SATELLITE DATA ARCHIVING

1998

SAT-14

TECHNICAL DOCUMENT

TD No. 909

TABLE OF CONTENTS

1. BACKGROUND

1.1 At the tenth session of the Commission for Basic Systems (CBS), the following was included in the terms of references for the CBS Working Group on Satellites (CBSWGSAT):

> *To co-ordinate with the other working groups of CBS on relevant matters, such as the exchange, management and archiving of satellite data .....[(f) of terms of reference].*

1.2 Subsequently, a work plan was developed by the chairman of the Working Group on Satellites with "Archiving" identified as a topic of high importance. A Rapporteur on Archiving was appointed.

1.3 Based on the work plan, the tasks of the CBSWGSAT Rapporteur on Archiving of satellite data were identified as:

- To develop standard WMO requirements on archiving and retrieval systems; and,
- To prepare a report for WMO Members on procedures for retrieval of satellite data from each satellite operator.

1.4 A draft of the report was submitted and discussed at the first session of the CBSWGSAT. It was then suggested that the draft of the report should be supplemented with more information on catalogue and data retrieval procedure and published as a WMO technical document.

1.5 After soliciting information from working group members, the paper was revised.

1.6 The revised draft was discussed at the second session of the CBSWGSAT, and finalised after some supplemental information from satellite operators.

1.7 The paper is structured as follows:

- In Chapter 2, the data archiving status of satellite operators is described.
- In Chapters 3 to 8, major aspects on data archiving, management, and retrieval are introduced. The chapters discuss: the characteristics of satellite data and products; requirement on archiving content; data archiving and disseminating medium; common data format for archiving and disseminating; catalogue system; and data retrieval procedure.

2. DATA ARCHIVING STATUS OF SATELLITE OPERATORS

EUMETSAT

2.1 The EUMETSAT Meteorological Archive & Retrieval Facility (MARF) has been in operation since mid-November 1995. All Meteosat image data and derived meteorological products are stored there in digital form.

2.2 The storage medium used in the MARF is the 6.55 GByte optical disk (WORM) on which all digital data are stored in compressed form. A more detailed discussion on the MARF is contained in Appendix A.

2.3 The content of Meteosat data archiving is shown in table 1.

Table 1
Summary of Satellite Data Archival by EUMETSAT

Name of satellite	Launch date	Dates of archived data	Products archive

Meteosat-1	23.11.1977	15.03.1978 to 25.11.1979 (temporal coverage somewhat intermittent)	3-channel image data: IR - 11 micron WV - 6 micron VIS - 0.7 micron
Meteosat-2	19.06.1981	28.07.1981 to 11.08.1988 (derived products from 23.04.1982)	3-channel image data: IR - 11 micron WV - 6 micron VIS - 0.7 micron Derived meteorological products[1]
Meteosat-3	15.06.1988	11.08.1988 to 19.06.1989 24.01.1990 to 19.04.1990 30.10.1990 to 05.11.1990 11.12.1990 to 13.12.1990 22.01.1991 to 25.01.1991	3-channel image data: IR - 11 micron WV - 6 micron VIS - 7 micron Derived meteorological products [1]
Meteosat-4	06.03.1989	19.06.1989 to 24.01.1990 19.04.1990 to 30.10.1990 05.11.1990 to 11.12.1990 13.12.1990 to 22.01.1991 25.01.1991 to 02.05.1991 03.05.1991 to 26.11.1991 29.11.1991 to 11.02.1992 25.02.1992 to 08.09.1992 24.09.1992 to 04.05.1993 07.05.1993 to 03.11.1993 18.11.1993 to 04.02.1994	3-channel image data: IR - 11 micron WV - 6 micron VIS - 7 micron Derived meteorological products[1]
Meteosat-5	02.03.1991	02.05.1991 to 03.05.1991 26.11.1991 to 29.11.1991 11.02.1992 to 25.02.1992 08.09.1992 to 24.09.1992 04.05.1993 to 07.05.1993 03.11.1993 to 18.11.1993 04.02.1994 to date	3-channel image data: IR - 11 micron WV - 6 micron VIS - 7 micron Derived meteorological products [1]
Meteosat-6	20.11.1993	not yet operational	

[1] Derived products are described in Appendix A

India

2.3 INSAT imagery and derived products are archived in the INSAT Meteorological Data Processing System (IMDPS) since 1992, on 6250 bpi tapes (2400 ft.) in VAX/MS files-11 format which is close to the ANSI standard. There are only two different sizes of records used, 2K or 16K bytes. Most of the administration records are only 2K and all the data records are 16K bytes.

2.4 In order to relate all the files of an archive product, the archive files are named as follows:

File Name: YYMMDDHHMMSSCC

2.5 Where YYMMDDHHMMSSCC is the data-stamp at the time of archiving. This value will be used as the file name extension for all files of the archive product.

Tape File Name	**File Content**
VISIBLE.<ext>	Visible file
IR BAND.<ext>	Infrared file
IR DOC.<ext>	Black Body file
AUX DATA.<ext>	Telemetry file

OLR GRID1DAY MN <ext> Old data file

2.6 Content of INSAT data archiving is shown in table 2

Table 2
Summary of Satellite Data Archival by the IMDPS

Data Set	Coverage	Format	Frequency
Imagery data	Full frame sector		3 hourly
Sea Surface Temperature (SST)	N40/S40 E40/E120	1 deg. Lat/Long. Grid	6 hourly, 1 day-mean Monthly Mean
Outgoing Long-wave Radiation (OLR)	N40/S40 E40/E120	2.5 deg. Lat/Long. Grid	3 hourly, 1 day-mean 5 day-mean, Monthly-mean
Quantitative Precipitation Estimates (QPE)	N40/S40 E40/E120	2.5 deg. Lat/Long. Grid	3 hourly, 1 day 5 day, Monthly
Cloud Motion Vectors (CMVs)	N40/S40 E40/E120	1 deg. Lat/Long. Grid	00, 12 UTC

Japan

2.6 Since April 1978, Geostationary Meteorological Satellite, GMS to GMS-4, had been operated to take the earth images with visible and infrared spectral bands. GMS-5 operation was started and new computer system was renewed in June 1995. The GMS images and products have been archived in digital and analogue formats at Meteorological Satellite Center (MSC).

