13:07	167.5	YES
014	NOAA-11	93/06/08	16:43:54	TUE	06:17	242.3	NO
015	NOAA-12	93/06/08	18:03:31	TUE	12:28	146.1	YES
016	NOAA-12	93/06/08	19:44:39	TUE	10:41	210.2	NO
017	NOAA-11	93/06/09	03:22:32	WED	12:46	022.5	YES
018	NOAA-11	93/06/09	05:03:47	WED	10:48	352.2	NO
019	NOAA-12	93/06/09	06:22:30	WED	10:43	036.2	NO
020	NOAA-12	93/06/09	08:01:54	WED	12:20	003.3	YES
021	NOAA-11	93/06/09	13:10:12	WED	07:14	091.6	NO
022	NOAA-11	93/06/09	14:46:59	WED	13:05	160.1	YES
023	NOAA-11	93/06/09	16:30:30	WED	08:25	229.0	NO
024	NOAA-12	93/06/09	17:42:36	WED	11:40	132.6	YES
025	NOAA-12	93/06/09	19:22:23	WED	11:58	195.0	YES

Fig. 5. An example of the reception schedule from 7-9 June, 1993. The item "DURATION" means the data acquisition period in minutes. The HRPT data of passes with the "DURATION" longer than 11 minutes 30 seconds are scheduled to be received, and the item "RECEPTION" is indicated as "YES".

Since the received HRPT data have a large volume of about 100 megabyte, we use a special optical disk with data storage capacity of 5 gigabyte. The 5-GByte optical disk (N9910-35/NEC) can contain the HRPT data obtained for about one week. The optical disk guarantees high quality data storage at least for several decades.

The reception dates and time, satellite name, stored optical disk of the HRPT data are collected and transferred to a personal computer for reference.