2.7 Magnetic Tape Specification in MSC is shown in table 3. In the present system single-reel cartridges are used mainly and these tapes are operated by using an automated library that handles as many as 1,300 tapes. This library has compression function, GMS visible image data is reduced to about 50%~60% of its original volume with no compressional data.

2.8 Status of GMS image data archiving is shown in table 4. GMS-5 has multi infrared spectral bands (IR1:10.5 ~ 11.5 μ m, IR2:11.5 ~ 12.5 μm , wv:6.5 ~ 7.0 μm), each sensor data and split-windows data (IR1-IR2) are archived.

2.9 Status of GMS product data archiving is shown in table 5 and which contains Sorbital satellite data (TOVS, AVHRR). Upper Tropospheric Air Humidity (UTM), Precipitable Water Amount (PWA), Solar Irradiation, Snow-ice Index. These are new products with system renewal and sensor addition on GMS. So single-reel cartridge with high data density is used mainly in the present system, the quantity per volume is more than that in the previous system. The retention period is extended for 30 in place of 10 years in the previous system.

2.10 Some of above described GMS images and products are issued as CD-ROM monthly report data from autumn 1996 in place of the original monthly report as book.

Table 3
Magnetic Tape Specification in MSC

Type	Open-reel	Double-reel cartridge (IBM incompatible)	Single-reel cartridge (IBM compatible)
Tape width	0.5 inch	0.5 inch	0.5 inch

Tape length	2400 feet	800 feet	1100 feet
Recording density	6250 bpi	32000 bpi	75742 bpi
Tracks	9	18	36
Storage capacity	120 MB (block length 10KB)	280 MB(block length 32KB)	830 MB (block length 24KB) (no compression)
Interblock gap	----------	0.08 inch	0.08 inch
Data compression	None	None	EDRC
Library system	None	None	1300 cartridges
Adoption in GMS data processing system	Oldest system (1878.4-1987.2) previous system (1987.3-1995.6) present system (1996-)	previous system (1987.3-1995.6) present system (1996-)	Present system (1996-)

Table 4
Status of GMS Image Data Archiving
(from Working Paper of JMA for CGMS)

Satellite	Observation Period (month-year)	Frequency	Digital data (Magnetic tape)	VTR (month-year)	Film (month-year)
GMS	4.78-1.81	3 hours	VIS/IR (12.78-11.79) IR(12.79-2.81) VIS/IR(3.81-11.81)	IR (4.78-11.81) [1]	VIS/IR (4.78-11.81)
GMS-2	11.81-1.84	3 hours	VIS/IR (11.81-1.84)	IR (11.81-1.84) [1]	VIS/IR (11.81-1.84)
GMS	1.84-6.84	3 hours	VIS/IR (1.84-6.84)	IR (1.84-6.84) [1]	VIS/IR (1.84-6.84)
GMS-2	7.84-9.84	6 hours	VIS/IR (7.84-9.84)	IR (7.84-9.84) [1]	VIS/IR (7.84-9.84)
GMS-3	9.84-2.87 3.87-12.89	3 hours 1 hour	VIS/IR (9.84-2.87) VIS/IR (3.87-12.89)	IR (9.84-2.87) [1] IR (3.87-89.12)	VIS/IR (9.84-2.87) VIS/IR(3.87-12.89)
GMS-4	12.89-6.95	1 hour	VIS/IR (12.89-6.95)	IR (12.89-6.95)	VIS/IR (12.89-6.95)
GMS-5	6.95-	1 hour	VIS/IR1/IR2/WV [2] 6.95-	VIR/IR1/WV/SP [3] 6.95-	VIS/IR1/WV 6.95-

[1] 16mm movie films
[2] "WV" means water vapour
[3] "SP" means split-window (IR1-IR2)

Table 5
Status of GMS Product Data Archiving
(Orbital Satellite Data Contained)

Data	Quantity (per volume)	Retention period
VISSR Histogram (VS/IR1/WV/SP)	10 days-1 month	30 years
Cloud Grid	3 days	30 years
Equivalent Blackbody Temperature (Hourly/5 day mean/10 day mean/monthly mean)	2 months-1 year	10-30 years
Cloud Amount (Hourly/5 day mean/10 day mean/monthly mean)	6 months-1 year	10-30 years
Sea Surface Temperature (Hourly/5 day mean/10 day mean/monthly mean)	1 month-1 year	10-30 years
Cloud Motion Wind	3 months	10 years
Typhoon Analysis	1 year	10 years
Upper Tropospheric Air Humidity (UTH)	6 months	30 years
Precipitable Water Amount (PWA)	6 months	30 years
Solar Irradiation	3 months	30 years
Snow-ice Index	3 month	30 years
Vertical Sounding (from TOVS and AVHRR data)	1 year	10 years
Total Ozone Amount (from TOVS data)	1 year	10 years
HRPT	1 day (max 6 orbits)	5 years

2.11 MSC constructed MeSDAS in 1996 to convert GMS MT/CT data to CD-ROM and to make a database for climate monitoring. MSC started this operation in June 1997 after the development of programmes such as editing GMS data and writing to CD-ROM.

2.12 MSC accomplished converting IR-VISSR data to CD-ROM from March 1981 to June 1995 in September 1997. The Number of IR-VISSR CD-ROM is 948, and 98,440 observation data are stored. The period number, observation interval, and days/CD are in Table 6.

Table 6
Status of GMS Data Archived in CD-ROM

Period	Number	Time interval	Days/CD
~ 28 Feb1981	0	0	0
1 Mar 1981 ~ 27 Feb 1987	186	3-hourly	12
28 Feb 1987 ~ 13 June 1995	762	Hourly	4

2.13 MSC is currently converting VIS-VISSR data to CD-ROM. VIS-VISSR data for 16 observations per a local (Japanese) day are stored into one CD-ROM. MSC will accomplish converting VIS-VISSR data

from March 1987 to June 1995 by July 1998. (IR-VISSR data before February 1981 and VIS-VISSR data before February 1987 had been scrapped.)