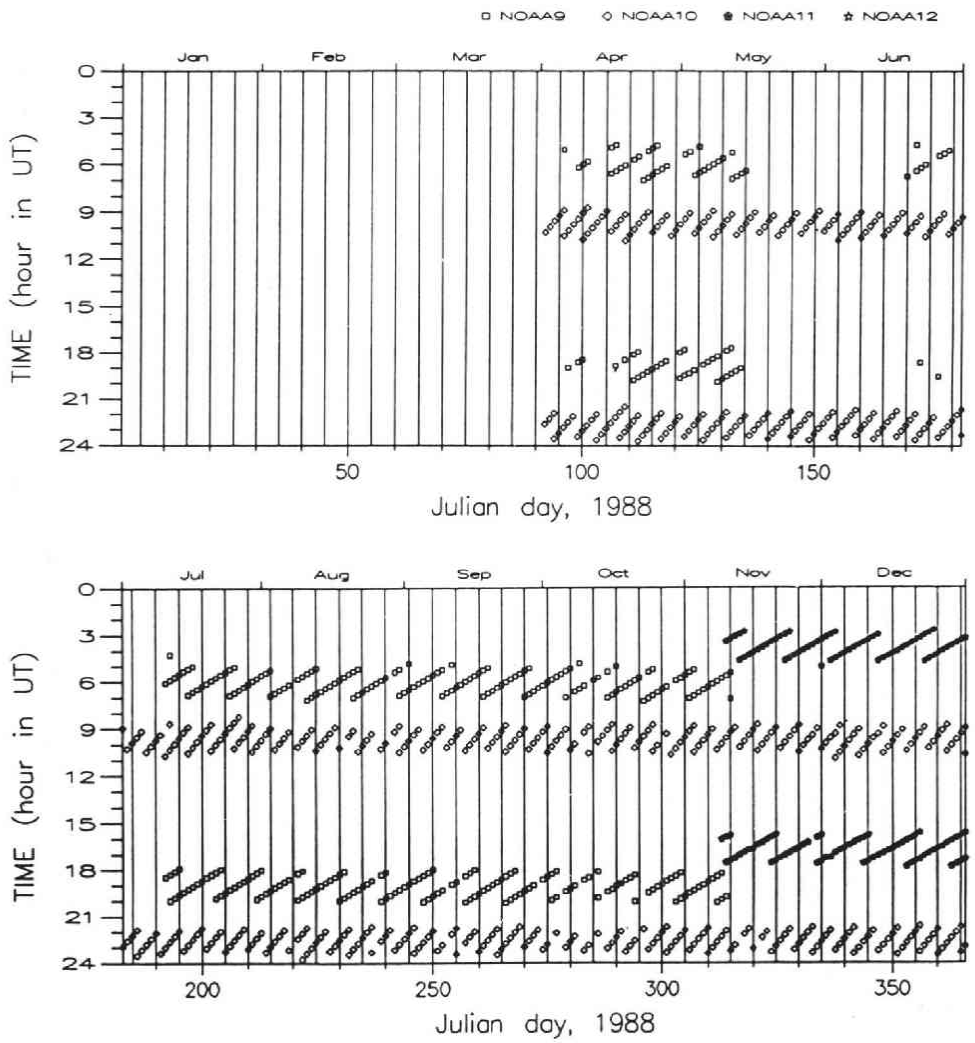


Fig. 6. The HRPT data archived in the Center. The horizontal axis shows the Julian day of the HRPT data reception, and the vertical axis time of the reception. The different symbols indicate the NOAA series satellites from NOAA9 to NOAA12.

4. The HRPT data set and the processed image data sets

The HRPT data reception started on a routine basis in April, 1988 using the system described above. The archived HRPT data from April 1988 to December 1992 are shown in Fig. 6 and Table 2. Each point shows the HRPT reception time, and the symbols designate the satellites. The NOAA 9, 10, 11, and 12 transferred the HRPT data during the period. It is obvious that the HRPT receiving time gets later and later, which is pointed out by researchers using the NOAA data (*e.g.*, Price, 1991). The total number of the HRPT data is 8565, and the averaged number of one-year acquisition is about 1900 (Table 2).