2.14 In addition, MSC plans to convert other GMS products, such as the basic histogram data and to accomplish converting MT/CT data from GMS-1 to GMS-4 to CD-ROM by the end of 1999.

People's Republic of China

2.15 FY-1 and FY-2 images have been archived in digital format at the Satellite Meteorological Centre (SMC) with IBM 3480 tape. The status of FY-1and FY-2 image data and products archiving is shown in Table 7.

Table 7
FY-1and FY-2 Satellite Data Sets

Data set	Sensor	Format	Coverage	Period of record
FY-1A (pre-processed data)	CAVHRR	Orbital data	Around China	Sep. 88-Oct. 88 Sep. 90-Jan. 91
FY-1B (pre-processed data)	CAVHRR	Orbital data	Around China	Sep. 88-Oct. 88 Sep. 90-Jan. 91
Daily mapped mosaics and 7 day min and max composites	CAVHRR	Orbital data	Around China	Sep. 88-Oct. 88 Sep. 90-Jan. 91
Sea Surface Temperature	CAVHRR	Lat/Long grid	Around China	Sep. 90-Jan. 91
Long-wave Radiation	CAVHRR	Lat/Long grid	Around China	Sep. 90-Jan. 91
Vegetation Index	CAVHRR	Lat/Long grid	Around China	Sep. 90-Jan. 91
FY-2A	VISSR		Full Disk	Nov. 97-

Russian Federation

2.16 The responsible organizations of ROSHYDROMET for the satellite data archiving in Russia are Research and Production Association “PLANETA” (NPO PLANETA) and Research Institute of Hydrometeorlogical Information - World Data Centre (RIHMI-WDC). NPO PLANETA is a leading organization in Russia in the field of Earth remote sensing from space, that plans the surveys, receives, processes and distributes the satellite data from domestic operational space systems RESURS-01, METEOR-3, OKEAN-01, and provides data accumulation and storage in satellite data archives. NPO PLANETA accepts orders for a current survey of any territory of the Earth's surface and the World Ocean, a delivery of data on an operation basis, and for the retrieval and presentation of the archival satellite data.

2.17 Natural resource and oceanographical information is stored in the NPO PLANETA satellite data archives. They contain the MSU-M and MSU-S data since 1974, and MSU-E and MSU-SK data since 1985, RM-08 and SLR data since 1983. Raw data are archived on photo (more than 160 000 from OKEAN and RESURS) and on high density digital tapes (65 tapes with more than 1200 scenes from RESURS). Satellite data obtained by NPO PLANETA are available to users in the form of:

- raw data (satellite data without any processing with an annotation containing the information on object, dates of survey, and geographical coordinates);

- primary data (satellite data after the noise elimination, structure restoration, and radiometric and geometric correction). Raw and primary data are produced in the form of separate scenes (frames) on black-and-white film (negatives) and on a photographic paper (photoprints), and in the digital form on magnetic carriers (magnetic tapes and PC diskettes);

- thematic data (satellite data after a desired thematic processing on special orders as applied to the problems of ecology, assessment of land-use, water and soil resources, shelf conditions, etc.);

Terms and forms of thematic data presentation are determined in agreement with the user. Archived data catalogues are issued and distributed between customers. Now an electronic catalogue is being prepared to make access easier.

2.18 The fulfilling of the State Archive with meteorological satellite data has been continued. operational data archive (up to 10 days) as well as thematic archives are handled by SRC "PLANETA". By the end of 1997 the INTERNET public server was created. The images from ELECTRO (8 sets similar to WEFAX daily) and OKEAN satellites are placed on this site. Together with a modern catalogue, including alphanumeric metadata and quick-looks of high and medium resolution operational images from RESURS-01 satellite that allows users a free and operational access to the data. The information is updated within one hour after receiving the data (SRC "PLANETA"). Long-term archiving techniques and facilities were developed in NITs IPR and RIHMI-WDC. The works were continued to create and maintain the State Division on rsources and oceanographic satellite data. The archiving system and technology with frame generation and visualisation have been put into a standard service. This allowed users to browse in the course of retrieval and assessment of data validity available in archive. Not only texts of session frame description but their images obtained for the 1996-97 period amounting to approximately 70000 (NITs IPR). Within the Agreement between Roshydromet and NASA (USA) NOAA HRPT data received in Yakutsk station were primarily controlled, stored and sent to the USA. More than 100 DDSs were sent since October 1995 (RIHMI-WDC).

USA

2.19 The Satellite Data Service Division (SDSD) of the National Climatic Data Centre (NCDC) archives data from the NOAA operational polar and geostationary satellites, the Defense Meteorological Satellite Program (DMSP) and certain NASA satellites. NCDC Satellite data sets are listed in Table 8.

Table 8
National Climatic Data Centre (NCDC) Satellite Data Sets [4]

Data set	Sensor	Format	Coverage	Period of record
1B (PREPROCESSED DATA)				
Global Area Coverage (GAC)	AVHRR	Orbital data sets	Global	Oct.78 – Present
Local Area Coverage (LAC)	AVHRR	Orbital segment data sets	Regional	April 85- present
High Res. Picture Transmission (HRPT)	AVHRR	Orbital segment	Regional	April 85- Present
TIROS Operational Vertical Sounder (TOVS)	HIRS, MSU SSU	Orbital data sets	Global	1978 – Present
Solar Backscatter Ultraviolet	SBUV	Orbital data sets	Global	1985 – Present
DMSP DMSP	SSM/T SSM/T	Orbital data sets Orbital data sets	Global Global	1987 – Present Nov 89 – Present
DERIVED PRODUCTS				
Vegetation Index	AVHRR	Lat/Long grid mapped polar and Mercator daily and 7-day composites	Global	1982 – Present
Sea Surface Temperature	AVHRR	Lat/Long grid	Global Regional Local	May 83 – Present