Using the AVHRR data in the HRPT, several data sets of the processed images are

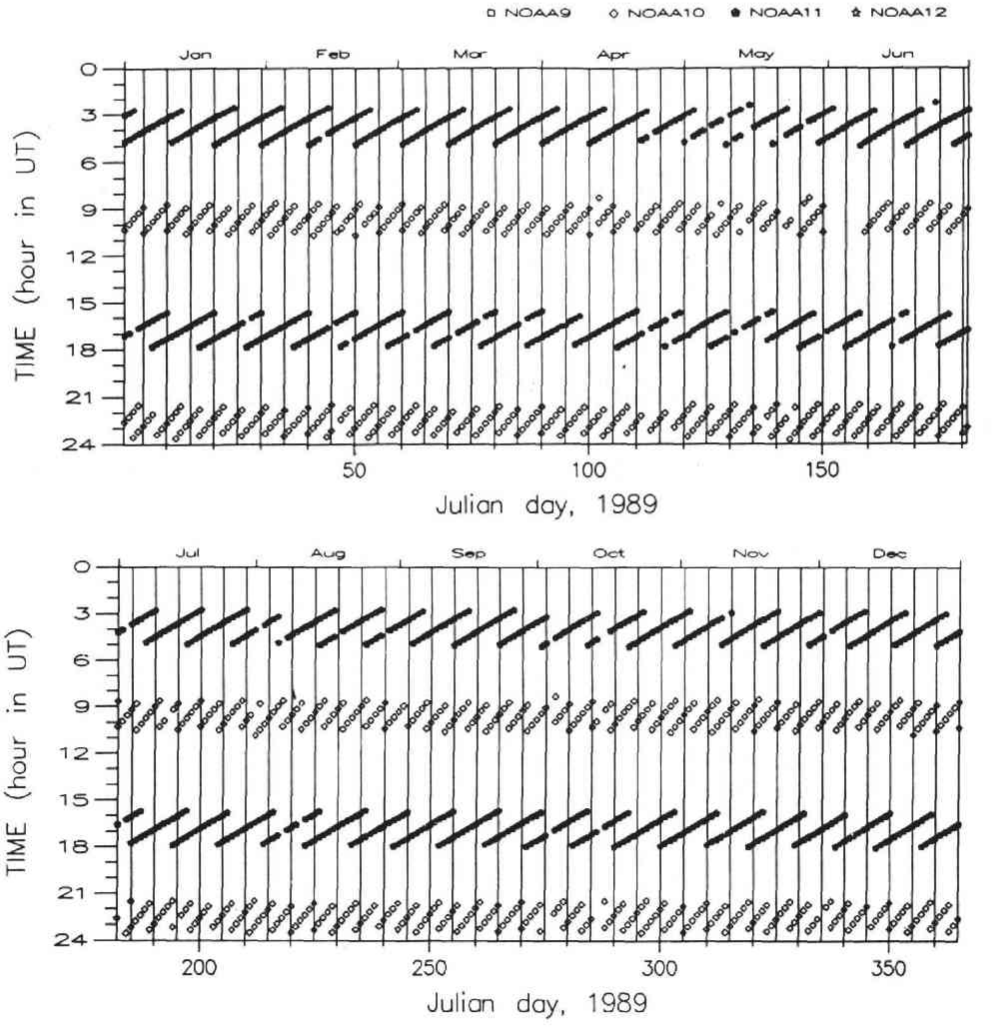


Fig. 6. Continued

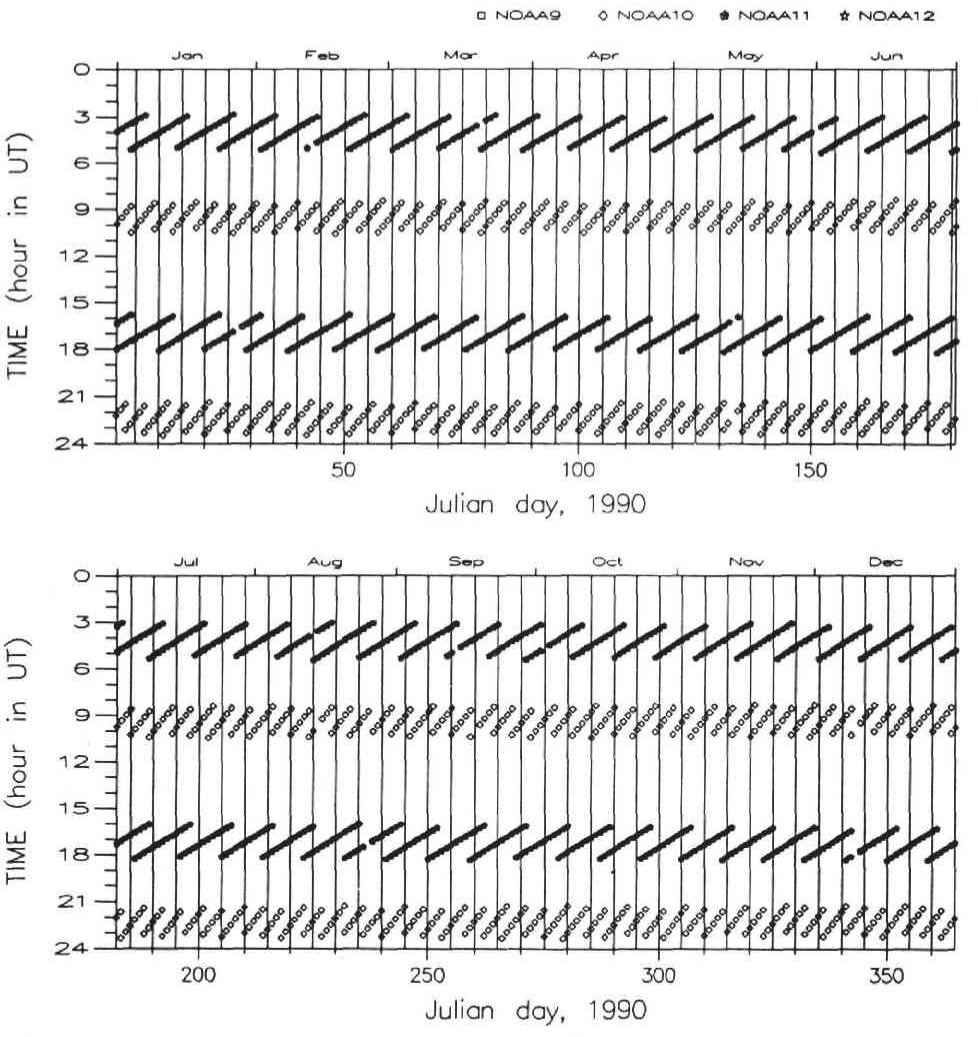


Fig. 6. Continued

produced. The processing of the AVHRR data is described by Kawamura *et al.* (1993a). Quick-look images of all the received HRPT data have been produced and printed out. An example of the quick-look image is shown in Fig. 2. These quick-look images are referenced to search phenomena to be investigated and to monitor conditions of the data reception. The image files are stored in the optical disk.