Data set	Sensor	Format	Coverage	Period of record
Daily mapped Mosaics and 7-day min and max composites	AVHRR	Polar and Mercator Map projections	Global Tropics Polar	Oct. 78 – Present
Heat budget	AVHRR	Polar and Mercator mapped monthly and seasonal yearly	Global	1974 – Present
Aerosol Optical Thickness	AVHRR	Lat/Long grid	Global	May 89 – Present
ISCCP	AVHRR GMS GOES VISSR METEOSAT	Lat/Long grid	Global	July 83 – Present
GOES Picture Pair Winds	VISSR	Earth located wind vectors	Regional	1974 – Present
TOVS Soundings	HIRS, MSU, SSU	Earth located profiles	Global	1979 – Present
DMSP Soundings	SMM/T profile	Earth located	Global	1989 – Present
Ozone profile	SBUV	Earth located profiles and total ozone	Global	1985 – Present
Polar Satellite ephemeris	AVHRR TOVS	Daily earth located	Global	1985 – Present
NASA and NAVY SEASAT	SAR, Altimeter SMMR SASS VIRR	SDR and GER	Regional Global	July Oct. 78
NIMBUS-7	CZCS	Level 1 and 2	Global	Oct 78 - June 86
GOES	Altimeter	"G" and "I"	Global	Apr 85 - Dec 78

More detailed information on NCDC polar orbital data is found in Table 9.

Table 9
Summary of polar orbiting satellite data archived by the Satellite Data Service Division by SDSD [3]

Name of Satellite	Launch date	Dates of Archived data	Form	Instruments

Name of Satellite	Launch date	Dates of Archived data	Form	Instruments
TIROS-1	1.4.1960	1.4.1960 - 14.6.1960	I	Vidicon
TIROS-2	23.11.1960	23.11.1960 - 27.9.1961	I	Vidicon, IR Radiometer
TIROS-3	12.7.1961	12.7.1961 - 23.1.1962	I	Vidicon
TIROS-4	8.2.1962	8.2.1962 - 18.6.1962	I	Vidicon, IR Radiometer
TIROS-5	19.6.1962	19.6.1962 - 14.5.1963	I	Vidicon
TIROS-6	18.9.1962	18.9.1962 - 21.10.1963	I	Vidicon
TIROS-7	19.6.1963	19.6.1963 - 26.2.1966	I	Vidicon, IR Radiometer
TIROS-8	21.12.1963	21.12.1963 - 12.2.1966	I	Vidicon
TIROS-9	21.1.1965	23.1.1965 - 9.9.1966	I	Vidicon
TIROS-10	2.7.1965	2.7.1965 - 2.4.1966	I	Vidicon
ESSA-1	3.2.1966	4.2.1966 - 6.10.1966	I	Advanced Vidicon Camera System (AVCS)
ESSA-3	2.10.1966	4.10.1966 - 1.6.1967	B	AVCS Low Resolution Radiometer (LRIR)
ESSA-5	20,4,1967	1.6.1967 - 3.12.1968	B	AVCS LRIR
ESSA-7	16.4.1968	16.4.1968 - 31.2.1969	B	AVCS LRIR
ESSA-9	26.2.1969	1.4.1969 - 15.11.1972	B	AVCS LRIR
ITOS-1	23.1.1970	28.4.1970 - 17.6.1971	B	Scanning Radiometer (SR) (VIS and IR) SR
NOAA-1	11.12.1970	26.4.1971 - 20.6.1971	B	SR, Very High Resolution, Radiometer
NOAA-2	15.10.1972	16.11.1972 - 19.2.1974	B	(VHRR) Vertical Temperature Profile Rad. (VTPR) SR, VHRR, VTPR
NOAA-3	6.11.1973	26.3.1974 - 17.12.1974	B	SR, VHRR, VTPR
NOAA-4	15.11.1974	17.12.1974 - 15.9.1976	B	SR, VHRR, VTPR
NOAA-5	29.7.1976	15.9.1976 - 16.3.1976	B	
GOES-3	9.4.1975	14.4.1975 - 1.12.1978	B	Radar Altimeter
Seasat	27.6.1978	7.7.1978 - 9.10.1978	B	SAR, SMMR, SCATT, ALT, VIRR
SEASAT	27.6.1978	7.7.1978 - 9.10.1978	B	SAR, SMRR, SCAT ALT, VIRR
Nimbus-7	24.10.1978	28.10.1978 - 23.6.1986	B	Coastal Zone Colour Scanner (CZCS)
TIROS-N	13.10.1978	30.10.1978 - 1.11.1980	B	Advanced VHRR (AVHRR), TOVS (HIRS, MSU, SSU)
NOAA-6	7.6.1979	27.6.1979 - 29.6.1983 21.6.1984 - 17.11.1986	B	AVHRR, TOVS
NOAA-7	23.6.1981	23.6.1981 - 18.2.1985	B	AVHRR, TOVS
NOAA-8	28.3.1983	20.6.1983 - 12.6.1984	B	AVHRR, TOVS
NOAA-9	12.12.1984	25.2.1985 - 7.11.1988	B	AVHRR, TOVS
NOAA-10	17.9.1986	17.11.1986 -16.9.1991	B	AVHRR, TOVS
NOAA-11	24.9.1988	8.11.1988 - 11.4.1995	B	AVHRR, TOVS
NOAA-12	14.5.1991	16.9.1991 - present	B	AVHRR, TOVS
NOAA-13	9.8.1993	9.8.1993 - 21.8.1993	B	AVHRR, TOVS
NOAA-14	30.11.1994	30.12.1994 – present	B	AVHRR, TOVS

2.20 Space Science and Engineering Center (SSEC), University of Wisconsin holds geostationary meteorological satellite data for NCDC. Table 10 below provides information on all of the geostationary meteorological satellites launched by the United States (plus the Meteosat satellite provided by ESA) and the SSEC archive holdings for each satellite.

Table 10
Summary of Geostationary Data Archived by SSEC for NCDC

Satellite name	Launch date	Dates of Archived Data	Form	Satellite Position
ATS-1	12.6.1966	11.12.1967 - 16.10.1972	F	Pacific

Satellite name	Launch date	Dates of Archived Data	Form	Satellite Position
ATS-3	11.5.1967	6.3.1968 – 11.12.1974	F	Atlantic
SMS-1	17.5.1974	27.6.1974 – 7.1.1976 27.1.1979 – 19.4.1979	F C	East (75W) East (75W)
SMS-2	6.2.1975	10.3.1975 – 3.4.1978 20.4.1979 – 5.8.1981	F,C C	West (135W) East (75W)
GOES-1	6.10.1975	8.1.1976 – 15.8.1977 5.4.1978 – 12.7.1978 2.12.1978 – 1.12.1979 29.11.1982 –31.5.1983 30.8.1984 – 3.2.1985	F F,C C F,C F,C	East (75W) West (135W) Indian (60E) West (135W) West (135W)
GOES-2	16.6.1977	15.8.1977 – 26.1.1979	C	East (75W)
GOES-3	16.6.1978	13.7.1978 – 4.3.1981	C	West (135W)
GOES-4	9.9.1980	5.3.1981 – 18.11.1982	C	West (135W)
GOES-5	15.5.1981	5.8.1981 – 29.7.1984	C	East (75W)
GOES-6	28.4.1983	1.6.1983 - 1.8.1984 2.8.1984 – 25.3.1987 26.3.1987 – 21.1.1989	C C C	West (135W) Prime (98-108W) West (135W)
GOES-7	26.2.1987	25.3.1987 – 20.2.1989 21.2.1989 – 22.4.1992 23.4.1992 – 18.1.1995 19.1.1995 – 11.1.1996	C C C C	East (75W) Prime (98-108W) Prime (112W) West (135W)
GOES-8	13.4.1994	14.4.1994 - 26.2.1995 27.2.1995 - present	C C	Central (90W) East (75W)
GOES-9	23.5.1995	9.6.1995 – 11.1.1996 12.1.1996 - present	C C	Central (90W) West (135W)
METEOSAT-3	15.6.1988	15.10.1992 - 22.2.1993 23.2.1993 - 26.2.1995 27.2.1995 - 31.5.1995	C C C	50W 75W 70W

Note: F Photographs (Film, Negatives, or Transparencies)
C Full resolution digital data on videocassettes.

2.21 Data holdings at all locations are primarily in digital format. At NCDC, IBM 3480 tapes are used, whilst SSEC data is stored in video tapes. However, a film library is maintained in the NCDC Satellite Data Service Division (SDSD) which serves as a browse facility to support digital data selection. More detailed information on future GOES satellite archiving is contained in Appendix B.

2.22 The Satellite Active Archive (SAA) began operations in early 1994. The development and management of the SAA is being led by the Office of Satellite Data Processing and Distribution (OSDPD) and in cooperation with the National Climatic Data Center (NCDC). Through the use of Internet-based online user interface systems, the SAA allows users to search its satellite data inventory, preview representative data images, place orders for data, and download the data via ftp. The user may also place orders for data to be placed on tape media. The SAA also offers online documentation in the form of data set guides and user manuals and, in some cases, has software available for reading the data.

2.23 The SAA currently archives over 6 Terabytes of data and the archive continues to grow. The SAA data available is shown in Table 11. The SAA can potentially archive up to 50 Tbytes of data with the current storage facility. The greatest volume of data consists of the NOAA AVHRR data sets and browse images. The SAA recently began offering the DMSP data sets which were transitioned to the SAA from NASA's Marshall Space Flight Center (MSFC) Distributed Active Archive Center (DAAC) when this Center ceased operations at the end of March, 1997. At this time, as might be expected, the greatest demand from the user community is for the AVHRR data sets.

Table 11
Table 11 SAA Data Sets available via FTP

DATA SET	SATELLITE	SENSOR/INSTRUMENT	LEVEL	TEMPORAL SPAN ARCHIVED
GAC	NOAA-12,14	AVHRR	1B	1/95-present
LAC	NOAA-12,14	AVHRR	1B	1/95-present
HRPT	NOAA-12,14	AVHRR	1B	1/95-present
MSU	NOAA-12,14	TOVS-MSU	1B	9/95-present
HIRS/2	NOAA-12,14	TOVS-HIRS/2	1B	9/95-present
SSU	NOAA-12,14	TOVS-SSU	1B	9/95-present
NOAA MSU Deep Layer Mean Temperatures (DLMTs)	NOAA-10,12	TOVS-MSU	3	Dec. 86 Dec. 94
T (one)	DMSP F10, F13	SSM/T	1B	2/97-present
T (two)	DMSP F12	SSM/T2	1B	2/97-present
TDR	DMSP F10,11,13	SSM/I		2/97-present
EDR	DMSP F10,11,13	SSM/I		2/97-present
SDR	DMSP F10,11,13	SSM/I		2/97-present
RADARSAT (Restricted Distribution)	RADARSAT	SAR	image	~2/97-present

2.24 In the near future, the SAA expects to archive AVHRR and TOVS data from NOAA-K which will be launched in May of 1998 and may be archiving data from some of the instruments on ADEOS, a satellite launched by the Japanese. It is also the intention of making other small data sets available for ftp through the SAA WWW home page.

3. CHARACTERISTICS OF SATELLITE DATA AND DERIVED PRODUCTS

3.1 In general, environmental satellite instruments are sensitive to electromagnetic radiation reflected or emitted from the Earth, either land, sea, clouds, or combinations thereof. The response of the instrument to the received energy is a time varying analogue signal that is converted to digital form as a series of scaled values. These values are the basic raw data, from which observations and geophysical products are derived.

3.2 While data are defined in terms of their source instruments, geophysical products are defined in terms of their applications by users, e.g., sea surface temperature for oceanographers or vertical profiles of atmospheric temperature or humidity for meteorologists. Raw data from the source instruments are subjected to calibration and correction. These adjusted data are then used individually or in combination with data from other channels of the same or other instruments to produce geophysical parameters through use of physically and/or statistically based algorithms. These algorithms are subject to continuing research and refinement, especially in the case of newer and more complex instruments. This whole process is essentially irreversible. Thus, there is a data management requirement to determine what combination of raw data, adjusted data, and final geophysical products must be preserved to meet user needs.