Regional image data, called the tohoku image, are automatically produced using the AVHRR data received around noon everyday, and stored in the optical disk. The channel 2 and 4 data of the AVHRR are processed to be the tohoku images of albedo (reflectance) and brightness temperature, respectively. The tohoku images are geographically corrected using the Mercator projection with a spatial resolution of 1.1 km square. The area of the image is about a 1,000 km square centering at 40°N and 141°E.

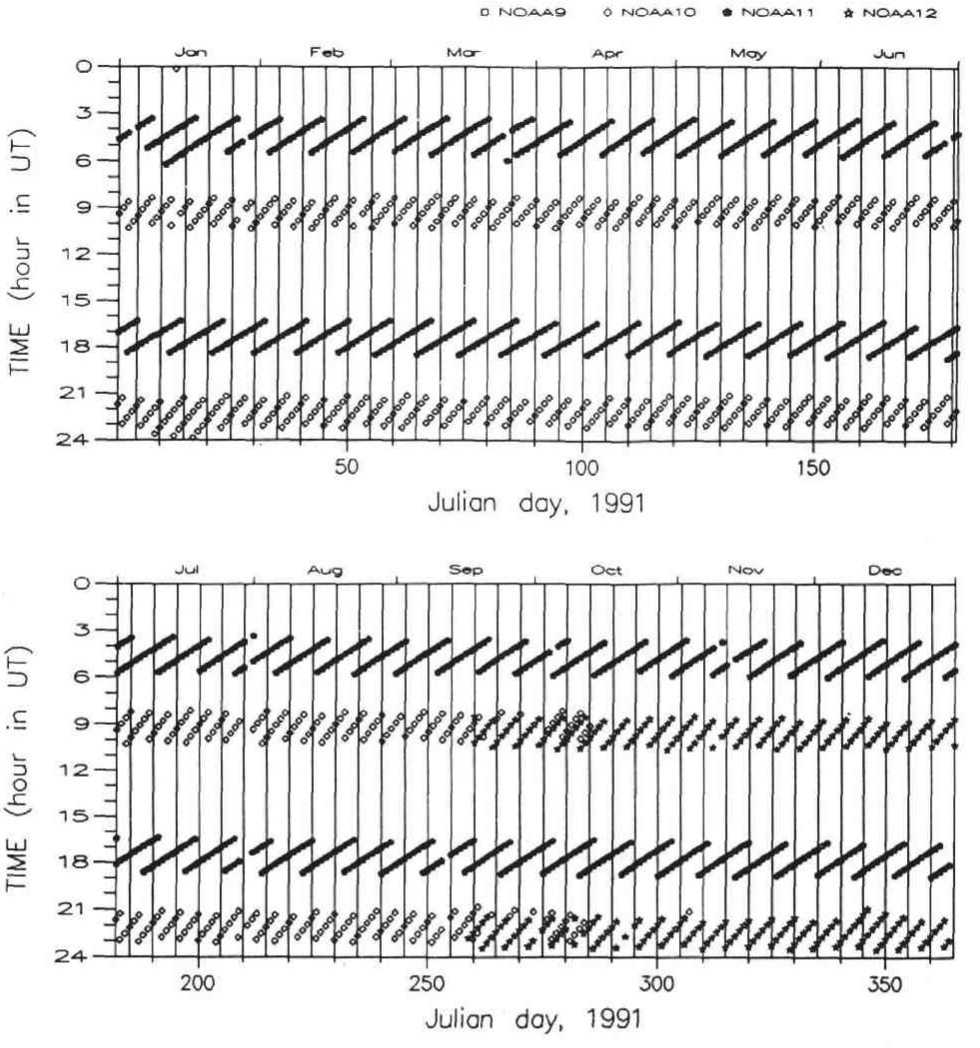


Fig. 6. Continued

Since April 1990, the daily tohoku images have been transferred to the Computer Center of the Tohoku University through the TAINS network, and registered into a satellite image database called "Tohoku Image database (TIDAS)". This database is open for public, and can be accessed through computer networks from outside of the Computer Center (Kawamura *et al.*, 1993b).

SST image data, called the Kuroshio images are also produced using the HRPT data received around midnight everyday. The brightness temperature of channel 4 is imaged to investigate large-scale oceanic features demonstrated by the sea surface temperature. The area of image is about a 3,900 km square centering at 35°N and 140°E. Successive four images are composed to eliminate clouds and to take wide views of the open oceans. An example of the composite Kuroshio image is shown in Fig. 7. The produced images

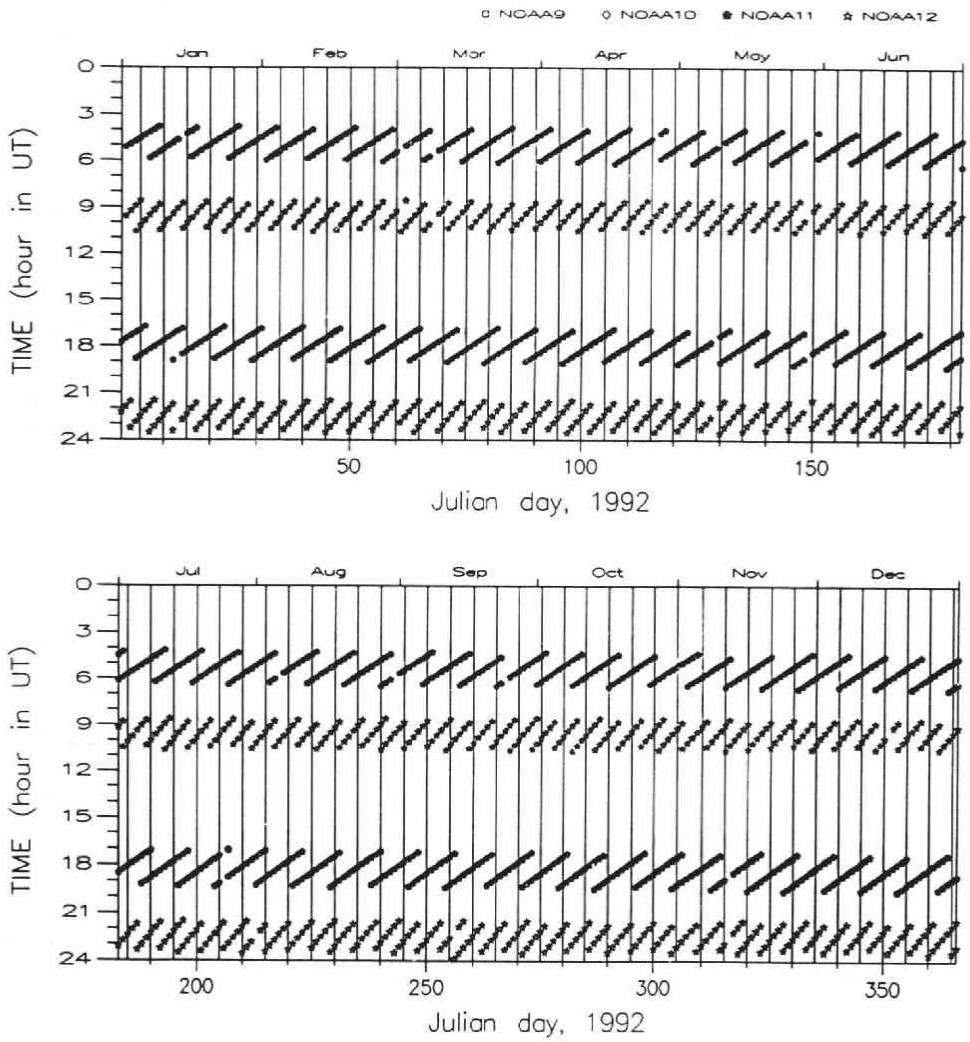


Fig. 6. Continued

are stored in the optical disk.

The HIRS/2 data of the TOVS are occasionally processed for a specified research purpose. Kawamura *et al.* (1991) developed the HIRS/2 data processing system, which extracts the HIRS/2 data from the HRPT data, and processes them to obtain the brightness temperature and make geocoded images.