3.3 The processes described above include quality control and validation. Quality control involves internal checks on data quality, such as calibration range checks or transmission error detection, while validation involves comparison of the data or derived parameters with an independent measurement. Quality control and validation may be performed operationally by data providers or by the archive during or after ingest.

3.4 Metadata is data that describe data. It provides an understanding of the content and utility of the data set and is usually contained in the data sets. Metadata may be used to select data for a

particular scientific investigation.

3.5 The raw data, adjusted data, derived geophysical products and metadata are all candidates to be added to the archive's primary database. From the data management system point of view, an incoming data stream might include raw data from the instrument more or less directly, adjusted data, and derived geophysical parameters produced by an operational data processing centre.

3.6 The overall structure of the satellite primary database maybe thought of as a simple hierarchy, with a very broad base. The base represents the very large volume of raw (Level 0) or adjusted (Level 1) satellite data. Intermediate levels represent summary or sampled products, or intermediate products such as direct conversions of data values to derived parameters in the original satellite geometry at original or sampled resolution (Level 2). A small apex represents the derived geophysical parameters, perhaps mapped to a standard grid or map projection (Level 3).

4. REQUIREMENT ON ARCHIVING CONTENT

4.1 For the understanding of Earth system, long-term and uniform data archiving is necessary. With the development of remote sensing technology, a vast amount of data is produced. At present, the collection of environmental data has been more effective than the system for archiving the data collected. The systems for archiving data are also more advanced than the systems for disseminating the data.

4.2 There are several potential solutions for data archiving:

- All the data lost

  The data is simply dumped for various reasons: the obsolescence of technology, reality of budget or data management problems.

- All the data saved

  All the data are captured and stored; this is most probably a theoretic alternative.

- Some data saved

  Save some of data, but, the subset of data to be saved should be well considered and designed. Regardless of the emergence of powerful archiving and dissemination technologies, a systematic approach to archiving content is required.

The following points are considered:

Digital Data

4.3 Digital data is in the first priority. Images and products are usually stored as digital data. With digital data, images and products can be reproduced. With the development of technology, it is possible that the data processing algorithm can be improved. To keep the data uniform in historical time series, the ability to reprocess the data is reserved. That is, it is necessary to preserve the minimum processed observation data and the related information. These include:

- All digital observation data from major satellite missions with minimum processing, based on which a variety of products can be derived;

- All necessary and complete information on initial gathering of the data with which calibration and navigation (location) can be performed, such as: spacecraft identification, orbital and altitude parameters, sensor identification, and observation time,

- Receiving stations and responsible persons,

- All necessary and complete information on data processing algorithm if any processing is performed on the data received;

- All necessary and complete information on data access.

Images

4.4 Images are retained depending on the ability of archiving facility. Browsing or data selection of images with reduced resolution is necessary.

Products

4.5 Products are also retained. These include:

- Radiation budget: planetary albedo, solar irradiance, outgoing long wave radiation etc.;

- Sounding products: temperature, humidity, wind etc.;

- Cloud detection products;

- Cloud motion winds;

- Aerosol, ozone, and other tracing gases;

- Land and ocean surface characteristics: Snow cover, sea ice, sea surface temperature, vegetation index etc.

Archiving system

4.6 The archive data management system is capable of producing summaries and other special products. These may be specially sampled granules, or statistical summaries, such as histograms generated from original data.

4.7 The archive system also allows archive users to develop new products by refining current or developing new algorithms or products. This requires preservation of the raw data values themselves and possibly some of the adjusted data as well as the original geophysical products. It is critical that all information, such as calibration coefficients or tables, that allow raw data values to be regenerated from adjusted data be preserved.

5. DATA ARCHIVING AND DISSEMINATING MEDIUM

5.1 Data archiving and dissemination mediums may change with the evolution of technology. Since technology continues to develop quickly, users of computer-readable media must be prepared to migrate to new ones. Otherwise, equipment may become obsolete and difficult to maintain. Although we expect the data storage mediums to have long life and reliability, data has to be migrated when equipment is out of date. There are three types of media: hard copy, magnetic tapes, and optical storage mediums. Their advantages and disadvantages for remote sensing data archiving are described as follows:

Hard Copy

5.2 These include photographic materials including microfilm, maps and tables. Negative films and microfilms can last for a long time. They are suitable for image archiving. The advantages of hard copy is easy to distribute, easy to make casual and first inspection of the fields to find patterns or other interesting attributes. Thus films are used for browsing and data selection. The main disadvantage lies in the inability of input to the computer. Thus, digital data should use magnetic tapes or optical media to store.

Magnetic Tapes

5.3 These include CCT, Digital Audio Tape (DAT), and Digital Audio Cassettes (DAC).

5.4 CCT is widely used with international standard. Its advantage is obvious. Its disadvantages are storage and shelf-life problems, and serial search mode. A typical CCT holds 180 Mbytes data in 2000 cubic cm. A more compact IBM 3480 tape holds 200 Mbytes data in 360 cubic cm.

5.5 DAT has a capacity of 13 Gbyte in a volume of about 80 cubic cm , while DAC, the Exabyte for instance, has a capacity of 46 Gbytes in about 25 cubic cm. DAT and DAC solve the problem of archiving space but they may not solve the problem of archive refresh cycles and slow search speed.

Optical Disks

5.6 Large amounts of data (order of 1 Gbytes) can be stored on optical disks. High data density is only one of the advantages of the optical media. The reading mechanism is using a light beam, so there can be no physical damage to the media at read time. The surface of optical disk is protected from scratches by a transparent plastic film. A considerable amount of redundant error checking information can be inserted. The digital recording optical disks can be sub-divided in three classes:

- The Compact Disk Read-Only Memory (CD-ROM),

  This is a device loosely based on the compact audio laser disk system and already commercially available. CD-ROM disks can now be easily written on cheep peripherals. A new high density specification for CD-ROM has been agreed by industry (double sided, multiple layers, increased density), which increases capacity to 5-10 Gbytes, making this more attractive as a archive medium. It can store 1 Gbyte or more data in 10 cubic cm. The CD-ROM devices connect directly to the personal computer via inexpensive easy-to-operate CD drives. These advantages make CD-ROM an idealised medium for data disseminating.