5. Summary and discussion

The HRPT data receiving system has been developed for reception and archive of the HRPT data in a routine basis. The data reception started in April 1988. The number of the HRPT data acquired from 1988 to 1992 is 8565, increasing about 1900 in

Table 2. Number of the stored HRPT data

	1988	1989	1990	1991	1992	total
NOAA 9	297					297
NOAA 10	570	874	904	680		3028
NOAA 11	133	963	995	998	975	4064
NOAA 12				264	912	1176
total	1000	1837	1899	1942	1887	8565

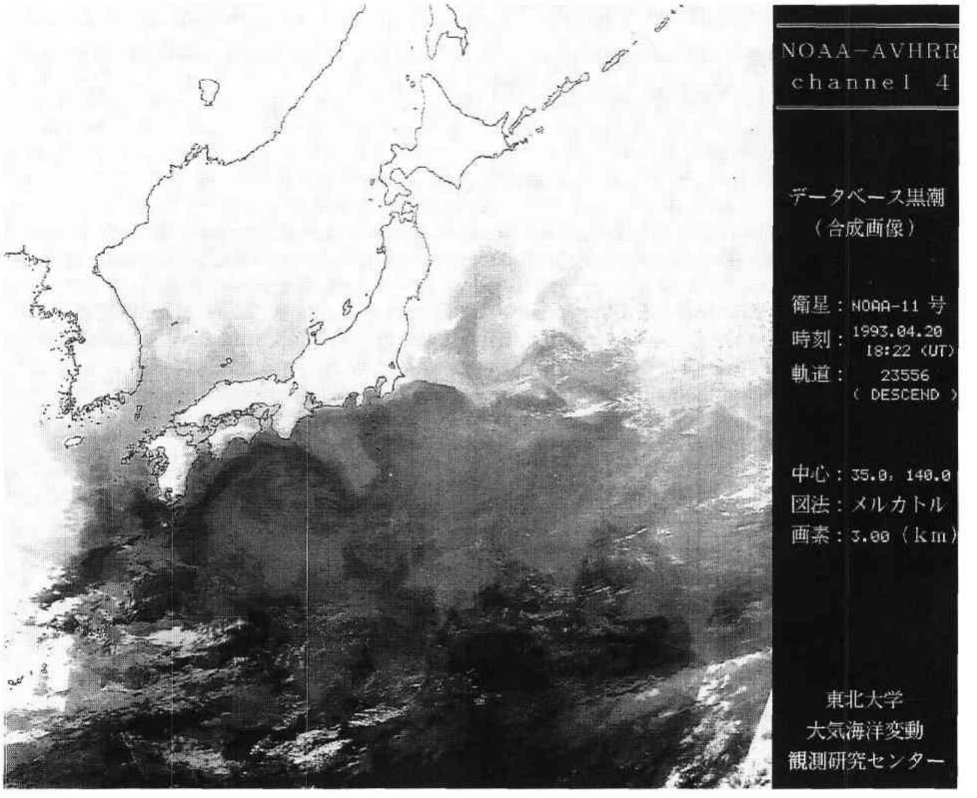


Fig. 7. An example of the Kuroshio composite image produced using the daily Kuroshio images from 18 to 21 April, 1993. A large meander of the Kuroshio current can be observed in the ocean south of Japan.

a year. The HRPT data and the daily processed images for researches and to monitor the reception condition are stored in the optical disk with recording capacity of 5 gigabyte, which enable us to use these data for several decades. The AVHRR data processing system and TOVS data processing system have been developed for various types of researches.

Old HRPT data received in Japan in the past were collected and have been archived in the optical disk (Kawamura and Saitoh, 1993). The oldest data was received in

January, 1981, and the number of the HRPT data before April, 1988 is 1570. Therefore, using the HRPT data received in the present station and collected, it is possible to investigate phenomena with a time-scale of ten years by means of the high resolution AVHRR. For example, it is pointed out that the Kuroshio behavior is related to larger scale phenomena with time-scale of ten years. As can be seen in Fig. 6, the AVHRR sea surface temperature images with high spatial and time resolution are quite useful to investigate the Kuroshio variations.

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