- The Erasable Optical Disks

  The erasable disks are generally magnet-optical systems that rely on an optically bistable medium that can shift between two states of reflectivity under the joint influence of a laser and of a magnetic field. The digital information is recorded by the heat from a laser which changes the coercitivity of a spot, thus making it susceptible to magnetic reorientation by a surrounding bias field. The advantages are high storage capacity, random access and high quality which make them particularly useful for unique data sets to be archived. The disadvantages are the current lack of standardisation, and high cost of reproduction.

- The Write Once Read Many (WORM)

  This media is like the CD-ROM, a plastic encapsulated metalised disk. A relatively high-power laser is used to create tiny holes in the thin metal film. The fact that this process is not reversible, i.e. that one cannot erase data from a WORM disk represents a definite advantage for a satellite data long-term archiving system. The claimed life of the disks has grown recently from 10 years to 30 years. Therefore, WORM is considered a good media for satellite data archiving. The medium costs more than magnetic tapes at present.

Direct Electronic Dissemination

5.7 The primary goal of Direct Electronic Dissemination is to make massive volumes of environmental satellite imagery and other satellite products available to users across the Internet. Direct Electronic Dissemination provides the ability to search, browse, peruse, order and network delivery

satellite data in a timely fashion for a wide user base.

5.8 The initial prototype Direct Electronic Dissemination System provides for up to 5 terabytes of nearline storage and has ASCII, Xwindow, and World Wide Web/Mosaic user interfaces, allowing users to preview imagery data from their remote workstations connected through the Internet, and receive up to 10 megabytes of data at no cost via network delivery. It is designed to be user friendly: easily Internet accessible (as well as other communications networks), easily extendable to other satellite and *in situ* data sets; and easily interoperable with the other data centres.

5.9 NOAA's Satellite Active Archiving (SAA) system enables users on Internet to quickly search, browse, order and receive satellite data. Detailed description on SAA is in Appendix C.

6. COMMON DATA FORMAT FOR ARCHIVING AND DISSEMINATING

6.1 The issue of common data formats, access and distribution are becoming of great importance as the amount of archived data grows even greater and the capacity for data production by new instruments increases.

6.2 The early Earth Observation projects used project specific methods for archiving, data handling and distributing. These projects had only limited requirements on interoperability with other projects. It is expected that current and future Earth Observation programmes will span many decades and produce very large amounts of data. If this data is not handled correctly, there will inevitably be inaccessibility problems. Therefore, with advancing in technology, the utilisation and application of standards and a layered approach to data handling is becoming even more important.

6.3 The recognition of the importance of these issues and the potential for applying standard approaches to their solution has led to a number of recommendations being made by various agencies and bodies.

6.4 Up to now there have been three main organizations involved in producing standards for space data handling: the Committee on Earth Observations Satellites (CEOS), the Consultative Committee for Space Data Systems (CCSDS) and the World Meteorological Organization (WMO). CCSDS provides a forum for Space Agencies in mutually developing standard data handling techniques. The primary products of CCSDS are technical recommendations which guide internal developments of compatible standard within each of participating Space Agencies. The CCSDS activities will significantly enhance the planning and execution of future co-operative space missions. The CEOS Working Group on Data (WGD) Catalogue Subgroup (CS) co-ordinates ideas and information for the development and operation of an international interoperable catalogue system.

6.5 Both CEOS and CCSDS use the same concept for data storage and distribution, that is the CEOS Superstructure and Standard Formatted Data Unit (SFDU) respectively.

6.6 The CEOS Superstructure and Standard Formatted Data Unit enables data to be encapsulated within a standard framework. The data format is independent of the physical media. It has four basic components:

- Volume directory which globally defines the configuration of the tape or tape set;
- File descriptions which describe in more detail the configuration of the files;
- Logical volume, or a logical grouping of files on one or more physical volume;
- Physical volume i.e. a unit of physical medium (e.g. one CAT, one CD-ROM etc.)

The overhead associated with the CEOS Superstructure is around 5% of the total user data.

6.7 The CEOS formats ease the problems of distribution of data to users through the adoption of a fixed format on sequential access media. Consequently, common software can be used to access the formats. Because the number of formats that a user can interpret is limited, more flexible approaches using the Superstructure concept to encapsulate multiple data formats are being studied including the use of data description languages.

6.8 The CCSDS SFDU concept is based on a single structure called the Label Value Object (LVO). This structure is comprised of two fields, the LABEL and a VALUE. LVO can be nested so that a compound LVO is built from a number of other LVOs. The percentage overhead associated with the CCSDS SFDU concept is extremely low. This is achieved through the use of unique level to identify elements of the SFDU.

6.9 The CCSDS SFDU concept requires that all data is completely self-describing. This means that all data must be accompanied by a data description, either in complete form with the data or by using a reference to a registered description.

6.10 The WMO binary codes BUFR (Binary Universal Form for the Representation of meteorological data) and GRIB (Processed data in the form of grid-point values expressed in binary form) could both be suitable for the archiving of satellite products and related data.

6.11 The Co-ordination Group for Meteorological Satellites (CGMS) at its twenty-first session, discussed co-ordination of data formats for the archive and retrieval of satellite data. The Group agreed that although the concept of common data formats, access and distribution was vital, it was not necessary for CGMS to develop another format but rather to use already available methods. In this respect the Group recommended that CGMS Members should review the detailed data formats specified by CEOS and CCSDS.

7. CATALOGUE SYSTEM

7.1 Until now, there has not been a centralised point of contact for satellite data distribution. There are difficulties in obtaining satellite data efficiently. To solve this problem, catalogue systems are needed. Catalogues generally contain more detailed information about the data and may contain data set processing, calibration, and quality control information. Catalogues often focus on data sets within a specific discipline. However, the description of the archive contents given by different catalogues must be easily understood by a large number of international users with experiences in different disciplines. Thus, the catalogue is accessible by outside systems, at least to the extent that user can make a decision as to whether the archive contents may be of interest. This open interoperable approach requires common standards across all co-operation archives for catalogue formats.

7.2 A catalogue system provides a service. It enables a user to obtain detailed information about whole data sets, typically specific to a discipline, data centre, or project, without being restricted by where the data is located. When a user searches a catalogue's listings, the system would communicate the search to all available catalogues and return to the user a combined list of available data from all archive locations, thus avoiding the problem of the users, (a) having to know where the data and catalogue reside, and (b) how to use the different systems to get the information required. A catalogue also allows a user to identify and retrieve a small part of the data sets for his review before ordering.

7.3 A catalogue service is assumed to have three main components: directory service, guide service, and inventory service.

7.4 A directory service provides description of metadata or data set catalogues containing high level information suitable for making an initial determination of the potential usefulness of a data set for some application. Information of the location of metadata or data set catalogues will be found in the directory. It gives an initial indication of the existence of suitable data sets and indicate the temporal and spatial coverage, whom to contact for copies of data and a brief description of the data. The directory contains information about a large and diverse number of data sets, but only provide brief overview information about the data sets. This serves as the first step in data set searches and would cut boundaries across agency and discipline when searching for data.

7.5 Guide service provides detailed information concerning specific data set which enables the user to make a detailed analysis of whether a data set or a specific granule within the data set will be of value for some application. It may also contain information necessary for analysis of the data (such as

calibration coefficients). After getting to know the existence of suitable data sets the user will then need to have more detailed information to be able to make effective and efficient use of the data. Access to contextual information is required to be able to make judgements as to the suitability of a data set. This type of detailed information is provided by a guide service.

7.6 The inventory contains information needed to identify and retrieve the individual granule(s) of the data set, given the specification of the independent variable range(s), and contains information extracted from the data set granule(s) (such as cloud cover), as well as information to enable ordering (price). In terms of content, structure and functionality, the inventory is the most heterogeneous in the three major components of catalogue service. It supports access to the data by providing detailed information about data granules and the physical location of the data A typical inventory is a tape inventory indicating which volumes contain data for a given time, location and sensor, etc. At the inventory level of inter-operability, the independent data systems have an increasingly common look and feel, and are able to efficiently exchange information across networks.

7.7 More detailed information on the catalogue system is contained in "Guidelines for an International Interoperable Catalogue System" [7]

8. DATA RETRIEVAL PROCEDURE

8.1 Users requesting satellite data from satellite operators should make every effort to supply as accurate and as much information as possible concerning their needs.

8.2 To order photographic products, the following information need to be specified as much as possible:

- Date(s) of interest
- Time(s) in GMT
- Type of product
- Geographic area
- Satellite
- Sensor instrument
- Special physical feature(s) to be shown in imagery
- Minimum acceptable size or resolution
- Geographic grid desired or not desired
- Final product: Print, Transparency, Negative, Slide, Microfilm, etc.
- Finish of photographic prints : Matte or Gloss

8.3 To order computer products, the following information need to be specified as much as possible:

- Date(s) of interest
- Time(s) in GMT
  -Geographic area and coordinates
- Types of data products: HRPT, LAC, GAC, TOVS etc.
- Satellite
- Orbit number
- Sensor instrument
- Channel type or numbers
- Packed or unpacked data
- Data medium: 3480 cartridges, CCT tapes etc.
- Data density

8.4 Mail the order to the proper satellite operators at the following address:

Meteorological Archive & Retrieval Facility (MARF)
EUMETSAT
Am Kavalleriesand 31
D-64295 Darmstadt
Germany

Fax: (49 6151) 807-379

International Meteorological Planning Division.
Management Department.
Japan Weather Association,
2-9-2 Kanada Nishikicho
Chiyoda:
Tokyo 101
Japan
Fax: 03-3262-9549

National Satellite Meteorological Center
Beijing 100081
People's Republic of China
Fax: 86-10-62172724

NPO"PLANETA"
Perromayskaya, 1
Dolgoprudny
Moscow Oblast
Russian Federation

NOAA/NESDIS/NCDC
Satellite Data Service Division
Princeton Executive Square, Room 100
5627 Allentown Road
Camp Spring MD 20746
USA
Fax: (301)7638443

8.5 After receiving ordering requirements, the satellite operators shall contact with the users by any means to clarify the ordering requirement, the data availability, and the way of payment.

8.6 Make payments to the satellite operators.

8.7 Receive data.

8.8 NOAA provides detailed ordering procedures which are listed in Appendix D.

9. REFERENCES

This report has been compiled using the following references:

(1) CEOS Consolidated Report, 1992

(2) CGMS Working Papers from ESA, EUMETSAT, Japan, People's Republic of China, and the USA

(3) Weather Satellites: Systems, Data, and Environmental Applications, Edited by P.K. Rao, S.J. Holmes, R.K. Anderson, J.S. Winston, and P.E. Lehr, American Meteorological Society, 1990

(4) Palaeogeography, Palaeoclimatology, Palaeoecology Vol 4 No 1-3 Global and Planetary Change Section Edited by G.Ohring, E.P.McCLAIN and J.O. Ellis, 1991

(5) Earth Observation and Global Change. Decision Making, J.W. Gingsberg and J.A.Angelo JR, 1992

(6) IGBP Global Change Report No. 20: Improved Global Data for Land Applications

(7) Guidelines for an International Interoperable Catalogue System, Catalogue Subgroup, Issue 21, April 1993

(8) 1993 CEOS Dossier, Vol B, Space Agency Ground Segment and Data Products, Sep 1993

(9) NOAA Satellite Active Archive, Robert L. Mairs, Abstract Brochure, The Meteorological Satellite Data User's Conference, September 1995.

APPENDIX A

THE EUMETSAT METEOROLOGICAL ARCHIVE AND RETRIEVAL FACILITY (MARF)

APPENDIX B

GOES DATA ARCHIVING

APPENDIX C

NOAA'S SATELLITE ACTIVE ARCHIVE

APPENDIX D

NOAA

RETROSPECTIVE SATELLITE DATA PRICE LIST, SATELLITE PRODUCTS LIST AND ORDERING PROCEDURES